DOMESTIC GAS CONSUMPTION, HOUSEHOLD BEHAVIOUR PATTERNS, AND WINDOW OPENING

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ABSTRACT

Domestic gas consumption for central heating is a function both of the efficiency of the heating system and the way in which it is used. While many studies have concentrated on the performance of systems and their controls, there have been few studies of occupant behaviour.

The thesis therefore studies household behaviour patterns relating to domestic gas consumption. There are two main aims: firstly, to study a variety of these patterns and, secondly, to make a detailed investigation of one particular behaviour pattern, namely window opening. These two studies centre on 113 households on two local authority estates, where all the dwellings are of similar construction.

The first study makes use of two main data sources: quarterly gas consumption readings and data obtained from an in-depth interview with each head of household. It identifies a variety of behaviour patterns and their underlying motivations. Additionally, this study shows that design heat loss and terrace position account for less than a third of the variance in winter consumption. A regression analysis using only behavioural and social variables resulted in a similar proportion of variance being explained. These two sets of independent variables could not justifiably be combined due to their inter-correlations. In conclusion, it was suggested that consumption may not be determined by a few variables of major significance but rather by a large number of inter-acting variables each with a small influence on consumption.

The second study, window opening, makes use of three data sources: a series of systematic window observations, meteorological data and data obtained from postal questionnaires. The study identifies the objective correlates of estate-wide window opening, as well as the subjective motivations for the opening and closing of windows. It highlights the wide range of variation in window opening amongst householders. In addition, the study indicates that householders adopt characteristic window opening patterns which they can reliably report.

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CHAPTER 1

REVIEW OF THE ENERGY CONSERVATION LITERATURE

1.1. General Introduction

This thesis involves two main studies. The first is concerned with householders' behaviour patterns, the motivations underlying the relative frequencies of these behaviours and their effects on domestic gas consumption (Chapter 4). The second is concerned with a detailed investigation of one particular behaviour pattern, namely window opening (Chapter 5).

However, before discussing these studies it is necessary to first review the related literature (Chapters 1 and 2) and to then examine the results of two pilot studies (Chapter 3).

The literature review in this chapter pertains mainly to conservation. Although it is accepted that a knowledge and understanding of the determinants of energy consumption are logically prior to an understanding of conservation, most of the relevant literature deals either with factors influencing peoples' conservation potentials or with particular conservation strategies. This is presumably because such studies are seen to be of obvious immediate relevance and the funding for such projects is consequently more easily obtained.

Chapter 2 deals with studies concerned with domestic energy consumption. Although the studies it reviews are fewer in number, they are of more direct relevance to the work of this thesis.

1.2. Introduction to the Literature Review

The energy crisis of 1973/1974 demonstrated the dependence of current Western lifestyles on the ready availability of an abundant supply of energy. The numerous responses to the crisis were of two types. The first included actions to protect energy availability and supply from future disruptions by forces beyond the control of the country concerned. Actions in this category include the exploration for, and the exploitation of indigenous energy resources. The second category of responses was concerned with attempting to reduce the energy dependence to current western lifestyles (Crossley, 1980).

Energy conservation is now a central element in the United Kingdom's energy policy. The government professes two principal energy conservation objectives. The first is the achievement of short term reductions in the use of energy, the second refers to longer term changes in the way it is used to provide a continuing saving of energy.

From a national viewpoint, conservation is desirable since it can contribute to a favourable trade balance both by reducing energy imports and by permitting an increase in energy exports. Moreover, despite the fact that the United Kingdom is particularly fortunate in that it now produces more fuel and power than it consumes, it is accepted that North Sea oil and gas reserves are limited.

Although buildings (domestic, commercial, industrial and institutional) have been identified as the key to a successful energy strategy, the literature review in this and the next chapter will pertain mainly to energy usage in domestic dwellings for space and water heating, as well as for cooking and such various purposes as lighting and refrigeration.

This decision has been made for three reasons. The first is that the residential sector accounts for a high proportion of direct total energy usage. In 1978 27% of total primary energy consumption went to domestic dwellings (General Household Survey, 1980). Secondly, direct energy usage in buildings and especially houses, is currently relatively inefficient. Romig and Leach (1977) have pointed out that it is in this area that the most rapid savings can be made through improvements in the efficiency of energy usage. The third reason is that the majority of domestic dwellings house families and because "the aggregate of families form the structure of society from which all other social institutions draw their component units, alternative futures are linked to family socialization and consumption processes" (Hogan, 1976). This implies that an individual brought up in a family where the energy use is wasteful, is likely to carry over his wasteful habits to his place of work.

The literature review in this chapter falls into two parts. The first deals very briefly with technological research on energy usage whilst the second examines the contribution of psychological research to energy conservation.

1.2.1. Technological Research

It is currently estimated that over 15% of national primary energy consumption could be saved by conservation in building services if applied to all building types including homes (BRE working party, 1975). The savings are achievable by a combination of measures, some of which (for example, improved insulation and heating appliance efficiency) are appropriate for existing buildings and some of which (for example, heat pumps, utilization of waste heat from power stations, reduced ventilation losses and the addition of solar collectors) are more suitable for new buildings.

A review of the literature indicates that theoretically large energy savings are consequent upon increased insulation. However, Nevrala (1979), discussing domestic energy consumption, has pointed out that once the building fabric has been made thermally efficient the building needs to be considered as a complete system. This means that account must be taken of four key factors affecting optimum performance, namely (1) sizing of the heating appliance and system with respect to peak demand, (2) appliance operation over the full range of demand, (3) heating system design and controls, and (4) mode of operation by the householder. The first three of these four aspects have been extensively researched. No attempt will be made to summarise their findings. Instead the reader is referred to an excellent review by Brundrett, Leach, Parkinson, Pickup and Rees (1977).

1.2.2. Social and Psychological Research

The Arab oil embargo in 1973 served as a major stimulus, especially in America, for the investigation of social factors affecting domestic energy usage and conservation. A modification of a classification system first outlined by Lipsey (1977) will be used to provide a framework within which to review the results of these studies.

In considering the antecedants of a variety of "ecologically responsible behaviours" Lipsey identified four main factors, namely personal predisposition (1.2.1), the ability and also the motivation to carry out energy conserving practices (1.2.2 and 1.2.3) and finally the facilitation of such behaviours by external factors (1.2.4). These factors are not mutually exclusive but will be discussed separately for reasons of simplicity.

1.2.2.1. Predisposition

Four variables were found by Lipsey to comprise personal predisposition namely, demographic characteristics, attitudes beliefs and intentions, individual differences in personality, and the effects of particular activities or experiences.

1.2.2.1.1. Demographic and economic characteristics

One demographic attribute which has consistently been demonstrated to be related to energy conserving behaviour is the level of education (Ellis & Gaskell, 1978). Several studies have shown that the higher a person's level of education, the more likely he or she is to have adopted conservation measures or to accept the need for government conservation policies (Bultena, 1976; Curtin, 1975; Gottlieb and Matre, 1976; Thompson and MacTavish, 1976; Zuiches, 1976). Although a few studies have failed to demonstrate a statistically significant relationship between education level and conservation (Kilkeary, 1975; Lopreato and Meriwether, 1976; Murray, 1974), no study has reported an inverse relationship.

The relationship between level of income and energy use is less clear. Although the majority of studies show that as income level increases, so does the likelihood of adopting conservation measures, other studies indicate that income level shows various effects on various social groups at different times and places (Crossley, 1980). The diversity of findings is explainable by the interaction of income level with other non-income factors for different socio-economic groups. Thus for example, although people with higher incomes have greater capacities to use and save energy than people with lower incomes (Desson, 1976; Dunne, 1977; Field & Hedges, 1977; Newman & Day, 1975; R.I.C.A., 1978); what they actually do depends on personal choice and circumstances (Seligman et al., 1978).

Several studies have explored sex differences and their relation to actual conservation. The majority of surveys have found no difference between energy conserving behaviours by men and women (Curtin,1976; Lopreato & Meriwether, 1976). However, Warren (1974) found that men more likely to save energy.

Although age appears to have a more significant influence (Gottlieb & Matre, 1976), its effects are found to vary with specific behaviours. Thus, for example, whilst Curtin (1976) reported that young people are more likely to save electricity, middle aged people, especially those with moderate or low incomes, are most concerned with reducing home heating and cooling costs (Curtin, 1975; Lopreato & Meriwether, 1976).

In conclusion, it seems that apart from education level, all other demographic relationships with energy use and conservation vary greatly in strength and direction. Ellis and Gaskell (1978) explain that this is to be expected since education, income and age are interactive.

1.2.2.1.2. Attitudes, beliefs and intentions

Most studies of energy use have tended to support Wicker's (1964) finding of a poor relationship between attitudes and behaviour. Three separate reviews by Anderson and Lipsey (1978), Lopreato and Meriwether (1976) and Olsen and Goodnight (1977) concluded that awareness of energy issues was not related to increased commitment to conservation practices. However, Ellis and Gaskell (1978) argue that several studies have demonstrated a relationship between specific attitudes and energy consumption or conservation (for example, Hogan, 1976; Seligman et al, 1978). Crossley (1980) maintains that the failure of most investigations to demonstrate attitude-behaviour relationships is due to methodological inadequacies. He identifies two sources of deficiency. The first is that many studies have relied on inexact surrogate measures of energy expenditure. The second is that some studies have indiscriminately used the terms attitudes, beliefs, opinions, knowledge and values to refer to variables measured in various ways.

1.2.2.1.3. Individual differences in personality

Of over 400 references reviewed by the researcher, only two examined the effects of personality on energy use and conservation. This is probably due to the fact that on a practical basis it is easier to group consumers by readily identifiable characteristics than by personality measures requiring close questioning or observation. However, as Crossley argues the effects of personality on behaviour are likely to be profound at the level of the individual. This is supported by a study of matrifocal households by Klausner (1979) who concluded that energy usage is related to the degree of social order in the household which is influenced by the sex of the head of household. However, in a replication of the study Defronzo (1979) found that although the results were in the hypothesised direction, they were statistically insignificant.

In view of the paucity of research on personality factors, Lipsey speculated that three factors might be relevant to an understanding of "ecologically responsible behaviours". These are:

(1) locus of control - a concept which distinguishes between those who feel that events are determined by forces beyond their control (external locus of control) and those who believe that their actions can influence situations (internal locus of control).

(2) future time perspective - a measure of the extent to which an individual is able to plan ahead and appreciate future consequences, and

(3) mutability of self concept - a factor which refers to peoples' varying abilities to perceive their own capacities for changing their lifestyles.

This last factor may be particularly important. Several researchers have remarked that reductions in energy usage are dependent upon changes in lifestyles (Gladhart, 1977; Hogan, 1976; Hungerford, 1978; Keith, 1977; Morrison, 1975). However, Milstein (1976) has noted that most householders are reluctant to adopt any energy conservation behaviours which necessitate significant changes in lifestyle, since such changes are assumed to result in a poorer quality of life. This assumption contradicts the findings of both Schipper and Ketoff (1980), and Mazur and Rossa (1974) who maintain that energy consumption is not significantly related to most lifestyle indicators, including those for health, education, culture, and social wellbeing.

1.2.2.1.4. Effects of participating in activities and experiences

Lipsey suggested three sets of circumstances which make individuals aware of the need for conservation, namely (1) difficulties in obtaining basic commodities, (2) exposure to environmental pollution and (3) familiarity and contact with the countryside. A fourth variable has been identified by several researchers (Ellis & Gaskell, 1978; Pallak & Cummings, 1975; Winett, 1977; Winett et al, 1979) who have concluded that experimental subjects who measure their own energy use are more likely to save energy than those who do not . Similarly, McClelland and Cook (1979) have demonstrated that user participation methods are more effective in achieving conservation than managerial methods.

1.2.2.2. Ability

Three variables may be identified as influencing a person's ability to adopt energy conservation practices, namely

(1) "energy literacy" (Matthews, 1978);

(2) social and institutional barriers (Blumstein et al, 1980), and

(3) financial constraints.

Energy literacy is a term that has been used to describe knowledge as to the relative costs and consequences of different energy using activities. Acceptance of the need for energy education has resulted in conservation programmes in many countries being aimed at increasing the level of energy awareness amongst consumers (Crossley, 1977).

The roles played by social and institutional norms in energy usage have been outlined by Blumstein who showed that the ability (and willingness) to conserve is affected by such varied factors as market structure, the desire for personal status, and peoples' habits. In addition, several researchers have pointed out that householders' abilities to conserve energy may be limited by the fact that the structural features of their dwellings are often chosen by someone else (Gladhart, 1977; Newman & Day, 1975).

Finally, financial considerations have frequently been observed to affect energy consumption (Desson, 1976; Fisk, 1978; Hunt, 1980; Newman & Day, 1975). In addition, as previously mentioned, income has sometimes been noted to influence householders' energy conservation potentials in that people with a low income may not be able to afford certain types of insulation. For example, both Milstein (1976) and Phillips and Nelson (1976) report a negative relationship between the price of insulation materials or energy saving equipment and the likelihood of their being installed in domestic dwellings.

1.2.2.3. Motivation

Factors which may influence a person's willingness to conserve energy include the effect of pricing strategies as well as social cohesion and the desire for conformity.

Initiators of pricing policies for conservation assume man to be an economically motivated animal. However, several studies show that the demand elasticity for energy, especially gas used for space heating, is low (Lopreato & Meriwether, 1976; Olsen & Goodnight, 1977). Ellis and Gaskell point out that this may be due to a variety of factors such as adaptation to higher prices and the masking of price increases by inflation. Negative psychological reactance to price increases may be another important factor, in that people sometimes resent having their priorities manipulated and consequently may resist pressures to change their behaviour. It is also possible that the structure of utility tariffs (with reduced rates beyond a certain consumption level) does not encourage conservation.

Finally, there is some evidence to suggest that social rewards may act as motivators (Condie et al, 1976; McClintock, 1976). A study of particular importance is that by Warren and Clifford (1975) which showed that people living in neighbourhoods with high levels of cohesion were more likely to save energy than those people living in less integrated environments. The authors assumed that such a cohesive environment facilitated the dissemination of a local energy conservation norm which was adopted by the majority of householders.

1.2.2.4. Facilitation

Four approaches have been shown to facilitate conservation. These approaches (behavioural, cognitive, social, and structural) will be discussed in turn.

1.2.2.4.1. Behavioural research on conservation

Behavioural strategies use influence to achieve compliance by individuals to desired forms of action. They assume that as individuals come to act differently, their attitudes and beliefs will shift to reflect their actions, and that as enough people begin to act differently, the total society will change (Olsen & Goodnight, 1977). The behavioural approach to conservation has considered three main variables, namely the effect of changes in the price of energy, the use of prompts; and the use of incentives (monetary and social). The first of these has already been discussed and so will not be dealt with in this subsection.

1.2.2.4.1.1. Incentives

Most researchers investigating the effects of incentives have tended to assume that money is a primary motivator and so have offered monetary rebates for reduced consumption levels. Such studies have generally examined the effects of rebates and prizes on small atypical samples of apartment residents and students living in college halls, as well as on small numbers of homeowners (Foxx & Hake, 1977; Hayes & Co., 1977; McCelland & Cook, 1978; Slavin & Wodarski, 1977; Winett et al, 1978; Winett & Nietzel, 1975).

However, econometric estimates suggest that large amounts of energy will not be saved by the use of monetary incentives. Several studies have shown that energy consumption reduction is not directly related to the amount of rebate offered, and that the monies distributed generally exceed the value of the energy saved. Moreover, although incentives can result in reductions of between 12% and 30% (depending upon season) the effects of such inducements seldom last longer than a few weeks. Additionally, Stern and Kirkpatrick (1977) warn that paying people to conserve energy makes significant long-term changes more unlikely, since it encourages conservation on the basis of temporary external motives.

On the other hand, Gordon suggests that selectively offered rebates may be useful. He cites evidence from studies using rebates to reduce "peaking" and concludes that time of day pricing can significantly reduce electricity use during peak hours, but that this effect depends on the length of the peak and on the price differential between peak and off-peak rates. He also notes that some psychologists have developed incentive based conservation programmes that increase the cost effectiveness of rebate experiments by only giving incentives for part of the time. Such programmes use partial re-enforcements schedules or reward only selected individuals, either those who meet predetermined criteria or who win energy conservation contests. Finally, he comments on the considerable body of research which shows that the occupants of master-metered dwellings use an estimated 25% to 35% more energy than comparable individually metered houses (Courtney & Jackman, 1976; Gross et al, 1975; McNair & White, 1977), and suggests that incentive schemes may be particularly useful in such settings.

Several researchers have offered explanations as to why rebates do not result in long-term changes in behaviour. These include inflation, adaptation, the masking of conservation efforts by rising energy costs, and a reluctance to give up comfort and perceived energy related health benefits (Seligman et al, 1979). Additionally, as Ellis and Gaskell(1978) remark, incentives alone provide no information as to how householders can save energy.

On the effects of social inducements Warren (1974) discovered that a major factor determining whether or not a person made any conservation efforts during the 1973/1974 crisis, was the extent to which his neighbours adopted such practices. Seaver and Patterson (1976) found that householders given a sign saying "we are saving oil" significantly reduced their levels of consumption.

1.2.2.4.1.2. Prompts

Prompts are messages which exhort or signal people to take certain actions but which may contain very little, if any, factual information. They vary from the general ("Save it") to the specific ("Shut off light when room is not in use"). However, a review of studies concerned with the effectiveness of prompts, suggests that if prompts are to be successful they should clearly indicate who is meant to do what and when (Winett & Neale, 1979).

1.2.2.4.2. Cognitive research on conservation

Cognitive strategies use communication to achieve commitment by individuals to desired attitudes, beliefs and goals. They assume that as individuals come to think and believe differently they will act differently, and that as enough people begin to act differently, the total society will change (Olsen & Goodnight, 1977). This exactly reverses the direction of cause and effect assumed by behavioural strategies (see 1.2.2.4.1). The cognitive approach has considered two main variables - information (about specific actions that will save energy) and feedback (information about the individual's current consumption rate). These will be discussed separately.

1.2.2.4.2.1. Information

The approach of providing information assumes that the motivation to save money or energy already exists, but that the individual's knowledge or understanding of his energy usage is inaccurate so that energy saving opportunities are not taken. The approach depends entirely on logic and explanation.

A review of the available literature suggests that there is some controversy among researchers as to the effectiveness of information. On the one hand it has been argued that information alone has no demonstrable effect (Shipple, 1979; Winett & Neale, 1979). On the other hand, others notably Crossley (1977) and Ellis and Gaskell (1978) have suggested that although information is unlikely to lead directly to changes in behaviour, it serves to change attitudes and create a climate of opinion which is receptive to more specific information. The effectiveness of specific information is supported by a study by Geller, Ferguson & Brasted (1978). They noted that subjects given flow limiters for their bathroom shower heads were more likely to use them when given information about how to install them and told that researches found them to be cost effective. They concluded that information was effective when it formed part of a co-ordinated conservation programme.

The general conclusion is that to be effective information must be specific in terms of the audience to which it is addressed, and the actions it encourages (Phillips & Nelson, 1976). It is also important that the information should be perceived to come from a reliable and creditable source.

1.2.2.4.2.2. Feedback

A strategy which can help the householder to achieve a fuller understanding of how energy using behaviours affect either consumption or costs or both, is feedback. It employs components from both the information and incentive strategies.

Psychclogists have shown considerable interest in the development of feedback programmes. Three main parameters have been explored; firstly, the effects of providing comparisons - to past use, expected use and others' use, and secondly, the effects of increasing the frequency of feedback and the time interval between energy use and feedback.

In general, studies have shown that frequent feedback produces short-term energy savings of between 10% and 30% of previous use. The savings depend on the type of fuel used, the end use and on the period during which the investigation is conducted. The greatest savings are for electricity in peak summer cooling seasons.

Winett and Neale (1979) note that since supplying users with written feedback is costly, efforts are currently being made to develop mechanical devices that signal energy overuse. Both Kohlenberg (1978) and Becker and Seligman (1978) report that such devices have proved successful in field studies. However, the most cost effective type of feedback is given when subjects are encouraged to monitor their own energy use. In one study the technique resulted in reductions of approximately 7% of electricity usage (Winett, 1978). A particular benefit of this method is that it encourages active participation by the householder.

The general conclusion from the literature is that to be effective feedback must be immediate and specific. However, although research has shown that the possible combination of terms (dollars or kilowatts per hour, day, month or year) comparisons (to own use, a norm, others' use or prediction based on weather), and frequency and duration are parameters which influence the effectiveness of feedback. Winett and Neale (1978) remark that it is still not clear which combinations are most effective in reducing certain types of energy use.

Finally, Ellis and Gaskell (1978) explain the effects of feedback by developing a conceptual model which emphasises the distinction between the motivational and teaching functions of feedback. They suggest that the teaching function of feedback is most effective when combined with strategies which concurrently increase the consumer's motivation (see Becker, 1977).

1.2.2.4.3. Social research on energy conservation

Some psychologists have tried to promote energy conservation by manipulating variables suggested by their knowledge of attitudinal processes, social influence and group functioning. More specifically, some researchers have suggested that the use of high status public leaders in publicity campaigns can be effective in enhancing the appeal of conservation. Others have tried to facilitate conservation by manipulating variables suggested by the attitude change literature. These variables include self-perception and the individual's desire for cognitive consonance. Thus, for example, "commitment compliance" has been found to be effective - in one study people who made a public commitment to conserve used less energy than control subjects (Pallak & Cummings, 1976).

1.2.2.4.4. Structural strategies for conservation

Structural strategies compel individuals and organisations to adopt desired courses of action. They assume that as the basic structure of society changes, individuals and organizations will come to act differently and alter their attitudes and beliefs to reflect these new activities (Olsen & Goodnight, 1977).

Very few structural strategies have been implemented. The reasons for this probably include an awareness that people may respond negatively to compulsory changes made without their consent, an awareness that reduced benefits for energy use must be perceived to be equally distributed amongst different segments of the population, as well as, of course, the practical difficulties involved in actually determining which changes in the energy-benefit balance would be effective.

However, one strategy which has been used to achieve changes in energy using behaviour is regulation. Regulation primarily involves setting performance standards, establishing operating rules and devising allocation schemes and otherwise modifying the structural framework within which people act (Olsen & Goodnight, 1977). Examples include insulation regulations and maximum thermostat settings in government buildings.

1.3. Social Mechanisms Underlying Conservation

The literature review in the preceding sub-section (1.2.4) has shown that a considerable number of studies have investigated a variety of strategies aimed at facilitating conservation. However, Gordon (1980) has pointed out that many do not "shed light on the sorts of behaviour which produce conservation". He consequently suggests that approaches which focus on group processes may be more useful in providing an understanding of conservation. Additionally, he notes that strategies based on group processes have the further benefit of reaching a large portion of the population.

Gordon suggests that a particularly useful paradigm for research on conservation among groups derives from the "tragedy of the commons" (Hardin, 1968). The analysis implies that when resources are in cheap and abundant supply people will inevitably use them until they are depleted. There is therefore a conflict between the individual's short-term interest and society's long term interest. Thus the framework suggests that conservation may be achieved by explaining the longer term social costs of energy usage. Additionally, it predicts difficulties for some other conservation strategies. For example, when group targets are given to the residents of master-metered dwellings, problems of the "free rider" will be encountered since there is no assurance that everyone will conserve.

However, on the positive side, several authors have reported the results of laboratory studies which show that people can be taught to act rationally in their longer term collective interests (Brechner, 1977; Harper, 1977; Schipee, 1978; Stern, 1976). These studies point to the importance of communication, group participation and pressure, norms, leadership, and risk perception and saliency.

Some of these variables have been investigated in field studies such as that previously mentioned by Warren and Clifford (1975) who found that cohesive communities conserve more energy.

1.4. Conclusion

The literature review has shown that a considerable amount of work has been done on the social factors affecting conservation. The research is seen to fall into two main divisions. The first deals with the relationships between specific isolated variables (for example, income and age) and energy use and consumption. The second deals with strategies (for example, incentives and information) which affect householders' consumption levels.

However, it is concluded that methods for promoting energy conservation assume that particular variables affect consumption. It is consequently necessary to review the consumption literature to see what variables have actually been found to influence domestic energy consumption.

CHAPTER 2

REVIEW OF THE ENERGY CONSUMPTION LITERATURE

This chapter is concerned with variations between householders in energy consumption levels for space and water heating, as well as for cooking and such miscellaneous uses as lighting and clothes washing and drying. It reviews studies which highlight such variations and examine the causal factors both per se and in relation to consumption.

2.1. Variations in Energy Consumption

In 1950, a report on heating research studies noted a two to one variation in the energy use of nineteen similar houses (Weston, 1951). The author concluded that "in occupied houses 'the thermal habits' of the occupants play a most important part in the results." Minogue (1977) has noted that although similar variations can be found in other comparative studies, they are not usually highlighted. Instead, most studies treat this variation as random error while attempting to model the thermal performance of the heating system. Minogue additionally notes that many studies deliberately take precautions "to obtain information in such a form that it is as far as possible independent of these habits or is representative of average behaviour."

More recently, however, a few studies have specifically pointed to the wide range of consumption levels amongst the occupants of similarly constructed houses (Brundrett, 1977; Heap, 1977, 1978; McNair, 1977, 1980; Sonderegger, 1977). The Princeton Twin Rivers Study is of particular importance in this context since its leader, Robert Socolow has admitted that when the project began the researchers expected to find that by using controlled technology all lifestyle effects would vanish. However, he eventually came to realise that the most important observation of the study was that energy consumption is influenced not only by technology but also by occupant behaviour.

> "People are far from alike, even in their use of gas and electricity. We have found a wide range of variation in consumption of both gas and electricity, both winter and summer, in nearly identical townhouses. The more a technology allows expression of individuality the more the expected variation, so that indeed there is more variation in summer electrical consumption ... than in winter electrical consumption and more variation in the latter than in gas consumption for winter. But even the variation in gas consumption for winter heating is substantial."
> (Socolow, 1975)

Consumer variability in consumption has also been observed in the United Kingdom, for example by Brundrett (1977). When studying 530 dwellings in seven high rise blocks, he found that there was no systematic relationship between space heating energy and the sizing of radiators. However, he noted (as did Socolow) that individual householders' consumption levels were significantly correlated from one year to the next and so concluded that householders had consistent "habits" which had a major influence on consumption.

Additionally, in a study of 1600 centrally heated local authority houses, the Scottish division of the Building Research Establishment noted that,

> "the data show a considerable spread of energy usage in houses of the same fabric heat loss. In well insulated houses, the 10% highest energy users used 2.5 times as much energy as the 10% lowest energy users, but in poorly insulated houses the 10% highest energy users used 6.5 times as much as the 10% lowest energy users."
> (Cornish, 1976)

Finally, research by British Gas has also focussed attention on variability in household consumption. Their approach has been to assume that design heat loss and external temperature influence space heating demand and that the number of occupants influences hot water demand. Such considerations resulted in the construction of an equation of the general form:

$$C = a + b \cdot DHL \cdot DD + d \cdot N$$

where C = annual gas consumption

DHL = design heat loss

DD = degree days

N = number of household occupants

Analysis of field data from 120 dwellings with design heat losses ranging from 4 to 14 kW, gave the following relationship:

$$C = 6.4 + \frac{7.4\ DHL}{222} \cdot DD + 6.2\ N$$

The multiple correlation for this equation was 0.74. It was consequently concluded that further work on the effects of human factors on consumption were merited, since such factors were believed to account for most of the remaining variance.

2.2. Causes of Variation in Consumption Levels

Researchers have suggested that the causes of variation in consumption levels relate to the way people use their houses and heating systems, and to their attitudes towards thermal comfort and energy usage. Although most researchers have concentrated on either behavioural or attitudinal explanations, a few have related consumption to both architectural and socio-economic variables. These three approaches will be discussed separately.

2.2.1. How People Use Houses

Only a few studies have investigated the ways in which people use their central heating systems and/or their houses. Three main topics have been researched, namely (1) internal house temperatures (Hunt & Gidman, 1980), (2) use and understanding of heating controls

(McGeevor, 1981) and (3) window and door opening behaviour patterns (Brundrett, 1976). Additionally, a small number of social surveys have been conducted. These have investigated a variety of household behaviour patterns including occupancy patterns, and use of and satisfaction with the heating system (Fields & Hedge, 1977; Hunt & Gidman, 1978; Minogue, 1977).

2.2.2. Predictions of Energy Consumption from Householders' Attitudes

A considerable number of studies, especially in America, have assessed householders' attitudes to energy and conservation. Most have measured energy attitudes alone or have relied on self report measures of behaviour. Such studies will not be reviewed in this section. However, four studies which have investigated the relationship between attitudinal variables and consumption will be discussed.

In the first study Seligman (1979) found that beliefs that personal comfort and health depend on air conditioning accounted for 30% of the variance in the summer electrical demand of occupants living in similarly constructed houses. Two other factors were identified as having a significant influence on consumption, namely beliefs that the collective effects of individual efforts to conserve energy would have an impact on national consumption, and that conservation efforts could result in personal financial savings. However, in a second administration of the questionnaire, these latter variables had insignificant effects. A similar study was conducted by Becker who used factor analysis to identify three factors (personal comfort and convenience, optimism and belief in science, and attitudes to health) which accounted for 18% of the variance in winter energy consumption and 59% of the variance in summer consumption. He attributed the large proportion of variance explained in summer, to the wider range of consumption levels.

In a third study, Hogan (1976) developed a "human responsibility scale" and an "ecosystems awareness scale". She found that both were negatively related to the rate of energy consumption per room. People who had higher levels of awareness and concern had a less energy intensive lifestyle.

However, while conducting a survey in Brisbane, Crossley (1980) found that although respondents were generally favourably oriented towards energy conservation, there was a general lack of correlation between beliefs and attitudes and energy using behaviour.

In conclusion, it seems that further work is necessary on the relationship between attitudes and energy consumption.

2.2.3. Predictions of Energy Consumption from both Physical and Social Variables

Very few studies have combined both architectural housing variables and socio-economic lifestyle variables in an attempt to explain consumption variatiability. However, a series of investigations with this specific aim were conducted at the College of Human Ecology in Michigan State University. The studies showed that various physical characteristics such as the number of rooms, windows and external doors doors were positively related to consumption. Single family dwellings used more energy than other dwelling types. Family characteristics found to be positively related to energy consumption included the number of household occupants, and family income. Families at the child rearing stages of the lifecycle used more energy (Morrison, 1975; Morrison & Gladhart, 1976). No significant differences in levels of consumption were found between households in which wives were employed full time, part time or were unemployed (Eichenberger, 1975).

Three other studies conducted within this framework are those of Cohen (1976), Donovan (1976) and Sansam (1981). In his study of gas consumption Cohen found that a third of the variance in consumption was accounted for by the number of rooms, the number of household occupants and climatic conditions. Results obtained in Donovan's study of oil consumption indicated that 58% of the variance could be predicted from a knowledge of the dwelling age, family size and income, and insulation. In a third study, approximately 68% of the variance in the total energy consumption of 36 warm air centrally heated houses was accounted for by variations in the hours of system use, window opening and use of the warm air outlet grilles.

It is concluded that these studies have provided interesting results which merit further investigation.

In particular, it is suggested that detailed research is required on the behavioural and attitudinal factors which affect consumption. Additionally, it is felt that such investigations should not be atheoretical, but should relate their findings to a specific framework such as that which was developed at Michigan State University and which is described in the next chapter (3.2.1).

CHAPTER 3

PILOT STUDIES

This chapter is concerned with the aims and selected results of two preliminary investigations of occupant behaviour patterns related to domestic energy usage. The researcher was involved in both studies, but at different levels since the first study at Tamworth near Birmingham was conducted under the auspices of West Midlands Gas, whilst the second study at Charnwood in Hillingdon was exclusively conducted and analysed by the present researcher. The studies are discussed separately with considerably more emphasis being placed on the Charnwood study which served as a pilot study for the main survey (Chapter 4).

3.1. The Tamworth Study

The results of a number of surveys conducted on behalf of British Gas had shown that householders vary widely in terms of gas consumption. An exploratory investigation under their West Midlands division was consequently authorised. The aim was to identify variations of building design and occupant behaviour which are associated with variations in the pattern of gas consumption. The present researcher was involved in designing the questionnaire and in assisting with the interviews, but took no part in analysing the results. A full report of the study is available from the researcher. Only important results and hypotheses are discussed in this section.

3.1.1. The Study

Gas consumptions for four consecutive quarters in 157 dwellings were analysed. The dwellings are all local authority properties on the one site. They are comprised of seven design types, with design heat losses varying between 6.6 kW and 10.7 kW. All dwellings have partial central heating to Parker-Morris standards.

Analysis revealed that consumption variations within identical dwellings were of a similar magnitude to variations between the averages of different design types. Moreover, differences in mean consumption of different design types were statistically significant in some cases only. In addition, the use of the heating system appeared to be different in bungalows for the elderly and in family houses.

In view of these preliminary results, British Gas decided that a small survey of a structured subsample of householders (N = 12) should be conducted, in order to achieve a better understanding of the factors affecting variations in gas consumption.

The results of interviews with these householders suggested that a large part of the variation in consumption is associated with variations in the period of use of the heating system, and with the use of individual radiators. In the study, these latter variables were also associated with the use of supplementary heaters, the orientation of the house, and the reported use of hot water. No significant difference was found between gas consumption for end of terrace and middle of terrace houses.

In addition to these statistically significant findings the survey served to operate two interesting hypotheses:

(a) Since ownership of a gas cooker was not significantly related to consumption, it was suggested that heat gains from cooking do not significantly reduce heating requirements in households cooking by electricity, and

(b) Since households possessing an electric fire had higher gas consumptions than other householders, it was suggested that tenants with electric heaters were trying to obtain a higher level of heating than that which the central heating alone could provide.

In conclusion, the study indicated that gas consumption is a complex variable associated with a variety of inter-related behaviour patterns. The author consequently decided that further research was merited.

3.2. The Charnwood Pilot Study

Knowledge gained from the literature survey, as well as meetings with academics and industrial personnel; experience of the Tamworth survey; and personal skills and preferences led the researcher to conduct her own pilot study. The study was a broadly based exploration of a number of energy related issues. The findings were expected to highlight important areas for further work. However, before the study itself is discussed, it is necessary to review briefly the underlying theory which served to generate the wide variety of topics raised during the interviews.

3.2.1. Background to the Study: The Human Ecosystems Framework

The literature review has shown that until recently the study of energy use in buildings and the prediction of variations in consumption was almost exclusively the province of the physical sciences. Yet, as previously mentioned, there are several indications that a significant proportion of the unexplained variance in the energy consumptions of similar buildings is due to occupant behaviour patterns (Minogue, 1978; Socolow, 1978; Weston, 1951).

The aim of the Charnwood study was to identify basic patterns of consumer behaviour among the occupants of similarly constructed houses and to relate those patterns to attitudinal data, as well as gas consumption. Attention was focussed on the household as a basic social unit that utilizes energy for its daily processes. The premise was that gas consumption is a consequence of lifestyle, and hence that household behaviour should be viewed as a complex system of inter-relating behaviour patterns within the family eco-system.

The human eco-systems framework

The effective implementation of solutions to the energy problem is contingent upon a thorough knowledge and understanding of the total problem environment. Implicit in this is a recognition of the need for a holistic approach, which allows both a broad overview, and specific insights into the determinants of gas consumption. Such an approach is adopted in the formulation of human eco-system frameworks which focus on the inter-dependence of the human organism and its environs.

Human eco-system studies are concerned with the household, a group whose members comprise a set of human resources, largely characterized by their prior developmental experiences and stage in the lifecycle, but susceptible to a variety of external influences and cultural norms. Each member of the household has an individual set of functions which must be attended to if the goals and value systems of the group are to be achieved. The manner in which these goals are fulfilled is based upon the group's perception of the nature and salience of its needs. This results in the adoption of a particular lifestyle as characterised by certain behavioural norms. The relationship between the chosen lifestyle and the enacted behaviour patterns is symbiotic. Changes occur in the lifestyle as the group progresses through the lifecycle, since external forces create new conditions of living which alter the group's perception of itself. This stimulates changes in values and goals, thereby creating a need for and the making of new decisions, with a resultant modification in the lifestyle.

The group is also influenced by its degree of openness to the "supra-environment", the sub-categories of which are the natural social and built environments. The latter exert forces that maintain the essential link between the group and the wider environment, and thereby influence behaviour and attitudes. The decisions made affect the interface between the group and the environment. The interchange between the two is modulated by feedback experienced in terms of the psycho-social wellbeing of the occupants. The process enables the group to become self-regulating and to take corrective action when necessary.

In short, the researcher hypothesised that lifestyle (as influenced by these various factors) was the primary cause governing conditions within the household and mediating the use of the central heating system (figure 3.1).

3.2.2. Methodology

3.2.2.1. The sample

The sample was made up of twenty six householders on a local authority estate for which gas consumption records from October 1977 to January 1979 were available. The estate selected was chosen for two reasons, (a) because all dwellings were of a similar design type and (b) because of the estate's proximity to Brunel University. The householders interviewed represented a subsample of the 130 households on the estate. Although it had originally been intended that a structured sub-sample of high, medium and low consumers would be interviewed, this did not prove possible given the limited time available. This was because it was considered necessary to complete the interview before the

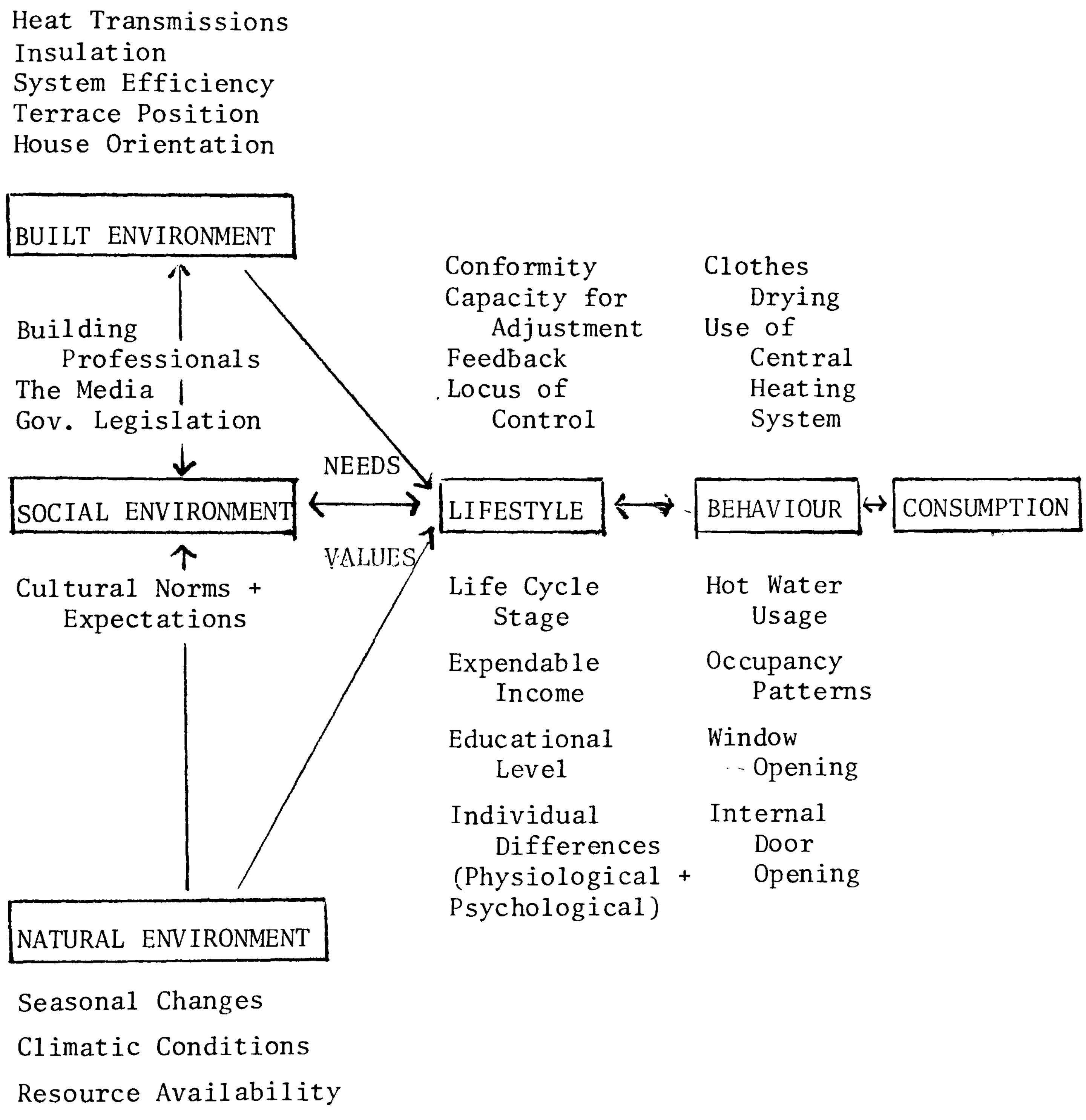


FIGURE 3.1. The human ecosystem's framework.

end of the heating season and the survey began as late as March. Thus, respondents were chosen on a quasi-random basis with all those willing to be interviewed being interviewed during the three week survey period.

All 26 houses are of a similar lightweight construction. However, the size of unit differs between the three housetypes on the estate. The first is the smallest in size and was designed essentially for use by two adults or a couple and small baby. The second type was designed for habitation by four people and the third type by six persons. These three house types are hereafter respectively referred to as 2, 4 and 6-person houses even though the actual number of occupants might differ from the design number. The central heating in all dwellings was designed to Parker-Morris standards, with no heating in the bedrooms.

3.2.2.2. Data sources

There were two main data sources: (a) quarterly gas consumption readings and (b) data obtained from open-ended interviews.

The Interviews

The interviews were held during March and April 1979, with one or both of the heads of household. They covered a variety of topics felt by the researcher to affect a household's lifestyle and consequently gas consumption. The interviews served to elicit

(a) demographic data about the household,

(b) information about the use of the central heating system and its controls,

(c) the underlying motivations for, and the frequency of particular behaviour patterns, and

(d) householders' attitudes to the domestic thermal environment and the energy crisis.

A semi-formal interviewing technique was adopted. A copy of the questionnaire used during the interviews is given in the appendix (figure A1).

3.2.2.3. Method of analysis

The data that emerged from the interviews were generally qualitative, but the responses where possible were quantified and related to consumption by the use of correlation coefficients plus tests for significant differences in mean weekly consumption. Since many of the interview questions concerned the weekly household routine the average number of therms consumed in a week was taken as the basic unit of analysis. The median test was employed as a test of significance since sample numbers were small and it was considered desirable to avoid the assumptions of parametric statistical tests.

The three periods for which mean household weekly consumptions were investigated were (a) the first winter quarter of 1979 (October 1978 - January 1979), (b) the two summer quarters of 1978 (April 1978 - October 1978) and (c) the two winter quarters of 1978 (October 1977 - April 1978).

3.2.3. Results

Only selected results are reported in this section. These results pertain mainly to the analysis of gas consumptions and attitudinal data. In many cases, reported behaviour patterns are not discussed since they are dealt with in greater detail in chapters 4 and 5.

3.2.3.1. Analysis of gas consumptions

The median test indicated that within each housetype the mean weekly consumptions of the interviewed sub-sample did not differ significantly from those of the remaining (not interviewed) houses of that housetype.

Relationship between Gas Consumption and the Built Environment

In each of the three periods of investigation, the range of consumption variation in all housetypes was of the order of a 3:1 ratio between the highest and lowest consumers. Figures 3.2 to 3.4 show histograms of the frequency distributions of 1979 winter consumption in the three housetypes.

Mean consumption differences between housetypes were insignificant for all three periods of investigation. The finding suggests that the range of consumption variation within housetypes is so great as to mask that between housetypes.

Although all the houses of a single type were nominally identical, some were centre-of-terrace dwellings (N = 14) whilst others were end-of-terrace dwellings (N = 12). Each housetype had an almost equal number of end-of-terrace and centre-of-terrace dwellings. Analysis showed that in all housetypes end-of-terrace dwellings had significantly higher gas consumptions ($X^2 = 7.72$, df = 1, $p < 0.5$).

TABLE 3.1. Mean weekly consumption in each housetype for three periods of investigation

House type	Number inter-viewed	D.H.L.* (kW)	Mean Weekly Consumption (Therms)		
			Oct 78-Jan 79	April 78-Oct 78	Oct 77-Apr 78
2 P	7	4.72	12.0	4.9	15.5
4 P	13	4.00	14.2	6.4	15.9
6 P	6	4.78	12.4	5.5	12.6

D.H.L. = design heat loss
* figures for end-of-terrace dwellings only

3.2.3.2. Household characteristics

Stage in the lifecycle is one of the main constituents of life-style. Its influence was found to be of primary importance since

FIGURES 3.2-3.4. Frequency distributions of mean weekly gas consumptions from January to April 1979.

FIGURE 3.2

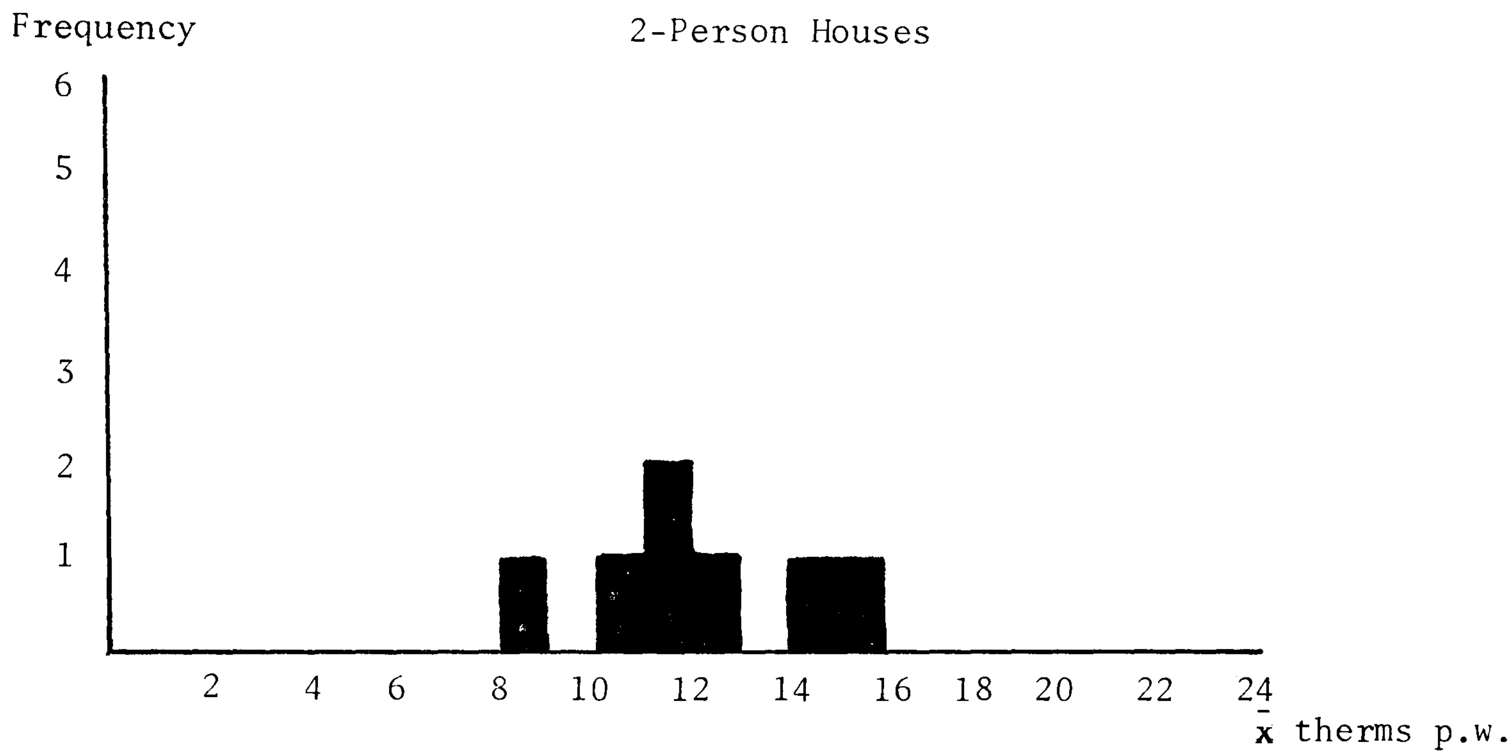


FIGURE 3.3

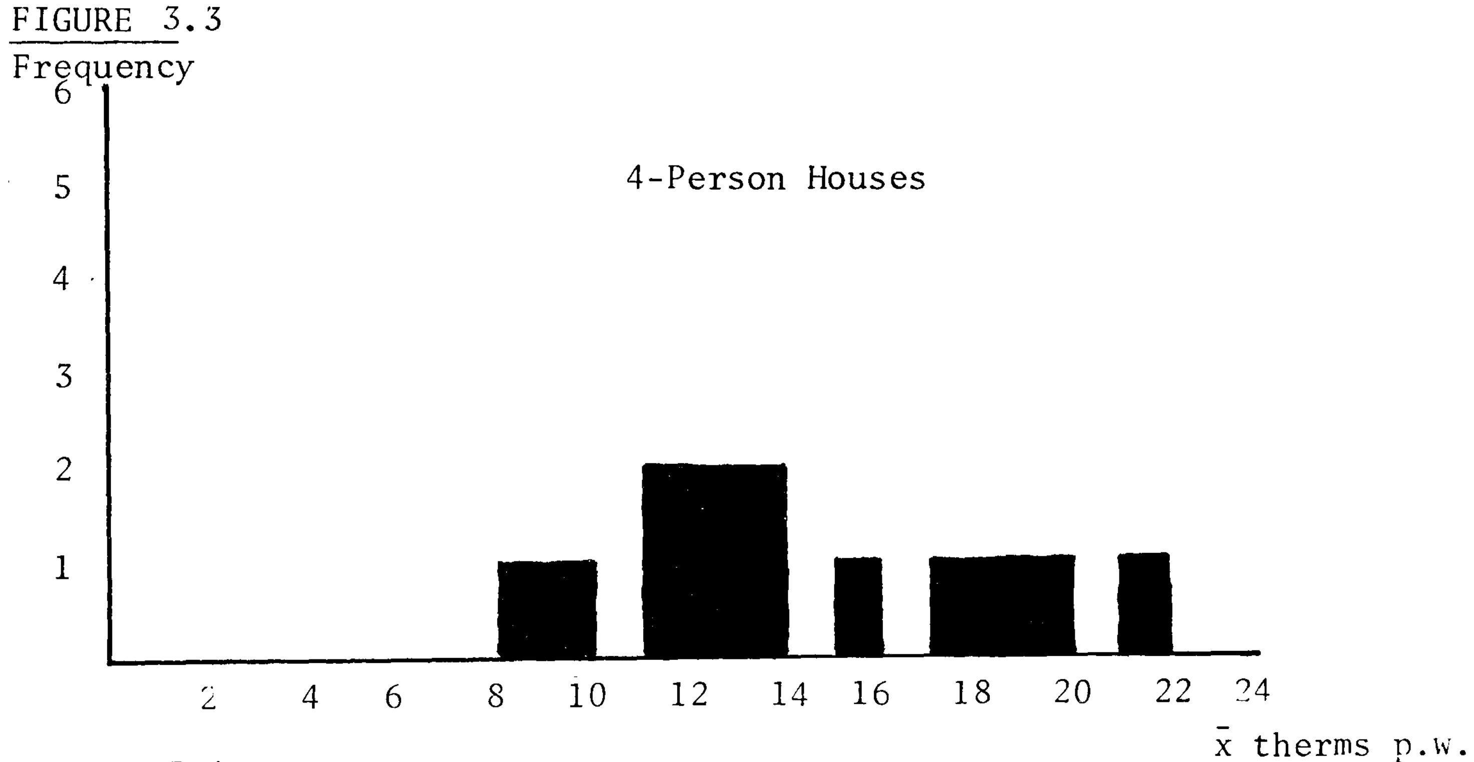
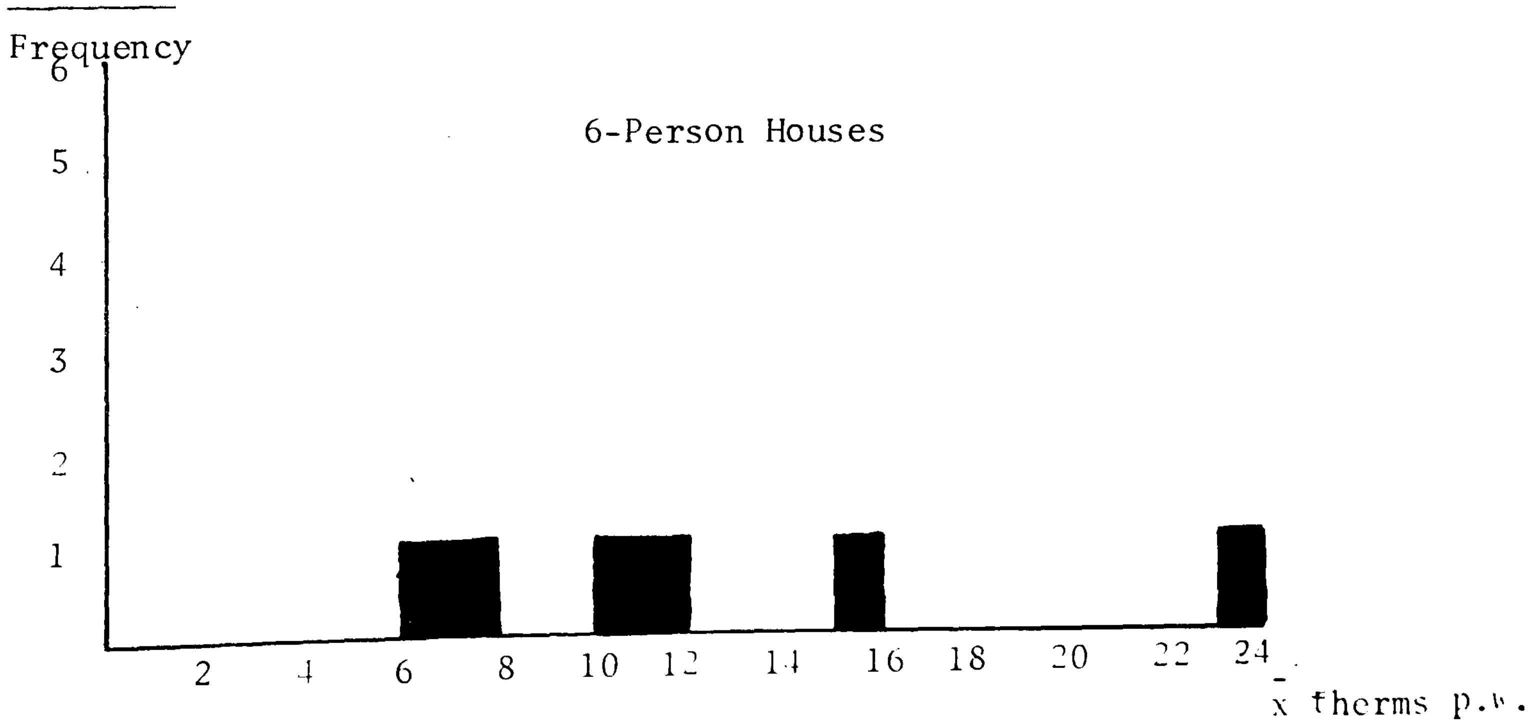


FIGURE 3.4



although consumption differences between households with different numbers of occupants were insignificant, when householders were grouped according to where they stood in the lifecycle these consumption differences were significant - families at either the beginning or end of the lifecycle[1] consumed significantly less gas than those in midcycle during the months from October 1978 to January 1979 ($X^2 = 4.26$, df = 1, $p < .05$).

No significant relationship was found between gas consumption and whether or not the housewife went out to work.

3.2.3.3. Householders' use of the central heating system and attitudes towards the controls

Analysis revealed that on average the central heating was reported to be on for approximately 12 hours a day during weekdays and 14.5 hours a day at weekends. The average thermostat setting was slightly above 21°C. Neither variable was significantly related to consumption.

Although 11 respondents reported that they did not use the time clock, the clock was used in all households where the housewife went out to work.

Householders were asked if they had been shown how to use the central heating when they first came into the house, whether or not they had understood the demonstration, and what control difficulties they still experienced.

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1. The existence of a household member (a) of less than 5 years of age or (b) of more than 55 years meant that that household was classified as being (a) at the beginning or (b) at the end , of the family lifecycle. Households at the beginning and end of the life-cycle were grouped together for analysis purposes since it was felt that their members were likely to occupy the dwelling for a larger proportion of the day than mid-cycle household members.

Analysis showed that although just under half of the householders (N = 12) reported that they had been shown how to use the controls only four said they had understood the demonstration. Moreover, although initial problems such as igniting the pilot light (n = 5) and setting the temperature control on the hot water tank (n = 3) were generally reported to have eventually been solved by trial and error, seven householders expressed a desire (at the time of interview) for further information. As one person said,

"I know enough to get by, but I don't really know what I'm doing."

Some tenants would have liked thermostatic radiator values. Others found the time clock confusing (n = 4) and one man felt he didn't need it. However, several tenants spontaneously remarked that they found the controls adequate and straightforward (n = 9).

General Attitudes Towards the Heating System

When asked about the heating system generally, 18 respondents said the arrangements were adequate and that they kept as warm as they wanted to. Five householders mentioned cost as being an inhibiting factor whilst the remaining three regarded the arrangements as inadequate and reported that they could not keep warm enough (Table 3.2).

"It's a constant even heat and always there."

"No-where's really cold - you're never desperately cold, you've always got the means to put it up - if you can afford it - if you're inconvenienced, it's because of the cost."

During the course of the interview householders frequently compared their systems to alternative methods of heating, often claiming that central heating was cleaner and safer than both gas and open fires or warm air central heating, and cheaper than electric heating. Moreover, occupants who had spent years filling paraffin stoves and fiddling with fires were well aware of their present system's relative ease and convenience though some commented that they "missed not having a focal point".

TABLE 3.2. Frequency distribution of occupants' assessments of their heating arrangements*

Heating arrangements	No.
Adequate and we keep as warm as we want to	18
Adequate but it's too expensive to keep it as warm as we'd like	5
Not really adequate but we keep reasonably warm	0
Not adequate and we cannot keep warm enough	3
TOTAL	26

* The questions and categories of response in this table are taken from the National Fuel and Heating Survey (1976).

Householders' present circumstances also bore strongly on their opinions. Thus, for example, mothers with young children tended to mention that they didn't have to worry so much about coughs and colds and working women spoke of central heating as being a great labour saver.

"It's nice to come into a warm house. I used to be scared of leaving open fires."

"It's convenient - there's no work attached to it, and I can get the washing dry on it when it's wet."

Criticism was levelled against the house design by a number of tenants. Badly fitting doors and windows were seen to diminish the advantages of central heating. Other respondents commented that the heat was "dry" or "uncomfortable", some regarding that as unhealthy.

A few disliked their total reliance on one particular type of heating.

"I miss the gas fire. I think you're warmer when you can see the heat."

"Central heating - it's alright if backed up by some sort of fire. The house takes ages to warm up and doesn't really hold the heat. What I'd really like would be radiators for background heat and gas fires for when you're in the room."

"It's a dry heat - the baby seems to get a lot of colds from it."

"Warm air heating was much quicker. Here I can get up an hour later and it's still no warmer. If it's really cold, we have to leave it on at 18°C for the night. It's a bit noisy too - it clicks."

Respondents' attitudes towards heating were ascertained along five dimensions namely, the need for bedroom heating, the association between a lack of heat and ill health in the elderly, the relationship between occupants' desired comfort levels and actual expenditure on gas, the effect of over-heating on health and the relative importance of heating. Table 3.3 records the findings.

The first of these shows that householders were divided as to whether or not they felt bedroom central heating was generally necessary. The attitude of one housewife was fairly typical,

"The bedrooms aren't as warm as down-stairs but then you don't live there, you only sleep there."

There was greater agreement as to the need for old people to have adequate heating. Whilst 15 respondents agreed that "older people often get ill because they don't have enough heating", a further 11 respondents strongly endorsed this statement. When asked for their opinion about the statement "we cannot afford to keep our home as warm as we'd like", most householders replied that they neither agreed nor disagreed ($n = 17$), saying, for example, "we can't really afford to, but we do - the bills get paid and so that I suppose means we can

TABLE 3.3. Respondents' attitudes towards heating*

	Number of respondents endorsing each category of response					
	agree	strongly agree	neither	disagree	strongly disagree	Don't know
It's not generally necessary to heat bedrooms	10	2	0	11	3	0
Older people often get ill because they haven't enough heating	15	11	0	0	0	0
We can't afford to keep our home as warm as we'd like	6	1	17	1	1	0
People who keep their homes very warm get lots of coughs and colds	11	4	8	1	1	0
It's very important to keep your home warm, even if the cost means saving on other things	21	4	1	0	0	0

* The questions and categories of response in this table are taken from the National Fuel and Heating Survey (1976).

afford it." However, only two respondents stated clearly that they could afford to maintain their houses at the temperatures they wished.

About half of the respondents felt that coughs and colds were consequent upon over-heating (n = 11), although a large number were unsure and were unwilling to commit themselves one way or the other (n = 8). In contrast, there was a high degree of consensus about the relative importance of home heating with all but one respondent agreeing that it was "very important to keep your home warm, even if it means saving on other things." As one person said,

"I just couldn't sit here and freeze."

Attitudes to full central heating were related to the household's stage in the family lifecycle. Families at the lifecycle extremes were very likely to be content with partial central heating. While only 7 of the 17 families at the cycle extremes favoured full central heating, 7 of the 9 mid-cycle families wanted it. Among families at the cycle extremes there was no difference in mean consumption between those requiring full and partial central heating. However, there was a difference among mid-cycle families - on average those wanting full central heating consumed less gas in the October 1978 to January 1979 quarter ($\bar{x}$ = 14.4 therms p.w., n = 7) than those not wanting it ($\bar{x}$ = 22.3, n = 2). However, in view of the small number of householders involved, this result must be treated with caution.

3.2.3.4. Household behaviour patterns

Although a variety of household activities were investigated, the analysis of two behaviour patterns provided particularly interesting results. They are dealt with separately.

Gas Cooking

Households cooking by gas had a higher mean weekly consumption rate during the months from October 1977 to April 1978 ($X^2 = 7.72$, df = 1, $p < .05$).

Window Opening

Window opening was investigated in terms of reported "open window hours" - each window in the house having a total of 24 possible hours for which it could be open on any one day. The scores for each window in each room were summed and the total taken as that house's daily number of "open window hours".

The range of variation on this parameter was quite considerable. Two of the 26 householders reported that they "never" opened any windows during the winter. The range for other householders extended from two to 52 "open window hours" per day. Households in general had an average of 18 "open window hours" per day.

However, since the housetypes differed in size and therefore in the total number of windows they had, it was decided that the percentage of the total possible number of open window hours should be investigated. It was then found that although the percentage of total open window hours appeared to rise with an increase in house size, the relationship was statistically insignificant.

Additionally, analysis showed that there was no significant relationship between window opening and whether or not the housewife went out to work.

Window opening was reported to occur when there was a need for either odour or moisture control (n = 9, n = 12 respectively) or for cooling (n = 2).

"I like to leave the windows open - it's healthier that way."

"I get plenty of fresh air during the day and feel closed in at night if the windows aren't open."

"I open them when it gets stuffy. Sometimes it's because it get's too stuffy - you may not have adjusted the heating properly or because there's washing on the landing."

3.2.3.5. Conservation and the energy crisis

Belief in the energy crisis was significantly associated with reduced consumption ($X^2 = 4.26$, df = 1, $p < .05$). Nine respondents reported that they did not believe in the existence of an energy crisis. Two individuals remarked that although there was not a general energy crisis, there was a petrol crisis.

Many householders commented on their difficulty in making a judgement on the crisis.

"There must be a crisis if you hear so much about it, but I'm not sure. Half of what you hear on television isn't true."

"They [the government] tell you there is [a crisis] but the way they go on, it doesn't seem as if there is."

Others were more certain.

"No, what with North Sea oil and gas we've never had it so good; we might be squandering it but there's no crisis."

"No, it's just an excuse to put the price up."

"Yes - nothing goes on for ever."

Only 8 householders believed the government had acted responsibly in view of a potential crisis. Many remarked that the government's behaviour was inconsistent.

"They tell you to save but the street lights [on the estate] were on all day during the summer. Their own buildings are far too hot."

"The lights in the Civic Centre are always on - they claim it doesn't make a difference."

"They don't seem to say very much or think there's a crisis - they should be looking for alternatives - North Sea oil will run out and then what?"

Most householders saw the government in a poor light.

"I've no trust in the government - they're too far removed."

"They're incapable."

Householders were also asked what they thought of the "save it" campaign. Although opinion was divided, two-thirds of the sample gave comments that were categorised by the researcher as negative. Ten householders referred to the campaign's superficiality.

"It didn't go on for long enough - it made you think then, but it needs to be revived. There should be a wide range of grants - Council tenants should be able to get them."

"I didn't take any notice - I use what I need, not what suits anyone else. It's a question of convenience."

"It was silly, didn't do any good either. Sensible people don't take notice of those sort of gimmicks and when they do it's because of the cost."

"Quite amusing but only on a superficial level. It only had an immediate effect."

Individuals varied as to whether or not they felt there was anything they could do to conserve energy. The general attitude appeared to accord with one man's statement "there's nothing we can do in the house". Indeed, not one individual specifically mentioned the possibility of economising on space heating, although 6 referred to savings from turning off lights and 3 spoke of economising on petrol. Four householders saw the problem as being industrial rather than domestic. Others saw conservation as being the responsibility of the building trade, generally feeling that house design and methods of heating should be diversified, that there should be higher insulation standards and that house construction quality should be improved. Some felt there was little they could do.

"What does it matter. We don't control what's happening anyway. Peoples' opinions make no difference."

"No one can resolve anything."

Four respondents said that if there were gas supply shortages, as there had been water and electricity cuts, then "people" would save. Others felt that "their bit wouldn't benefit the country anyway", whilst some felt that if the action were collective savings would result.

"If everyone got together you could do something. When that happened with the water shortage you could <u>see</u> what was happening."

"I can cut down but if it's not collective, all I'm doing is making a bit more for someone else to waste."

The last remark was indictive of many householders' feelings. Although some felt that "if you don't use it and you don't waste it, then you've got to save", a number of householders remarked "what I save, others only waste". One woman added,

"What's the point anyway. I get no thanks."

3.2.4. Discussion

The results reported in the previous five sub-sections will be discussed in this section. The first sub-section will deal with the relationship between gas consumption and a number of readily identifiable parameters. The remaining four sub-sections will cover household characteristics (3.2.4.2), use of and attitudes towards central heating (3.2.4.3), window opening (3.2.4.4) and the energy crisis (3.2.4.5).

3.2.4.1. The relationship between gas consumption and readily identifiable parameters

It had been hypothesised that a variety of parameters would be significantly related to consumption. These parameters were expected to include such variables as whether or not the housewife went out to work, the method of cooking, possession of an additional heat source and the number of hours for which the central heating was on.

Analysis showed that both terrace position and the method of cooking were related to gas consumption. It is felt that the influence of terrace position on weekly consumption between October 1978 and January 1979 was magnified by the particularly severe weather conditions during that period, since that parameter yielded no significant difference in consumption during the previous winter. It is also suggested that the same bad weather caused the relative importance of the space heating load over the cooking load to be enchanced. This could explain why the method of cooking(by gas or electricity)was significant in the first winter (1977 - 1978), but not in the second particularly cold winter.

The lack of relationship between consumption and other parameters may be due to the small number of households involved in the study (N = 26). Alternatively the findings may indicate that consumption is not determined by a few variables of large significance, but by a large number of inter-related variables each with a small influence upon consumption. It is not possible to choose between these two explanations.

3.2.4.2. Household characteristics

The average number of occupants in households at the extremes of the lifecycle was 3.0 (n = 17), compared with 4.3 in mid-cycle households (n = 9). This difference in the mean number of occupants between the two lifecycle groups was insignificant. However, consumption differences between the two lifecycle groups were statistically significant ($X^2 = 4.26$, df = 1, $p < .05$). This would seem to indicate that it was not the number of occupants that was particularly important, but that it was the difference in lifestyle that was the influential factor. The validity of this hypothesis is supported by the finding that there was no significant difference in consumption between beginning and end-of-cycle households, despite the fact that the difference between the average number of occupants in each was significant (the average number of occupants was 3.6 and 1.8 in beginning and end-of-cycle households respectively).

3.2.4.3. Use of, and attitudes towards the heating system

No relationship was found between consumption and either the number of hours for which the central heating was reported to be on or the thermostat setting. It is suggested that this may have been due to the frequency of thermostat adjustment. Indeed, only two householders reported that they never adjusted the thermostat.

Many householders showed a clear lack of understanding as to how their heating system worked. Several (n = 7) expressed a desire for further knowledge.

However, the majority of householders were satisfied with their heating arrangements. The principal advantages mentioned were ease and convenience (n = 21), health and hygienic benefits (n = 13), comfort (n = 10), and cost (n = 7). Past and present circumstances were found to affect householders' satisfaction with the system. The finding of a relationship between requirements for full or partial central heating and household stage in the lifecycle is also taken as support for the hypothesis that respondents endorse views that correspond with their own circumstances. It is suggested that families at the cycle extremes may be less well off financially than those in mid-cycle and could not easily afford the increased expenditure consequent upon installation of full central heating. A similar situation may have existed for mid-cycle families who already had high consumption rates. It is therefore suggested that the findings may in part be explained by householders' desire for cognitive consonance (Festinger, 1957).

3.2.4.4. Window opening

There was a wide range of variation amongst householders in terms of reported "open window hours". However, no relationship was found between the percentage of total "open window hours" and whether or not the housewife worked.

3.2.4.5. The energy crisis

Belief in the energy crisis was associated with reduced consumption levels. The relationship between attitudes and behaviour is often questioned. It is therefore suggested that although the association may not be causal, the finding is an important one meriting further investigation. It is additionally suggested that the finding may be a further indication of the operation of cognitive consonance in that householders who cannot afford adequate heating, may prefer to explain their behaviour in terms of conservation rather than give the less acceptable explanation of expense.

Since even among experts there is little consensus as to the precise nature and significance of an energy crisis, it is not surprising that only 9 householders believed in the existence of a crisis. A far clearer and more informative presentation by public bodies of the state of primary energy resources and the consequences of consuming them at various rates is necessary if conservation is to be encouraged.

Two householders reported that there was not a general energy crisis but a petrol crisis. The responses are explicable in view of the petrol shortage being experienced at the time of interview.

Many householders found it hard to say whether or not there was a general crisis. It is suggested that the constant use of the term "crisis" has devalued the meaning of the term, and that inflation has also served to mask the increases in fuel prices. Both of these factors have made the impact of the crisis less salient than it might otherwise be.

Few householders believed the government had acted responsibly, and many felt the government's own actions were inconsistent with appeals to the public to save energy. Moreover, most of the comments regarding the government were negative. The findings are daunting in view of the preponderance of psychological literature on imitation which clearly indicates the importance of model status and consistency. In addition, it is generally accepted amongst social psychologists that the credibility of the communicator is critical for the effectiveness of the message (Begin, 1962).

Since the 'save it' campaign was basically a strategy for promoting building insulation materials, it is not surprising that it failed to reach many local authority tenants, who as a group may be less able to make long term investments - four householders didn't even remember the campaign.

Respondents seemed to feel unequal to the task of saving on space heating. The majority could envisage no way of economising and felt they used "the minimum necessary". Such a perspective highlights the link between lifestyle and the behaviour patterns that affect consumption. Some comments were made as to the possibility of real savings by big companies and in domestic electricity and petrol usage. These comments draw attention to the importance of cue saliency and proximity. Heat is invisible and the long delay in feedback between cause and effect, the use of the heating system and consumption reduces the individual's sense of responsbility and externalises the locus of control. The situation appeared to be exacerbated by the lack of solidarity and "esprit de corps" among the general public, since conservation was not perceived to be a collective effort. The benefits that accrued were felt to be minimal and to go unnoticed. There was no norm of social recommendation and no system of reward and thus little incentive to conserve.

3.2.5. Conclusion

The study demonstrated that the behaviour patterns which result in particular levels of consumption cannot be understood except in terms of a household's total lifestyle. The utility of the eco-system's framework was thus confirmed.

In addition the study indicated the importance of descriptive data and the need for further research on a larger scale.

It was therefore decided that an in-depth study of a larger number of households should be conducted, in conjunction with an investigation of the same householders' window opening habits. The second study was felt to be necessary since window opening was considered to be one of the main variables influencing gas consumption. Moreover, it was felt that the structure of window opening as a behaviour pattern and the way it is influenced by attitudes and beliefs would be illustrative of the way other behaviour patterns may be influenced by such factors.

These two studies are discussed separately in chapters 4 and 5.

CHAPTER 4

HOUSEHOLDERS' BEHAVIOUR PATTERNS

The Charnwood pilot study described in the previous chapter was an exploratory investigation of a number of topics concerned with domestic energy use. There, the aim was to achieve a broad understanding of occupant behaviour and thereby to develop a perspective from which a more detailed investigation could be made. The approach in the present study is based on the findings of the pilot study, the objective being to describe householders' behaviour patterns and motivations.

4.1. Methodology

Both the household sample and principal data sources are described in this section.

4.1.1. Sample Selection

The study centered on the householders on two local authority estates in Middlesex, one at Cowley and one at Mezen in Northwood. Local authority dwellings were specifically chosen since it was felt that rented properties are unlikely to be significantly altered by their occupants. This was important because it was considered desirable to choose similarly constructed houses in order to minimise as far as possible, variations in gas consumption associated with variations in building design.

This consideration dictated the choice of the two estates. It was necessary to study two estates since no one estate in the

Hillingdon Borough had a sufficiently large number of similarly constructed dwellings. Ideally, all the dwellings chosen would have been physically identical and in the one location. This was not possible since estates are generally planned to provide a variety of dwelling types for both social and aesthetic reasons.

The two estates selected are approximately five miles apart. The Cowley estate has 78 dwellings comprised of five house types. There are 35 dwellings of three house types at Mezen. Table 4.1 provides a description of the number and basic design features of each house type on the two estates. Architect's drawings and site plans are given in figures 4.1 - 4.8. The figures show that the eight house types are the same in terms of the basic arrangement and size of rooms - they all conform to Standard Borough 2PA plans. Different elevations and external building materials were however used for the different house types (see Chapter 5, Figures 5.1 - 5.12). Additionally, dwellings at Mezen are joined to each other in a different way from those at Cowley, namely end-to-side rather than by the more common side-by-side arrangement. This allows clusters of houses to be formed at Mezen, as opposed to the terraces at Cowley (Figures 4.7 and 4.8). This in turn permits different window arrangements on the two estates (Chapter 5).

Dwellings at both Cowley and Mezen have gas central heating to Parker-Morris standards, with no heating in the bedrooms. All the dwellings are of a lightweight design. Dwellings at Cowley were constructed in 1974, those at Mezen in 1975.

There are two principal ways in which dwellings at Cowley and Mezen differ. The first is that all dwellings at Cowley have internal bathrooms with no windows. The second is that Mezen 4-person houses have a dining room (Figure 4.6).

TABLE 4.1. Basic design features of each house type at Cowley and Mezen

Estate	House type	Description	D.H.L.† (BTU)	No. in sample
Cowley	Ground floor flat	1 bedroom 2-person flat	20295	16
Cowley	1st floor flat	1 bedroom, 1 box room 2-person flat	24140	16
Cowley	4-person, 2 storey house	2 bedroom 4-person house	31360	23
Cowley	4-person, 3 storey house	2 bedroom 4-person house	34210	10
Cowley	6-person, 3 storey house	3 bedroom 6-person house	38830	13
Mezen	Ground floor flat	1 bedroom 2-person flat	22411*	10
Mezen	1st floor flat	1 bedroom, 1 box room 2-person flat	22411*	10
Mezen	4-person house	2 bedroom, 4-person house	35921	15

* Borough figures do not distinguish between ground floor and first floor flats at Mezen in terms of design heat loss.

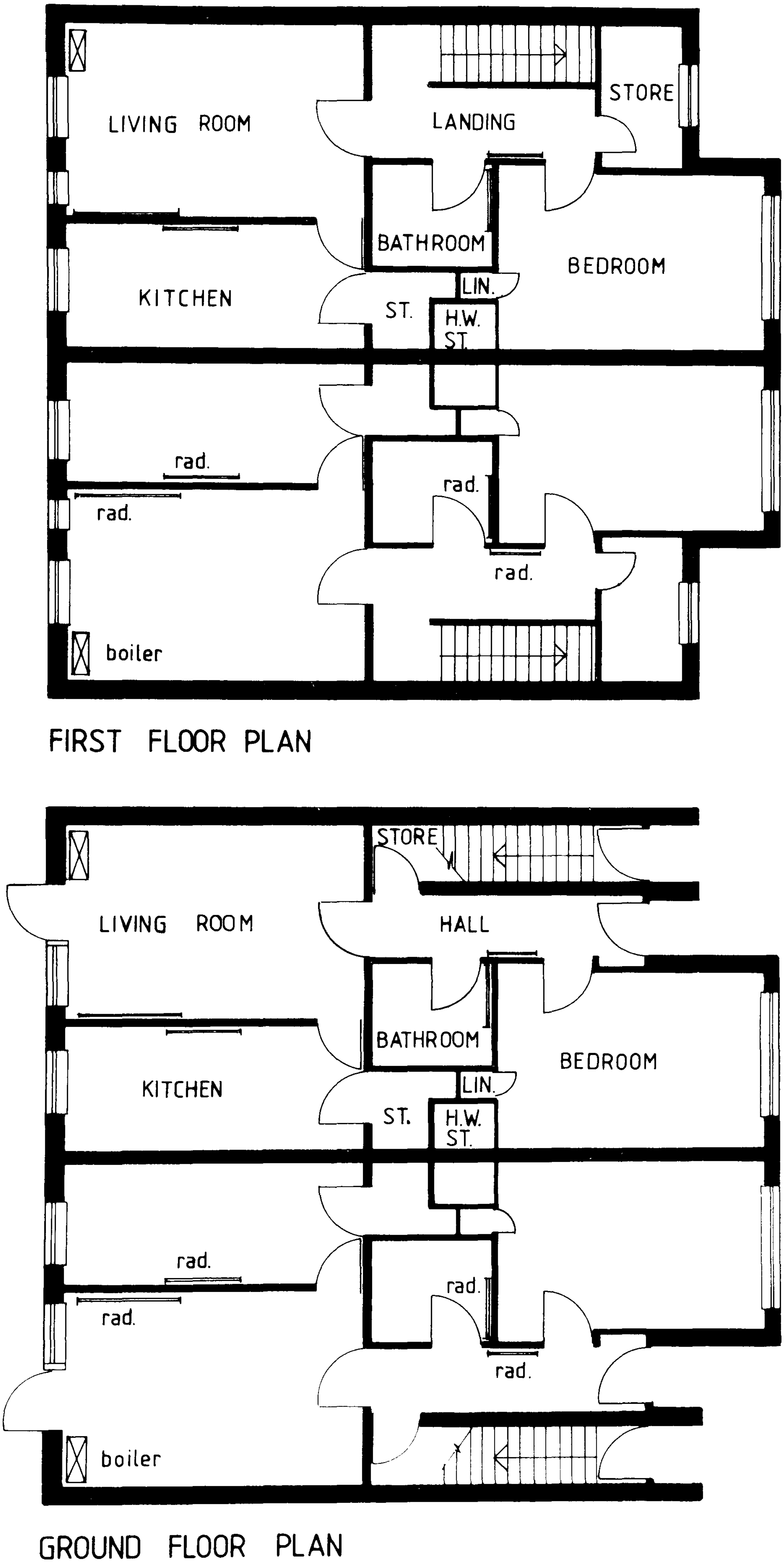
† Design heat loss figures are calculated for end-of-terrace dwellings in each house type.

D.H.L. = design heat loss.

4.1.2. Quarterly Gas Consumption

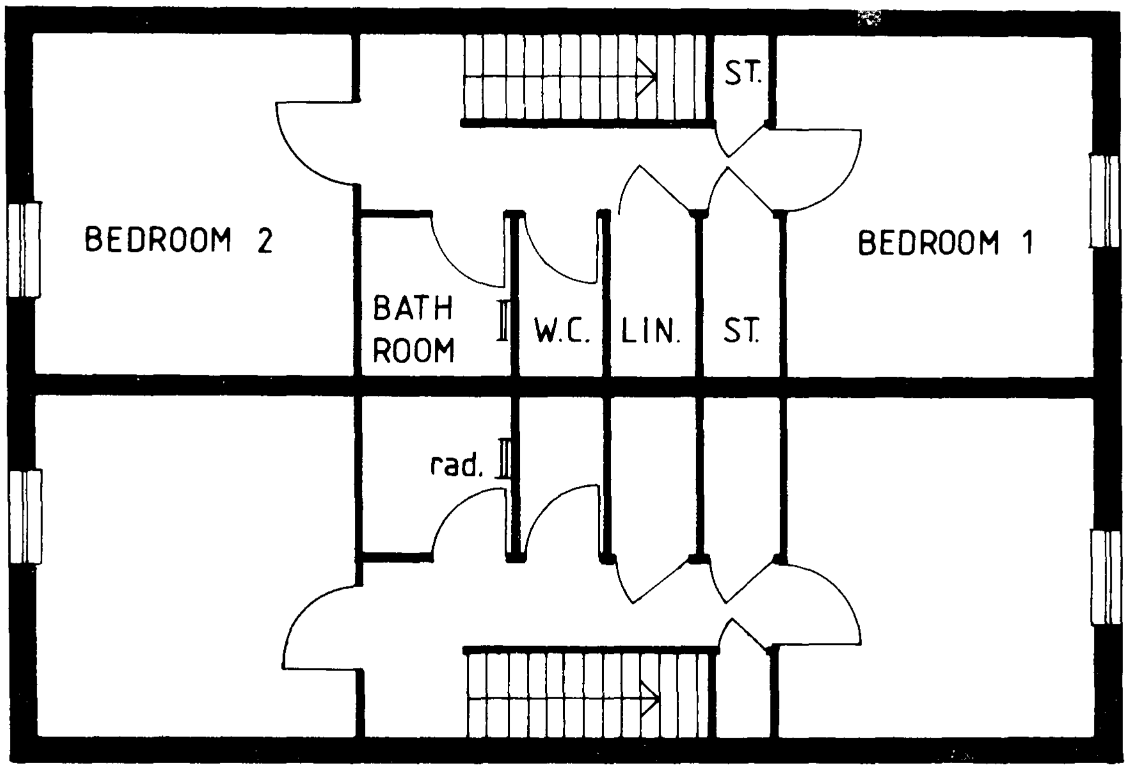
Access to quarterly gas consumption readings from October 1978 to April 1980 (inclusive) was given to the researcher by the North Thames Gas Board. In some cases householders are billed according to their own meter readings or gas board estimates. This means that consumption values for such householders may be inaccurate over a short

FIGURE 4.1. Outlay of ground floor and 1st floor flats at Cowley (two mirror image drawings shown)

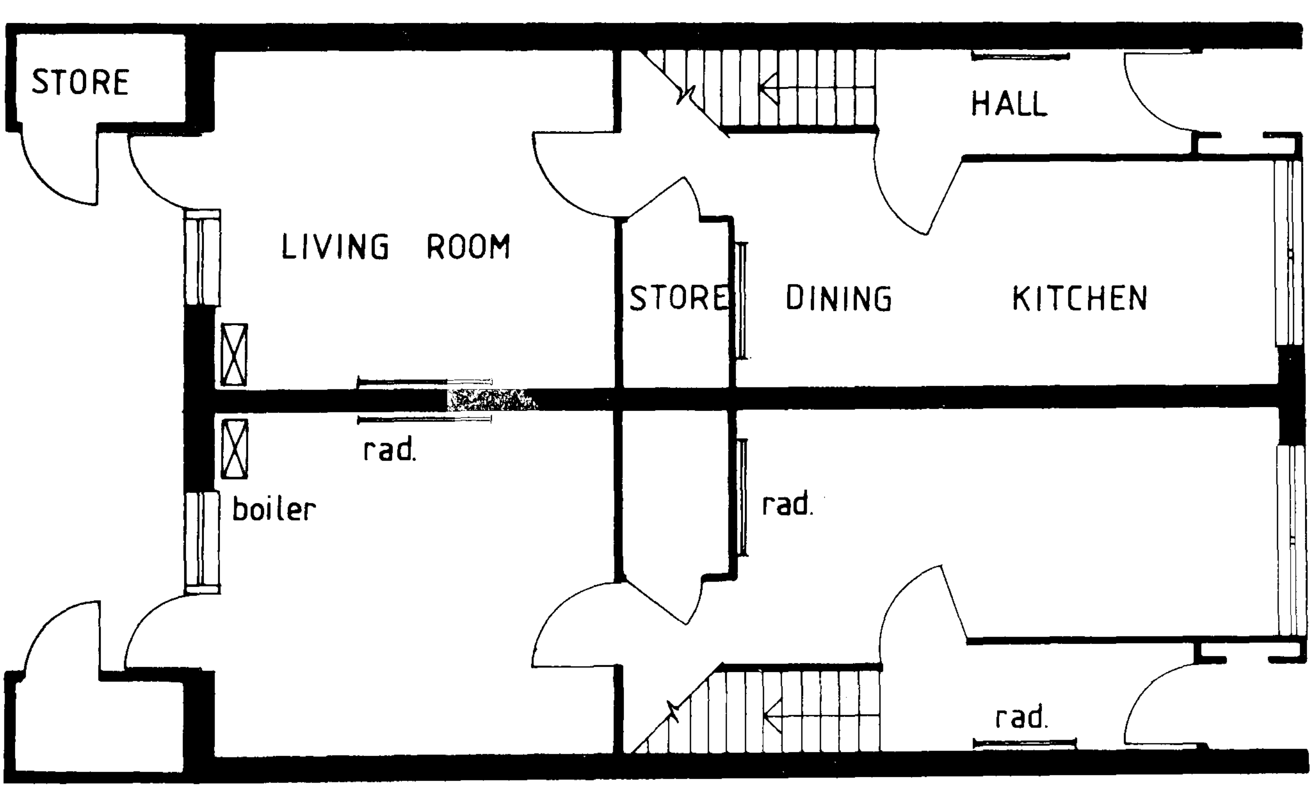


Scale 1:120

FIGURE 4.2. Outlay of 4 Person, 2 storey houses at Cowley (two mirror image dwellings shown)



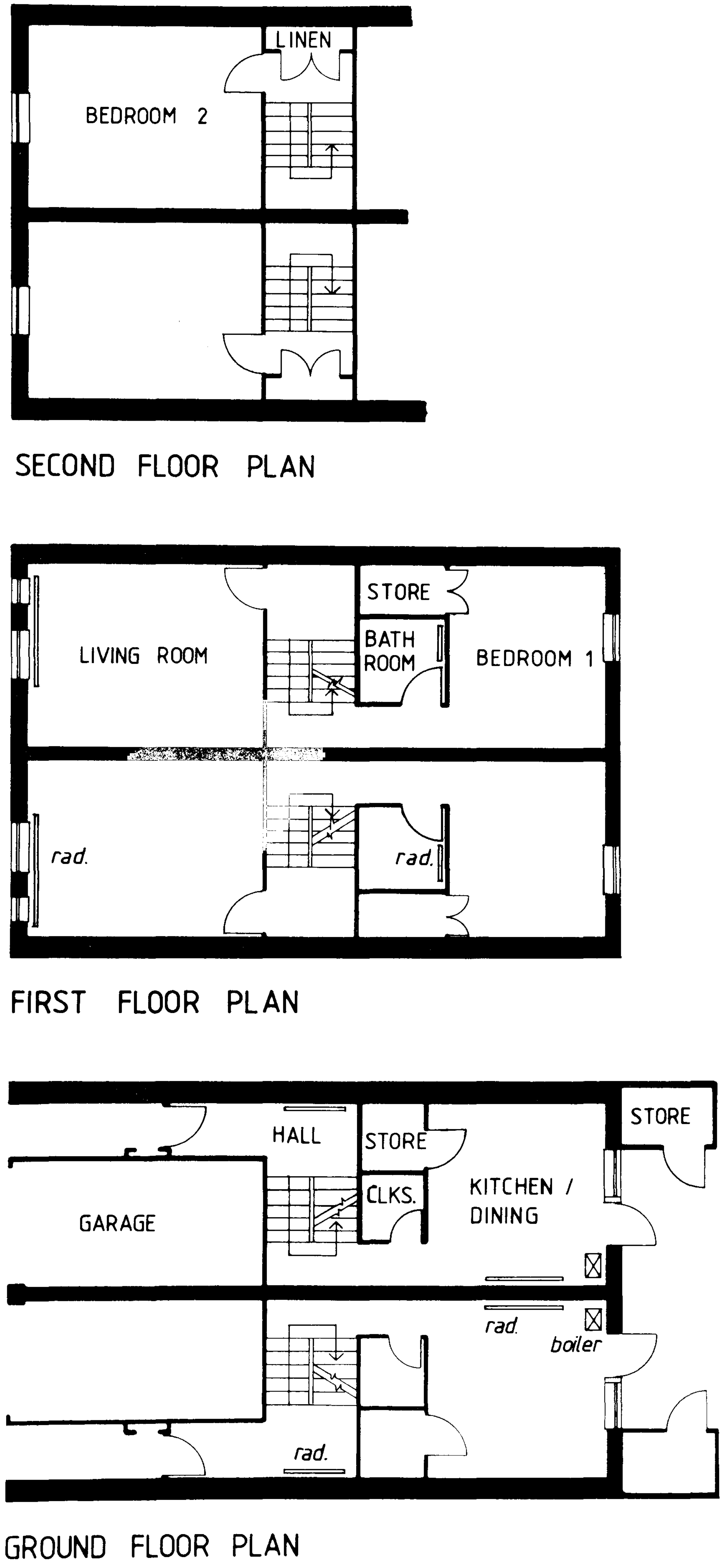
FIRST FLOOR PLAN



GROUND FLOOR PLAN

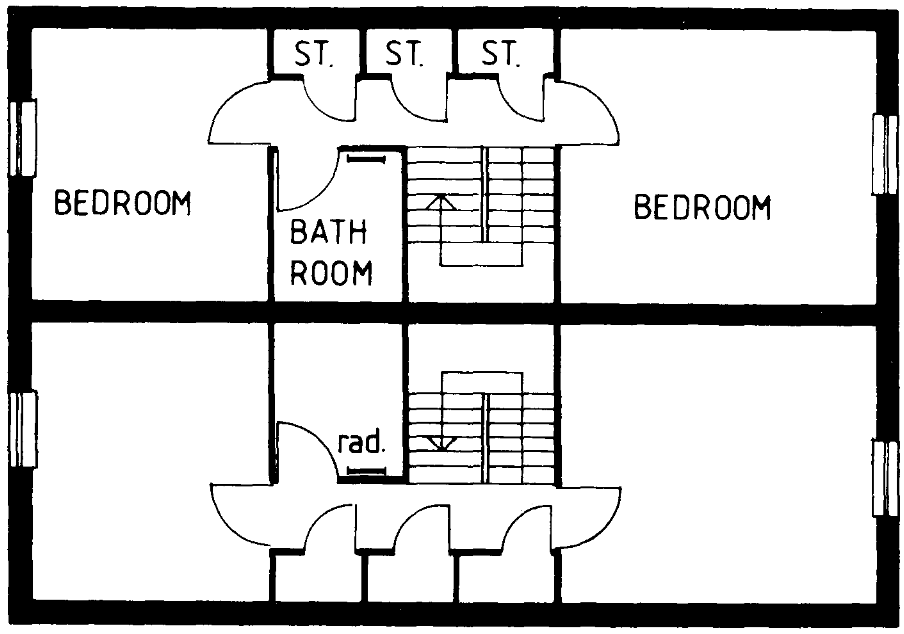
Scale 1:120

FIGURE 4.3. Outlay of 4 person, 3 storey houses at Cowley (two mirror image dwellings shown)

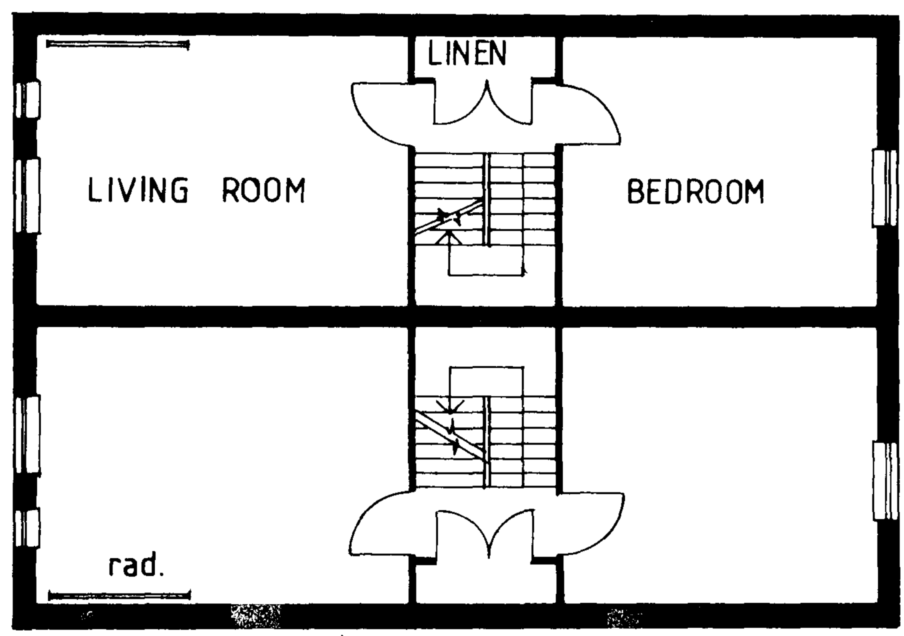


Scale 1:120

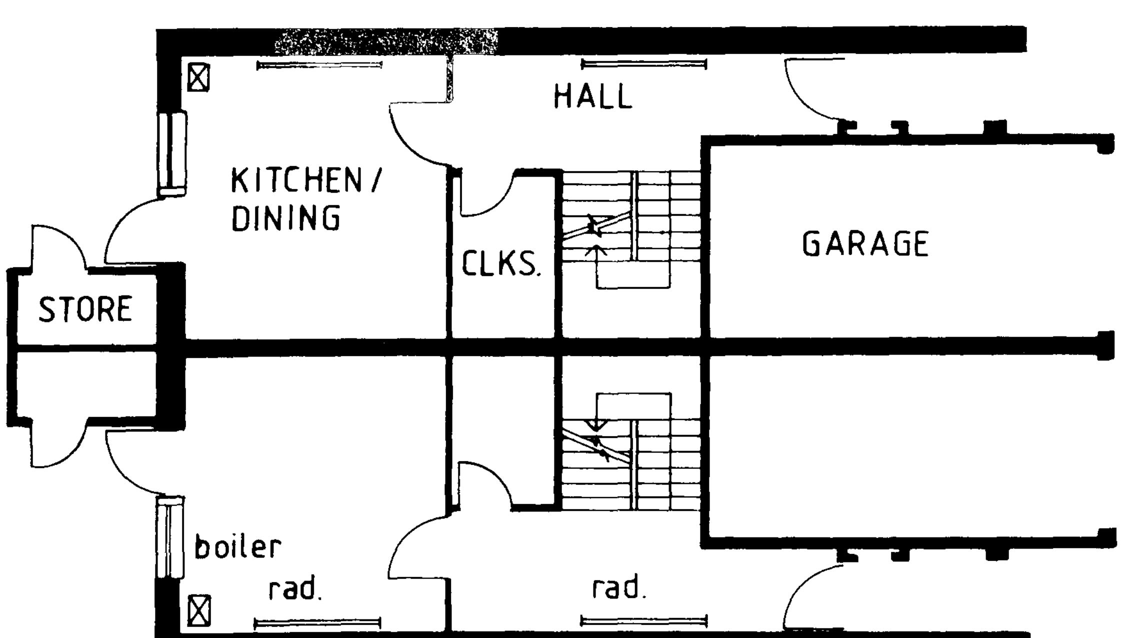
FIGURE 4.4. Outlay of 6 person, 3 storey houses at Cowley (two mirror image dwellings shown)



SECOND FLOOR PLAN



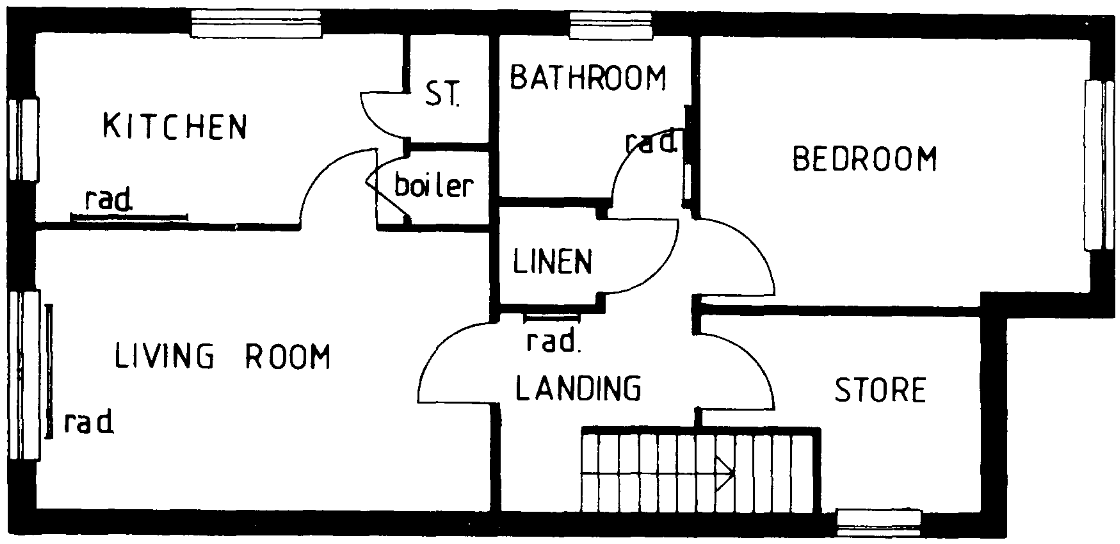
FIRST FLOOR PLAN



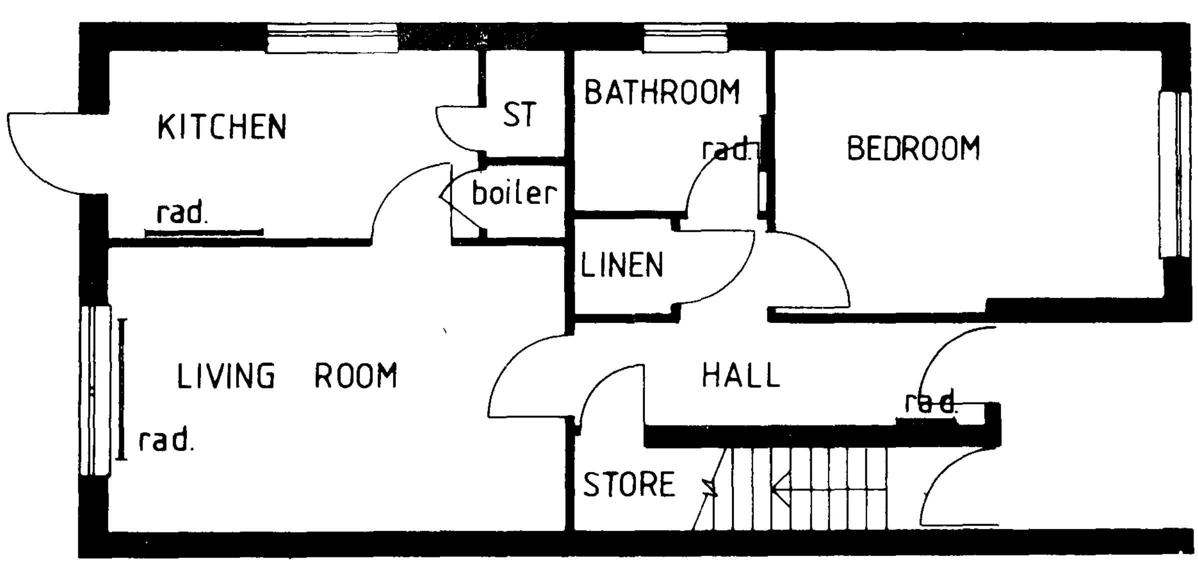
GROUND FLOOR PLAN

Scale 1:120

FIGURE 4.5. Outlay of ground floor and 1st floor flat at Mezen (two dwellings shown, one per floor)



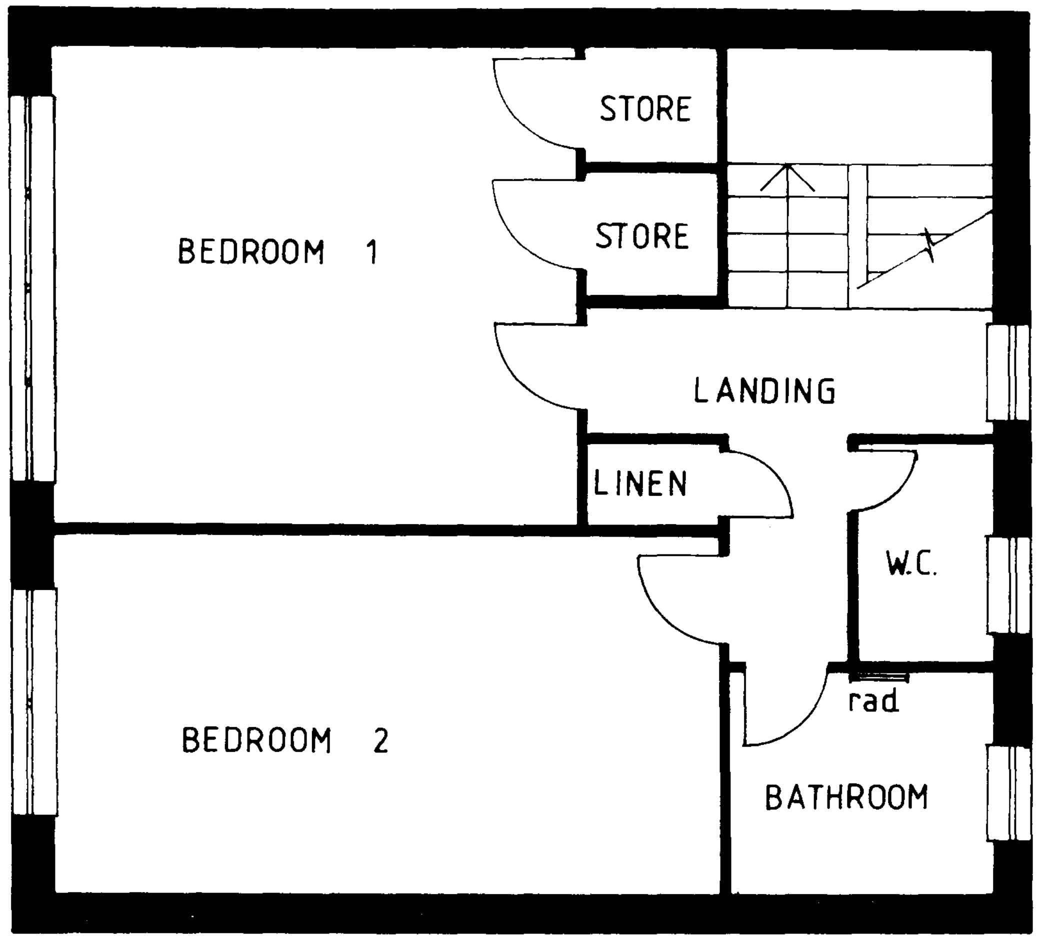
FIRST FLOOR PLAN



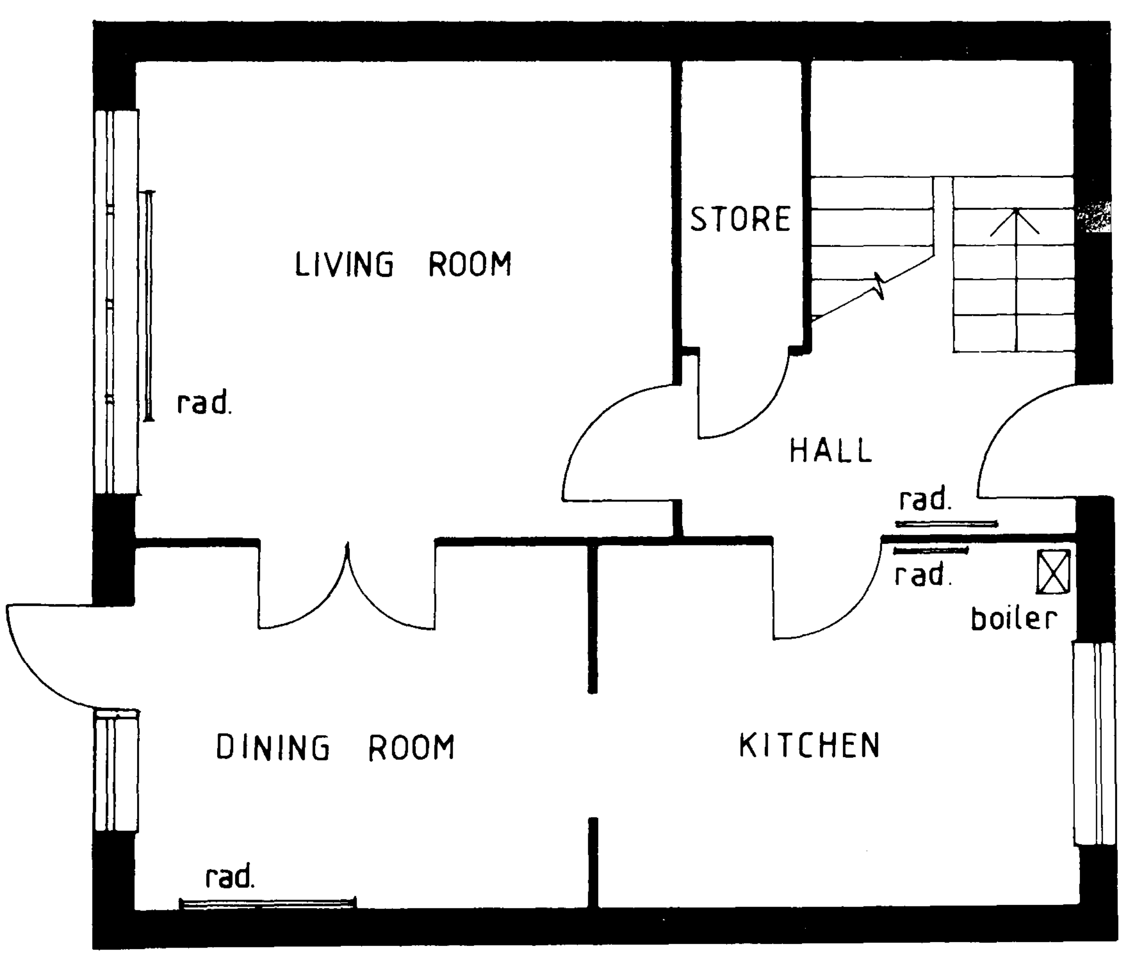
GROUND FLOOR PLAN

Scale 1:120

FIGURE 4.6. Outlay of 4 person houses at Mezen
(one dwelling on two floors shown)



FIRST FLOOR PLAN



GROUND FLOOR PLAN

Scale 1:120

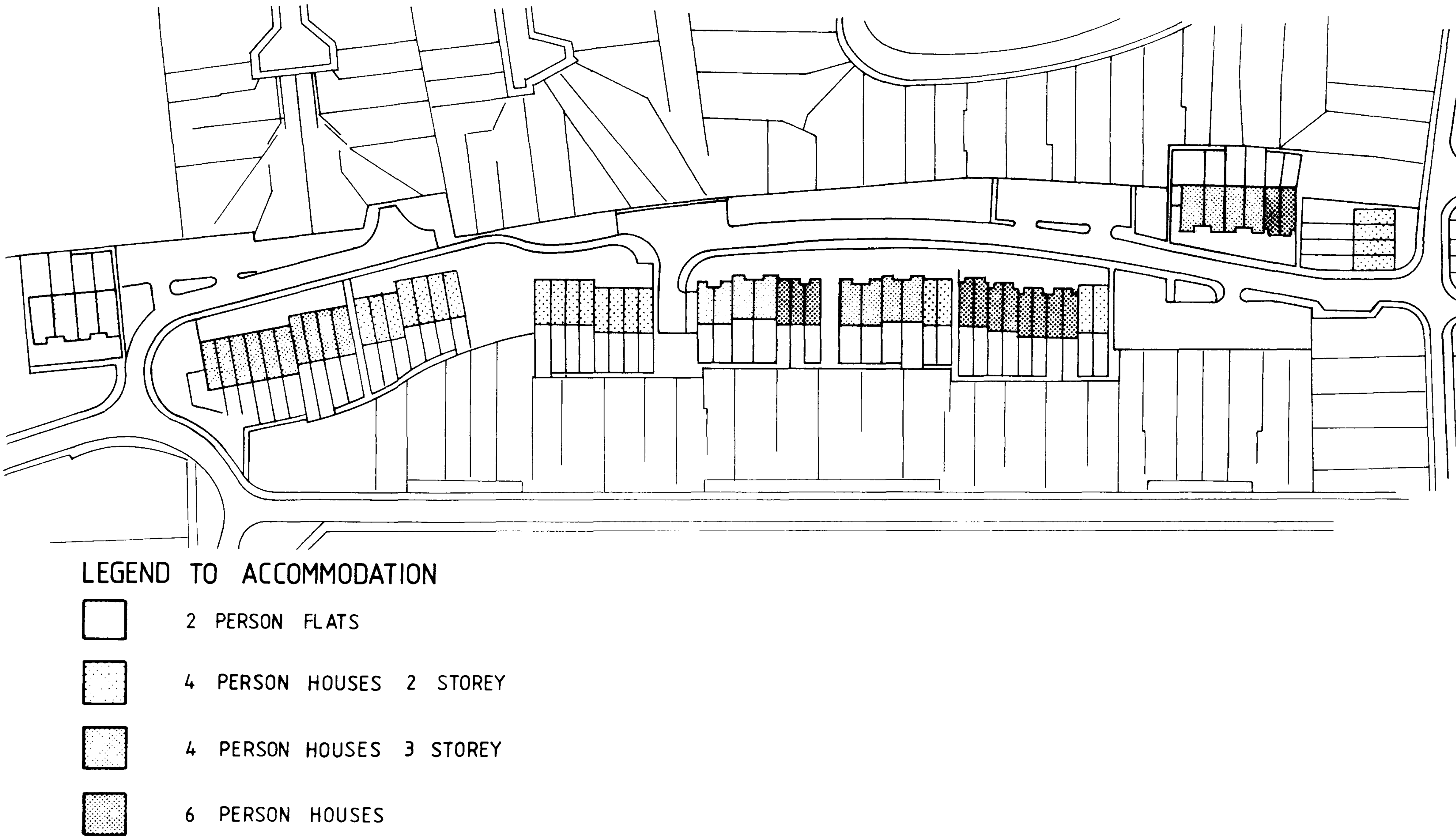


FIGURE 4.7. Site outlay at Cowley

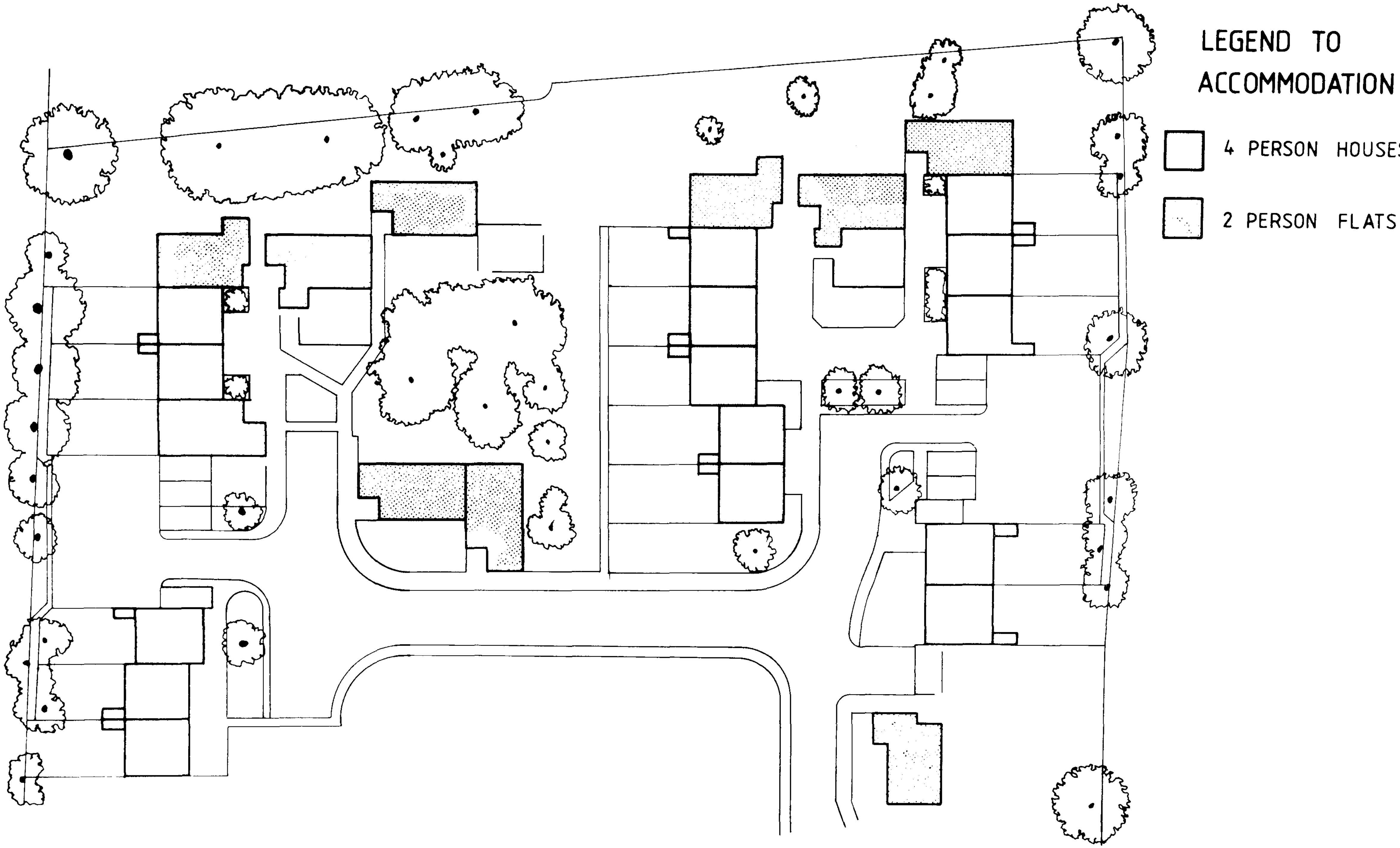


Fig. 4.8. Site outlay at Mezen

time period. It was therefore decided that when a householder's estimated reading appeared particularly high or low, the reading would be coded as missing data and would not be included in any correlations. Without this precaution some consumption readings would have been negative.

4.1.3. The Interview

The interviews took place between October 1979 and March 1980. The majority were conducted in the daytime between 9 a.m. and 6 p.m., but if after three visits the occupants had not been contacted, three further evening calls were made. If contact was made but it was not convenient to talk to the householder at that particular time, an interview at a future date and time was arranged.

The aim was to interview the head (or spouse) of each of the 113 households on the two estates, and to collect from them basic demographic and behavioural data. The interview schedule (Figure A2[1]) was divided into five main areas:

a) physical characteristics of the dwelling

b) occupant characteristics

c) occupant use of, and attitudes towards the central heating controls

d) occupant satisfaction with the heating system

e) household behaviour patterns

4.1.4. Postal Questionnaire

When the interviews had been completed a postal questionnaire was sent to all of the 113 householders. The principal aim was to investigate reported window opening behaviour patterns. However, the first section of the questionnaire was concerned with occupants' under-

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1. 'A' is used to refer to figures and tables which are presented in the appendix.

standing of the central heating system, and the results are consequently discussed in this chapter.

4.2. Analysis of Gas Consumption

Table 4.2 gives the correlation coefficients obtained between each of the six quarters for which data were available. Inspection of the table shows that all 15 correlations are significant, 9 at the 1% level, 6 at the 5% level. In terms of gas consumption, this indicates a degree of household consistency across different metering periods as illustrated, for example, by figure 4.9. However, the obtained correlations are low in comparison to those found in some other British Gas surveys. No explanation could be found for this discrepancy either by the researcher, or by British Gas.

TABLE 4.2. Correlation coefficients obtained between gas consumption for 6 different quarters

Quarter ending	QUARTER					
	29/04/80 "ACON"[1]	25/01/80 "BCON"	26/10/79 "CCON"	27/07/79 "DCON"	01/05/79 "ECON"	29/01/79 "FCON"
"ACON"		.62**	.44**	.2o*	.64**	.63**
"BCON"			.18*	.17*	.64**	.78**
"CCON"				.18*	.28**	.40**
"DCON"					.19*	.17*
"ECON"						.66**

** < .01

* < .05

1. ACON is the consumption during quarter A (29/01/80 to 29/04/80) etc.

FIGURE 4.9. The relationship between consumption in two winter quarters ("ACON" and "BCON")

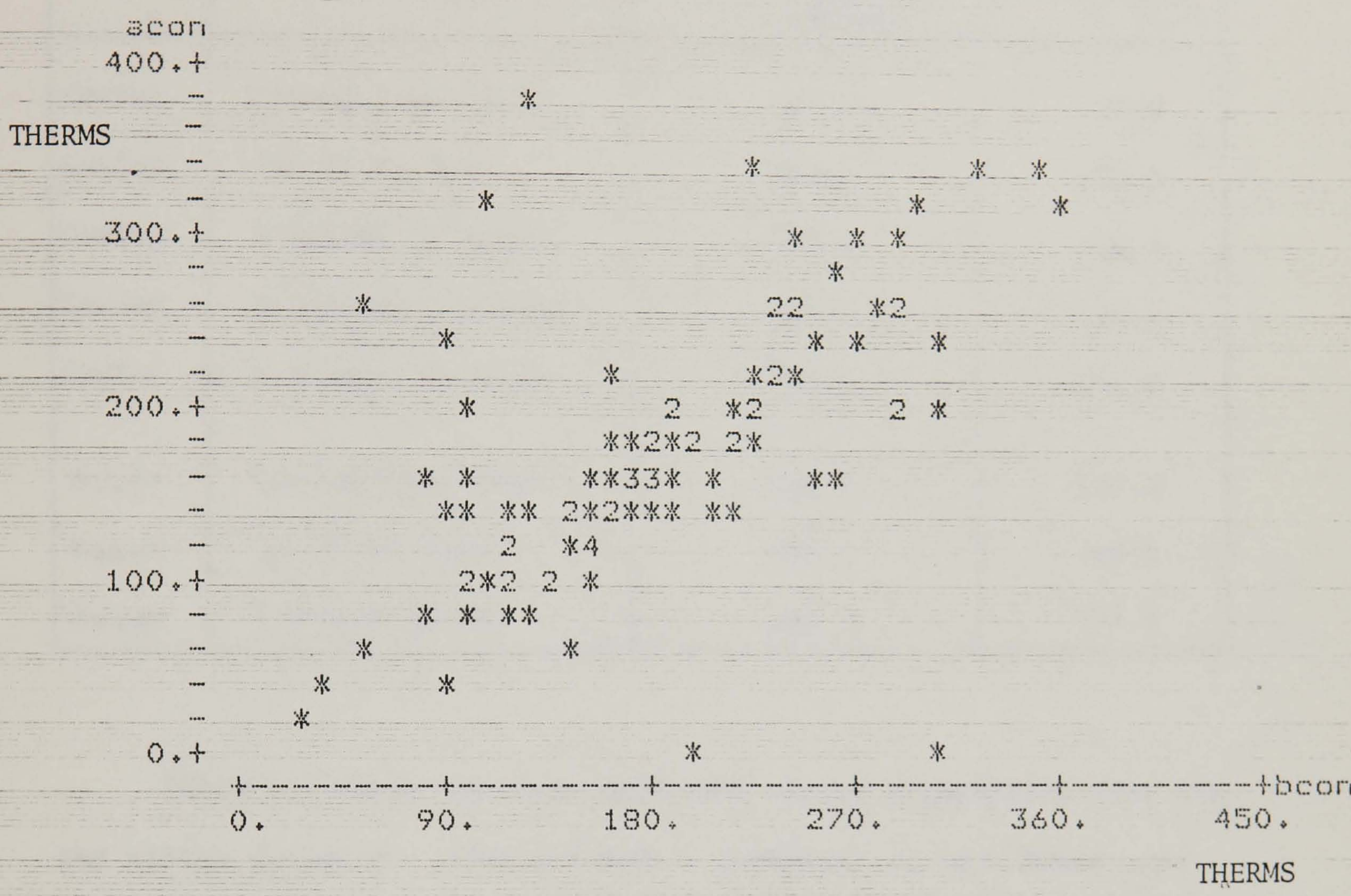


TABLE 4.3. Mean and standard deviation of winter consumption in each house type

Estate	House type	Mean winter consumption (THERMS)	Standard deviation
Cowley	Ground floor flat	257.2	82.9
Cowley	1st floor flat	294.2	100.4
Cowley	4 person, 2 storey	426.4	156.2
Cowley	4 person, 3 storey	423.3	154.7
Cowley	6 person, 3 storey	444.7	112.0
Mezen	Ground floor flat	355.0	107.3
Mezen	1st floor flat	298.1	60.6
Mezen	4 person house	368.7	174.9

Table 4.3 shows the mean 1979-1980 winter consumption (for the two winter quarters - ACON and BCON - combined) in each house type. The means are based on data from figure A3 which includes the appropriate consumption readings for each household. Figures 4.10 - 4.17 are histograms of these data. They show that within each house type there is a wide variation in winter gas consumption, the ratio being about 4:1 between the highest and lowest consumers. The variations are reflected in the standard deviations given in table 4.3. They suggest that physical parameters alone cannot account for gas consumption and that a large proportion of the variance in gas consumption is due to occupant behaviour. This hypothesis is supported by the finding that in general the only significant differences in winter consumption between house types, as indicated by Mann-Whitney tests, are those found when the winter consumptions of large dwelling types are compared with those of much smaller dwelling types (Table 4.4).

FIGURES 4.10-4.13. Range of 1979-1980 winter consumptions in individual house types

FIG. 4.10. Cowley, ground floor flats

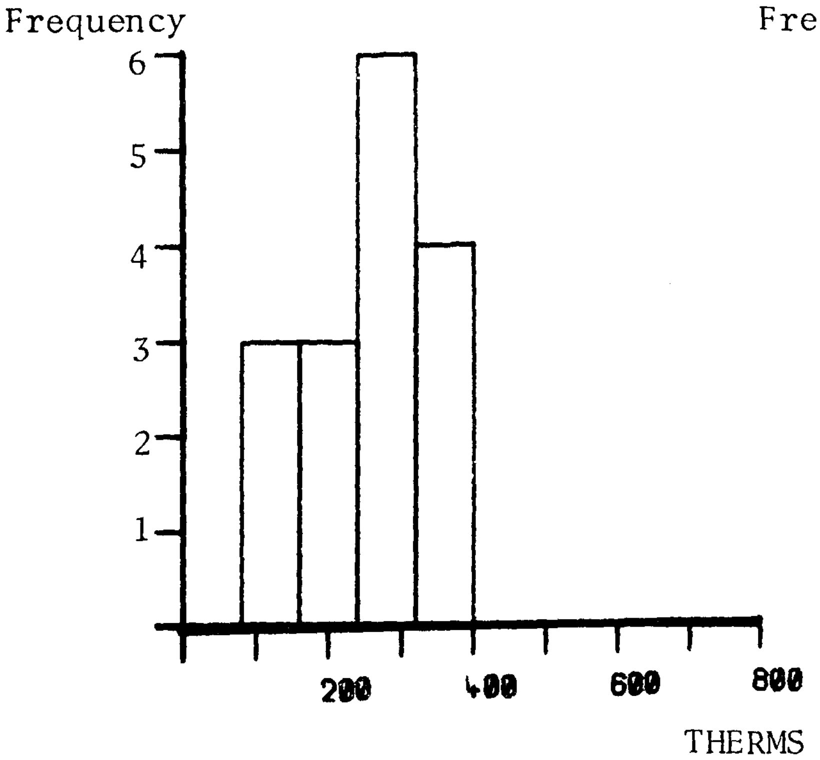


FIG. 4.11. Cowley, 1st floor flats

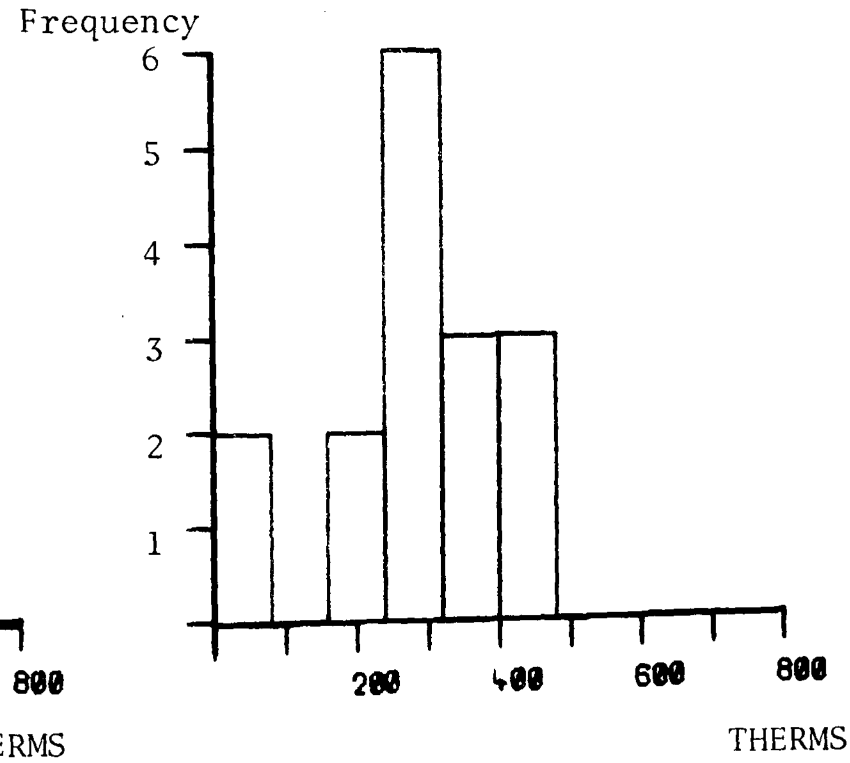


FIG. 4.12. Cowley, 4 person, 2 storey houses

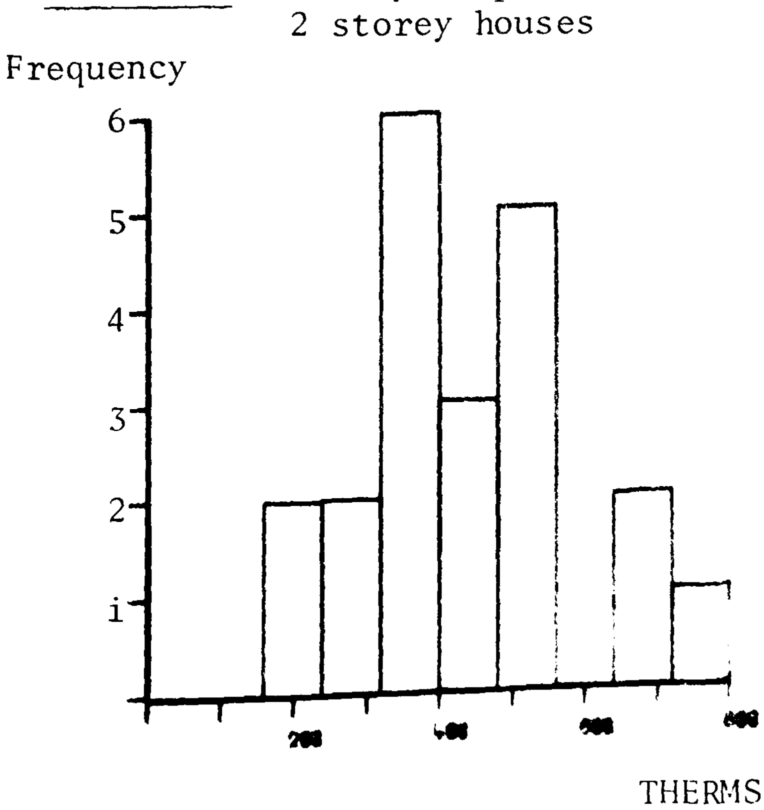
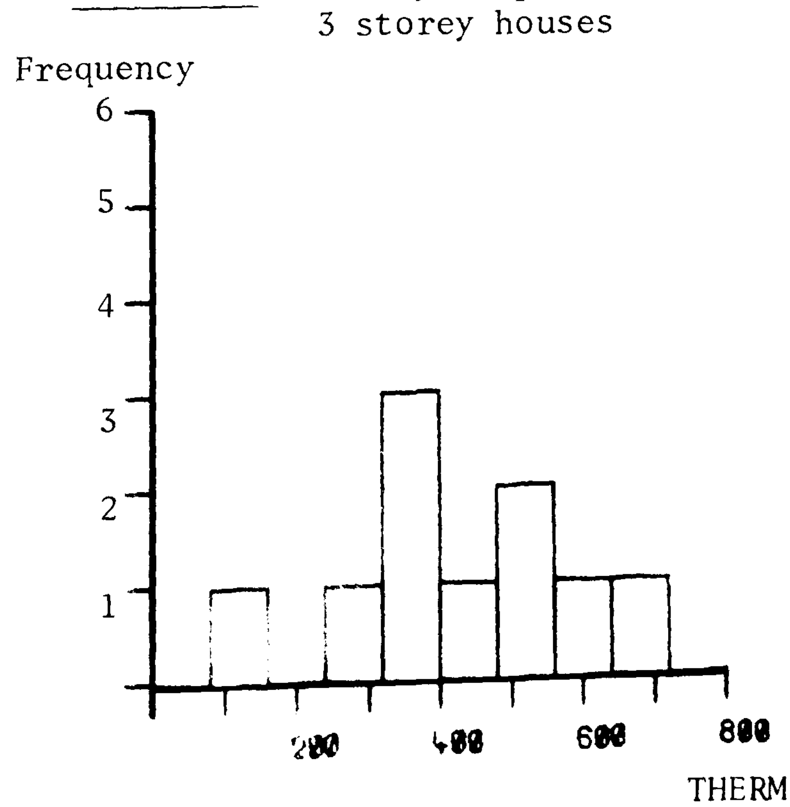


FIG. 4.13. Cowley, 4 person, 3 storey houses



FIGURES 4.14.-4.17. Range of 1979-1980 winter consumptions in individual house types

FIG. 4.14. Cowley, 6 person, 3 storey houses

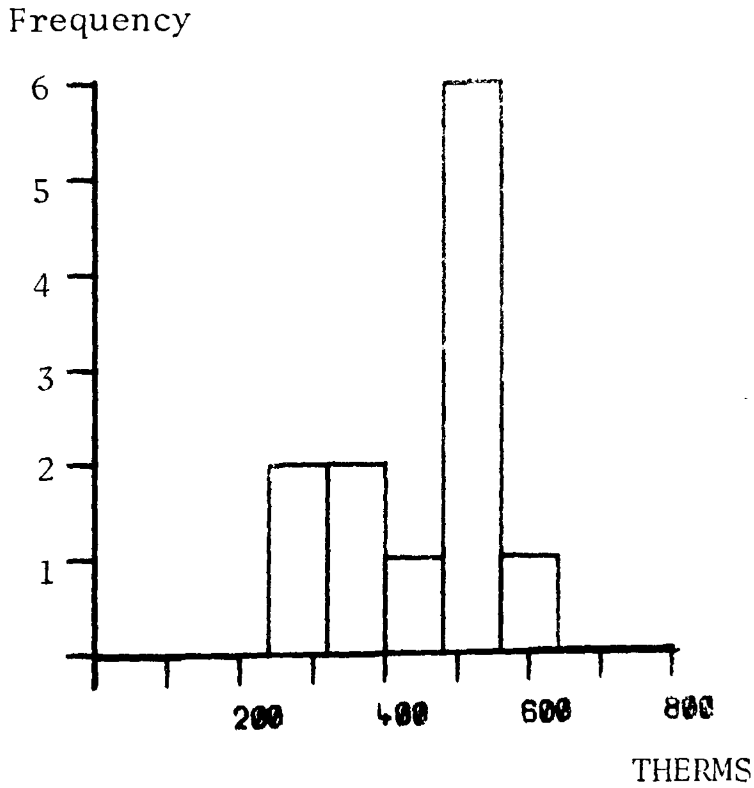


FIG. 4.15. Mezen, ground floor flats

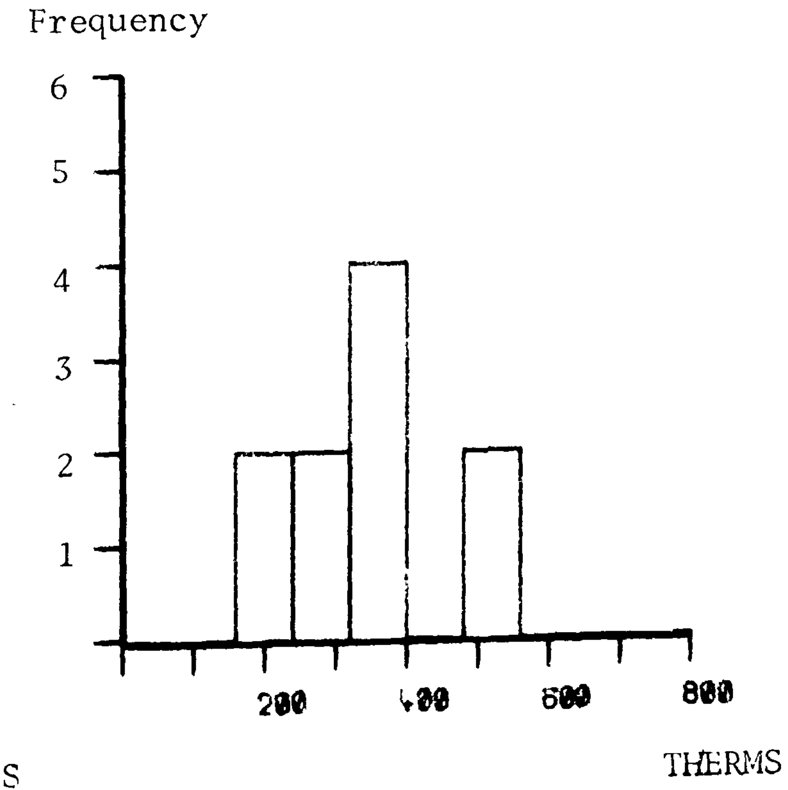


FIG. 4.16. Mezen, 4 person houses

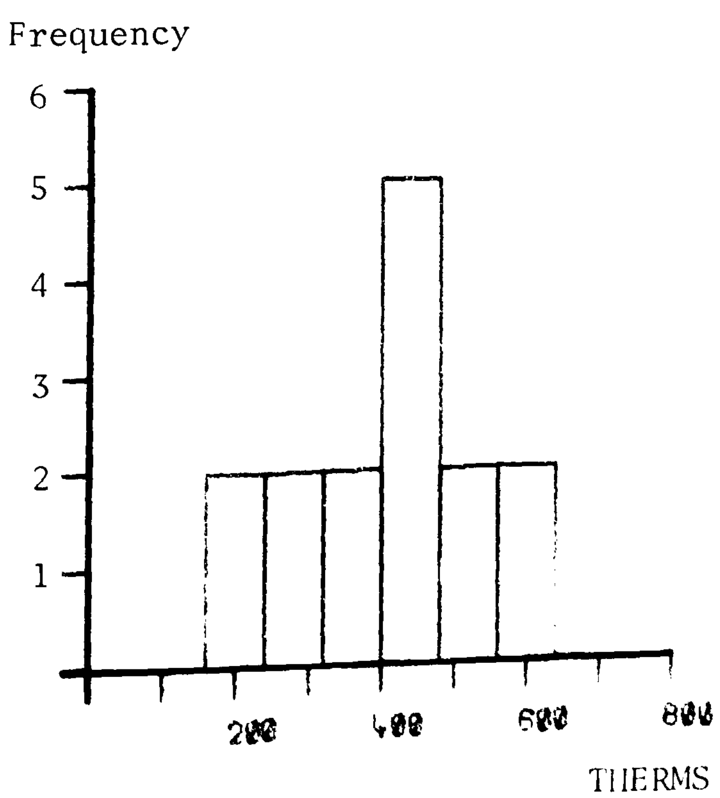


FIG. 4.17. Mezen, 1st floor flats

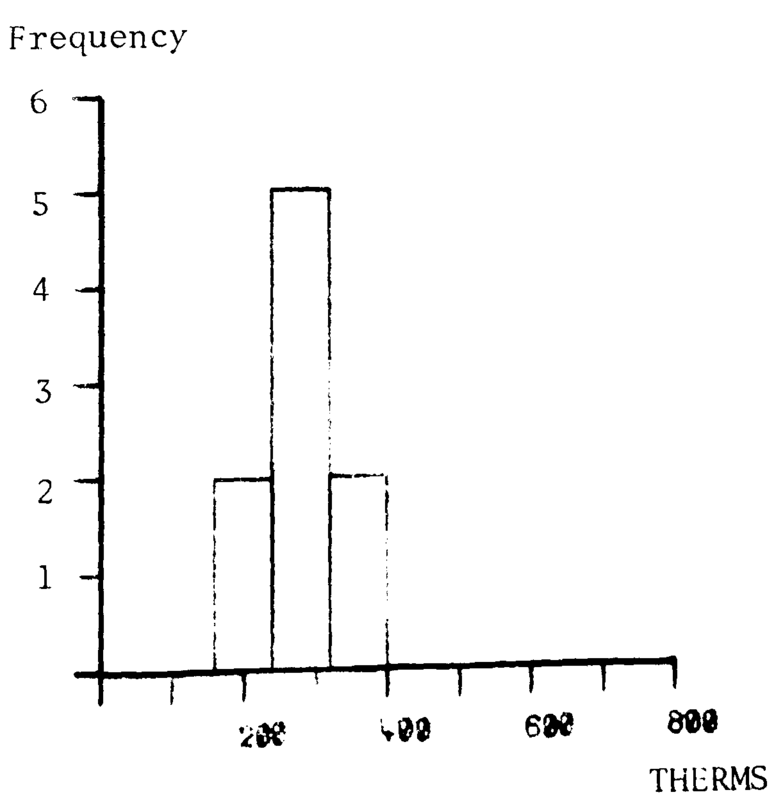


FIGURE 4.18. Range of 1979-1980 winter consumption in all house types together

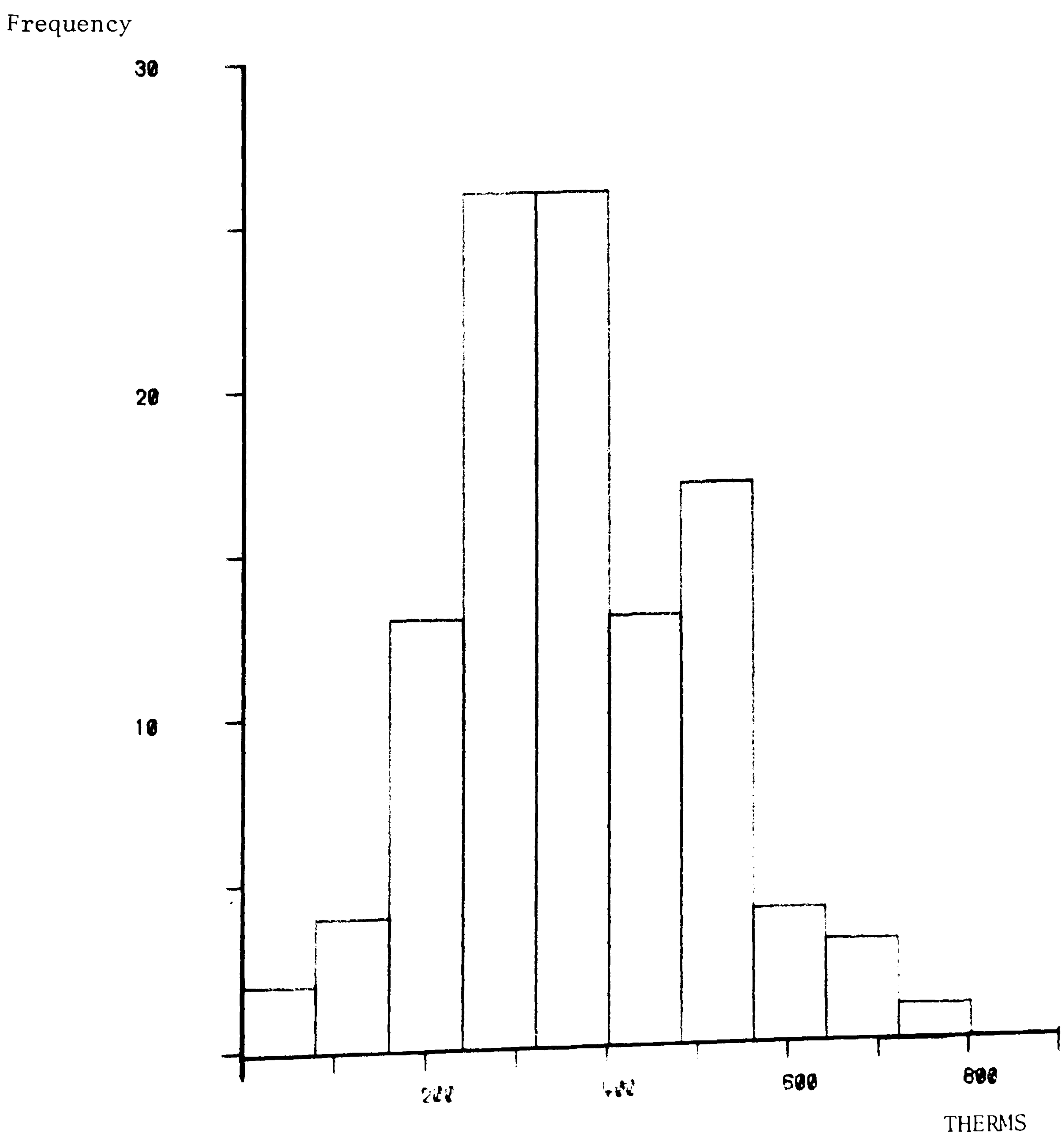


TABLE 4.4. Significance results of Mann-Whitney tests between winter consumptions in each house type

House type	House Type							
	C-G flat	C-1st flat	M-G flat	M-1st flat	C-4P 2S	C-4P 3S	M-4P	C-6P 3S
C-G flat	-	N.S.	<.05	N.S.	<.01	<.01	<.05	<.01
C-1st flat			N.S.	N.S.	<.01	<.05	N.S.	<.01
M-G flat				N.S.	N.S.	N.S.	N.S.	N.S.
M-1st flat					<.05	N.S.	N.S.	<.01
C-4P, 2S						N.S.	N.S.	N.S.
C-4P, 3S							N.S.	N.S.
M-4P								N.S.

N.S. = not significant

G = Ground floor

1st = 1st floor

P = person

S = storey

C = Cowley

M = Mezen

4.2.1. Prediction of Gas Consumption from Physical Variables

Design heat loss is the main physical variable which might be expected to account for much of the variation in gas consumption shown in figure 4.18. In the present study the only design heat loss figures obtainable were for end-of-terrace dwellings in each house type. These design heat loss figures are given in table 4.1. To overcome this limitation terrace position was included in the regression equation as a "dummy" variable (coded 1 and 2 for middle-and end-of-terrace dwellings respectively). However, it must be admitted that this assumes that the effect of terrace position is similar for all house types of varying design heat losses. Amongst the 113 dwellings there were almost equal numbers of end-of-terrace and middle-of-terrace dwellings (n = 60 and n = 53 respectively).

Table 4.5 shows the summary results of a regression analysis between winter consumption as the dependent variable and design heat loss and terrace position as the independent variables. Inspection of the regression coefficients shows that

a) for each increase of 1000 B.T.U.'s in the estimated design heat loss of a dwelling, approximately 11 more therms are consumed, and
b) that on average in winter an end-of-terrace dwelling uses an extra 71 therms compared with a middle-of-terrace dwelling.

TABLE 4.5. Prediction of 1979-1980 winter gas consumption from physical variables

The regression equation is

$$y = -74.2 + 0.0114 \times D.H.L + 70.7 \times TCE.POS$$

Column	Coefficient	St. dev. of coef.	T-ratio = coef/s.d.
--	-74.16	75.28	-0.99
D.H.L.	0.011410	0.001887	6.05
TCE. pos.	70.68	24.88	2.84

the st. dev. of y about regression line is s = 115.9

with (94-3) = 91 degrees of freedom

r-squared = 29.5 percent

r-squared = 27.9 percent, adjusted for d.f.

However, design heat loss and terrace position together account for less than a third of the variance in winter consumption. This suggests that occupant behaviour plays an important role in gas consumption. It is consequently appropriate to discuss in detail householders' responses to interview questions.

4.3. Analysis of Interview Responses

This section deals with the responses to interview questions in each of the five main topic areas. In most cases, information was obtained by first asking the occupant a fairly general question to which there were precoded answers. This was then followed by an open-ended question which allowed the householder to express his own view in detail. Results are consequently generally given first in terms of the frequency with which particular responses were recorded and then in terms of a content analysis followed by a discussion of the data.

The percentages given in all the tables are rounded to the nearest whole number with the result that cumulative percentages do not always total to 100%.

4.3.1. Occupant Characteristics

91 householders (81% of the sample) were interviewed. The majority of the remaining householders (n = 17) could not be contacted. Only five householders outrightly refused to be interviewed.

Basic demographic data covering all household members were obtained from each interviewee. Tables A1 - A5 show the frequency distributions found for each of the following variables:

a) number of household occupants - coded according to the actual number of occupants
b) household lifecycle stage - (i) coded 1 (lifecycle extremes) if there was either (a) a child of four years or under or (b) an occupant of 65 years or more in the household and (ii) coded 2 (middle of lifecycle) if all household occupants were between 5 and

65 years of age

c) number of occupants going out to work - the total score for each household is given. The score is calculated by summing each individual household member's score, coded 1 for part-time employment and 2 for full-time employment.

d) number of hours per week for which the house is occupied - calculated by subtracting from 168 hours (24 hours x 7 days) the total number of hours for which the dwelling was reported to have been empty in the week preceding the interview.

e) total average nett weekly income - total reported weekly income (before tax deduction) for both heads of household, plus if applicable rent payments from wage earning children.

Table 4.6 shows the mean sample value for each of these variables. Inspection of the means and frequency distributions shows that where comparable population norms are available for these variables, there are no marked deviations between them and the sample values (C.S.O. Annual Abstract of Statistics, 1981). In terms of the number of household occupants and nett weekly income, the sample population does not differ markedly from the U.K. population.

TABLE 4.6. Mean sample values of occupant characteristics

Characteristic	Mean	No. of respondents
No. of occupants	2.7	101
Lifecycle stage	1.4	101
No. of occupants going out to work	2.8	101
no. of hours p.w. for which the house is occupied	150.8	91
total nett weekly income	85.7	88

4.3.2. Occupant Use of, and Attitudes Towards Central Heating Controls

Householders can control their central heating in two main ways, namely by regulating room temperature through use of the room thermostat, and by controlling the number of hours for which the heating is on, either by using the system manually or by using the time clock.

All dwellings on both estates have a Drayton thermostat, situated in the sittingroom. The design is basic with four possible settings; a low night setting and three other settings numbered 1, 2 and 3 intended for use during the day (Figure 4.19).

The make and the location of the boiler differs according to house type. In addition, although all dwellings have a Randall time clock, the model design varies according to house type (Table 4.7). The principal difference is that the 30-33 programmers in the Cowley flat and four person, two storey houses have a time clock face which is numbered from one to twelve, and from one to twelve again. In all other house types, time clocks use the 24 hour clock. The basic mode of time clock operation is identical in all house types.

On both estates boiler servicing (by British Gas) has to be requested and paid for by the householder.

4.3.2.1. Reported use of the central heating: use of the time clock and thermostat

Householders were asked how long their central heating was normally on for (a) during the week and (b) at weekends. Tables 4.8 and 4.9 give the means and frequency distributions for the response given, showing that on average householders reported that they used the heating for about nine hours a day during the week, and for about eleven hours a day at weekends.

The majority of householders used the heating for a few hours in the morning and several more hours in the evening. However, some

FIGURE 4.19. The Drayton room thermostat

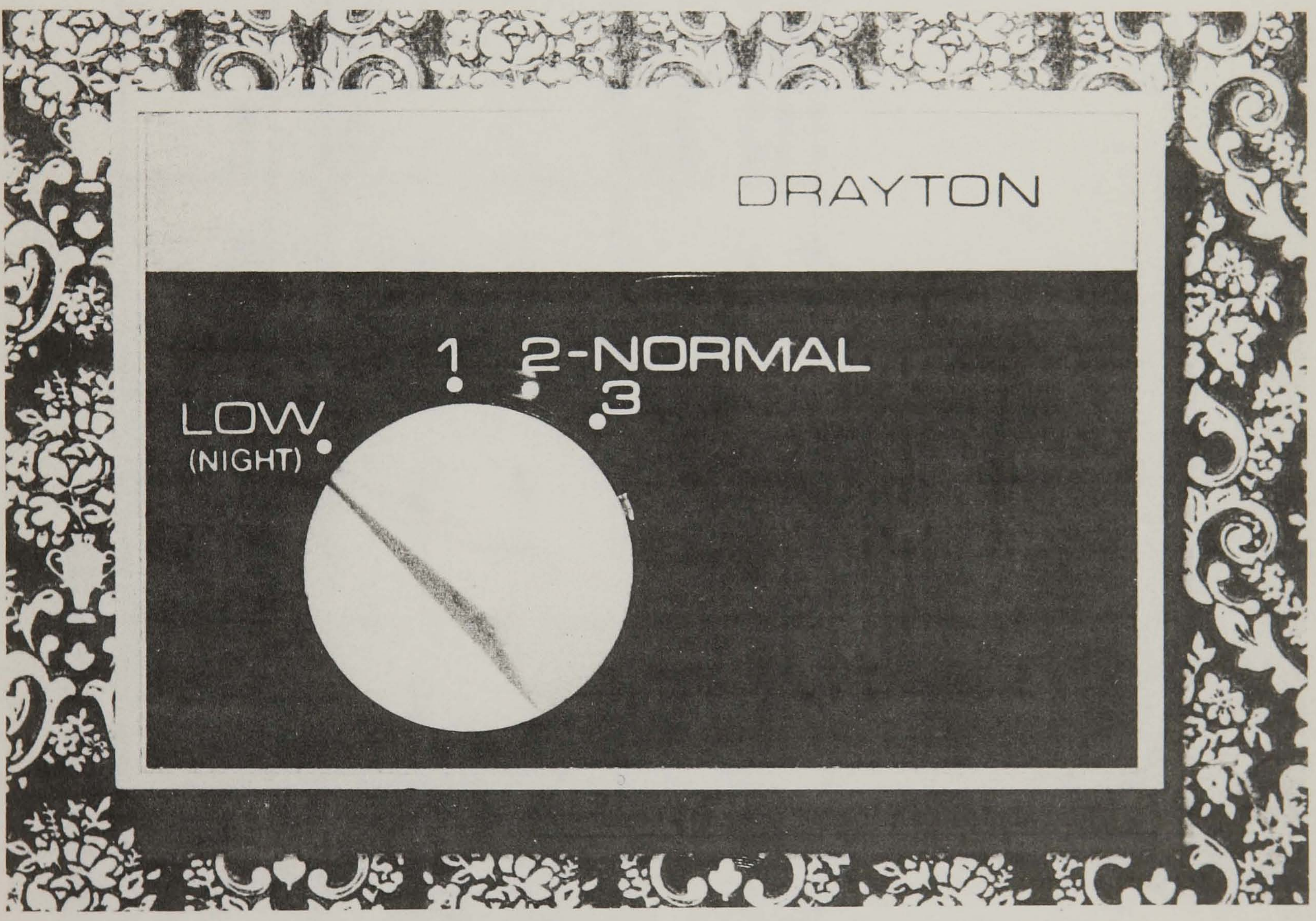


TABLE 4.7. Heating controls in each house type

Estate	House type(s)	Boiler Boiler type	Boiler rated output BTU/HR	Location	Flue	Programmer Randall	Room thermostat
Cowley	Flats, 4P2S	Thorn Pacific	50,000	Sittingroom	balanced with wire guard	30-33	Drayton
Cowley	4P, 3 Story	Glowworm Space Saver	50,000	Kitchen	"	"	"
Cowley	6P, 3 Storey	Glowworm Space Saver	52,000	Kitchen	"	"	"
Mezen	Flats	Vulcan Continental	40,000	Off kitchen	conventional with vent grills	30/40	"
Mezen	4P House	Glowworm Space Saver	38,000	Kitchen	balanced with wire guard	30/20P	"

TABLE 4.8. Mean and frequency distribution of the reported number of weekday central heating hours

Total no. weekday hours	Absolute frequency
10 - 20	10
21 - 40	33
41 - 60	38
61 - 80	14
81 - 100	2
120	3

Mean = 46.7 (hours)

TABLE 4.9. Mean and frequency distribution of the reported number of weekend central heating hours

Total no. weekend hours	Absolute frequency
4 - 8	6
9 - 16	27
17 - 24	34
25 - 32	25
33 - 40	5
48	3

Mean = 21.2 (hours)

householders said they didn't use the central heating on weekday mornings (n = 12) or on Saturday and Sunday mornings (n = 10), because, for example,

"I'm warm during the day - I'm always moving around and so, it is really only at night that I need it."

One householder added that although she felt she didn't really need to have the central heating on in the morning, she put it on since,

"Because the cycle has to rev up like a cold car, I use more energy if it gets too cold."

In three households the heating was reported to be on 24 hours a day during both the week and at weekends. All three householders maintained that this was necessary for health reasons, two because they suffered from bronchitis and one because he was disabled as a result of a spinal injury.

Although there is a wide variation amongst householders in terms of the reported number of hours for which the central heating is on, no relationship was found between the total number of central heating hours per week and 1979-1980 winter gas consumption (Figure 4.20). This suggests that consumption is not simply proportional to weekly hours of use but is influenced by "the thermal storage effects in the structure and contents of a house and the use of thermostatic control" (Sansam, 1981). The control of individual radiators may be a further influence.

Use of the Time Clock

Householders were also asked whether or not they used the time clock, and why. Analysis revealed that 54% of interviewers used the time clock, the remaining 46% choosing to operate the system manually. Of those householders using the system manually, 23% set the heating to continuous and used the thermostat as a regulator to effectively turn it on and off, the remaining householders switching the boiler on and off as required.

Tables 4.10 and 4.11 provide content analyses of householders explanations as to why they did or did not use the time clock. There was no limit as to the number of reasons each respondent could give, but if a particular reason was mentioned twice by the same respondent it was only counted once. The maximum number that could be recorded

FIGURE 4.20. Relationship between gas consumptions in two winter quarters (ACON & BCON combined) and reported total central heating hours per week

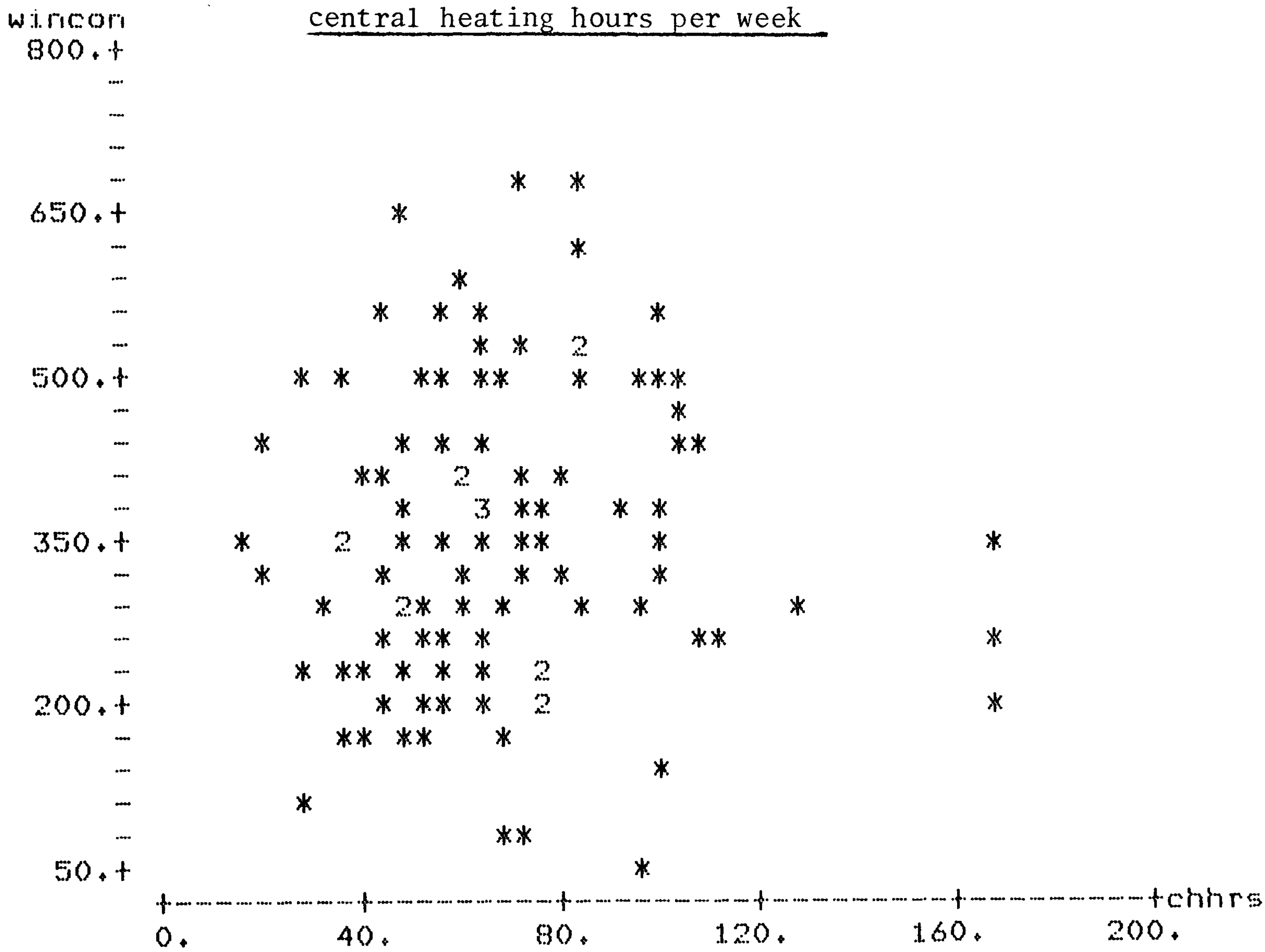


TABLE 4.10. Content analysis of motivations underlying use of the time clock

Motivation	No. of respondents
Cheaper than continuous	21
So that it's warm when I/we wake up	13
So that it's warm when I/we come in	8
Ease and convenience	9
Saves forgetting to turn on the heating	4

TABLE 4.11. Content analysis of movations underlying non-use of the time clock

Motivation	No. of respondents
Unpredictable lifestyle	21
Prefer to use thermostat as a regulator	21
More economical - only on when necessary	5
Don't understand time clock	7
Want constant warmth	1
Controls are awkward to get at	1

against any one motivation was therefore the number of respondents. Frequency of response occurrence is taken as an indication of the relative importance of each motivation.

Table 4.10 shows that reasons of economy were often given as justification for the use of the time clock (n = 21). The finding accords with opinions commonly expressed in the media, and in government and industry advertising but must be tempered with the result given in table 4.11, namely that just as many householders justify their non-use of the time clock on the grounds that their lifestyles prohibit such preprogramming. Indeed, five respondents specifically said that it was cheaper to use the system manually rather than to have it switch itself on when no-one was in the house.

The high proportion of householders using the thermostat as an "on-off" switch is explicable in view of the relative ease of such a mode of operation, compared with the potential difficulties in setting a time clock. Indeed, seven householders spontaneously said they didn't understand their time clocks. It is also possible that the thermostat, situated in the sittingroom is not only simpler and quicker to use, but is more accessible.

One respondent who used the system manually because of his unpredictable lifestyle, claimed to overcome the advantages of preprogramming by using an electric fire to obtain rapid warmth, until the central heating had been on sufficiently long to have warmed the room.

Householders using the time clock were also asked how often, and at what time of day, they tended to override it. Analysis shows that of the 49 interviewees using the time clock only 8 (16%) said they never overrode it, the majority reporting that they overrode it at weekends or depending on the weather (n = 21, 43%) whilst 15 respondents (31%) said they regularly overrode it because of personal circumstances.

Three of the householders using the time clock were unable to identify a specific time of day when overriding was likely to occur. However, the majority of the remaining householders (n = 17) reported that time clock overriding generally occurred in the early or late evening.

The most commonly stated reason for overriding the time clock was that the house was occupied at a time of day when it was normally empty (n = 8), for example at weekends or when someone was sick and at home for the day. Seven householders said they overrode the clock if they felt cold during the part of day for which the heating was not timed to be on, whilst six householders gave watching late night television as a possible reason. Two householders reported that they sometimes turned the central heating on specifically to dry clothes. Finally, three householders said that although they used the time clock, it had been set by someone else and they were afraid to touch it either because they were "terrified of it" or because they didn't understand it -

"It seems so complicated!"

Use of the Thermostat

Householders were asked about their normal room thermostat setting. Discrepancies between observed and reported responses were checked at the time of interview so as to obtain the most accurate response for each householder. Analysis shows that the most common setting amongst the 91 interviewees was the middle setting, number 2 (n = 56, 62%).

Although 13 householders reported that they never change the thermostat setting, 53 householders do so regularly or at weekends and depending on the weather. This reported frequency of thermostat adjustment may account for the previously mentioned lack of correlation between winter consumption and the number of hours for which the heating is reported to be on, in that although the heating may be switched on at the boiler, the room thermostat may be set sufficiently low for the boiler to be very unlikely to fire. Indeed, the high number of interviewees unable to say at what time of day they tended to adjust the thermostat setting (n = 68, 74%) supports the hypothesis that thermostat adjustment is a common occurrence, easily forgotten and difficult to pinpoint because of its frequencies and the ease with which it can be done.

Several householders said they turned the thermostat up when watching television and when sitting down in the evening (n = 9). The result supports Croome's hypothesis (1975) that comfort levels are affected by activity and interest factors. Two householders gave adaptation as a reason for turning up the thermostat, one woman adding,

"I just get used to it. The heat can go up and up and as long as I'm not doing anything, I don't even notice it."

Five householders reported that they turned it down at night because,

"There's too big a build-up of heat."

Manipulation of Individual Radiators

One further control occupants can exercise over their central heating is through the non or partial use of certain radiators. Analysis reveals that this particular means of control is "never" used by the majority of respondents (n = 66, 73%) and "seldom" by another 15% of respondents. Only 10% of respondents "often" turn individual radiators on and off.

Tables 4.12 and 4.13 provide content analyses of interviewees' responses. Table 4.12 shows that the principal reason given for not turning off certain radiators is that householders feel that when heat is needed, it is required in all the rooms, since many householders like the house to be "warm all over". Indeed, several householders' views accorded with that of one woman who said,

"How can you turn one off? They're all essential rooms."

Ten respondents reported that they did not know what the "knobs" were for, four that using them would "do more harm than good" and another four that they had been told (by a variety of sources) not to touch them. Taken together these replies suggest that many householders do not fully understand the options offered by their heating systems.

TABLE 4.12. Content analysis of reason for not turning individual radiators on and off

Motivation	No of respondents
Need heat in every room	23
Don't know what the knobs are for	10
No need	9
Don't bother	8
Prefer to turn it all off at the switch	5
Would do more harm than good	4
You're told not to	4
The valves are difficult/awkward to adjust	3
It doesn't save any money	2

TABLE 4.13. Content analysis of reasons for turning individual radiators on and off

Motivation	No. of respondents
Kitchen gets too warm when cooking	20
Only need heat in one room at a time	2
Mild weather	2
No point in heating bathroom/hall	3

Twenty respondents (22%) remarked that they turned off the kitchen radiator when cooking. Two respondents made a habit of turning off the radiators in all rooms other than those actually occupied, one adding,

"I'm not one for a lot of heat, I come from the North East and prefer the cold to the heat."

4.3.2.2. Occupants' understanding of the central heating system

When the interview had been completed and the ventilation questionnaire was being drafted, it was decided that a section concerned with householders' comprehension of central heating controls and use of the system should be included in order to clarify concepts often vaguely referred to during the interview. The section aimed to explore (a) typical ways of heating the sittingroom quickly, (b) householders' understanding of the thermostat and (c) the frequency of, and reasons for the central heating being left on when the house was empty.

During the interview several householders implied that they used the thermostat as if it regulated heat output rather than room temperature. It was also apparent that a number of householders correctly perceived the possibility of heating a cold room more rapidly by increasing the boiler thermostat setting. However, since the interview contained no direct questions on these topics, the researcher was uncertain as to the prevalence of such behaviour patterns. It was also unclear as to whether the occupants perceived a relationship between heat loss and ventilation.

The ventilation questionnaire was delivered to all the householders on both estates. Table 4.14 gives the percentage of questionnaire respondents (N = 81, 71 of whom were interviewed), endorsing the 'yes' and 'no' response categories for each question. The table shows that in order to heat the sittingroom quickly, the majority of respondents (71%) turn up the thermostat and turn it down later on, although a few respondents leave it at the increased setting. These percentages are remarkably high given that neither action (a) nor (b) actually achieves a faster warm up. The large proportion of respondents reporting that they subsequently lower the thermostat setting seems to indicate that some householders do not realise that the thermostat automatically cuts out when the correct room temperature has been achieved.

TABLE 4.14. Ways of achieving a fast warm-up in the sittingroom - percentages of respondents endorsing each response category

Question: If you want to get the front room warm quickly, do you	Response category (%)	
OPTION	YES	NO
(a) Turn room thermostat up and turn it down later	71	29
(b) turn the room thermostat up and leave it at that setting	19	81
(c) turn the hot water thermostat up	11	89
(d) check that the front room window is closed	77	23
(e) check that the vent in the front room window is closed	37	63

Only nine respondents (11%) said that they turned up the boiler thermostat in order to achieve a faster warm up. This may indicate either that most householders do not perceive a relationship between hot water temperature and rate of heat output or else that increasing the boiler setting is considered too troublesome. It is not possible to distinguish between these two explanations.

Twenty-three per cent of respondents said they did not ensure that the sittingroom window was closed when trying to heat the sittingroom quickly. The percentage of respondents not checking vent positions is even higher (63%). The findings suggest either that fresh air is required when the heating is on, or else that ventilation rates are not perceived to affect room temperature. Saliency may also be an important factor in that it is presumably more difficult to see from a distance whether or not the smaller vents (as opposed to the windows) are open. This may account for the fact that most householders report that they "always" have the vents open in winter, a finding which may additionally reflect beliefs about the width to which a window must be open before heat is lost. In conclusion, it seems that the vents, intended as a finely controlled means of ventilation, may not be deliberately used by occupants.

More than two thirds of the respondents correctly reported that when the heating was on and the thermostat set to number 2, the sitting-room temperature would not "always stay exactly the same" but would "stay roughly the same" (Table 4.15)

TABLE 4.15. Understanding of the room thermostat - percentages of respondents endorsing each response category

Question: Imagine that the central heating is on. The room thermostat is set to number 2. Will the front room temperature

OPTION	Response category (%)	
	YES	NO
(a) always stay exactly the same	31	69
(b) stay roughly the same	66	34
(c) change with the temperature of the hot water supply	15	83

Use of the central heating system when the house is unoccupied

Finally, questionnaire respondents (N = 81) were asked if they ever left the central heating on when the house was empty for an hour or more. Although the largest single percentage is seen in the "seldom" response category (Table 4.16), nearly half of the respondents said they "quite often" or "very often" did so. Table 4.17 provides possible explanations for such behaviour and shows the percentages of respondents who endorsed each of the four response categories for each option given.

Inspection of the ranked percentages in the "quite often the

TABLE 4.16. Percentages of respondents leaving the central heating on when the house is empty for an hour or more

Response category	Percentage %
Never	26
Seldom	32
Quite often	20
Very often	21

TABLE 4.17. Reasons for leaving the central heating on when the house is empty - percentages of respondents endorsing each response category

Question: Do any of the following reasons explain why you leave your central heating on when the house is empty for an hour or more?				
OPTION	Response category (%)			
	never the reason	seldom the reason	quite often the reason	very often the reason
(a) because it is difficult to turn off	94	3	2 (5)	2
(b) because you forget to turn it off	62	27	11 (2)	0
(c) because the savings are not enough to make it worthwhile	71	11	6 (3)	11
(d) because you want the house to be warm when you come in	10	10	29 (1)	52
(e) because of animals in the house	86	8	5 (4)	2
(f) because it is too troublesome to turn it off	95	3	0 (7)	2
(g) because you might forget to turn it on again	90	6	2 (5)	2

Numbers in brackets in the 'quite often' response category indicate the rank position (from highest to lowest) of each option.

reason" column reveals that warmth for the returning occupant received the highest number of endorsements. This suggests that occupants place a high priority on their thermal comfort. However, forgetting to turn the system off, received the second highest number of endorsements, perhaps because as some householders said "the savings are not enough to make it worthwhile". This latter comment may refer to the difficulty householders have in identifying the costs associated with different modes of system operation.

4.3.2.3. Control difficulties

During the interview householders were asked what kind of difficulties they had experienced with both the time clock and the thermostat. Table 4.18 and 4.19 provide content analyses of the responses given.

TABLE 4.18. Content analysis of reported difficulties with the time clock

Difficulty	No. of respondents
Didn't know which settings are for on/off or day/night	20
Difficult to ignite pilot light	19
Meaningless, complicated appearance	14
No idea how to set it	8
24 hour clock	4
Too small	4
Programming options don't suit occupant's needs	2
Other difficulties	7

TABLE 4.19. Content analysis of reported difficulties with the room thermostat

Difficulty	No. of respondents
Prefer it to be calibrated in degrees	6
Prefer wider range of calibrations	5
Unattractive	5
Positioned above radiator	3
Positioned in hottest room	3
Don't know what it's for	2
Other difficulties/complaints	4

Difficulties with the time clock

The principal difficulty associated with the time clock was the difficulty in determining which of the four movable plastic indicators on the dial (numbered 1, 2, 3 and 4) were for "on" and which were for "off". Some householders using the Randall 30-33 programmer experienced the same type of difficulty with their time clocks - namely, they did not know which of the two-coloured zones on the clock represented "day" and which represented "night". However, these were difficulties initially experienced when the householders first moved in.

More important therefore are the comments by 14 householders who said that even now the time clock as a whole was meaningless to them, and that it was "too complicated". Indeed, 8 householders said they had "no idea how to set it". Difficulties created by use of the 24-hour clock were mentioned by four interviewers. The main ergonomic factor creating problems was the size of the clock face - it was too small (n = 1) and consequently too "fiddly" (n = 2), since the divisions were too close together (n = 1). One householder's principal complaint was that she "couldn't read it in one go". It is felt by the researcher that it is this factor which may well account for the complicated appearance frequently referred to. Additionally, two householders felt that there were often times when, although heating was required, it was unnecessary for the hot water to be on, an option not permitted by the time clock. A similar programming difficulty was experienced by one householder who, although she would have liked to use the time clock, didn't since it was impossible to have it on only in the evenings and for a very short length of time.

Nineteen householders spontaneously mentioned difficulties in igniting the pilot light.

Difficulties with the room thermostat

In terms of the room thermostat, the majority of complaints were associated with the small range of possible settings (n = 11). Six householders said they would have preferred a thermostat calibrated in degrees, whilst the remaining five asked only for a wider range of marked gradients. Although the thermostat operated over a continuous range, most householders only used the four numbered positions.

The positioning of the thermostat also caused problems - because it was unattractive (n = 5), because it was positioned above the radiator (n = 3) and also because it was in the hottest room (n = 3) and "too high up the wall to give an accurate reading" (n = 1). Several householders raised the question of whether or not the thermostat should be placed in the warmest or coldest room.

4.3.2.4. Use of additional heat sources

In addition to the central heating a large number of householders (n = 69, 76%) possessed local space heaters such as electric fires (n = 39), fans (n = 10), convector heaters (n = 8) and Dimplex radiators (n = 5). However, six of these householders never made use of their appliances, whilst a further 26 householders reported that it was rarely used, nine householders saying that it was only used in an emergency such as when the central heating broke down.

These additional heat sources were generally reported to be used in the evening between 7 and 10 o'clock at night (n = 31), and by some householders in the morning between 7 and 10 a.m. (n = 5) or between 3 o'clock and 6 o'clock (n = 5). Two householders used Dimplex radiators 24 hours a day.

Additional heating was most common in the bedrooms (n = 28) and then in the sittingroom (n = 9). Children and babies (n = 5 and n = 8) were most frequently given as reasons for the use of such heat sources, indicating that many householders believe that the young require high temperature levels. Seven adults reported that they used it in the bedroom to "take the chill off" and four more that they used it when dressing. Electric fires were reported to have been used in two households at the beginning of winter before the central heating had been switched on. Ten householders used additional heating when they felt particularly cold, and two more householders because they preferred localized heat.

4.3.3. Occupant Satisfaction with the Heating System

Householders were asked how satisfied they were with the central heating system, both generally and in terms of a number of specific aspects, namely achieved thermal comfort, and the relationship between their present system and the heating in their last house; they were also asked in which rooms they felt radiators were necessary. Each of these topics is discussed separately.

4.3.3.1. Satisfaction with the heating system

Householders were asked (a) what do you think are the good points bout your present heating arrangements and (b) what do you feel are the bac points. Tables 4.20 and 4.21 give content analyses of householders' replies.

TABLE 4.20. Content analysis reported satisfactory aspects of the central heating system

Good points	No. of respondents
Warms the house	50
Convenient, easy to use	24
Controllability	19
Cost	18
Clean and tidy	17
Fast response	17
Hot water	12
Drying clothes	12
Constant supply	11
None of the mess/dirt associated with open fires	7
Radiators are neat in appearance	4
Reliable	3
Safe	2
Other comments	7

TABLE 4.21. Content analysis of reported unsatisfactory aspects of the central heating system

Bad points	No. of respondents
No bedroom central heating	41
Too hot in the kitchen	12
Position of radiators restricts furniture arrangements	8
Noisy	8
Draughts	7
Nothing to look at	6
Unreliable	5
Cost	5
Stuffy	3
Condensation	3
Dry	3
Boiler is awkward to get at	2
Radiators are ugly	2
Too much hot water	2

Inspection of table 4.20 shows that 55% of respondents (n = 50) spontaneously mentioned that the heating was effective in achieving a general feeling of warmth throughout the house. This was particularly important for many of the householders who had previously had heating in only one or two rooms. Indeed, one man in particular remarked,

"Central heating makes a big difference to our general way of life."

He then went on to describe how in the previous damp and cold house, it had been necessary to huddle over electric fires, and move swiftly from room to room, the doors of which were all always shut.

Twenty-four householders found the system "easy and convenient" to use. Seventeen householders remarked that the central heating was "clean", several interviewees going on to say that there was none of the mess (n = 7) or work (n = 4) associated with open fires. These and other comments indicate that in assessing a heating system the respondents' previous experience is an important factor. System controllability was seen as an advantage by 19 householders. Several householders mentioned the security afforded by a constant supply (n = 11).

"It's on tap."

"It's there at the flick of a switch."

"The gas people don't go on strike."

Several householders reported that the system was "useful for drying clothes" (n = 12). Two further good points mentioned were safety (n = 2) and reliability (n = 3).

Table 4.21 gives the principal reasons for reported dissatisfaction with the system. The main cause for complaint was the lack of central heating in the bedrooms (n = 41, 45%). Several householders reported that the kitchen was too easily overheated (n = 12) and some suggested that the kitchen radiator should consequently be removed and put upstairs, either in the bedroom or on the top landing. Eight householders reported that the system was noisy. Another 8 householders disliked the way furniture arrangements were restricted by the position of the sittingroom radiator. Some householders reported that they missed "having something to look at" (n = 5), one woman remarking that although the house was warm, it wasn't "very homely". Most other complaints referred either to air quality (stuffiness (n = 3), condensation (n = 3) and dryness (n = 3)) or inadequate insulation and poor workmanship resulting in draughts (n = 7).

In conclusion, it seems that most householders were well pleased with the heating system, although almost half of them would have liked bedroom central heating. Opinion was divided over some issues, namely cost (whilst 18 householders mentioned cost as a good point, 5 other householders saw it as a bad point), appearance (good - (n = 5); bad - (n = 2)) and reliability (good - (n = 3); bad - (n = 5)).

4.3.3.2. Occupant's previous heating

The householders interviewed had had a variety of heating systems in their previous houses, the most common being gas central heating (29%) and warm air central heating (23%). However, most householders reported that it had been inadequate and expensive (Tables 4.22 and 4.23). In comparison the present method was rated either good or very good by 80% of the sample, and reasonable or cheap in terms of cost by a similar proportion of respondents.

TABLE 4.22. Reported satisfaction with the heating system - percentages of respondents endorsing each response category.

Response category	Previous system (%)	Present system (%)
Inadequate	64	4
Reasonable	17	15
Good	8	39
Very good	11	42

TABLE 4.23. Reported satisfaction with the cost of the heating system - percentages of respondents endorsing each response category

Response category	Previous system (%)	Present system (%)
Too expensive	37	5
A bit too costly	24	14
Reasonable	33	63
Cheap	6	18

It is therefore not surprising that only a third of the sample reported that they were trying to cut down on the amount of gas they need, mainly by having the central heating on less frequently (n = 11), lowering the thermostat (n = 6) and by cooking less (n = 3). Sixteen householders gave expense as the motivation underlying such action. One woman remarked,

"EVeryone says put it up but I have to pay the bills."

However, many householders reported that they already used the minimum possible (n = 34), whilst others said they had no reason to cut down (n = 11). A further three householders reported that they were not prepared to reduce their consumption since warmth was important for their children.

"Warmth's as important as food."

"I use it when I need it. There's no point in being in the house and being freezing cold. I think you might as well be warm and pay for it afterwards. I begrudge it but ..."

"I'm prepared to economise so long as it doesn't interfere with the pleasures of living."

These comments reflect important attitudes, namely the high priority placed on comfort and the unwillingness to change lifestyle patterns.

4.3.3.3. Thermal comfort

Interviewees were asked if, when thinking of their house generally, there had been times when they had been too hot or too cold, why this happened and what action had been subsequently taken.

Analysis reveals that whilst householders were almost equally divided as to whether or not they had sometimes been too cold, 67% of the sample reported that they had sometimes been too hot. The finding suggests that householders may prefer to err on the 'hot' side (rather than the 'cold' side) of thermal comfort.

Seventeen householders reported that they had sometimes been "a bit too cold" in the bedroom. Other householders referred to poor insulation (n = 8), weather related causes (n = 6) or individual factors (n = 7). The most typical remedial action was to put on a jumper or cardigan (n = 22), turn up the thermostat (n = 17), override the time clock (n = 14) or use an additional heat source (n = 10). The large number of "cold" householders reporting that they put on extra clothing indicates that although many householders normally wear only light clothing when at home (nearly half of the people interviewed reported that they generally wore what was judged by the researcher to be the approximate equivalent in clo values of shirt sleeves and trousers), many are prepared to wear heavier clothes when necessary. It is suggested that such simple cost effective behaviour should be encouraged as a potential way for householders to meet rising energy costs.

The majority of "hot" respondents attributed their discomfort to overheating (n = 25), generally because the thermostat was "up too high" or the heating had been on "too long", although 4 householders reported overheating on sunny and warm days. Thirteen householders reported that the kitchen was too warm when meals were being prepared and when the oven was on. Seven householders mentioned that they sometimes became too hot when they had visitors, perhaps because of the extra body-heat sources.

The typical response to overheating was for the thermostat setting to be lowered (n = 26) or for the system to be switched completely off (n = 23). However, some householders opened windows (n = 13) and doors (n = 9) or took off articles of clothing (n = 9).

Householders were asked if there was any one in the family who felt the cold more than the others. Mothers, fathers and individual children received 44, 13 and 6 mentions respectively. The explanations given were numerous and various, adhering to popular theories and often contradictory beliefs couched in such terms as "thick" and "thin blood". Responses included references to the following factors - anemia (n = 3), inactivity (n = 4), exposure to different temperature levels either at work (n = 6) or experienced at some stage in one's life (n = 2), old age (n = 3), illness (n = 3), thinness (n = 4) and female sensitivity to the cold (n = 4). The variety of explanations offered suggests, not only that thermal comfort is perceived to be influenced by a number of factors but also that householders subscribe to various theories and beliefs about the human body's response to different environmental conditions. These beliefs have not been explored in the present study.

Rooms Needing Central Heating

It is standard practice for most centrally heated local authority dwellings to be provided with radiators in the sittingroom, kitchen, hall and bathroom. In an effort to test user satisfaction with this practice, householders were asked if there were any rooms which they felt didn't need a radiator.

Analysis shows that 27 householders reported that the kitchen radiator was unnecessary, generally because of overheating due to cooking processes, and also because in some households (Table 4.7) the boiler was situated in the kitchen or just off it.

"You don't need the kitchen radiator ... when you're there, you're generally cooking and anyway it's got the boiler for when you're not."

Twenty-two householders said bedroom central heating was unnecessary, either because they preferred to sleep in a cool room or because they felt it was healthier.

"If it's too warm in the bedroom, you can't sleep properly."

"You should be warm enough in bed without extra heat."

Some householders would have particularly liked bedroom central heating in children's bedrooms, for example:

"The children's bedroom needs a radiator; we just sleep in our bedroom, but they play in theirs."

Thirty householders spontaneously remarked that they would have liked bedroom central heating.

Use of Electric Blankets

One further aspect of thermal comfort was investigated, namely householders' use of electric blankets. Analysis shows that more than half of the sample did not own electric blankets (59%), some adding that they were dangerous (n = 14), unnecessary (n = 29), too costly (n = 5) or unwanted because the interviewee disliked heat in bed (n = 8).

Most electric blanket owners possessed only one blanket which was used in the main bedroom, generally because the householder liked a warm bed (n = 10) or because he found the bedroom rather cold n = 10).

4.3.4. Household Behaviour Patterns

Interviewees were asked about (a) a variety of household activities, namely cooking, hot water usage and clothes washing and (b) about window and internal door opening behaviour patterns. These topics will be discussed separately.

Household Activities

More than two-thirds of the sample cooked by gas for a reported average of 21 hours a week. The majority of householders had their hot water on for several hours a day ($\bar{x}$ = 9 hours). Thirty three householders had it on 24 hours a day. Most householders (79%) possessed a clothes washing machine and washed on average six loads per week.

Behaviour Patterns

Both window and internal door opening are behaviour patterns which reflect householders' lifestyles and which may be expected to affect heat loss. Window opening is discussed in detail in chapter 5 and so will not be dealt with in this section.

Internal Door Opening

Inspection of table 4.24 shows that high proportions of householders report that they always leave bedroom doors open whilst less than one third of respondents always leave the sittingroom door open.

Tables 4.25 and 4.26 provide content analyses of explanations as to why occupants did or did not leave doors open. Inspection of table 4.25 shows that 22 householders reported that they left doors open in order to heat the bedrooms and that a further ten householders kept doors open so as to achieve an even temperature throughout the whole house. In addition, six householders reported that they opened particular doors when certain rooms became too hot. These results suggest that occupants are aware of heat and air flow mechanisms, a hypothesis supported by the finding that 20 householders gave ventilation as their underlying motive. This latter result indicates a potential way for householders to ventilate rooms without the extreme heat losses associated with window opening.

"If the heat's on, I don't want the windows open. I'd prefer to open a door ... there's no point in wasting money."

Social and psychological factors are also important. Although it was desirable for some householders to restrict small children and pets to certain rooms (n = 9), 7 householders left doors open to give their children and animals room to move freely throughout the house, whilst 4 householders said it was impossible to keep doors closed when there were children in the house. One householder added that it was

TABLE 4.24. Reported frequency of internal door opening - percentages of respondents endorsing each response category

Room	Category of response (%)			
	Never	seldom	often	always
Kitchen	15	17	30	37
Sittingroom	23	22	26	29
Bathroom only	29	22	14	35
WC/bathroom + WC	20	13	29	38
Main bedroom	11	15	17	57
Bedroom 2	9	9	18	64
Diningroom	0	10	50	40

TABLE 4.25. Content analysis of reported reasons for leaving internal doors open

Motivation	No. of respondents
To heat the bedroom(s)	22
Ventilation	20
Access	12
No reason / habir	10
Hear children / door / phone	10
"Claustrophobia"	10
Preference	10
To let heat escape from an overheated room	6
Give animals room to move	5
Makes the room bigger / more open	5
Impossible to keep them shut with children	4
Makes the room lighter / brighter	3
Give the baby room to move	2

TABLE 4.26. Content analysis of reported reasons for keeping internal doors shut

Motivation	No. of respondents
Prevent draughts	20
Keep heat in	13
Makes house look neater / tidier	10
Stop cooking smells spreading	7
Stop animals going into other rooms	5
Keep baby in one room	4
Stop baby's / cnildren's noise penetrating	4
Cold weather	3
Windows are open	3
Preference	3
Other reasons	2

undesirable in any case since,

"If the doors are shut and the children are running around, there's nothing but banging and noise."

Additionally, whilst 10 householders kept doors open in order to hear their children, the phone or the door bell, 4 householders reported closing doors in order to prevent children's shouting or crying penetrating. The importance of free and easy access was mentioned by 12 householders as a reason for leaving doors open.

Several householders referred to an almost claustrophobic feeling which they experienced when doors were kept shut (n = 10), whilst other householders said they preferred the more open feeling (n = 5) or brighter appearance (n = 3) given by a room with an open door. However, on the other hand one retired man remarked, "a room is a room, I don't like this open-plan idea", whilst 10 householders reported that they kept doors shut in order to give the house a "neat and tidy appearance". Although 10 householders said they simply preferred to keep the doors open, 10 other householders admitted doors were often left open either for no particular reason or as a matter of habit.

"It's not necessary - if it was a cold house, then we'd keep the doors closed."

This remark was not uncommon and suggests that the invisibility of heat and the delay between the householders' actions and the gas bill, make it difficult for householders to realise the consequences of such behaviour. Seven householders reported that they shut the kitchen door when cooking, in order to prevent steam and smells spreading throughout the house.

In conclusion, it seems that internal door opening is an integral part of a householder's lifestyle.

4.4. Prediction of Winter Gas Consumption in Individual Households

One of the original aims of the study was to identify the specific behavioural and attitudinal determinants of gas consumption. However, when all the variables discussed in the previous sections were coded and correlated with consumption, it was clear that consumption is not dependent upon a few variables of major significance but upon a large number of inter-related variables, each with a small influence on consumption. There are a few exceptional variables which exert larger influences. These include the number of household occupants, average weekly income and whether or not the time clock is used.

Consumption figures for the two winter quarters during which the interviews were conducted (ACON and BCON in Table A3) were summed to give a total 1979 to 1980 winter consumption figure for each household. As previously mentioned, consumption readings for some households were recorded as missing data (4.1). All households with missing data were rejected from the regression analysis.

The correlation between winter consumption and the number of household occupants is 0.54. The correlation between winter consumption and use of the time clock (coded one for use and two for non-use) is -0.22. Although weekly income is significantly correlated with gas consumption, it is also significantly correlated with the number of household occupants. Colinearity considerations therefore excluded income from the regression analysis.

Table 4.27 shows the summary results of the regression analysis between winter consumption as the dependent variable and the number of household occupants and use of the time clock as the independent variables. The table shows that these two variables together account for 31% of the variance in consumption. This is almost equivalent to the amount of variance explained by the physical parameters of design heat loss and terrace position (4.2.1).

TABLE 4.27. Prediction of 1979-1980 winter gas consumption from social variables

The regression equation is

y = 248 + 61.4 x No.Occ - 35.2 x time clock

Column	Colefficient	st.dev. of coef.	t-ratio = coef/s.d.
--	247.71	50.16	4.94
No. occupants	61.42	10.48	5.86
Time clock	-35.17	24.18	-1.45

The st. dev. of 9 about regression line is s = 114.7

with (94-3) = 91 degrees of freedom

r-squared = 30.9 per cent

r-squared = 29.4 per cent, adjusted for d.f.

Examination of the regression coefficients shows (a) that on average an extra 61 therms is consumed for each additional occupant and (b) that non-use of the time clock is associated with an average reduction of 35 therms. The latter finding suggests that possession of a time clock per se does not automatically result in reduced consumption levels. Rather, it is the use made of the time clock by the householder which is important. This use is associated with other lifestyle factors which in turn influence consumption. The finding may therefore only be an indirect effect.

Inspection of the residuals shows that there are three outliers. They represent different housetypes whose occupants have different life-styles. No explanation can therfore be offered for their existence.

Although it was originally planned to report a third regression analysis combining the physical and social variables, this did not prove possible since colinearity was observed between design heat loss and the number of household occupants. This factor would have resulted in unstable and unreliable regression coefficients, had the analysis been conducted. The two regressions may therefore be considered as alternative routes to the prediction of householders' consumption levels.

4.5. Conclusion

Examination of the sample consumption ranges showed that there was a variation of approximately 4:1 between the highest and lowest consumers within each housetype. Since design heat loss and terrace position were found to account for less than a third of the variance in winter consumption, it was suggested that householders' behaviour patterns were significantly related to consumption.

However, although a large number of behaviour patterns thought to relate to domestic gas consumption were investigated and the motivations underlying their relative frequencies of occurrance were successfully identified, attempts to predict winter consumption from behavioural and social variables did not result in a higher proportion of the variance being explained. It is suggested that this is due to the interaction between variables, as well as to factors such as differences in boiler efficiency, quality of house construction and metering inaccuracies. These latter factors have not been investigated, and although it may be assumed that they act randomly throughout the sample, this assumption cannot be verified. Additionally, differences between households in terms of specific behaviour patterns which individually might have significant effects on consumption, may be cancelled out by other behaviour patterns when the family's total lifestyle is considered, with the result that, in general, no significant relationship is observed between consumption and a particular independent variable.

It was therefore decided that a detailed investigation of one particular behaviour pattern, namely window opening, should be conducted so as to provide an example of the complex structure of behaviour patterns in general.

CHAPTER 5

WINDOW OPENING

5.1. Introduction

Differences between theoretical and actual energy consumption have been hypothesised to be a function of ventilation due to window opening (Brundrett, 1975). Both the exploratory investigation at Tamworth and the pilot study at Charnwood (Chapter 3) had shown reported window opening to vary considerably among householders. A window opening survey was therefore undertaken as part of the main study.

This was done for two main reasons. The first was that window opening was considered to be one of the main variables influencing gas consumption. The second was that the structure of window opening as a behaviour pattern and the way it is influenced by beliefs and attitudes, was felt to be illustrative of the way in which other behaviour patterns may be influenced by such factors. These behaviour patterns might include the use of time clocks, thermostats and internal doors.

The aim of the study was to specify the objective and demographic correlates of window opening, and to identify the motivations for the opening and closing of windows. However, before discussing the study, it is necessary to take a closer look at the wider range of properties and functions of the window. This is to put the ventilating aspects of window opening in context.

5.2. Literature Survey

There are many criteria by which the window may be evaluated.

Its roles - visual, thermal and ventilation, are interrelated, and its design is therefore an optimization problem since change in one property affects the rest (Ludlow, 1976). However, for reasons of clarity each of these roles will be discussed separately.

5.2.1. Visual Functions

The admission of daylight is generally regarded as one of the main purposes of a window, and its qualitative superiority over artificial illumination is well documented (Manning, 1965; Markus, 1967; Wells, 1965). Sunlight is another component of natural illumination. Its desirability has been widely demonstrated (Bitter & van Ierland, 1967; Grandjean, Gilgen & Barrier,1973; Hopkinson, 1961; Markus, 1967), though shown to be influenced by personal, occupational and climatic considerations (Goromosov, 1968; Longmore & Ne'eman, 1973; Morgan, 1967; Richards, 1967). A further property of the window is that of providing a view out (Manning, 1967). The window's traditional communication function, the linking of the subject to the external world (Markus, 1967) is well accepted. The characteristics which make the view good or bad, however, are less well understood. Some workers suggest that window shapes should be matched according to the proximity and information content of the view (Cooper, Whiltshire & Hardy, 1973; Kaplan & Wendt, 1972; Keighley, 1973; Ludlow, 1972; Ne'eman & Hopkinson, 1970). It is also suggested that the shape and size of the window should be designed according to the shape and size of the room (Markus, 1967). Other parameters that have been investigated include the influence of the window on the sense of privacy (Markus & Gray, 1973) and spaciousness (Collingro & Raessler, 1972; Imamoglu & Markus, 1973; Mercer, 1971; Inui & Miyata, 1973).

5.2.2. Thermal Functions

Although it is accepted that windows can result in excessive heat gains in summer and in equally undesirable heat losses in winter, Baxter (1981)has remarked that the quantitative assessment of the influence of solar radiation and ventilation on the annual energy consumption is a fairly recent topic of exploration (Dickson, 1980; Siviour, 1976; Warren, 1975). Such study has been necessitated by the fact that the increase in insulation level expected in future housing will augment the relative influence of both variables on the energy balance (Brundrett & Barker; Etheridge & Phillips, 1977). The contribution of conduction heat losses through the window is a complex issue in its own right which will not be dealt with in this chapter.

5.2.3. Ventilation and Air Quality Functions

In selecting the site, size, shape and orientation of housing, man has long exercised a control over natural ventilation (Banham, 1969). The scientific study of ventilation requirements, however, did not begin until the eighteenth century. Diverse theories were postulated and though few withstood the test of time (Woods, 1970), it was gradually shown that many diseases once attributed to foul air (Lavoisier, 1777; Saeltzer, 1872; Tredgold, 1836; von Pettenkofe, 1862) were actually caused by bacteria and viruses.

Today ventilation is commonly understood by scientists in terms of the following topics:

a) Oxygen and carbon dioxide thresholds

b) dilution of toxic contaminants

c) odour dilution

d) moisture and condensation control

3) thermal control, and

f) air movement.

Although in reality these functions overlap and are interrelated, clarity requires that they be dealt with separately.

5.2.3.1. Oxygen and carbon dioxide thresholds

The necessity of oxygen for life-giving processes and the relationship between respiration, body metabolism and carbon dioxide production are well understood. It is known that breathing becomes difficult at oxygen concentrations below 12% by volume. However, houses normally have sufficient natural ventilation for the satisfactory maintenance of oxygen levels and dangerously low concentrations are rarely reached. Similarly, dangerously high carbon dioxide levels are rare.

Carbon dioxide is the most abundant pollutant produced by people. Expired air contains about 4% carbon dioxide, the exact proportion depending on individual factors. Although it is non-toxic at low concentrations, laboured breathing and headaches occur at concentrations of 3 - 5% (Hamilton & Hardy, 1974). The recommended threshold limiting value is 0.5%. The production rate of carbon dioxide is fairly standard and is easily measured. Its concentration is therefore often used as a general indication of the adequacy of ventilation.

5.2.3.2. Dilution of toxic contaminants

Reducing infiltration[1] and ventilation[2] rates in buildings can lead to elevated levels of internally generated air contaminants which in excessive concentration may impair the health, safety and/or comfort of the occupants (Hollowell et al., 1981). Four gaseous contaminants of particular concern in residential buildings are carbon monoxide and

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1. Air infiltration is the uncontrolled flow of air through a building as a result of adventitious openings in the structure.

2. Ventilation is the process of supplying and removing air by natural or mechanical means, to and from any space.

nitrogen dioxide from unflued gas appliances, and formaldehyde and radon from building materials. The dangers associated with elevated levels of carbon monoxide are well established (Schulte, 1964; Stewart, 1974; WHO, 1962). Less well known is the finding that in homes with gas cookers, concentrations of carbon monoxide above the level recommended by the World Health Organization can occur at peak periods (Traynor, 1980). The effects of undesirable levels of formaldehyde have also been studied (Andersen et al., 1975). Although much attention has recently been focussed on the presence of radon in domestic dwellings, it is not yet possible to assess with any certainty the associated health risks (Cliff, 1978; Steinhausler, 1975; Taniguchi, 1977).

5.2.3.3. Odour dilution

Although air quality standards are set in precise physical terms (Huber & Wanner), the quality is in practice judged by the odour level. This is problematic in that the perception of an odour depends on its intensity and social acceptability, as well as on personal factors (Moncrieff, 1967). Thermal variables are also important - sensitivity increases with increased ambient temperature and decreases with increased humidity (Kerka & Humphreys, 1956; Kuehner, 1956). The situation is complicated by the fact that odours are not additive (Cain, 1977).

Odours in living rooms generally come from the occupants themselves. All people emit a complex mixture of 'effluents' which in sufficient concentration produce an unpleasant odour, although adaptation occurs with prolonged exposure (Adrian, 1928). Odour generation is a function of individual variability, age and personal hygiene (Yaglou et al, 1936, 1937). The rate at which odour intensity increases depends on the amount of space per person, as well as on ventilation rate. Many ventilation requirement codes are expressed in terms of volumetric exchange rates per person.

Tobacco smoke has been the subject of much investigation and the results of studies on the effect of the rate of smoking and ventilation rate on the acceptability of smoke odour have been summarised by Brundrett (1975), HEW (1975) and Schmeltz (1975).

5.2.3.4. Moisture and condensation control

There have been many studies of moisture generation in buildings (Conklin, 1958; Fournol, 1957; Loudon, 1971; Smith, 1948). Two main sources of moisture have been distinguished, namely the occupants and their activities. Brundrett (1977) has highlighted the implications of the findings in terms of the importance of moisture level for the avoidance of condensation at one extreme, and electrostatic shocks at the other. Although the physical origins of condensation and the nature of mould growth are well documented (Bravery, 1980; Loudon, 1971; Minogue, 1981), it is not known why local authority houses are particularly subject to condensation (Enderby, 1980), nor indeed why there is such a high incidence of condensation generally. Change in lifestyle (Allen, 1972) and the adoption of both intermittent and partial heating patterns (Field, 1972) have been suggested as potential explanations. Although the significance of mould growth to health is an emotive topic, there is no firm evidence of allergic reation to mould spores (Austwick, 1966; Lacey, 1972).

Experiments in climate chambers have shown that at any given temperature an increase in the relative humidity results in a feeling of increased warmth. This effect is most marked at high temperatures (Koch, Jennings & Humphreys, 1960; Nevins et al, 1966); the effect of humidity at comfortable air temperatures is however small (Bedford, 1936; Inouye et al, 1953; Mc'Intyre, 1975, 1978; Fanger, 1973; Gagge et al, 1971; Rohes & Nevins, 1971). This implies that claims for the saving of energy by means of air humidification, and thus the reduction of temperature, must be discounted (Mc'Intyre, 1980). In any case, the energy required to cause evaporation exceeds the savings. Furthermore, many studies demonstrate subjects' inability (at normal temperatures) to reliably detect differences in relative humidity when other conditions are held constant (Berg-munch, 1981; Koch, 1963; Mc'Intyre, 1978; Rasmussen, 1971).

It is commonly believed that there is an association between low humidities and dry throats. The majority of experimental results however do not corroborate such claims (Andersson et al, 1975; Kraemer, 1977). Ewert (1965) reported that the effect was due to reduced mucus flow rates. The available evidence, however, is inconclusive (Andersen et al, 1974; Carleton & Welch, 1971; Green, 1974).

5.2.3.5. Thermal control

It has been suggested that windows are often opened to reduce excessively high internal temperatures (Brundrett, 1977; Hunt & Gidman, 1980). This suggestion has not been validated. Several studies show that air is felt to be less dry at lower air temperatures than at higher ones (Berg-Munch, 1981; Langkilde, 1979; McNair, 1973; Wyon et al, 1974). It is therefore suggested that window opening may be seen by some people to combine the advantages of lower temperatures with the relief of symptoms associated with dryness.

5.2.3.6. Air movement

In warm conditions, air movement may be increased to reduce discomfort. The effect on comfort of permutations in permissible draught speeds and temperatures, part of the body subject to the draught, variable air flow, ambient temperature and the subject's initial thermal sensation of being hot or cold have all been investigated (Burton et al, 1975; Fishman, 1978; Houghten et al, 1938; Madsen, 1977; Mc'Intyre, 1979; Ostergaard et al, 1974). The most important finding is perhaps that there seems to be no association between airspeed and pleasantness or freshness (Berg-Munch, 1981; Erikson et al, 1978; Mc'Intyre, 1975, 1976; Wanner, 1972). Air speeds above 0.5 m/s, however, can cause annoyance.

5.2.4. Conclusion

Windows can result in excessive heat gains and losses. This fact, coupled with concern for energy conservation and advances in the development of artificial illumination and mechanical ventilation, has led to their use being questioned. The literature shows, however, that windows have a variety of functions. Additionally, psychological studies indicate the typical reaction to a windowless environment to be one of dislike or passive tolerance; the degree of acceptability depending on the characteristics of the space itself (Collins, 1975). For the great majority of householders windows have definite beneficial qualities and for them windowless housing is unacceptable.

5.3. Methodology

Window opening is one of a number of aspects of our behaviour affecting energy consumption. Since it can be recorded relatively unobtrusively and since the reliability of reported data is often questionable, a series of actual window observations was made as part of an in-depth investigation of window opening.

5.3.1. The Sample

The study is concerned with the window opening habits of the householders described in chapter 4. These householders were used since the researcher had already developed a degree of rapport with them and had obtained a considerable amount of background information about them.

The sample size was therefore 113; 78 households being on the Cowley estate, 35 on the Mezen estate.

5.3.2. Data Sources

The study made use of four data sources: a series of systematic window observations, a postal questionnaire, mean hourly meteorological data and data obtained at the original interviews (Chapter 4). These are discussed in turn.

5.3.2.1. Window observations

Several studies have included window observations (Brundrett, 1977, 1978; Dick & Thomas, 1951; Hartmann, 1980; Warren, 1980); of these, Hartmann's is the most rigorous. By using photographic techniques, he was partially able to exclude observer biases and to accurately sample the effect of time of day on the opening of windows in a single compact wall. The use of such techniques was impractical in the present study because of the layout of the two estates (Figs. 4.7 and 4.8) and the large number of cameras which would have been required and which would have had to be made secure and be concealed. The observations were therefore made by walking through the estates.

All houses were surveyed on one day and this was repeated one hundred times during the period from October 1979 to April 1980. The days and times were chosen in such a way that each house was surveyed twice at each of the hours from 9 a.m. to 6 p.m. inclusive. This particular range of hours was chosen for two reasons - the first was that it was felt that these were the times when householders were most likely to open their windows, the second was that it was considered impractical for the observer to repeatedly visit the estates at other times.

It is important to note, however, that the hours recorded as the hours of visit are not necessarily the exact times at which observations were made. For example, an observation recorded as having been made at 3 p.m. would actually have been made sometime between 3 and 4 p.m. This was because on average it took twenty minutes to make a round of observations. Observations were thus made in one direction one day (for example, from the near to the far end of the estate) and in the opposite direction the following day. This resulted in the observer arriving at particular houses sometimes early and sometimes late. Despite the slight inaccuracy, the collection of data at specific hours of the day represents a refinement of the method employed in earlier studies where observations have simply been collected as morning or afternoon observations.

The possibility of a bias caused by the presence of an observer cannot be discounted (see, for example, Roethlisberger & Dickson, 1939). That the researcher soon acquired a knowledge of householders' general window opening habits may have been a source of further bias in that she may occasionally have recorded not what she actually saw, but what she thought she saw.

Observations were also made during the Christmas 1979 holiday period. There was in addition one weekend observation for each month from October to April. These last two sets of observations were taken since it was felt that they covered periods when most houses or flats would probably be occupied.

Prepared charts were used to record the observations and the time and date of each visit to the estates (Tables A6 and A7). The charts contain spaces for each window in a house, set out in a topographical arrangement, corresponding to the building elevations. Each row on each chart represents one house. The information is summarized in table 5.1, where the slashes between numbers indicate that in a few cases, dwellings

TABLE 5.1. Number of openable windows in each house type

Estate	Type	n	SIT	KIT	DIN	BTH	WC only	B_1	B_2	B_3	LND
Cowley	Top flat	16	2	1				1	1		
Cowley	Btm. flat	16	1	1				1			
Cowley	4P, 2S	23	1	1				1	1		
Cowley	4P, 3S	10	2	1				1	1		1
Cowley	6P, 3S	13	2	1				1	1	1	
Mezen	Top flat	10	2	2/3		1		2	1		1
Mezen	Btm. flat	10	1	1/2		1		1			
Mezen	4P, 2S	15	1	1	1	1	1	2	2		1

SIT = sittingroom

KIT = kitchen

DIN = dining room

BTH = bathroom/combined bathroom and toilet

WC = toilet

B_1 = main bedroom

B_2 = second bedroom

B_3 = third bedroom

LND = landing

P = Person

S = Storey

of the same type did not have exactly the same window arrangements.

Figures 5.1 to 5.12 provide typical examples of the window layout in each house type on both estates. It can be seen that there are a few differences between the two estates (see Chapter 4, Figures 4.1 - 4.6). As previously mentioned, all dwellings at Cowley have internal bathrooms with a ventilating fan operated from the light switch cord. At Mezen, however, the four person houses have a separate bathroom and toilet, both with their own windows (Figure 5.13), whilst the flats have a combined toilet and bathroom (Table 5.1; Chapter 4, Figures 4.5 and 4.6). Another difference is that the four person houses

MEZEN. 4 PERSON.

Figure 5.1

Front View

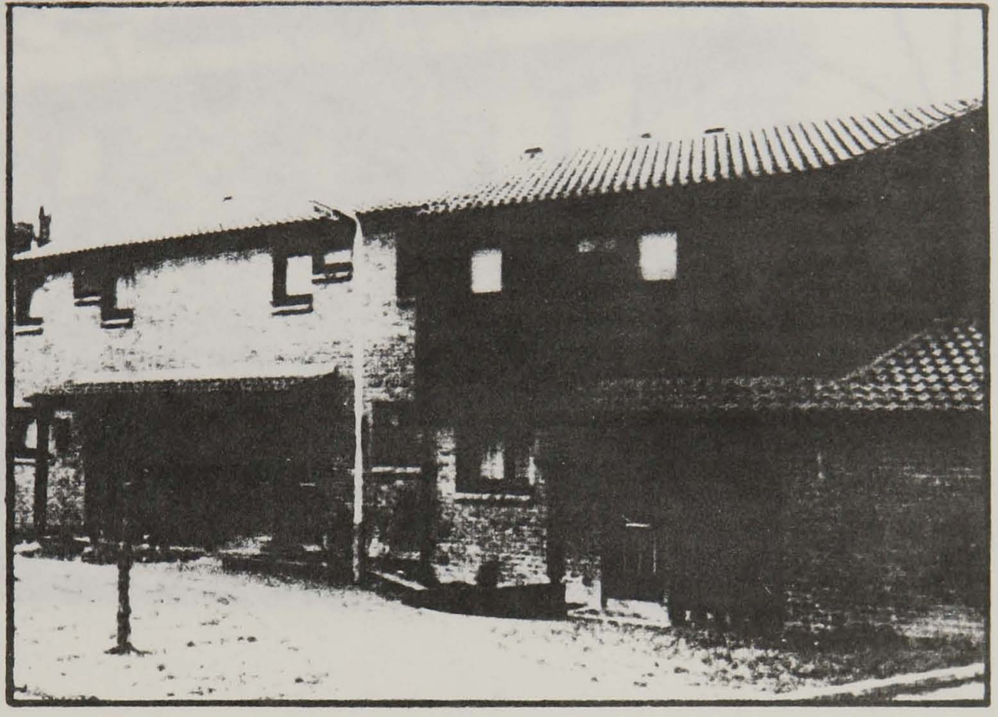


Figure 5.2 Figure 5.3

Back View

MEZEN FLATS

Figure 5.4

Front View

Figure 5.5

Back View

COWLEY FLATS

Figure 5.6

Front View

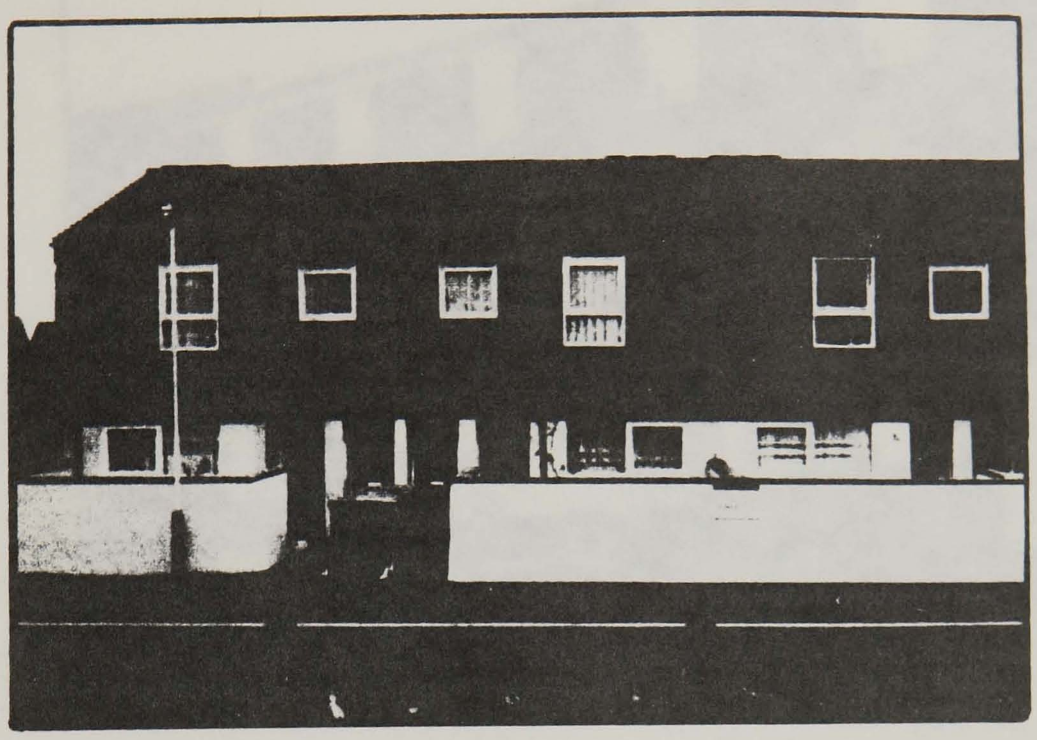
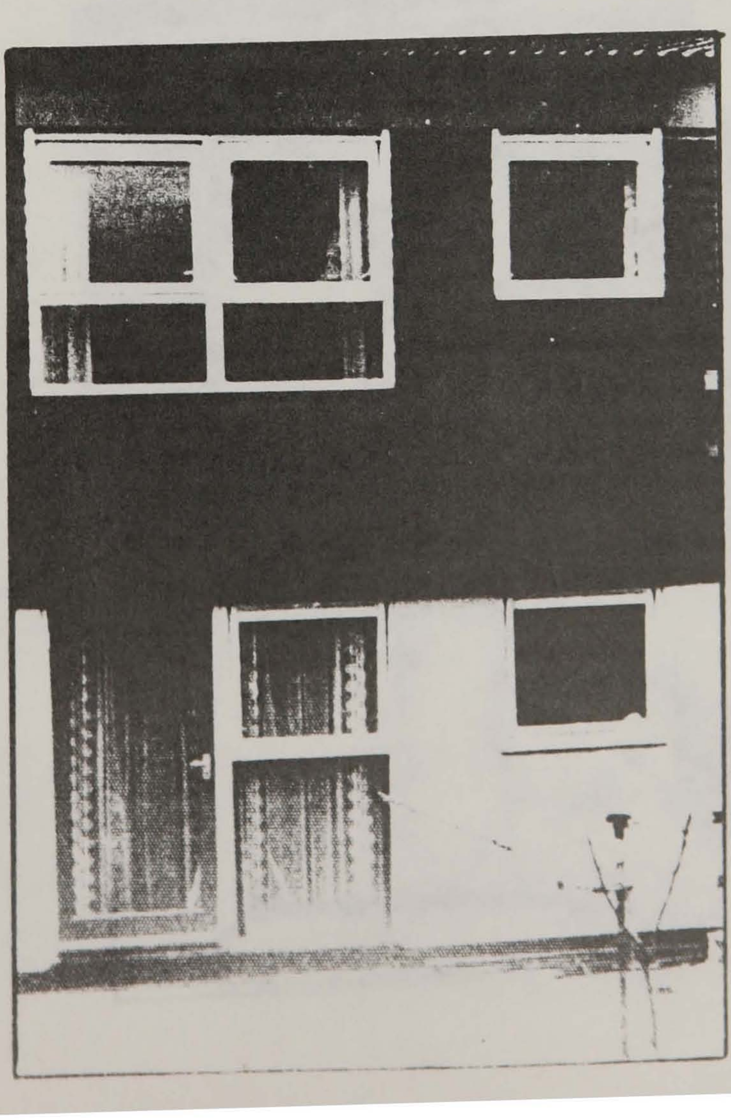


Figure 5.7

Back View



COWLEY 4 PERSON 3 STOREY

Figure 5.8

Front View

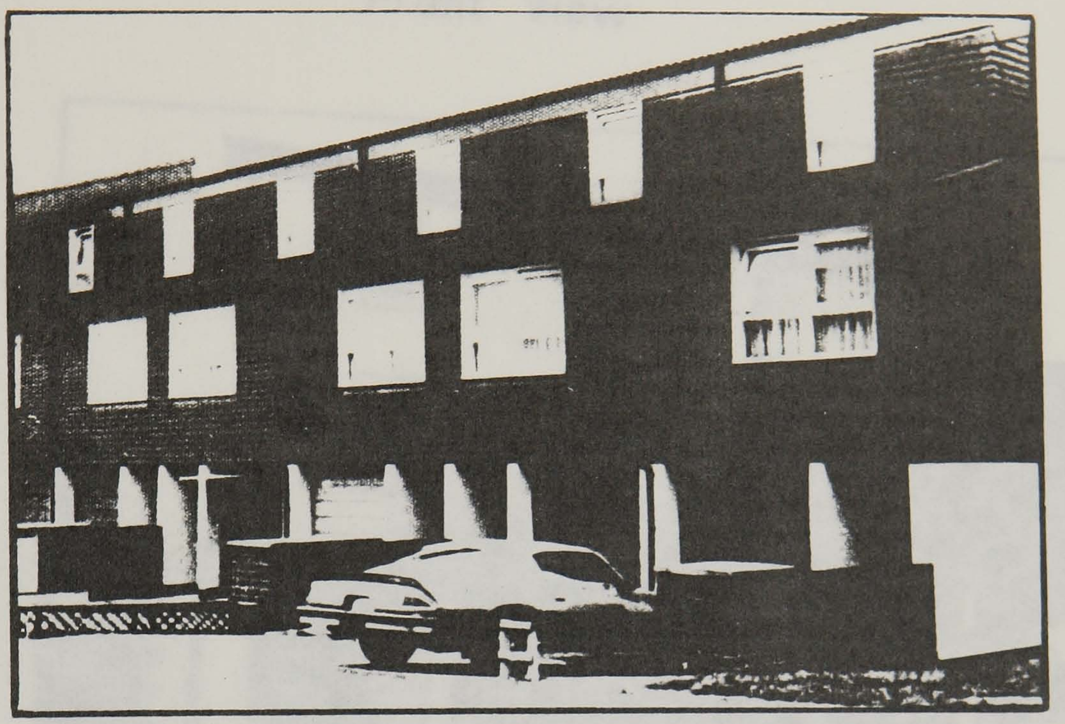
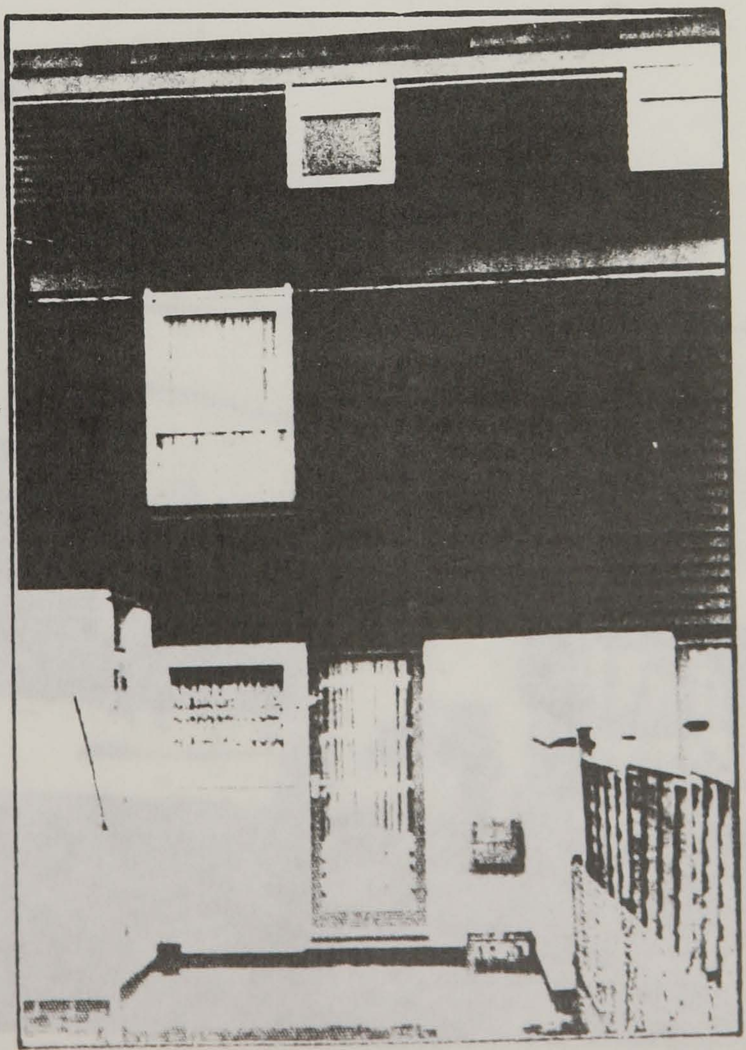


Figure 5.9

Back View



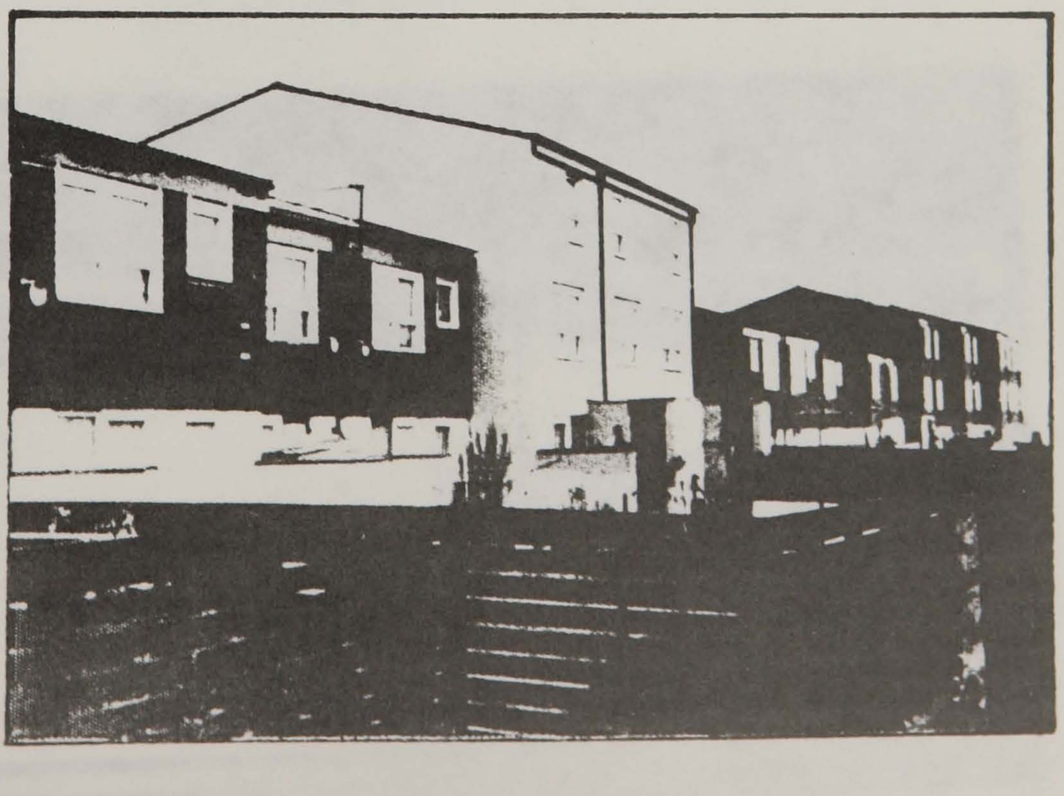
COWLEY 6 PERSON, 3 STOREY

Figure 5.10

Front View

Figure 5.11

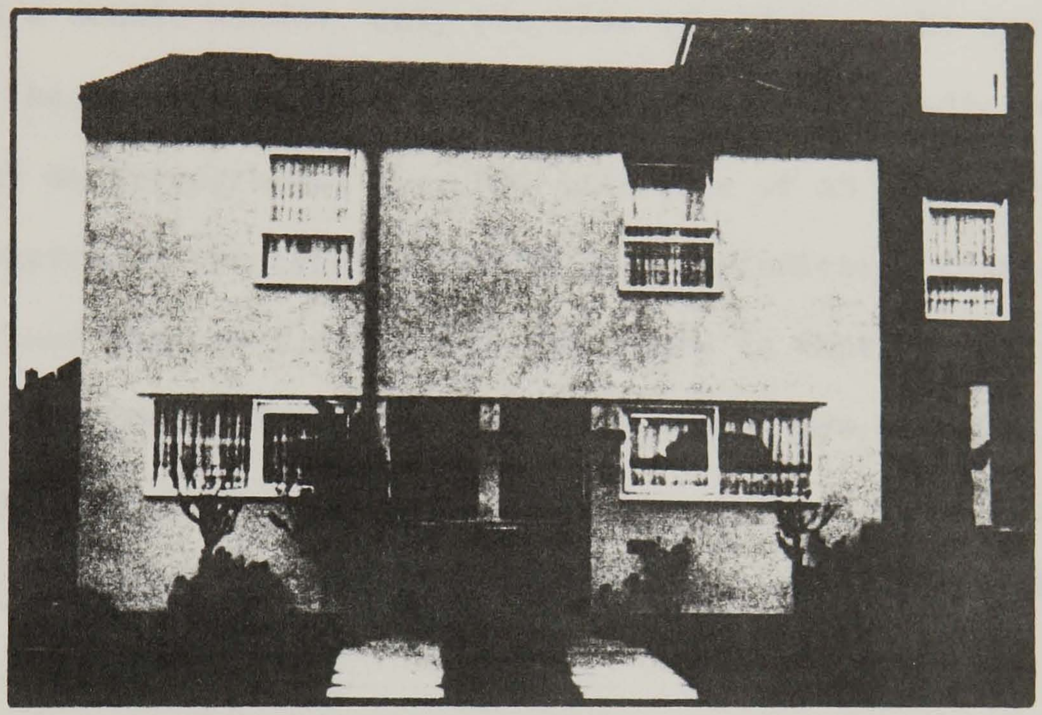
Back View



COWLEY 4 PERSON, 2 STOREY

Figure 5.12

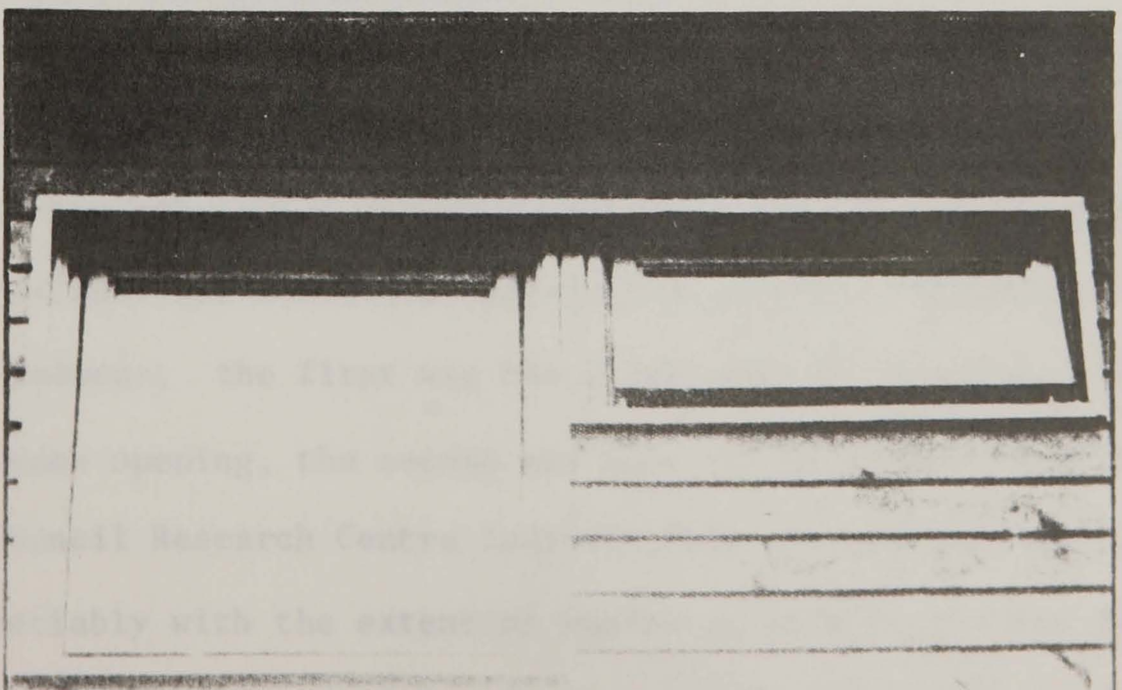
Front View



MEZEN. 4 PERSON.

Bathroom & Toilet Window.

Figure 5.13



at Mezen have an extra room - a dining room which has a door opening out to the garden, at the side of which is a window of the same height, divided horizontally into two sections, the top one being openable (Figure 5.2). A similar arrangement was made in the sittingrooms of the Cowley dwellings (Figures 5.7, 5.9 and 5.11). At Mezen, however, the sittingroom has a double window, only one side of which can be opened (Figure 5.3). The horizontal shading of areas in Table A7 indicates the presence of such an arrangement, i.e. the existence of an unopenable glazed area; whereas a completely blacked-in area indicates that the house does not have that particular type of window in that position. For example, in the Cowley flats, only the top flats have a second bedroom and two openable sittingroom windows (Figure 5.6 and 5.7). Figure 5.14 shows how this point was incorporated into the observation charts.

FIGURE 5.14. Window arrangements in Cowley flats

	Front			Back				
	Ground	1st flor		Ground		1st floor		
No.	B_1	B_1	B_2	SIT	KIT	SIT A	SIT B	KIT
24								
25								
23								

It was decided that windows would be recorded as open if the bottom edge of the window was judged to be more than one inch away from the frame. A window was otherwise recorded as closed. This decision was made for two reasons; the first was the difficulty of recording the extent of window opening, the second was that results obtained at the Electricity Council Research Centre indicate that ventilation rates do not vary appreciably with the extent of window opening beyond the first inch (Dickson, 1980). Figures 5.2 and 5.3 in conjunction with table 5.2

illustrate the application of this criterion since the ground floor sittingroom and dining room windows would be taken as being closed whilst the upstairs ones would be recorded as open.

TABLE 5.2. Record of open and closed windows

Ground		Back 1st floor			
DIN	SIT	B 1A	B 1B	B 2A	B 2B
X	X	X	✓	X	✓

When the one hundred observations had been completed the data were summarised to facilitate the analysis of window opening patterns in individual rooms. Thus data matrices such as that in Table 5.3 were compiled for each of the principal room types (sittingroom, kitchen and main bedroom) on both estates. Ticks were converted to numbers, each tick counting as one unit. A count was also made of the total number of open windows in each house on each day. Thus, for example, if a house had open a sittingroom, a dining room and a bedroom window, its total for that particular day would have been three. The individual figures from each house were then summed column-wise to give the number of windows (sittingroom, kitchen, main bedroom or total) open on the estate for each of the one hundred days.

TABLE 5.3. Chart used to record the number of open windows of a given type, on each of the one hundred days

Room type: Sittingroom							
		No. of open windows					
Estate	House No.	Day 1	Day 2	Day 3	→	Day 99	Day 100
Cowley	1	0	0	0		0	0
Cowley	2	1	1	1		1	0
	↓						
Cowley	78	1	0	0		0	0
Grand Total Day_x: No. of windows open on estate		43	43	49	→	15	10

5.3.2.2. Postal questionnaire

A postal questionnaire was used to obtain data aimed at achieving an understanding of householders' window opening habits. This method of data collection was chosen since it was felt to be more economical than a second round of interviews, in terms of the researcher's time and labour, and since householders might in any case object to a further intrusion upon their time and privacy and might therefore prefer to fill it out at their own leisure.

Drafts were extensively piloted, first among friends and advisors, then among twenty householders (not otherwise involved in the study) on a local authority estate near Hillingdon in Middlesex. This pilot study showed that the questionnaire was viable, but that repeated statements reminding householders to answer all the questions had to be included.

The final questionnaire was a twenty page document, sub-divided for clarity into sections indicated by number codes and page colour (Figure A4). It was delivered personally to each householder with a covering letter and a stamped addressed envelope, the opportunity being taken to encourage the occupants' co-operation by stressing the imprtance of obtaining a record of his or her individual actions, so that an accurate assessment of window opening habits could be made (Figure A5). The questionnaires were delivered at the end of April. If after three weeks a reply had not been received, a reminder letter was then sent out (Figure A6), and if necessary this was followed after a further ten days, by a visit to the householder who was then given a second copy of the questionnaire and another stamped addressed envelope.

The questionnaire covered four main areas. The first dealt with the motivations for the opening and closing of windows in winter and summer. The remaining three were concerned with the factors which basically define window opening:

a) Likelihood - the likelihood that certain windows, namely the sittingroom, kitchen and main bedroom windows, would be open in specific weather conditions. The conditions were chosen to accord as far as possible with the weather parameters obtained from the Meteorological Office (5.3.2.3) and thus covered a range of conditions; temperature, relative humidity, sunshine, rainfall and wind direction.

b) Amount - the amount, from closed to fully open, by which a window (sittingroom, kitchen or main bedroom) is open in specified weather conditions.

c) Duration - the length of time for which particular windows are generally left open. It was not considered practical to ask householders about the effect of weather conditions on this variable.

5.3.2.3. Mean hourly meteorological data

Meteorological readings were obtained from the Meteorological Station at Heathrow Airport. This station is about five miles away from both estates. Although it is accepted that local factors such as the shape and nature of the ground and the size, shape and height of surrounding buildings influence the weather conditions in a particular area (Miller & Parry, 1975), regional variations are still "relatively unimportant in assessing energy usage" (Heap, 1978). It was therefore considered reasonable to use Heathrow data.

The mean hourly values of five parameters were collected. They were:

a) external air temperature (°C)

b) relative humidity (%)

c) rainfall (mm)

d) windspeed (knots)

e) sunshine duration (tenths of an hour).

The mean values recorded are for the sixty minutes immediately following the tabulated time. Thus, for example, the value for relative humidity at three o'clock is actually the mean of the values between three and four o'clock. This corresponds precisely to the system of window opening recording described in section 5.3.2.1. These particular parameters were chosen since a number of earlier studies had demonstrated their influence on ventilation and window opening (Brundrett, 1977, 1978; De Grids et al, 1979; Dick & Thomas, 1951; Hartmann, 1980). Wind direction was not recorded because there was thought to be an insufficient relationship between open field wind directions and the direction of air movement around the elevations of any complex array of buildings (Etheridge, 1979). The value of each parameter at the time and day of each window observation period was abstracted from the full meteorological station data. A printout of this abstracted information is included in table A8.

5.3.2.4. Interview data

Not all householders completed both the interview (Figure A2) and the questionnaire, but where possible information obtained at the original interview (Chapter 4) was used to supplement questionnaire data. The information included was demographic and sociological in nature and referred mainly to processes that might be expected to influence the amount of ventilation required.

5.4. Analysis and Results of the Observed Data

The analysis falls into two parts. The first deals with observed data. The aim is to see what people actually do with their windows, and to highlight the relationships between the number of open windows, specific weather conditions, time of day and room type. The second part makes use of reported data of a more subjective nature, collected mainly from the questionnaire filled out by individual householders. The aim is to achieve an understanding of the observed data; why people open their windows, what their basic motivations are, how these motivations relate to demographic characteristics; and reported responses to a variety of weather conditions.

5.4.1. The Physical Parameters

Six objective parameters were used in the study, namely five weather parameters (external air temperature, relative humidity, windspeed, sunshine duration and rainfall), and time of day.

5.4.1.1. A description of the data

Before analysing the results it is useful to take a closer look at the raw data. Figures 5.15 to 5.19 show the frequency distribution of each of the five weather parameters. Although 'hour of observation' was included in the analysis as a sixth parameter, its distribution is not shown since the sampling method employed ensured that there were ten observations at each of the ten possible hours. The results are shown separately for the Cowley and Mezen estates, since the observations were not taken at the same times on the two estates; the general procedure was for the observer to visit one estate in the morning, and the other in the afternoon, and to reverse the order on the following day.

The axes in figures 5.15 to 5.19 were chosen by the computer and do not always correspond for the two estates. This is an unavoidable feature of the programme that was used and occasionally makes comparison difficult. The original data, however, indicate that there were no significant differences between the weather parameter values of the two estates.

The different weather parameters produce different distribution configurations. The distributions for temperature and windspeed are approximately bell-shaped. The configuration for relative humidity is negatively skewed, whilst that for rainfall is positively skewed. The distribution for sunshine duration is U-shaped. The shapes of these distributions are important in that they influence the accuracy with which the effects of the corresponding parameters on window opening can be assessed (5.4.5).

Table 5.4 shows the mean and standard deviation for each parameter over the one hundred days. The spread of values is much as expected given that the 1979-1980 winter was fairly mild. The low figure for mean sunshine duration can probably be attributed to the high proportion of observations which were made in the twilight or the dark.

FIGURE 5.15(a) & (b). Frequency distribution of external air temperature at a) Cowley and b) Mezen

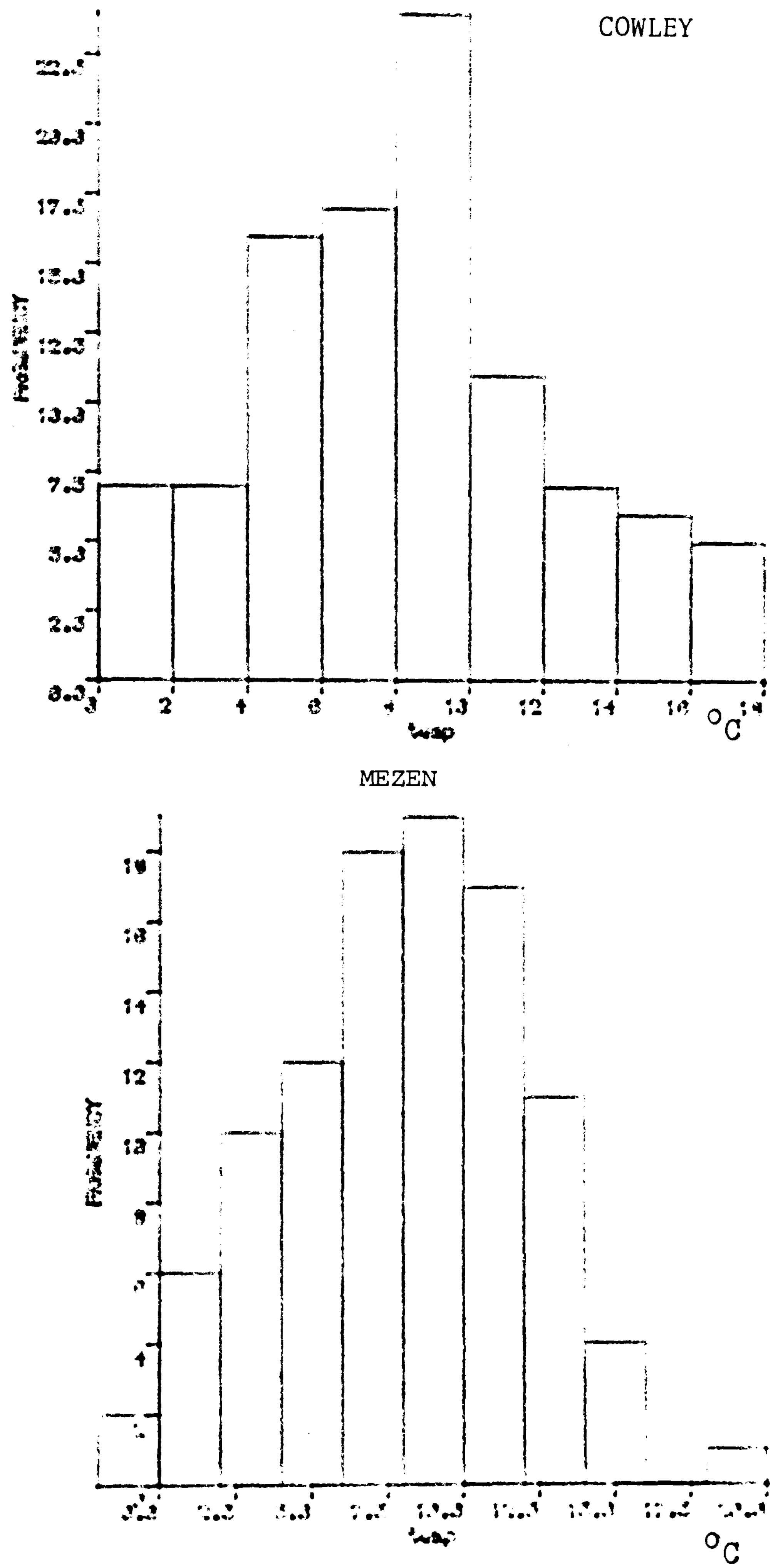
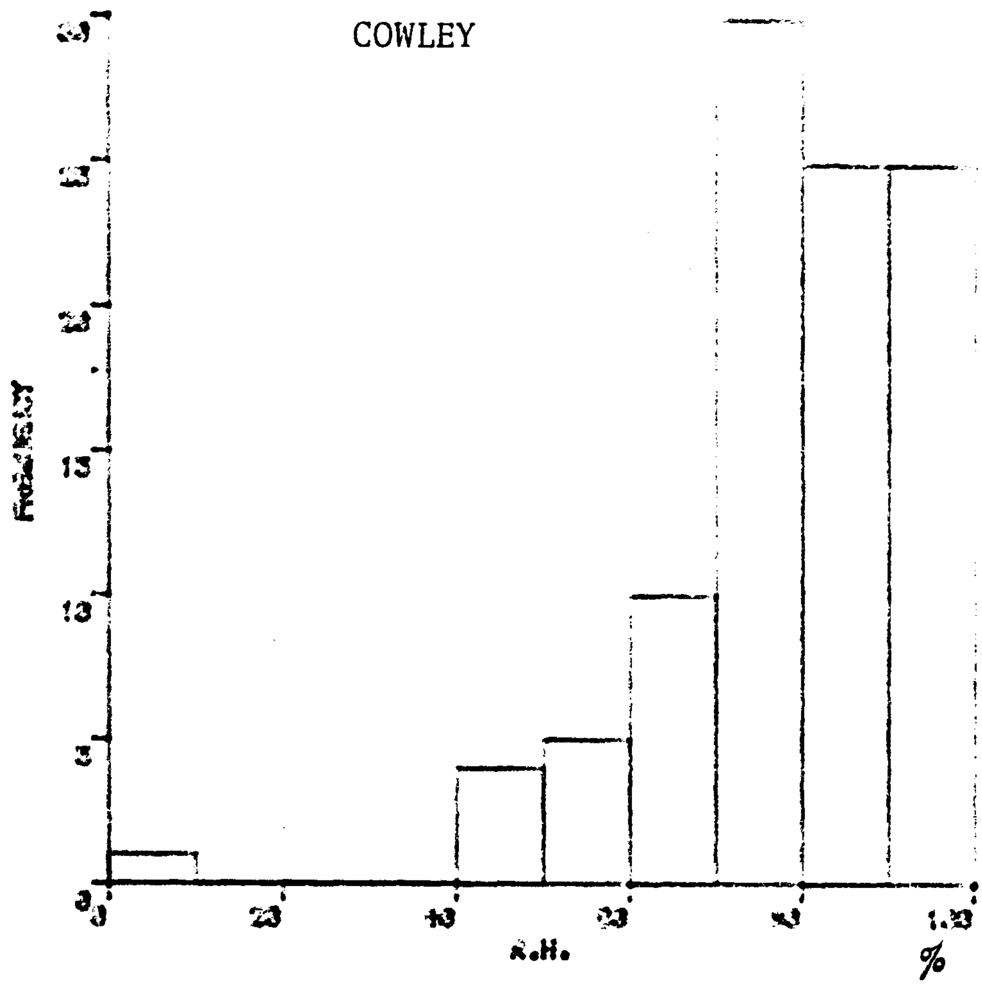


FIGURE 5.16(a) & (b). Frequency distribution of relative humidity at a) Cowley and b) Mezen



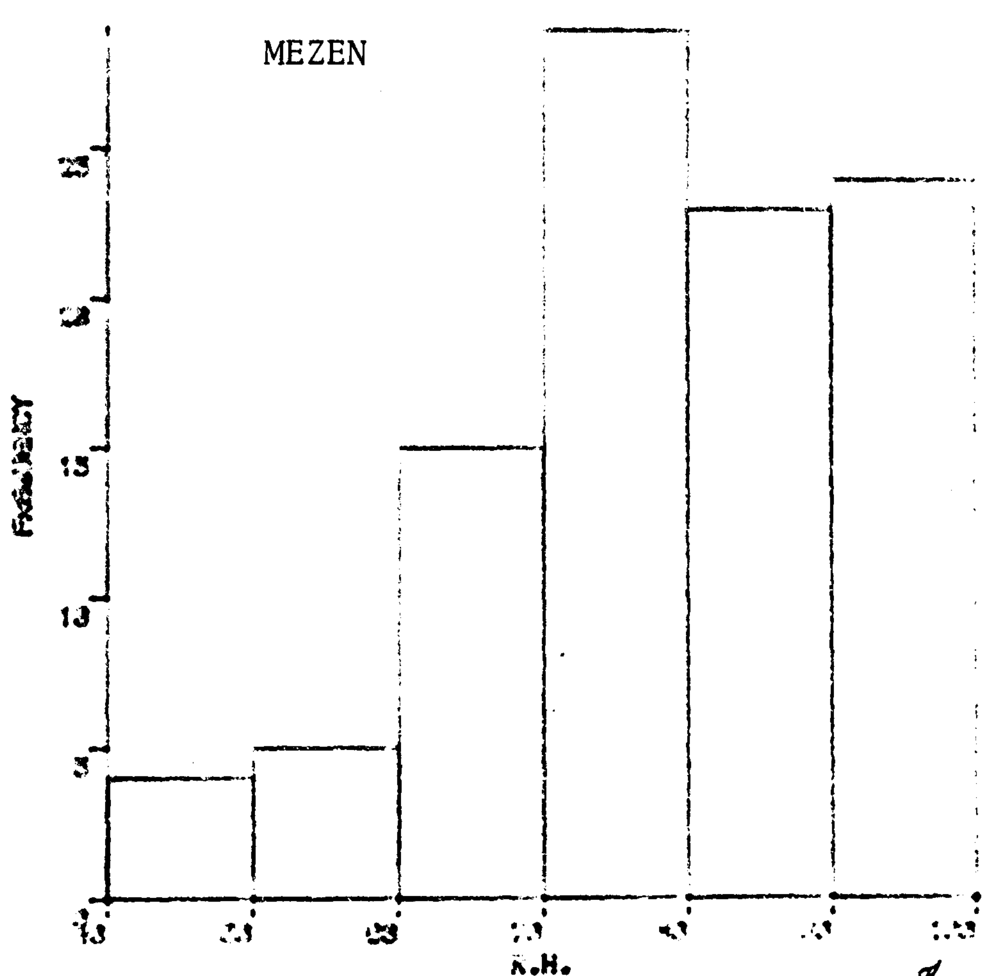


FIGURE 5.17(a) & (b). Frequency distribution of windspeed at a) Cowley and b) Mezen

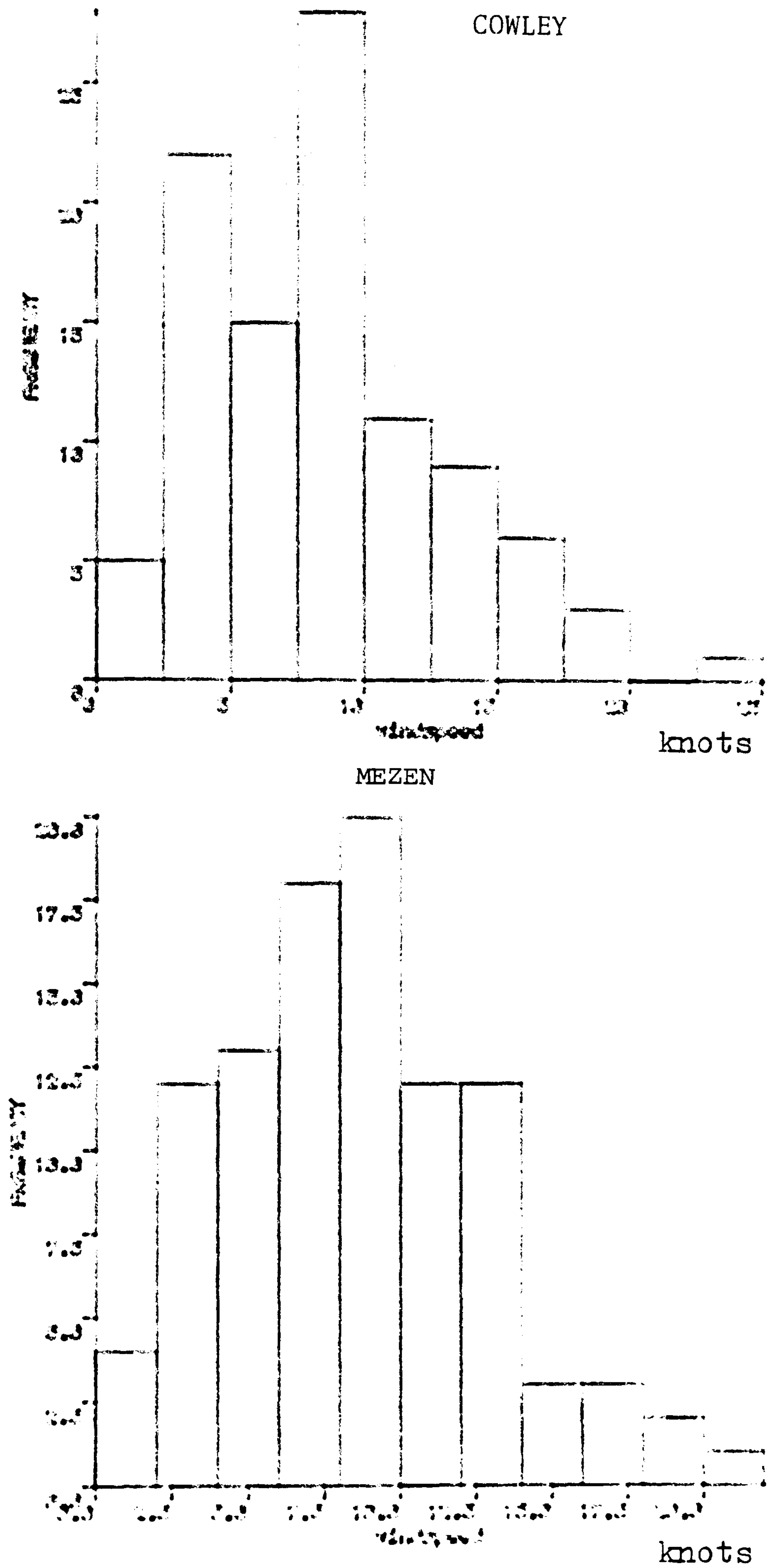
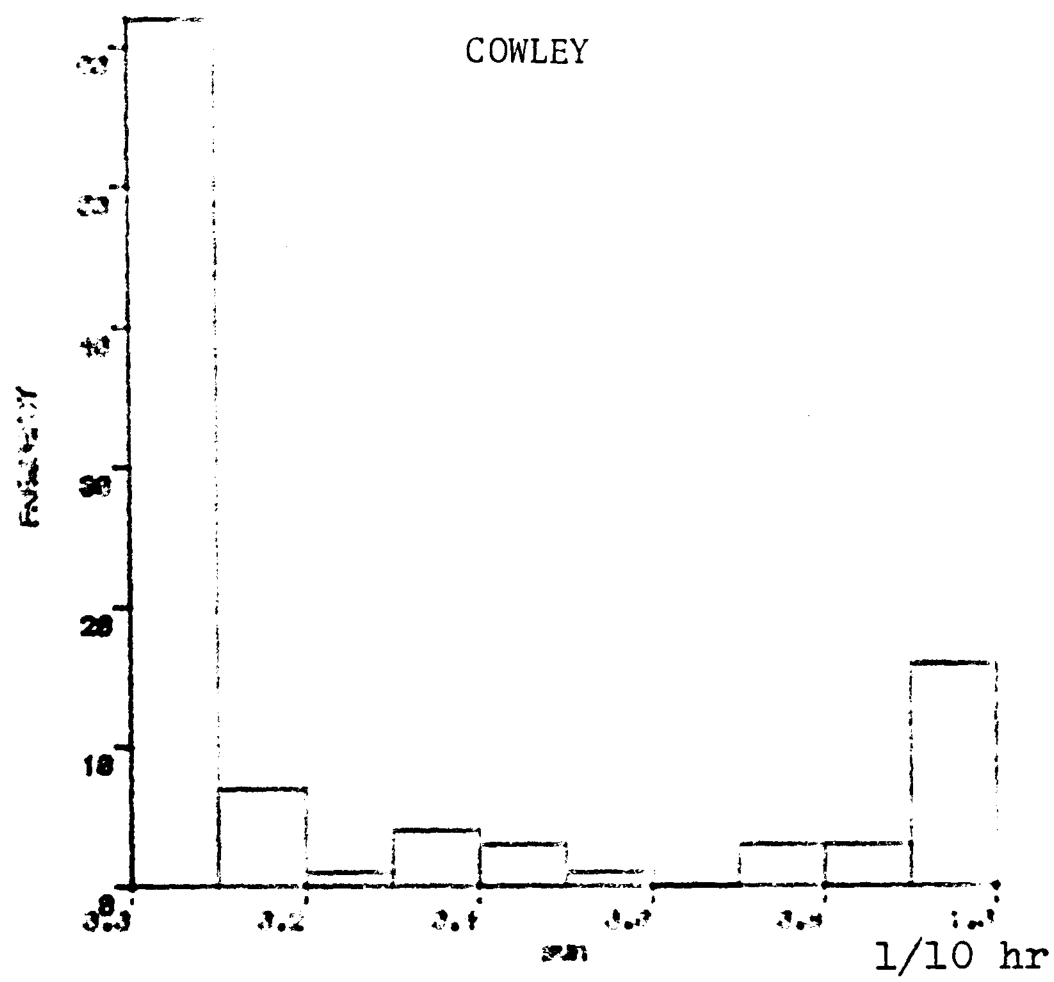


FIGURE 5.18(a) & (b). Frequency distribution of sunshine duration at a) Cowley and b) Mezen



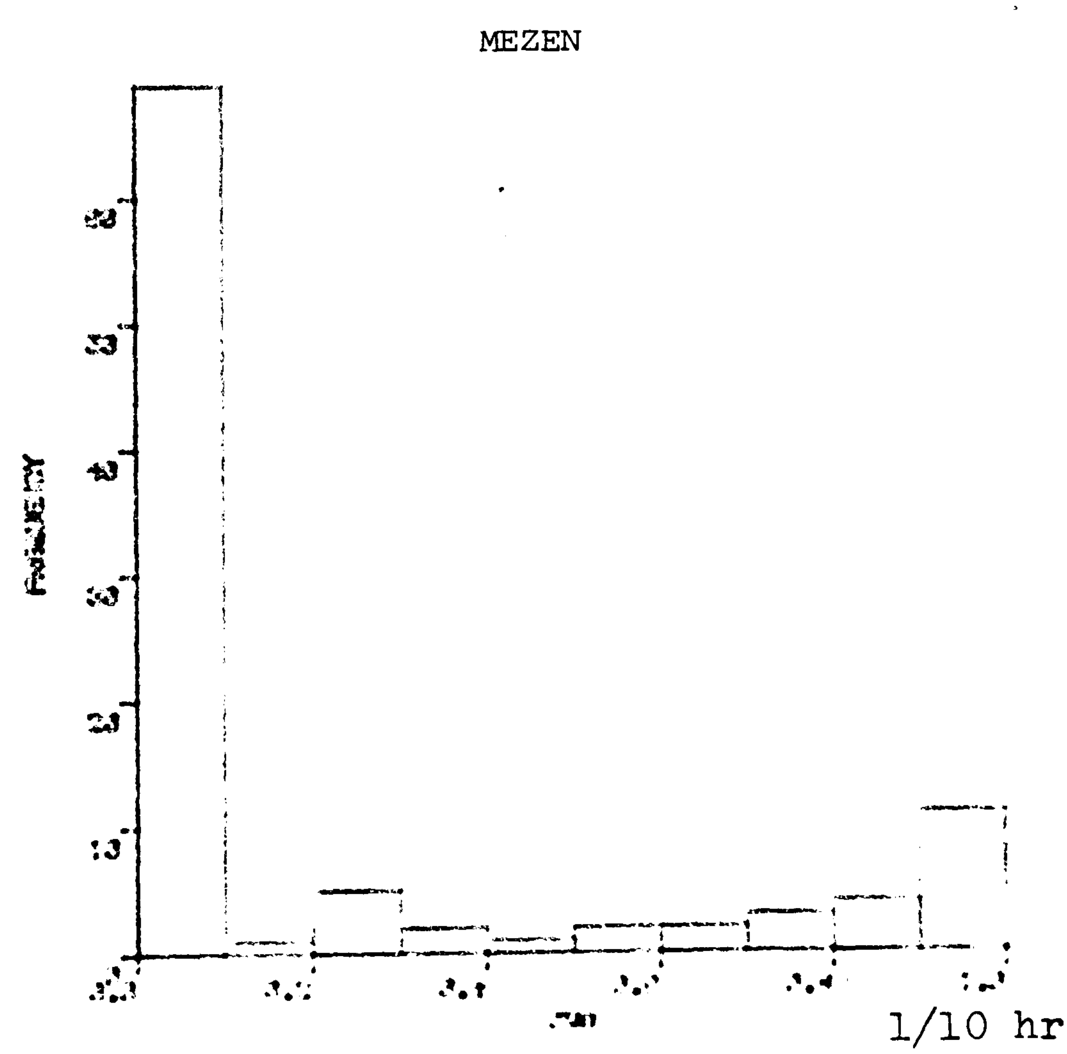


FIGURE 5.19(a) & (b). Frequency distribution of rainfall at a) Cowley and b) Mezen

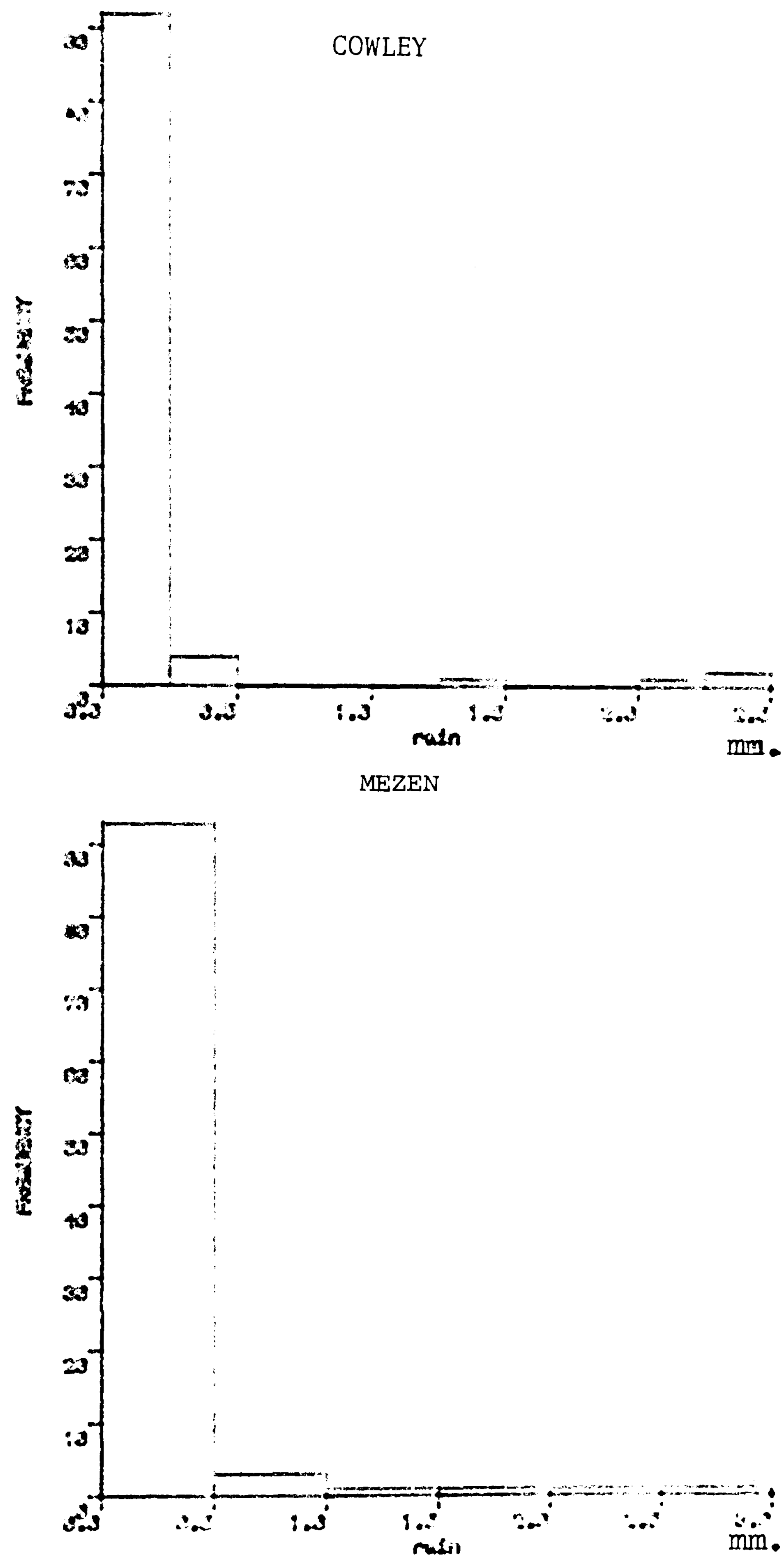


TABLE 5.4. Means and standard deviations of weather parameters

Weather parameter	Estate			
	Cowley		Mezen	
	$\bar{x}$	S.D.	$\bar{x}$	S.D.
Temperature (°C)	8.5	4.0	8.2	4.0
Relative Humidity (%)	79.6	13.1	79.6	12.9
Windspeed (knots)	8.9	4.4	9.0	4.3
Sunshine duration (1/10 hour)	0.3	0.4	0.2	0.4
Rainfall (mm)	0.1	0.4	0.1	0.4

$\bar{x}$ = mean

S.D. = standard deviation

5.4.1.2. Inter-relationships between weather parameters

Figures 5.20 to 5.29 illustrate the relationships between weather parameters. The correlation coefficients are shown in tables 5.5 and 5.6. Although the correlations between relative humidity and windspeed, sunshine duration and rainfall are statistically significant on both estates (2 tailed test, df = 98, $p < .05$), only at Cowley is the correlation between relative humidity and temperature statistically significant (2 tailed test, df = 98, $p < .05$). The diffuse scatters in all figures, however, show that none of the relationships, not even those that are statistically significant, was particularly strong.

FIGURE 5.20(a) & (b). Relationship between external air temperature and relative humidity at a) Cowley and b) Mezen.

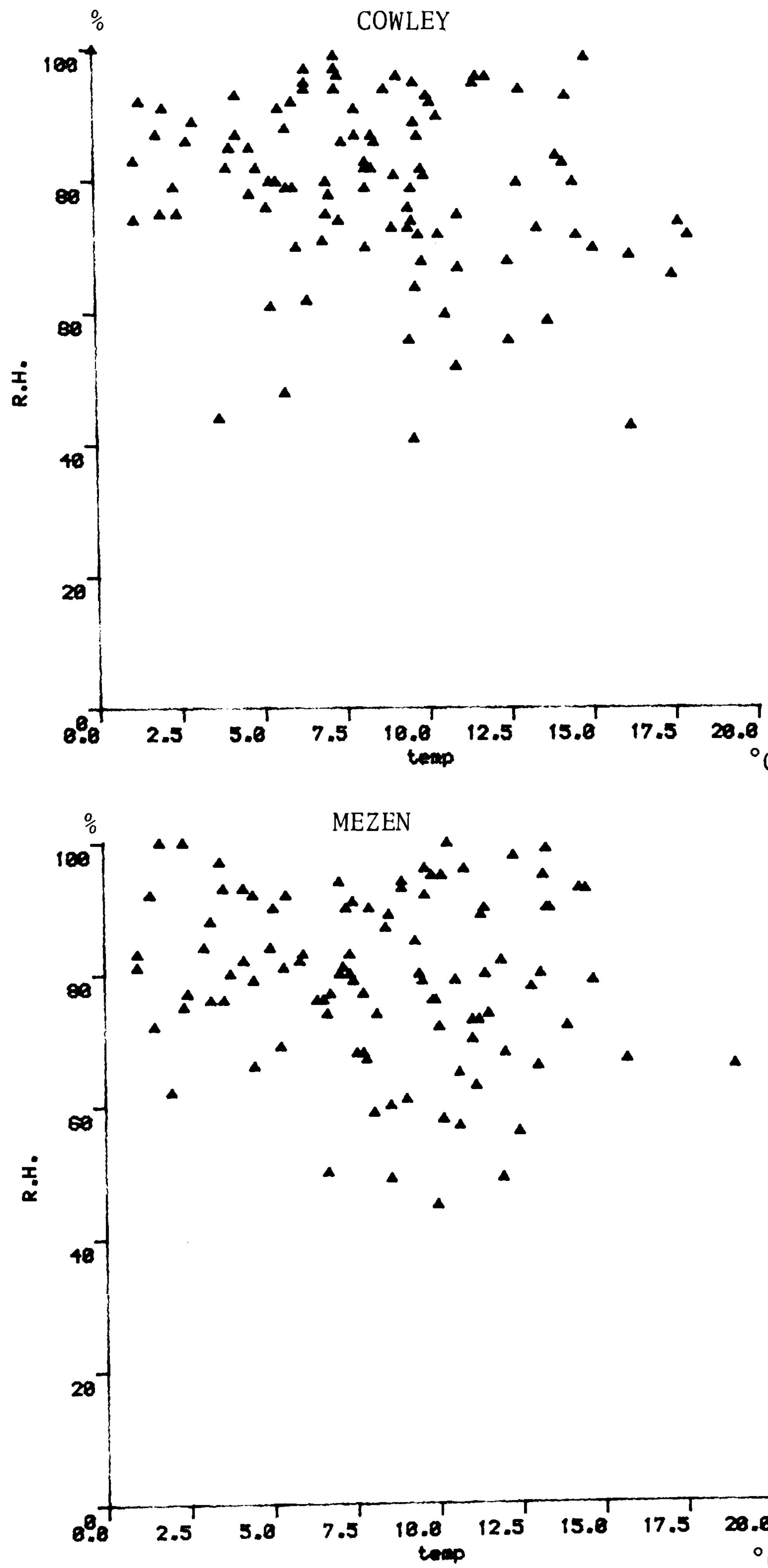


FIGURE 5.21(a) & (b). Relationship between external air temperature and windspeed at a) Cowley and b) Mezen

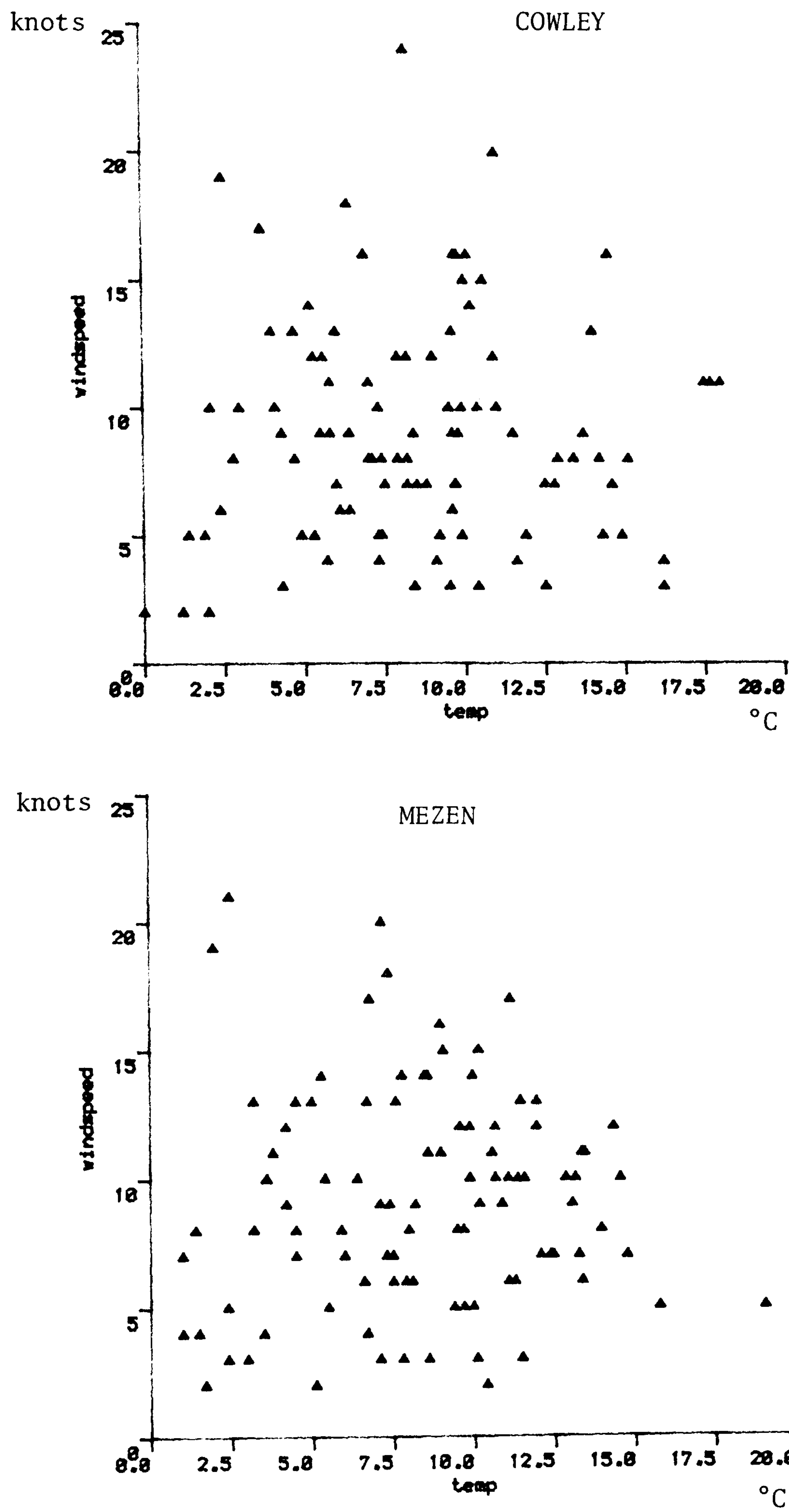
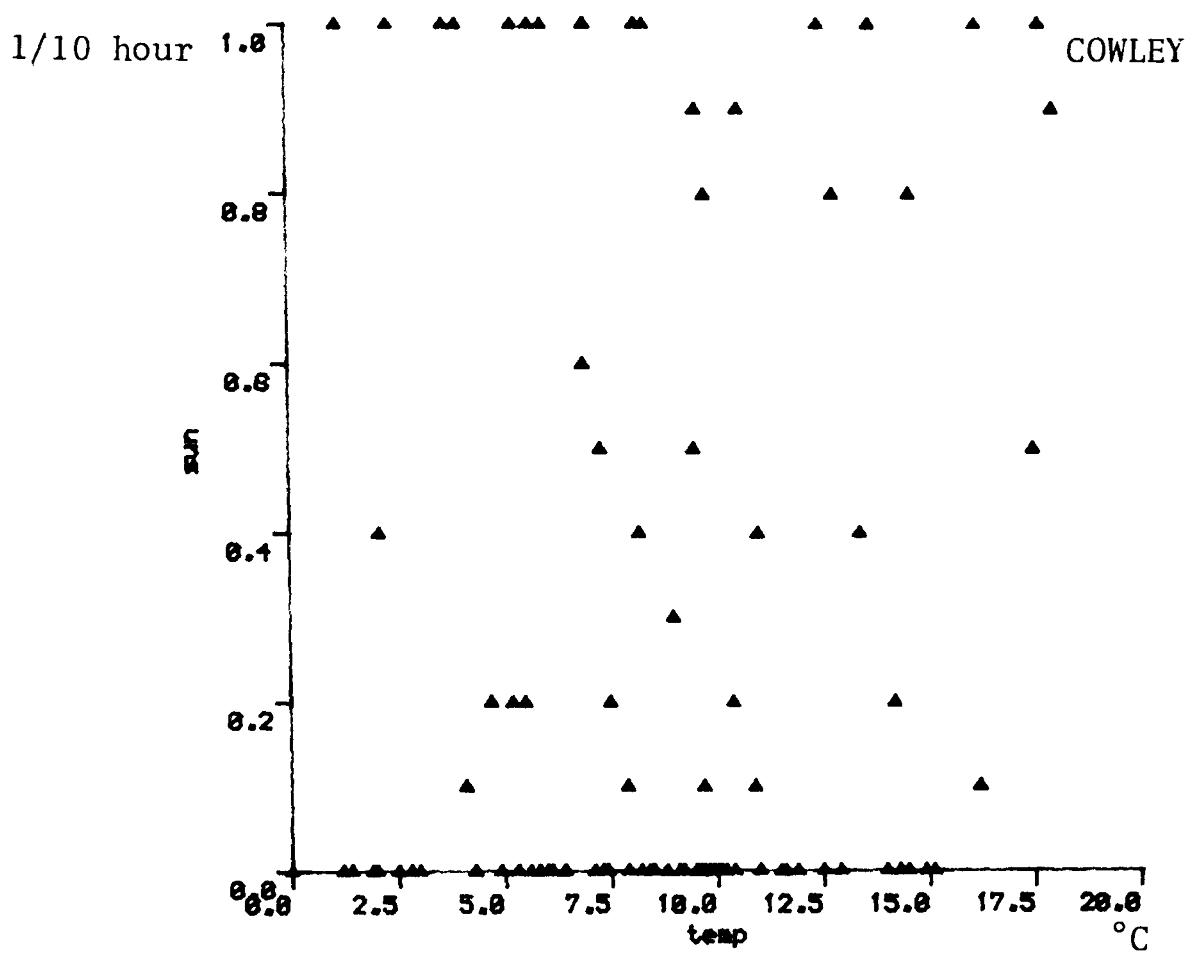


FIGURE 5.22(a) & (b). Relationship between external air temperature and sunshine duration at a) Cowley and b) Mezen



MEZEN

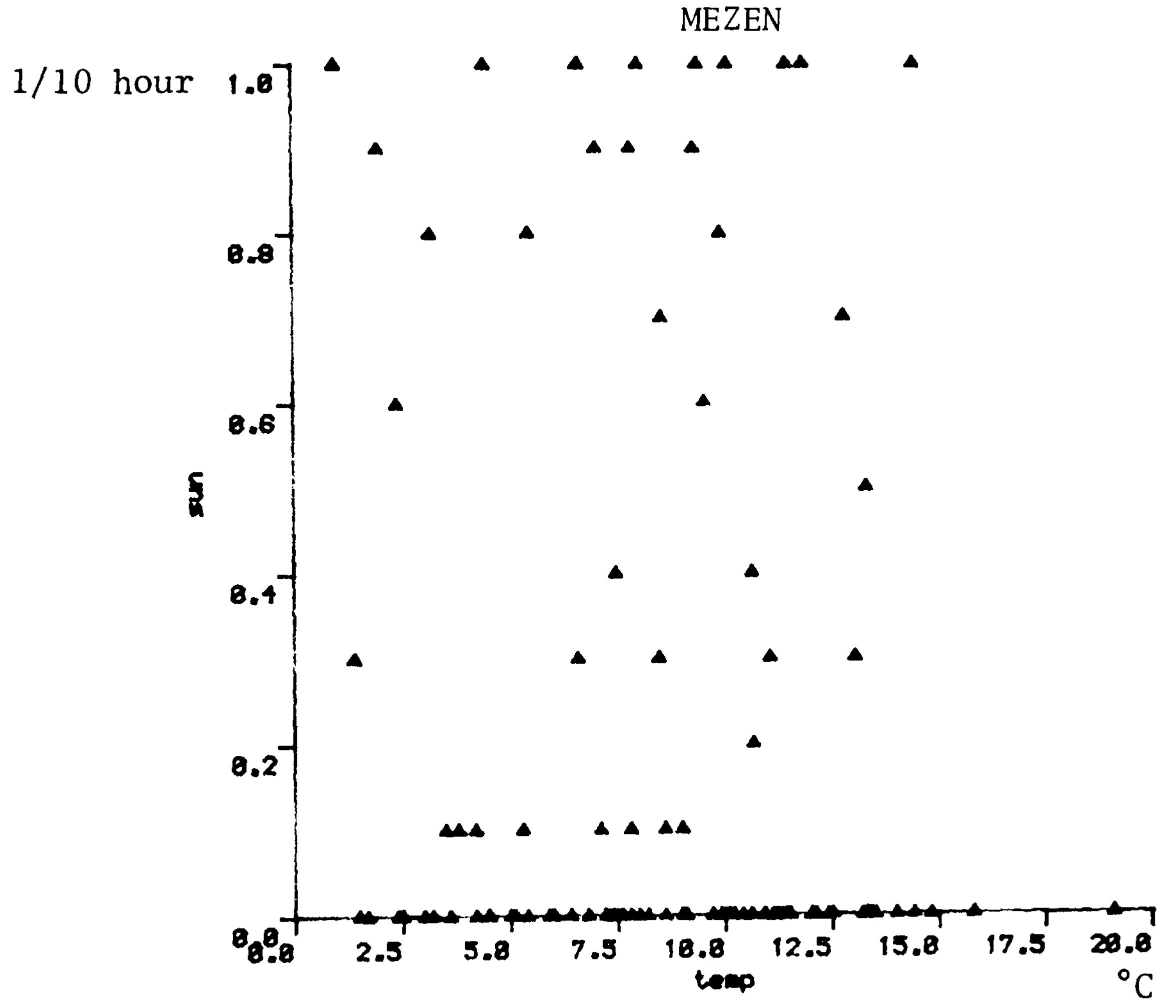
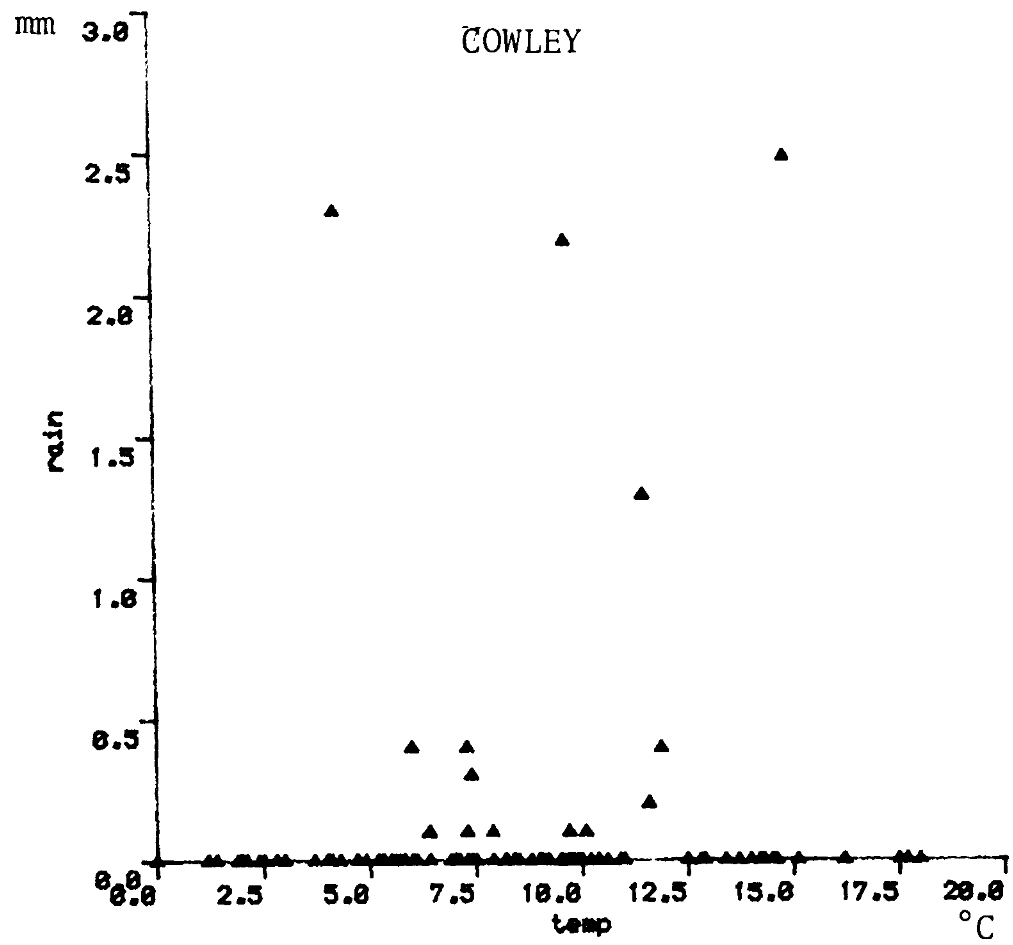


FIGURE 5.23(a) & (b). Relationship between external air temperature and rainfall at a) Cowley and b) Mezen



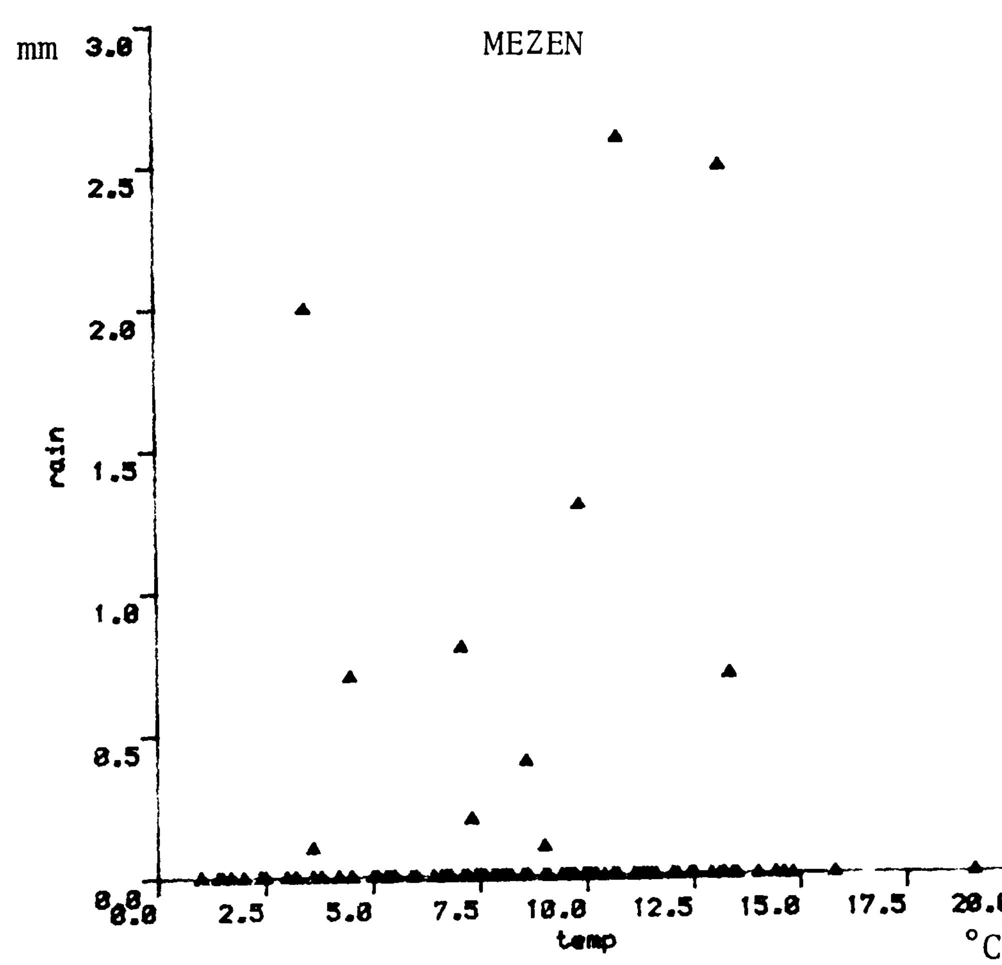
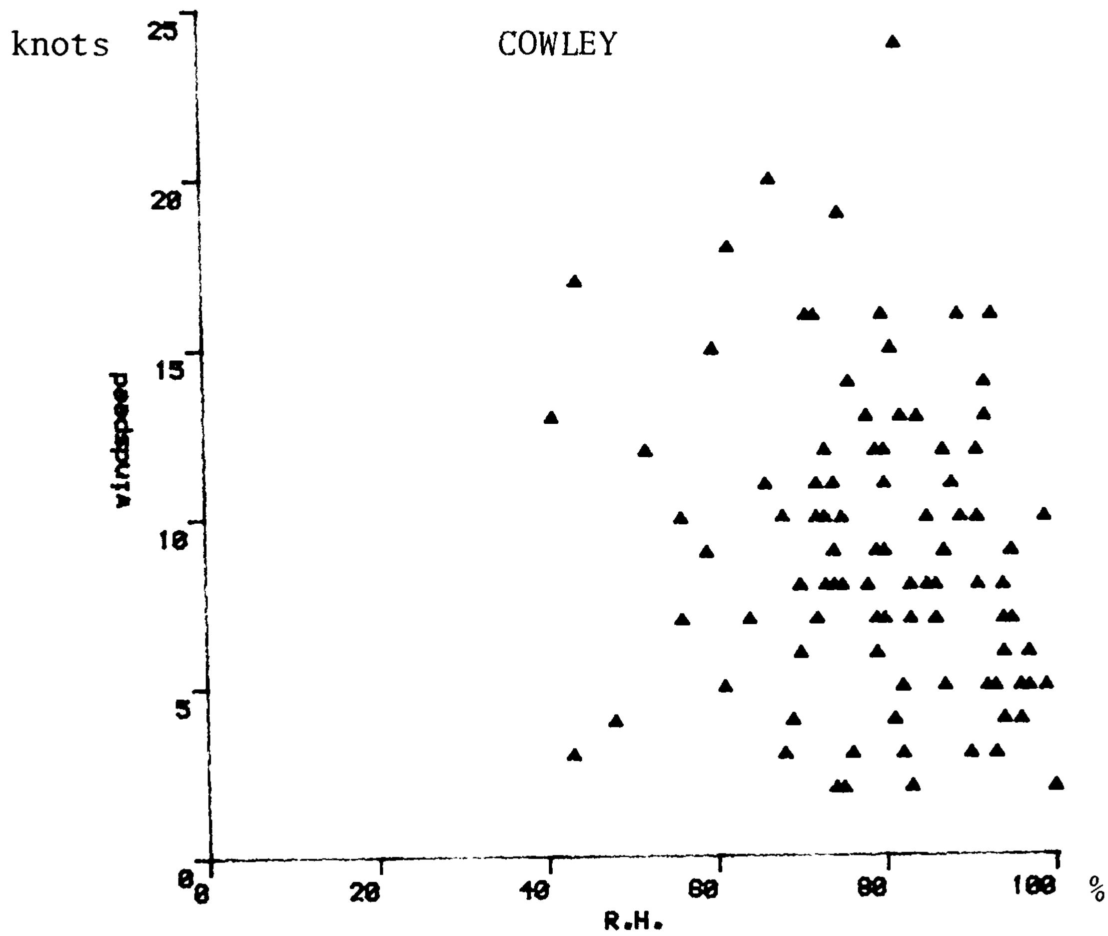
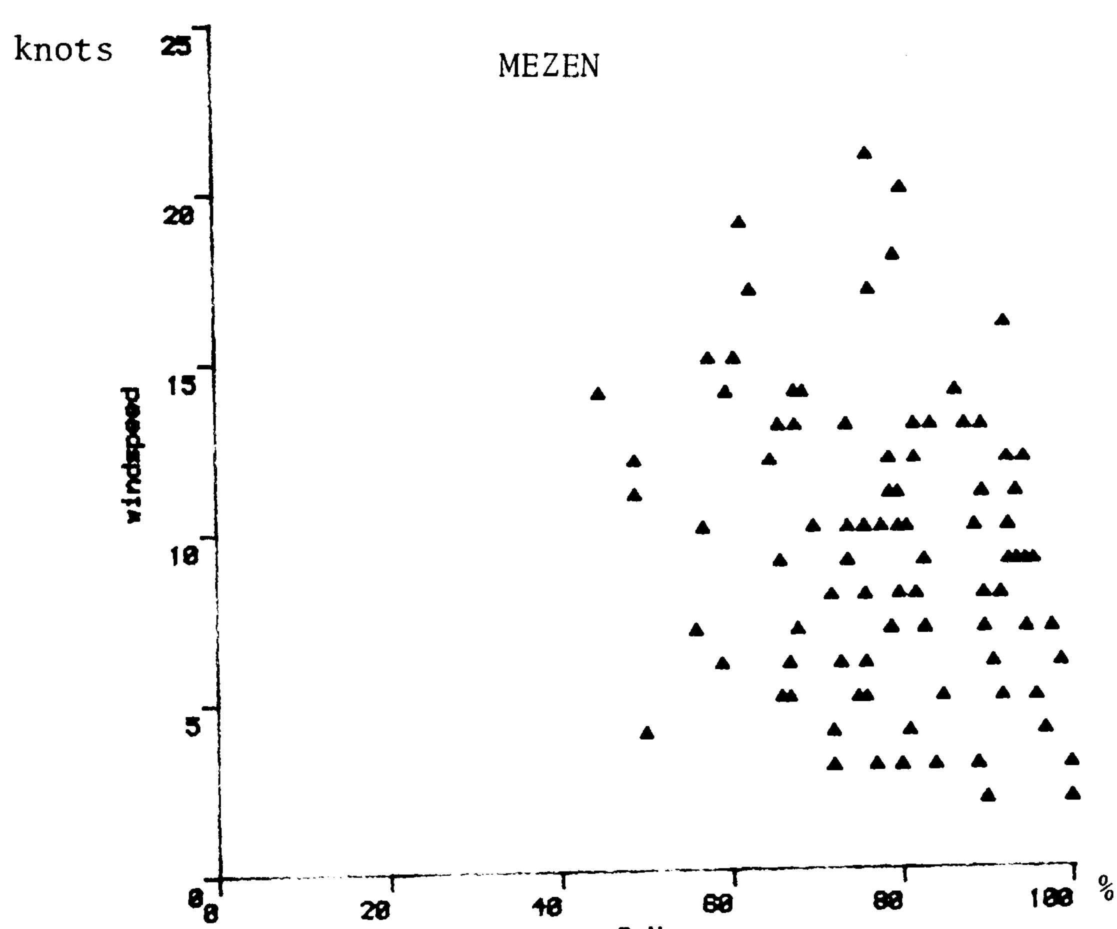


FIGURE 5.24(a) & (b). Relationship between relative humidity and windspeed at a) Cowley and b) Mezen





FIGURES 5.25(a) & (b). Relationship between relative humidity and sunshine duration at a) Cowley and b) Mezen

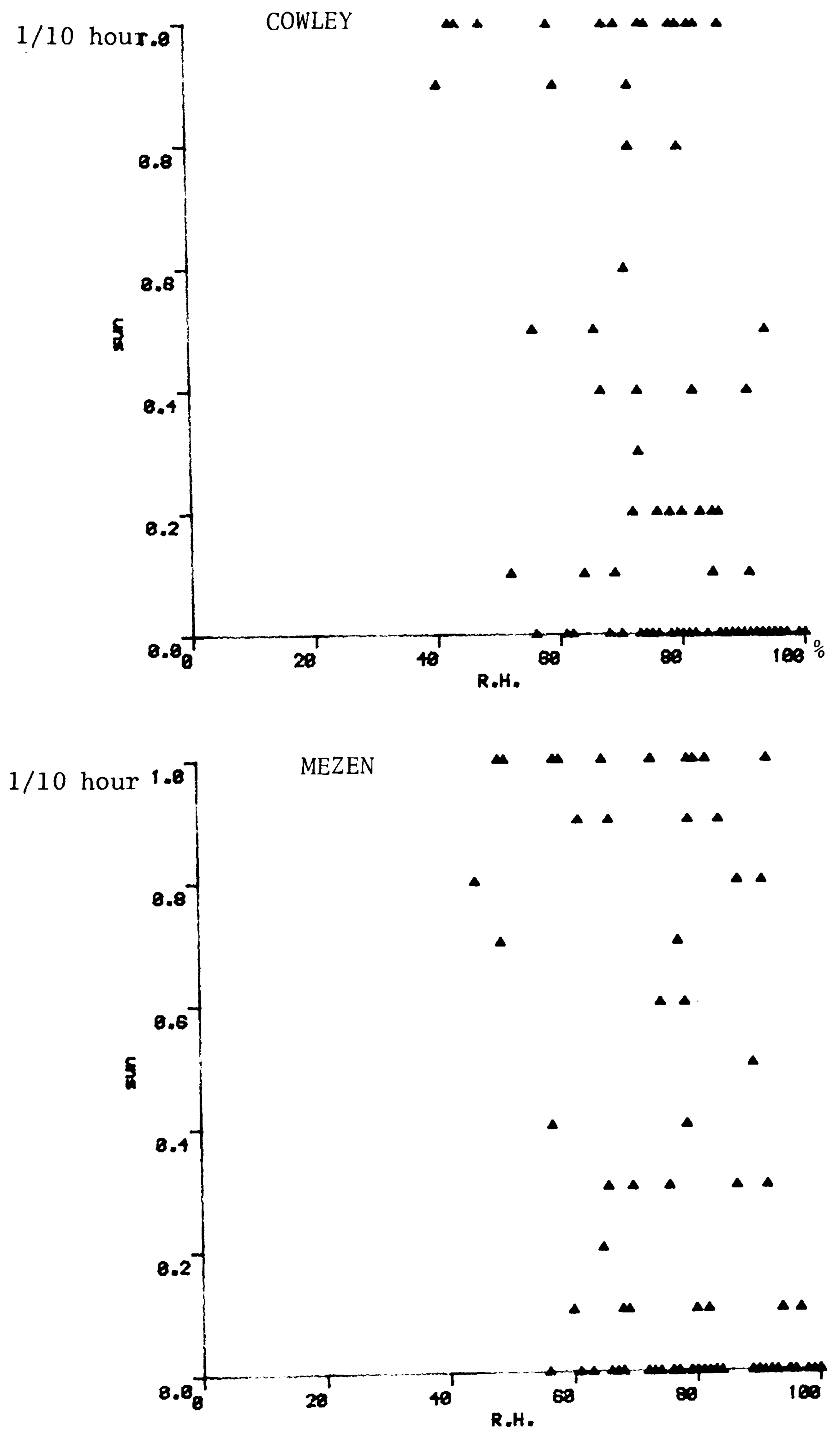
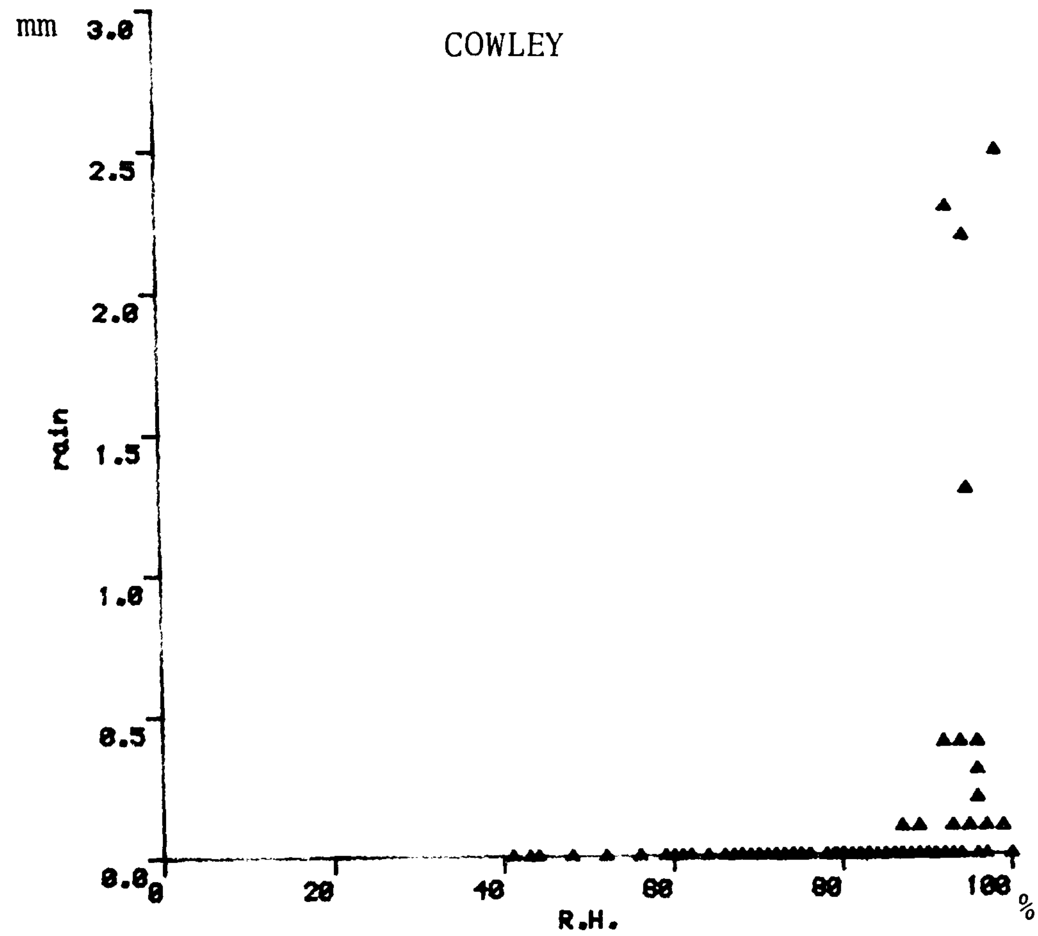


FIGURE 5.26(a) & (b). Relationship between relative humidity and rainfall at a) Cowley and b) Mezen



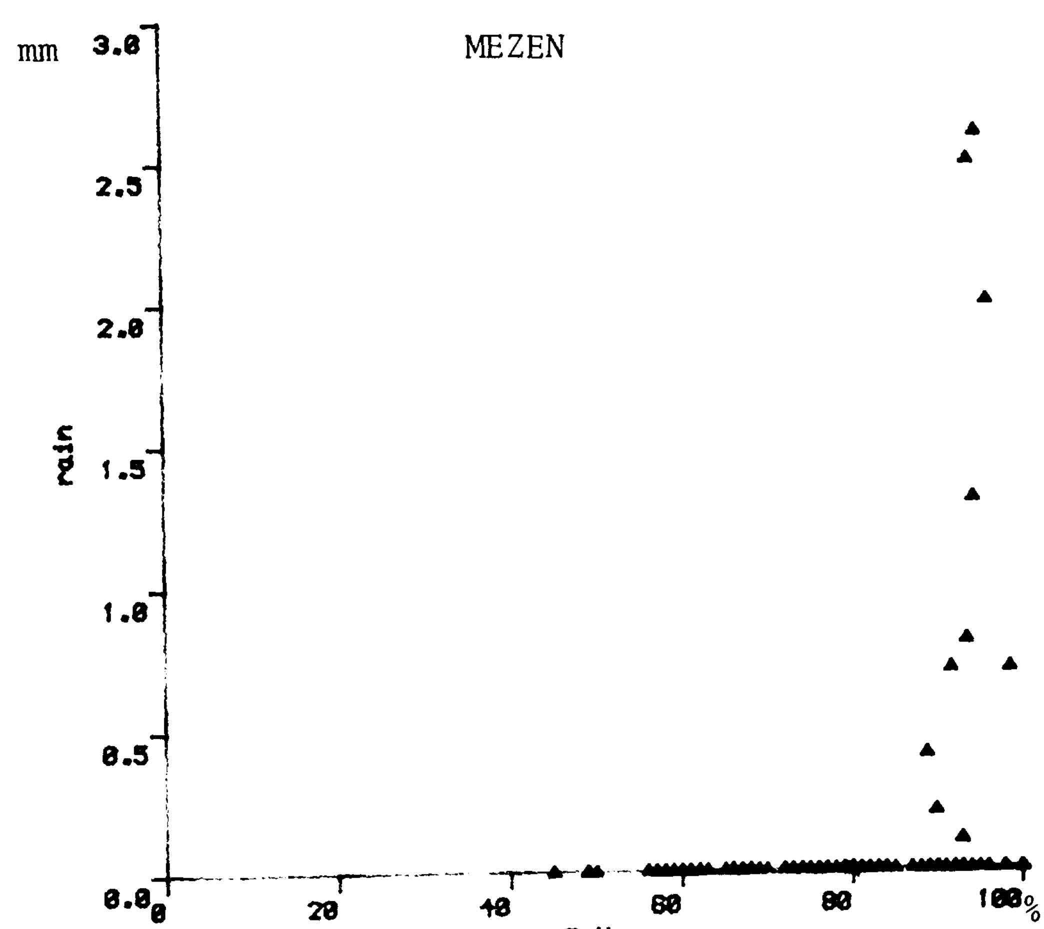
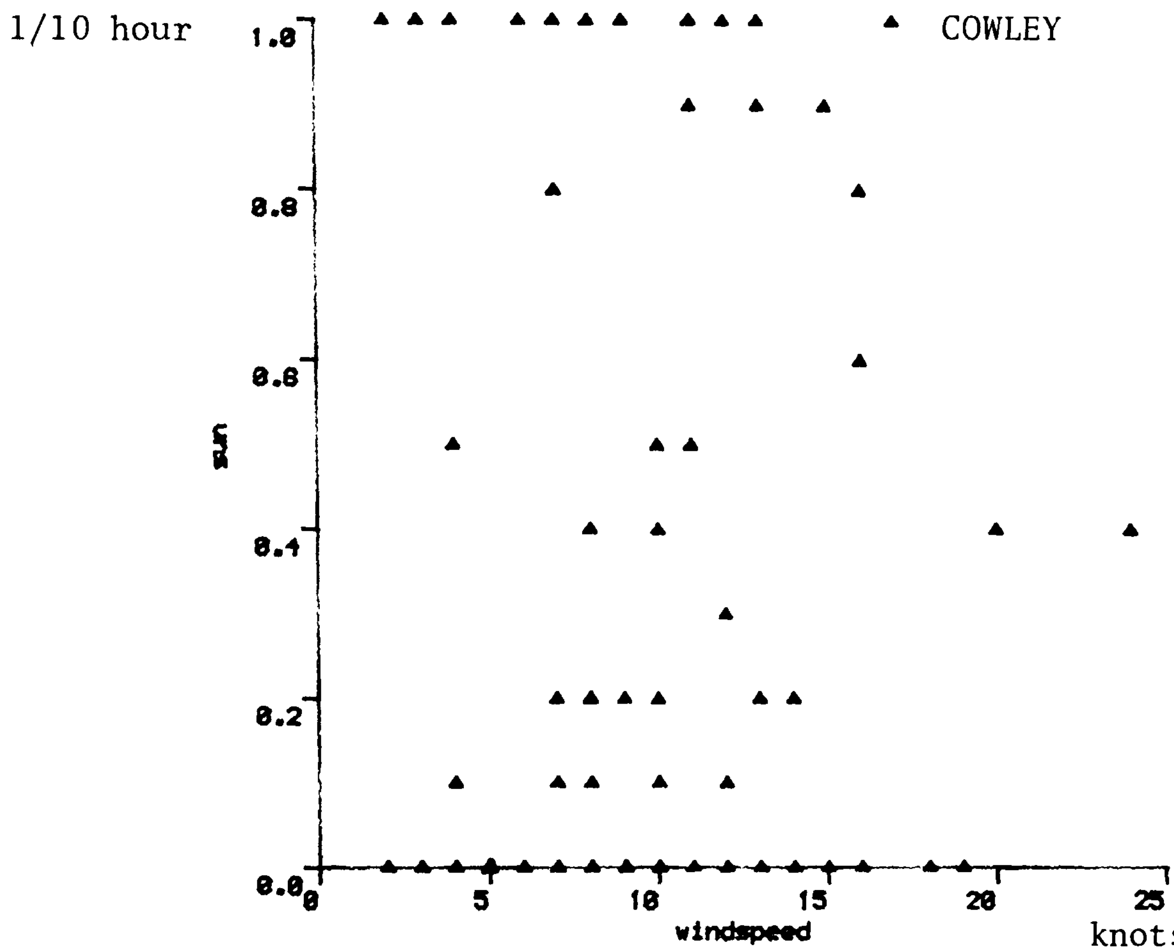


FIGURE 5.27(a) & (b). Relationship between windspeed and sunshine duration at a) Cowley and b) Mezen



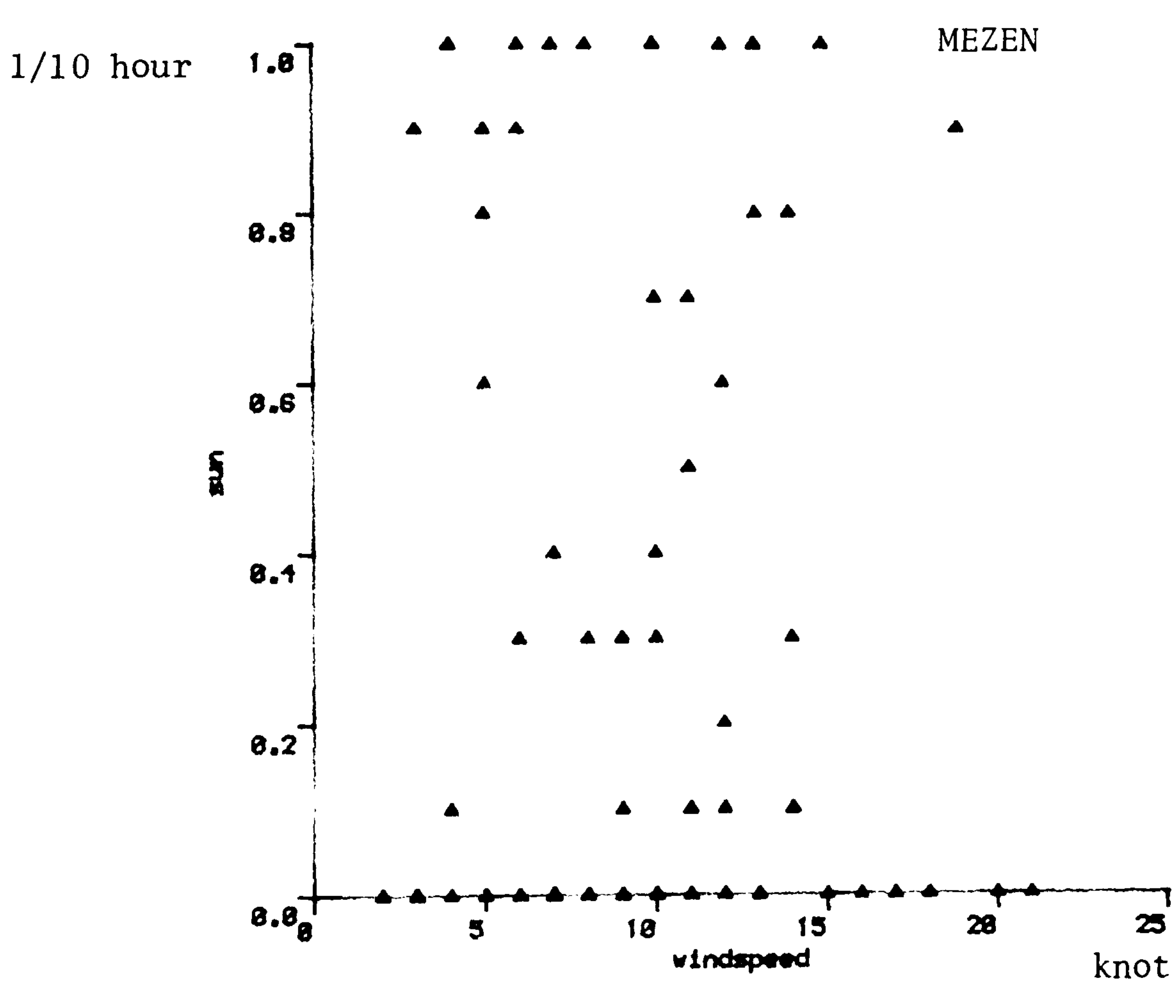
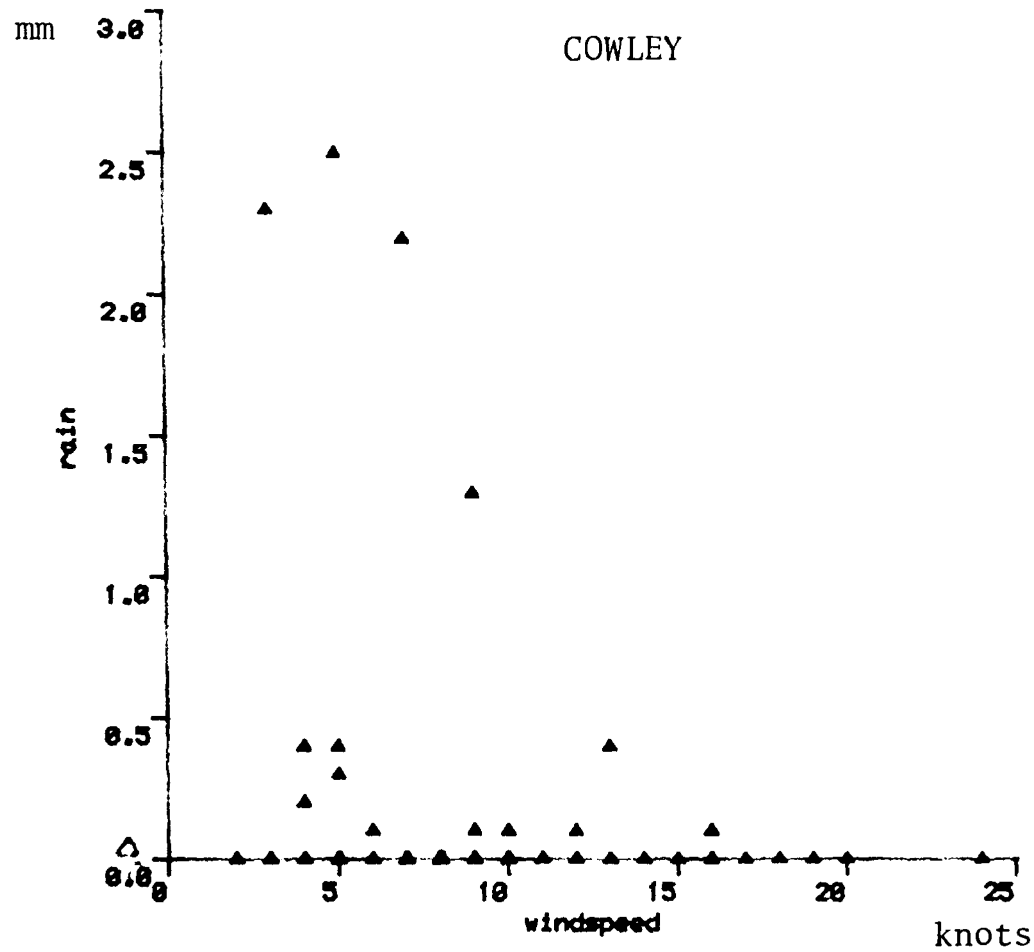


FIGURE 5.28(a) & (b). Relationship between windspeed and rainfall at a) Cowley and b) Mezen



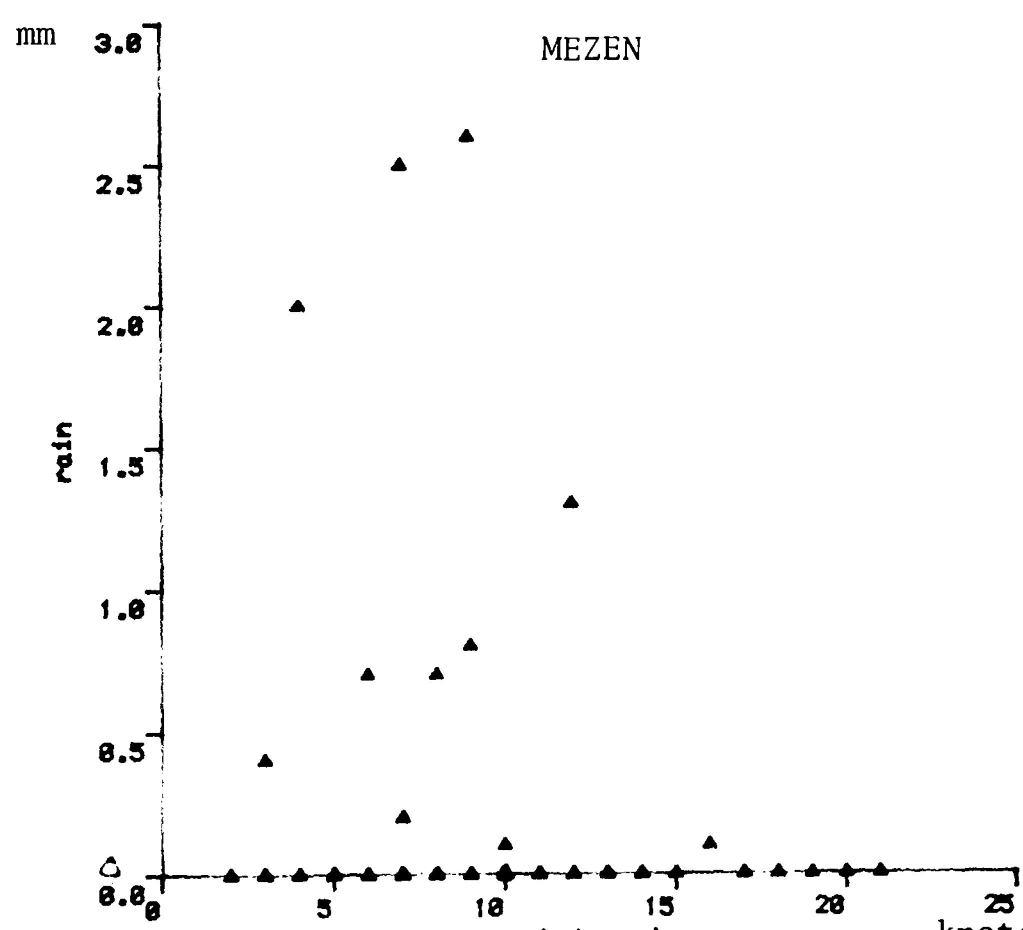
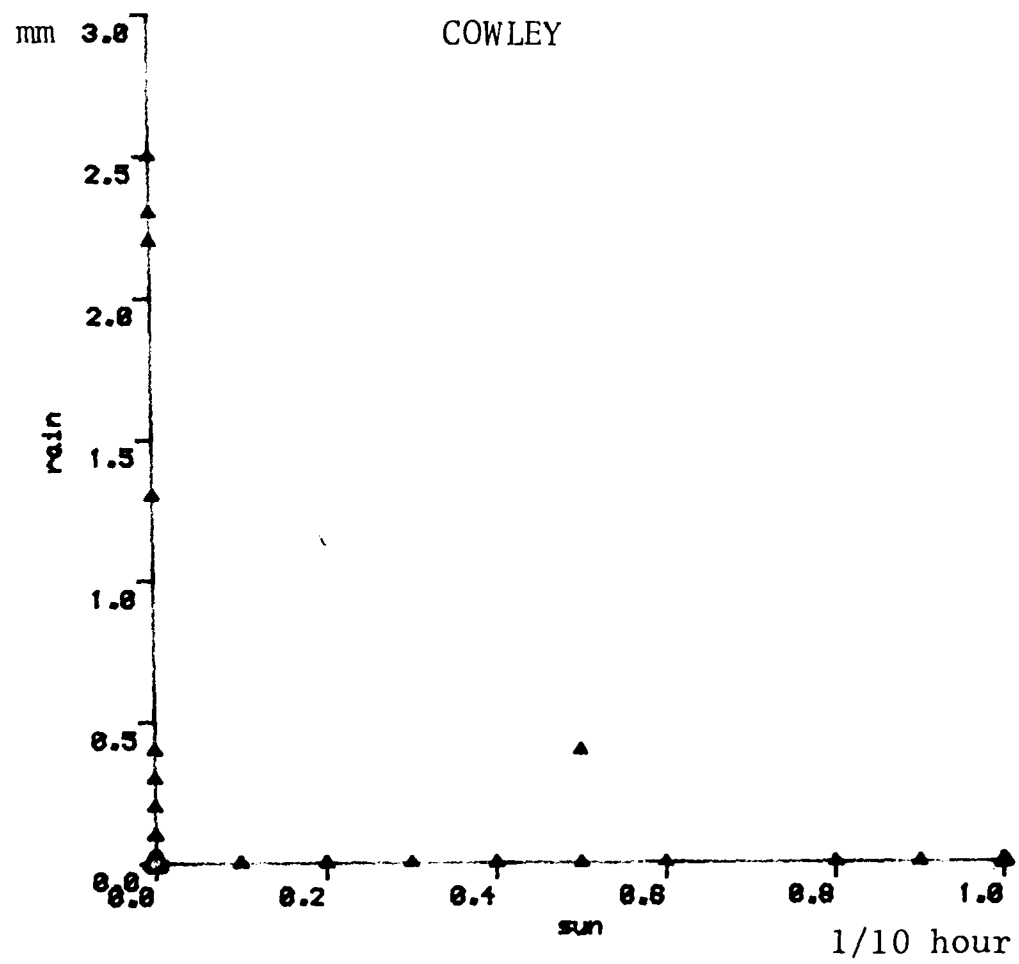


FIGURE 5.29(a) & (b). Relationship between sunshine duration and rainfall at a) Cowley and b) Mezen



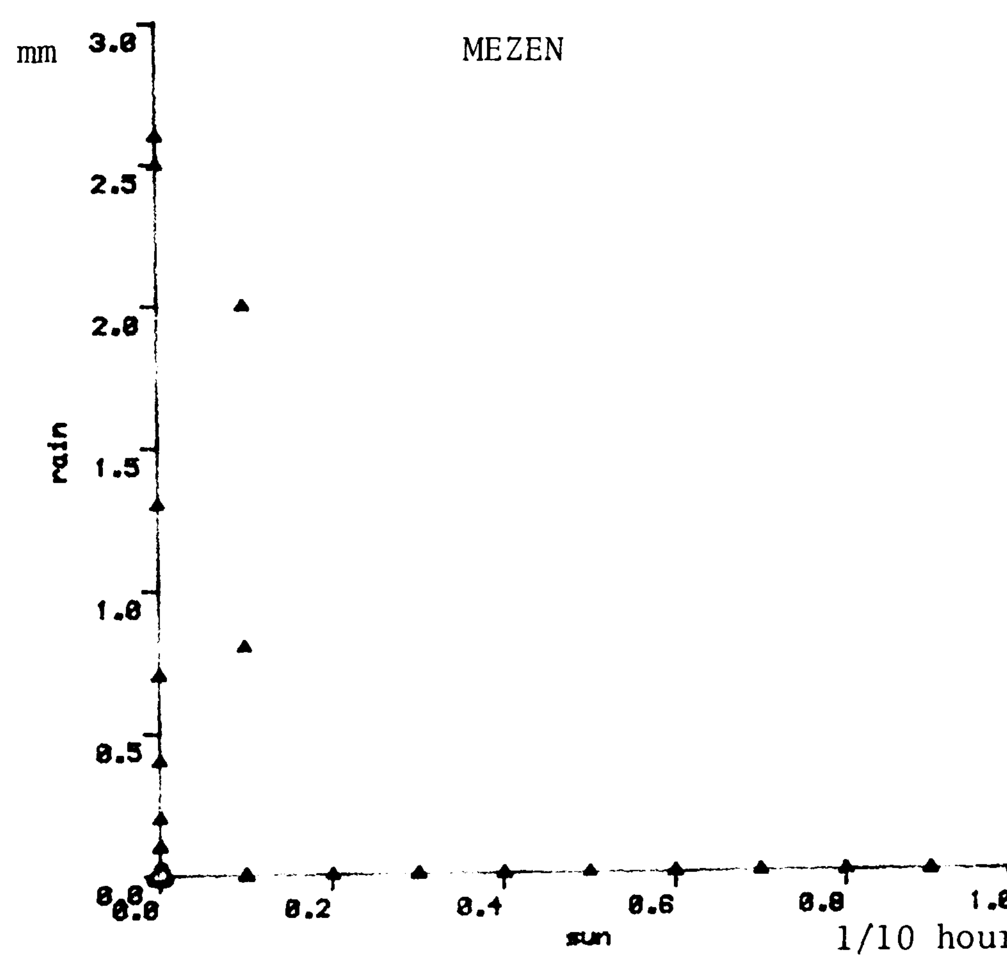


TABLE 5.5. Correlation coefficients obtained between weather parameters at Cowley (n = 100)

Weather Parameter	Weather parameter				
	Temperature	Relative humidity	Windspeed	Sunshine	Rainfall
Temperature		-.21*	.07	.10	.08
Relative humidity			-.20*	-.46**	.30**
Windspeed				.10	-.16
Sunshine					-.16

* p < .01

** p < .05

TABLE 5.6. Correlation coefficients obtained between weather parameters at Mezen (n = 100)

Weather parameter	Weather parameter				
	Temperature	Relative humidity	Windspeed	Sunshine	Rainfall
Temperature		-.17	.08	-.08	.07
Relative humidity			-.28**	-.37**	.32**
Windspeed				.06	-.08
Sunshine					-.14

** p < .01

* p < .05

5.4.1.3. Relationship between weather parameters and hour of observation

Scattergrams of the relationships between the five weather parameters and the 'hour of observation' are provided in figures 5.30 to 5.34. Their respective correlations are shown in table 5.7. The low

FIGURE 5.30(a) & (b). Relationship between external air temperature and hour of observation at a) Cowley and b) Mezen

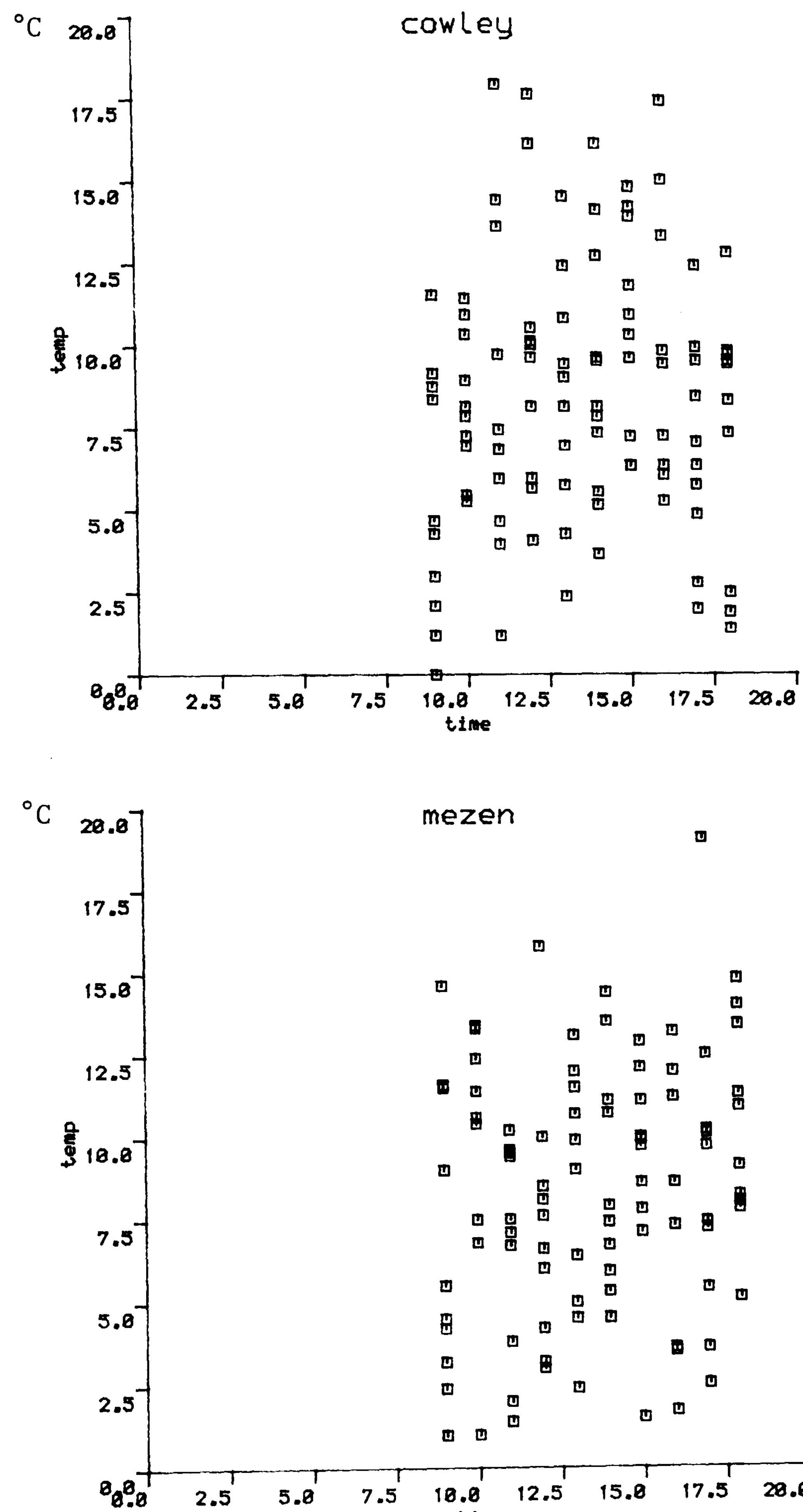


FIGURE 5.31(a) & (b). Relationship between relative humidity and hour of observation at a) Cowley and b) Mezen

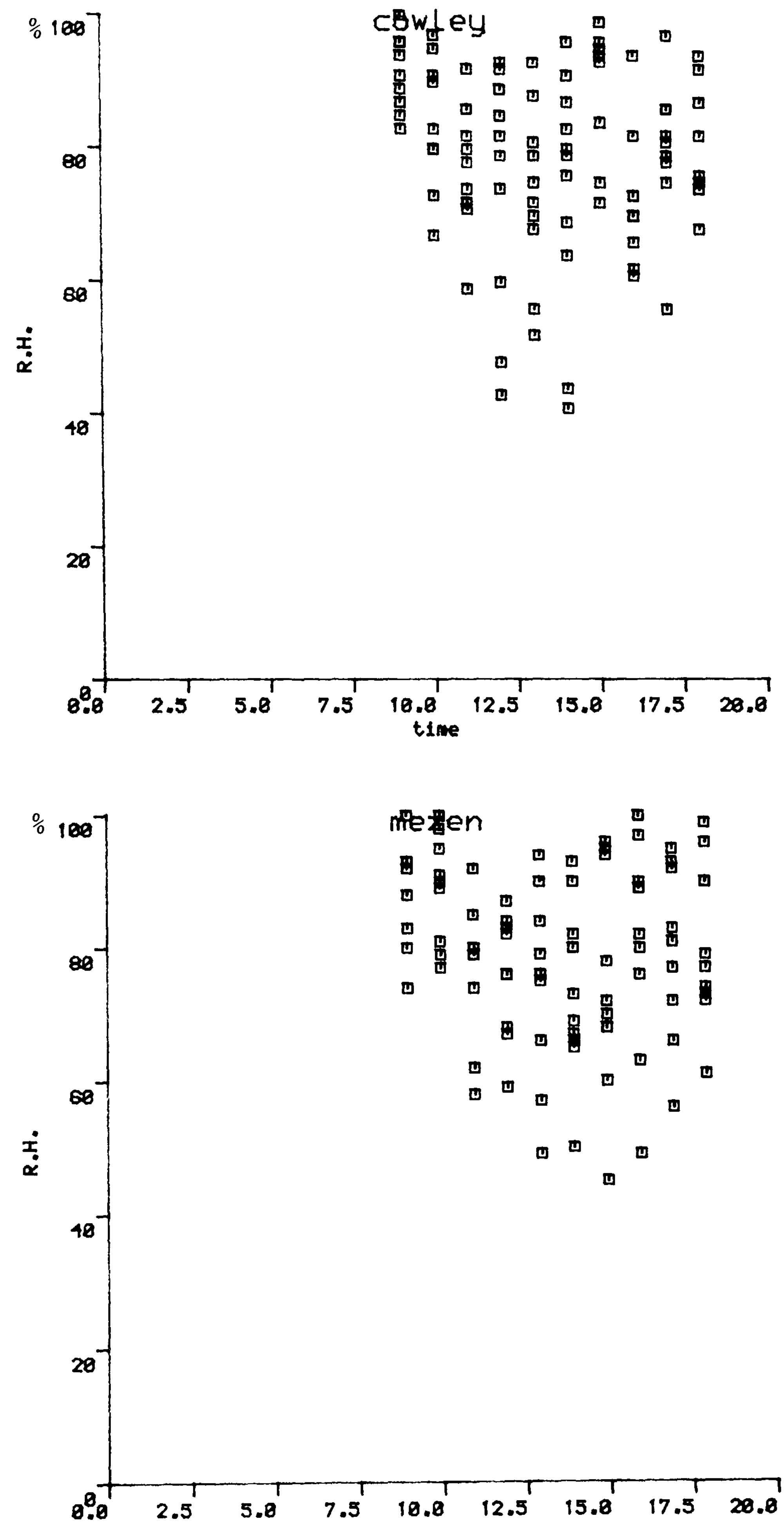
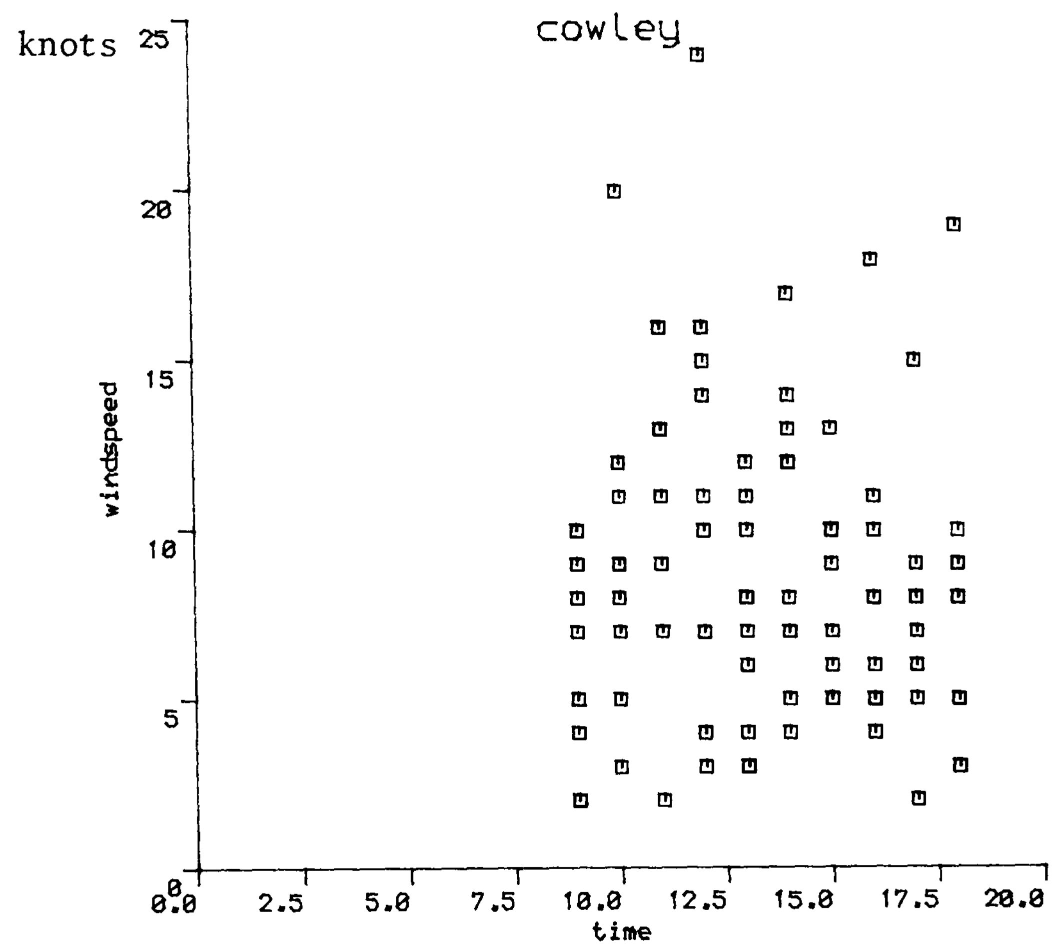


FIGURE 5.32(a) & (b). Relationship between windspeed and hour of observation at a) Cowley and b) Mezen



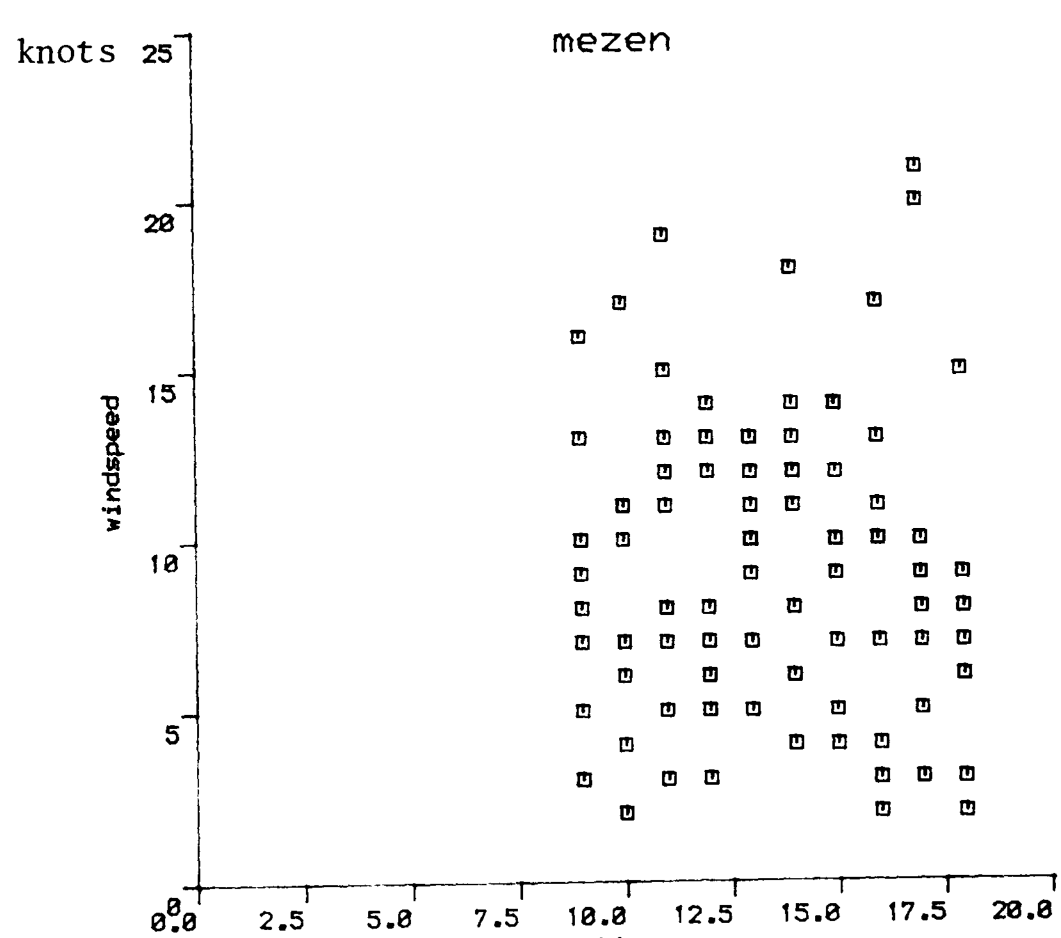
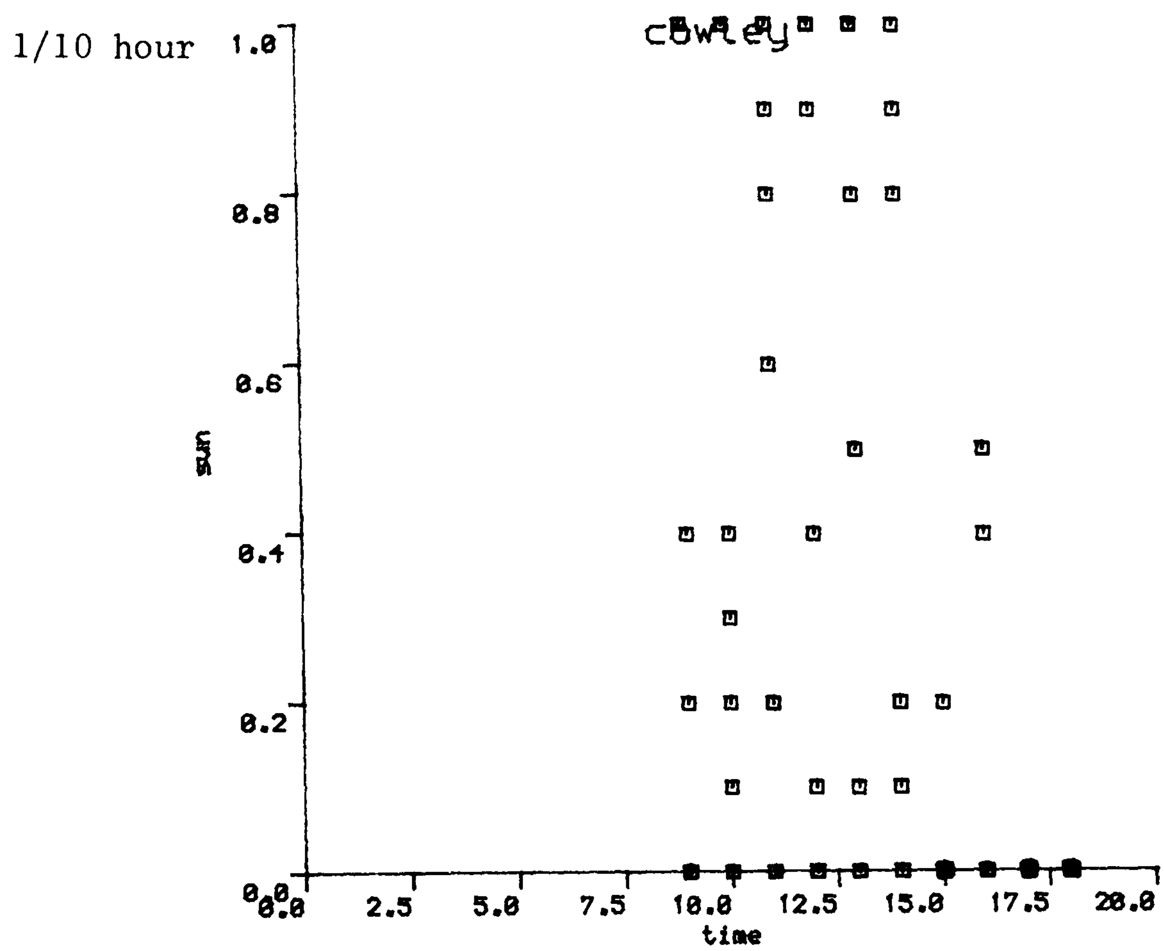


FIGURE 5.33(a) & (b). Relationship between sunshine duration and hour of observation at a) Cowley and b) Mezen



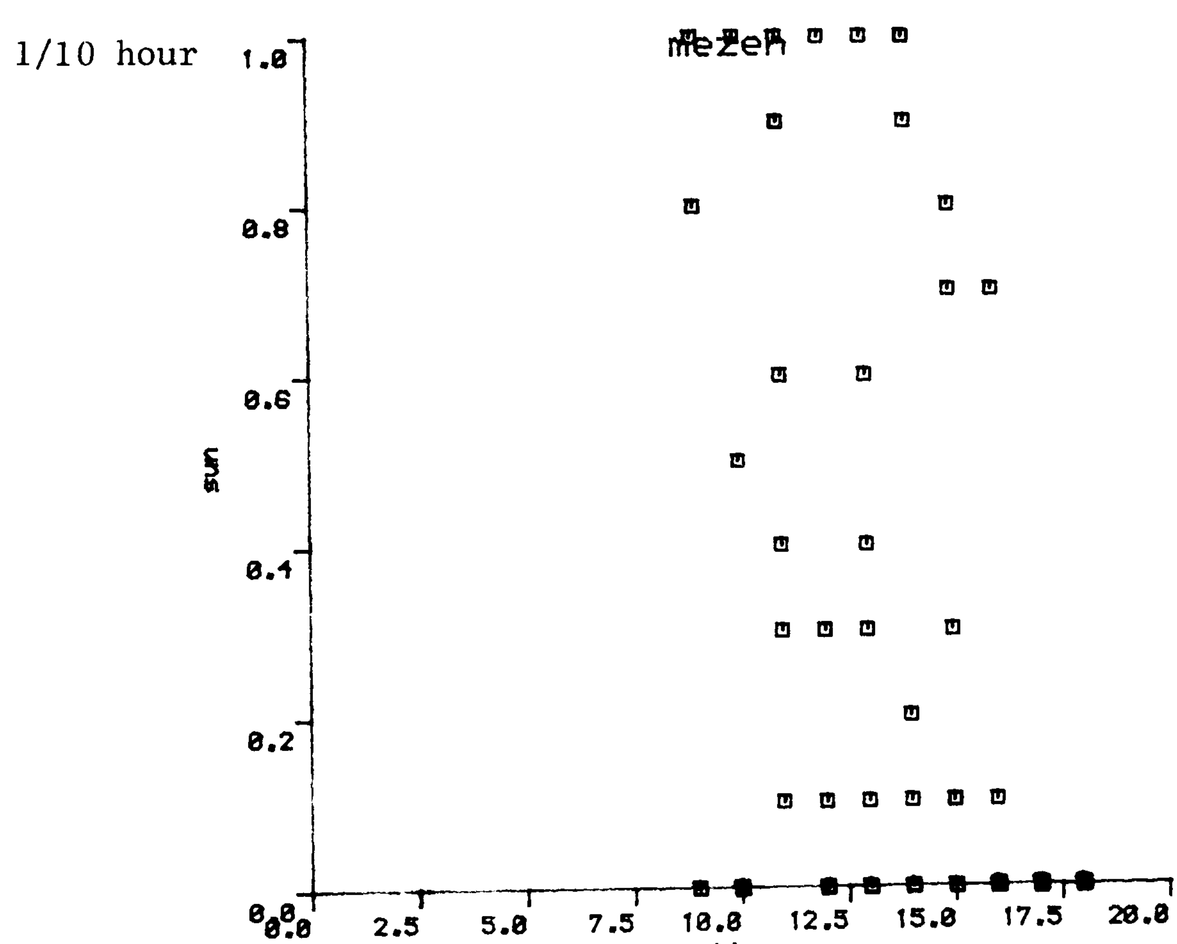
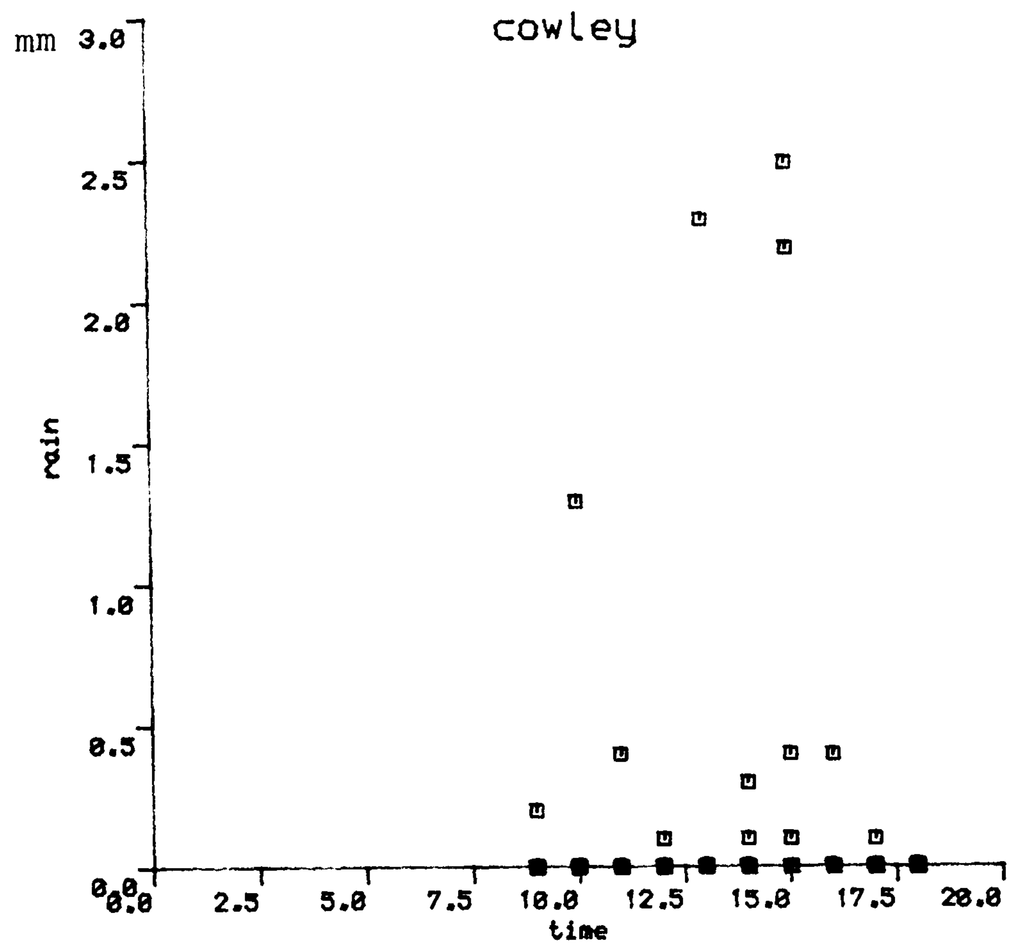
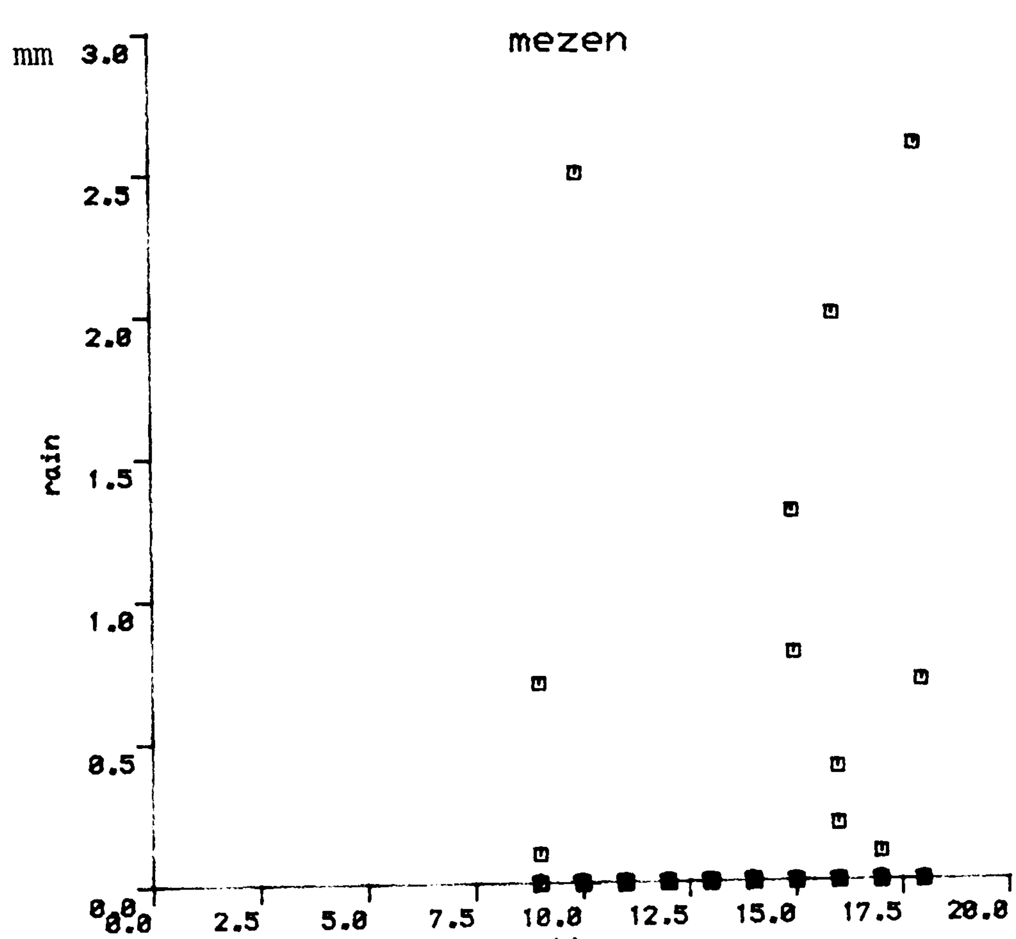


FIGURE 5.34(a) & (b). Relationship between rainfall and hour of observation at a) Cowley and b) Mezen





correlations are not taken to demonstrate a total lack of systematic relationship between the time of day and each of the weather parameters. For example, it is expected that on any one day the external temperature is likely to be greatest around mid-day (Heap, 1978) with humidity exhibiting the opposite pattern. Rather, the scattergrams and correlation coefficients are taken to indicate a lack of inter-correlation favourable to the application of multiple regression (5.6).

TABLE 5.7. Correlation coefficients obtained between weather parameters and hour of observation

Weather parameter	Estate	
	Cowley	Mezen
Temperature	.08	.17
Relative humidity	-.11	-.17
Windspeed	-.12	.01
Sunshine	-.38**	-.39**
Rainfall	.02	.10

** $p < .01$

* $p < .05$

5.4.2. Elementary Analysis of the Window Opening Data

This section deals with elementary characteristics of the window opening data, as well as with basic features of the analysis.

5.4.2.1. Basic statistics

Window opening was recorded as described in section 5.3.2.1. Scores were calculated for the number of open windows for (a) individual households over the one hundred days (N = 113 households), (b) the two estates separately on each of the one hundred days (N = 100 days for each estate), (c) weekends (N = 7 days for each estate), and (d) the Christmas period (N = 9 days for Cowley, N = 10 days for Mezen). Special attention was focussed on three contrasting room types which exist without exception in all dwellings. These are the sittingroom, the kitchen and main bedroom. The actual number of open window observations at Cowley and Mezen on each of the one hundred days, in total and for each of the three room types separately, is included in table A8.

The word 'total' in this context continues to refer to all windows in the dwelling. Only the results of the main part of the survey (the one hundred observations) will be discussed in this section (5.4). The data collected at weekends and over the Christmas period will be considered later (5.8). The number of open windows in each house during the whole observation period is shown in table A9. The average daily number of total open windows,

$$\frac{\sum_{\text{day } 1}^{\text{day } 100} (\text{Total})}{100}$$

and the standard deviation about that mean is shown for each house in table A10. The table also shows that the number of openable windows differed according to estate and house type. Glazed unopenable areas are not included in this figure.

5.4.2.2. Household consistency

The number of total open windows for the observation period for the two estates combined has a mean of 1.27 (N = 113 households), and a standard deviation of 1.5 window observations. This figure is larger than the standard deviation of total daily window opening for most of the individual households (Figure 5.35) indicating that the variability between households (in terms of their total daily window opening) was greater than that within households. This essentially means that whilst householders did fluctuate in their window opening from day to day, they were still fairly consistent over the one hundred days. Some householders consistently opened only a few windows, whilst others consistently opened several windows. Indeed, as previously mentioned, after the first twenty or thirty observations the experimentor was able to make a reasonable guess as to which windows would be open in a particular house.

5.4.2.3. The number of windows observed to be open in relation to the number of openable windows

Since different house types have different numbers of windows (Table 5.8 and A10), it seemed reasonable to take account of this fact in the analysis. Figure 5.36 is a scattergram of the relationship between the number of openable windows in a dwelling and the total number of windows observed to be open in each house over the one hundred days. As expected the results of a Wilson Chi Squared Test (Table 5.10) show a positive relationship between the number of openable windows in a house and the total number recorded as open ($X^2 = 25.19$, $df = 5$, $p < .01$). The median number of total open windows for the two estates was 112.

This finding is taken to indicate that the number of openable windows in a house is a potentially important explanatory variable. Indeed, inspection of figure 5.36 suggests that the number of windows opened is approximately proportional to the number of openable windows. It was therefore decided that results would henceforth be expressed as percentages. However, it must be noted that when the proportion of open windows in each house type is used in a second chi-square test, the results are still significant, though this time only at the 5% level (Tables 5.11 and 5.12).

FIGURE 3.35. Standard deviations of total open window observations for 113 households

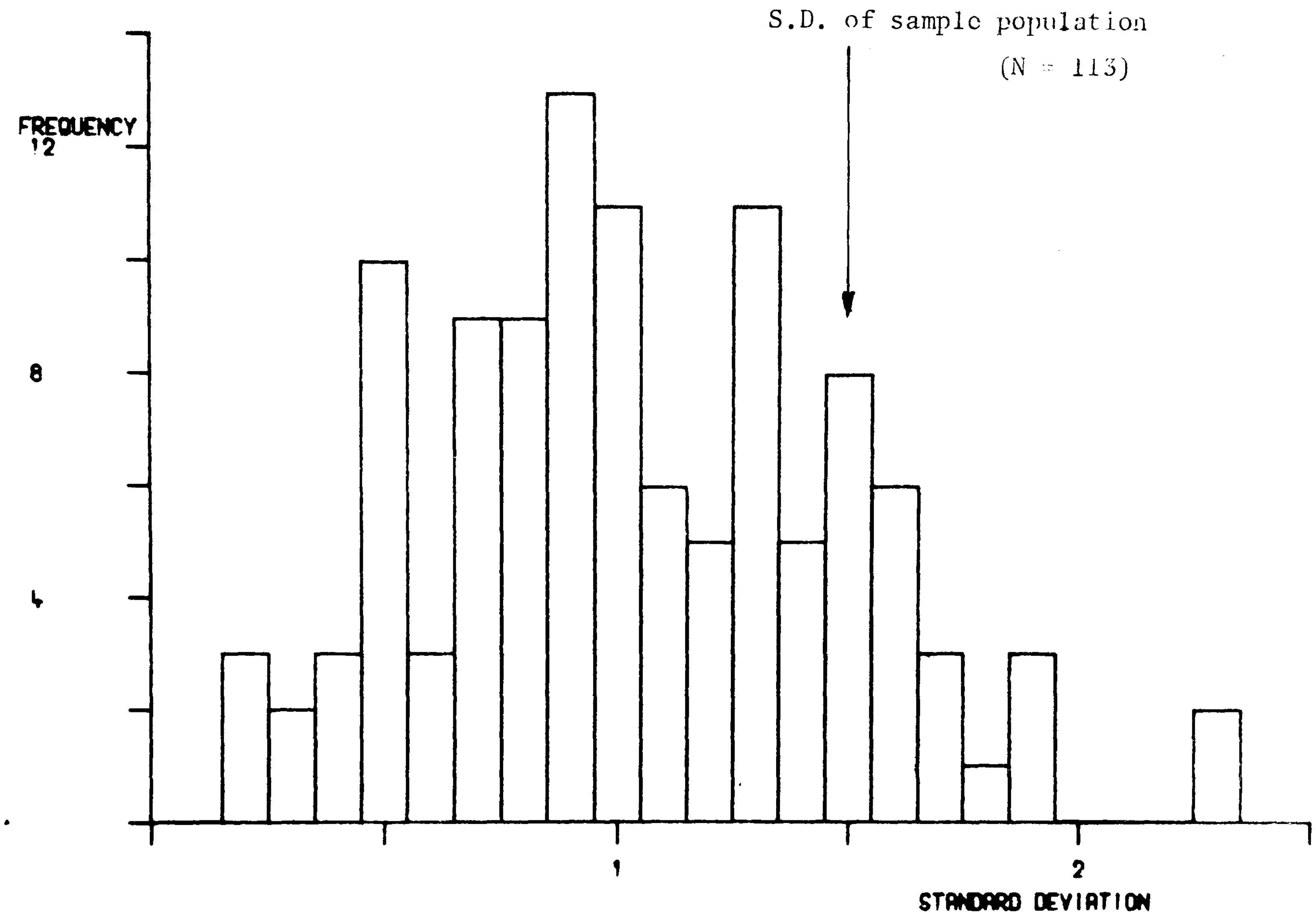


FIGURE 5.36. Relationship between number of openable windows and the number of total open window observations

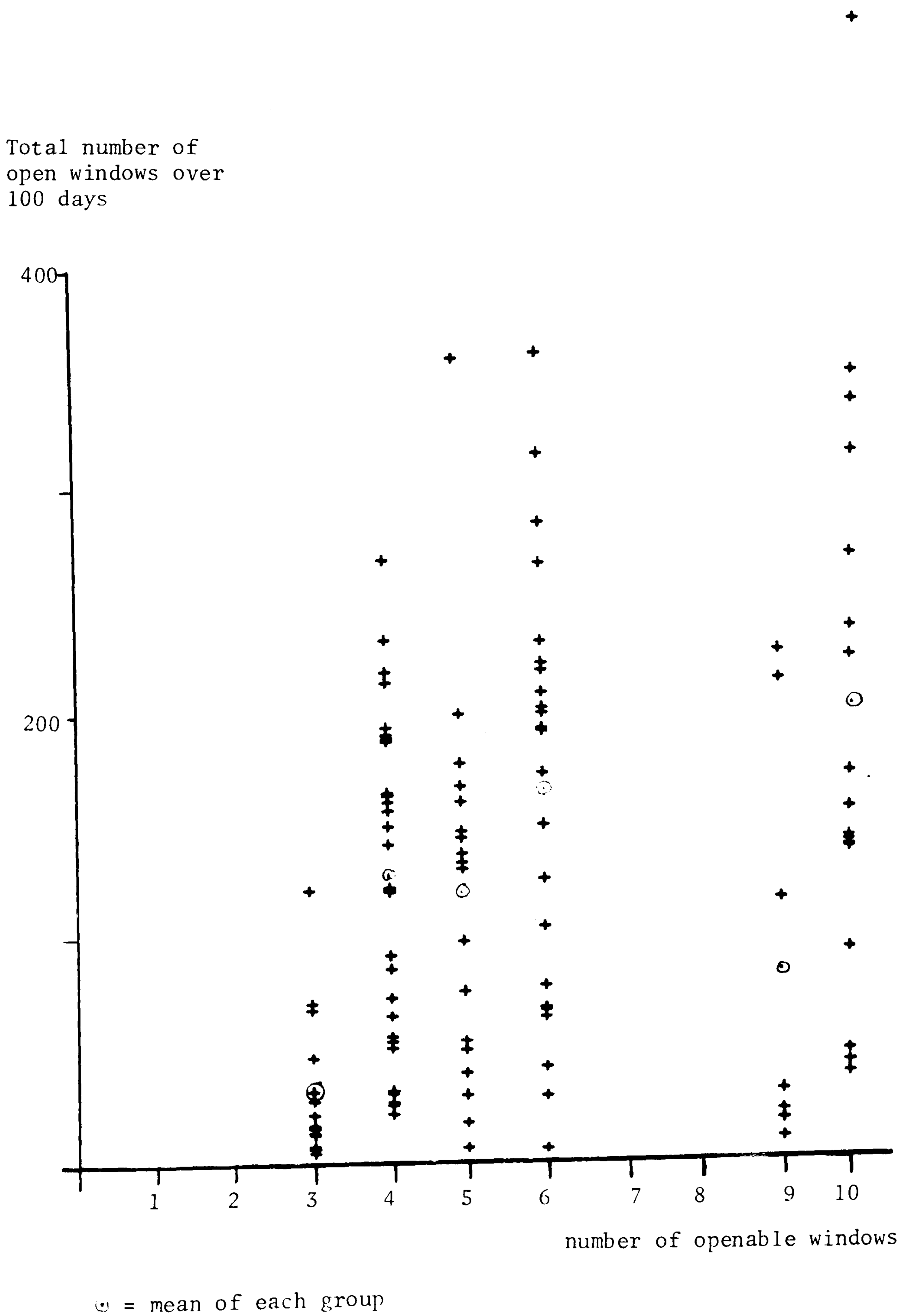


TABLE 5.8. Total number of openable windows in relation to house type

Estate	House type	Number in sample	Total number of openable windows
Cowley	Top flat	16	5
	4P, 2 storey	23	3
	4P, 3 storey	10	6
	6P, 3 storey	13	6
Mezen	Top flat	10	9 (n = 8) 10 (n = 2)
	Bottom flat	10	4 (n = 8) 5 (n = 2)
	4P house	15	10

P = person

TABLE 5.9. Distribution of houses with a given number of openable windows

Number of openable windows	3	4	5	6	9	10
Number of houses	16	23	18	23	8	17

TABLE 5.10. Data for a Wilson χ^2 test for the relationship between the number of windows observed to be open and the number of openable windows

Number of openable windows	3	4	5	6	9	10
Number above sample median	0	17	10	15	2	13
Number below sample median	16	14	8	8	6	4

TABLE 5.11. Relationship between house type and percentage of total open windows

House type	Btm flat	4P 2S	Btm flat	Top flat	4P 3S	6P 3S	Top flat	4 person
Estate	C	C	M	C	C	C	M	M
$\bar{x}$ No. windows	3	5	4.2	5	6	6	9.2	10
% open	10.4	33.3	26.8	23.3	23.9	30.2	13.1	18.7

$\bar{x}$ = mean C = Cowley M = Mezen

TABLE 5.12. Data for a Wilson χ^2 test for the relationship between the percentage of total open windows and the number of openable windows

n windows	3	4	5	6	9	10	Total
Above median	3	21	10	14	2	7	57
Below median	13	10	8	9	6	10	56

5.4.3. Window Opening in Specified Room Types

Window opening in the sittingroom, kitchen and main bedroom as well as total window opening will be discussed in this section.

5.4.3.1. Mean percentage of open window observations

Table 5.13 gives the mean percentage of total open window observations at Cowley and Mezen (N = 100 days in each case). The mean percentage of open window observations in the three room types is also given. As an illustration of the derivation of values in table 5.13, it can be seen from table 5.14 that there were 117 sittingroom windows on the Cowley estate, some houses having one sittingroom window, others

TABLE 5.13. Mean percentage of open window observations at Cowley and Mezen

Estate	Mean percentage of open window observations			
	SIT	KIT	B1	TOTAL
Cowley	12.6	28.4	36.9	25.8
Mezen	10.0	21.7	23.8	18.1

TABLE 5.14. Number of openable windows in specified room types at Cowley and Mezen

Estate		Room type			TOTAL
		SIT	KIT	B1	
Cowley N = 78 households	Sample distribution	1w x 39d 2w x 39d	1w x 78d	1w x 78d	3w x 16d 4w x 23d 5w x 16d 6w x 23d
	Total no. on estate	117	78	78	358
Mezen N = 35 households	Sample distribution	1w x 25d 2w x 10d	1w x 23d 2w x 4d 3w x 8d	1w x 10d 2w x 25d	4w x 9d 5w x 2d 9w x 8d 10w x 17d
	Total no. on estate	45	55	60	284

w = window, d = dwelling, B1 = main bedroom

having two. This generates a theoretical maximum of 117 times one hundred open window observations, over one hundred days. The actual number of open windows observed was 1468, giving a percentage of

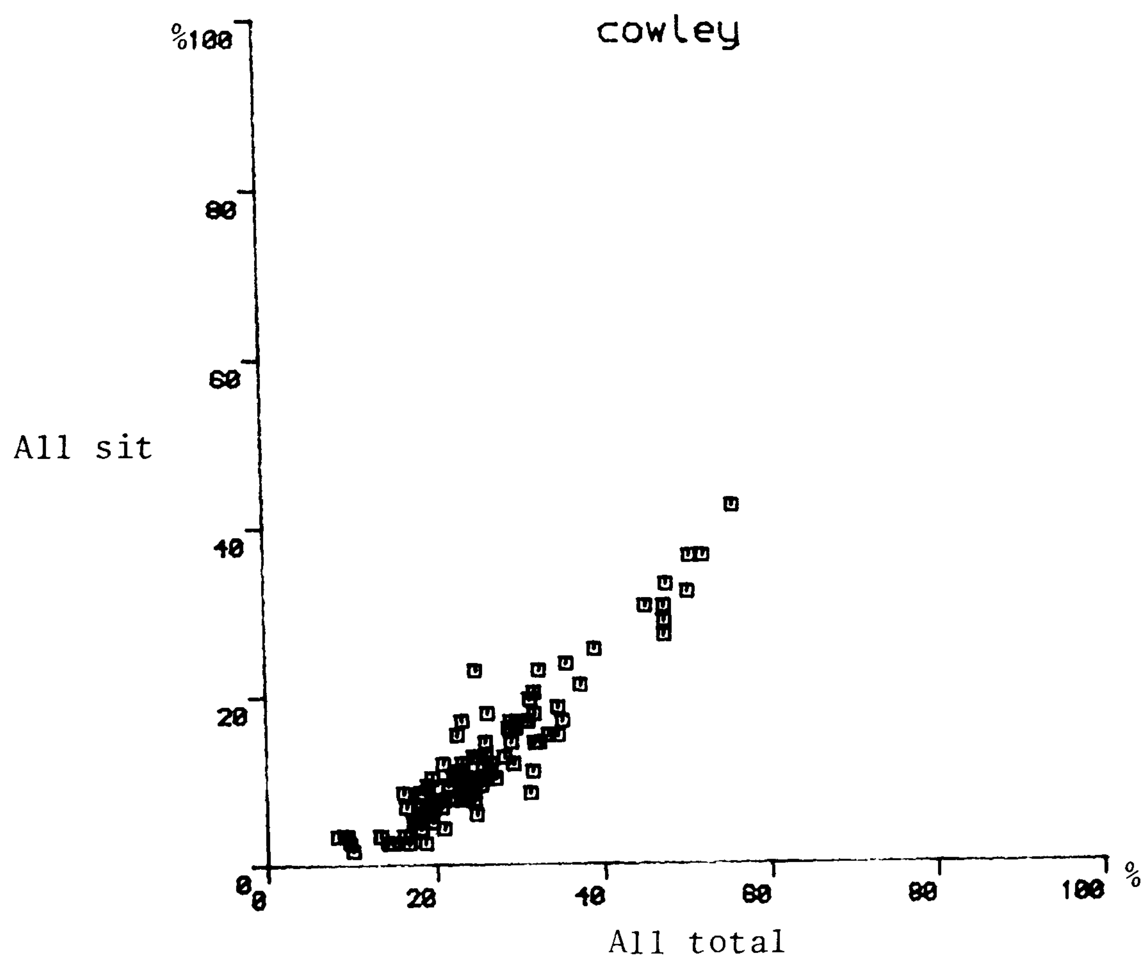
$$\frac{1468 \times 100}{117 \times 100} \text{ or } 12.6\%$$

The table shows that on both estates, the windows in the main bedroom were open more frequently than those in either the sittingroom or kitchen. This finding is in agreement with Brundrett's observations (1977) and Hunt's analysis of reported data (1980). The sittingroom windows were seldom observed to be open. When window opening is measured as described above, the Cowley estate has a higher level of window opening than Mezen. The results for the two estates will therefore continue to be shown separately.

5.4.3.2. Inter-relationships between window opening in different room types

Householders have been shown to be fairly consistent in terms of their daily window opening (5.4.2.2.). Figures 5.37 to 5.42 show that this consistency extends across room types; that is, there is a strong positive relationship between window opening in different rooms. Each diagram has one hundred points. The percentage scores on each axis represent the number of open window observations on a given day in relation to the maximum possible number of open window observations for the estate shown. Tables 5.15 and 5.16 show the corresponding correlation coefficients. The results confirm the hypothesis that householders adopted general window opening levels. Thus, for example, householders who had their bedroom windows open for a high proportion of observations, tended to have other windows open for similarly high proportions of observations. These correlations do not necessarily indicate that windows in different room types are open simultaneously, though this may well be the case. The table shows an unusually low correlation between main bedroom(B1) and sittingroom window opening at Mezen. Potential explanations include an added factor of security for ground floor rooms, and the location of

FIGURE 5.37(a) & (b). Relationship between total and sittingroom window opening at a) Cowley and b) Mezen



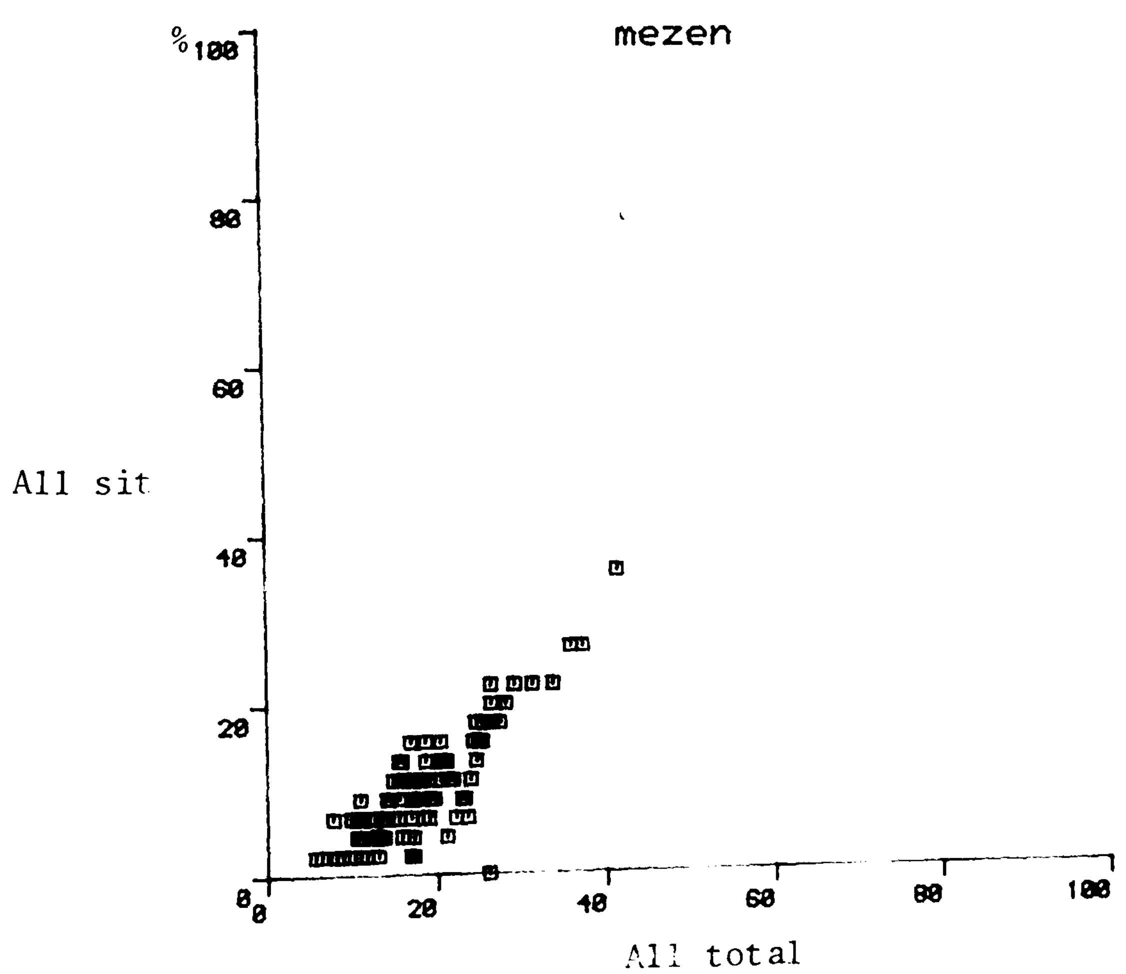
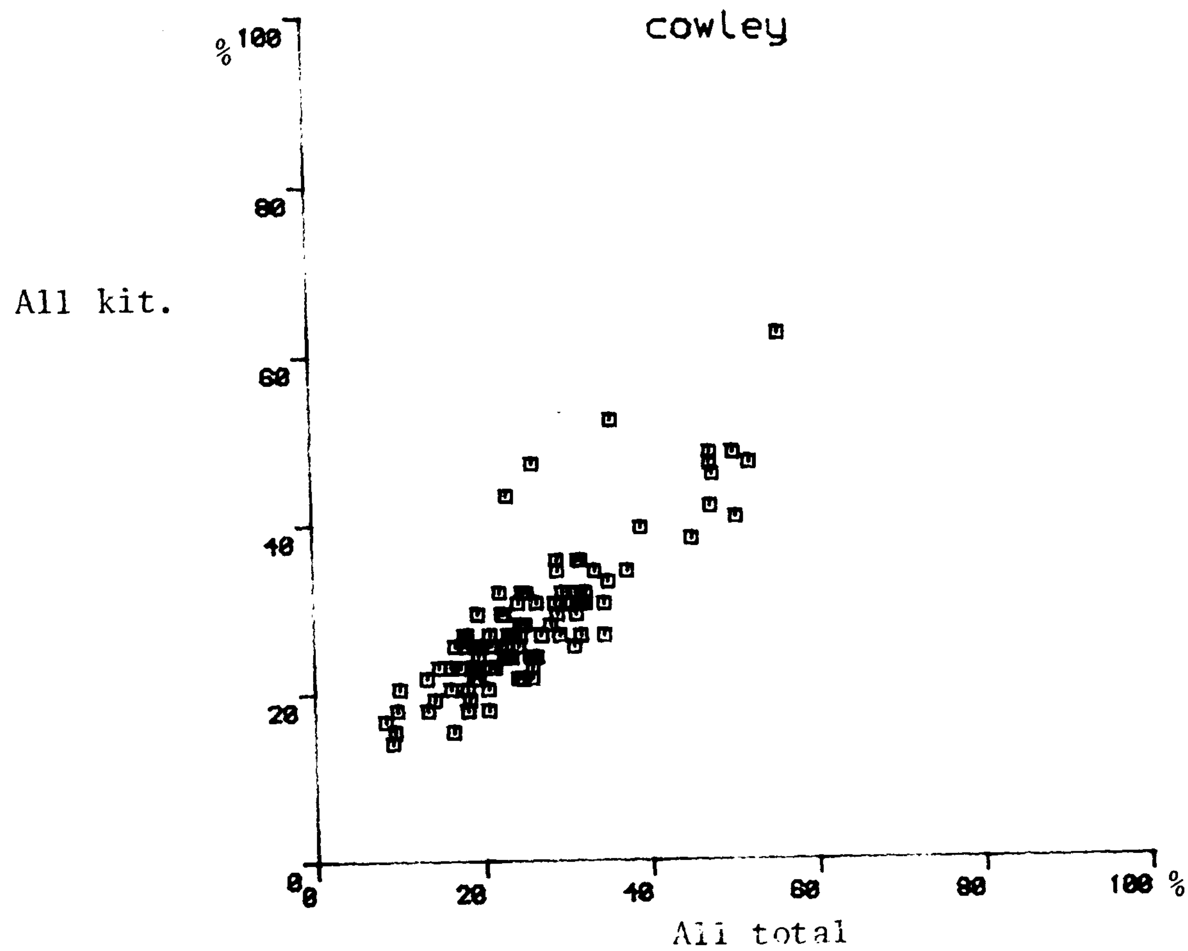


FIGURE 5.38(a) & (b). Relationship between total and kitchen window opening at a) Cowley and b) Mezen



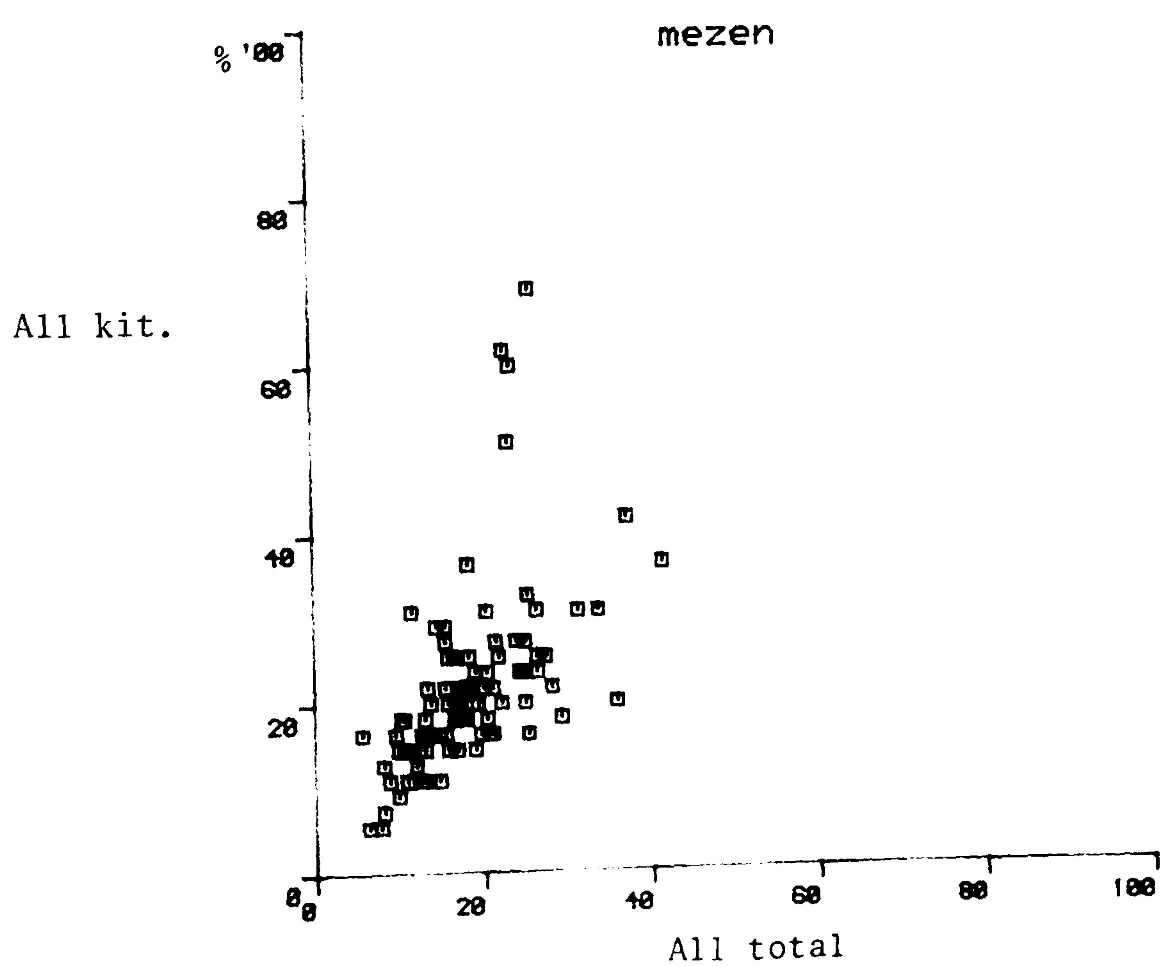
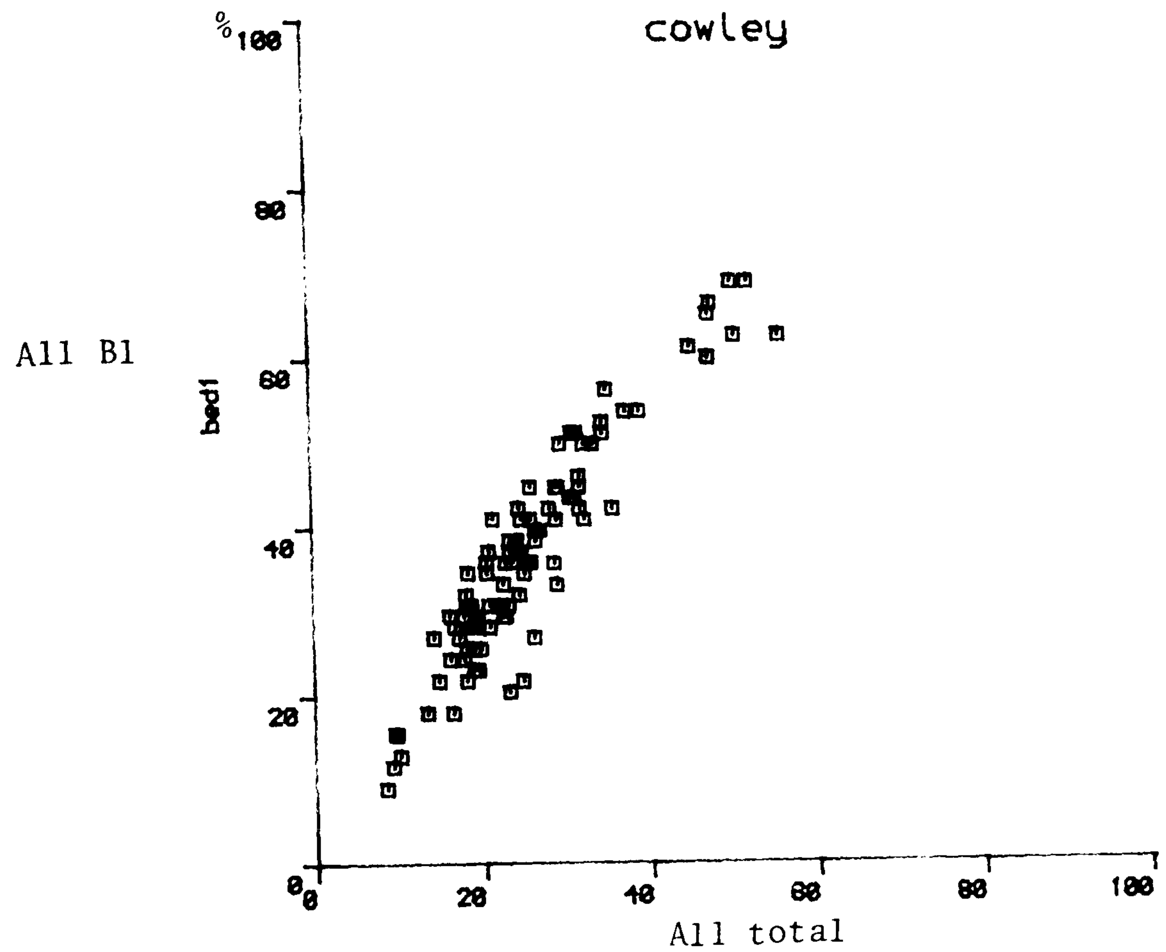


FIGURE 5.39(a) & (b). Relationship between total and main bedroom window opening at a) Cowley and b) Mezen



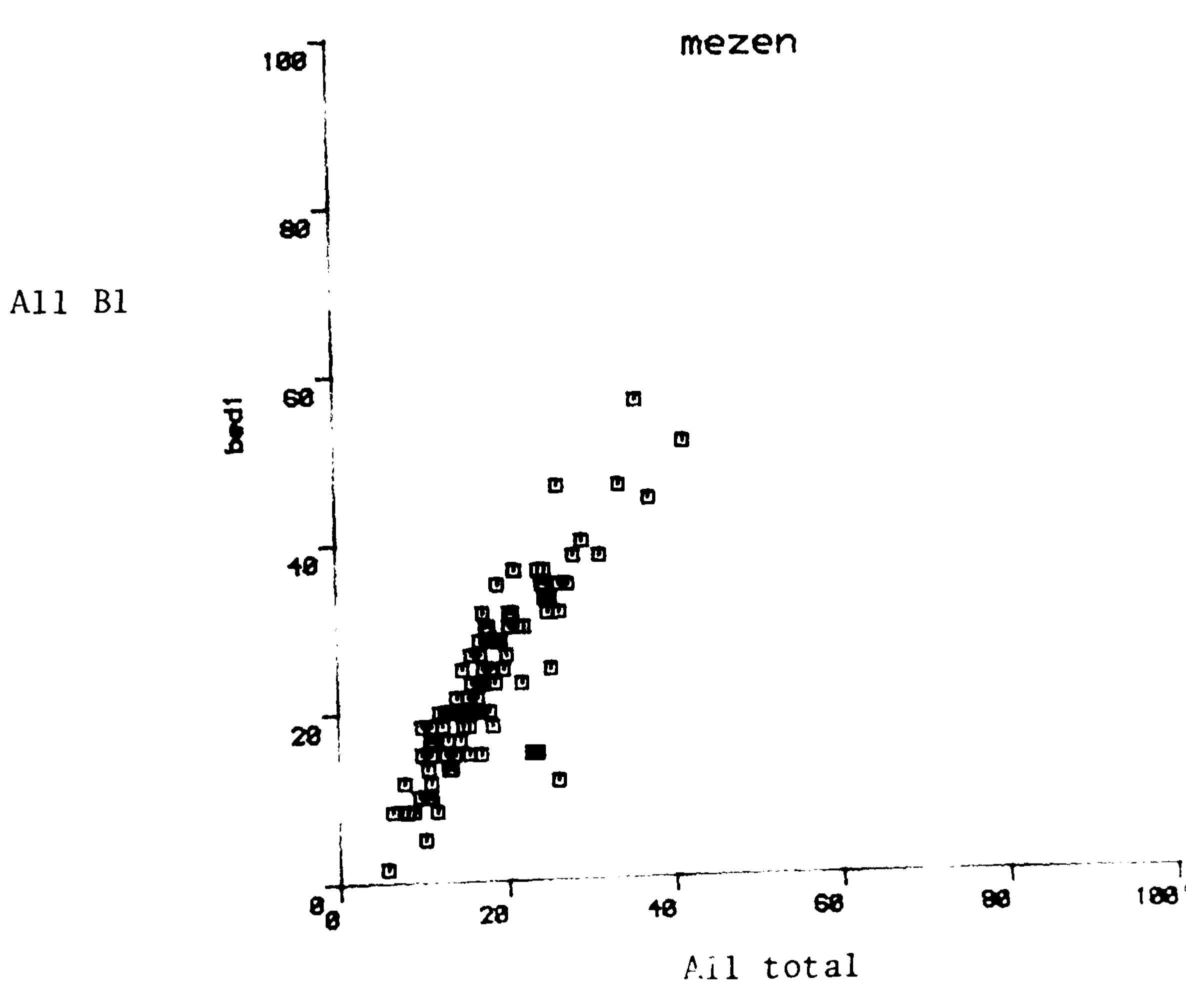
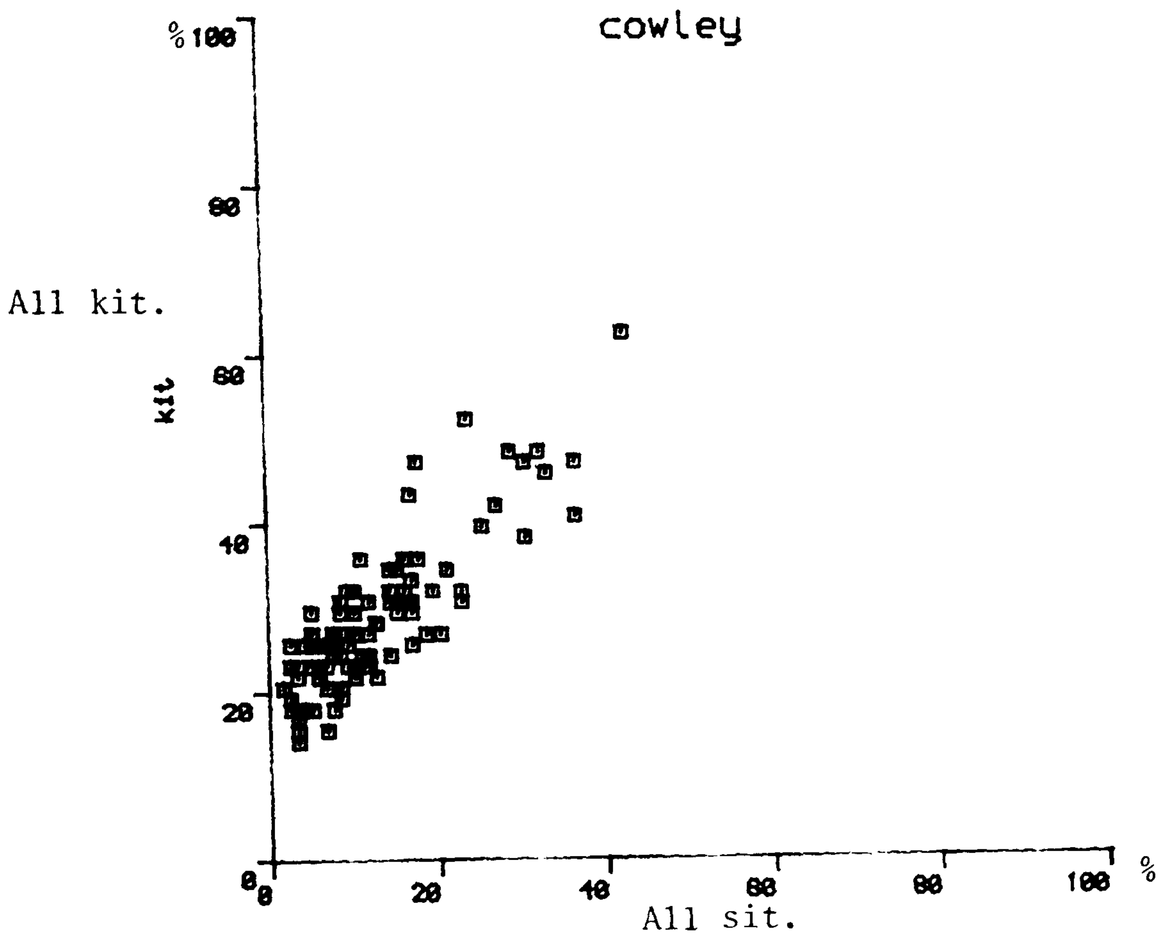


FIGURE 5.40(a) & (b). Relationship between sittingroom and kitchen window opening at a) Cowley and b) Mezen



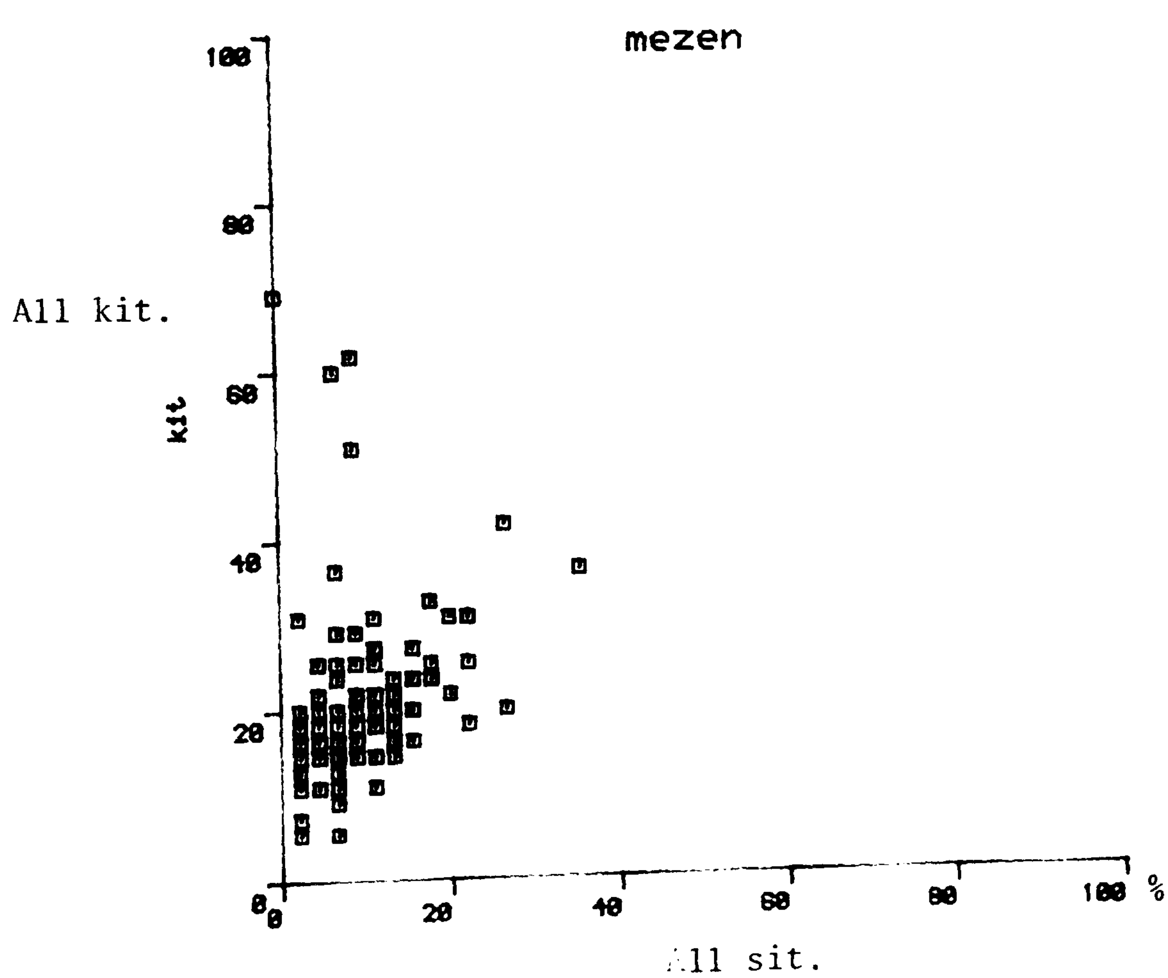
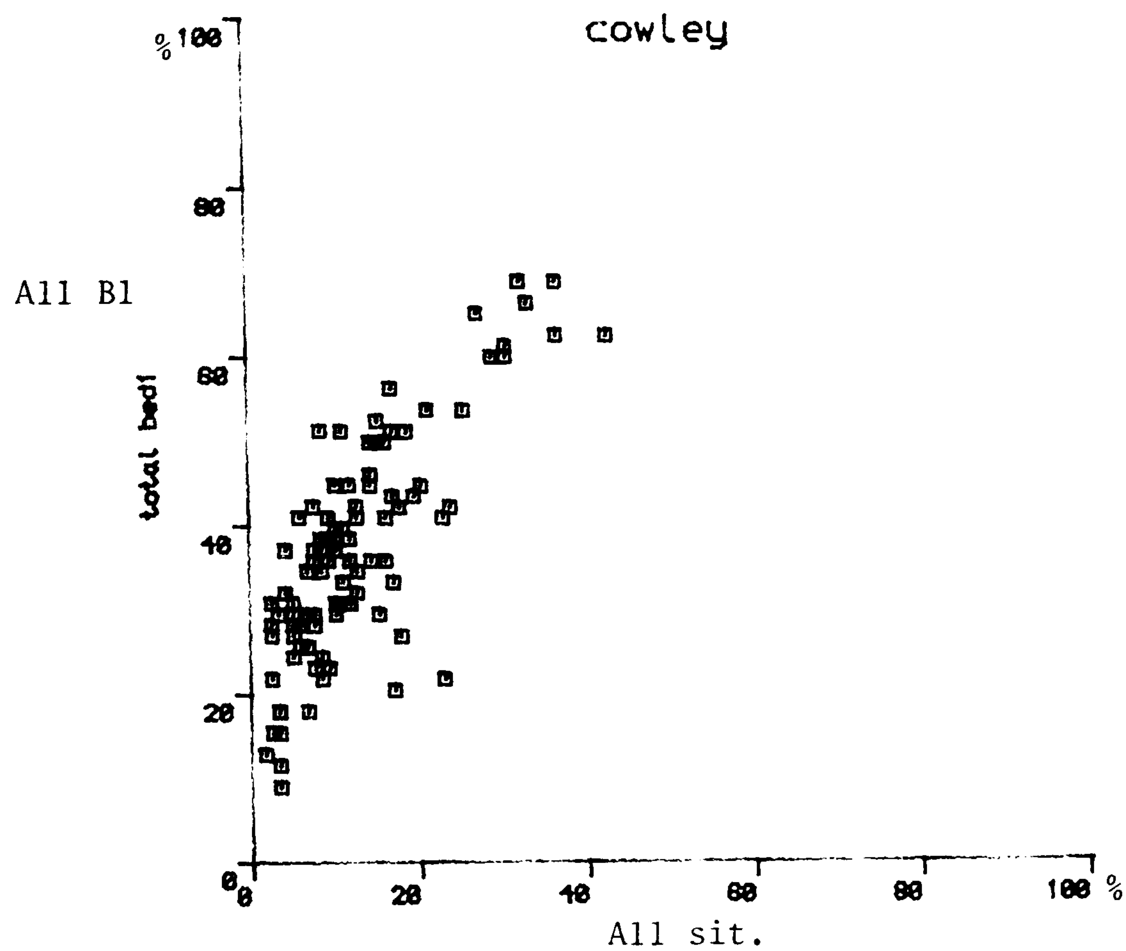


FIGURE 5.41(a) & (b). Relationship between sittingroom and main bedroom window opening at a) Cowley and b) Mezen



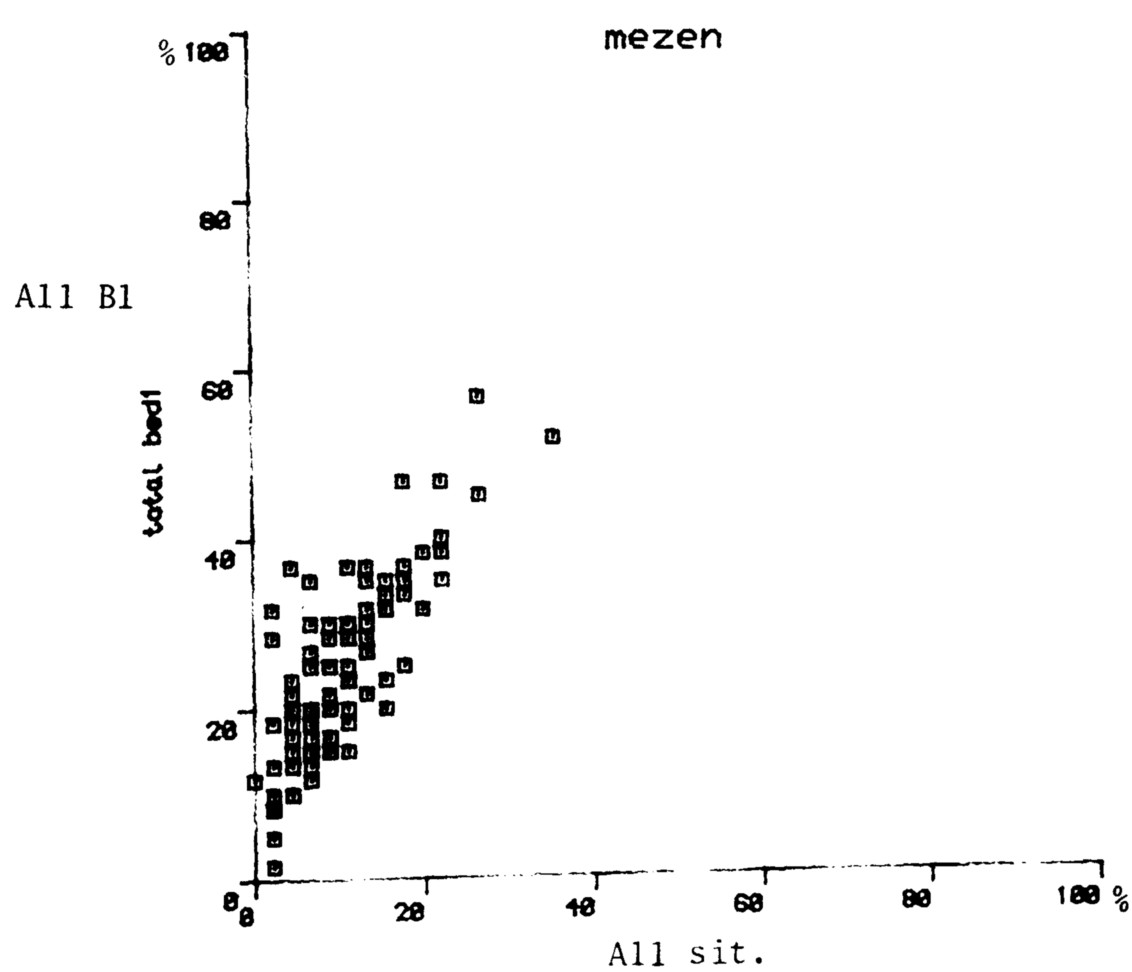
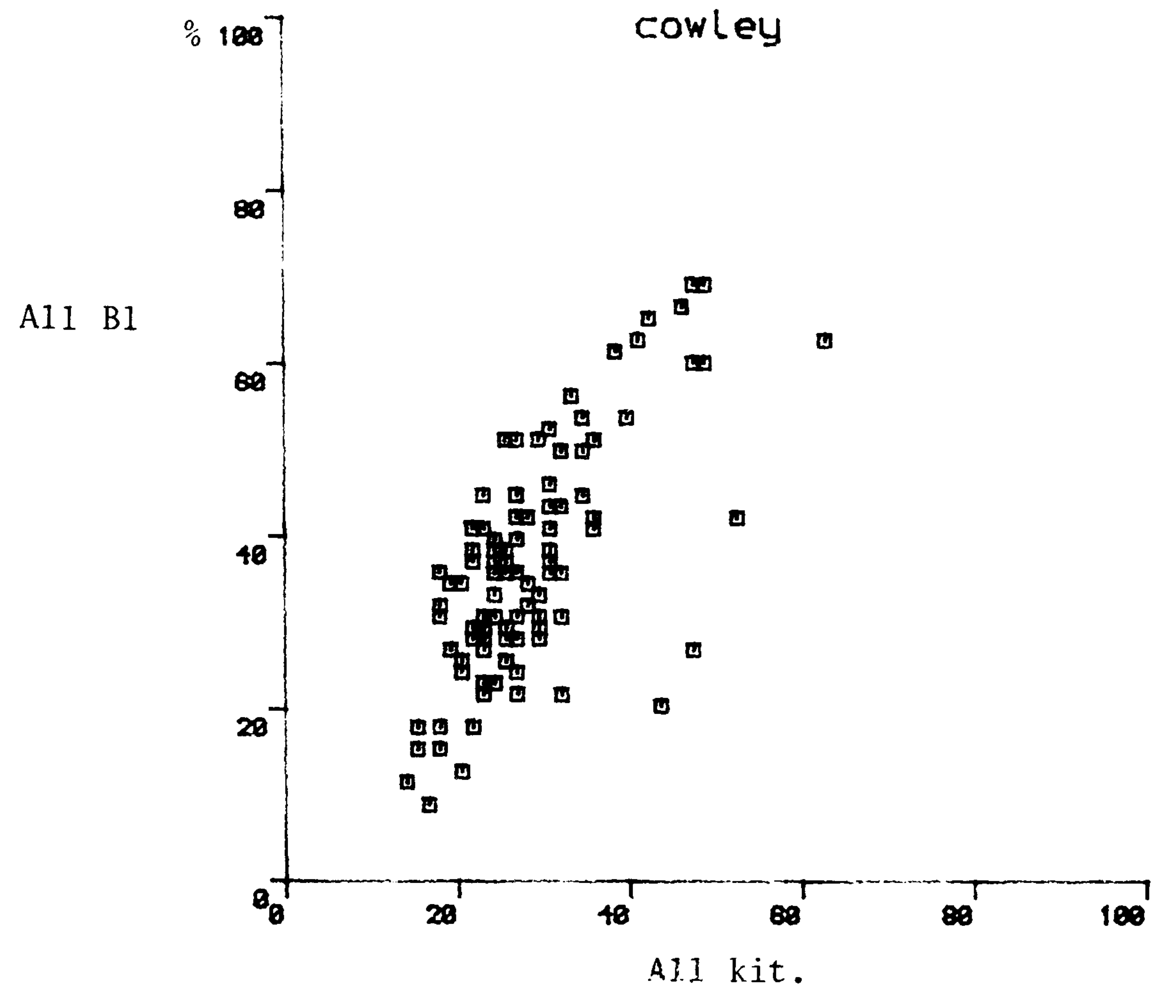
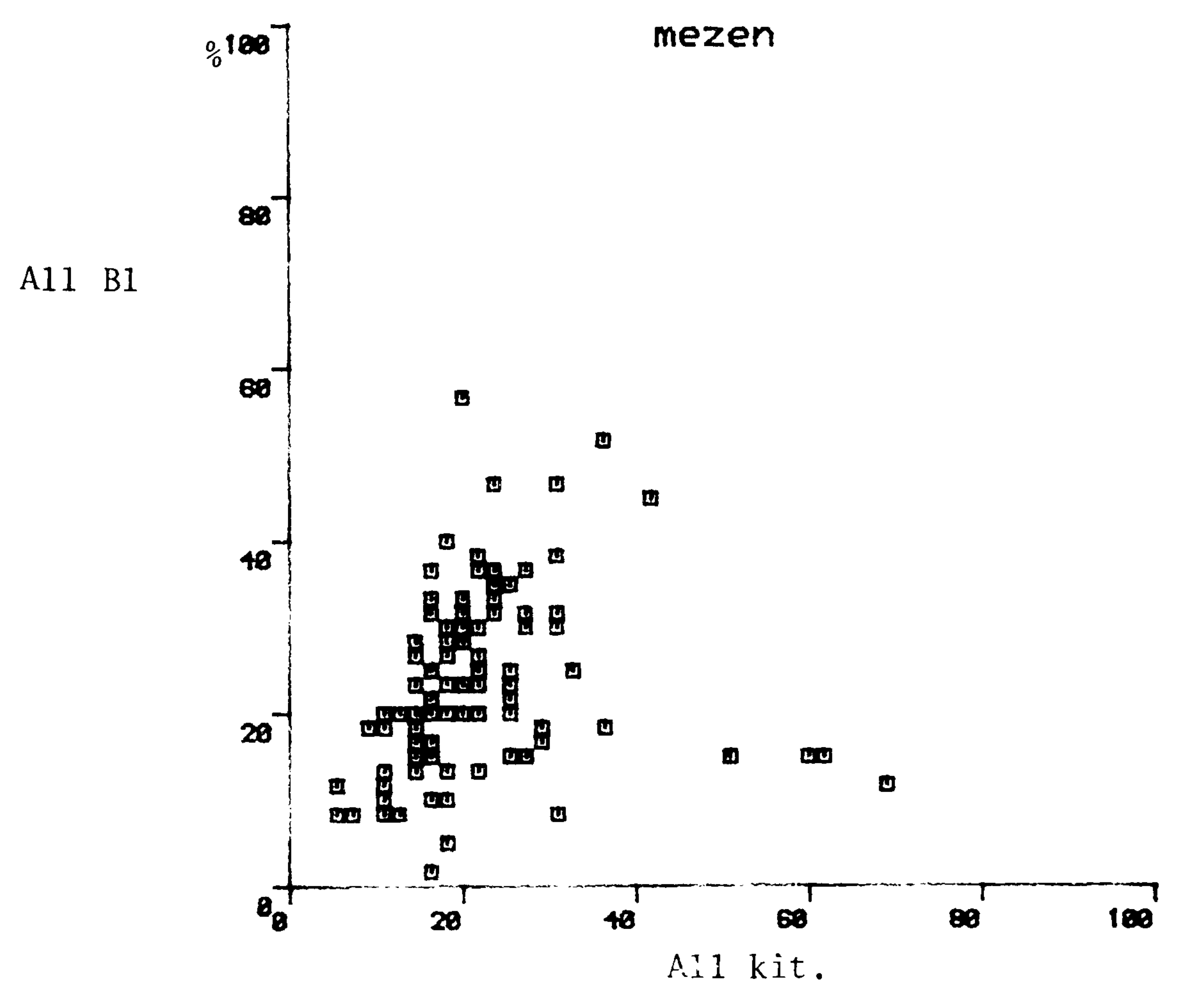


FIGURE 5.42(a) & (b). Relationship between kitchen and main bedroom window opening at a) and b) Mezen





radiators (Chapter 4). However, these factors do not appreciably differ between the two estates, and no explanation for the low correlation can therefore be offered.

TABLE 5.15. Correlation coefficients obtained between window opening in different room types at Cowley (N = 78)

Room type	Room type			
	SIT	KIT	B1	Total
SIT		.36**	.50**	.71**
KIT			.42**	.63**
B1				.85**

** $p < .01$

TABLE 5.16. Correlation coefficients obtained between window opening in different room types at Mezen (N = 35)

Room type	Room type			
	SIT	KIT	B1	Total
SIT		.41**	.14	.49**
KIT			.53**	.72**
B1				.79**

** $p < .01$

Several of the scattergrams in figures 5.37 to 5.42 immply a linear relationship for which the approximate gradient and intercept terms may be judged by eye. In the cases where both axes refer to individual rooms, the intercept suggests a simple interpretation. For example, figure 5.40(a) suggests that twenty per cent of kitchen windows are open on the estate before a significant number of sittingroom windows begin to be opened. Once this point has been reached, sittingroom and kitchen windows are then opened in similar proportions. Figure 5.42(a) suggests that there are always about twice the number of main bedroom windows open as kitchen windows (one window per room in each case). The scattergrams in figure 5.42(a) and (b) both have four anomalous points. These are data points for days 5, 16, 18 and 19 at Cowley and 17 to 20 at Mezen. Inspection of table A8 reveals that the temperature was well above the median for the hour of observation on each of these days and that additionally, all eight observations were made around meal times. These two factors are regarded as possible explanations for the unusually high levels of kitchen window opening.

5.4.3.3. Relationship between window opening in room types and hour of observation

The correlation coefficients for the relationships between open window observations in different room types and hour of observation are shown in table 5.17. Only three of these correlations are significant (two tailed test, df = 98, $p < .01$). The results of questionnaire data (5.5.3.3.1) show that with the exception of bedroom windows, most windows are closed at night. One would therefore expect to find the mean percentage of open windows to rise in the early part of the day and to fall at night, producing an inverted U-shaped graph. Figures 5.47 to 5.50 for Mezen do not show such a relationship. The curves indicate little change with time of day although there is a suggestion of increased window opening at meal times. In all four diagrams (Figures 5.43 to 5.46) for Cowley, there is a suggestion of an inverted 'U'-shaped relationship. It is possible that this shape would have emerged more clearly had it been practical to collect data over a wider range of hours. It is appreciated that the correlations in table 5.17 are highly dependent on the restricted range of hours chosen (9 a.m. to 6 p.m.) and

FIGURE 5.43. Relationship between sittingroom window opening and hour of observation at Cowley

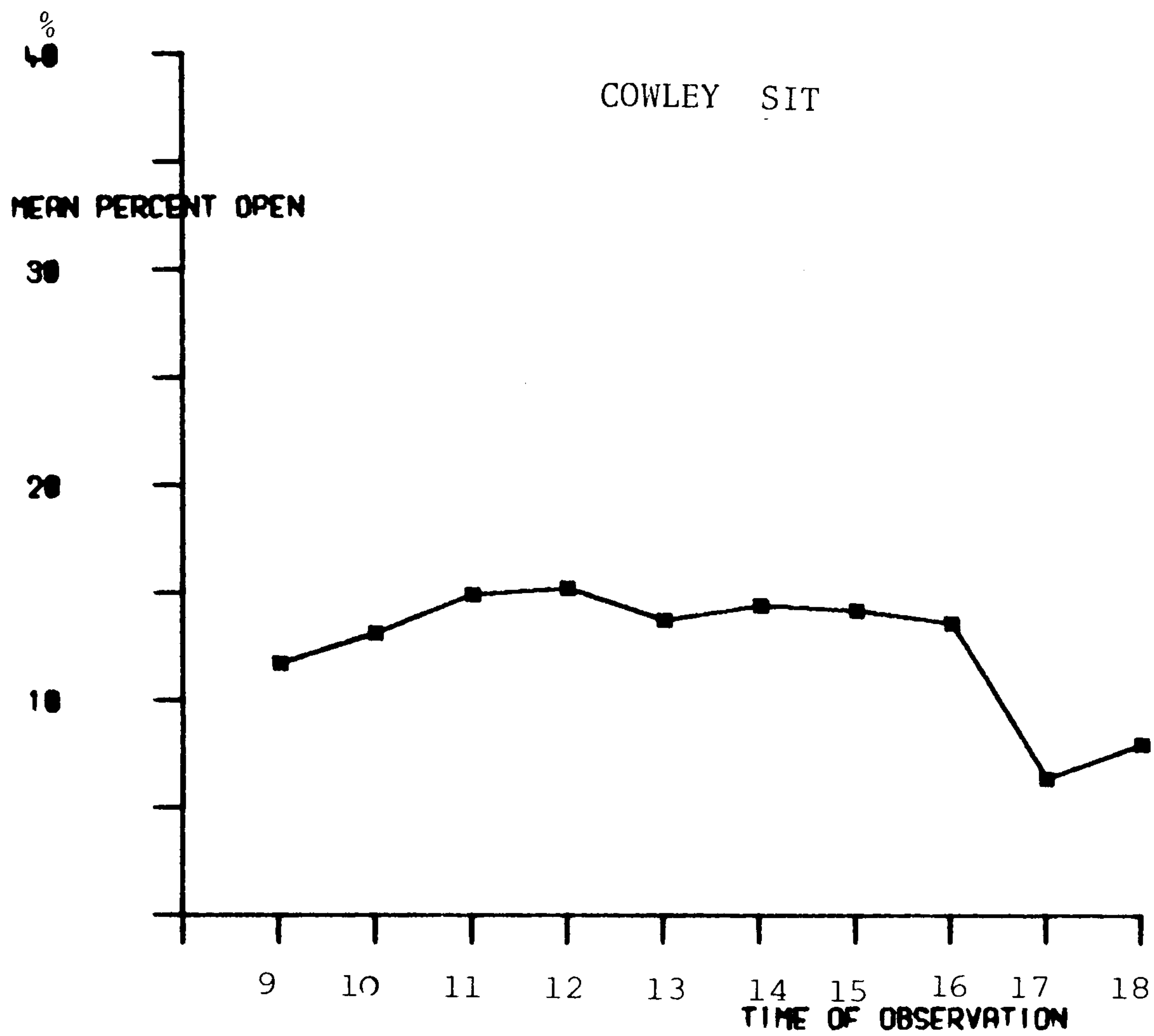


FIGURE 5.44. Relationship between kitchen window opening and hour of observation at Cowley

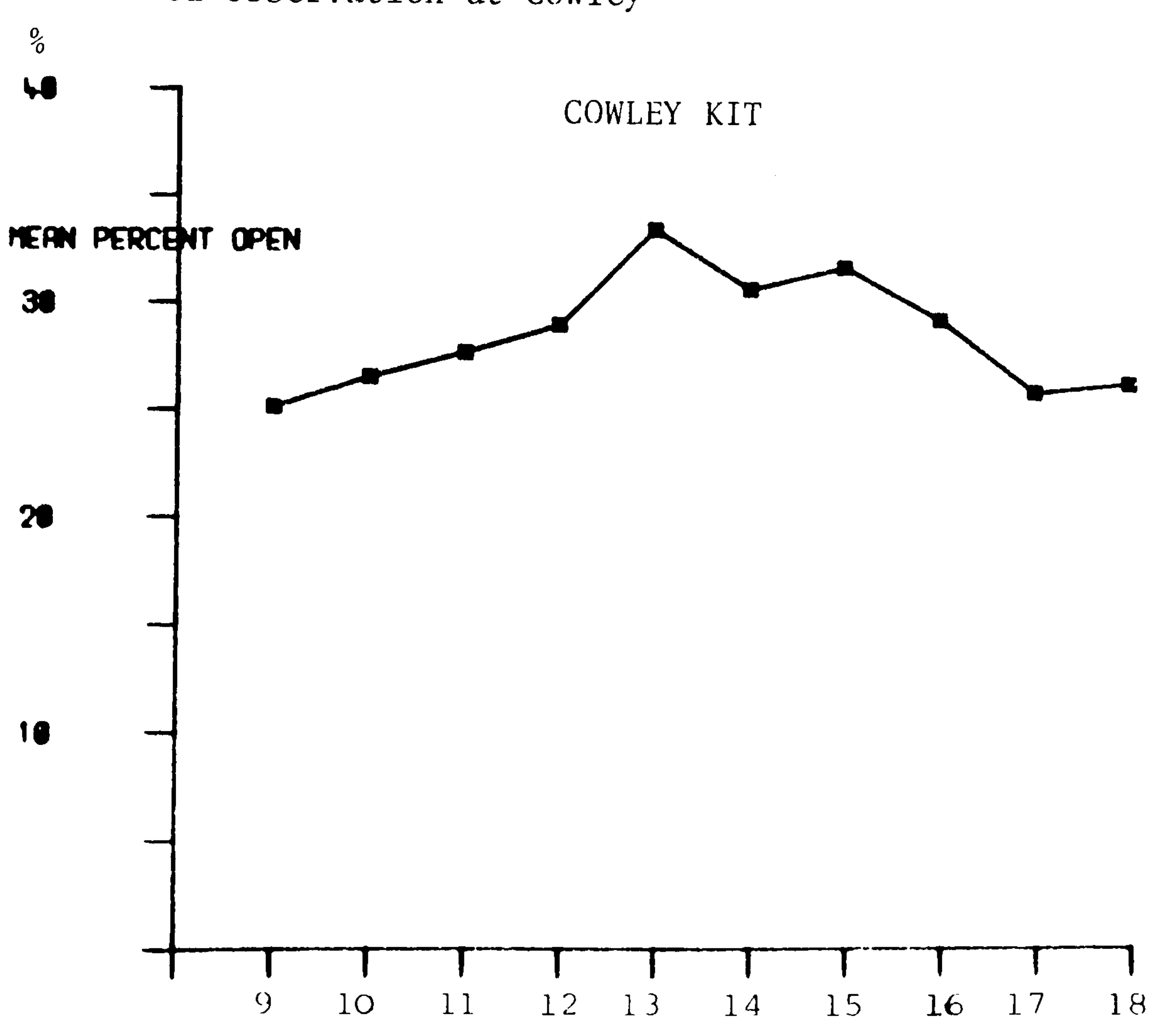


FIGURE 5.45. Relationship between main bedroom window opening and hour of observation at Cowley

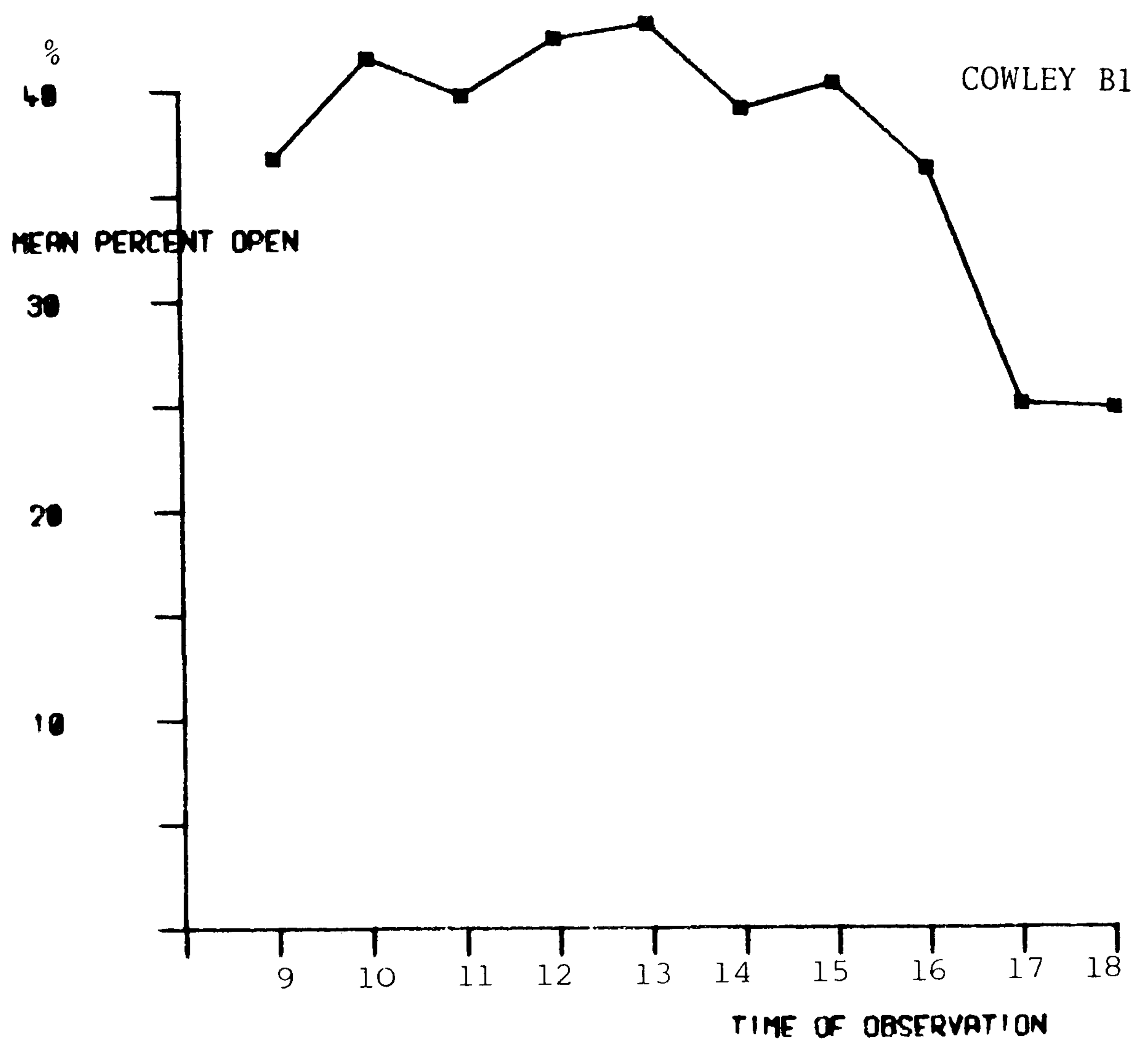


FIGURE 5.46. Relationship between total window opening and hour of observation at Cowley

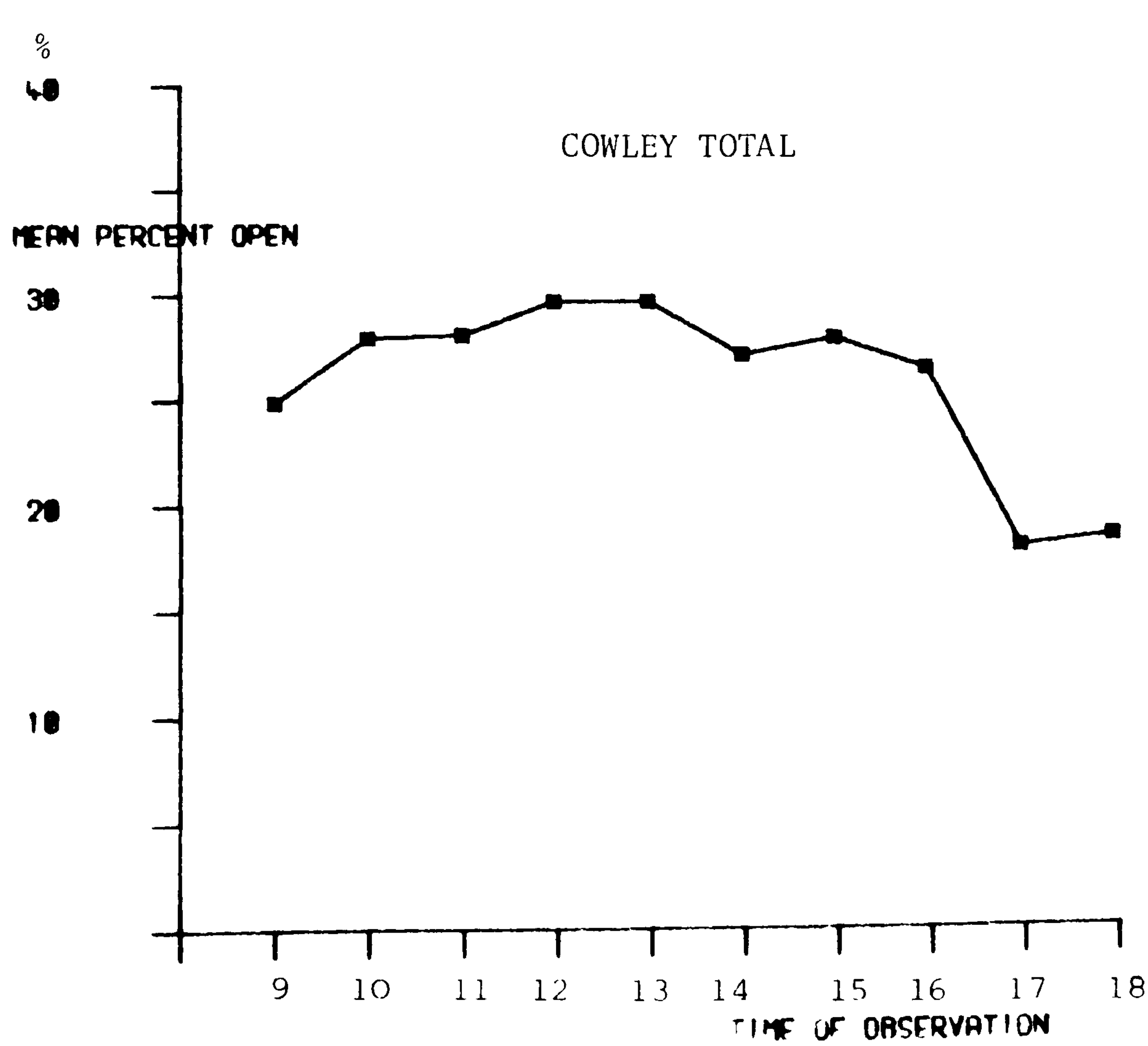


FIGURE 5.47. Relationship between sittingroom window opening and hour of observation at Mezen

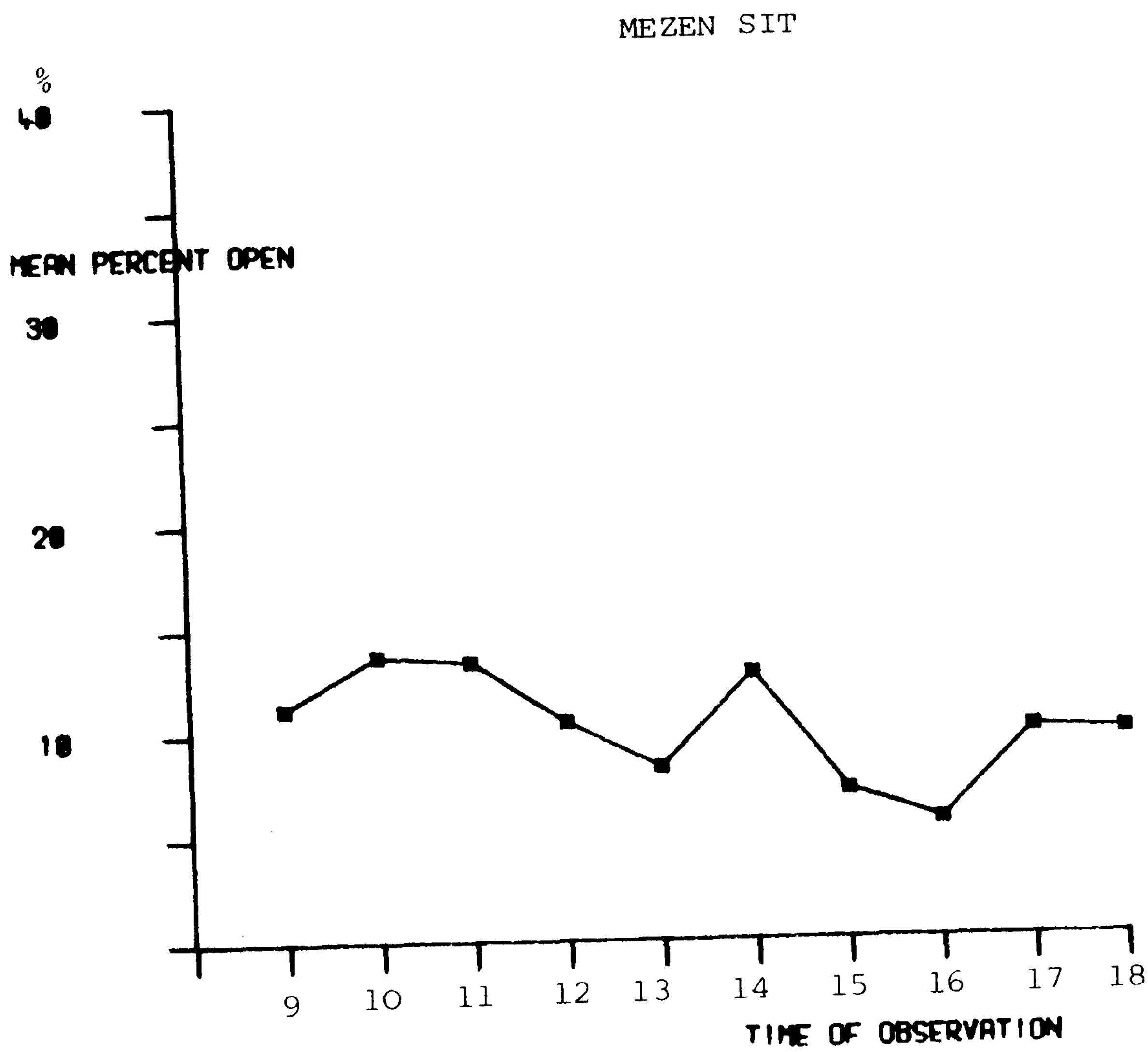


FIGURE 5.48. Relationship between kitchen window opening and hour of observation at Mezen

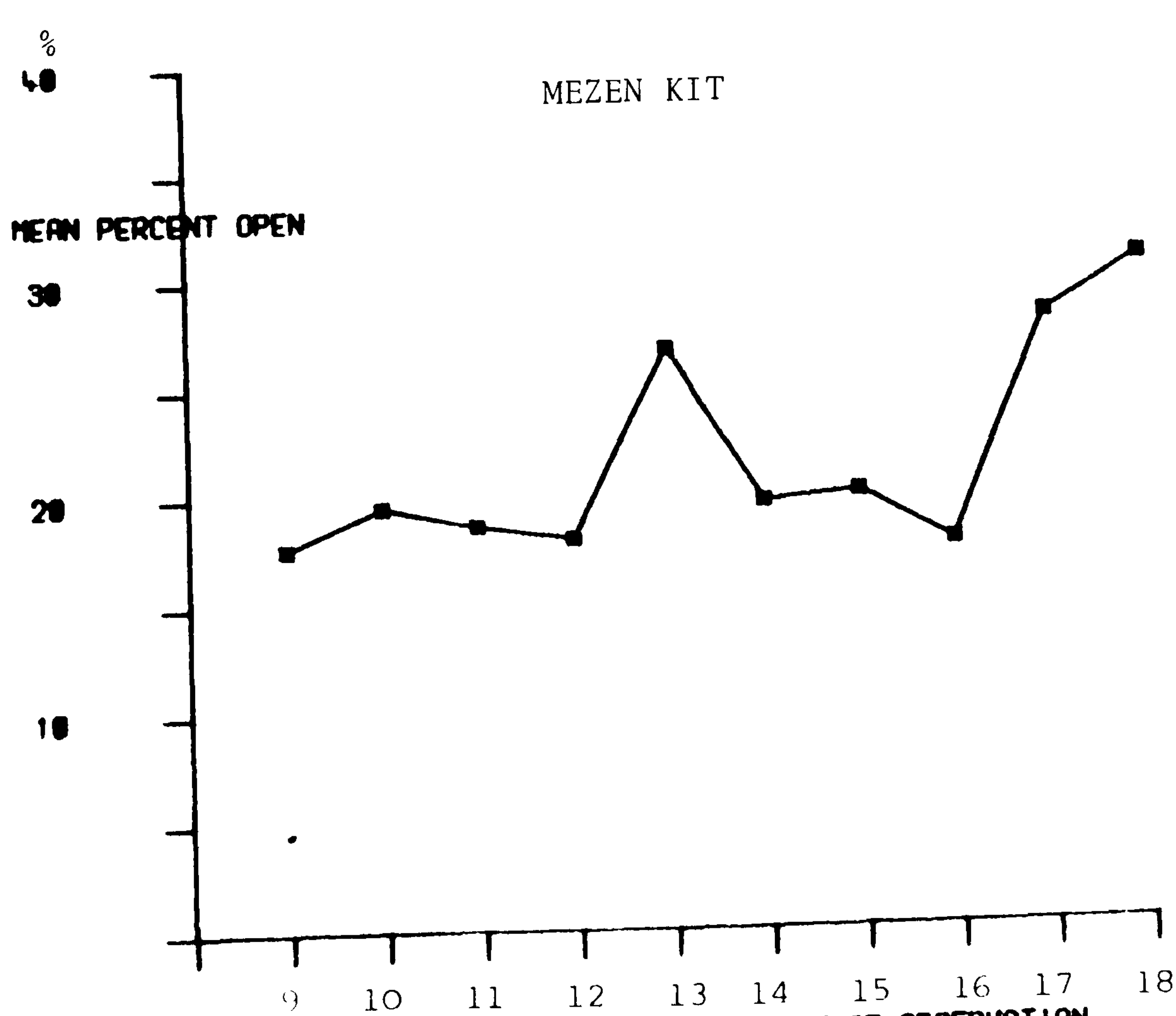


FIGURE 5.49. Relationship between main bedroom window opening and hour of observation at Mezen

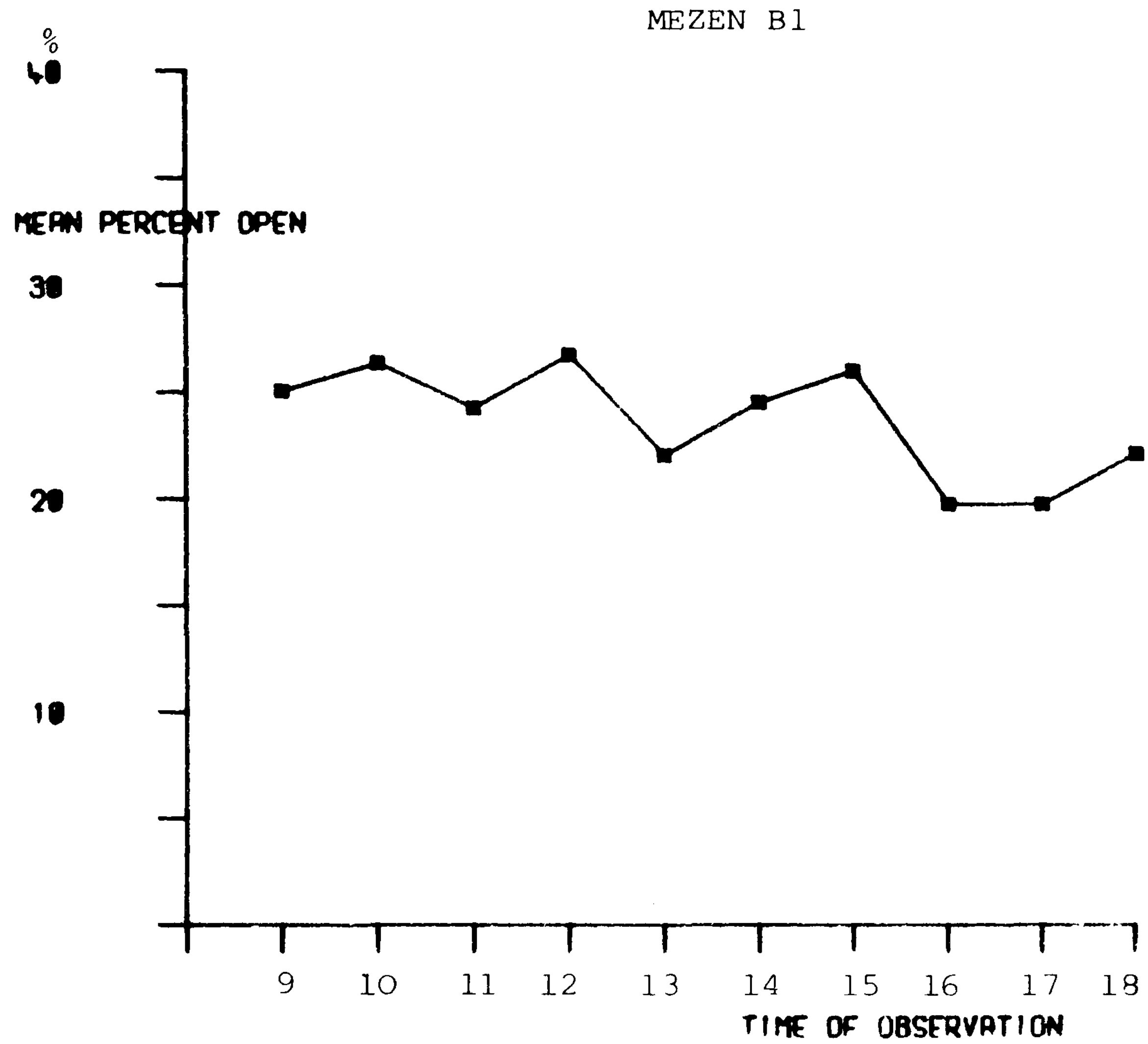
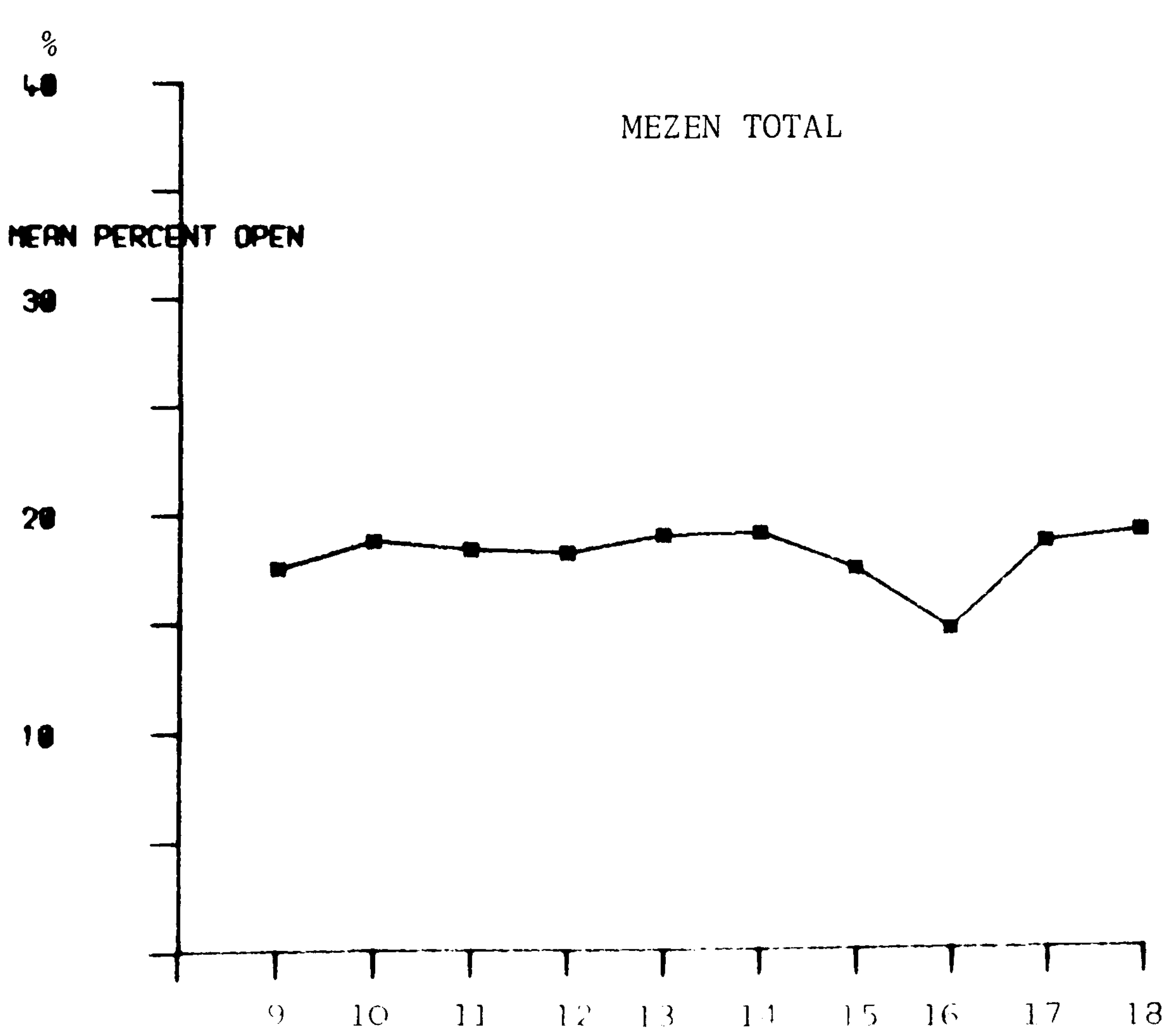


FIGURE 5.50. Relationship between total window opening and hour of observation at Mezen



that figures 5.43 to 5.50 are therefore more meaningful than these correlations.

TABLE 5.17. Correlation coefficients obtained between window opening in room types and hour of observation

Room type	Estate	
	Cowley	Mezen
SIT	.18	.19
KIT	.03	.29**
B1	.33**	.18
Total	.26**	-.02

** $p < .01$

5.4.4. Relationships Between Window Opening and Weather Parameters

This section deals with the relationships between window opening and the five weather parameters (temperature, relative humidity, windspeed, sunshine duration and rainfall) for three room types (sittingroom, kitchen, main bedroom) and total (all windows in each dwelling).

Table 5.18 shows the correlation coefficients obtained between open window observations, and weather parameter values at the hour of observation. The correlations between open window observations and external air temperature are highly significant and take high values for all room types on both estates (one tailed test, df = 98, $p < .01$). The results for other weather parameters differ according to estate and room type. All the correlations for relative humidity are negative. Under a null hypothesis that relative humidity had no effect, this represents a probability of one in 256. Also, four of the correlations are highly significant. Similarly, the correlation coefficients for

TABLE 5.18. Correlation coefficients obtained between window opening in specified room types and weather parameter values at the hour of observation

Weather parameter	Estate	Room type SIT	KIT	B1	TOTAL
Temperature	Cowley	.76**	.73**	.66**	.74**
	Mezen	.57**	.53**	.62**	.73**
Relative humidity	Cowley	-.20*	-.13	-.22*	-.23**
	Mezen	-.24**	-.07	-.31**	-.32**
Windspeed	Cowley	-.13*	-.23**	-.08	-.15
	Mezen	-.17*	-.12	-.09	-.17*
Sunshine duration	Cowley	.32**	.19*	.35**	.36**
	Mezen	.26**	-.13	.15	.12
Rainfall	Cowley	.17*	.15	.14	.14
	Mezen	-.08	.02	-.10	-.06

** $p < .01$

* $p < .05$

windspeed are all negative, though only one is highly significant. Seven of the sunshine duration correlations are positive; four are highly significant. However, there is no apparent relationship between rainfall and open window observations on either estate. These findings agree with the results of earlier studies (Brundrett, 1977; Dick & Thomas, 1951).

Figures 5.51 to 5.55 show third order polynomial fits of the open window observations for each room type against each of the five weather parameters. Figures A8 to A167 include diagrams of polynomial curves superimposed on the raw data for figures 5.51 to 5.55. It must be noted that for any one weather parameter, values are not uniformly spread over

FIGURE 5.51(a) & (b). Relationship between temperature and window opening in specified room types at a) Cowley and b) Mezen

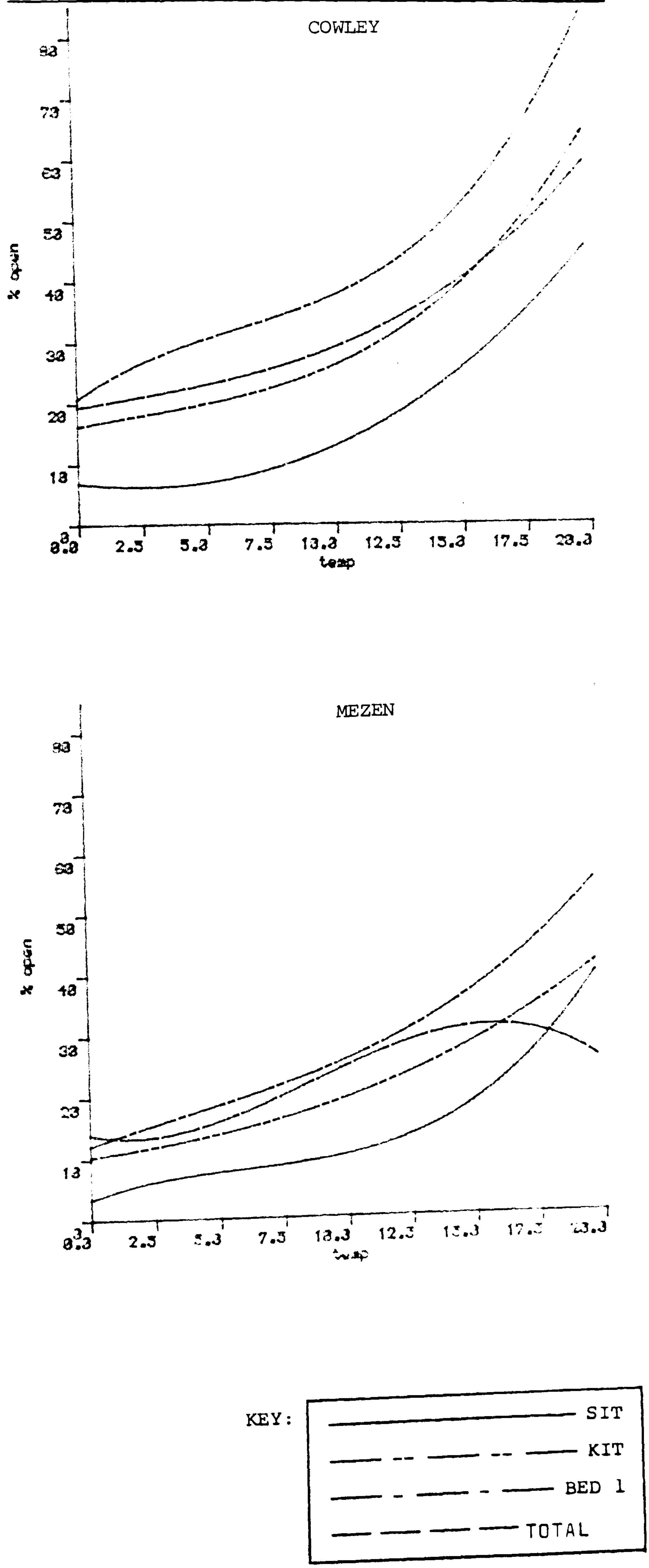


FIGURE ~~5.52 (a) & (b)~~. Relationship between relative humidity and window opening in specified room types at a) Cowley and b) Mezen

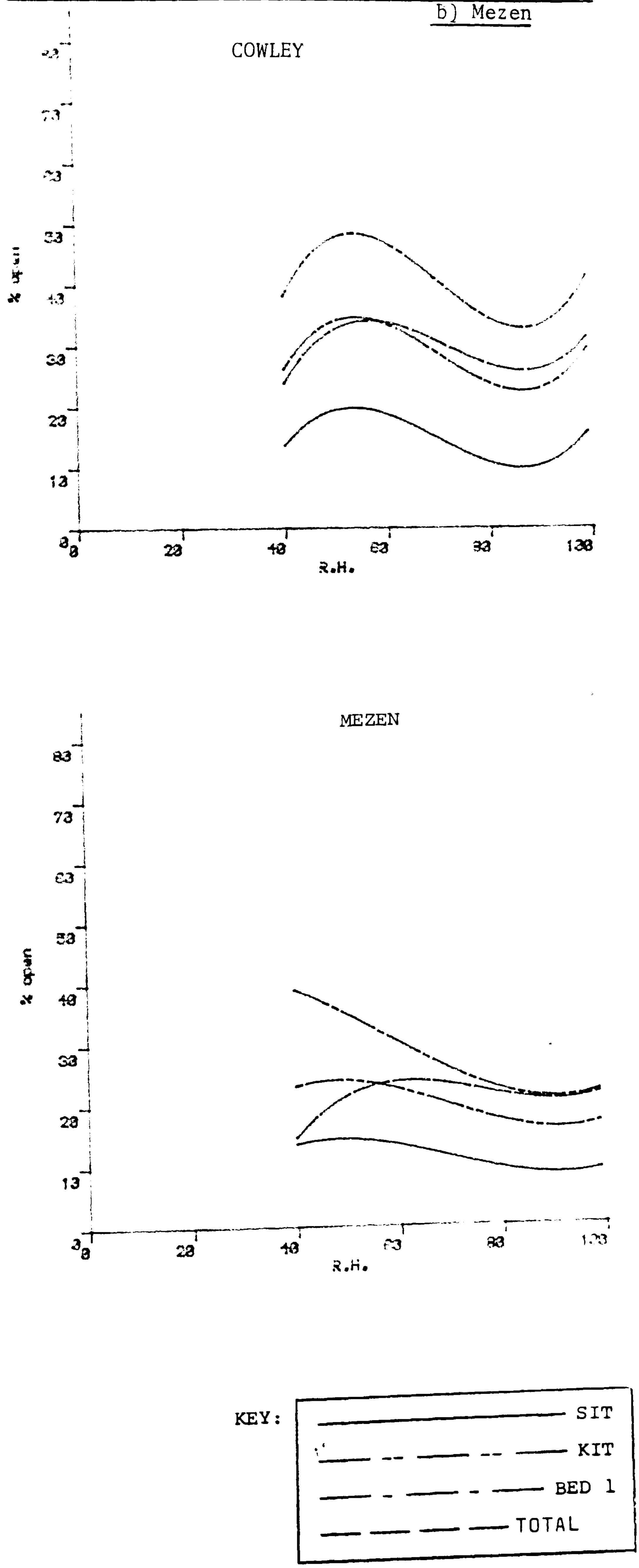


FIGURE 5.53(a) & (b). Relationship between windspeed and window opening in specified room types at a) Cowley and b) Mezen

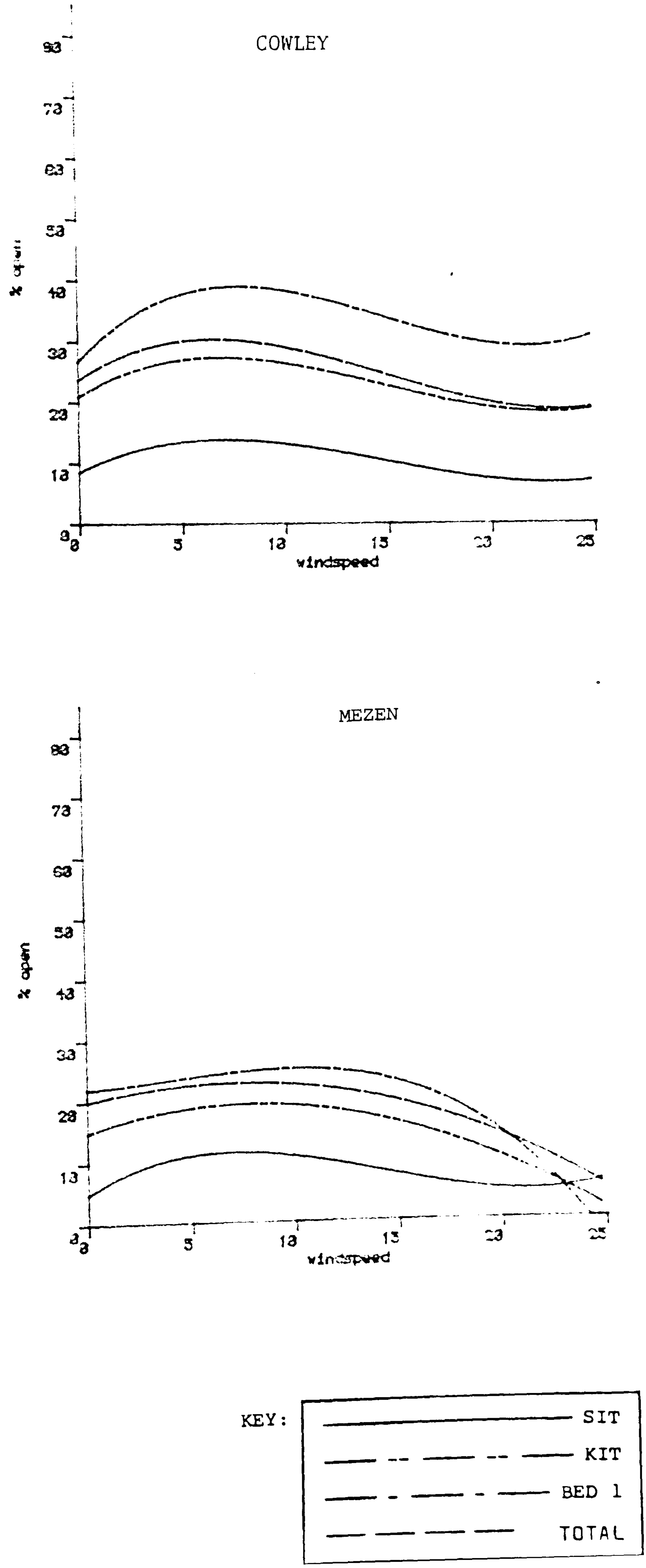


FIGURE 5.54(a) & (b). Relationship between sunshine duration and window opening in specified room types at a) Cowley and b) Mezen

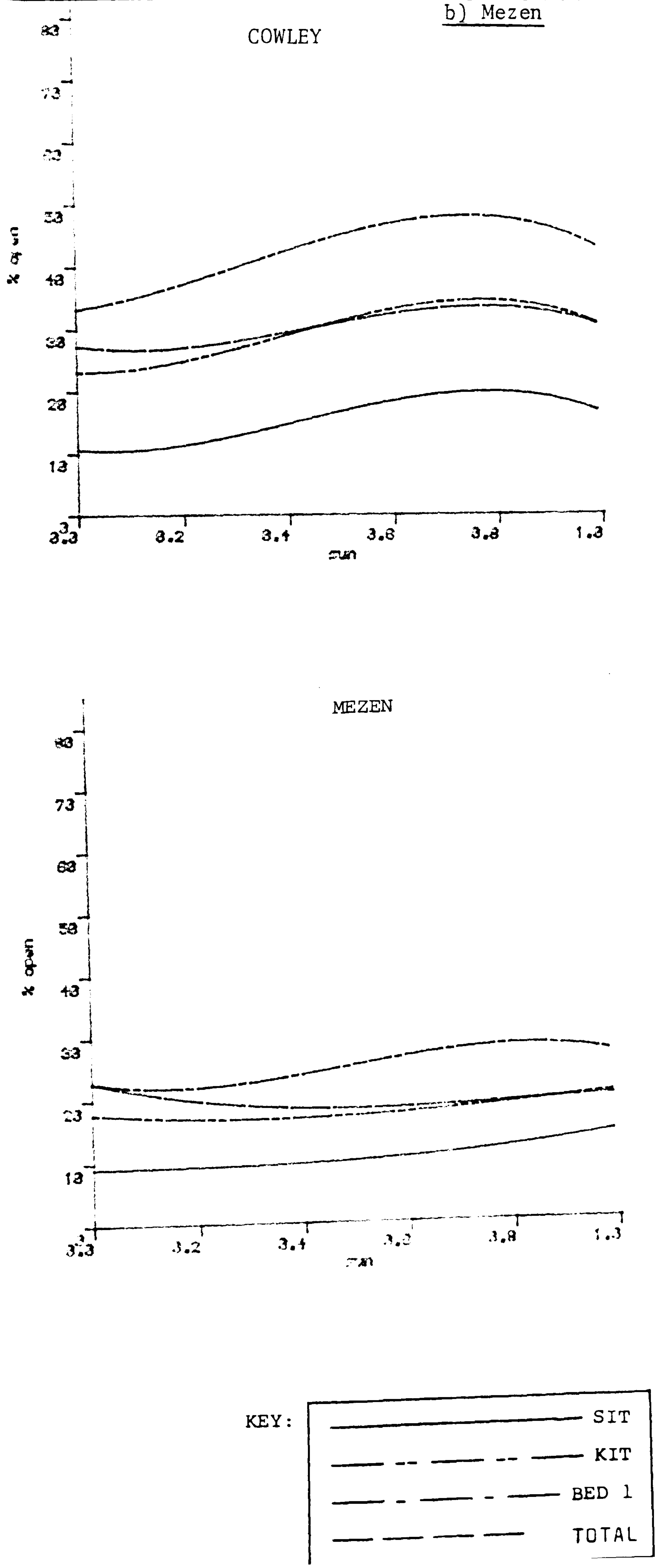
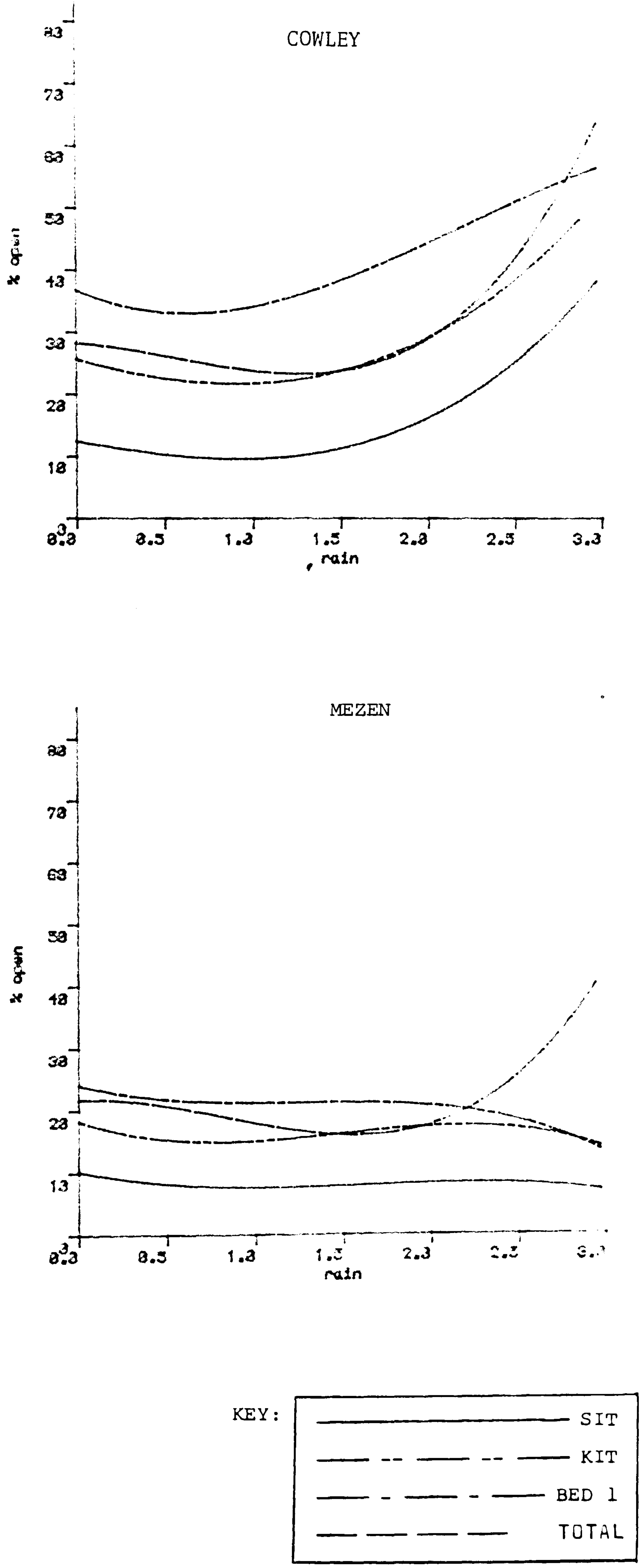


FIGURE 5.55(a) & (b). Relationship between rainfall and window opening in specified room types at a) Cowley and b) Mezen



the entire distribution range (5.4.1.1). The polynomial curves should be interpreted with reference to the distribution of each weather parameter value (Figures 5.15 to 5.19). For example, there are few temperature values outside the range 2° to 16°C and therefore too much importance should not be attached to the curve extremes. On the other hand, the extremes of the curves relating window opening to sunshine duration are probably more reliable than the central regions.

Figures 5.51(a) and (b) confirm that there is a strong positive relationship between window opening and external air temperature. The relationship is a particularly clear one, marking this out as a major result of the study.

Inspection of figure 5.16 shows that the relative humidity fell below 60% for only ten observations at Cowley and nine at Mezen. Thus the left-hand extremes of figures 5.52(a) and (b) cannot be relied upon. However, the suggestion of an upturn at the right-hand extreme of these figures is supported by examination of the original scattergrams in Appendix A (Figures A40 to A71). It is possible that this upturn is associated with rainfall (Figure 5.26(a) and (b)), although there is no further evidence to substantiate this. Inspection of figure 5.52 reveals that the curves for the three individual rooms (sittingroom, kitchen and main bedroom) have similar shapes within each diagram and differ only by displacement parallel to the vertical axis. It may be thought that the appearance of three curves of similar shape alone provides stronger evidence of a particular relationship than a single curve. However, it must be recognised that the three curves in these diagrams are not strictly speaking independent, as data for the three rooms on any given day must appear on a single vertical line. As usual it is the number of data points in a region of a curve which determine the reliability that can be attached to the trend indicated in that region.

The histogram of windspeeds in figure 5.17 shows that most of the observations fall between three and fifteen knots. Inspection of the curves in figure 5.53 within that range suggest a slight negative gradient for the Cowley data only, and no relationship for the Mezen data. The scatter diagrams (Figures A72 to A103) show a wide range of open window percentages but with a tendency for the points to converge at high wind speeds.

The curves in figure 5.54(a) suggest a slight increase in window opening with sunshine duration, though no such increase is apparent at Mezen. The scatter diagrams (Figures A104 to A135) add little to this impression. The histograms in figure 5.19(a) and (b) and the scatter-grams in figures A136 to A167 both show that in the great majority of occasions, no rain fell in the hour of observation. The intercepts with the vertical axes in figure 5.55(a) and (b) therefore correspond closely with the values given in table 5.13. The shapes of the curves to the right of each diagram are based on few points and may be ignored.

Tables A11 to A15 show the correlations obtained between the weather parameters and window observations for all room types at:

a) the hour of observation,

b) 8 a.m., and

c) 12 noon on the day of observation. The correlations between open window observations and the total-day weather parameter values (the summation of values over 24 hours) on

d) the day of observation and

e) the day preceding observation, are also given.

This analysis was made since it was felt that window opening might be governed either by householders' daily timetables or by the effect of weather conditions at 'strategic' times of day. For example, a person going out to work may leave the windows open or shut in a way that is more closely related to weather conditions at 8 a.m. than at the hour of observation. Additionally, there may be times of day when householders who do not go out are more likely to open or close windows, for example at lunchtime. Inspection of tables A11 to A15 and A16 to A20 shows that in general the correlations are not greatly affected by the five ways (a - e) of defining the parameters.

Some regularities are apparent; for example, comparing the correlations generated by previous day parameters with those at the hour of observation, the previous day correlations are similar for the parameters temperature and windspeed, and considerably lower for the parameters relative humidity, sunshine duration and rainfall. Nevertheless, for reasons of clarity and simplicity, the weather parameter values used in all subsequent analyses are for the hour of observation.

5.4.5. A Tentative Model of Window Opening

Based on the analysis discussion of the previous section, a model of window opening is proposed. It is hypothesised that window opening is primarily a function of external air temperature and that relative humidity and windspeed are influential only at high values. Also, that for any individual household the temperatures occurring at the times when windows are opened are approximately normally distributed with the same standard deviations for all households but with means varying from one household to another (Figure 5.56). The model predicts that the percentage of open windows at given temperatures follows the cumulative normal distribution. It is a feature of the model that at extremely low temperatures all households will have no windows open, and similarly that at extremely high temperatures all households will have all windows open.

Window observations were restricted to a six month winter period. On the one hand the winter itself was mild and low air temperatures were rarely reached, with the result that some households had a few windows open on almost every observation day. On the other hand, the omission

FIGURE 5.56. Illustrative normal distribution curves for two households

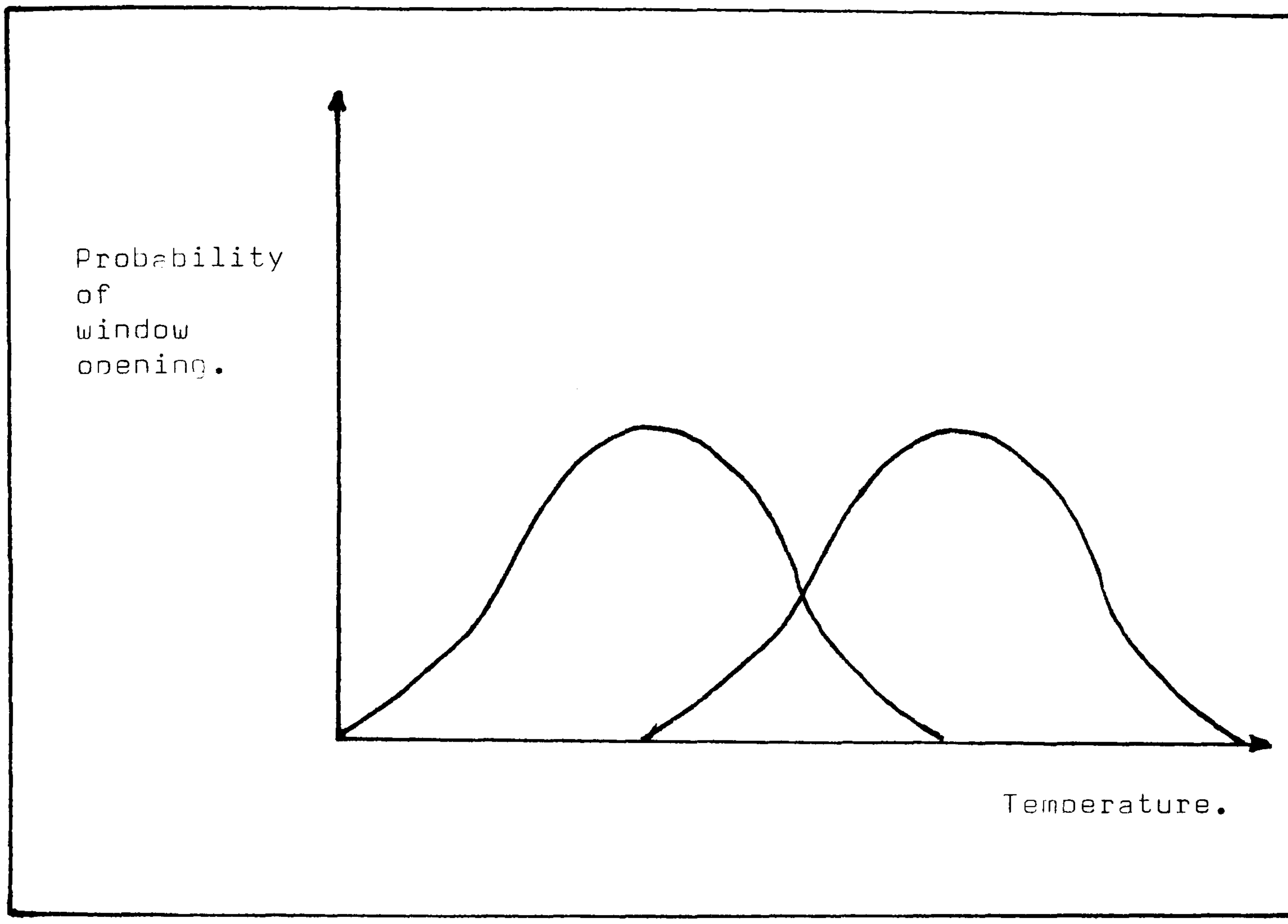
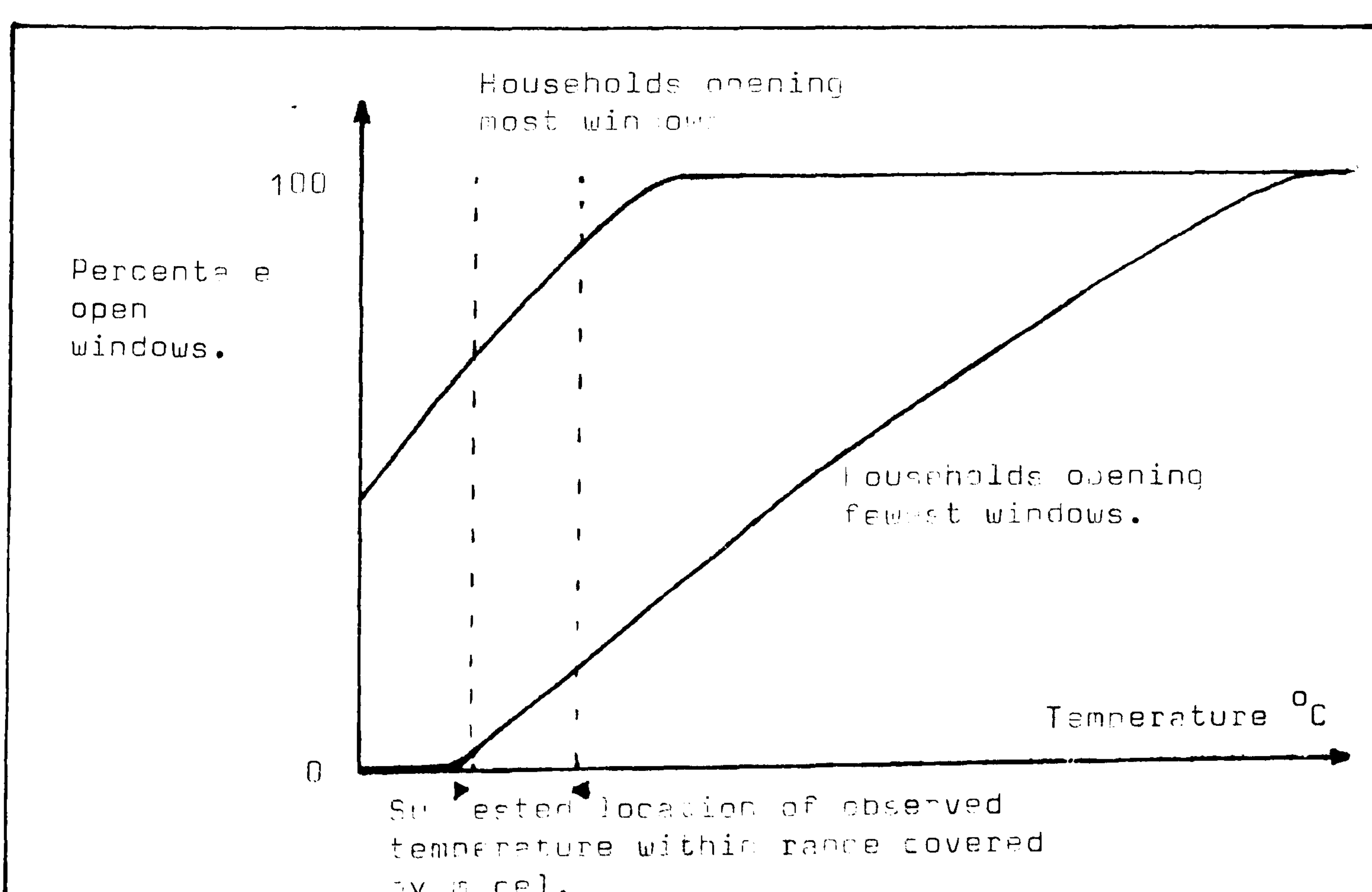


FIGURE 5.57. Hypothesised cumulative distribution curves for sample extremes



of summer observations meant that few high temperature values were included in the data and window opening saturation was never reached. It is suggested that the observation period covers only the central portions of the curves as indicated in figure 5.57.

Figure 5.58 shows a frequency distribution of the average percentage of open windows (over the 100 days) in each household (N = 113). The distribution is skewed and covers almost the entire percentage range. In order to test the proposed model, households were divided into three groups:

a) a"low" group who tend to open a small proportion of their windows,
b) a "medium" group of householders who on average open a moderate proportion of their windows, and
c) a "high" group who tend to open most of their windows.

These three groups together comprise "all" households (N = 78 and N = 35 for Cowley and Mezen respectively).

The 113 households fall into eight house types as discussed in chapter 4. The total number of windows opened (over the 100 days) by householders within a particular house type, were listed in descending order and divided accordingly into three groups, i.e. the top, middle and bottom third. The "high" window openers from each house type were then collectively referred to as the "high" group, and similarly for the "medium" and "low" groups. Thus each house type was represented as equally as possible in the three groups. This is shown in tables 5.19 and 5.20. The actual numbers of open windows rather than their respective percentages have been used; by either method the division would be identical.

The curves generated by the third order polynomial fits to the scattergrams in figures A8 to A167 provide a test of the model.

Figures 5.59 to 5.66 provide tentative confirmation of the model outlined in figures 5.56 and 5.57. At the lower temperatures the curves

FIGURE 5.58. Frequency distribution of the average percentage of total open window observations in 113 households.

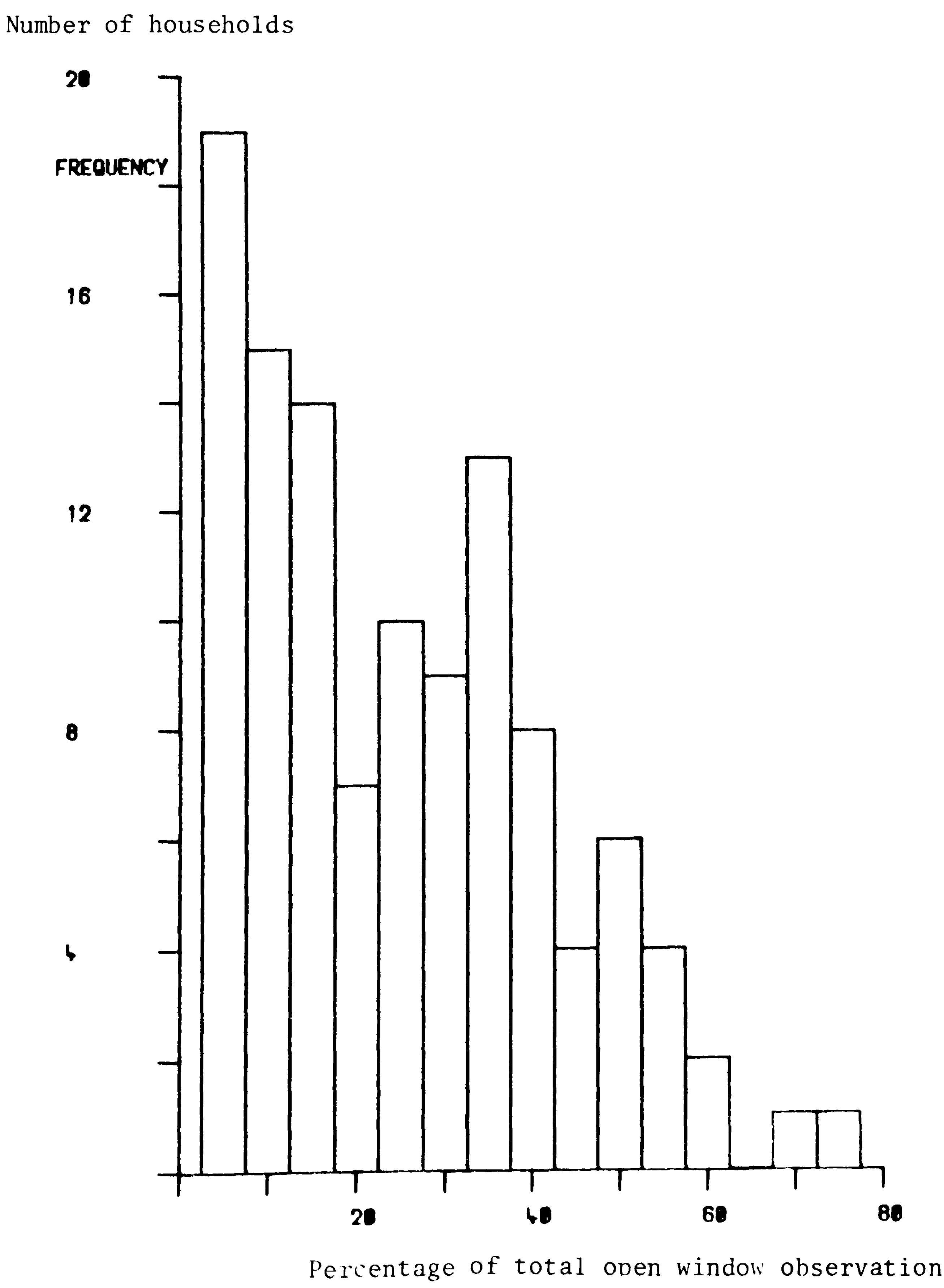


TABLE 5.19. Mean number of total open windows according to house type at Cowley

GROUP TYPE		HOUSE TYPE					
		Btm. Flat	Top Flat	4P, 2S	4P, 3S	6P, 3S	$\bar{X}$ & n in Group.
HIGH	$\bar{X}$	68	201	214	232	295	197
	n	(5)	(5)	(7)	(3)	(4)	(24)
MEDIUM	$\bar{X}$	20	119	139	138	202	121
	n	(6)	(6)	(9)	(4)	(5)	(30)
LOW	$\bar{X}$	8	30	45	63	42	37
	n	(5)	(5)	(7)	(3)	(4)	(24)
House Type $\bar{X}$ + n	$\bar{X}$	31	117	133	143	181	118
	n	(16)	(16)	(23)	(10)	(13)	(78)

TABLE 5.20. Mean number of total open windows according to house type at Mezen.

GROUP TYPE		HOUSE TYPE			
		Btm. Flat	Top Flat	4P	$\bar{X}$ + n in Group.
HIGH	$\bar{X}$	192	260	339	277
	n	(3)	(3)	(5)	(11)
MEDIUM	$\bar{X}$	116	95	150	123
	n	(4)	(4)	(5)	(13)
LOW	$\bar{X}$	29	14	72	48
	n	(3)	(3)	(5)	(11)
House Type $\bar{X}$ = n	$\bar{X}$	120	113	187	147
	n	(10)	(10)	(15)	(35)

FIGURE 5.59. Relationship between temperature and window opening in three groups at Cowley

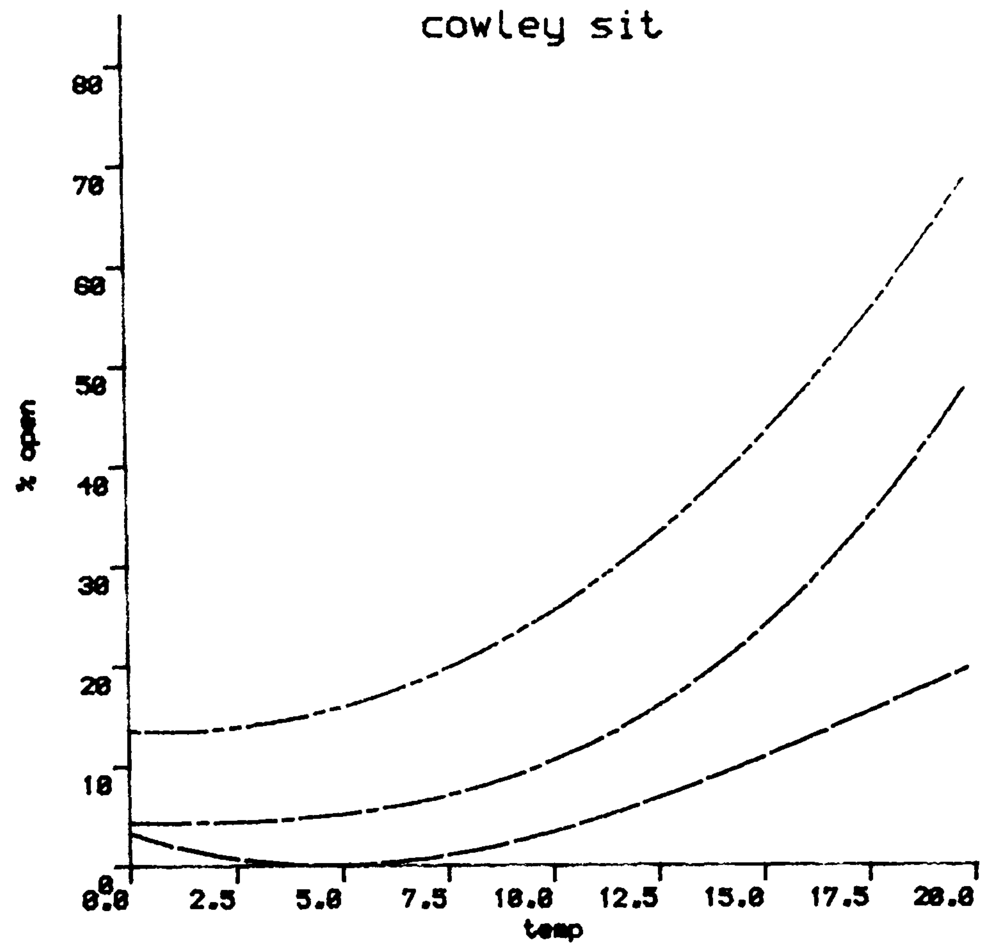
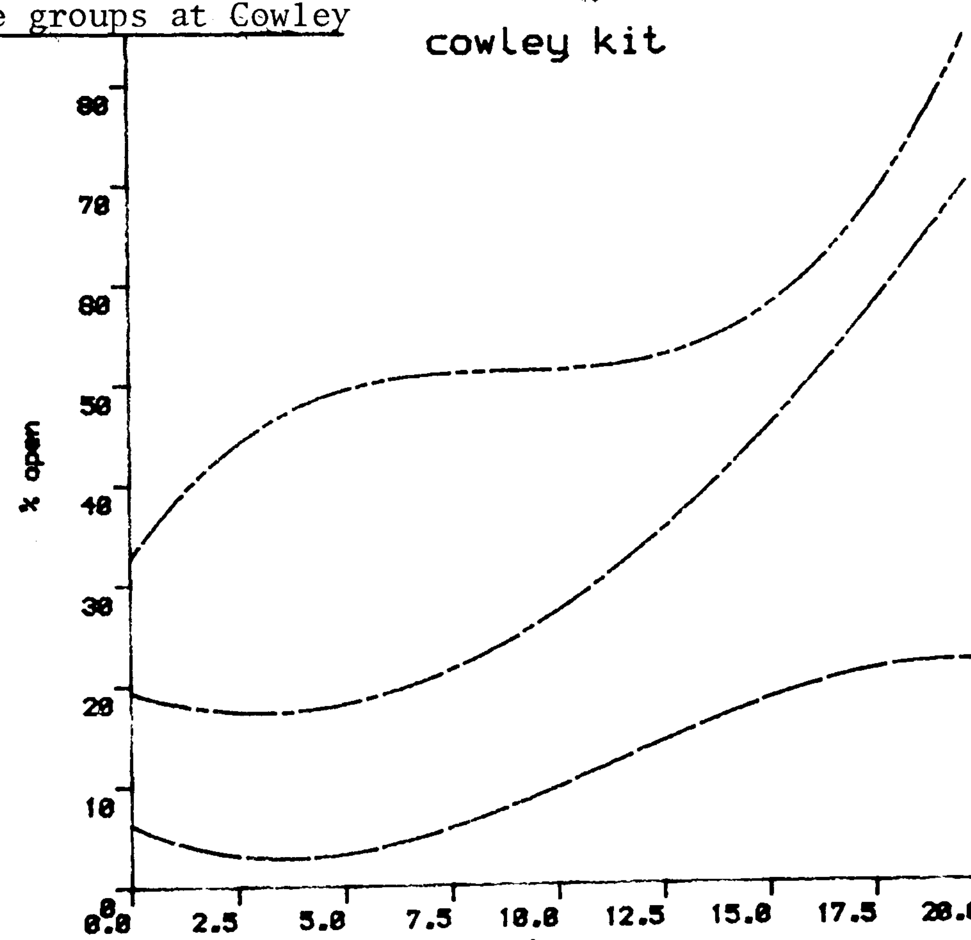


FIGURE 5.60. Relationship between temperature and kitchen window opening in three groups at Cowley



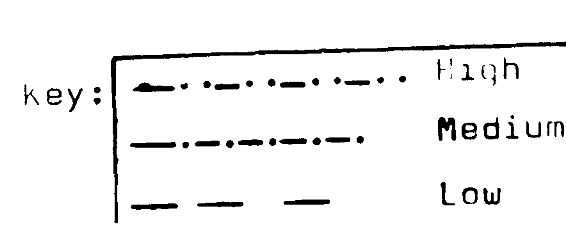


FIGURE 5.61. Relationship between temperature and main bedroom window opening in three groups at Cowley

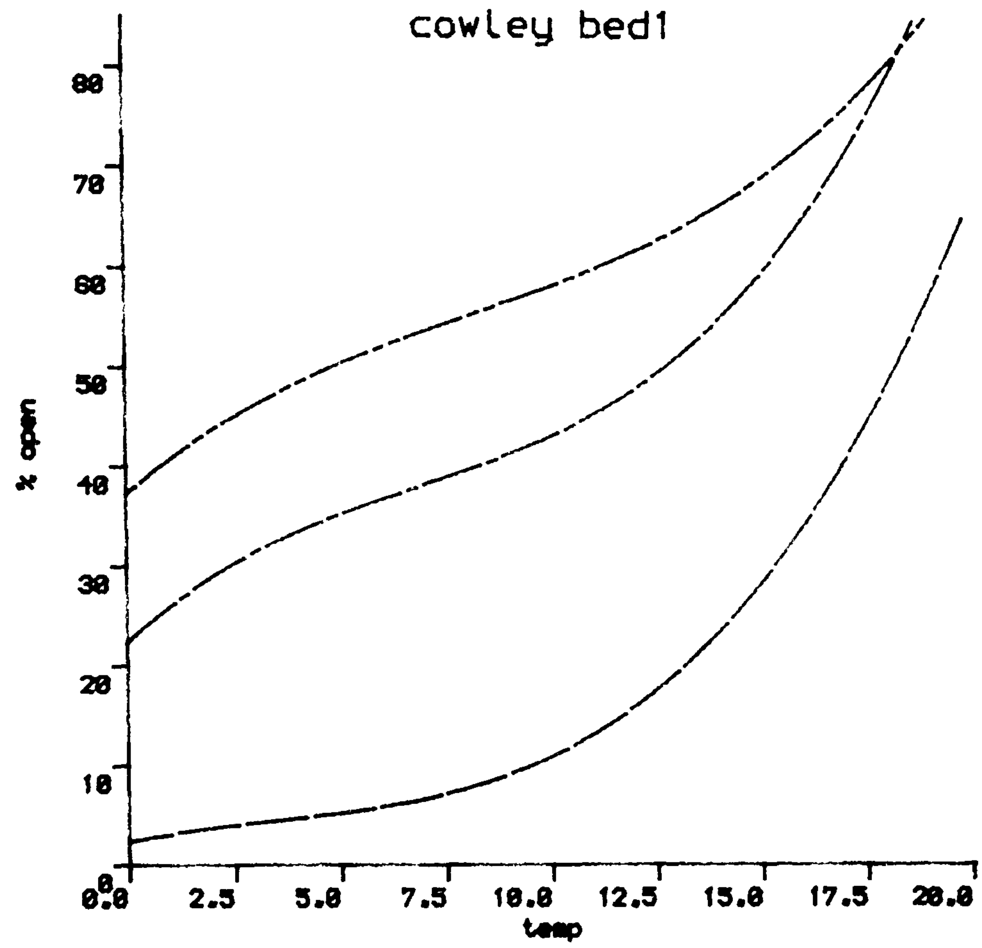
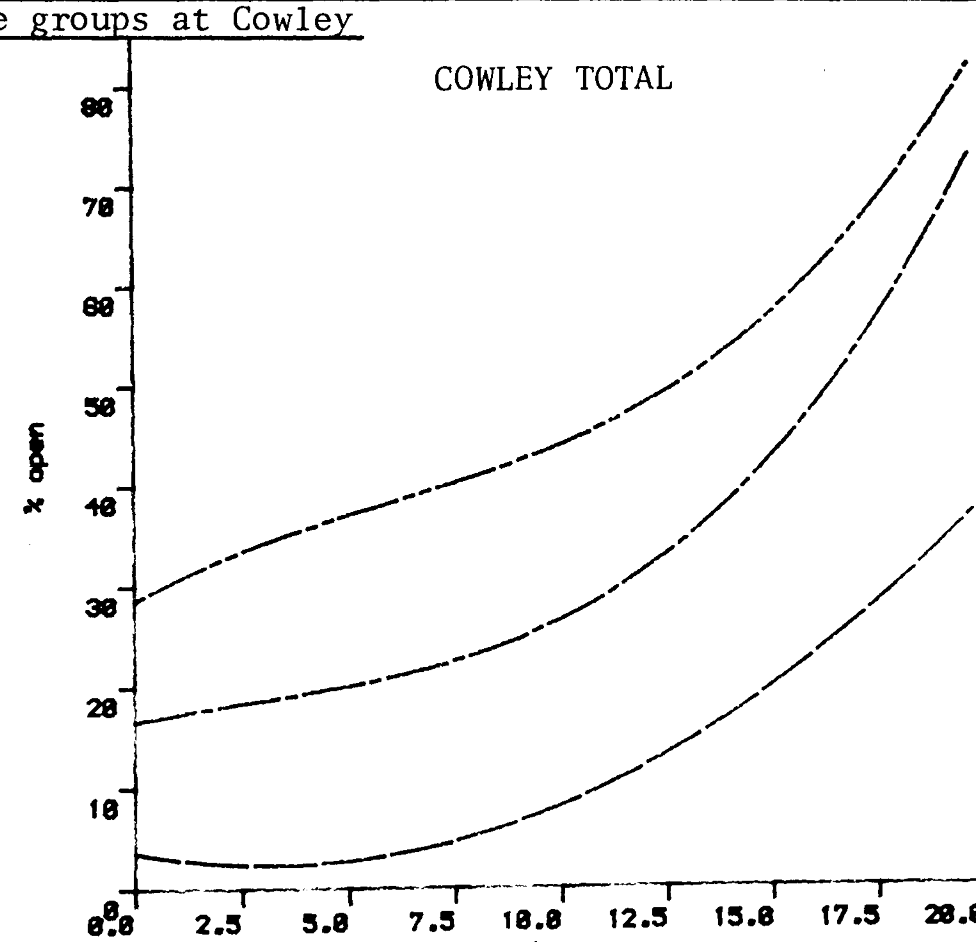


FIGURE 5.62. Relationship between temperature and total window opening in three groups at Cowley



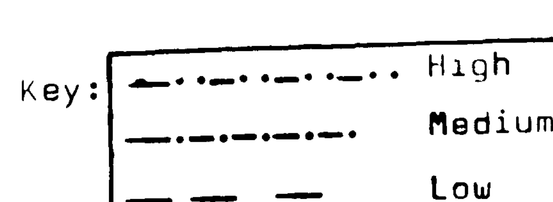


FIGURE 5.63. Relationship between temperature and sittingroom window opening in three groups at Mezen

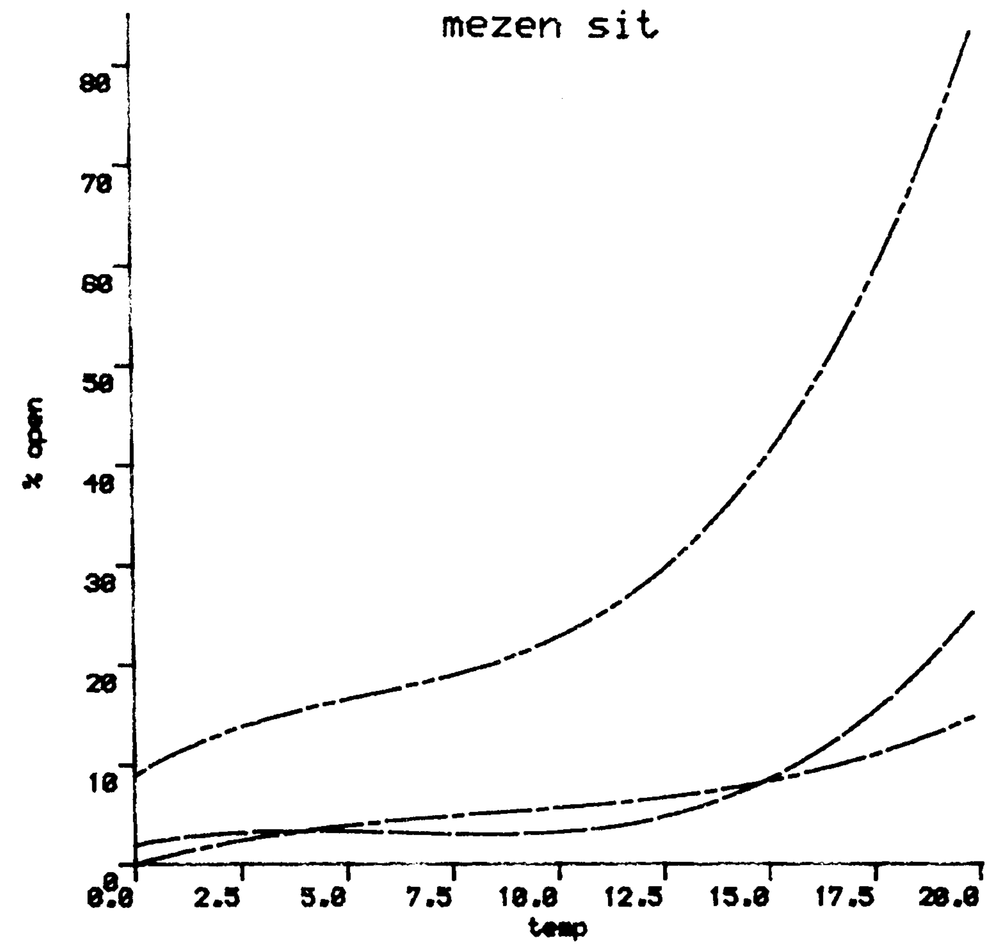
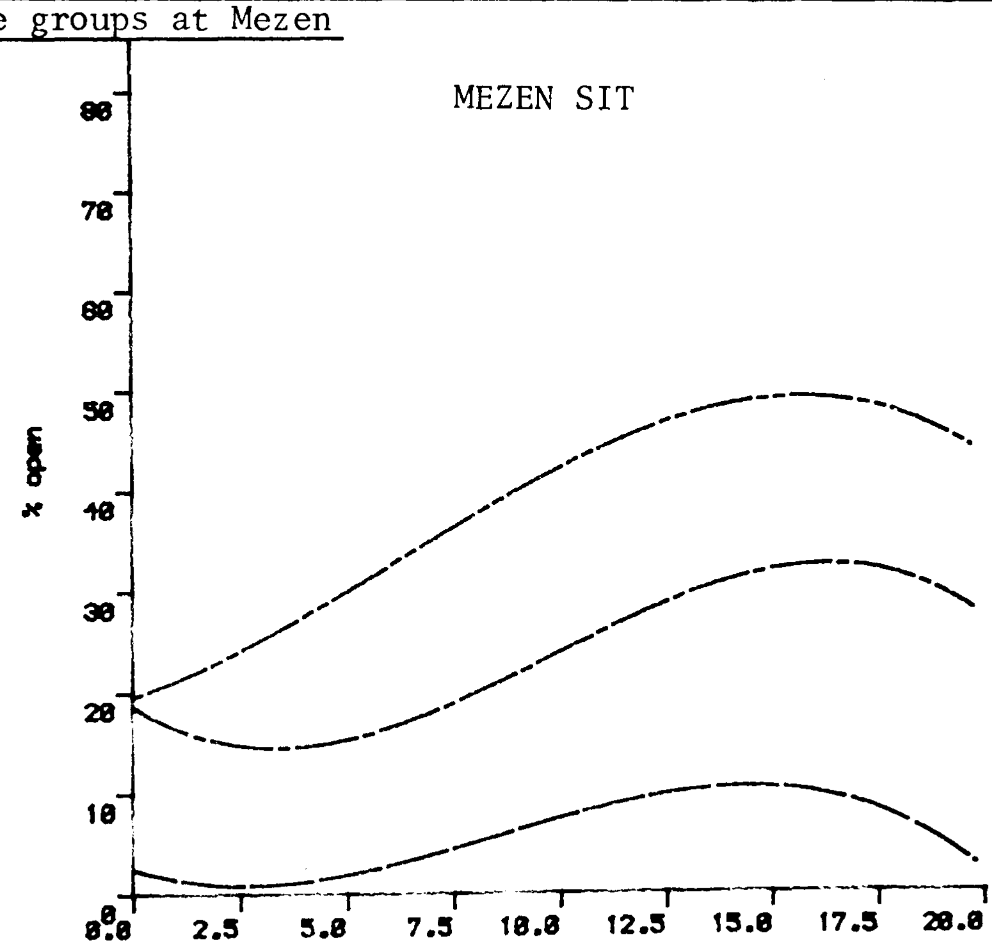


FIGURE 5.64. Relationship between temperature and kitchen window opening in three groups at Mezen



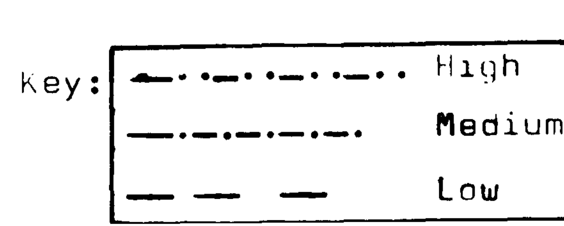


FIGURE 5.65. Relationship between temperature and main bedroom window opening in three groups at Mezen

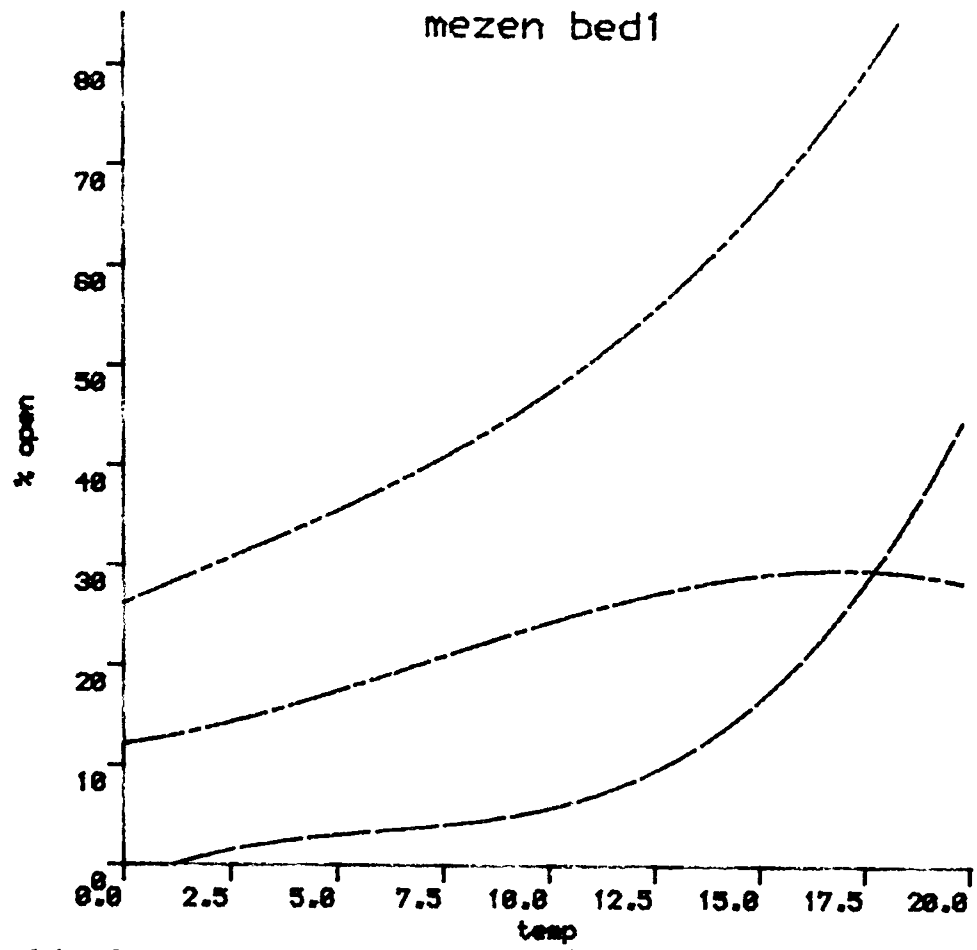
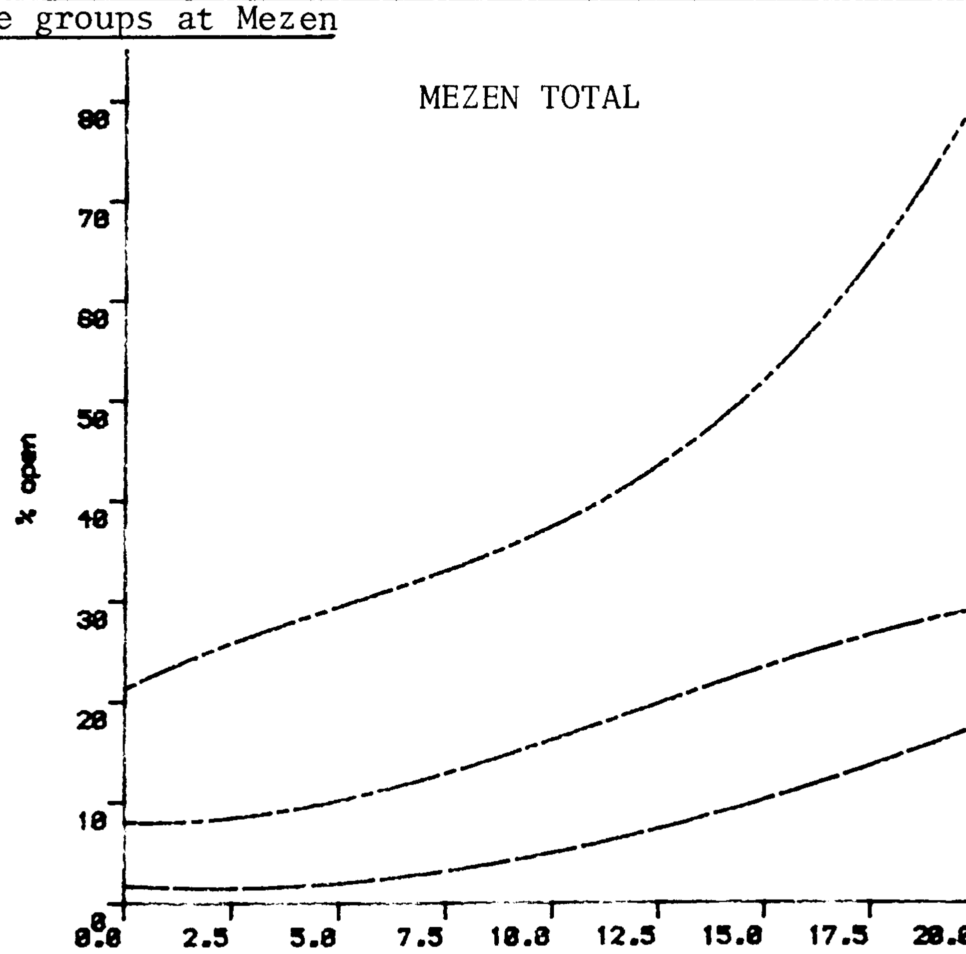


FIGURE 5.66. Relationship between temperature and total window opening in three groups at Mezen



Key: High
Medium
Low

for the low groups have the smallest gradients, those for the medium groups have a small positive gradient, whilst those for the high groups have a larger positive gradient. This is as predicted from the theoretical curves in figure 5.57. Indeed, figure 5.59 suggests that at the lowest observed temperatures the high group will already have a proportion of windows open, followed respectively by the medium and low groups. This feature is confirmed by figures 5.62 and 5.66. All eight diagrams provide evidence of a strong positive association between window opening and external air temperature. There is a slight exception however - the downturn of curves in figure 5.64. These are due to only two data points drawn for days 1 and 99. The negative portions of the curve are therefore unreliable.

Figures 5.67 to 5.74 show the relationship between window opening and relative humidity in different room types for the high, medium and low groups. The polynomial curves for the three groups are approximately parallel. Three potential explanations for the similarities in shape are suggested:

a) all householders are independently affected by the weather parameter in question,

b) all householders are independently affected by some other weather-related factor(s).

c) Congruence - conformity: householders see other householders opening their windows and feel an urgent need to conform.

The three groups are composed of different individual householders and it is therefore unlikely that important factors other than the weather parameters or factors correlating with weather parameters, produce similar window opening patterns. Thus, in this context similarity in the form of the three curves can be taken as evidence for the reliability of a particular trend in window opening patterns.

S-shaped relationships between window opening and relative humidity

FIGURE 5.67. Relationship between relative humidity and sittingroom window opening in three groups at Cowley

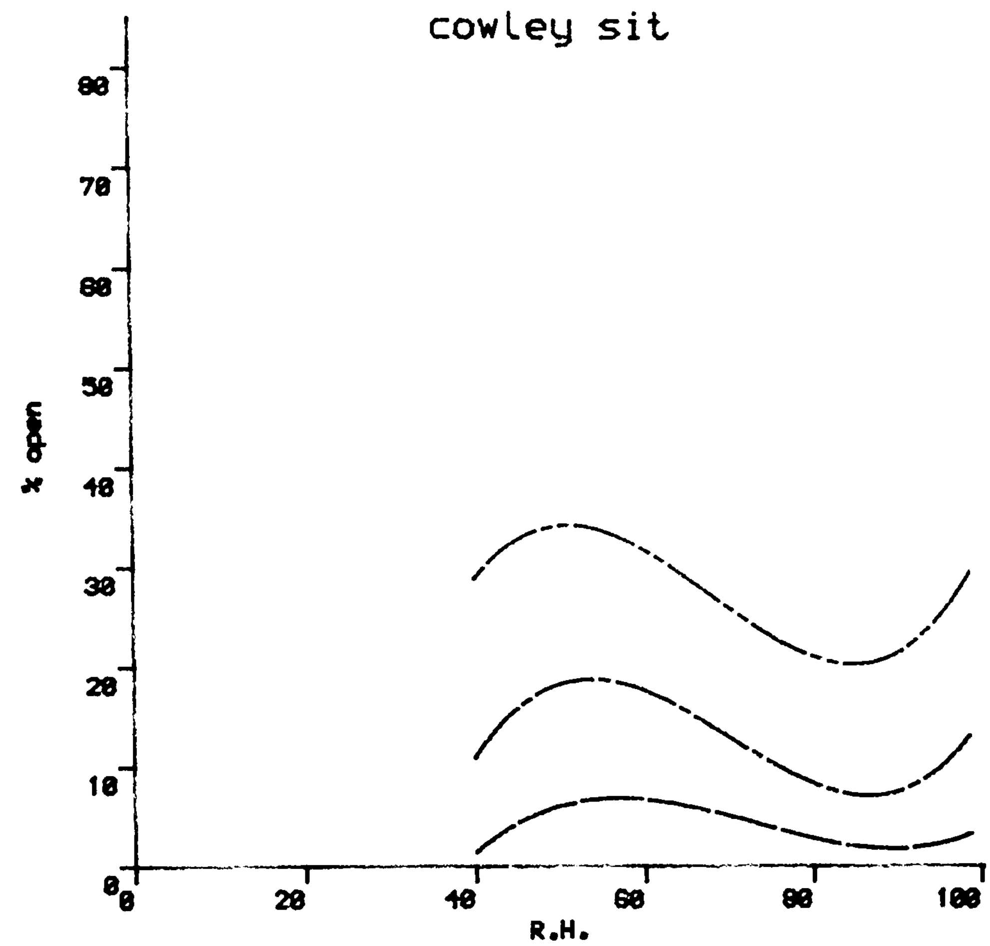
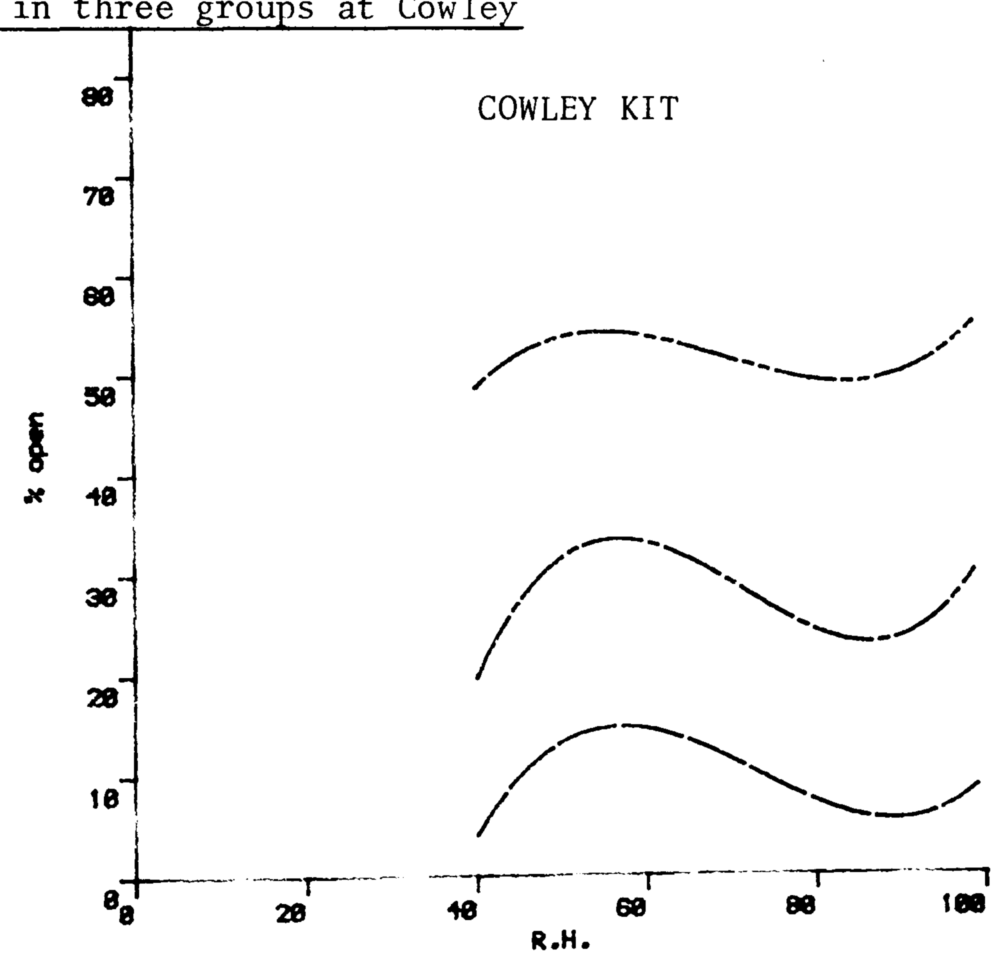


FIGURE 5.68. Relationship between relative humidity and kitchen window opening in three groups at Cowley



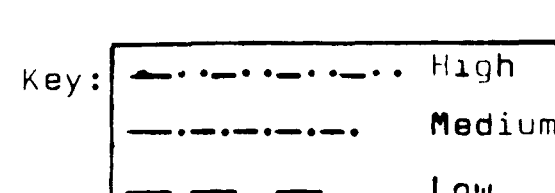


FIGURE 5.69. Relationship between relative humidity and main bedroom window opening in three groups at Cowley

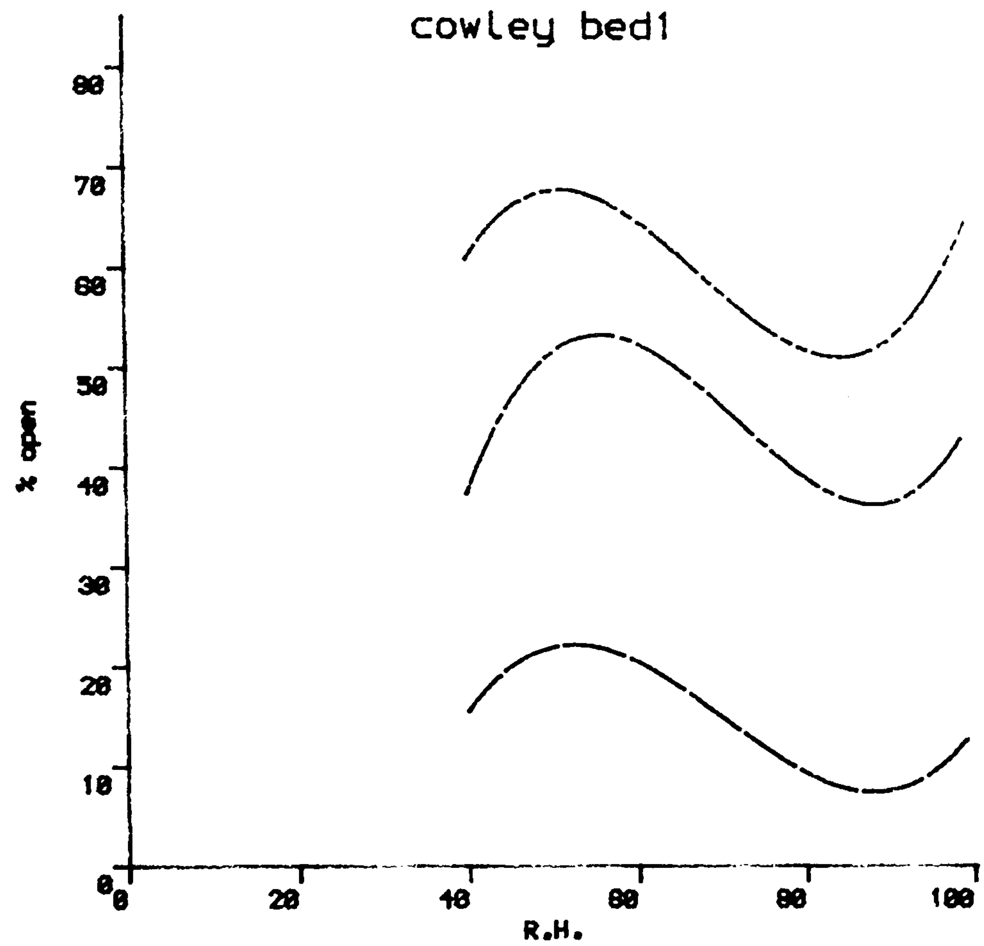
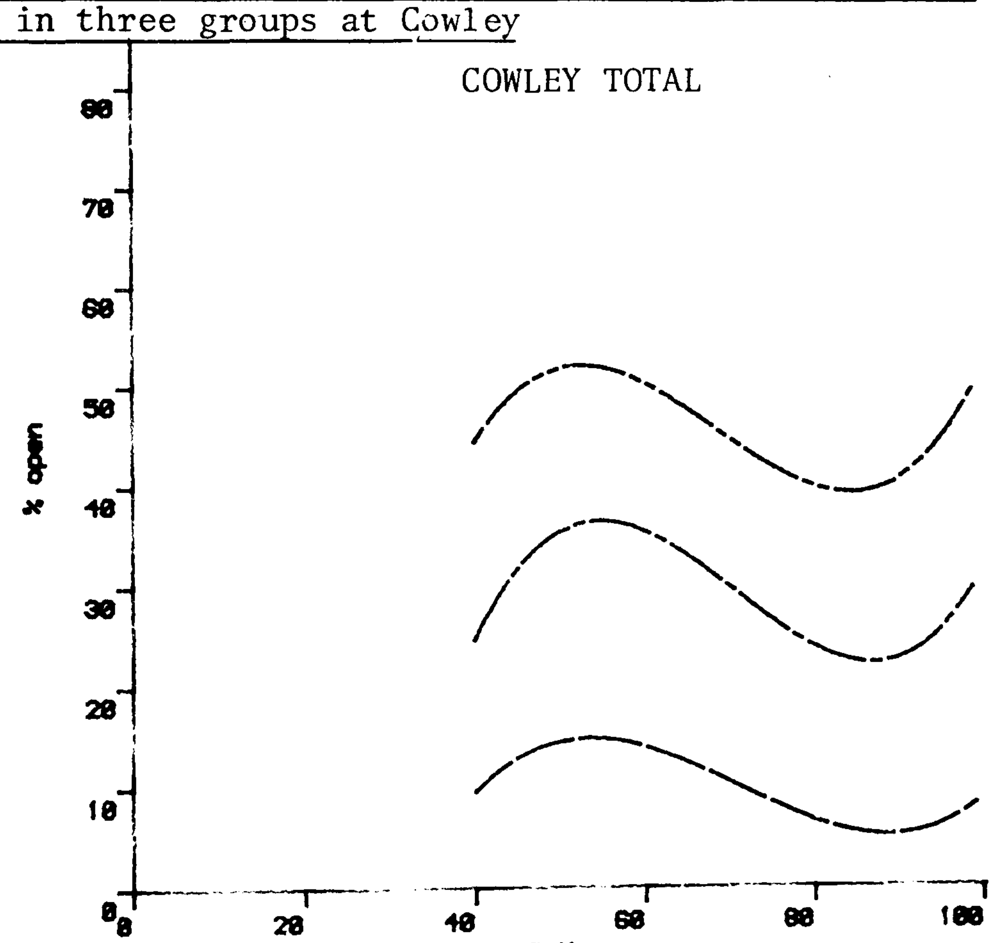


FIGURE 5.70. Relationship between relative humidity and total window opening in three groups at Cowley



Key: High, Medium, Low

FIGURE 5.71. Relationship between relative humidity and sittingroom window opening in three groups at Mezen

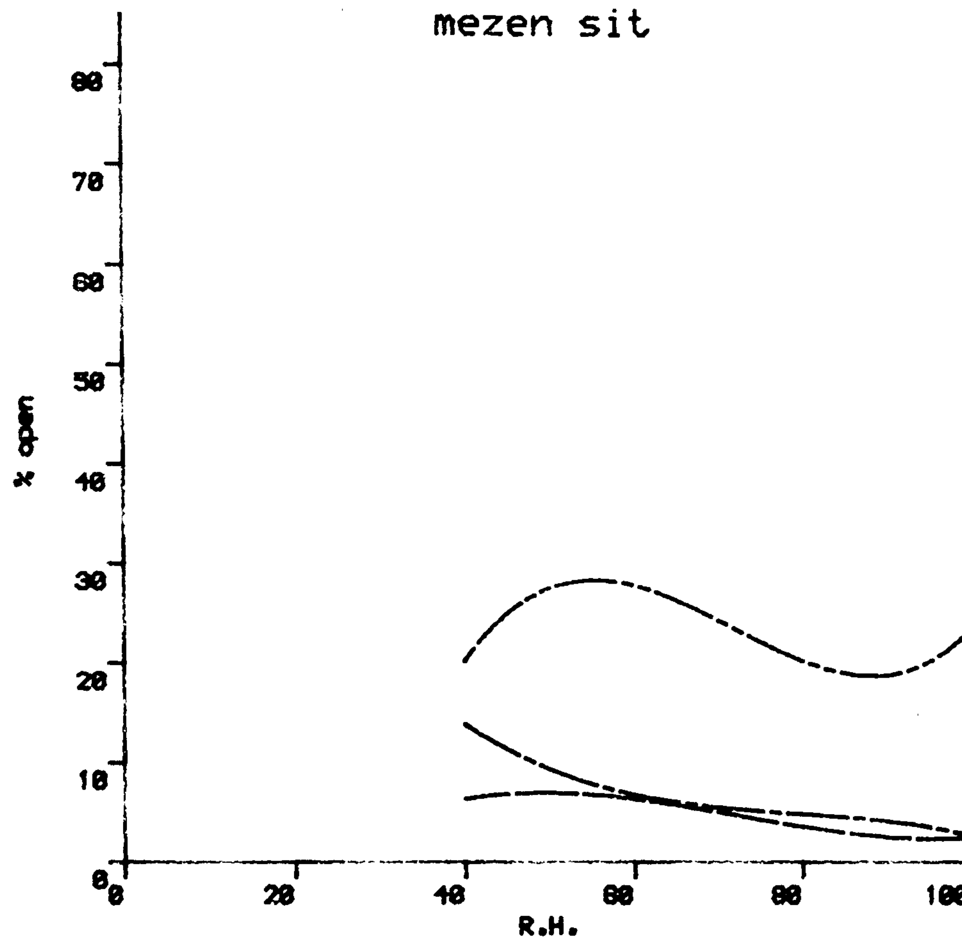
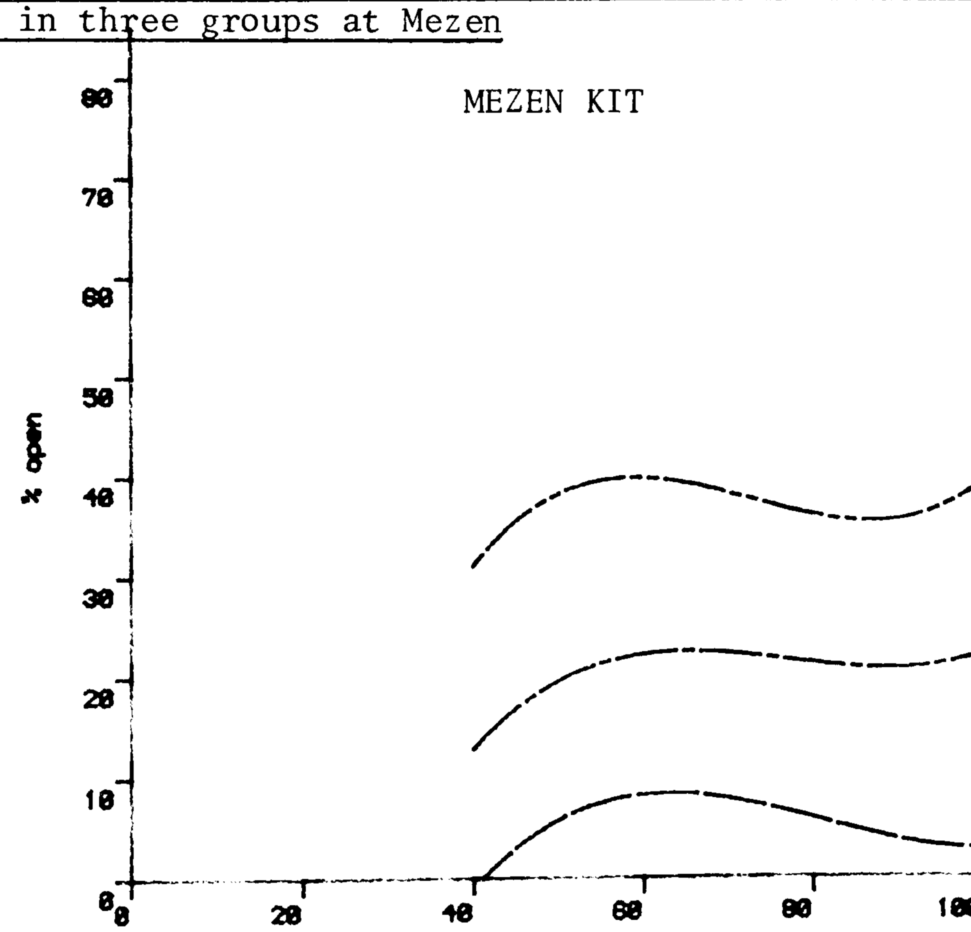


FIGURE 5.72. Relationship between relative humidity and kitchen window opening in three groups at Mezen



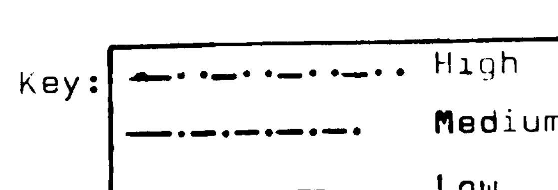


FIGURE 5.73. Relationship between relative humidity and main bedroom window opening in three groups at Mezen

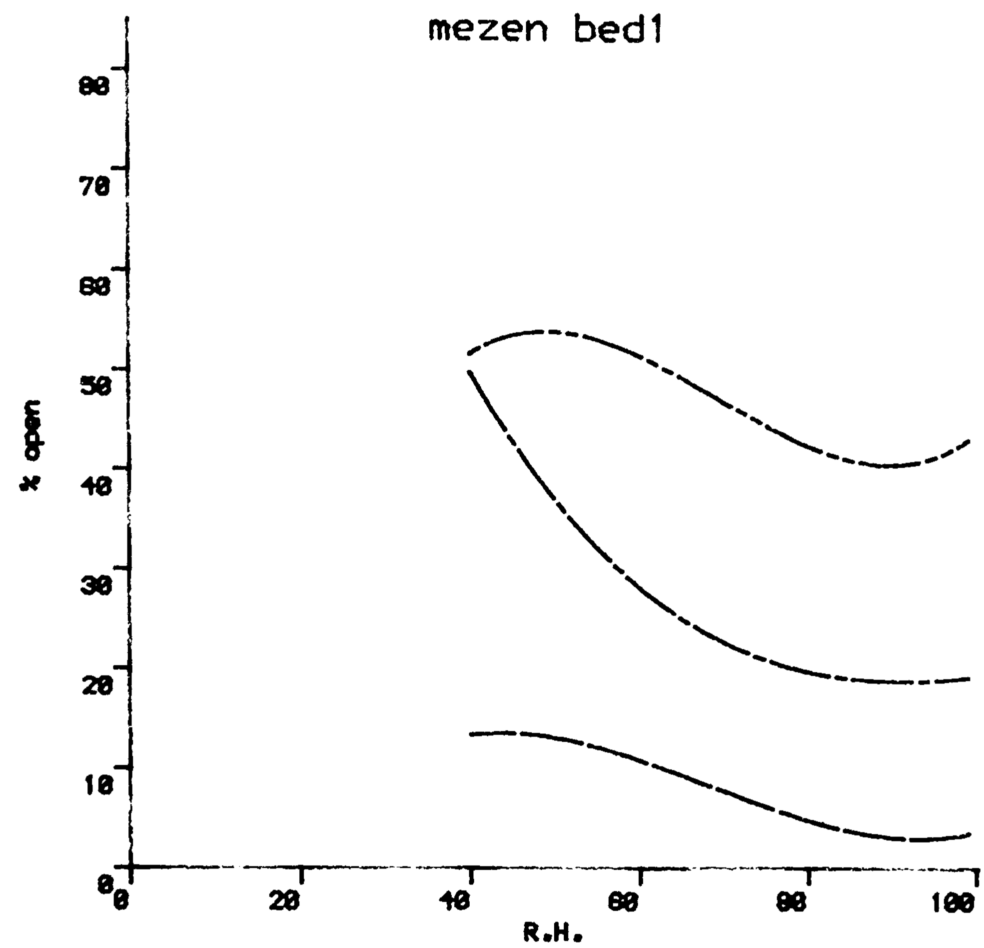
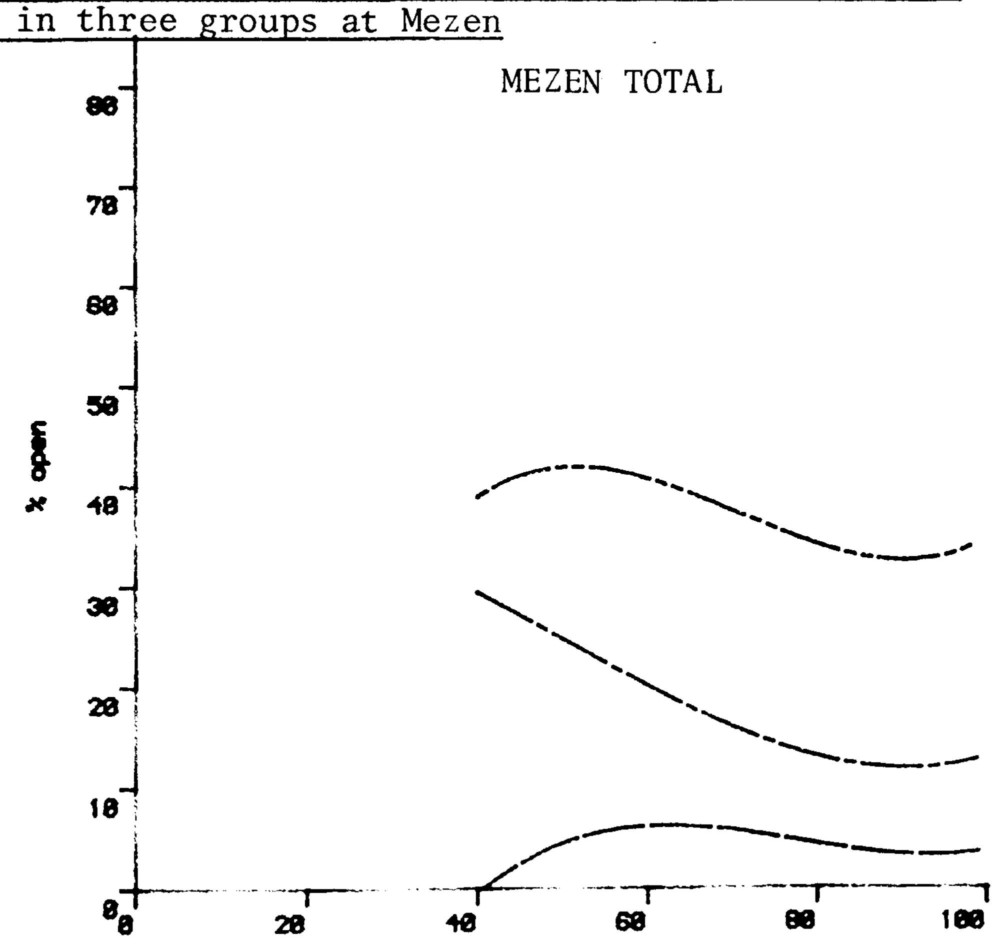
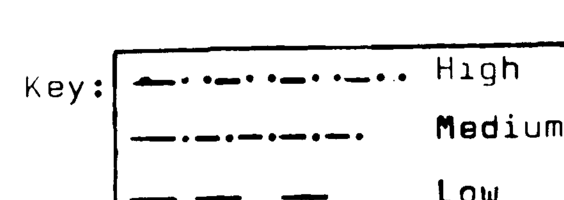


FIGURE 5.74. Relationship between relative humidity and total window opening in three groups at Mezen





are strongly present at Cowley, and to a lesser degree in the three Mezen groups. The agreement in terms of curve shape between the room types for each estate (5.4.4) could be explained by other factors - such as householders adopting general window opening patterns, with the decision to open one window increasing the likelihood of further window opening. However, it is difficult to explain the similarity shown by four out of the six graphs for separate groups except in terms of common influences, namely perceived changes in the weather. No explanation can be provided for the initial maximum point in these four sets of curves, although it must be noted that this maximum occurs between 40 - 60% relative humidity, and relies on a small number of points (10, and 9 points respectively for Cowley and Mezen). Nevertheless, the right-hand extremes of these curves are based on substantial numbers of data points. The upturn between 80 - 100% relative humidity may be attributable to the emergence of an awareness of relative humidity in this range, possibly associated in some cases with the onset of rain. The convergence of data points (Figures A40 to A71) on the polynomial curves supports this suggestion of an increasing sensitivity to relative humidity with increases in relative humidity. The portions of these curves with a negative slope may reflect the association of relative humidity with temperature.

Figures 5.75 to 5.82 for windspeed show a peak followed by a decline in four out of six cases for the separate rooms. In all cases the curves include a substantial portion of negative gradient as windspeed increases. The one exception is for the Cowley high group where the upturn is based on one data point. No explanation can be offered for the existence of the maximum points. However, the negative gradient is consistent with the hypothesis that people close windows when windspeeds are sufficient to cause draughts or damage. In this connection, a tendency for the data points to converge upon the

FIGURE 5.75. Relationship between windspeed and sittingroom window opening in three groups at Cowley

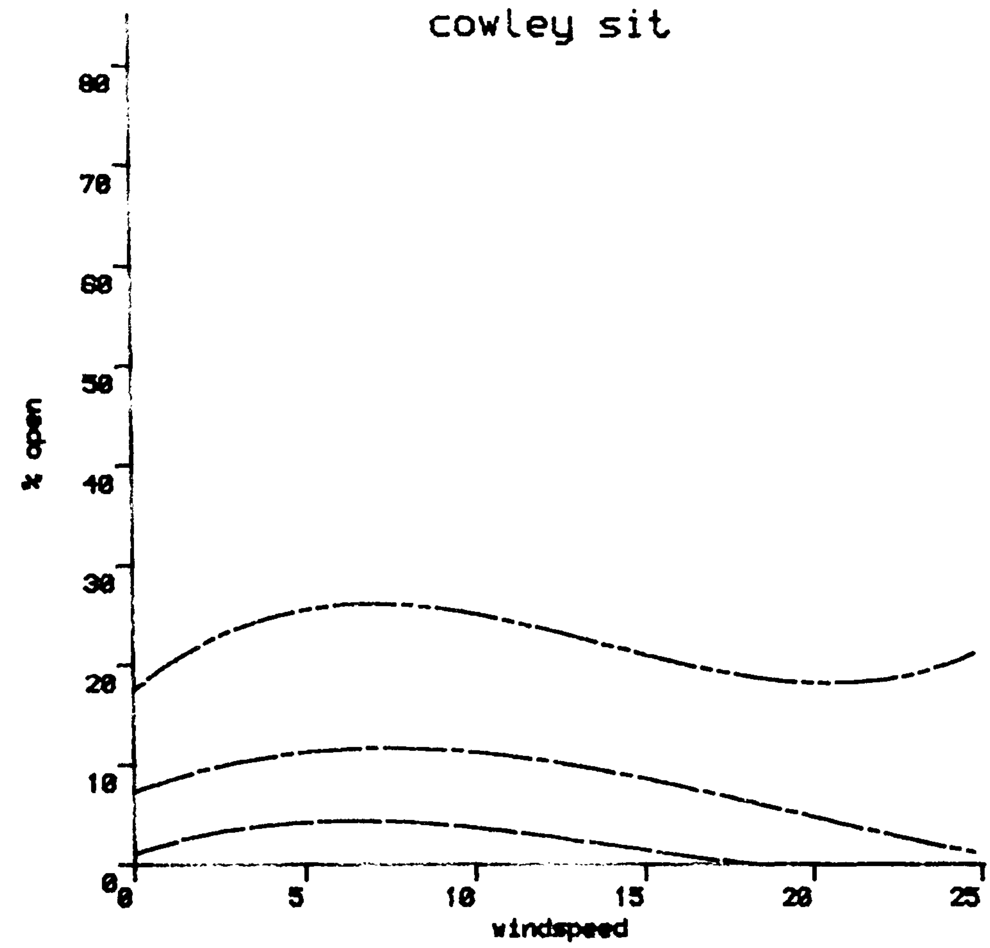
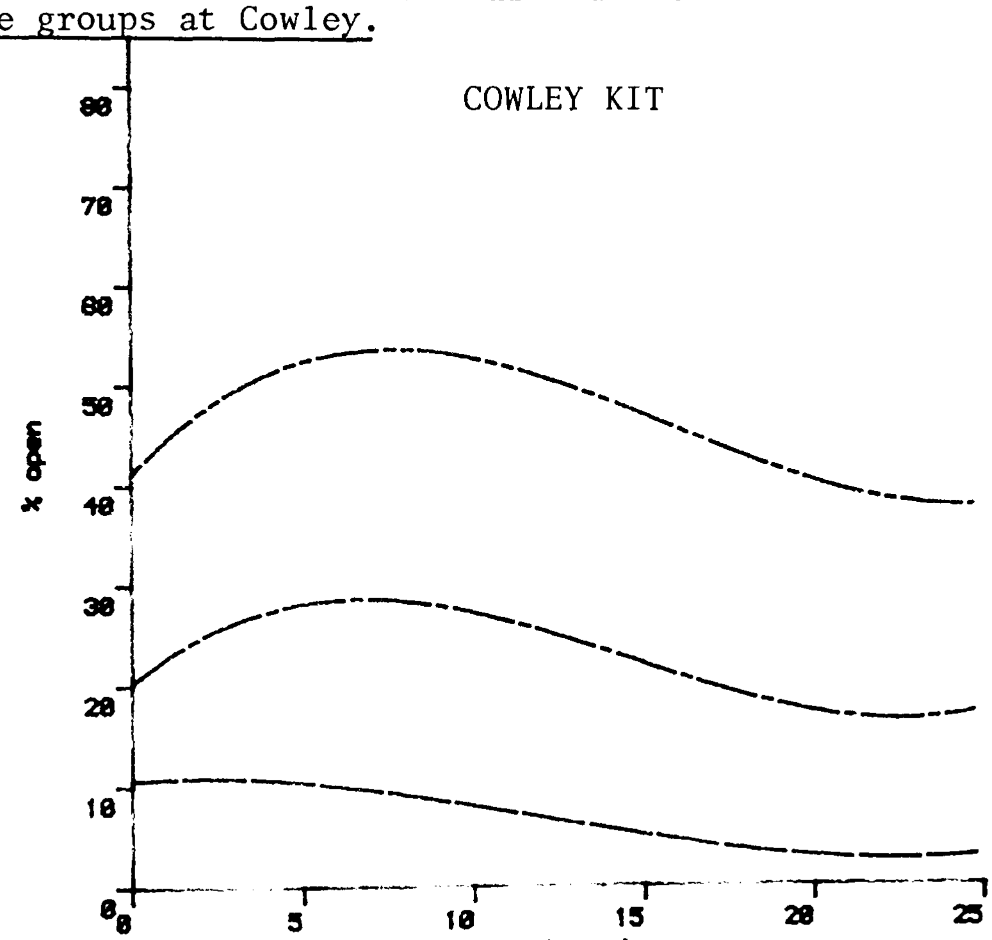


FIGURE 5.76. Relationship between windspeed and kitchen window opening in three groups at Cowley.



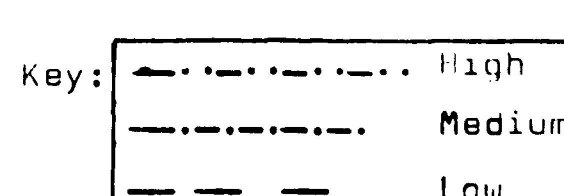


FIGURE 5.77. Relationship between windspeed and main bedroom window opening in three groups at Cowley

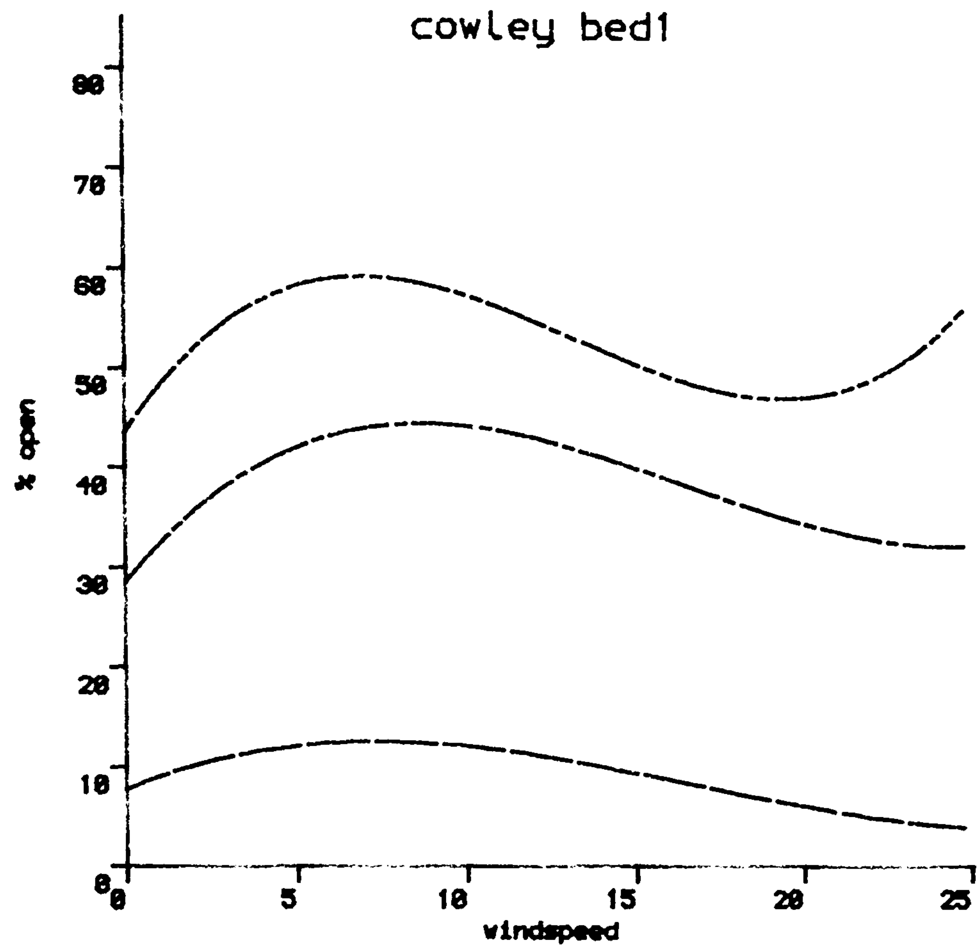
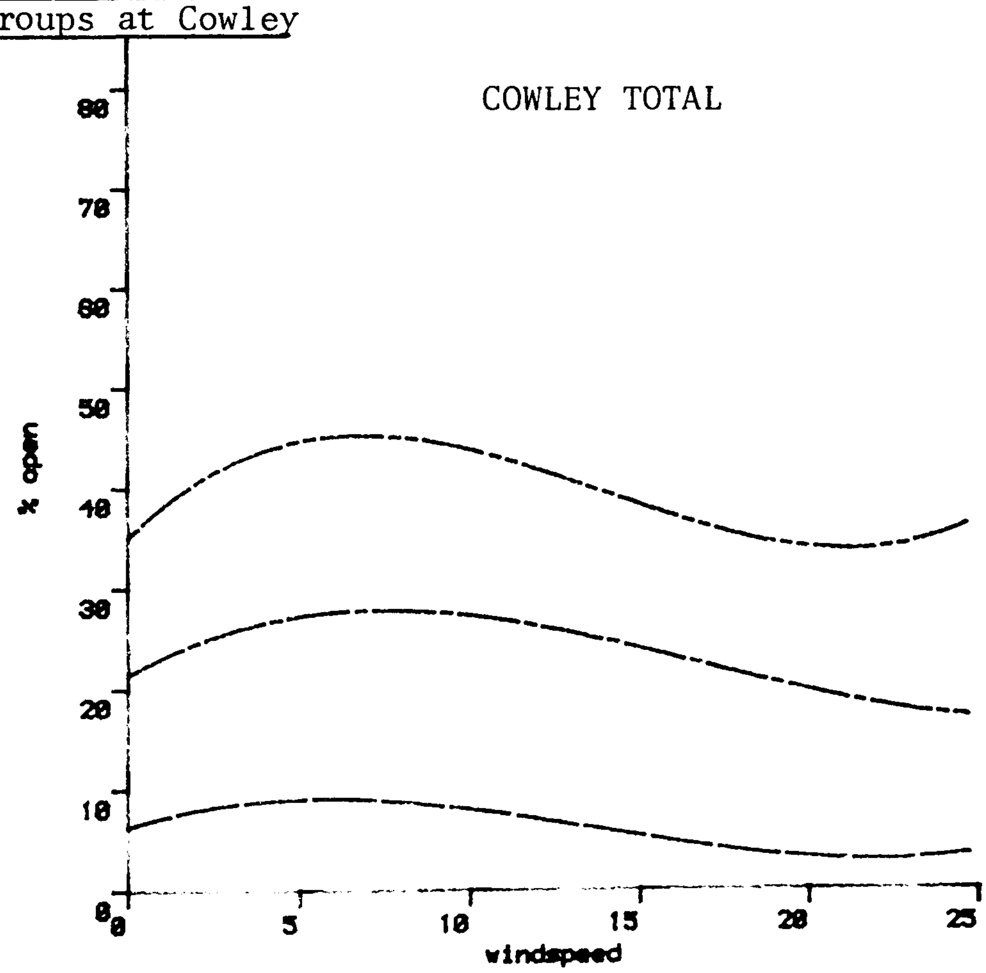


FIGURE 5.78. Relationship between windspeed and total window opening in three groups at Cowley



Key:
- —·—·—·— High
- —·—·—·— Medium
- — — — Low

FIGURE 5.79. Relationship between windspeed and sittingroom window opening in three groups at Mezen

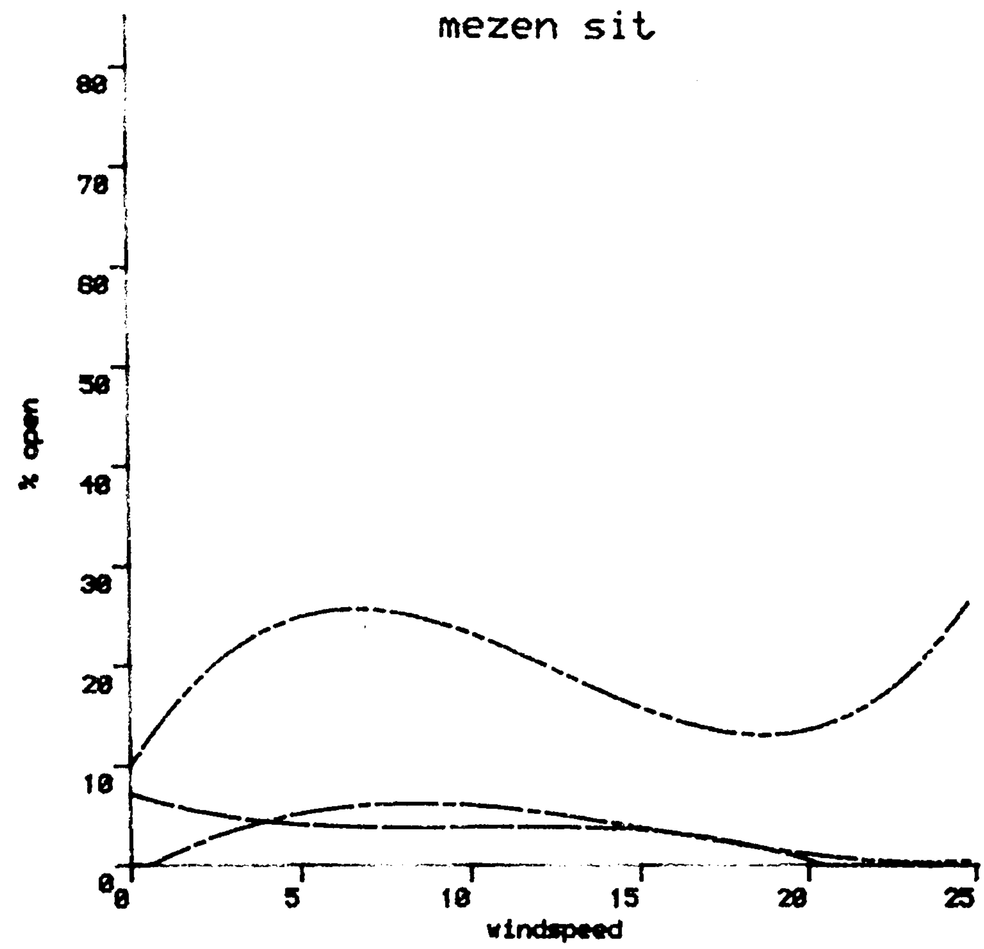
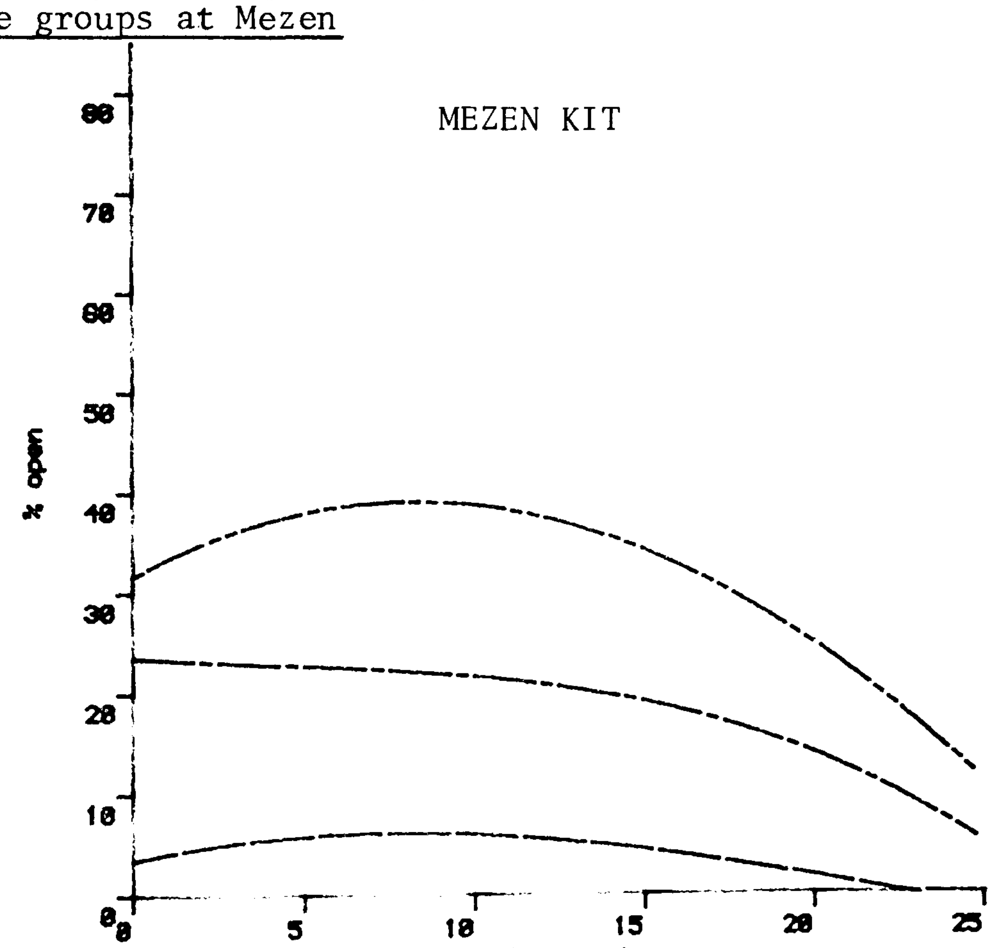


FIGURE 5.80. Relationship between windspeed and kitchen window opening in three groups at Mezen



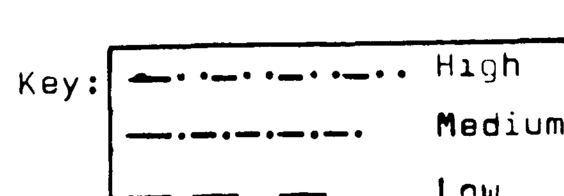


FIGURE 5.81. Relationship between windspeed and main bedroom window opening in three groups at Mezen

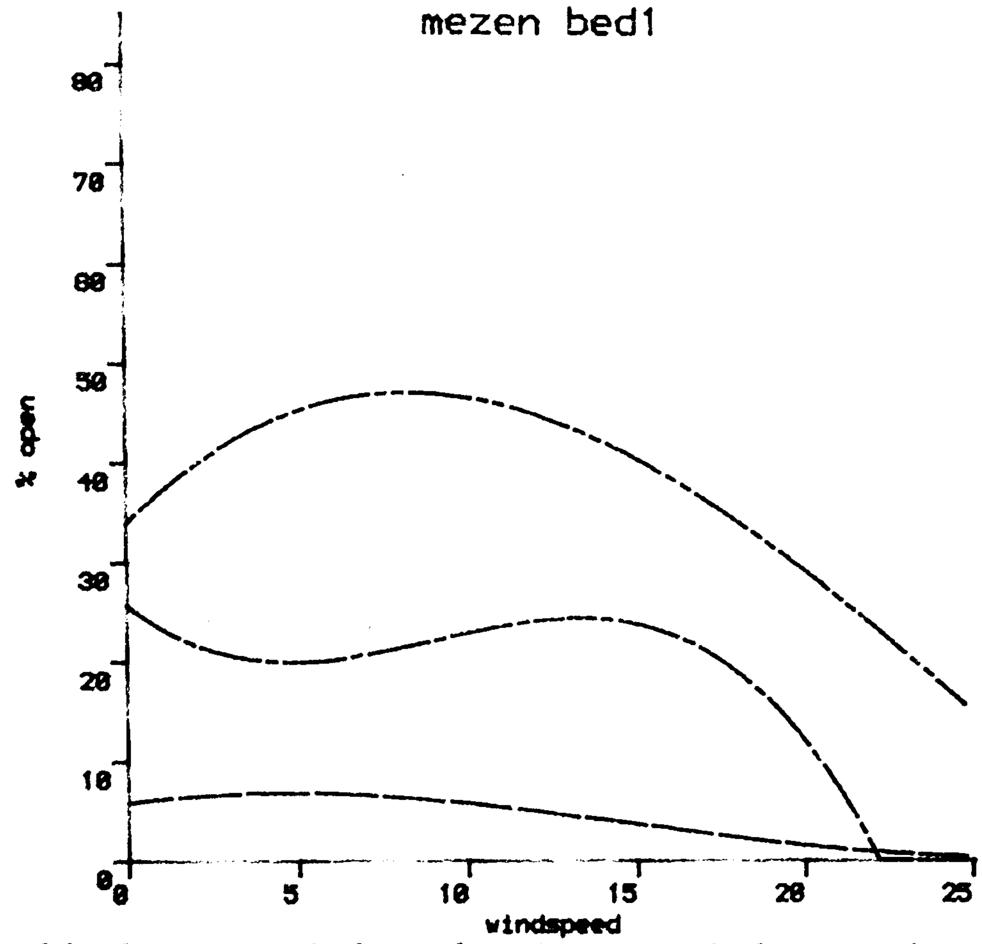
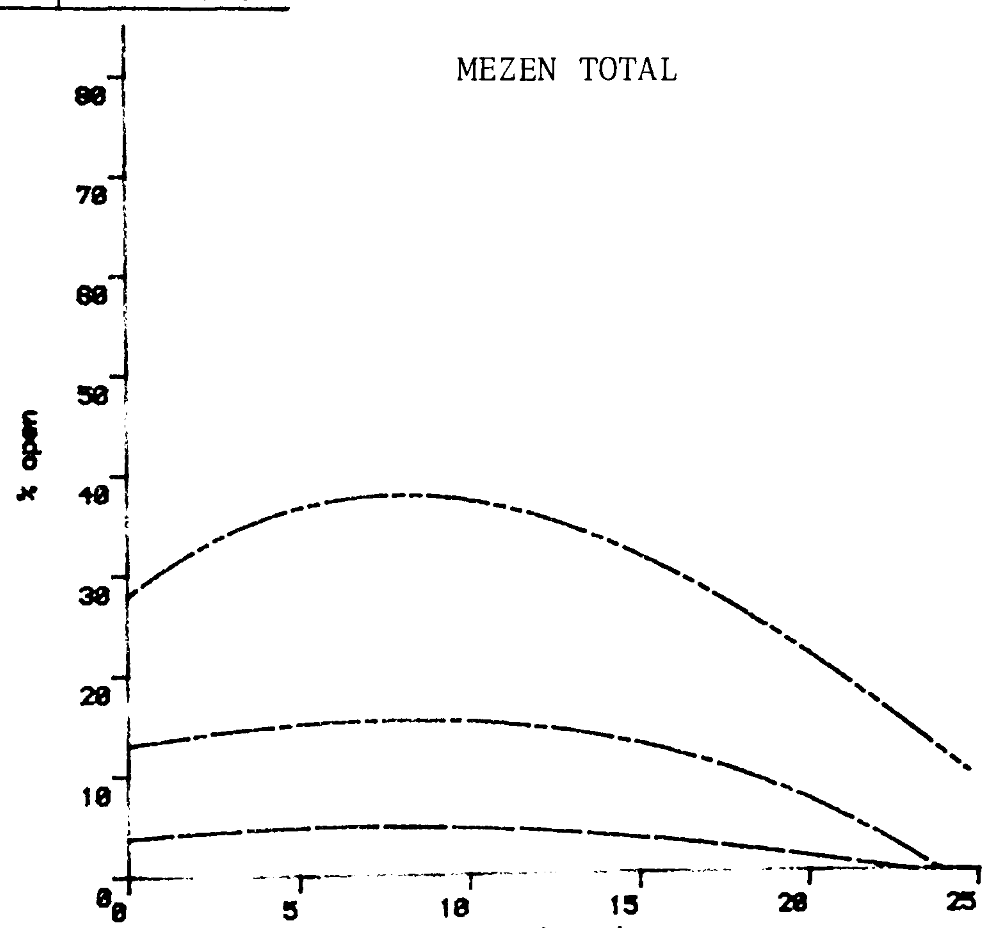


FIGURE 5.82. Relationship between windspeed and total window opening in three groups at Mezen



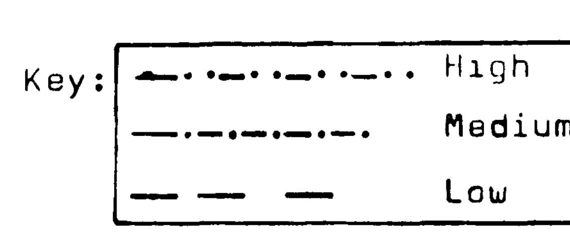


FIGURE 5.83. Relationship between sunshine duration and sittingroom window opening in three groups at Cowley

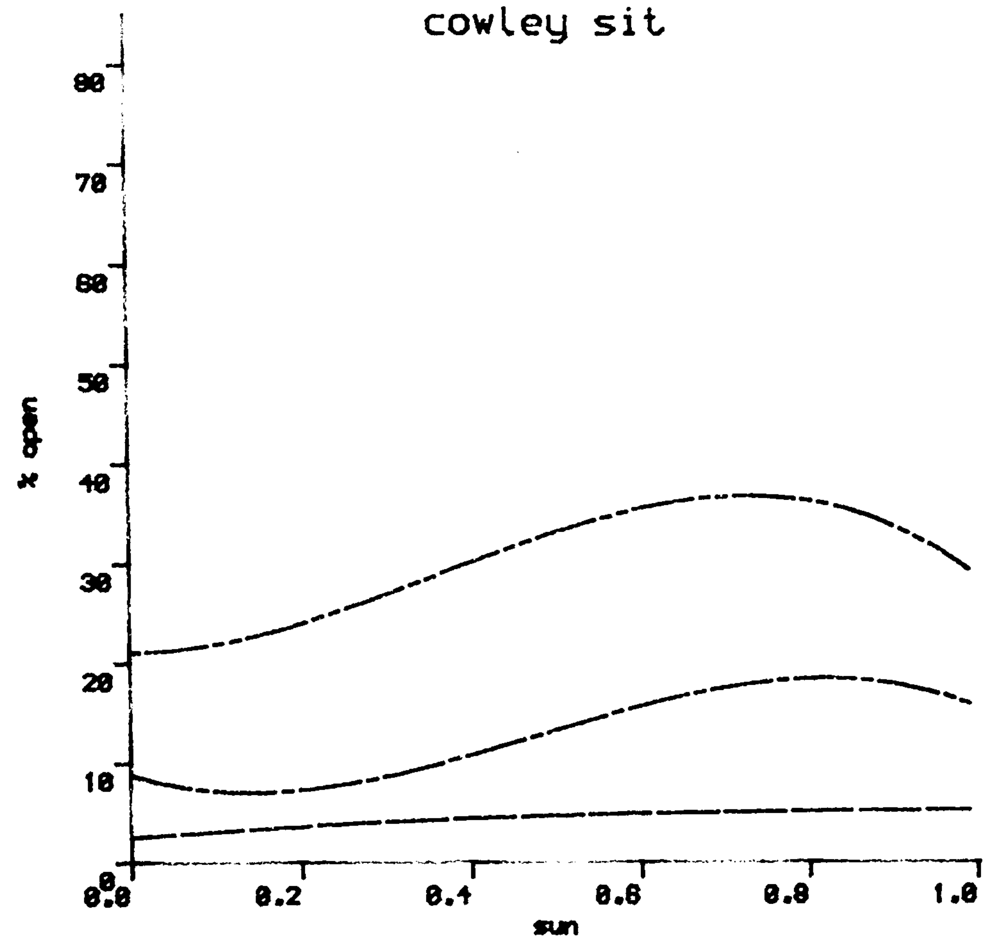
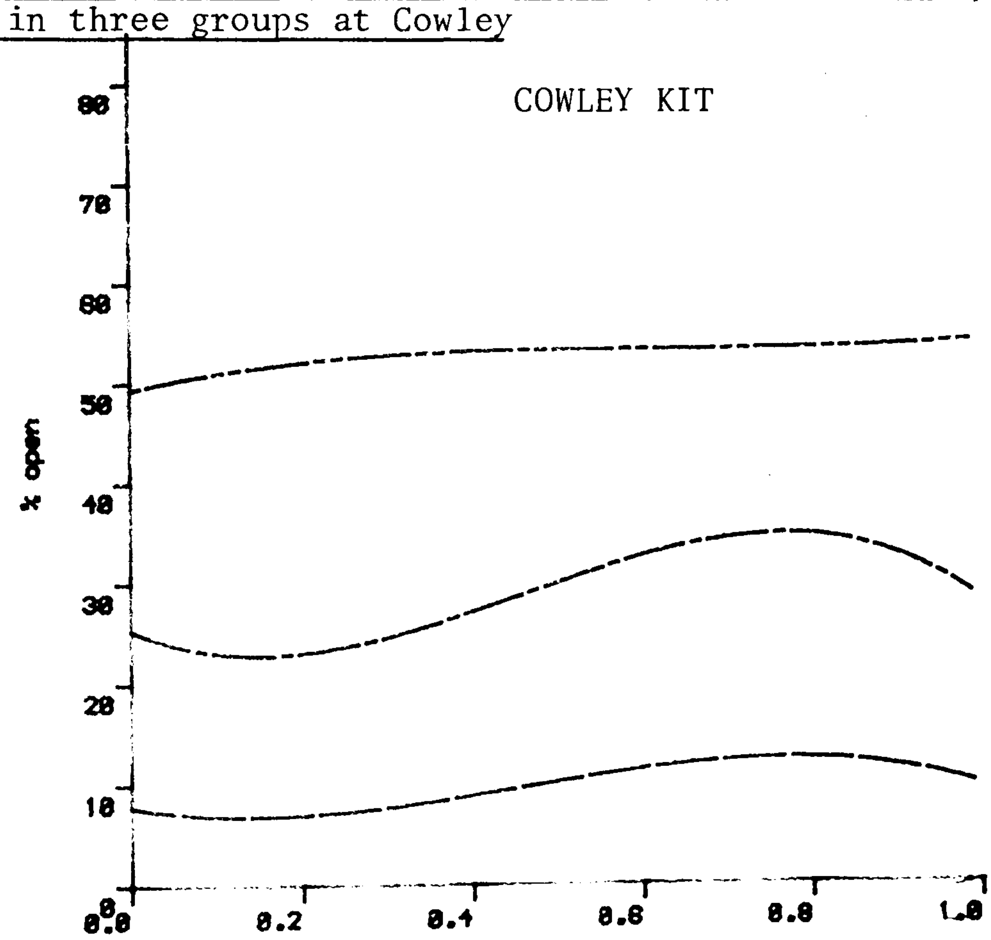


FIGURE 5.84. Relationship between sunshine duration and kitchen window opening in three groups at Cowley



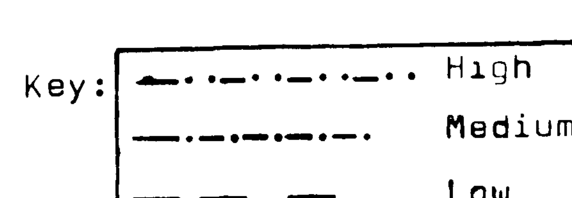


FIGURE 5.85. Relationship between sunshine duration and main bedroom window opening in three groups at Cowley

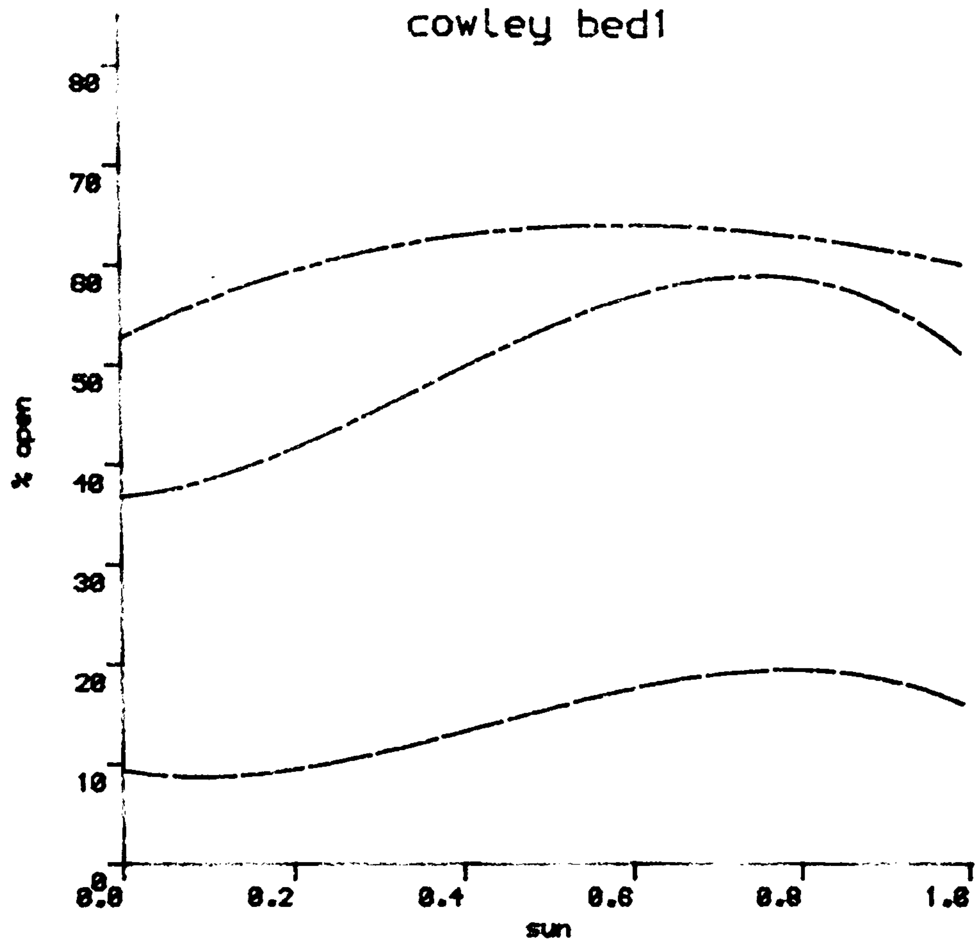
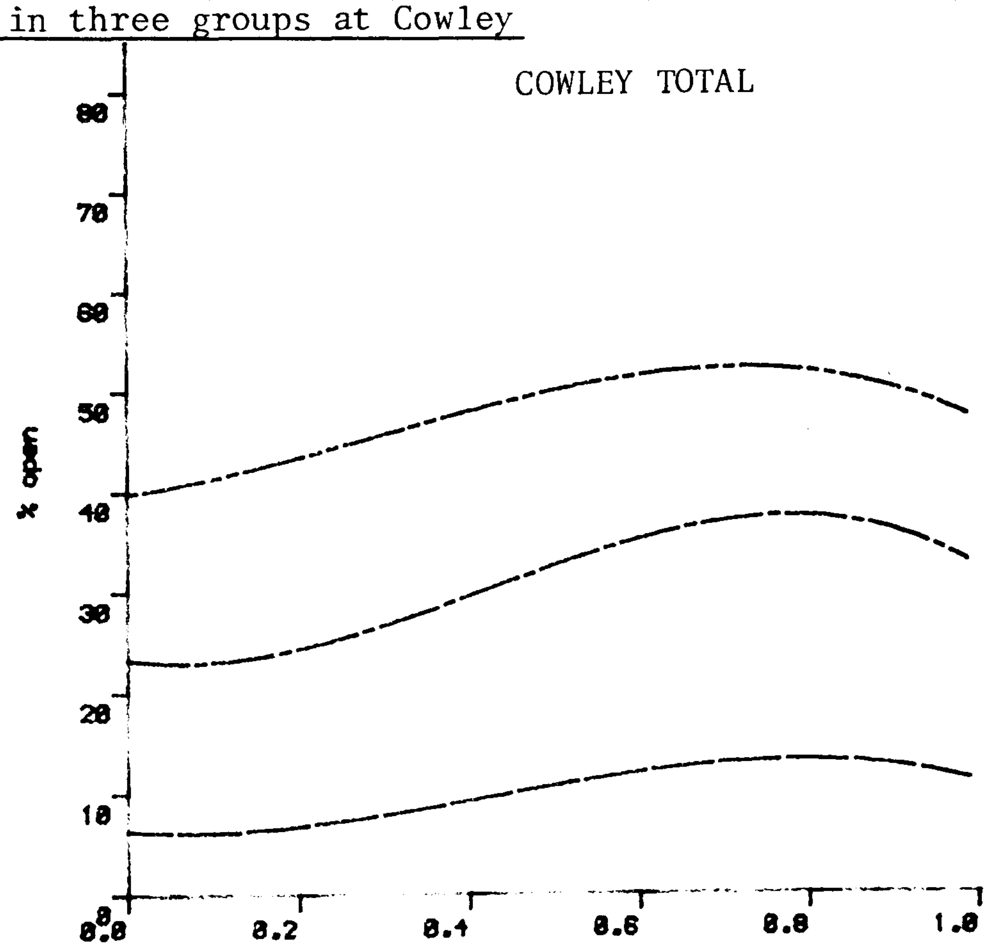


FIGURE 5.86. Relationship between sunshine duration and total window opening in three groups at Cowley



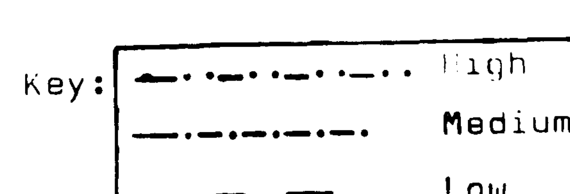


FIGURE 5.87. Relationship between sunshine duration and sittingroom window opening in three groups at Mezen

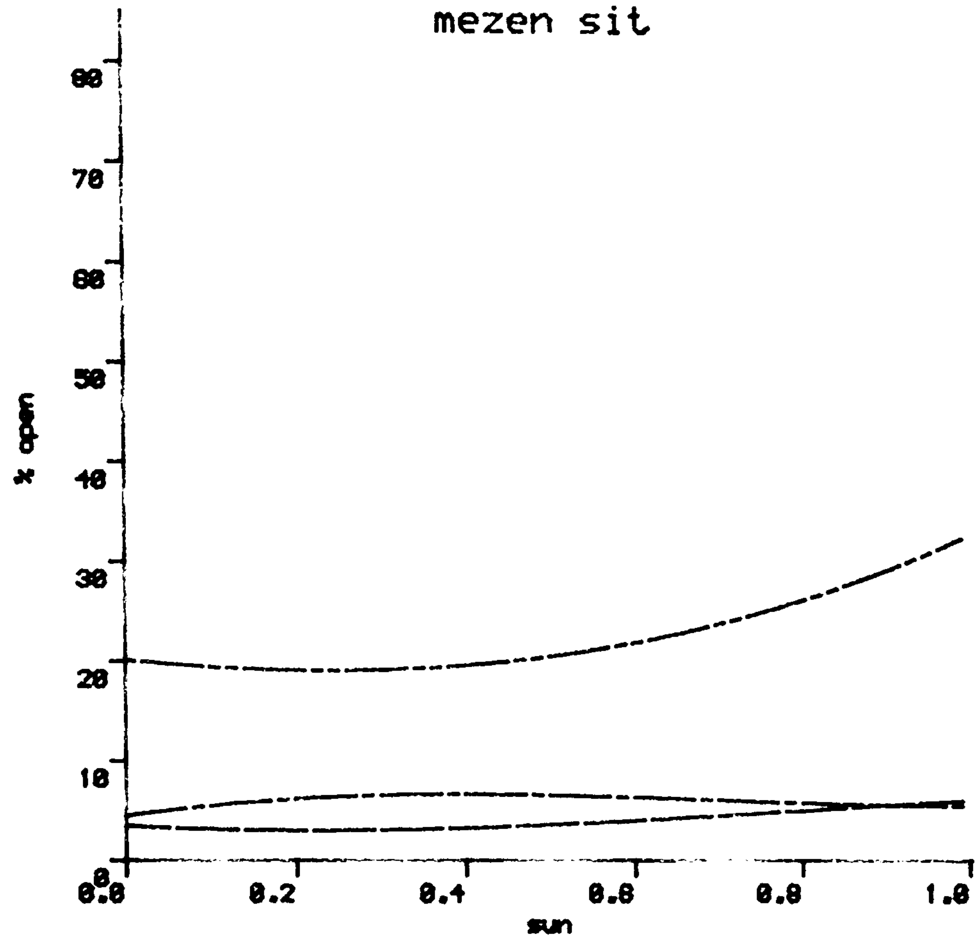
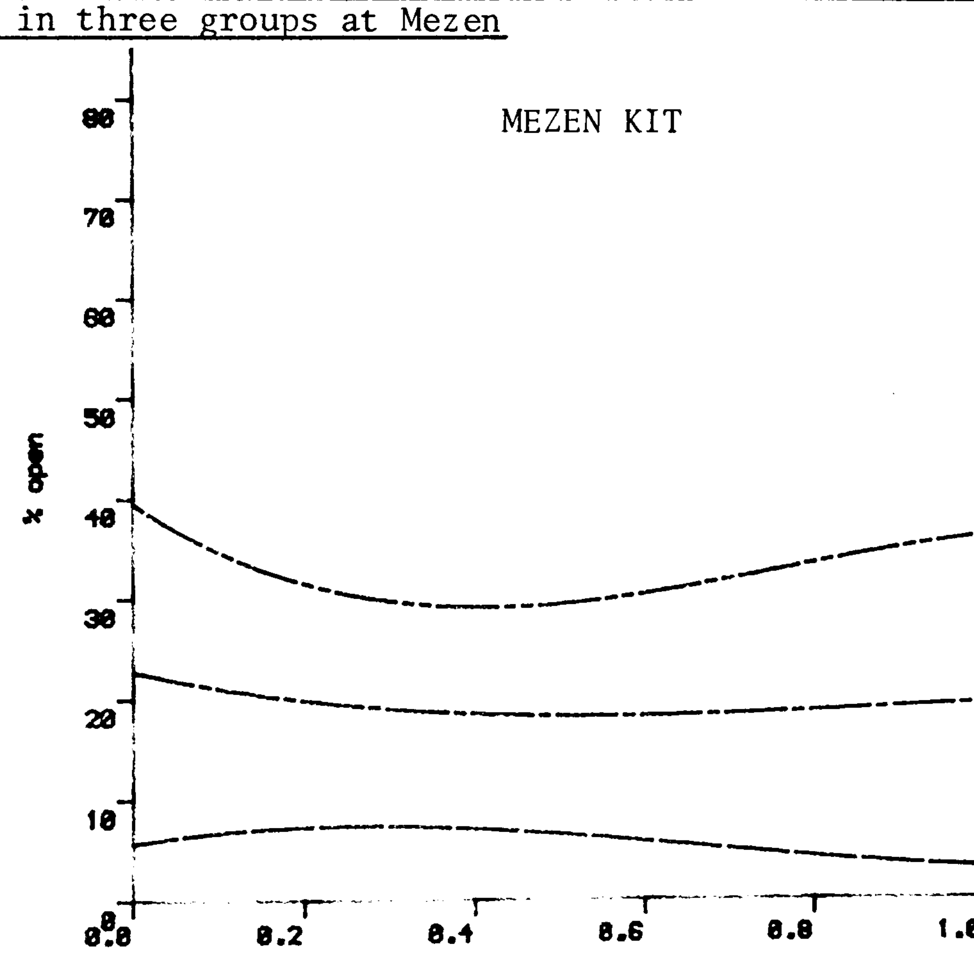


FIGURE 5.88. Relationship between sunshine duration and kitchen window opening in three groups at Mezen



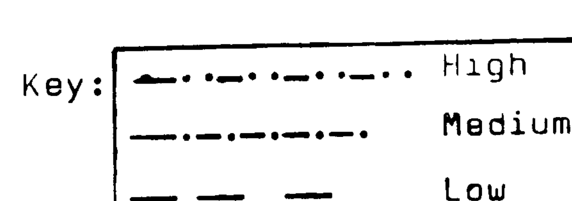


FIGURE 5.89. Relationship between sunshine duration and main bedroom window opening in three groups at Mezen

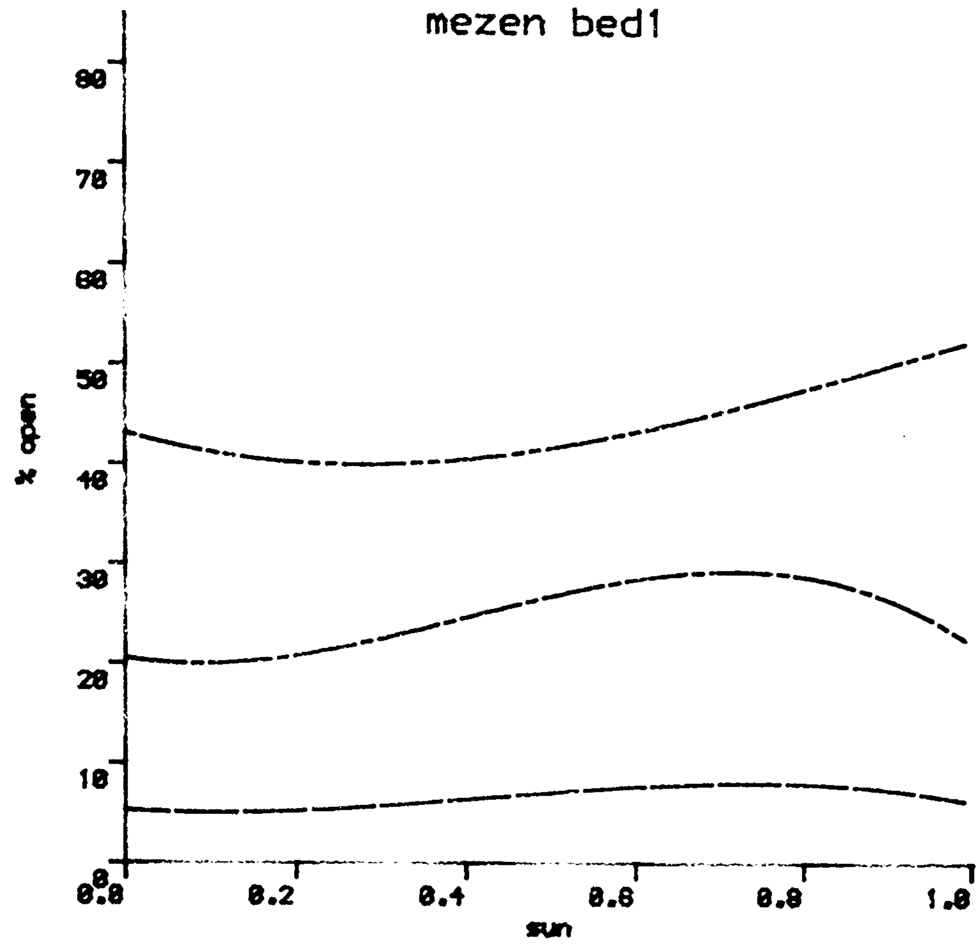
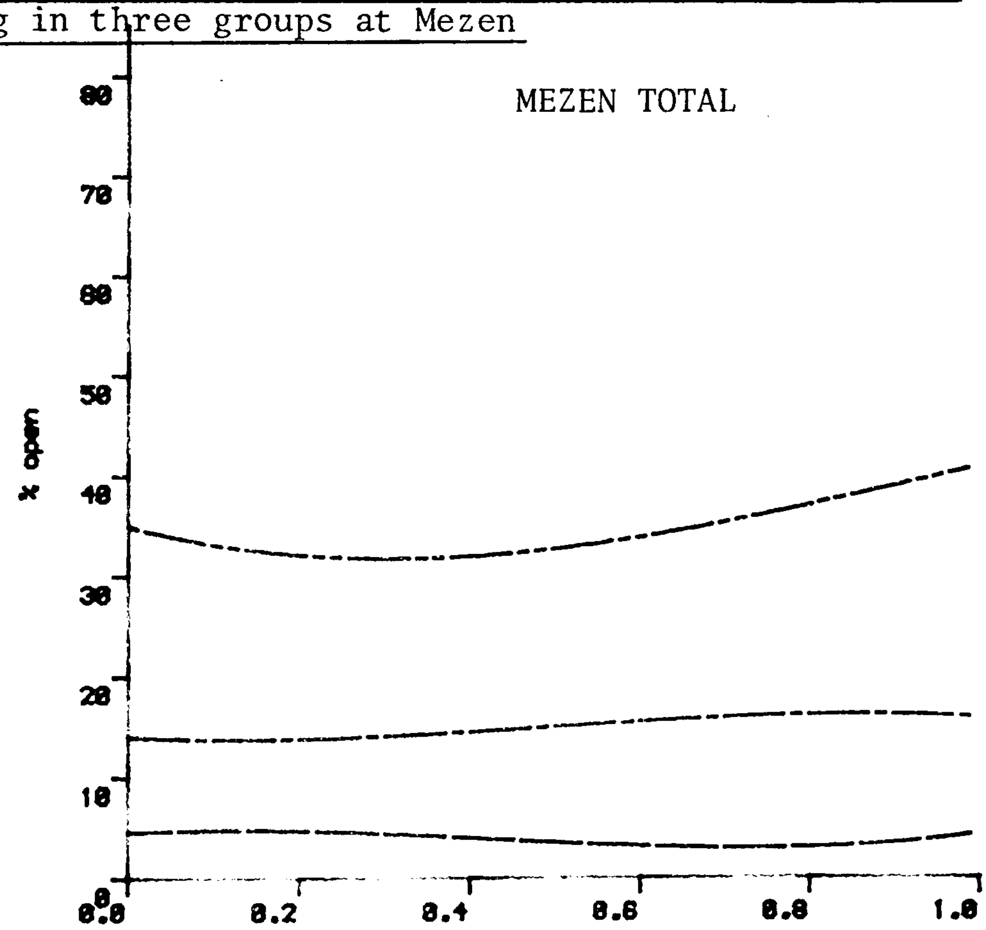


FIGURE 5.90. Relationship between sunshine duration and total window opening in three groups at Mezen



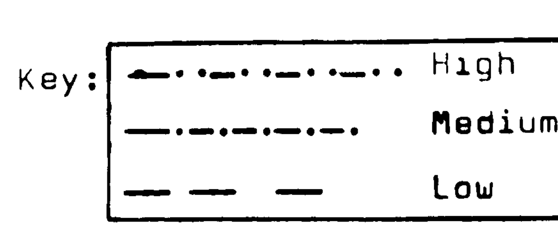


FIGURE 5.91. Relationship between rainfall and sittingroom window opening in three groups at Cowley

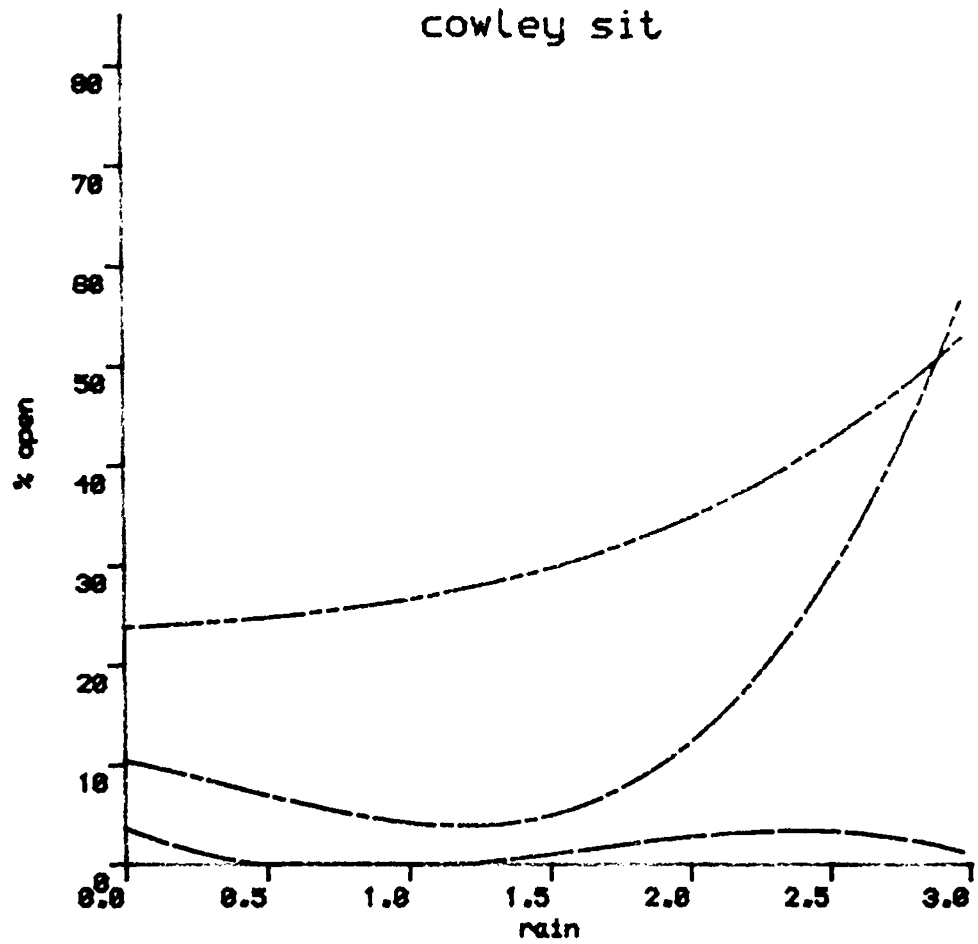
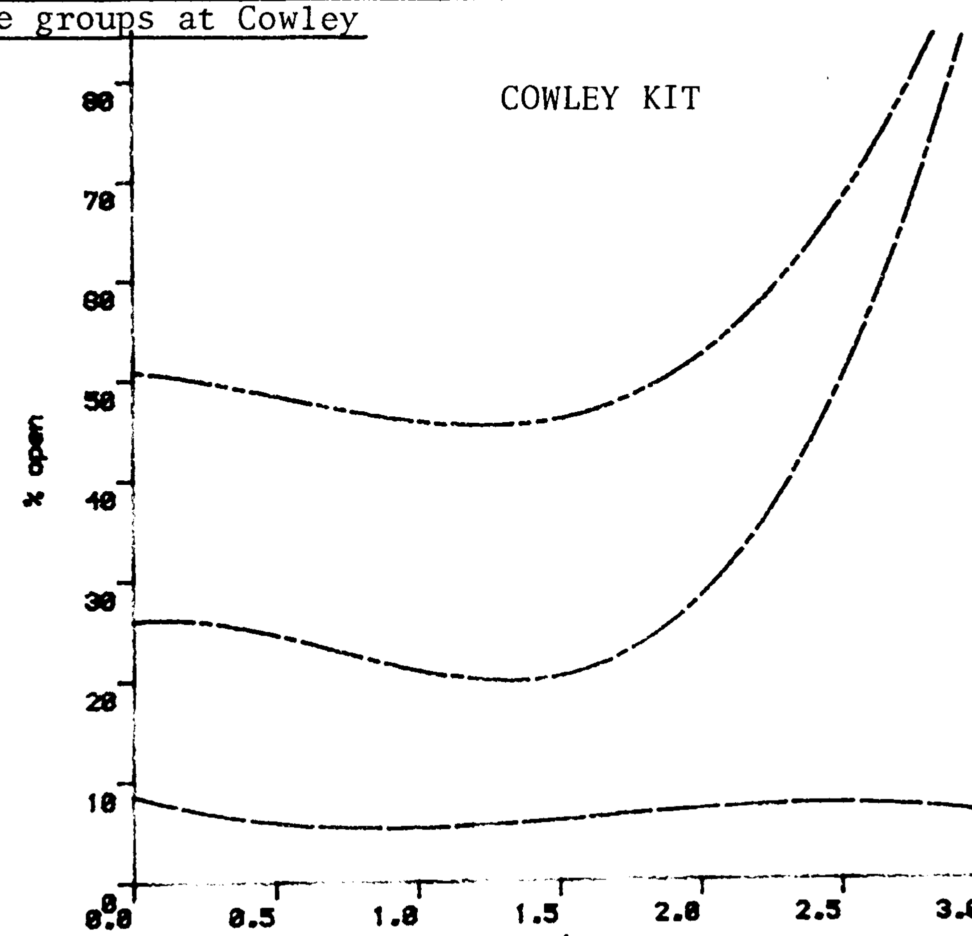


FIGURE 5.92. Relationship between rainfall and kitchen window opening in three groups at Cowley



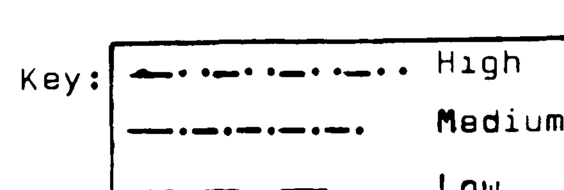


FIGURE 5.93. Relationship between rainfall and main bedroom window opening in three groups at Cowley

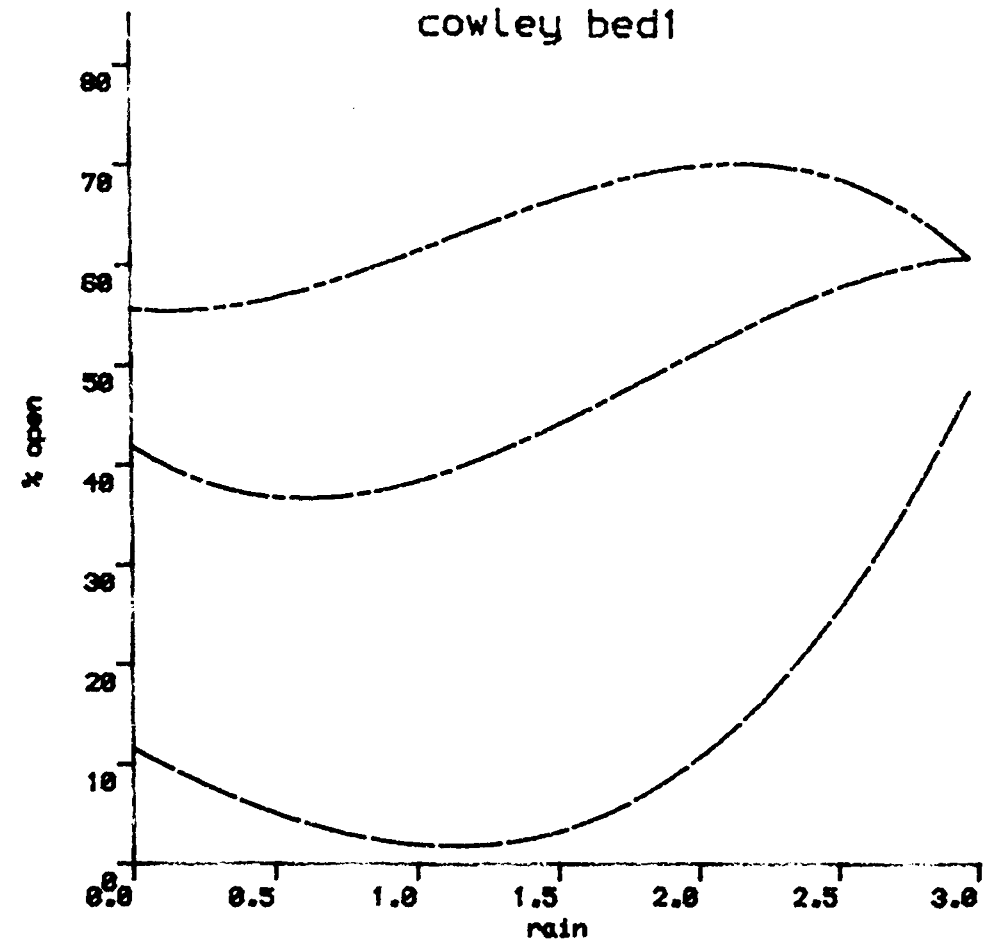
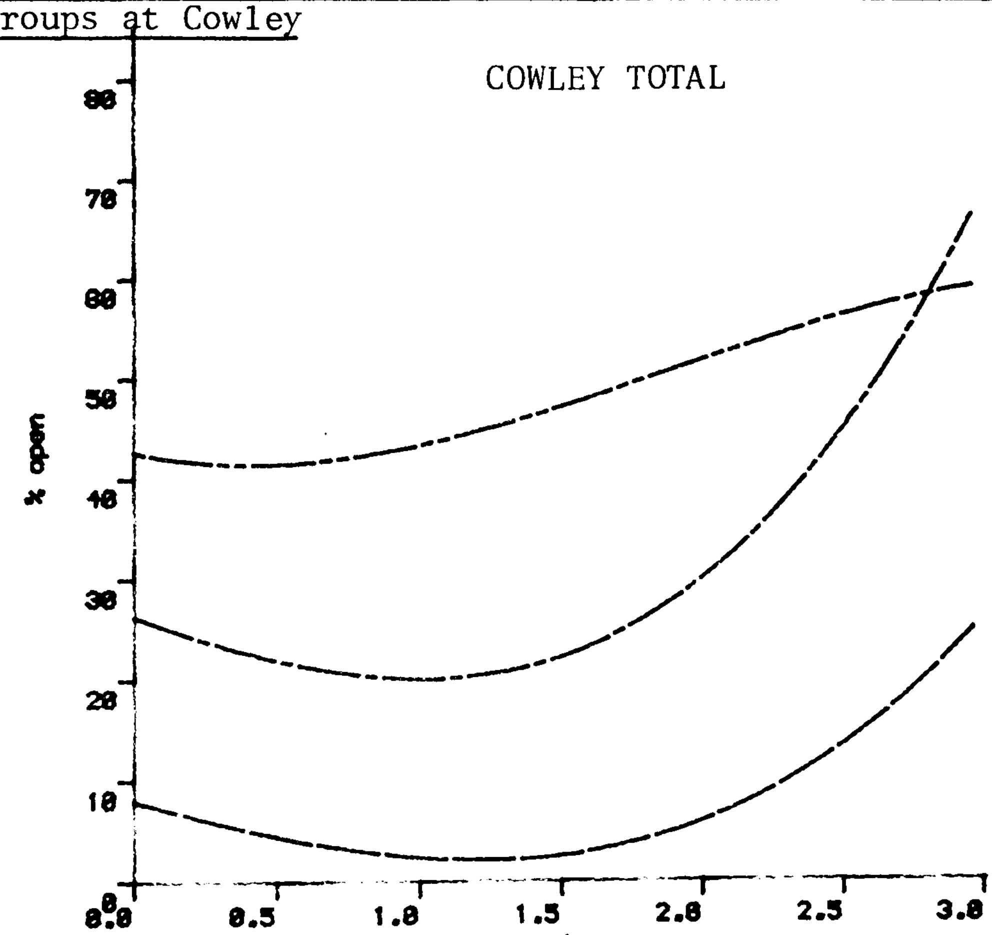


FIGURE 5.94. Relationship between rainfall and total window opening in three groups at Cowley



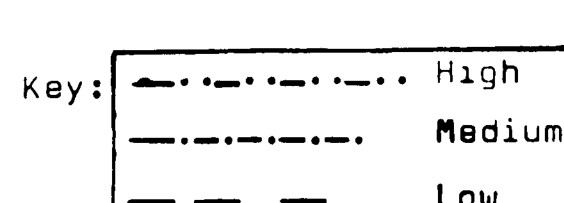


FIGURE 5.95. Relationship between rainfall and sittingroom window opening in three groups at Mezen

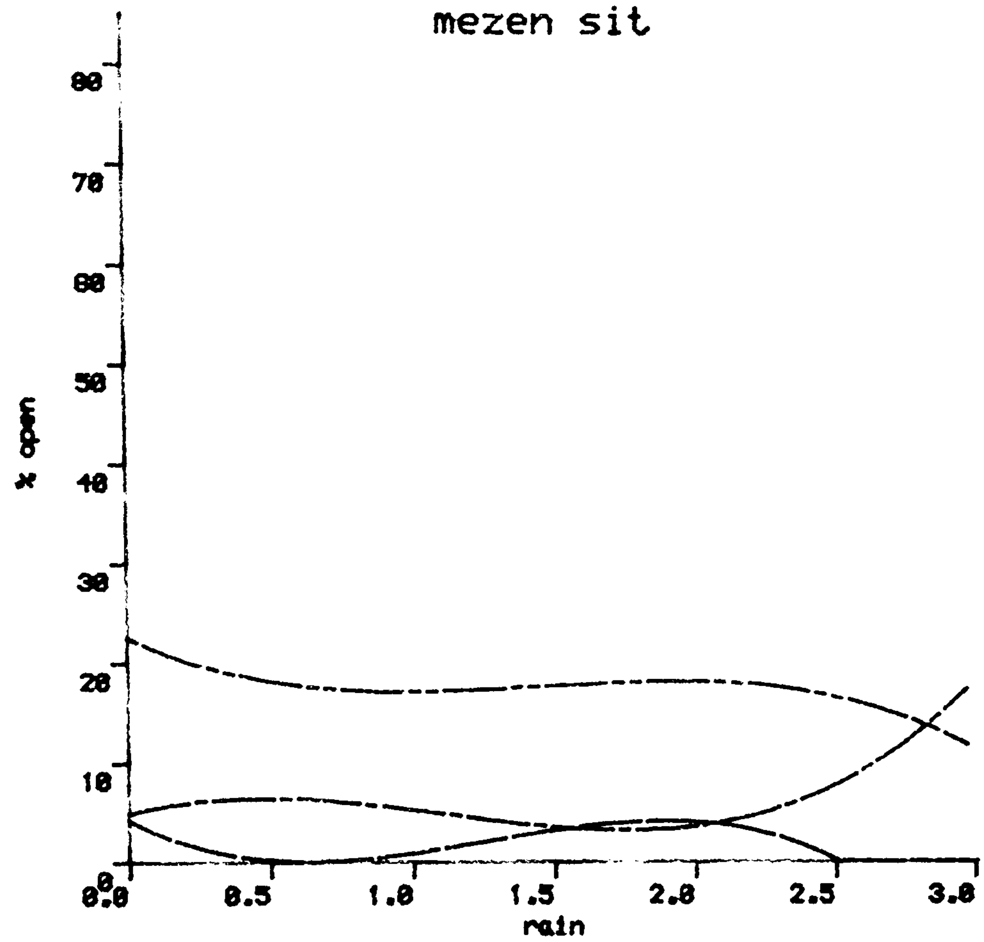
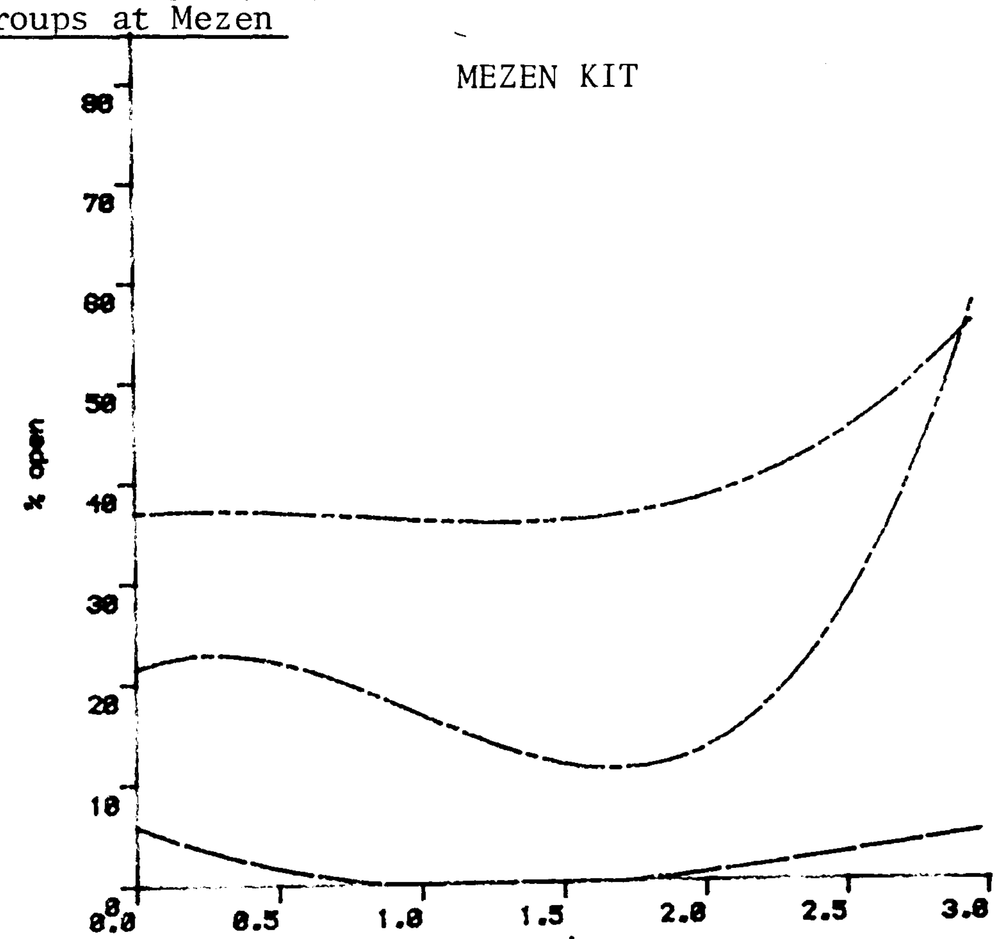


FIGURE 5.96. Relationship between rainfall and kitchen window opening in three groups at Mezen



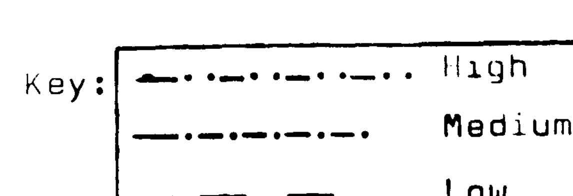


FIGURE 5.97. Relationship between rainfall and main bedroom window opening in three groups at Mezen

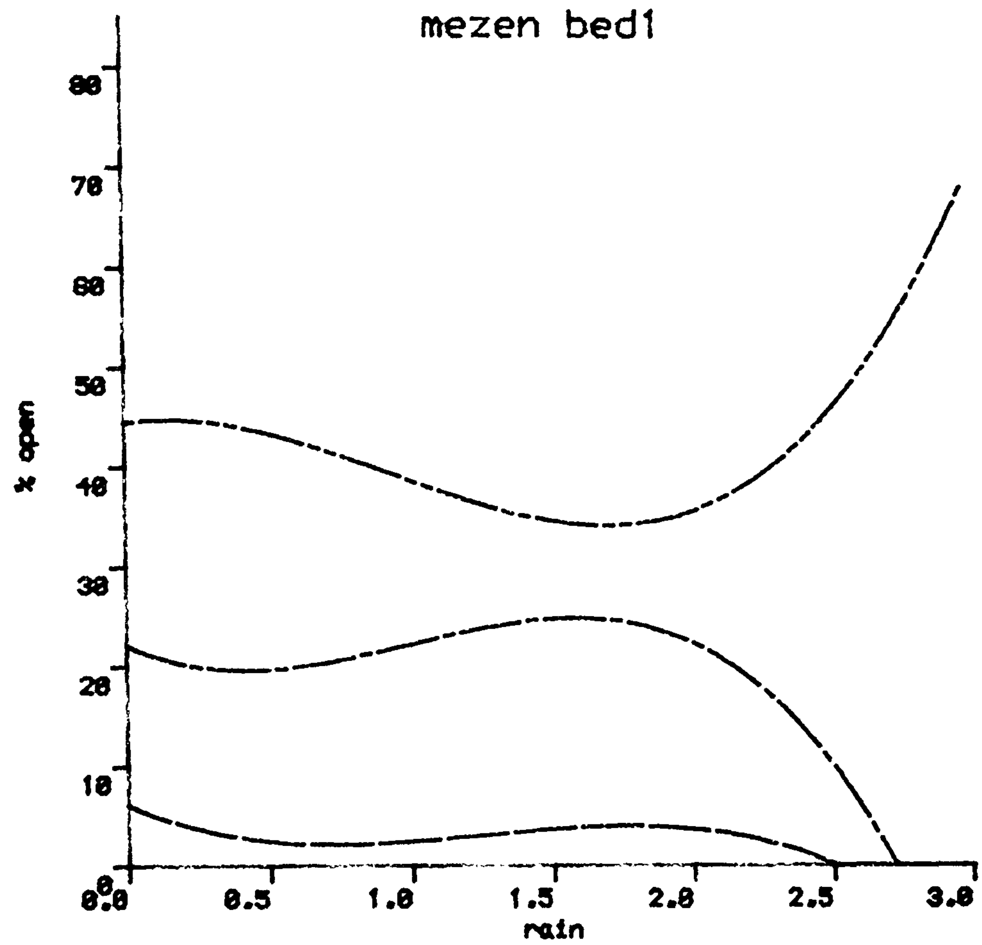
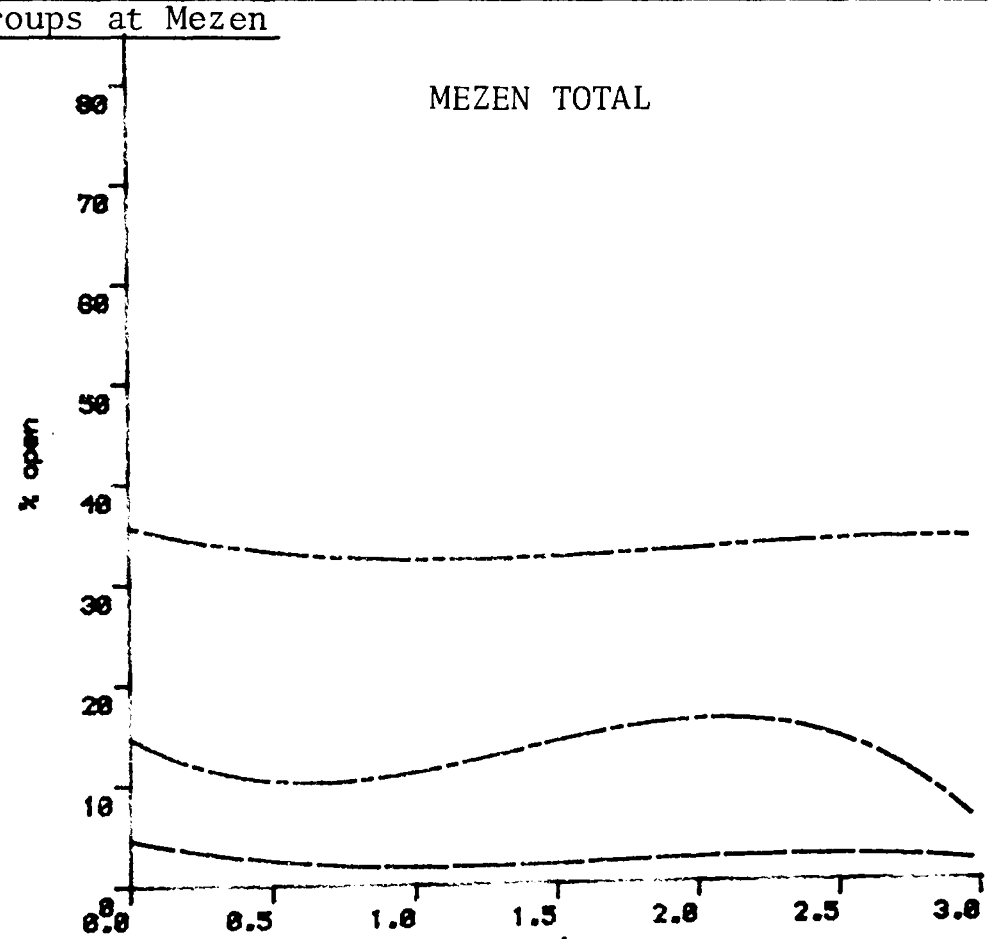
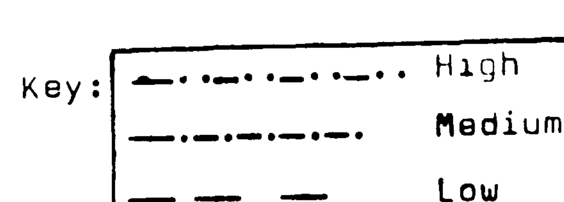


FIGURE 5.98. Relationship between rainfall and total window opening in three groups at Mezen





polynomial curve at high windspeeds suggests the relative importance of windspeed increases with the windspeed itself.

When considering sunshine duration and rainfall, the division of householders into three groups, reveals no common pattern and adds nothing to the earlier discussion (Figures 5.87 to 5.98).

5.4.6. Comparison of Relationships between Open Window Observations and Weather Parameters at Cowley and Mezen

Figure 5.99 to 5.118 show third order polynomial curves of all (high, medium and low groups combined) open window observations for each room type against each weather parameter. The curves shown have already been included in figures 5.52 to 5.56, but are brought together here to enable comparison of the two estates. This comparison provides a further opportunity to judge the similarity of the window opening response to weather parameters for independent groups; here the two geographically separated estates. Inspection of the first four graphs shows that with one minor exception (Figure 5.99) the curve for Cowley lies above that for Mezen for the sittingroom, kitchen, main bedroom and total windows. Similar relative levels of window opening are shown in the diagrams for the remaining four weather parameters, but this is in any case virtually assured since for each room type the underlying distribution of open window percentages is the same in all cases. The mean percentages for window opening in the different room types on the two estates have already been shown in table 5.13. Differences between window opening levels at Cowley and Mezen may be due either to differences in dwelling design or differences between householders, or to both. At this stage, we have no means for identifying the causes.

FIGURE 5.99. Relationship between temperature and sittingroom window opening at Cowley and Mezen

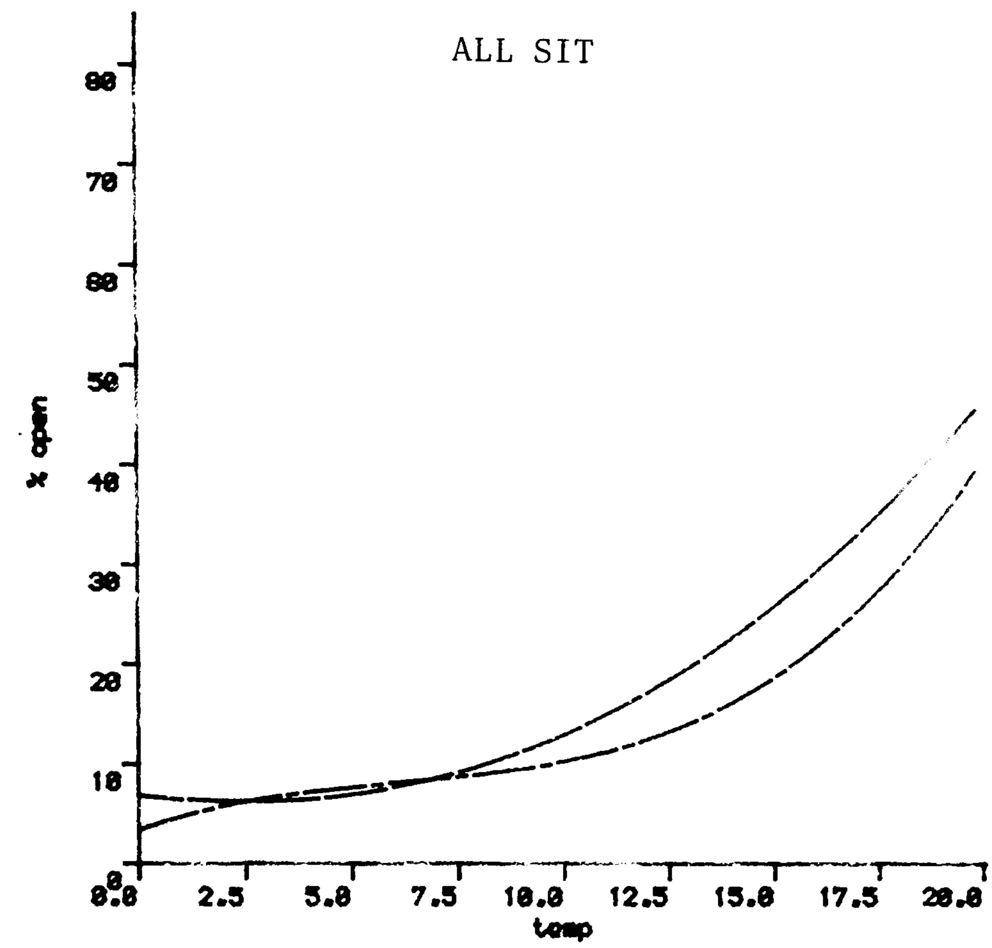
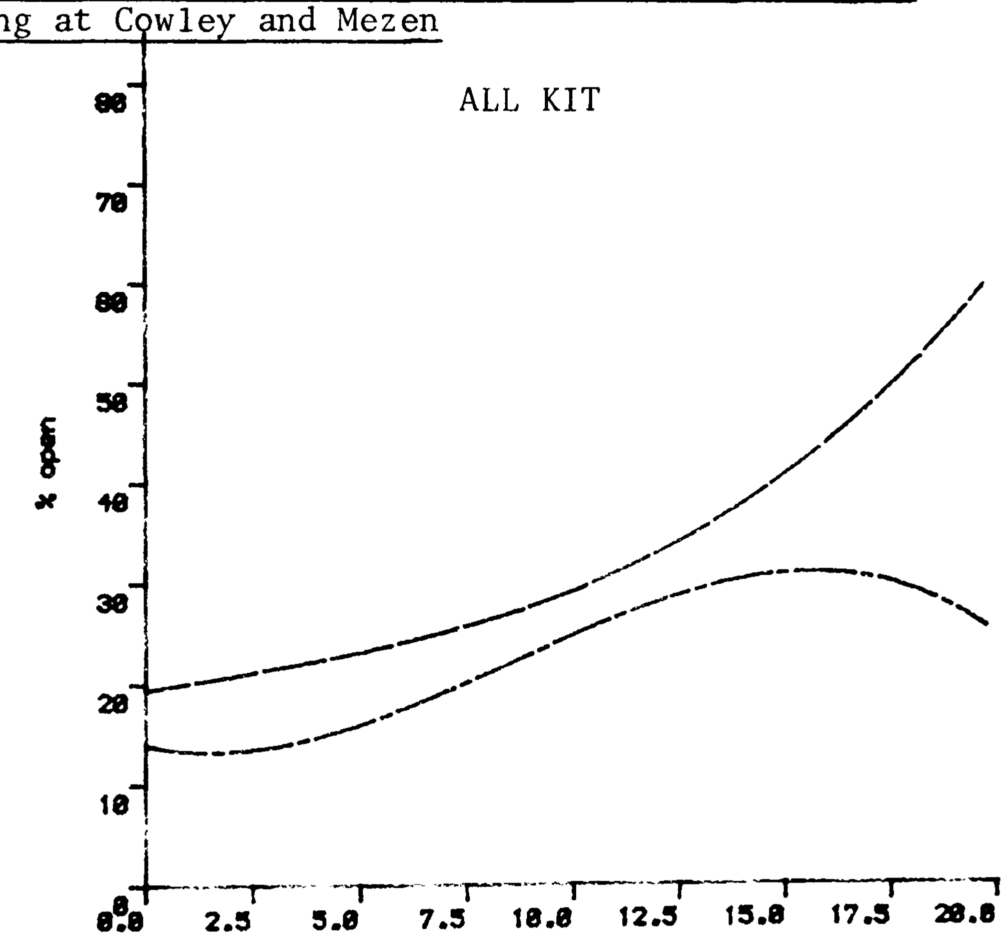


FIGURE 5.100. Relationship between temperature and kitchen window opening at Cowley and Mezen



Key: ——— ——— Cowley; —.—.— Mezen

FIGURE 5.101. Relationship between temperature and main bedroom window opening at Cowley and Mezen

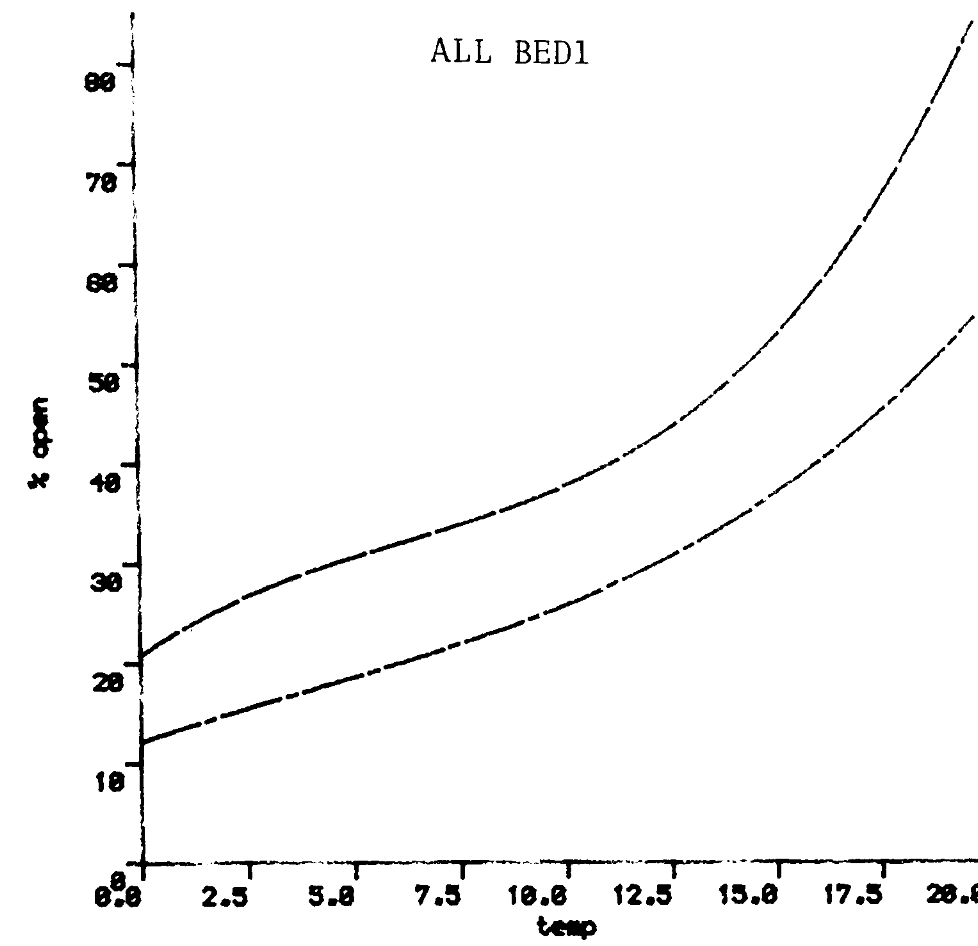
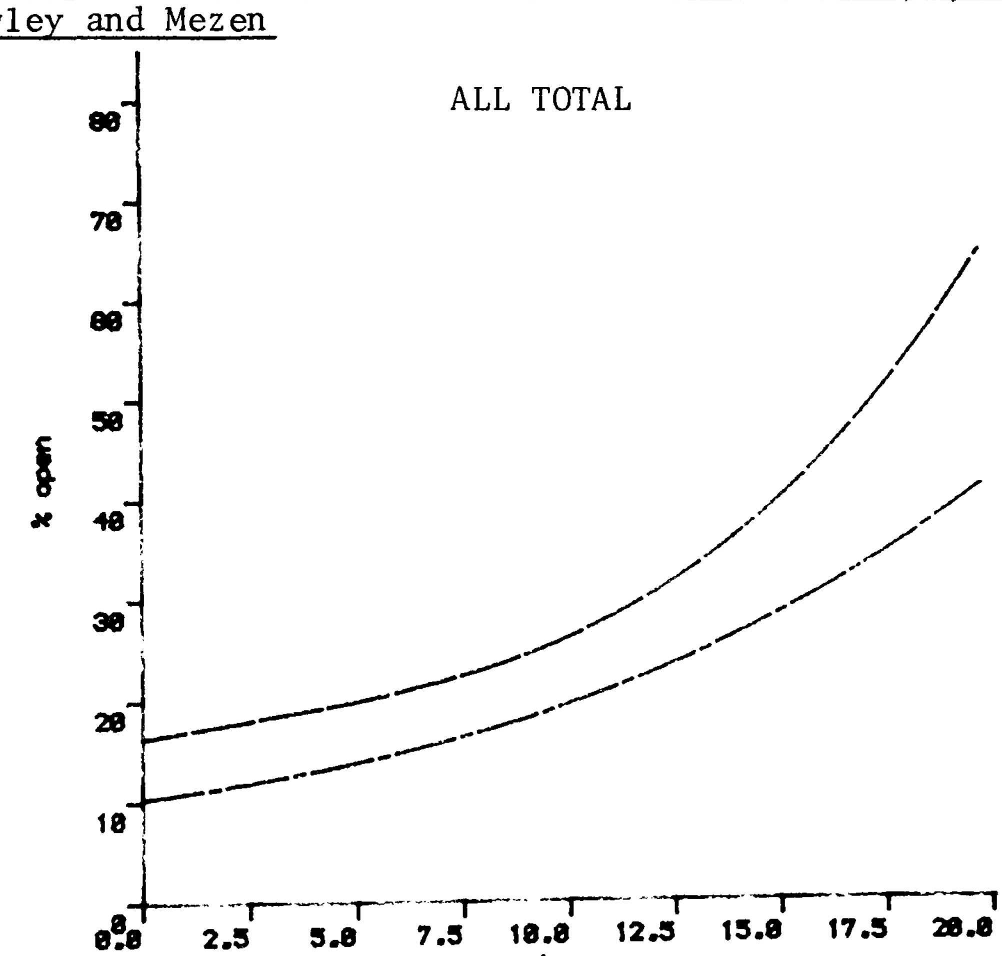


FIGURE 5.102. Relationship between temperature and total window opening at Cowley and Mezen



Key: ——— ——— Cowley
—.—.— Mezen

FIGURE 5.103. Relationship between relative humidity and sittingroom window opening at Cowley and Mezen

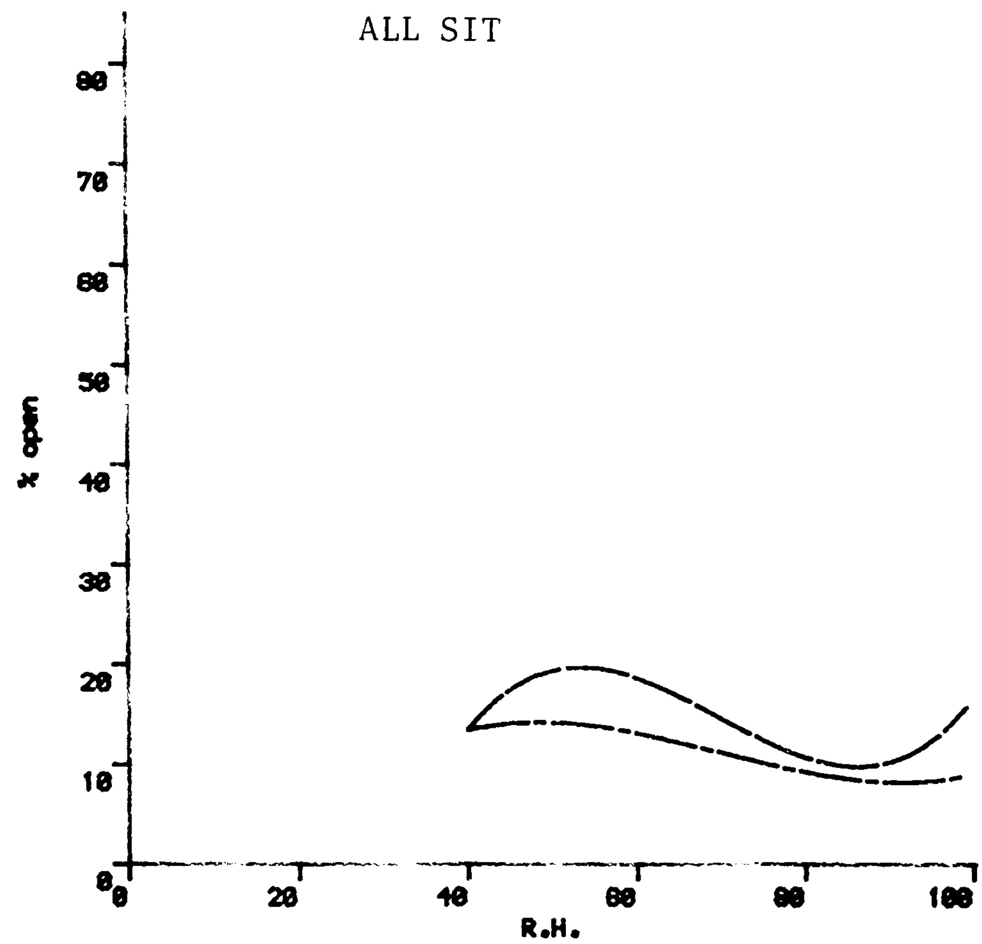
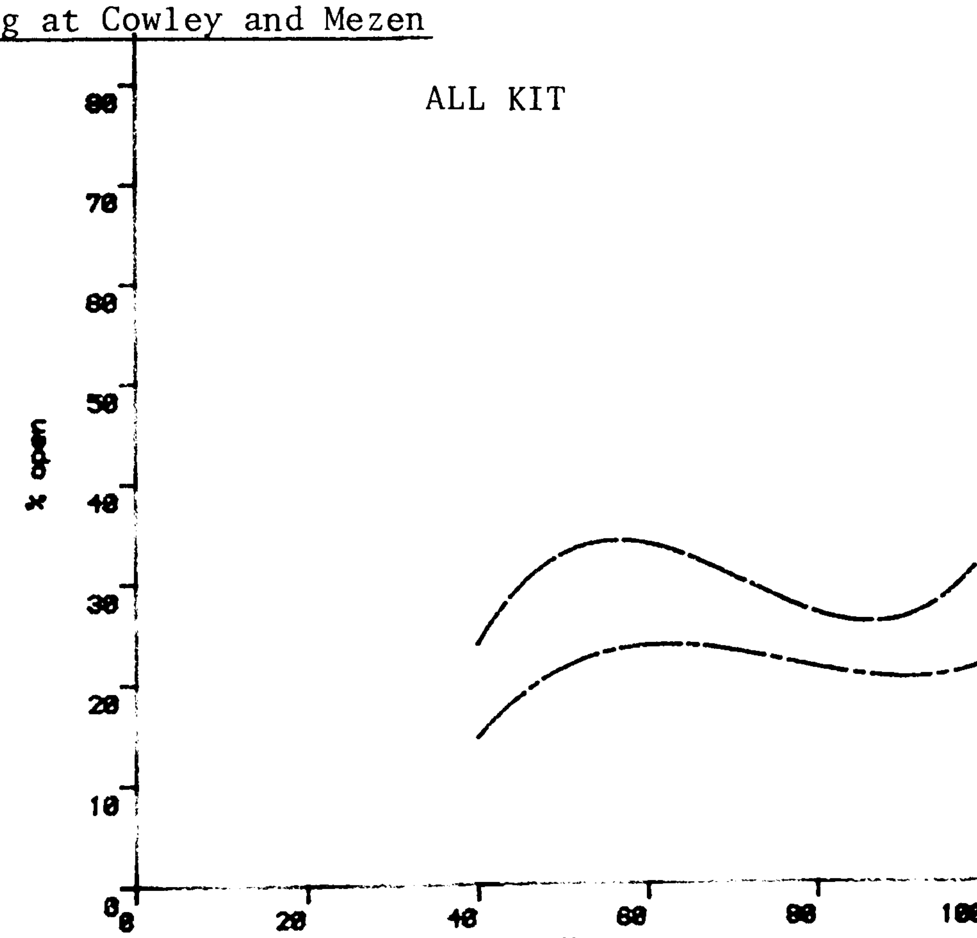


FIGURE 5.104. Relationship between relative humidity and kitchen window opening at Cowley and Mezen



Key: —— —— Cowley
—.—.— Mezen

FIGURE 5.105. Relationship between relative humidity and main bedroom window opening at Cowley and Mezen

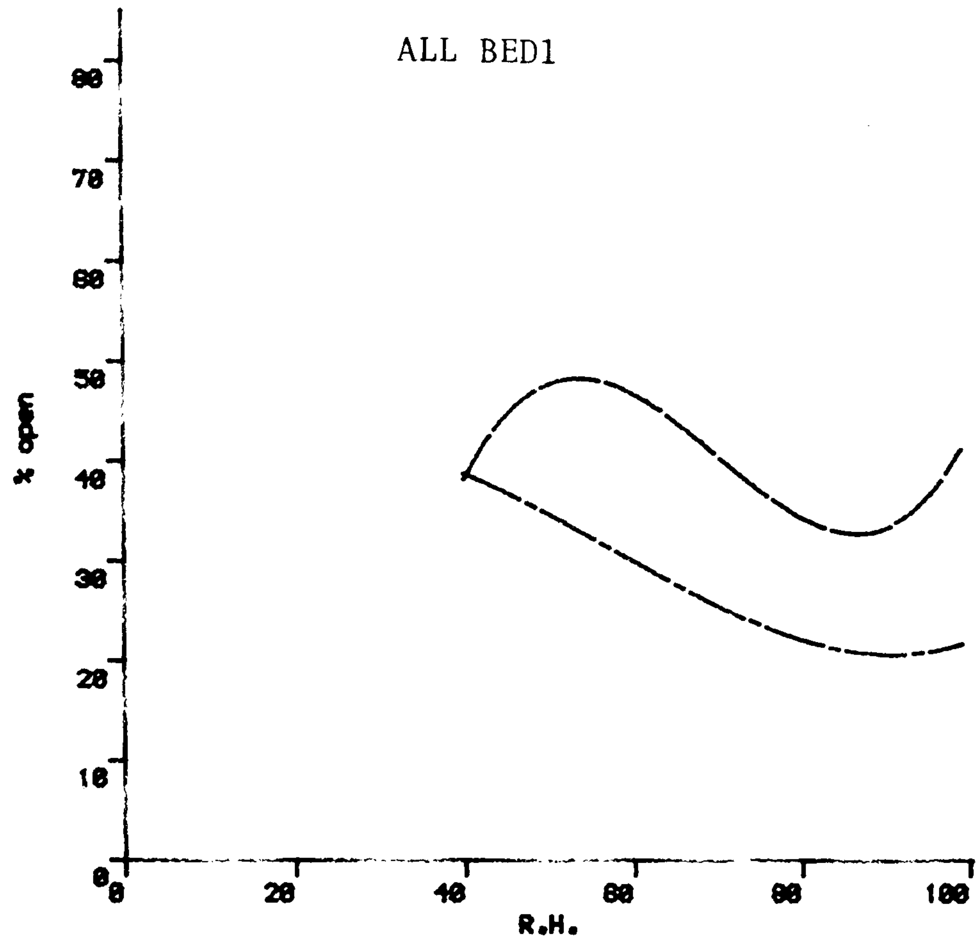
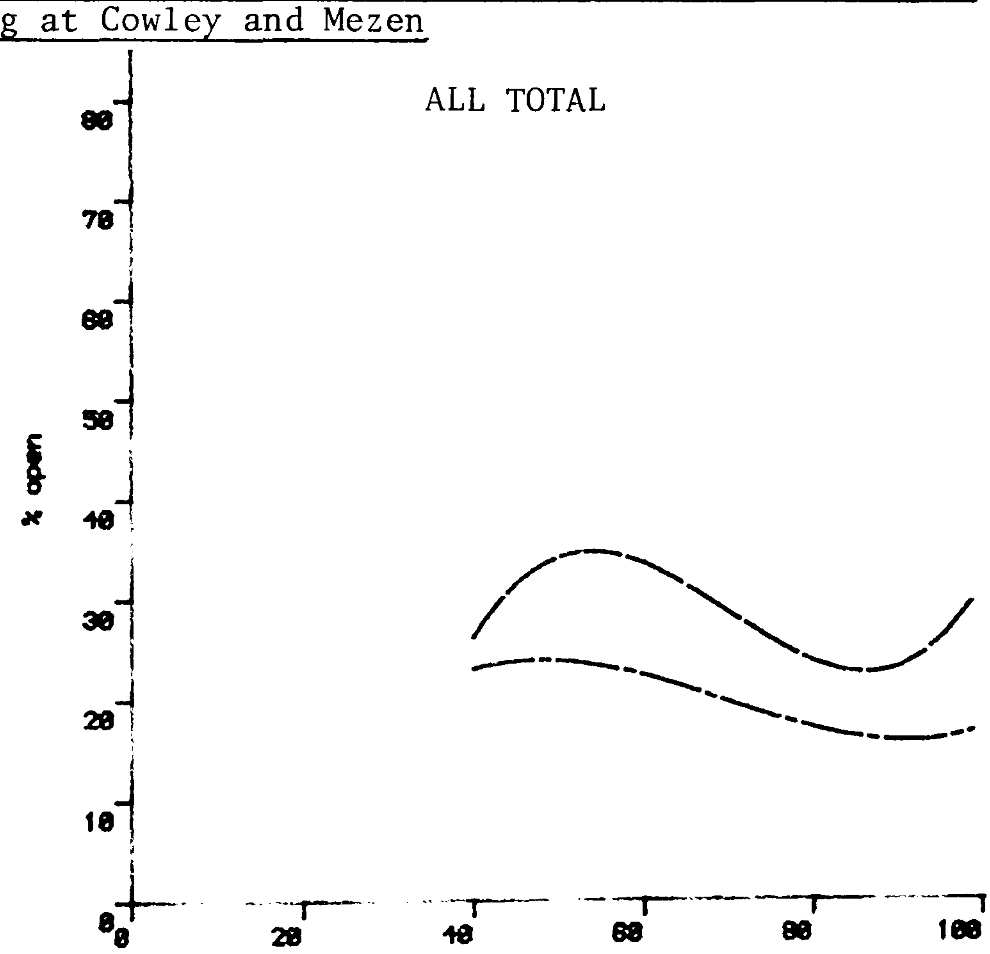


FIGURE 5.106. Relationship between relative humidity and total window opening at Cowley and Mezen



Key: —— —— Cowley
—.—.— Mezen

FIGURE 5.107. Relationship between windspeed and sittingroom window opening at Cowley and Mezen

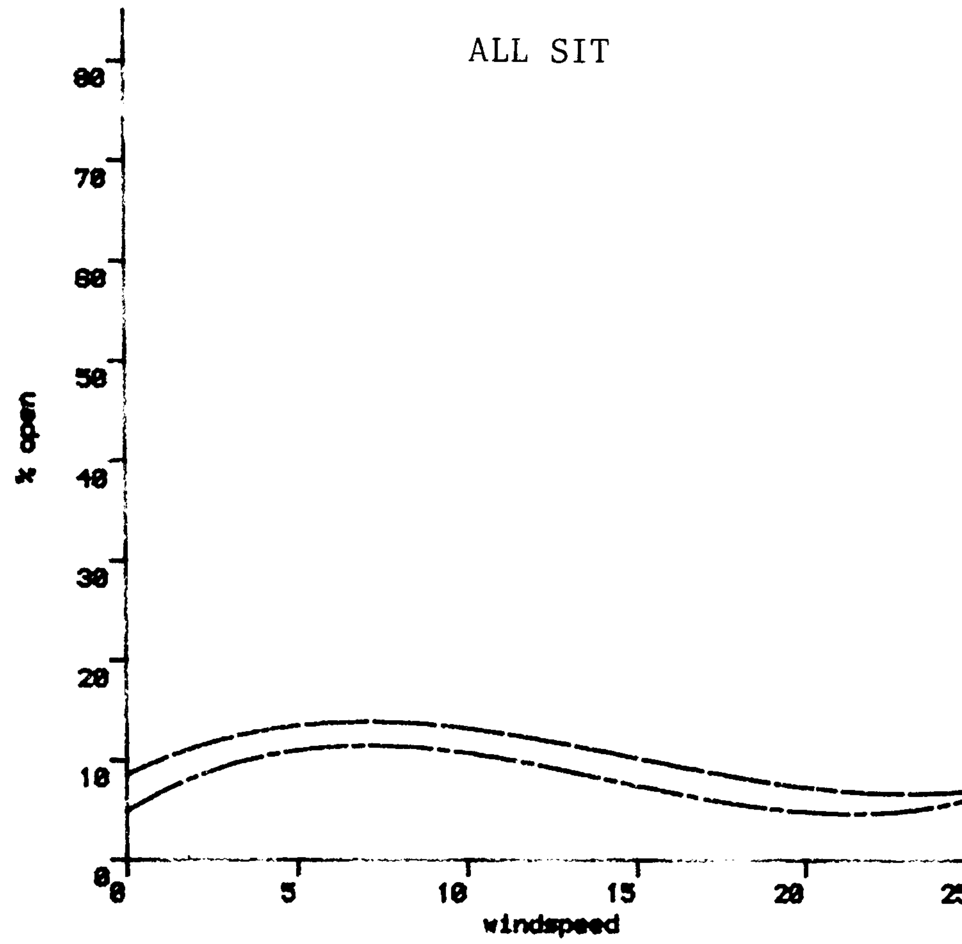
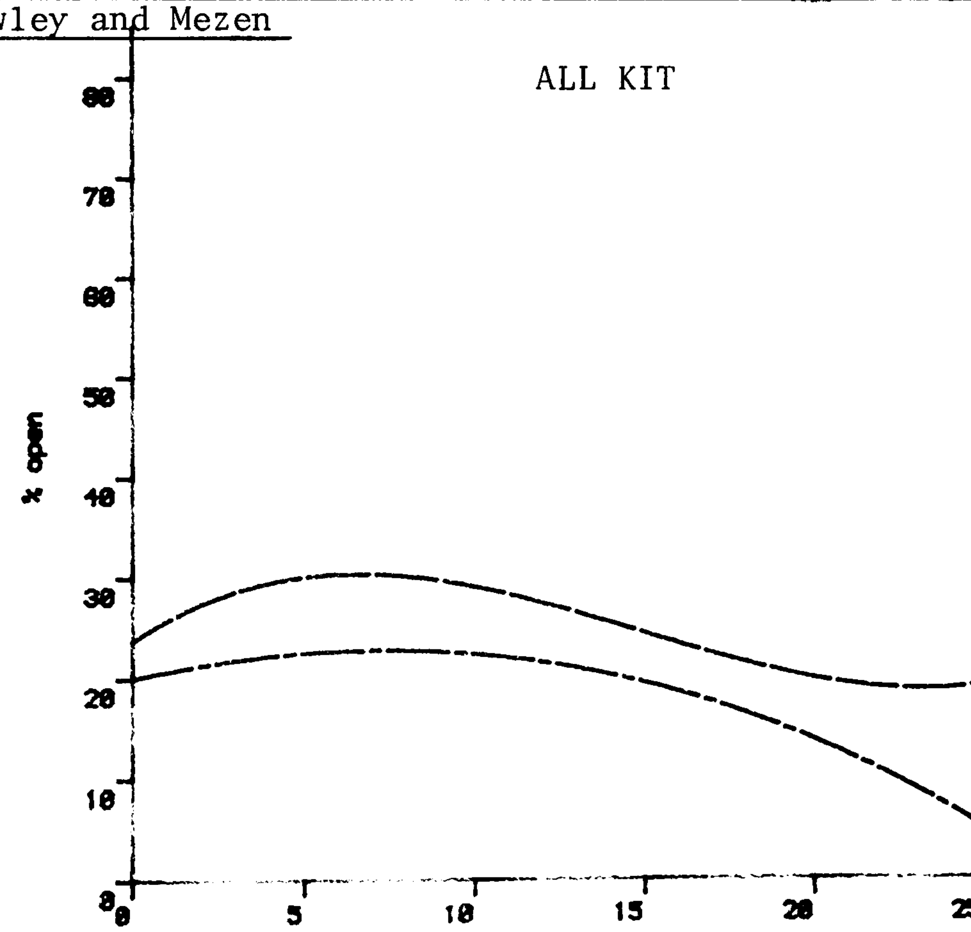


FIGURE 5.108. Relationship between windspeed and kitchen window opening at Cowley and Mezen



Key: —— —— Cowley; —.—.— Mezen

FIGURE 5.109. Relationship between windspeed and main bedroom window opening at Cowley and Mezen

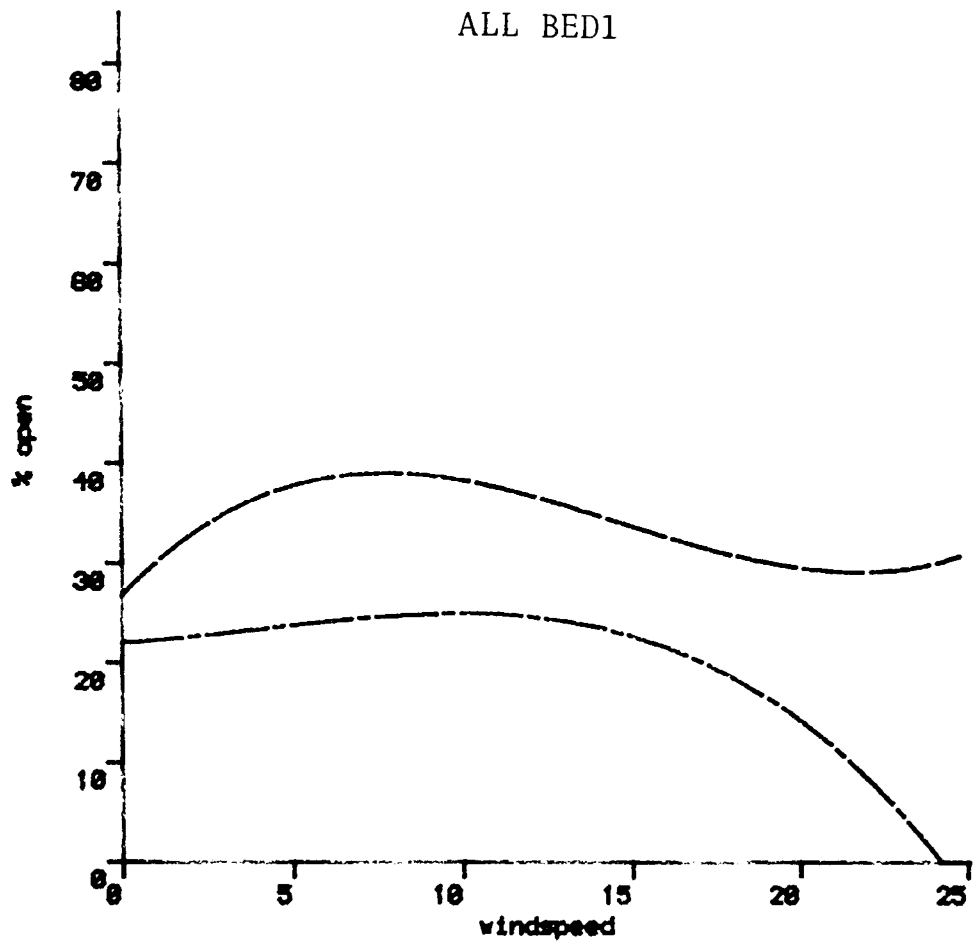
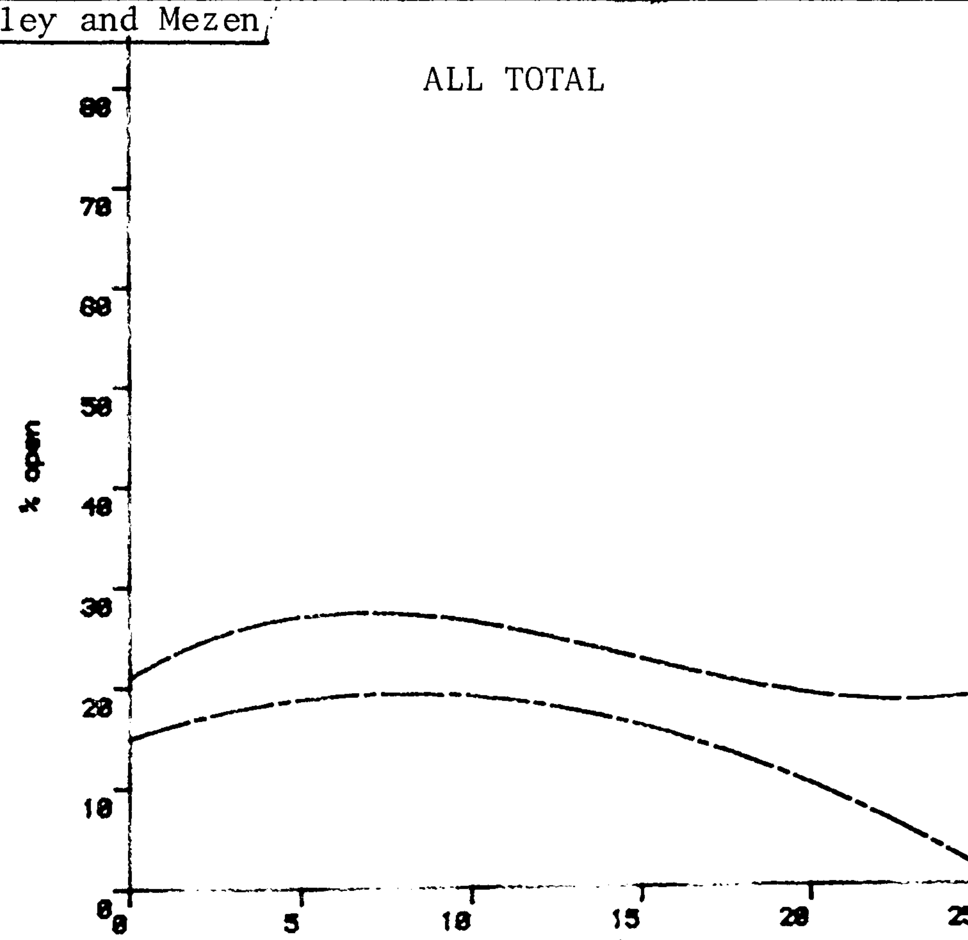


FIGURE 5.110. Relationship between windspeed and total window opening at Cowley and Mezen



Key: —— —— Cowley
—.—.— Mezen

FIGURE 5.111. Relationship between sunshine duration and sittingroom window opening at Cowley and Mezen

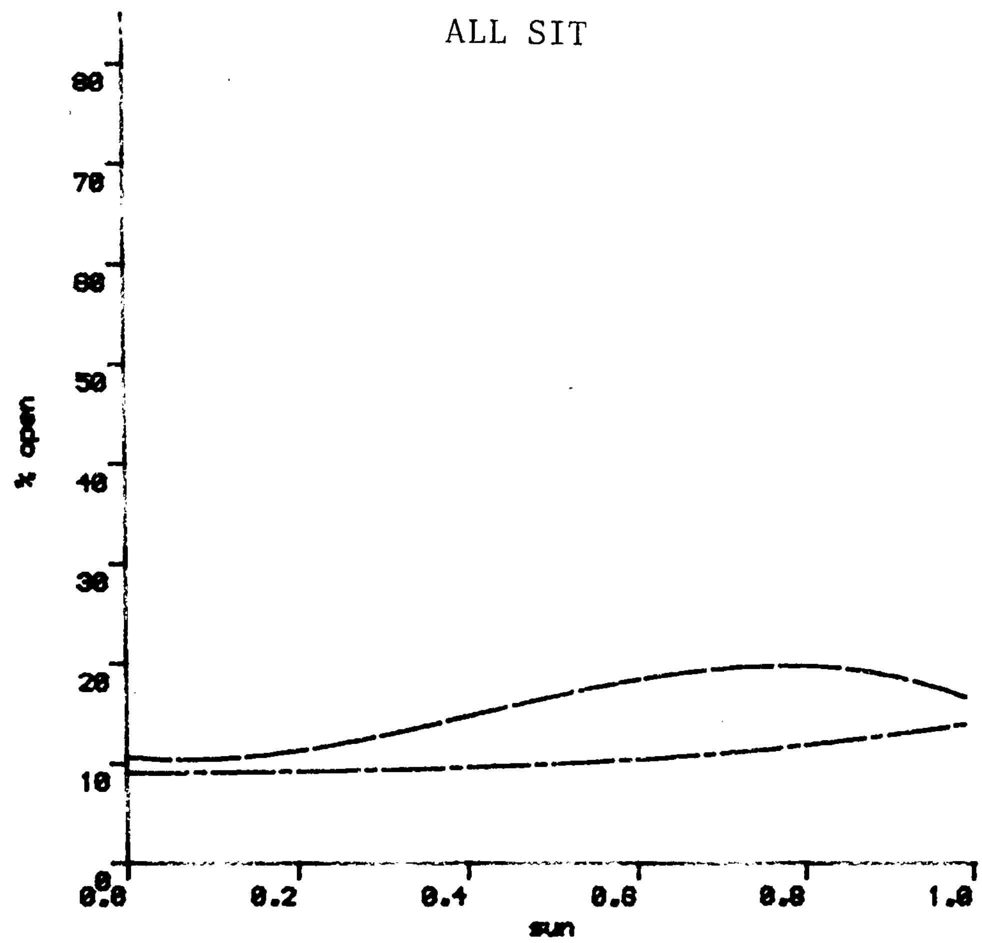
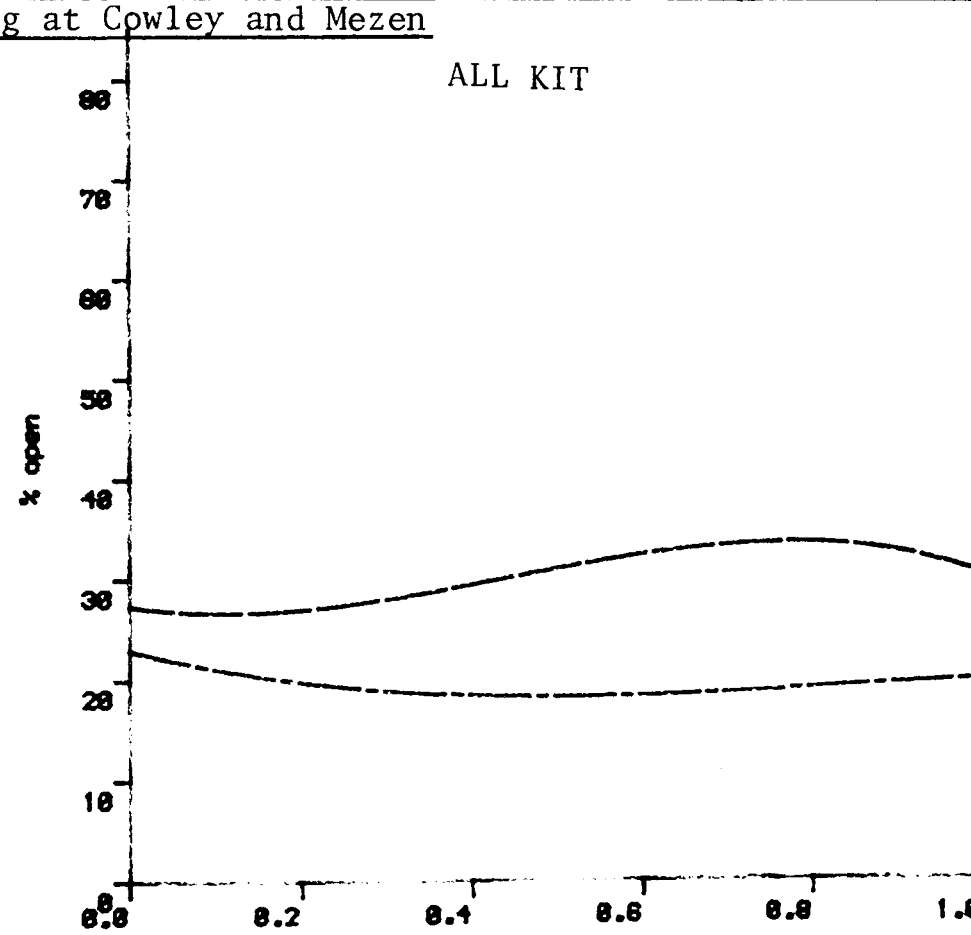


FIGURE 5.112. Relationship between sunshine duration and kitchen window opening at Cowley and Mezen



Key: —— —— Cowley
—.—.— Mezen

FIGURE 5.113. Relationship between sunshine duration and main bedroom window opening at Cowley and Mezen

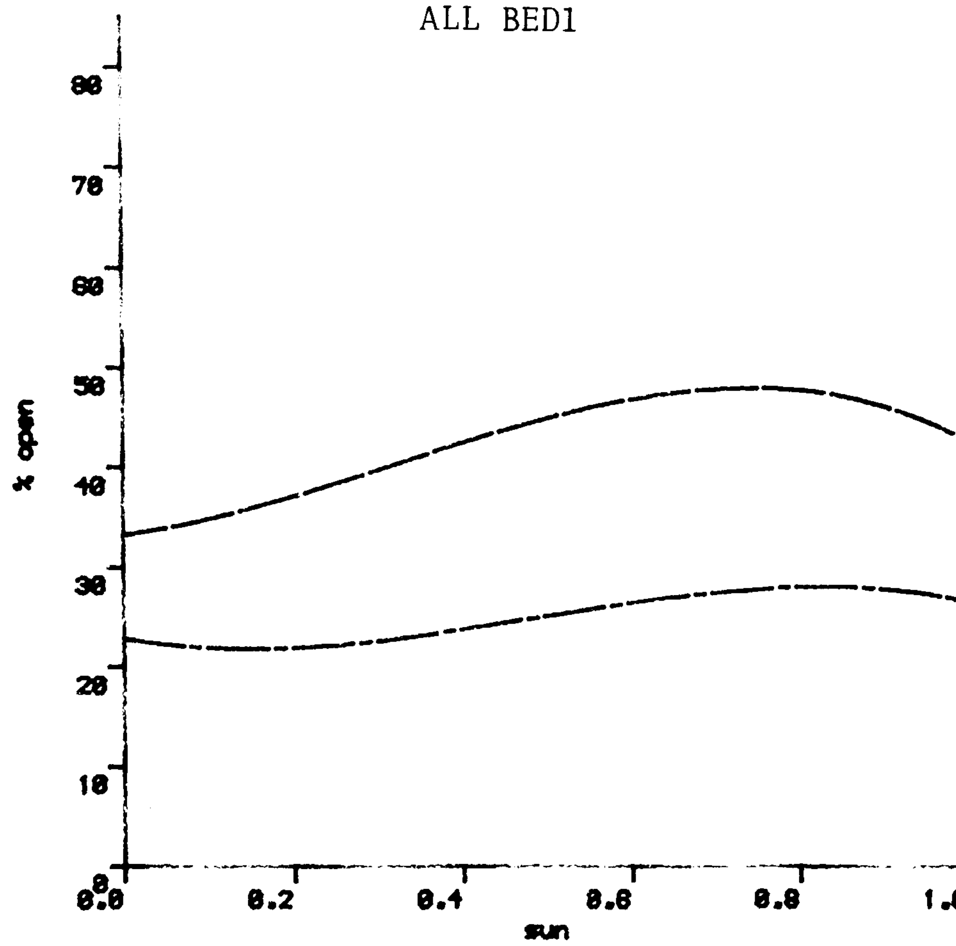
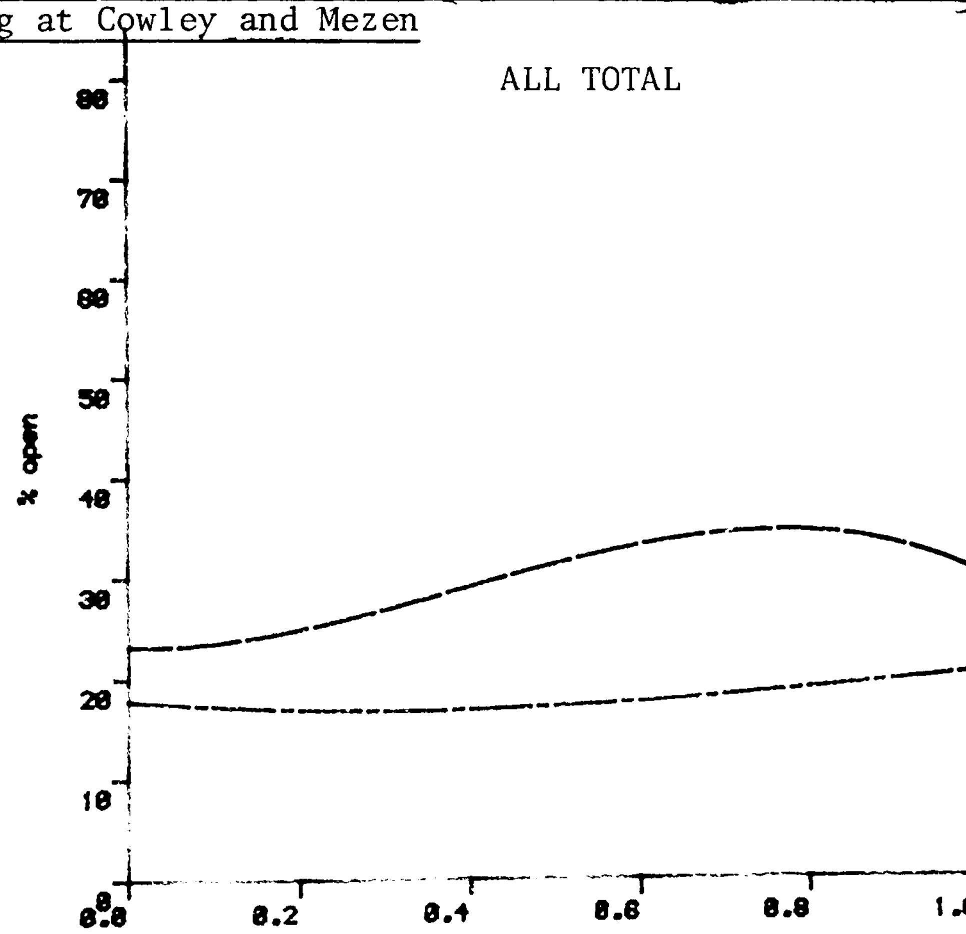


FIGURE 5.114. Relationship between sunshine duration and total window opening at Cowley and Mezen



Key: —— —— Cowley; —.—.— Mezen

FIGURE 5.115. Relationship between rainfall and sittingroom window opening at Cowley and Mezen

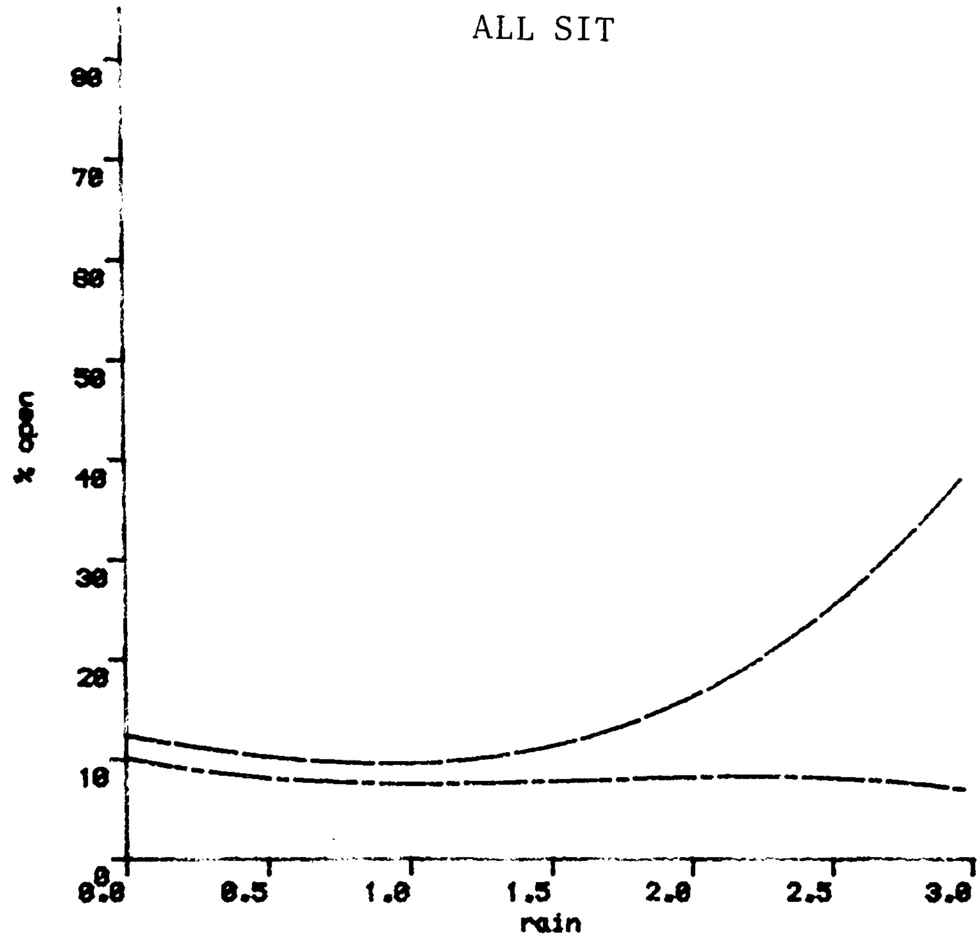
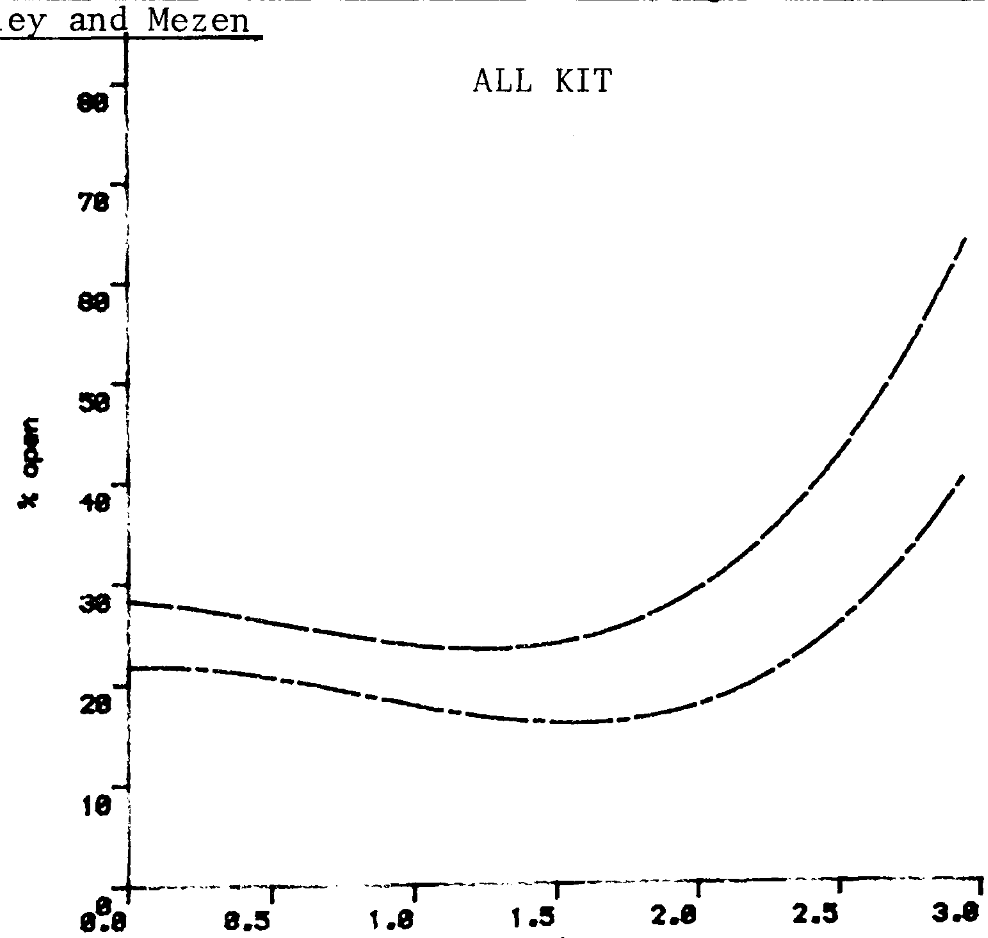


FIGURE 5.116. Relationship between rainfall and kitchen window opening at Cowley and Mezen



Key: —— —— Cowley
—.—.— Mezen

FIGURE 5.117. Relationship between rainfall and main bedroom window opening at Cowley and Mezen

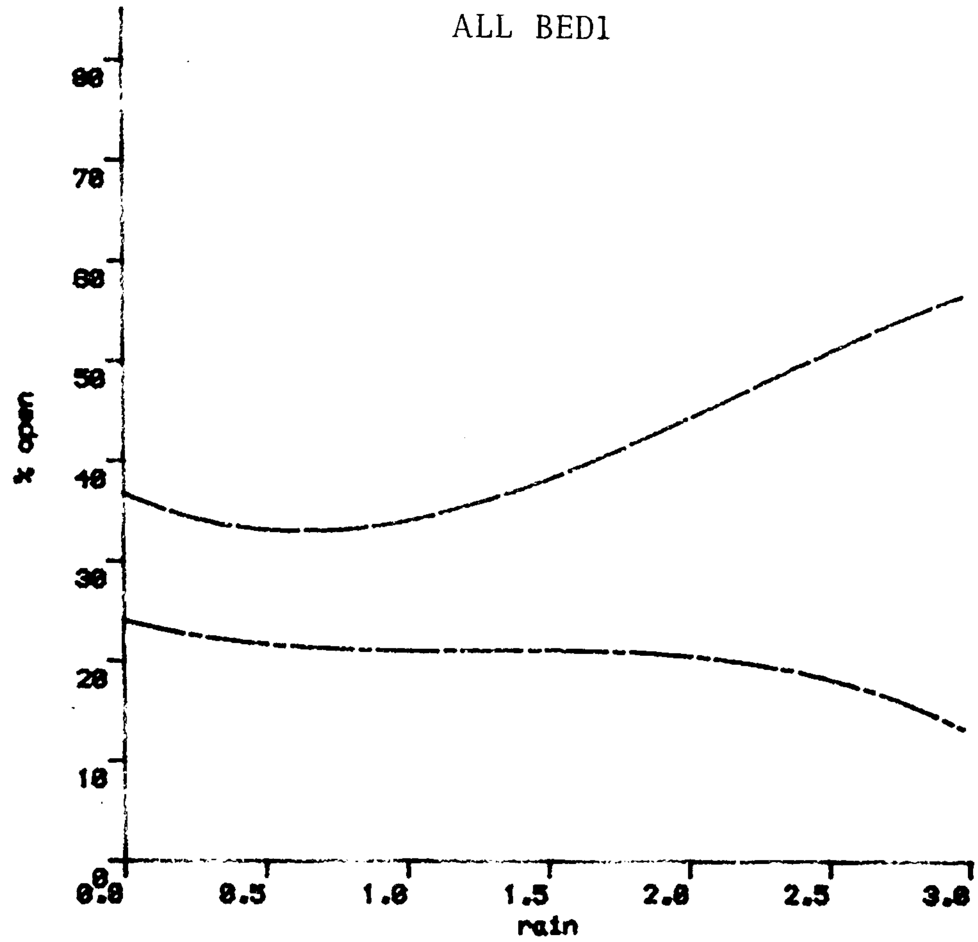
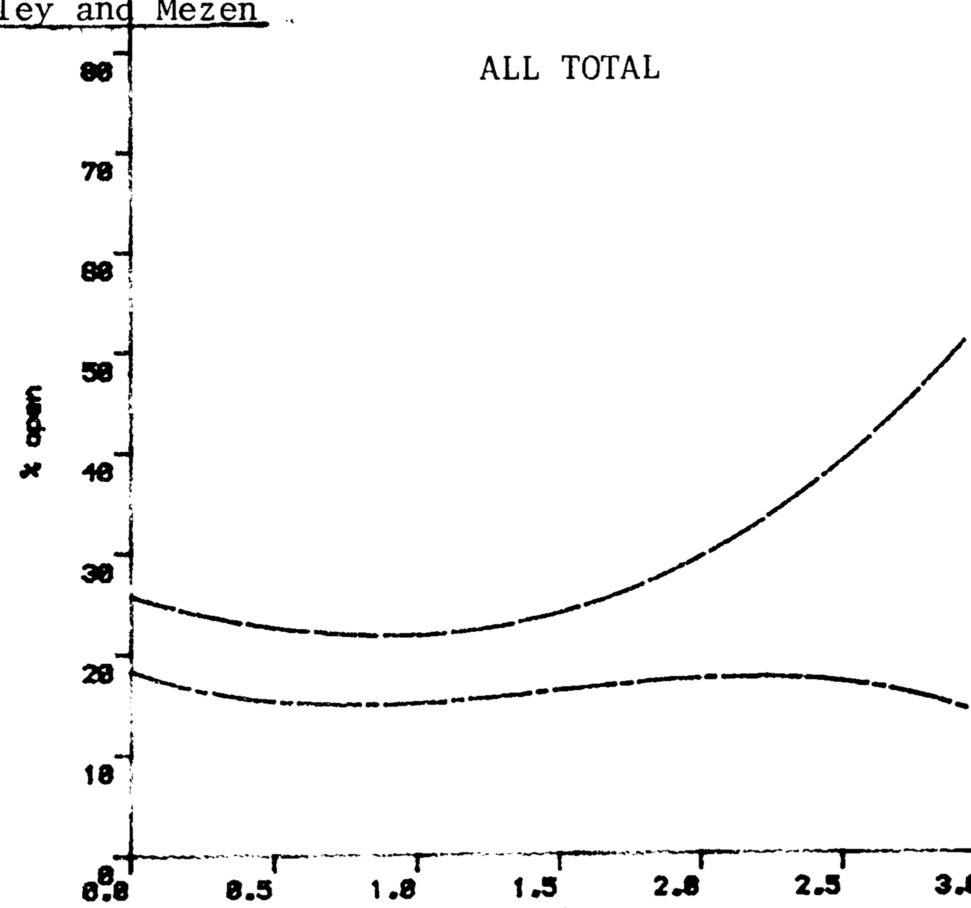


FIGURE 5.118. Relationship between rainfall and total window opening at Cowley and Mezen



Key: —— —— Cowley
—.—.— Mezen

5.5. Results and Analysis of the Reported Data

This section deals with the results of questionnaire data in terms of three main categories - the demographic characteristics of respondents (5.5.1), their motivations for opening and closing windows (5.5.2) and the ways in which they claim to regulate their window opening in certain weather conditions (5.5.3).

5.5.1. Demographic Characteristics of the Questionnaire Population

The response rate to the questionnaire was high: 72% of all householders (n = 81) returned it completed to the researcher. The response rate from both estates was approximately the same: 71% (n = 55/78) from Cowley and 74% (n = 26/35) from Mezen. The results of reported data are given for both estates combined.

Tables A21 to A25 show the results of five one-way analyses of variance to test for the significance of differences in proportions of windows opened when households are grouped according to the following variables:

a) the number of occupants

b) the stage in the lifecycle

c) the number of occupants going out to work

d) the number of smokers, and

e) the number of hours for which the central heating is on during weekdays.

These variables were chosen for analysis since they were simple to measure and were hypothesised to be significantly related to window opening. However, the tables show that only 'number of occupants' and 'stage in the lifecycle' are significantly related to the proportion of open windows (df = 5,95; $p < .01$ and df = 2.98; $p < .05$ respectively).

Table A21 shows that the proportion of open window observations increases as the number of occupants rises. The result might have been expected had the dependent variable been the absolute number of windows opened, since the correlation between 'number of occupants' and 'number of openable windows' is r = .24. However, the present analysis indicates that even the proportion of windows opened increases with the number of occupants.

Stage in the lifecycle was expected to influence window opening. As in earlier analyses, family lifecycle was divided into three main stages: beginning, middle and end. Households were allocated to one of the three groups as follows:

a) Beginning - if there was a child of four or under in the household (coded stage 1)

b) Middle - if all household occupants were between 5 and 64 years of age (coded stage 2)

c) End - if there was an occupants of 65 years or more in the household (coded stage 3).

Although (a) and (c) are not strictly mutually exclusive, the above groupings operated without ambiguity in the present study.

TABLE 5.21. Cross tabulation between stage in the lifecycle and selected variables

Variable		Stage in the lifecycle (Beg) 1	(Mid) 2	(End) 3
No. openable windows	$\bar{x}$	6.9	5.6	4.6
No. open window observations	$\bar{x}$	155.9	152.9	80.9
% open window observations	$\bar{x}$	25.0	28.5	16.9
No. occupants	$\bar{x}$	3.5	3.2	1.6

$\bar{x}$ = mean

Table 5.21 shows that on average stage 1 households (comprised mainly of young couples with their first baby and sometimes an older child) have 3.5 occupants. They tend to live in flats if they have only one child but in 4 person houses if they have two children. In general, they have 6.9 openable windows. Stage 2 households include both childless couples and families whose members are all between the ages of 5 and 64. They normally live in flats if they have no children and in 4 or 6 person houses if they have children. These households have a mean number of 5.6 openable windows. Stage 3 households are generally retired couples or windowed pensioners. They tend to live in flats and have on average 4.6 openable windows.

When households are grouped according to stage in the lifecycle each stage group (1, 2 and 3) has a different mean number of (a) open window observations (156, 153 and 81 respectively) and (b) proportion of open window observations (25%, 29% and 17% respectively). It may be thought that households where someone is in for most of the day would have high proportions of open window observations. However, inspection of the raw data reveals that although no occupant in 20 out of the 34 stage 3 households goes out to work, there is only one such household amongst the stage 2 group and two in the stage 1 group. The relatively low proportion of open window observations in the stage 3 group is therefore surprising. It seems that there must be distinct behavioural or attitudinal differences between the three stage in the lifecycle groups. The hypothesis is supported by the finding that although in general 'number of openable windows' and 'number of occupants' accounts for 24.6% of the variance (n = 101) in the number of open window observations, the amount of variance explained differs considerably when the regression analysis is made spearately for each group (Table 5.22). The latter provides summary results of two further regressions between 'number of open window observations' and (a) 'number of openable windows' and (b) 'number of occupants'. These results suggest that different variables are important for different stage in the lifecycle groups. The finding is not unexpected since it is generally well accepted that socio-economic factors influence peoples' behaviour. However, at this stage of the analysis, no more specific explanation can be offered.

TABLE 5.22. Results of regression analyses between number of open window observations and (a) number of openable windows and (b) number of occupants in three lifecycle stage groups

Dependent variable = number open window observations		
Independent variables	Stage in lifecycle	% variance explained
Number of windows) Number of occupants)	1 (n = 29)	17.0
	2 (n = 38)	1.0
	3 (n = 34)	39.7
Number of windows)	1	0.4
	2	0.8
	3	28.1
Number of occupants)	1	16.8
	2	0.2
	3	15.3

5.5.2. Motivations for Opening and Closing Windows

Respondents were asked for their reasons for opening and closing their windows in winter and summer. The questions asked about the relative frequency with which windows were opened or closed for several different reasons, irrespective of the absolute frequency of window opening. The aim was to measure the relative strengths of particular motivations. The answers were coded 1 to 4 respectively when a motivation was:

a) never the reason

b) seldom the reason

c) quite often the reason

d) very often the reason

- why windows were open or shut.

5.5.2.1. Motivations for winter window opening

Table 5.23 gives the proportion of respondents in each of the four response categories when asked about their motivations for opening windows a) in winter and b) in summer. The table shows that in winter of all the window opening motivations, 'fresh air' received the most endorsements in the 'very often' response category. Indeed, nearly half of the respondents said fresh air was very often the reason why they opened their windows. This was followed respectively by the need to open windows a) in order to control condensation (29.6%), b) because of cleaning (25.9%) and because of (c) smells (23.5%), (d) smoke (22.2%), (e) stuffiness (19.8%), (f) dryness (13.6%) and (g) humidity (12.3%). Few respondents said that animals, appearance or cooling a room were very often reasons for winter window opening.

No discussion of responses to the open-ended questions about window opening, obtained at the original interview, was given in chapter 4. Those replies will now be examined in order to help explain the questionnaire results. Table 5.24 gives a content analysis of interview responses. There was no limit to the number of motivations a respondent could give but if a particular motivation was mentioned twice by the same respondent it was only counted once. The maximum number that could be recorded against any one motivation was therefore the number of respondents. Frequency of response occurrence is taken as an indication of the relative importance of a motivation. The results in table 5.24 provide a general confirmation of those in

TABLE 5.23. Motivations for the opening of windows: percentages of respondents endorsing each of the four response categories (each season x motivation considered separately).

Response category	Season	Fresh air	Cool the house	Let out smoke	Stop condensation	"Dry"	"Humid"	Looks better	Clean Windows	Let animals in/out	'Smells"	"Stuffy"
never	Winter	8.6	62.5	37.0	29.6	51.9	45.7	93.8	18.5	85.2	24.7	35.8
	Summer	1.2	7.5	30.0	41.3	46.2	13.7	88.8	16.2	90.0	22.5	21.2
seldom	Winter	7.4	15.0	17.3	4.9	13.6	14.8	2.5	23.5	1.2	19.8	22.2
	Summer	0.0	6.3	17.5	15.0	20.0	5.0	2.5	25.0	2.5	16.2	12.5
quite often	Winter	37.0	12.5	23.5	35.8	21.0	27.2	1.2	32.1	7.4	32.1	22.2
	Summer	17.5	26.2	15.0	13.7	13.7	35.0	2.5	27.5	3.7	28.8	18.8
very often	Winter	46.9 (1)	10.0 (9)	22.2 (5)	29.6 (2)	13.6 (7)	12.3 (8)	2.5 (11)	25.9 (3)	6.2 (10)	23.5 (4)	19.8 (6)
	Summer	81.3 (1)	60.0 (2)	37.5 (5)	30.0 (8)	20.0 (9)	46.2 (4)	6.3 (10)	31.3 (7)	3.7 (11)	32.5 (6)	47.5 (3)

TABLE 5.24. Content analysis of spontaneously reported motivations for window opening (interview responses)

Motivation	No. of respondents
Fresh air	58
Let out steam/cooking vapours	38
Condensation	24
Stuffy atmosphere	24
Let out smells	16
Let out smoke	10
Room is too hot	9
Dry atmosphere	6
Part of cleaning routine	5
Too many people in room/visitors	4
Person is hot (e.g. when doing housework)	3
Air the bed	3
Dry out atmosphere	2
Dry clothes	2
Let animals come in and out freely	2
Other	5

table 5.23. Fresh air is again the dominant motivation with 63.7% (58/91) interviewees spontaneously mentioning it. A typical remark was,

"I'm a fresh air fanatic."

One woman explained her preference for fresh air as being,

"Especially due to six years of working in an office with false lights and false heat."

The high percentage of references to fresh air is to be expected since fresh air is a general expression embracing more specific factors such as dryness or stuffiness. Fresh air may in addition have connotations of good health and well-being, as well as moral virtues which have not been proved in this study. The specific factors which motivate occupants to open windows are discussed in the following sub-sections (5.4.2.1.1 and 5.4.2.1.2).

5.5.2.1.1. Condensation

Condensation appears to be a main cause of winter window opening. The questionnaire does not differentiate between two broadly distinguishable sets of circumstances in which condensation occurs - firstly, when abnormal levels of humidity (for example, due to cooking and clothes drying) cause condensation on even relatively warm surfaces, and secondly when unusually cold surfaces attract condensation (for example, due to large internal-external air temperature differences) even when humidity levels are not excessive. Steam from cooking, baths, clothes washing and clothes drying are classified as representing circumstances of the first kind and were mentioned 59 times out of 144. By comparison, condensation due to internal-external air temperature differences was mentioned 24 times. This suggests either that occupant-related condensation occurs more often on the two estates or else that it is more salient since it is the householders' own activities which cause the condensation.

Table 5.25 lists the number of people who suggested specific causes of condensation in their homes. As in all the content analyses, the table is generally given using respondents' actual words shich explains why some of the phrases, such as 'the heating', do not identify precise causes. The table shows that many people when talking about condensation are referring to temporary condensation unlikely to cause long-term damage. One woman, for example, remarked,

"It's only on the windows, not in the rooms."

TABLE 5.25. Content analysis of spontaneously reported causes of condensation (interview responses)

Cause	No. of respondents
Steam from cooking	34
Internal-external air temperature differences	21
Insufficient ventilation	15
Clothes drying	10
Don't know	10
Baths	10
Peoples' breath	8
Cold weather	6
The heating	5
Clothes washing	5
Not enough heat	4
Lots of people	3
Partial central heating	3
Damp house	2
Damp weather	2
Other	6
Total number of responses	144

Another said,

"I've condensation from cooking but that's normal condensation."

Some occupants understood factors other than their immediate behaviour to be involved in causing condensation. Indeed, the interrelationship between weather conditions, heating and condensation were often referred to, though sometimes rather tentatively. For example, one man said,

"You get it when you've too much heat, mind you, I don't know why."

And another woman replied,

"It's from the heating. That's what they say anyway. You get it in cold weather."

However, some occupants did specifically mention the effects of partial and intermittent central heating. In a few cases, the inter-relationship between the house and the external environment also received comment (n = 3). Not all occupants were as knowledgeable. No respondent was able to supply a full account of the causes of condensation, although most householders had at least some under-standing - they could reply to the question but could not explain their answers. Ten respondents outrightly remarked that they did not know what caused condensation.

Table 5.26 gives the reported results of condensation. The table shows that condensation of a serious nature occurred in several houses, producing such effects as severe mould growth (n = 3) and the rotting of window frames (n =2). Although 28 householders said condensation often resulted in pools of water on their window sills, this was not generally considered a serious problem.

TABLE 5.26. Reported results of condensation

Reported result	No. of respondents
Pools of water on window sills	28
Rotting window frames	3
Severe mould growth	3
Damp walls	2
Other	3

Respondents were asked what they did to control condensation in their houses. Nine householders said they did nothing to control it, though the majority said they opened windows (n = 44) (Table 5.27).

"I always open my windows in the morning because of the condensation build-up - I like to shift it."

The high proportion of occupants opening windows to control condensation again indicates that most householders had some understanding of condensation - indeed, fifteen householders gave insufficient ventilation as a cause. A large number of occupants, however, simply applied remedial solutions to the problem by wiping up the pools of water which collected on their window sills or leaving tissues there to soak up the moisture. The majority accepted the procedure as normal and as part of the daily routine. No one suggested that changes in the household lifestyle might lessen condensation.

TABLE 5.27. Measures taken to control condensation

Measure	No. of respondents
Open window	44
Wipe away condensation	22
Open door	10
Put tissues on window sills	9
Do nothing	9
Turn on radiator	4
Use extractor fan in bathroom	4
Keep door shut	3
Other	2

5.5.2.1.2. Other motivations for window opening

The majority of other motivations for window opening can be subsummed under the general heading of air quality requirements. Odour removal was frequently given as a reason for window opening (n = 16) -

"The kitchen holds smells, I always like a lot of fresh air to come through when I'm cooking."

Few respondents gave tobacco smoke as a potential motivation (n = 10) despite the fact that 73 households had one or more smokers. The finding is consistent with the results of earlier studies which show that smokers and those living in the same household develop a tolerance for tobacco smoke.

The sensation of stuffiness also causes people to open their windows, especially it seems in the morning -

"The house is stuffy after being shut up all night - I always open them when I get up."

"Sleeping in warm dry conditions makes you feel all stuffed up when you wake up."

Some occupants open their windows when they feel the room atmosphere is too dry (n = 6). Many occupants seem to associate this dryness with the central heating.

"It's a dry heat - you're inclined to get headaches with it."

"I've a bowl of water by the radiator to keep the atmosphere right."

Indeed, many people made comments similar to that made by one housewife -

"You need ventilation with this central heating, it's claustrophobic."

Some householders, however, did express the idea of "being caught in a vicious circle", and though a few were aware that they were "heating the garden" they felt they had no alternative if comfortable living conditions were to be achieved. Indeed, table 5.28 shows that a high proportion of respondents said they left windows open when the central heating was on. In general, the kitchen and main bedroom windows were reported to be left open 'quite often' when the heating was on, although this was 'seldom the case' in the sittingroom. This is perhaps because the sittingroom is used most in the evenings when occupants are seated and at rest and require greater warmth which can only be achieved with the windows closed. Indeed, it is possible that householders feel that different rooms require different levels of ventilation which have different effects on their comfort levels and which in turn influence window opening decisions. For example, it may be felt that there are times when kitchen windows 'have to' be open (for example, when cooking). Alternatively, householders may feel that since bedrooms are not directly heated, the windows in those rooms can reasonably be left open.

TABLE 5.28. Frequency of reported window opening in specified room type when the central heating is on

Room	Mean response code
Sittingroom	2.2
Kitchen	2.8
Main bedroom	3.1

Response codes: 1 = never

2 = seldom

3 = quite often

4 = very often.

The correlation coefficients obtained between group type (high, medium and low) and whether or not sttingroom, kitchen and main bedroom windows are open when the central heating is on, are significant for the kitchen and main bedroom (Table 5.29). Although the high group obviously have higher percentages of open windows, they do not necessarily have to open these windows when the central heating is on. Indeed, there is no significant difference between the three group types in terms of reported central heating hours (r = 0.15). The finding is therefore taken as support for the suggestion given in the descriptive data, namely that some householders desire simultaneous ventilation and heating. It appears that those householders could well be those of the high group. Table 5.29 gives the correlation coefficients obtained between group type and window opening in specified room types when the central heating is on.

TABLE 5.29. Correlation coefficients obtained between group type and window opening in specified room types when the central heating is on

Room	Correlation coefficient
Sittingroom	.17
Kitchen	.39**
Main bedroom	.34**

** $p < .01$

Finally, circumstantial factors such as pet ownership or giving a party account for most of the remaining window opening motivations.

5.5.2.1.3. Inter-relationships between winter window opening motivations

Table 5.30 gives the correlation coefficients obtained for the inter-relationships between winter window opening motivations. The correlations are based on the coded scores from 1 to 4 as described in section 5.5.2. The table shows that the highest correlations are obtained between the motivations of dryness and stuffiness of the atmosphere and internal humidity. Fresh air is best correlated with

TABLE 5.30. Inter-relationships between winter window opening motivations

Motivation	Fresh air	Cool the house	Let out smoke	Stop condensation	"Dry"	"Humid"	Looks better	Clean windows	Let animals in/out	"Smells"	"Stuffy"
Fresh air		.17	.28**	.05	.35**	.27**	.15	.03	-.10	.31**	.36**
Cool the house			.28**	.11	.38**	.51**	.27**	.20*	-.17	.22*	.38**
Let out smoke				.16	.20*	.32**	.21*	.19*	-.12	.46**	.25*
Stop condensation					.13	.28**	.24*	.08	.06	.33**	.22*
"Dry"						.55**	.23*	.21*	-.09	.31**	.54**
"Humid"							.24*	.23*	-.01	.38**	.72**
Looks better								.25*	-.09	.29**	.33**
Clean windows									-.03	.25*	.25*
Let animals in/out										-.04	-.03
"Smells"											.38**

** $p < .01$

* $p < .05$

air quality factors - stuffiness (r = .36), dryness (r = .35), smells (r = .31), smoke (r = .28) and humidity (r = .27). The results suggest that occupants may not distinguish between these terms. No correlation is found between fresh air and condensation motivations, suggesting that the latter may be a distinct kind of window opening motivation.

5.5.2.1.4. Relationship between group type and winter window opening motivations

Table 5.31 shows the percentage of respondents in each of the three group types (high, medium and low, coded 3, 2 and 1) who endorsed each of the four response categories for a particular motivation. The numbers in brackets show the rank order of the percentage values for each group, when for simplicity of analysis, only the proportions of responses in the 'very often' row are considered.

The table shows that when the motivations at the 'very often' level are ranked as described, these ranks are not very different for the high, medium and low groups. This suggests that the three group types have similar motivational structures. In addition, however, table 5.31 reveals an unexpected property. It will be recalled that the motivation questions were phrased so as to measure the relative occurrence of different motivations, and not their absolute strength. Nevertheless, the table shows that at the 'very often' response level the high group percentage exceeds that for the low group for nearly every motivation. The same is true of the medium group in relation to the low group. This finding cannot be explained in terms of the relative occurrence of motives and may indicate rather that the high group are influenced by their greater frequency of window opening or by a greater absolute strength of each motive. At this point it is not possible to distinguish between these two potential explanations.

TABLE 5.31. Relationship between group type and winter window opening motivations: percentage of respondents endorsing each of the four window opening motivation response categories (each group type x motivation considered separately)

Response category	Group type	MOTIVATION										
		Fresh air	Cool the house	Let out smoke	Stop condensation	"Dry"	"Humid"	Looks better	Clean windows	Let animals in/out	"Smells"	"Stuffy"
Never	High	3.6	67.9	32.1	17.9	39.3	32.1	92.9	17.9	78.6	17.9	25.0
	Medium	3.3	44.8	30.0	33.3	46.7	43.3	93.3	23.3	93.3	26.7	33.3
	Low	21.7	78.3	52.2	39.1	73.9	56.2	95.7	13.0	82.6	30.4	52.2
Seldom	High	7.1	17.9	17.9	3.6	14.3	17.9	0.0	17.9	0.0	14.3	21.4
	Medium	0.0	17.2	16.7	6.7	20.0	16.7	3.3	30.0	0.0	16.7	30.0
	Low	17.4	8.7	17.4	4.3	4.3	21.7	4.3	21.7	4.3	30.4	13.0
Quite often	High	35.7	7.1	21.4]	39.3	28.6	35.7	0.0	32.1	14.3	39.3	35.7
	Medium	36.7	20.7	23.3	33.3	20.0	23.3	3.3	20.0	3.3	26.7	10.0
	Low	39.1	8.7	26.1	34.8	13.0	21.7	0.0	47.8	4.3	30.4	21.7
Very often	High	53.6 (1)	7.1 (9)	28.6 (4)	39.3 (2)	17.9 (6)	14.3 (8)	7.1 (9)	32.1 (3)	7.1 (9)	28.5 (4)	17.9 (6)
	Medium	60.0 (1)	17.2 (7)	30.0 (2)	26.7 (4)	13.3 (9)	16.7 (8)	0.0 (11)	26.7 (4)	3.3 (10)	30.0 (2)	26.7 (4)
	Low	21.7 (1)	4.3 (8)	4.3 (8)	21.7 (2)	8.7 (5)	4.3 (8)	0.0 (11)	17.4 (3)	8.7 (5)	8.7 (5)	13.0 (4)

5.5.2.1.5. Motivations for summer window opening

Table 5.23 includes the proportion of respondents in each of the four response categories when asked about their reasons for window opening in summer. The table shows that fresh air is the dominant motivation (81.3% of responses fall in the 'very often' response category) followed by window opening in 'order to cool a room' (60%). However, air quality considerations are also important. In most cases the percentage response in the 'very often' response category is greater in the summer than in the winter. This could be due either to increased occupant sensitivity in summer or to different window opening frequencies between winter and summer. It may be that heat conservation acts as a constraint on winter window opening with people rationalizing their actions and being willing to accept less pleasant environments than they would in the summer when the cost of an open window may be seen as nil. The second hypothesis seems more likely since, for example, although the mean response to the 'smoking motivation question' increases in the summer, it is doubtful if occupants actually smoke more in the summer than in the winter.

5.5.2.1.6. Relationship between winter and summer window opening motivations

Table 5.23 shows the proportion of respondents in winter and summer who endorsed each of the four response categories for a particular motivation. The numbers in brackets show the rank order of the percentage values for both season when, for simplicity of analysis, only the proportions of responses in the 'very often' row are considered.

The table shows that fresh air is the dominant motivation in both winter and summer. However, although condensation is ranked second in the winter it is ranked eighth in the summer where it is replaced by 'cooling the house', a motivation which is ranked ninth in winter. Humidity and stuffiness both increase their rank positions in summer suggesting a greater influence of air quality considerations in warmer weather. Most other motivations show little seasonal change - 'smoke', for example, is ranked fifth in both winter and summer.

5.5.2.2. Motivations for winter window closing

Table 5.32 gives the proportion of respondents in each of the four response categories when asked about their motivations for closing windows a) in winter and b) in summer. The table shows that in winter when only the proportion of people who ticked the 'very often' response category are considered, draught prevention and security are the main motivations for closing windows (60.0% and 53.7% respectively). Heat conservation and keeping out the rain are also important (38.7% and 20.0% respectively) Few respondents said that dirt, privacy, appearance or difficulty in opening windows were very often reasons for closed windows.

Interview answers to the open-ended questions about window closing behaviour patterns will be discussed in this section in order to clarify the questionnaire results. Table 5.33 gives the content analysis of interview responses into categories with the number of replies which could be so classified. The table shows that people spontaneously mention external air temperature (and with lesser frequency wind, rain and dampness) as reasons for closing windows. This suggests that the householders studied respond directly to these variables and that the equations derived in section 5.6 are not merely predictive through correlating variables but instead model the situation directly.

TABLE 5.32. Motivations for the closing of windows: percentages of respondents endorsing each of the four response categories (each season x motivation considered separately)

Response category	Season	Motivation								
		Keep out rain	For privacy	Keep out dirt	For security	Keep house warm	Prevent draughts	Looks better	Difficult to open	No need to be open
Never	Winter	45.0	65.0	72.5	18.8	21.2	8.8	95.0	96.2	58.7
	Summer	32.9	64.6	64.6	12.7	48.1	50.6	97.5	96.2	64.6
Seldom	Winter	18.8	23.8	15.0	8.8	16.2	6.3	2.5	1.2	11.2
	Summer	25.3	20.3	25.3	12.7	27.8	24.1	0.0	2.5	17.7
Quite often	Winter	16.2	5.0	7.5	18.8	23.8	25.0	1.2	1.2	11.2
	Summer	21.5	7.6	5.1	22.8	15.2	15.2	1.3	1.3	7.6
Very often	Winter	20.0 (4)	6.3 (6)	5.0 (7)	53.7 (2)	38.7 (3)	60.0 (1)	1.2 (8)	1.2 (8)	18.8 (5)
	Summer	20.3 (2)	7.6 (6)	5.1 (7)	51.9 (1)	8.9 (5)	10.1 (3)	1.3 (8)	0.0 (9)	10.1 (3)

TABLE 5.33. Content analysis of spontaneously reported motivations for window closing

Motivation	Number of respondents
Cold outside	27
Safety	25
Keep heat in	20
Prevent draughts	10
Rain	4
Windy	4
Damp	3
Person feels cold	3
Gnats	2
Other	6

In general occupants had little to say about window closing motivations. Indeed, many found the question quite difficult to answer, implying that closed windows are regarded as the norm and that special reasons are required for opening them but not for closing them.

The response 'because there is no need' for them to be open was included for this reason. It was hypothesised that a householder noticing a window to be open at a time when conditions made it a matter of indifference whether it should be open or closed, would be most likely to close the window in order to ensure that it did not continue to be open at some future time when it would be decidedly advantageous for it to be closed (for example, when the house is empty or it is raining). The response to the option just described included few endorsements of the 'very often' response category. This may reflect the negation of this hypothesis or may alternatively be due to the fact that the wording did not capture the intended meaning.

5.5.2.2.1. Inter-relationships between winter window closing motivations

Table 5.34 gives the correlation coefficients obtained for the inter-relationships between winter window closing motivations. The high correlations a) between 'difficulty in opening a window' and 'looks better' (.90) and b) between 'privacy' and 'dirt' (.58) must not be overemphasised since inspection of table 3.32 shows that the high values are largely dependent on the responses of one householder. Indeed, a substantial majority of respondents said that these motivations were 'never' or 'seldom' reasons for closing windows.

5.5.2.2.2. Relationship between group type and winter window closing motivations

Table 5.35 shows the percentage of respondents in each of the three group types (high, medium, and low) who endorsed each of the four response categories for a particular motivation. The numbers in brackets show the rank order of the percentage values for each group when, for simplicity of analysis, only the proportions of responses in the 'very often' row are considered.

The table shows that when the motivations at the 'very often' level are ranked, there are hardly any differences in these ranks between the high, medium and low groups. Indeed, 'draughts', 'security' and 'warmth' are ranked first, second and third respectively all three groups. It is therefore concluded that group type is not associated with varying window closing motivational structures.

However, as in section 5.5.2.1.3 an unexpected feature is revealed in the data, namely that for seven out of the nine motives the 'very often' response category is endorsed by a higher percentage of the low group than of the high group. Of the two possible explanations suggested in the aforementioned section, this result supports the

TABLE 5.34. Inter-relationships between winter window closing motivations

Motivation	Keep out rain	For privacy	Keep out dirt	For security	Keep house warm	Prevent draughts	Looks better	Difficult to open	No need to be open
	Motivation								
Keep out rain		.36**	.29**	.24*	.32**	-.12	-.04	-.04	.05
For privacy			.58**	.36**	.31**	.06	..01	-.01	.05
Keep out dirt				.27**	.09	-.03	-.01	.01	.03
For security					.36**	.23*	.14	.14	.08
Keep house warm						.32**	.16	.19	.04
Prevent draughts							.08	.12	.27
Looks better								..90**	-.06
Difficult to open									.04

** p < .01

* p < .05

TABLE 5.35. Relationship between group type and winter window closing motivations: percentages of respondents endorsing each of the four window closing motivation response categories (each group type x motivation considered separately)

Response category	Group type	Motivation								
		Keep out rain	For privacy	Keep out dirt	For security	Keep house warm	Prevent draughts	Looks better	Difficult to open	No need to be open
Never	High	33.3	63.0	70.4	25.9	18.5	14.8	96.3	92.6	70.4
	Medium	46.7	70.0	65.7	13.3	16.7	6.7	96.7	100.0	
	Low	56.5	60.9	69.6	17.4	30.4	4.3	91.3	95.7	56.5
Seldom	High	22.2	25.9	22.2	7.4	7.4	3.7	0.0	3.7	7.4
	Medium	16.7	20.0	10.0	10.0	23.3	6.7	3.3	0.0	20.0
	Low	17.4	26.1	13.0	8.7	17.4	8.7	4.3	0.0	4.3
Quite often	High	22.2	7.4	3.7	14.8	37.0	25.9	3.7	3.7	11.1
	Medium	16.7	3.3	10.0	16.7	20.0	23.3	0.0	00.0	13.3
	Low	8.7	4.3	8.7	26.1	13.0	26.1	0.0	0.0	8.7
Very often	High	22.2 (4)	3.7 (6)	3.7 (6)	51.9 (2)	37.0 (3)	55.6 (1)	0.0 (8)	0.0 (8)	11.1 (5)
	Medium	20.0 (4)	6.7 (6)	3.3 (7)	60.0 (2)	40.0 (3)	63.3 (1)	0.0 (8)	0.0 (8)	16.7 (5)
	Low	17.4 (5)	8.7 (6)	8.7 (6)	47.8 (2)	39.1 (3)	60.9 (1)	4.3 (8)	4.3 (8)	30.4 (4)

conclusion that in answering the questionnaire, respondents are influenced more by the strength of motives, than by the number of occasions on which these motives are exercised.

5.5.2.2.3. Motivations for summer window closing

Inspection of table 5.32 shows that the strength of particular window closing motivations differ according to season. Security and keeping out rain remain at a high priority in summer. Most other motivations are less important in the summer than in the winter. The results are logical in that there is presumably less need to conserve heat or prevent draughts in summer due to higher external temperatures, whilst rain is always wet and burglars are a perceived problem at any time of year.

5.5.2.2.4. Relationship between winter and summer window closing motivations

Table 5.32 shows the proportion of respondents in winter and summer who endorsed each response category for a particular motivation. The numbers in brackets show the rank order of the percentage values when, for both seasons, only the proportions of responses in the 'very often' row are considered.

The table shows that draught precaution loses its prime importance in the summer but that the ranks for most other motivations remain fairly constant.

5.5.3. Parameters Defining Window Opening

Window opening is defined by three basic parameters (5.3.2.2) - the likelihood with which windows are open in certain weather conditions, the amount to which they are open, and the duration or length of time for which they are open. These three aspects will be discussed separately.

5.5.3.1. Likelihood of window opening

Respondents were asked how likely (on a four point scale coded 1 to 4 from very unlikely to very likely) they were to open the sittingroom, kitchen and main bedroom windows, in winter and in summer on:

a) a sunny day

b) a set day

c) a humid or close day

d) a mild day

e) a cold day

f) a windy day when the wind is not blowing into the house

g) a windy day when the wind is blowing into the house.

5.5.3.1.1. Reported likelihood of winter window opening

This section looks at the reported likelihood of winter window opening in room types (5.5.3.1.1.1) and in specified weather conditions (5.5.3.1.1.2). The relationship between group type and reported likelihood of winter window opening is also investigated.

5.5.3.1.1.1. Reported likelihood of winter window opening in three room types

Tables 5.36(a)-(h) show the percentages of respondents who endorsed each of the four response categories when asked how likely they were to open the sittingroom, kitchen and main bedroom windows in certain weather conditions. Table 5-36(h) gives the mean response of the 81 questionnaire respondents for each room type in winter. This mean is calculated by first averaging each respondent's scores to the seven questions (a - g) in order to find his personal average, and by then summing and dividing by 81 the personal averages to obtain the grand mean ($G\bar{x}$) for the questionnaire population. These grand mean percentages are taken to indicate the general level of reported window

TABLE 5.36(a)-(h). Reported likelihood of winter window open in three room types - percentages of respondents endorsing each response category

(a) "Sunny day"

Response category	Room type		
	SIT	KIT	B1
Very unlikely	7.4	6.2	6.2
fairly unlikely	8.6	3.7	34.6
quite likely	30.9	21.0	0.0
Very likely	53.1 (3)	69.1 (1)	59.3 (2)

(b) "Wet day"

Response category	Room type		
	SIT	KIT	B1
Very unlikely	50.6	28.4	33.3
Fairly unlikely	25.9	12.3	22.2
Quite likely	17.3	2.0	23.5
Very likely	6.2 (3)	38.3 (1)	21.0 (2)

(c) "Humid/close day"

Response category	Room type		
	SIT	KIT	B1
Very unlikely	14.8	7.5	9.9
Fairly unlikely	12.3	6.3	8.6
Quite likely	33.3	25.0	35.8
Very likely	39.5 (3)	61.2 (1)	45.7 (2)

TABLE 5.36 continued

(d) "Mild day"

Response category	Room type SIT	KIT	B1
Very unlikely	7.4	6.2	3.7
Fairly unlikely	14.8	4.9	8.8
Quite likely	40.7	28.4	40.0
Very likely	37.0 (3)	60.5 (1)	47.5 (2)

(e) "Cold day"

Reponse category	Room type SIT	KIT	B1
Very unlikely	66.7	34.6	42.0
Fairly unlikely	17.3	18.5	18.5
Quite likely	9.9	18.5	17.3
Very likely	6.2 (3)	28.4 (1)	22.2 (2)

(f) "Windy but wind not blowing into house"

Respose category	Room type SIT	KIT	B1
Very unlikely	44.4	25.9	28.4
Fairly unlikely	21.0	12.3	16.0
Quite likely	22.2	28.4	28.4
Very likely	12.3 (3)	33.3 (1)	27.2 (2)

(g) "Windy day when the wind is blowing into the house"

Response category	Room type SIT	KIT	B1
Very unlikely	81.5	49.4	59.3
Fairly unlikely	12.3	18.5	18.5
Quite likely	3.7	16.0	7.4
Very likely	2.5 (3)	16.0 (1)	14.8 (2)

TABLE 5.36 continued

(h) Grand mean percentages

Response category	Room type		
	SIT $G\bar{x}$	KIT $G\bar{x}$	B1 $G\bar{x}$
Very unlikely	11.1	7.4	4.9
Fairly unlikely	49.4	27.2	43.2
Quite likely	33.3	30.9	29.6
Very likely	6.2 (3)	34.6 (1)	22.2 (2)

window opening in each room type. It is accepted that this indicator is an approximation since it cannot be assumed that the seven weather conditions occur in equal proportions.

When for simplicity of analysis only the percentages in the 'very often' response categories are ranked, it can be seen that in all seven specified weather conditions, respondents say they are most likely to open the kitchen window, and then the bedroom and sittingroom windows respectively. The same rank order (kitchen, main bedroom and sitting-room is found when reported likelihood of window opening is averaged over specific weather conditions (Table 5.26(h)).

However, inspection of table 5.15 (5.4.3.1) reveals a different rank ordering for the observed data, namely when the mean percentage of open window observations are ranked from the highest to the lowest, the order is from main bedroom to kitchen and then to sittingroom. It is thought that the order reflected in the reported results may be due to the effect of a salience factor in that if it is assumed that house-holders use the kitchen for a greater part of the day than the bedroom, then they are probably more aware of when the kitchen window is open than when the bedroom window is open. Householders may consequently over-emphasise kitchen window opening. Alternatively, the results of the reported data may indicate that kitchen windows are opened more frequently in any particular day, but for short periods of time. This type of behaviour pattern cannot be inferred from the observed data, and would not cause the mean percentage of open window observations for the kitchen window to rise above that for the main bedroom window, unless the kitchen window was open for a greater proportion of the day than the bedroom window, thereby increasing the observer's chance of making an open window observation.

5.5.3.1.1.2. Reported likelihood of winter window opening in specified weather conditions

Inspection of table 5.37(a)-(c) enables examination of the differences in reported likelihood of winter window opening in specified weather conditions. The percentage values in these tables are those given in tables 5.36(a)-(g), but reordered for ease of comparison.

Of the seven weather options specified 'sunny days' received the highest proportion of 'very likely' responses, for all rooms. Psychological studies indicate the importance of sunlight penetration in good window design (5.2.1). Inspection of the observed data, however, reveals that householders actual window opening levels are not significantly correlated with sunshine duration (Table 5.18). This lack of relationship cannot be attributed to an association between sunshine duration and other weather parameter values during the observation period which might reduce window opening (Figures 5.20 to 5.29). It is therefore suggested that occupants either (mistakenly) associate sunshine with more favourable weather conditions in which they open more windows, or else simply over-emphasise the psychological effects and benefits of sunlight.

Mild and humid conditions are ranked second or third, depending on room type. The results support the significance attributed to

TABLE 5.37(a)-(c). Reported likelihood of winter window opening in specified weather conditions - percentages of respondents endorsing each response category

(a) "Sittingroom"

Response category	Weather conditions						
	Sunny	Wet	Humid	Mild	Cold	Wind not	Wind is
Very unlikely	7.4	50.6	14.8	7.4	66.7	44.4	81.5
Fairly unlikely	8.6	25.9	12.3	14.8	17.3	21.0	12.3
Quite likely	30.9	17.3	33.3	40.7	9.9	22.2	3.7
very likely	53.1 (1)	6.2 (5)	39.5 (2)	37.0 (3)	6.2 (5)	12.3 (4)	2.5 7)

(b) "Kitchen"

Response category	Weather conditions						
	Sunny	Wet	Humid	Mild	Cold	Wind not	Wind is
Very unlikely	6.2	28.4	7.5	6.2	34.6	25.9	49.4
Fairly unlikely	3.7	12.3	6.3	4.9	18.5	12.3	18.5
Quite likely	21.0	21.0	25.0	28.4	18.5	28.4	16.0
Very likely	69.1 (1)	38.3 (4)	61.2 (2)	60.5 (3)	28.4 (6)	33.3 (5)	16.0 (7)

(c) "Main Bedroom"

Response category	Weather conditions						
	Sunny	Wet	Humid	Mild	Cold	Wind not	Wind is
Very unlikely	6.2	33.3	9.9	3.7	42.0	28.4	59.3
Fairly likely	34.6	22.2	8.6	8.8	18.5	16.0	18.5
Quite likely	0.0	23.5	35.8	40.0	17.3	28.4	7.4
Very unlikely	59.3 (1)	21.0 (6)	45.7 (3)	47.5 (2)	22.2 (5)	27.2 (4)	14.8 (7)

Wind not = windy day when the wind is not blowing into the house

Wind is = windy day when the wind is blowing into the house.

relative humidity and temperature in previous discussions of the observed data.

On wet days, the rank order differs according to room type, and is highest in the kitchen where it may be assumed that occupants sometimes have to open the window even in inclement weather.

Windy days when the wind blows into the house are ranked seventh for all room types supporting the finding that draught prevention influences window opening (5.5.2.2). Windy days when the wind is not blowing into the house are ranked slightly higher in all room types, suggesting that in addition to windspeed, wind direction has an important influence on window opening.

5.5.3.1.1.3. Relationship between group type and reported likelihood of winter window opening

Table 5.38 gives the correlation coefficients obtained between likelihood responses (coded 1 to 4 from very unlikely to very likely) and group type (coded 1 to 3 from low to high). All the correlations for the main bedroom and kitchen are significant at the 1% level, indicating a strong relationship between the observed data and the reported likelihood of window opening, especially for the kitchen where the correlations are particularly high. For the sittingroom three of the correlations are significant at the 1% level, and two at the 5% level. This may be due to the fact either that householders overemphasise sittingroom window opening and that reported scores are therefore inflated, or else that the observed data do not reflect the actual duration of window opening and that the mean proportion of open sittingroom window observation scores is consequently reduced if sittingroom windows are assumed to be open for only a short proportion of the day.

The significant relationships between 19 of the 28 likelihood

TABLE 5.38. Correlation coefficients obtained between group type and reported likelihood of winter window opening

Weather condition	Room type		
	SIT	KIT	B1
Sunny	.15	.34**	.31**
Wet	.27**	.43**	.40**
Humid	.36**	.47**	.31**
Mild	.17	.46**	.30**
Cold	.18**	.43**	.38**
Wind not	.17	.40**	.35**
Wind is	.28**	.38**	.30**
Grand mean	.25*	.48**	.40**

** $p < .01$

* $p < .05$

responses and group type, indicate a greater than expected reliability of reported data. Ideally in assessing the reliability of reported data, the observed and reported data would both measure the same variables. This is not the case for four reasons. Firstly, the observed data do not include as an open window observation any window that was open less than one inch (5.3.2.1), even though the householder might consider the window to be open. Secondly, the observed data cannot take account of windows which were open at times other than between 9 a.m. and 6 p.m. Thirdly, window observations are dependent upon the proportion of time for which windows are open, and not necessarily upon the frequency with which they are opened or closed. Fourthly, it will be recalled that householders within house types were allocated in approximately equal numbers to one of the three group types on the basis of their total window opening scores. This has two effects: (a) total window opening scores are not of course perfectly correlated with scores for particular room types, and (b) it may be the case that the occupants of certain house types tend to be high or low window openers and reflect this in their reported scores. Such an effect of house type would not be apparent in the group types.

In conclusion, the correspondence between reported and observed data is impressive.

5.5.3.1.2. Reported likelihood of summer window opening

This section deals with the reported likelihood of summer window opening in room types (5.5.3.1.2.1) and in specified weather conditions (5.5.3.1.2.2). The relationship between group type and reported likelihood of summer window opening is also discussed.

5.5.3.1.2.1. Reported likelihood of summer window opening in three room types

Tables 5.39(a)-(h) show the percentages of respondents who endorsed each of the four response categories when asked how likely they were to open specified windows in summer. Table 5.39 gives the grand mean response of all 81 respondents separately for each room type.

The rank order (kitchen, main bedoom, sittingroom) of reported likelihood of summer window opening, is the same as that for reported winter window opening in five of the seven weather conditions, the two exceptions being on sunny and humid days.

5.5.3.1.2.2. Reported likelihood of summer window opening in specified weather conditions

Tables 5.40(a)-(c) enable examination of the differences in reported likelihood of summer window opening in specified weather conditions. Inspection of the ranked percentages indicates that as in

TABLES 5.39(a)-(h). Reported likelihood of summer window opening in three room types - percentages of respondents endorsing each response category

(a) "Sunny day"

Response category	Room type		
	SIT	KIT	B1
Very unlikely	1.2	2.5	0.0
Fairly unlikely	0.0	0.0	0.0
Quite likely	21.0	12.3	25.0
Very likely	77.8 (2)	85.2 (1)	75.0 (3)

(b) "Wet day"

Response category	Room type		
	SIT	KIT	B1
Very unlikely	26.6	13.7	15.0
Fair unlikely	20.3	12.5	23.8
Quite likely	24.1	26.2	16.2
Very likely	29.1 (3)	47.5 (1)	45.0 (2)

(c) "Humid/close day"

Response category	Room type		
	SIT	KIT	B1
Very unlikely	3.7	2.5	2.5
Fairly unlikely	5.0	3.7	2.5
Quite likely	26.2	19.8	32.1
Very likely	65.0 (2)	74.1 (1)	63.0 (3)

TABLES 5.39(a)-(h) continued

(d) "Mild day"

Response category	Room type		
	SIT	KIT	B1
Very unlikely	1.2	2.5	2.5
Fairly unlikely	6.2	2.5	25.
Quite likely	30.9	23.5	30.9
Very likely	61.7 (3)	71.6 (1)	64.2 (2)

(e) "Cold day"

Response category	Room type		
	SIT	KIT	B1
Very unlikely	38.7	24.7	34.6
Fairly unlikely	28.8	13.6	12.3
Quite likely	17.5	21.0	18.5
Very likely	15.0 (3)	40.7 (1)	34.6 (2)

(f) "Windy day but wind not blowing into house"

Response category	Room type		
	SIT	KIT	B1
Very unlikely	17.3	13.6	21.0
Fairly unlikely	21.0	11.1	12.3
Quite likely	30.9	24.7	22.2
Very likely	30.9 (3)	50.6 (1)	44.4 (2)

TABLES 5.39(a)-(h) continued

(g) "Windy day when the wind is blowing into the house"

Response category	Room type		
	SIT	KIT	B1
Very unlikely	51.9	39.5	42.0
Fairly unlikely	22.2	18.5	22.2
Quite likely	12.3	16.0	12.3
Very likely	13.6 (3)	25.9 (1)	23.5 (2)

(h) Grand mean percentages

Response category	Room type		
	SIT	KIT	B1
Very unlikely	2.5	2.5	2.5
Fairly unlikely	24.7	18.5	24.7
Quite likely	45.7	32.1	33.3
Very likely	27.2 (3)	46.9 (1)	39.5 (2)

winter, 'sunny days' received the highest proportion of 'very likely' responses for all three room types. The percentages recorded for humid days are ranked second for the sittingroom and kitchen and third for the main bedroom.

In summer (as was previously found in winter) the lowest likelihood percentages are given for windy days when the wind is blowing into the house.

5.5.3.1.2.3. Relationship between group type and reported likelihood of summer window opening

Table 5.41 gives the correlation coefficients obtained between group type (coded 1, 2, 3) and summer likelihood responses (coded 1 - 4).

TABLES 5.40(a)-(c). Reported likelihood of summer window opening in specified weather conditions - percentages of respondents endorsing each response category

(a) "Sittingroom"

Response category	Weather condition						
	Sunny	Wet	Humid	Mild	Cold	Wind not	Wind is
Very unlikely	1.2	26.6	3.7	1.2	38.7	17.3	51.9
Fairly unlikely	0.0	20.3	5.0	6.2	28.8	21.0	22.2
Quite likely	21.0	24.1	26.2	30.9	17.5	30.9	12.3
Very likely	77.8 (1)	29.1 (5)	65.0 (2)	61.7 (3)	15.0 (6)	30.9 (4)	13.6 (7)

(b) "Kitchen"

Response category	Weather condition						
	Sunny	Wet	Humid	Mild	Cold	Wind not	Wind is
Very unlikely	2.5	13.7	2.5	2.5	24.7	13.6	39.5
Fairly unlikely	0.0	12.5	3.7	2.5	13.6	11.1	18.5
Quite likely	12.3	26.2	19.8	23.5	21.0	24.7	16.0
Very likely	85.2 (1)	47.5 (5)	74.1 (2)	71.6 (3)	40.7 (6)	50.6 (4)	25.9 (7)

(c) "Main bedroom"

Response category	Weather condition						
	Sunny	Wet	Humid	Mild	Cold	Wind not	Wind is
Very unlikely	0.0	15.0	2.5	2.5	34.6	21.0	42.0
Fairly unlikely	0.0	23.8	2.5	2.5	12.3	12.3	22.2
Quite likely	25.0	16.2	32.1	30.9	18.5	22.2	12.3
Very likely	75.0 (1)	45.0 (4)	63.0 (3)	64.2 (2)	34.6 (6)	44.4 (5)	23.5 (7)

Wind not = windy day when the wind is not blowing into the house

Wind is = windy day when the wind is blowing into the house.

Twenty-three of the 24 correlations are significant with 7 of the kitchen-likelihood correlations, 5 of the main bedroom-likelihood correlations and 7 of the sittingroom-likelyhood correlations, being significant at the 1% level. Since the correlations are between observed winter data and reported summer data, the finding suggests that householders have characteristic window opening patterns which they can reliably report.

TABLE 5.41. Correlation coefficients obtained between group type and reported likelihood of summer window opening

Weather condition	Room type		
	SIT	KIT	B1
Sunny	.28**	.20*	.22*
Wet	.31**	.42**	.32**
Humid	.29**	.32**	.22*
Mild	.12	.38**	.38**
Cold	.30**	.41**	.33**
Wind not	.35**	.33**	.24*
Wind is	.27**	.36**	.27**
Grand mean	.30	.35**	.32**

** P < .01

* p < .05

5.5.3.1.3. Inter-relationship between reported likelihood of window opening responses

Matrices giving correlation coefficients between likelihood responses a) in winter and b) in summer were drawn up but are too numerous to be included in the thesis. The correlations are between likelihood responses for different weather conditions in given room types for a given season.

Inspection of these matrices shows that the correlations are all high and significant at the 1% level. This suggests that householders have characteristic window opening levels, though the varying percentage levels in the 'very likely' response categories of tables 5.36 and 5.39(a)-(g) indicate that reported window opening is still influenced by specific weather conditions.

The high correlations could also be due to the fact that respondents gave similar replies to all the weather condition questions, not so much because this reflected their actual behaviour but because they tended to adopt characteristic answering patterns, choosing for example always to endorse the 'quite likely' category. However, the higher percentage values in table 5.42 for reported summer window opening make this hypothesis unlikely.

5.5.3.1.4. Relationship between reported likelihood of winter and summer window opening

Inspection of table 5.42 shows that the percentage of respondents saying they are very likely to open windows increases in the summer for all room types. If the winter-summerdifference between the grand mean for each room is considered, the sittingroom shows the largest seasonal change, and the kitchen shows the smallest. This suggests that in winter, sittingroom window opening is subject to more constraints than a) in the summer and b) than window opening in other rooms, and that these constraints are partially relaxed in summer when the weather is presumably better.

In conclusion, it seems that reported window opening is a function of individual householders' window opening levels as well as of season, weather condition and room type levels.

TABLE 5.42. Relationship between reported likelihood of winter and summer window opening: percentages of respondents endorsing the 'very likely' response category

Weather condition	Season	SIT	KIT	B1
Sunny	Winter	53.1	69.1	59.3
	Summer	77.8	85.2	75.0
Wet	Winter	6.2	38.3	21.0
	summer	29.1	47.5	45.0
Humid	Winter	39.5	61.2	45.7
	Summer	65.0	74.1	63.0
Mild	Winter	37.0	60.5	47.5
	Summer	61.7	71.6	64.2
Cold	Winter	6.2	28.4	22.2
	Summer	15.0	40.7	34.6
Wind - not	Winter	12.3	33.3	27.4
	Summer	30.9	50.6	44.4
Wind - is	Winter	2.5	16.0	14.8
	Summer	13.6	25.9	23.5
Grand mean	Winter	6.2	34.6	22.2
	Summer	27.2	46.9	39.5
Winter-Summer differences		21	12.3	17.3

5.5.3.2. Amount of window opening

Respondents were asked how wide they opened the sittingroom, kitchen, and main bedroom windows in specified weather conditions. There were five response categories -

not at all (coded 1)

a tiny bit (coded 2)

a little bit (coded 3)

half open (coded 4)

fully open (coded 5)

5.5.3.2.1. Reported amount of winter window opening

This section looks at the reported amount of winter window opening in particular room types (5.5.3.2.1.1) and in specified weather conditions (5.5.3.2.1.2). The relationship between group tyne and reported amount of winter window opening (5.5.3.2.1.3) is also investigated.

5.5.3.2.1.1. Reported amount of winter window opening in three room types

Tables A26(a)-(h) give the percentages of respondents who endorsed each of the five response categories. Table 5.32(h) gives the grand mean percentages of the 81 questionnaire respondents for each room type in winter. These grant mean percentages are calculated as previously described in section 5.5.3.1.1.1 and are taken to indicate the general amount to which windows are reported to be left open, when the amount of window opening is averaged over specific weather conditions.

The discussion of reported data in previous sections (5.5.2 and 5.5.3.1) has been in terms of the percentage of respondents endorsing the most extreme positive category, namely the 'very often the reason' category for window opening motivations, and the 'very likely' category for reported likelihood of window opening.

However, the method cannot reasonably be used in this section since the percentage of respondents reporting that they open their windows fully, is very small - the mean percentages in winter being 1.2%, 3.7% and 1.2% for the sittingroom, kitchen and main bedroom respectively. The percentages in the 'half' and 'full' categories are therefore added together, and it is these combined 'half and full' percentages that are shown in table 5.43. The numbers in brackets show the rank order of percentage values for each room type. When the same percentage value for a given weather condition occurs for two room types, the room type having a higher proportion of respondents in the 'fully open' response category is ranked higher, although if there is no difference between the two room types in this category, they are both given the same rank order.

TABLE 5.43. Reported amount of winter window opening in three room types - percentages of respondents in the combined 'half and full' categories

Weather condition	Room type		
	SIT	KIT	B1
a) Sunny	29.6 (3)	42.0 (1)	30.9 (2)
b) Wet	4.9 (3)	18.5 (1)	7.4 (2)
c) Humid	35.8 (1)	32.1 (2)	29.6 (3)
d) Mild	27.2 (2)	30.9 (1)	27.2 (2)
e) Cold	3.7 (3)	8.8 (1)	4.9 (2)
f) Wind - not	6.2 (3)	9.9 (1)	7.4 (2)
g) Wind - is	2.5 (2)	6.4 (1)	2.5 (2)
h) Grand mean	7.4 (2)	17.3 (1)	9.8 (2)

Inspection of the rank orders in table 5.43 shows that in 7 of the 8 options, the kitchen received the highest proportion of respondents in the "half and full" combined category followed by a) the main bedroom and then by b) the sittingroom. The rank ordering indicates that kitchen windows tend to be opened the widest and sittingroom windows the least.

If it is assumed that occupants believe that the proportion of fresh air entering a room is related to the amount or width to which the window in that room is open, the result suggests that occupants operate different ventilation strategies for different rooms, allowing the most fresh air to enter the kitchen and the least the sittingroom. This implies either that different rooms require varying amounts of fresh air or else that they have similar ventilation requirements which are achieved in different ways for different rooms.

It is hypothesised that there is an interaction between the likelihood, amount and duration of window opening. For example, it may be that sittingroom windows are seldom opened, and even then not very wide but when they are open, are left open for long periods of time. Alternatively, kitchen windows may be very likely to be wide open in all weather conditions but only for short periods of time. Such ventilation strategies would reflect different comfort threshold levels for different room types, as well as varying atmospheric conditions within these rooms, produced by different levels and types of use.

The dominant kitchen, main bedroom, sittingroom rank order found for reported amount of winter window opening was previously seen in the analysis of reported likelihood scores. In addition, table 5.44 shows that highly significant correlations are obtained between grand mean likelihood scores (coded 1 - 4) and grand mean scores for reported amount of winter window opening (coded 1 - 5) for all three room types. This suggests that as the likelihood of opening a window increases, the amount by which it is opened, also rises.

TABLE 5.44. Correlation coefficients obtained between grand mean scores for reported likelihood and reported amount of winter window opening

Room type		
SIT	KIT	B1
.46**	.64**	.55**

**p < .01

The one exception to the "kitchen, main bedroom, sittingroom" rank order is found on humid days when the sittingroom is ranked first, the kitchen second, and the bedroom third. No explanation can be offered for this result.

5.5.3.2.1.2. Reported amount of winter window opening in specified weather conditions

Table 5.45 shows the ranked percentages of respondents in the combined "half and full" categories. The percentage values are those given in table 5.43 but reordered here to enable an examination to be made of the differences in reported amount of winter window opening in specified weather conditions.

Inspection of table 5.43 reveals little change in the rank order of weather conditions with room type. In addition, the rank orders closely follow those given in tables 5.37(a)-(c) for the reported likelihood of winter window opening in specified weather conditions.

In table 5.45, sunny and humid days are ranked first or second depending on room type. Mild days are ranked third in all room types. As before, windy days when the wind is blowing into the house, are ranked last.

TABLE 5.45. Reported amount of winter window opening in specified weather condition - percentages of respondents in the combined 'half and full' categories

Room type	Weather condition						
	Sunny	Wet	Humid	Mild	Cold	Wind not	Wind is
SIT	$29.5^{(2)}$	$4.9^{(5)}$	$35.8^{(1)}$	$27.2^{(3)}$	$3.7^{(6)}$	$6.2^{(4)}$	$2.5^{(7)}$
KIT	$42.0^{(1)}$	$18.5^{(4)}$	$32.1^{(2)}$	$30.9^{(3)}$	$8.8^{(6)}$	$9.9^{(5)}$	$6.4^{(7)}$
B1	$30.9^{(1)}$	$7.4^{(5)}$	$29.6^{(2)}$	$27.2^{(3)}$	$4.9^{(6)}$	$7.4^{(4)}$	$2.5^{(7)}$

5.5.3.2.1.3. Relationship between group type and reported amount of winter window opening

Table 5.46 gives the correlation coefficients obtained between winter grand mean 'amount' responses (coded 1 - 5) and group type (coded 1 - 3). All the correlations for the main bedroom are significant, 6 at the 1% level. Seven of the kitchen correlations are significant, six at the 1% level. Only three of the sittingroom correlations are significant at the 1% level.

The correlation coefficients between 'amount' grand mean responses and group type are lower than those between 'likelihood' grant mean responses and group type (Table 5.38). This is to be expected since the window observations did not take account of the width to which windows were open. Nevertheless, it is interesting to see that the amount of window opening is positively related to group type, and that the relationship is stronger in the kitchen and main bedroom. On the one hand this suggests that constraints influencing the amount of sittingroom window opening may affect all group types, possibly because this is the room where occupants both expect and require high comfort levels and are also more sensitive to changes in these levels. On the other hand, the reported amount of kitchen and main bedroom window opening is related to group type implying that these rooms may be perceived to be subject to fewer window opening constraints (such as heat conservation) with the result that householders can consequently give a freer rein to their window opening preferences.

TABLE 5.46. Correlation coefficients obtained between group type and reported amount of winter window opening

Weather condition	Room type		
	SIT	KIT	B1
Sunny	.05	.23*	.23*
Wet	.26**	.28**	.37**
Humid	.14	.32**	.21*
Mild	.02	.25*	.28**
Cold	.28**	.33**	.36**
Wind - not	.27**	.33**	.34**
Wind - is	.13	.47**	.36**
Grand mean	.16	.38**	.32**

** $p < .01$

* $p < .05$

5.5.3.2.2. Reported amount of summer window opening

This section looks at the reported amount of summer window opening in room types (5.5.3.2.2.1) and in specified weather conditions (5.5.3.2.2.2). The relationship between reported amount of summer window opening and group type is also investigated (5.5.3.2.2.3).

5.5.3.2.2.1. Reported amount of summer window opening in three room types

Tables A27(a)-(h) give the percentages of respondents who endorsed each of the five response categories. However, as in section 5.5.3.2.1, it is the percentages of respondents in the combined 'half and full' categories in table 5.47 which will be discussed.

The table reveals no clear overall rank order for room types in terms of the reported amount of summer window opening, although a "kitchen, main bedroom, sittingroom" rank order is seen in inclement weather, namely on wet, cold and windy days when the wind is blowing into the house. However, the sittingroom is ranked first when more favourable conditions prevail (sunny, humid, mild and windy days when the wind is not blowing into the house).

This suggests that provided the weather is reasonable, sitting-room window opening constraints are partially relaxed in summer. In an earlier section (5.5.3.1.4), it was found that the likelihood of window opening increases in summer but that sittingroom windows are still less likely to be open than other window types. That result and the finding that sittingroom windows are opened wider than windows in other room types in favourable summer conditions, suggests that house-holders may bring sittingroom window opening more into line with window opening in other rooms, not by increasing the likelihood or frequency of sittingroom window opening, but by increasing the amount to which sittingroom windows are open, that is, by operating different ventilation strategies for different rooms.

Table 5.48 shows the correlation coefficients obtained between summer grand mean 'likelihood" scores (coded 1 - 4) and grand mean 'amount' scores (coded 1 - 5) for reported summer window opening in three room types. The correlations are all significant at the 1% level, suggesting that there is a strong positive relationship between the likelihood and amount of summer window opening. The summer correlation in table 5.48 are all higher than those given for the winter in table 5.44.

TABLE 5.47. Reported amount of summer window opening in three room types - percentages of respondents in the combined 'half and full' categories

Weather condition	Room type		
	SIT	KIT	B1
Sunny	74.1 (1)	72.9 (2)	67.9 (3)
Wet	18.5 (3)	21.0 (1)	18.5 (2)
Humid	64.2 (1)	58.1 (2)	58.0 (3)
Mild	56.8 (1)	55.0 (3)	51.8 (2)
Cold	9.9 (2)	13.6 (1)	9.9 (2)
Wind - not	22.2 (1)	18.5 (3)	19.7 (2)
Wind - is	7.4 (2)	9.9 (1)	7.4 (2)
Grand mean	22.3 (2)	24.7 (1)	22.2 (3)

TABLE 5.48. Correlation coefficients obtained between grand mean scores for reported likelihood and amount of summer window opening

Room type		
SIT	KIT	B1
.62**	.68**	.63**

** $p < .01$

5.5.3.2.2.2. Reported amount of summer window opening in specified weather conditions

Table 5.49 shows the ranked percentages of respondents in the combined 'half and full' categories. The percentage values are those given in table 5.47 but are reordered here to enable an examination to be made of the differences in reported amount of summer window opening in specified conditions.

Inspection of table 5.49 shows that (a) there is very little change in the rank ordering of weather conditions with room type, (b) the rank order is the same as that for reported amount of winter window opening and (c) closely approximates that for reported likelihood of winter and summer window opening.

This suggests that the reported likelihood and amount of window opening are influenced in similar ways by specified weather conditions (a) irrespective of season and (b) of room type.

TABLE 5.49. Reported amount of summer window opening in specified weather conditions - percentages of respondents in the combined 'half and full' categories

Room type	Weather condition						
	Sunny	Wet	Humid	Mild	Cold	Wind not	Wind is
SIT	74.1 (1)	18.5 (5)	64.2 (2)	56.8 (3)	9.9 (6)	22.4 (4)	7.4 (7)
KIT	72.9 (1)	21.0 (4)	58.1 (2)	55.0 (3)	13.6 (6)	18.5 (5)	9.9 (7)
B1	67.9 (1)	18.5 (5)	58.0 (2)	51.8 (3)	9.9 (6)	19.7 (4)	7.4 (7)

5.5.3.2.2.3. Relationship between group type and reported amount of summer window opening

Table 5.50 gives the correlation coefficients obtained between grand mean summer 'amount' responses (coded 1 - 5) and group type (coded 1 - 3). All the correlations for the kitchen and main bedroom are significant at the 1% level. Of the sittingroom correlations, two are significant at the 1% level and two at the 5% level.

The high proportion of significant correlations is notable since they indicate not only a relationship between observed and reported data, but between winter observed data and summer reported data - that is, between an approximate measure of window opening propensity (group type) and reported amount of summer window opening. It must also be remembered that open window observations are not dependent on the amount to which windows are open.

In conclusion, it seems that householders have characteristic window opening patterns which persist across season and room type.

TABLE 5.50. Correlation coefficients obtained between group type and reported amount of summer window opening

Weather condition	Room type		
	SIT	KIT	B1
Sunny	.14	.27**	.27**
Wet	.25*	.34**	.31**
Humid	.12	.31**	.30**
Mild	.13	.37**	.26**
Cold	.33**	.36**	.35**
Windy - not	.09	.33**	.26**
Windy - is	.30**	.54**	.39**
Grand mean	.2o*	.43**	.39**

* p < .05 ** p < .01

5.5.3.2.3. Relationship between reported amount of winter and summer window opening

Comparison of the percentages in the combined 'half and full' categories of tables 5.43 and 5.47 show that in all room types, windows are reported to be opened wider in summer than in winter. The sittingroom shows the largest winter-summer grand mean difference, supporting the hypothesis that sittingroom window opening is subject to more constraints (a) in winter than in summer and (b) than window opening in other rooms.

5.5.3.3. Duration of window opening

Respondents were asked for how long they left the sittingroom, kitchen and main bedroom windows open, in winter and in summer. The response categories to this first question were as follows:

not open	(coded 1)
about an hour	(coded 2)
a few hours	(coded 3)
most of the day	(coded 4)
all day	(coded 5)
all night	(coded 6)
all day and all night	(coded 7)

Although these categories are not mutually exclusive, they operated without ambiguity in the present study. It was not considered practical to ask householders about the effect of specific weather conditions on the duration of window opening. However, in a separate question, respondents were asked how much difference (none, very little, some or a lot - coded 1 to 4) the weather made to the length of time for which they left windows open.

5.5.3.3.1. Reported duration of winter window opening

This section looks at the reported duration of winter window opening in relation to room types (5.5.3.3.1.1) and group types (5.5.3.3.1.2). The stated importance of weather conditions on the duration of winter window opening is also investigated (5.5.3.3.1.3).

5.5.3.3.1.1. Reported duration of winter window opening in three room types

Table 5.51 shows the percentages of respondents who endorsed each of the seven response categories when asked about the duration of sittingroom, kitchen and main bedroom window opening. Since few respondents reported that they left their windows open 24 hours a day, it is the percentages in the 'most of the day' response category which will be discussed. The numbers in brackets indicate the rank order of percentages in this category.

As was found forlikelihood and amount of window opening (sections 5.5.3.1 and 5.5.3.2 respectively) the rank order is from kitchen to main bedroom to sittingroom, showing that kitchen windows are reported to be more likely to be open and open wider and for longer than a) the main bedroom or b) the sittingroom windows.

TABLE 5.51. Reported duration of winter window opening in three room types: percentages of respondents endorsing each response category

Reponse category	Room type		
	SIT	KIT	B1
Not open	24.7	9.9	15.0
One hour	33.3	24.7	23.8
A few hours	28.4	29.6	22.5
Most of the day	6.2 (3)	18.5 (1)	16.2 (2)
All day	4.9	11.1	8.8
All night	2.5	6.2	3.7
All day and all night	0.0	0.0	10.0

Table 5.52 shows the correlation coefficients obtained between duration of winter window opening in three room types (coded 1 - 7) and a) grand mean winter 'likelihood' scores (coded 1 - 4) and b) grant mean winter 'amount' scores (coded 1 - 5). All the correlations are significant at the 1% level. This suggests that the three winter window opening parameters (likelihood, amount and duration) are positively interrelated.

TABLE 5.52. Correlation coefficients obtained between duration of winter window opening in three room types and winter grand mean likelihood and amount scores

x variable = duration of winter window opening			
	Room type		
y variable	SIT	KIT	B1
$G\bar{x}$ likelihood	.44**	.59**	.57**
$G\bar{x}$ amount	.26**	.54**	.41**

** $p < .01$

5.5.3.3.1.2. Relationship between reported duration of winter window opening and group type

Table 5.53 shows the correlation coefficients obtained between group type (coded 1 - 3) and reported duration of winter window opening (coded 1 - 7). The sittingroom and kitchen correlations are significant at the 1% level, the main bedroom correlation at the 5% level. Such positive correlations are to be expected since open window observations are dependent upon the proportion of time for which windows are open.

TABLE 5.53. Correlation coefficients obtained between group type and reported duration of winter window opening

Room type		
SIT	KIT	B1
.36**	.39**	.22*

** $p < .01$

* $p < .05$

5.5.3.3.1.3. Importance of weather conditions on the reported duration of winter window opening

Table 5.54 shows the percentages of respondents who endorsed each of the four response categories. The ranked percentages in the 'makes a lot of difference' categories, indicate that weather conditions are reported to be important in influencing winter sittingroom window opening. Kitchen windows are ranked third, suggesting that kitchen window opening is relatively independent of external conditions. These findings support earlier suggestions of constraints which affect sittingroom but not kitchen window opening.

TABLE 5.54. Importance of weather conditions on reported duration of winter window opening - percentages of respondents endorsing each response category

Response category	Room type		
	SIT	KIT	B1
No difference	22.0	29.3	25.6
Very little difference	9.8	28.0	20.7
Some difference	34.1	23.2	26.8
A lot of difference	34.1 (1)	19.5 (3)	26.8 (2)

5.5.3.3.2. Reported duration of summer window opening

This section looks at the reported duration of summer window opening in three room types (5.5.3.3.2.1) and in relation to group type (5.5.3.3.2.2). The stated importance of weather conditions on the duration of summer window opening (5.5.3.3.2.3) is also investigated.

5.5.3.3.2.1. Reported duration of summer window opening in three room types

Table 5.55 gives the percentages of respondents who endorsed each of the response categories when asked about the duration of summer window opening. Inspection of the ranked percentages in the 'most of the day' response category reveals a "kitchen - sittingroom - main bedroom" rank order. There are many potential explanations for this change away from the dominant "kitchen - main bedroom - sittingroom" rank order but none can be justified.

TABLE 5.55. Reported duration of summer window opening in three room types - percentages of respondents endorsing each response category

Responde category	Room type		
	SIT	KIT	B1
Not open	1.2	3.7	0.0
One hour	6.2	2.5	5.0
A few hours	22.2	16.0	18.8
Most of the day	28.4 (2)	35.8 (1)	17.5 (3)
All day	28.4	27.2	22.5
All night	0.0	1.2	3.7
All day and all night	13.6	13.1	32.5

Table 5.56 shows the correlation coefficients obtained between duration of summer window opening in three room types (coded 1 - 7) and (a) grand mean summer 'likelihood' scores (coded 1 - 4) and (b) grand mean summer 'amount' scores (coded 1 - 5). All the correlations are significant at the 1% level, indicating significant interrelationships between the three window opening parameters.

TABLE 5.56. Correlation coefficients obtained between duration of summer window opening in three room types and grand mean summer 'likelihood' and 'amount' scores

x variable = duration of summer window opening			
	Room type		
y variable	SIT	KIT	B1
$G\bar{x}$ likelihood	.36**	.40**	.34**
$G\bar{x}$ amount	.38**	.38**	.44**

** $p < .01$

5.5.3.3.2.2. Relationship between reported duration of summer window opening and group type

Table 5.57 gives the correlation coefficients obtained between reported duration of summer window opening (coded 1 - 7) and group type (coded 1 - 3). The kitchen and main bedroom correlations are significant at the 1% level, the sittingroom correlation at the 5% level, suggesting that observed winter window opening is predictive of the reported duration of summer window opening.

TABLE 5.57. Correlation coefficients obtained between group type and reported duration of summer window opening

Room type		
SIT	KIT	B1
.24*	.45**	.29**

** $p < .01$

* $p < .05$

5.5.3.3.2.3. Importance of weather conditions on reported duration of summer window opening

Table 5.58 shows the percentages of respondents who endorsed each of the four response categories. The ranked percentages in the 'makes a lot of different' category suggest that weather conditions exert a greater influence on sittingroom window opening than on main bedroom or kitchen window opening.

TABLE 5.58. Importance of weather conditions on reported duration of summer window opening - percentages of respondents endorsing each response category

Response category	Room type		
	SIT	KIT	B1
No difference	32.9	41.5	40.2
Very little difference	18.3	25.6	23.2
Some difference	26.8	17.1	20.7
A lot of difference	22.0 (1)	15.9 (3)	15.9 (2)

5.5.3.3. Relationship between reported duration of winter and summer window opening

A comparison of the percentages in tables 5.51 and 5.55 shows that the reported duration of window opening rises in summer in all room types, the largest winter-summer difference in the 'most of the day' response category, being seen for the sittingroom. Although in winter no windows are reported to be left open 24 hours a day, 32.5% of respondents say that in summer they leave their main bedroom windows open 'all day and all night'. A number of respondents also leave sittingroom and kitchen windows open 24 hours a day in summer (13.6% and 13.1% respectively).

A comparison of tables 5.54 and 5.58 shows that in winter higher proportions of respondents endorse the response category which states that weather conditions make some difference to the length of time for which windows are left open. This suggests either that in summer householders assume that the weather is better and that constraints such as heat conservation are reduced.

5.6. Prediction of Estate-wide Window Opening

The relationships within physical parameters and between each one of these parameters separately and window opening for different room and group types have already been investigated (5.4.3 and 5.4.4). The combined effects of these physical parameters on window opening will be discussed in this section.

5.6.1. Prediction of Estate-wide Window Opening at Cowley and Mezen

Multiple regression was used to establish the relationships between window opening and selected physical variables. The aim was to see how much of the variance in estate-wide window opening could be predicted given a knowledge of specified weather conditions at the hour of observation.

The dependent variable for each estate separately was the percentage of open window observations on each of the one hundred days. The independent variables were those physical variables which had been found to be significantly correlated with window opening (Table 5.18) or which were felt intuitively to be important, namely temperature, relative humidity, windspeed, and hour of observation.

No strong inter-relationships were found between any of these independent variables (Figures 5.20-- 5.34) indicating a lack of collinearity favourable to the application of multiple regression.

Four regression analyses were made for each estate separately by first including temperature as the main independent variable and by then introducing in turn relative humidity, windspeed, and hour of observation. Tables A28 - A33 give the full results of each of these analyses.

Inspection of tables A28 and A31 show that at Cowley approximately 1.8% and at Mezen approximately 1.3% more windows are opened for each 1°C rise in external air temperature. This may reflect the different window arrangements at Cowley and Mezen - not only do dwellings at Mezen tend on average to have more windows (8.1) than dwellings at Cowley (4.6) but some Mezen dwellings have several windows in the one room. The different regression coefficients may therefore indicate that occupants do not regard all windows as equal and thus do not open them in equal proportions.

The proportions of variance accounted for by temperature (and then by additional variables) are given in table 5.59. Inspection of the table shows that on both estates temperature alone accounts for just over half of the variance (54.8% at Cowley, 53% at Mezen). Thereafter the inclusion of extra variables produces a slight increase in the variance explained.

TABLE 5.59. Proportions of variance accounted for in four regression analyses

Dependent variable	Independent variables	Proportion of variance explained (%) Estate: Cowley	Mezen
Proportion of open window observations on estate	Temperature	54.8	53.0
	Temperature, relative humidity	55.3	56.9
	Temp., relat. humidity, windspeed	60.1	65.2
	Temp., rel. humidity, windspeed, hour of observation	74.1	68.8

When relative humidity is included in the regression analysis, the variance explained rises by 0.5% at Cowley and by 3.9% at Mezen. Although the regression coefficients (Tables A29 and A32) are negative for both Cowley and Mezen, a comparison of their magnitudes suggests a difference between the two estates in response to changes in relative humidity, namely a 10% change in relative humidity causes 1.5% fewer windows to be open at Mezen but only 0.9% fewer at Cowley. However, this discrepancy is insignificant in view of the standard deviation of the two coefficients.

Tables A30 and A33 show that a one knot increase in windspeed causes about 0.5% fewer windows to be open on both estates.

When hour of observation is included as a fourth independent variable a total of 74.1% of the variance is explained at Cowley and 68.8% at Mezen. However, the variable appears to produce real differences in window opening between the two estates - on average, there is a 0.5% drop in the total number of open window observations at Mezen compared with a 1.3% drop at Cowley for every hour that passes between 9 a.m. and 6 p.m. Although these coefficients must depend upon the survey times chosen (since the drop cannot be maintained past the point when all windows are shut) the inclusion of this variable is justified by the high proportions of variance explained.

The regression coefficients for relative humidity, windspeed and hour of observation generally change little when extra variables are added. This confirms earlier suggestions of good non-collinearity.

Tables 5.60 and 5.61 give a summary of the results obtained when all four independent variables are included in the regression analyses.

TABLE 5.60. Summary results of regression analysis on Cowley data: prediction of proportion of open window observations on estate from temperature, relative humidity, windspeed and hour of observation

```
-- regr 'perc' 4 'temp' 'rh' 'ws' 'hour'
The regression equation is   y = 43.2 + 1.86 x temp - 0.125
   x Rh - 0.629 x Ws - 1.31 x Hour
```

	Column	Coefficient	st.dev. of coef.	t-ratio = coef/s.d.
	--	43.222	4.993	8.66
1.	Temp	1.8553	0.1320	14.06
2.	Rh	-0.12475	0.04138	-3.01
3.	Ws	-0.6294	0.1208	-5.21
4.	Hour	-1.3067	0.1829	-7.14

The st. dev. of y about gression line is s = 5.136
with (100 - 5) = 95 degrees of freedom
r-squared = 74.1 per cent
r-squared = 73.0 per cent, adjusted for d.f.

TABLE 5.60. continued

Analysis of variance

due to	df	ss	ms = ss/df
Regression	4	7151.87	1787.97
Residual	95	2505.85	26.38
Total	99	9657.72	

TABLE 5.61. Summary results of regression analysis on Mezen data (N = 100 days): prediction of proportion of open window observations on estate from temperature, relative humidity, windspeed and hour of observation

-- Regr 'perc' 4 'temp' 'rh' 'ws' 'hour'

The regression equation is y = 31.6 + 1.27 x Temp - 0.166 x Rh - 0.489 x Ws - 0.466 x Hour

	Column	Coefficient	St. dev. of coef.	t-ratio = coef/s.d.
	--	31.626	3.817	8.28
1.	Temp	1.2682	0.1018	12.46
2.	Rh	-0.16630	0.03237	-5.14
3.	Ws	-0.48904	0.09529	-5.13
4.	Hour	-0.4657	0.1397	-3.33

The st. dev. of y about regression line is s = 3.910

with (100 - 5) = 95 degrees of freedom

r-square = 68.8 per cent

r-square = 67.5 per cent, adjusted for d.f.

Analysis of variance

Due to	df	ss	ms = ss/df
Regression	4	3204.10	801.03
Residual	95	1452.44	15.29
Total	99	4656.54	

Inspection of the residuals generated by the equations in tables 5.60 and 5.61 shows large residuals occurring on days 3, 5, 7, 19 and 40 at Cowley and on days 3, 12, 33, 71 and 96 at Mezen. Table A34 shows the observed and predicted percentages of open window observations on these days as well as their respective physical parameter values. Potential explanations for these outliers include particularly high and low survey temperatures (for example, days 3 and 5 at Cowley and days 3 and 71 at Mezen) and high windspeeds (day 40 at Cowley). However, no single explanation holds for all ten outliers.

Nevertheless, despite these ten outliers, it seems that estate-wide window opening can be predicted with a reasonable degree of accuracy from only four simple, easily obtainable variables. However, it must be noted that the regression equations given in table 5.60 and 5.61 are for two specific estates. Indeed, as discussed earlier, it seems that window opening depends not only on the prevailing weather conditions but on the number and type of openable windows as well, perhaps as on occupant differences.

However, if desired the regression equation generated when the data sets from both estates are combined (Table 5.62) may be used as an approximate guide to the percentages of open window observations that may be expected in specified weather conditions. It will be seen that the variance accounted for by the same four variables is less for the two data sets combined (N = 200 days) than for either estate separately. This is not surprising in view of the different influence of temperature and hour of observation for each estate.

TABLE 5.62. Summary results of regression analysis on combined Cowley and Mezen data (N = 200 days): prediction of proportion of open window observations from temperature, relative humidity, windspeed and hour of observation

```
-- regr 'perc' 4 'temp' 'rh' 'ws' 'hour'
The regression equation is  y = 30.1 + 1.57 x Temp - 0.109 x Rh
    - 0.150 x Ws - 0.832 x Hour
```

	Column	Coefficient	st. dev. of coef.	t-ratio = coef/s.d.
1.	Temp	30.122	4.256	7.08
1.	Temp	1.5659	0.1183	13.24
2.	Rh	-0.10873	0.03622	-3.00
3.	Ws	-0.1502	0.1062	-1.41
4.	Hour	-0.8320	0.1609	-5.17

The st. dev. of y about regression line is

s = 6.427

with (200 - 5) = 195 degrees of freedom

r-square = 53.4 per cent

r-squared = 52.5 per cent, adjusted for d.f.

Analysis of variance

Due to	df	ss	ms = ss/df
Regression	4	9238.48	2309.62
Residual	195	8054.92	41.31
Total	199	17293.40	

5.7. Prediction of Individual Householders' Window Opening

The regression equations generated in section 5.6 predict estate-wide window opening on particular days. However, they do not enable assessment of individual householders' window opening propensities, which are known to vary considerably (Figure 5.58). Three further regression analyses were therefore made, each aiming to predict the total number of open window observations over one hundred days, in individual households. All three regression analyses included as an independent variable, the maximum possible number of open window observations which could have been made during the survey period since, as previously noted, window opening is influenced by the number of openable windows (r = .36). The additional independent variables used in the three regression analyses were as follows: first, motivational variables; second, reported likelihood of winter window opening; and third, social variables. These additional variables were selected by trial and error. In all three analyses it was found that beyond the first additional variable, other variables accounted for only a small proportion of the variance.

5.7.1. Prediction of Individual Householders' Window Opening from Motivational Variables

Information about the 81 householders who returned the questionnaire formed the data base for this regression analysis. The aim was to see how much of the variance in individual householders' ovserved window opening could be predicted from two simple variables - namely the number of windows in the dwelling and householders' response to the question 'how often is fresh air the reason why you open your windows?' This second variable was included since it was the motivation which received the highest proportion of 'very often the reason' responses (5.5.2) and was the motivational variance most highly correlated with the number of open window observations (r = .42). The correlation coefficients obtained between these two variables is zero, indicating a lack of collinearity favourable to the application of multiple regression.

Table 5.63 gives the summary results of the regression analysis showing that the two variables together account for 31% of the variance in individual householders' window opening. That this figure is considerably lower than the proportions of variance explained when estate-wide window opening is regressed against physical parameters (5.6) is to be expected since more variables are necessary to describe important aspects of householders' behaviour than to provide an adequate description of the weather.

Examination of the residuals generated by use of the regression equation reveals only one outlier (1.2% of the regression population). This is for a household where the total number of observed open windows exceeds that predicted by approximately a factor of two. Reference to the the interview and questionnaire data for this household reveals that the dwelling is a six person house on the Cowley estate (St. Helen's No. 49), occupied by a husband and wife and their two children. The mother does not go out to work but instead stays at home to look after her four year old son. She reports a strong dislike of condensation and preference for fresh air, adding that in winter her kitchen window is open 24 hours a day, all three bedroom windows all day and the sittingroom window all morning. Such extreme window opening patterns may account for the large discrepancy between observed and predicted values in this case.

5.7.2. Prediction of Individual Householders' Window Opening from Reported Likelihood of Winter Window Opening

The reported likelihood of winter window opening was discussed in section 5.5.3.1 where it was shown to be well correlated with group type. The variable was also found to be significantly related to reported amount and duration scores. Such inter-relationships prevent a meaningful regression analysis being made with all three parameters. Thus, in addition to the maximum possible number of open window

TABLE 5.63. Summary results of regression analysis predicting individual householders' window opening from motivational variables

Dependent variable: nopen

Coefficients and confidence intervals

Variable	B	STD Error B	T	95.0 PCT Confidence Interval	
WAIR	46.119024	10.144973	4.5460568	25.922534	66.316714
NPOSS	.15310742	.38990450E-01	3.9267929	.75483400E-01.	23073145
CONSTANT	-105.36820	40.841542	-2.5926230	-188.27929	-24.457101

Summary Table

Variable entered	Variable removed	F to Enter or Remove	Significance	Multiple R	R Square	R Square Change	Simple R	Overall F	Significance
1 WAIR		17.18013	.000	.42264	.17862	.17862	.42264	17.18013	.000
2 NPOSS		15.41970	.000	.56053	.31420	.13557	.36399	17.86784	.000

observations, the only other independent variable in this second regression analysis, is the mean response of each of the 81 householders to questions concerning the likelihood of winter window opening.

The mean likelihood score for each household was calculated by adding the seven responses (coded 1 to 4 from very unlikely to very likely) to the likelihood questions for each of the three room types (sittingroom, kitchen and main bedroom), and by then dividing the total by 21. The scores thus obtained are taken to indicate each household's general level of reported winter window opening. However, it is accepted that the indicator is an approximation only, since it cannot be assumed that the seven weather conditions occur in equal proportions. Additionally, had the householder been asked the direct question 'how likely are you to open your windows in winter?' with no reference to weather conditions or room type being made, he might not have given the same response as was calculated for him.

Nevertheless, the results in table 5.64 indicate that the two independent variables account for 37% of the variance in individual householder's window opening. The finding indicates that reported data can reliably predict window opening when specific questions are asked of the householder. This suggests that when actual window observations are impractical or impossible an approximate indication of householders' window opening propensities can be obtained.

Examination of the residuals generated by use of the regression equation shows that there are three outliers, namely numbers 11 and 21 at Mezen and as before number 49, St. Helen's, Cowley. No single factor appears to be common to all three households and thus no explanation can be offered for the discrepancies between observed and predicted scores.

TABLE 5.64. Summary results of regression analysis predicting individual householder's window opening from reported likelihood of winter window opening

Dependent Variable: Nopen

Coefficients and Confidence Intervals.

Variable	B	STD Error B	T	95.0 PCT Confidence Interval	
LIKE	3.2566450	.58525035	5.5645333	2.0915011	4.4217890
NPOSS	.13344504	.34506634E-01	3.8605421	.64629062E-01	.20226282
CONSTANT	-58.372617	29.961744	-2.0085724	-116.23011	-.51512838

SUMMARY TABLE

Step	Variable Entered	Variable Removed	F to Enter or Remove	Significance	Multiple R	R Square	R Square Change	Simple R	Overall F	Significance
1	LIKE		26.08267	.000	.49821	.24821	.24821	.49821	26.08267	.000
2	NPOSS		14.90379	.000	.60730	.36881	.12060	.34387	22.78847	.000

5.7.3. Prediction of Individual Householder's Window Opening from Social Variables

Table 5.65 shows the correlation coefficients obtained between selected social variables and window observations in individual households. The social variables shown generally refer to questions asked at the original interview (Chapter 4). Although the demographic variables (number of occupants, stage in the lifecycle, number of smokers, and whether or not the house is occupied for the best part of the day) refer to responses obtained either at the interview or from the questionnaire.

The aim of this third regression analysis was to see how much of the variance in individual householder's window opening could be predicted from demographic and behavioural characteristics. All the variables initially selected were chosen because they can be obtained easily and are fairly objective in that responses to such questions are unlikely to be subject to distortion. These two considerations were felt to be important since should replication of this part of the study be required in the future, little time would need to be devoted to the field work.

Inspection of the correlation coefficients in table 5.65 narrowed the choice of independent variables to three, namely, the maximum possible number of open window observations, the total number of baths per week (for the household as a whole) and whether or not the housewife cooked with gas or electricity.

Summary results for the regression analysis are given in table 5.66. The table shows that the three independent variables account for 34% of the variance. This suggests that water creating processes are strongly related to window opening. Inspection of the regression coefficients show that possession of a gas cooker causes approximately 30.3% more windows to be opened over one hundred days. Approximately

TABLE 5.65. Inter-correlation coefficients obtained between selected social variables

Variable	Total No. open window observations	No. occupants	Stage in lifecycle	No. smokers	Income per week	No. hours house occupied per week	Possess washing machine	Possess gas cooker
No. occupants	.41**							
Stage in lifecycle	.02	.09						
No. smokers	.12	.20	.01					
Income per week	.23*	.47**	-.32**	.27**				
No. hours house occupied per week	.03	-.14	.37**	-.15	-.43**			
Possess washing machine	.25*	.46**	-.23*	.13	.51**	-.19		
Possess gas cooker	.12	.06	.04	.07	-.00	-.06	-.05	
No. baths per week	.50**	.59**	.03	.21*	.43**	-.05	.36**	.05

** $p < .01$

* $p < .05$

TABLE 5.66. Summary results of regression analysis predicting individual householder's window opening from social variables

Dependent variable: nopen

Variable	R	STD Error B	T	95.0 PCT Confidence Interval	
BATHS	6.3506811	1.3751544	4.6181587	3.6058614	9.0955007
NPOSS	.12416276	.42266437E-01	2.9376206	.39798595E-01	.20852692
GAS	30.261068	21.299488	1.4207416	-12.252888	72.775024
CONSTANT	-61.121170	47.857139	-1.2771589	-156.64442	34.402080

SUMMARY TABLE

Step	Variable Entered	Variable Removed	F to Enter or Remove	Significance	Multiple R	R Square	R Square Change	Simple R	Overall F	Signif-icance
1	BATHS		23.00370	.000	.50003	.25003	.25003	.50003	23.00370	.000
2	NPOSS		7.46906	.008	.56943	.32425	.07422	.32547	16.31473	.000
2	GAS		2.01851	.160	.58653	.34402	.01976	.12178	11.71223	.000

6.4% more windows are opened for each additional bath taken by a family in an average week.

Examination of the residuals shows six outliers, namely numbers 4, 6, 23 and 35 at Mezen and at St. Helen's, Cowley numbers 6 and 45. No explanation can be offered for the discrepancies between observed and predicted window opening scores in these cases.

5.7.4. Conclusion

In conclusion it seems that, with a fair degree of accuracy, various reported variables can act as predictors of actual window opening behaviour. The aim of the present study has not been to provide a shortened questionnaire for future use which would elicit accurate estimates of householders' window opening. Nevertheless, it is suggested that the results indicate the feasibility of such an approach.

5.8. Weekend and Christmas Window Observations

In addition to the main window opening survey (N = 100 days), two smaller surveys were conducted with window observations being made (a) at weekends and (b) during the 1979 Christmas period. The aim was to investigate the relationship between window opening on weekdays and at other times when different occupancy and household behavioural patterns might be presumed to exist; that is, to examine the consistency of household window opening patterns in a variety of circumstances.

5.8.1. Methodology

One set of weekend window observations was made at Cowley and Mezen separately for each of the seven months between October and April (inclusive). Within a given month the observer was free to choose the date (between the first and last day of the month), day (Saturday or Sunday) and time (9 a.m. to 6 p.m.) of her visit.

The restrictions governing Christmas observations were tighter. The observation period covered the ten weekdays between the 24th December 1979 and 4th January 1980 (inclusive). Observations were made once at each hour between 9 a.m. and 6 p.m. within each of the two weeks, half of the observations were morning observations and half evening observations.

Window observations were recorded in precisely the same way as weekday observations (5.3.2.1).

5.8.2. Results

Tables A35 to A38 show the weather parameter values and hour of observation for the weekend and Christmas periods at Cowley and Mezen. The total number of open window observations recorded on each day is also shown. It will be noted that only nine observations are given for the Cowley estate at Christmas. This was due to the observer being unable to visit the estate on one particular day because of a downpour.

5.8.3. Analysis

Table 5.67 gives the mean value of each of the five weather parameters and the mean number of total open window observations at Cowley and Mezen for

a) the main survey (N = 100 days)

b) weekends (N = 7 days) and

c) the 1979 Christmas period (N = 9 or 10 days).

The table shows that there are no major differences between weather parameter values for the three periods except between the mean values for temperature during the main survey and at Christmas on both estates.

TABLE 5.67. Mean weather parameter values for three periods of observation

Period of observation	Estate	Mean weather parameter value				
		TEMP	RH	WS	SUNDUR	RAIN
Main survey	Cowley	8.5	79.6	8.9	0.3	0.1
(N=100 days)	Mezen	8.2	79.6	9.0	0.2	0.1
Weekends	Cowley	8.8	70.4	12.1	0.5	0.0
(N=7 days)	Mezen	9.2	65.4	12.9	0.4	0.0
Christmas	Cowley	3.3	83.1	9.0	0.2	0.1
(N=9/10 days)	Mezen	3.9	85.4	10.4	0.3	0.2

TABLE 5.68. Correlation coefficients obtained between the total number of open window observations in three observation periods and their respective weather parameter values

Period of observation	Estate	Correlation coefficients				
		TEMP	RH	WS	SUNDUR	RAIN
Main survey	Cowley	.74**	-.23**	-.15	.36**	.14
(N=100 days)	Mezen	.73**	-.32**	-.17*	.12	-.06
Weekends	Cowley	.43	-.06	.19	-.16	-.18
(N=7 days)	Mezen	.80**	-.14	.30	.11	.00
Christmas	Cowley	-.21	-.42	.03	.36	-.23
(N=9/10 days)	Mezen	-.03	-.18	-.19	.35	-.42

** $p < .01$

* $p < .05$

TEMP = temperature

RH = relative humidity

WS = windspeed

SUNDUR = sunshine duration

RAIN = rainfall

Table 5.68 gives the correlation coefficients obtained between the total number of open window observations and weather parameter values for each of the three observational periods. Although six of the correlations for the main survey period (N = 100 days) are significant, only one "weekend" correlation is significant, and no "Christmas" correlation is significant. This might be taken to indicate that weekend and Christmas window opening are not related to weather parameter values. However, in view of the small numbers of observations at weekends and at Christmas, it is important to test whether the weekend and main survey, and Christmas and main survey correlation coefficients differ significantly from each other. Tests reveal that the only significant correlation difference is that at Mezen for the correlation between temperature and total open window observations (a) during the main survey (r = .73) and (b) at Christmas (r = -.03).

Moreover, when the mean number of total open windows for each household on each estate is calculated for each of the three observation periods (Tables A39 and A40) highly significant correlations are obtained (Tables 5.69 and 5.70).

This suggests that household window opening is consistent across different observational periods.

TABLE 5.69. Correlation coefficients obtained between mean number of total open windows observations during three observation periods at Cowley

Observation Period	Observation period		
	Main survey	Weekends	Christmas
Main survey	-	.88**	.76**
Weekends	-	-	.69**

** $p < .01$

TABLE 5.70. Correlation coefficients obtained between mean number of total open window observations during three observation periods at Mezen

Observation Period	Observation period		
	Main survey	Weekend	Christmas
Main survey	-	.91**	.78**
Weekends			.73**

** p < .01

5.8.4. Relationship Between Weekday and Weekend Window Opening

Inspection of table 5.71 shows that the mean percentage of open window observations for all room types is generally larger at weekends than during weekdays at both Cowley and Mezen. This corresponds with the analysis of questionnaire data since table 5.72 shows that although the majority of householders report that sittingroom, kitchen and main bedroom windows are open in summer and winter for similar lengths of time on weekdays and at weekends, in winter 20 - 40% of householders report that they leave these windows open longer at the weekend. The percentages of householders reporting that they leave windows open longer at the weekends rises to between 30% and 40% in summer.

Table 5.71 also shows that the largest observed weekday-weekend difference is seen for the kitchen and the smallest for the sittingroom. The rank order of the reported weekday-weekend differences is from kitchen to sittingroom to main bedroom in both winter and summer.

5.8.5. Motivations for Leaving Windows Open Longer at the Weekend than During the Week

If respondents reported that they left certain windows open longer at the weekend, they were then asked if any of several motivations

TABLE 5.71. Mean proportions of open window observations on weekdays (N = 100 days) and at weekends (N = 7 days) at Cowley and Mezen

Observation period	COWLEY				MEZEN			
	Room				Room			
	SIT	KIT	B1	Total	SIT	KIT	B1	Total
(N = 100) Weekdays	12.6	28.4	36.9	25.8	10.0	21.7	23.8	18.1
(N = 7) Weekends	15.3	36.1	43.2	31.0	9.21	34.9	27.9	21.4
Weekday-Weekend difference	2.7 (3)	7.7 (1)	6.3 (2)	5.2	-0.8 (3)	13.2 (1)	4.1 (2)	3.2

TABLE 5.72. Relationship between reported duration of weekday and weekend window opening - percentages of respondents endorsing each response category

Room type	Season	Response category		
		Open longer at weekend	No difference	Open less at weekend
Sittingroom	Winter	27.4 (2)	61.9	10.7
	Summer	41.7 (2)	52.4	6.0
Kitchen	Winter	40.5 (1)	52.4	7.1
	Summer	41.7 (1)	52.4	6.0
Main bed-room	Winter	20.2 (3)	71.4	8.3
	Summer	33.3 (3)	60.7	6.0

were 'never, 'seldom', 'quite often' or 'very often' the reason for their behaviour. Table 5.73 shows the percentages of respondents who endorsed each of the four response categories. The table shows that of the nine options offered the motivation 'because more cooking is done at the weekend' received the highest proportion of 'very often the reason' responses. This may explain the large weekday-weekend difference seen for kitchen windows in table 5.71. An increase in the number of occupants is ranked second.

TABLE 5.73. Reasons for leaving windows open more often at the weekend than during the week

QUESTION: in winter, do any of the following reasons explain why you open your windows more often at the weekend than in the week?

Option	Response category			
	Never the reason	Seldom the reason	Quite often the reason	Very often the reason
(a) house is stuffier	14.3	33.3	38.1	14.3 (9)
(b) cleaning	19.0	16.7	42.9	21.4 (6)
(c) more time	31.0	16.7	26.2	26.2 (5)
(d) not open much during week	35.7	26.2	19.0	19.0 (8)
(e) more cooking	7.1	9.5	40.5	42.9 (1)
(f) more clothes washing	21.4	26.2	26.2	26.2 (4)
(g) more tobacco smoke	35.7	21.4	21.4	21.4 (7)
(h) more people at home	16.7	21.4	26.2	35.7 (2)
(i) am at home to shut them	31.0	9.5	26.2	33.3 (3)

CHAPTER 6

SUMMARY AND CONCLUSIONS

6.1. Summary

The thesis involved two main studies. The first was concerned with householders' behaviour patterns, the motivations underlying the relative frequencies of these behaviours and effects on domstic gas consumption. The second was concerned with a detailed investigation of one particular behaviour pattern, namely window opening. However, before the studies themselves were discussed it was considered necessary to review the related literature and to then examine the results of two pilot studies.

The first literature review (Chapter 1) pertains mainly to conservation. It reviews the literature on the social factors affecting energy consumption and shows that most of the research falls into two main divisions. The first deals with the relationship between specific isolated variables (for example, income or age) and energy use and consumption. The second deals with strategies (for example, incentives and information) which affect householders' consumption levels. The review indicates that methods for promoting energy conservation have assumed that particular variables affected consumption. It was consequently considered necessary to review the consumption literature in order to see what variables had actually been found to relate to energy consumption.

The aim of the energy consumption literature review (Chapter 2) was therefore to highlight studies concerned with variations between householders in energy consumption levels, and to review investigations which have examined the causal factors both per se and in relation to consumption. The review showed that a number of studies have pointed to the wide range of consumption levels amongst the occupants of similarly constructed houses, and that researchers have suggested that the causes of these variations relate to the way people use their houses and heating systems and to their attitudes towards thermal comfort and energy usage. It was noted that only a few studies have related consumption to both architectural and socio-economic variables. It was consequently concluded that there was a need for further detailed research on the behavioural and attitudinal factors which affect consumption levels amongst the occupants of similar houses. Additionally, it was felt that this research should be related to a theoretical framework, and should use established psychological theories and concepts in the explanation of results.

The Charnwood pilot study (Chapter 3) was a quasi-random field survey of twenty-six houses of similar construction. Data from open-ended interviews supplemented the quarterly meter readings and were used to aid explanation of the observed variability in gas consumption. There were three basic areas of investigation - the relationship between certainly readily measurable social and physical variables and gas consumption; attitudes and reactions to the thermal environment; and consumer knowledge and perception of energy issues and the energy crisis. The study demonstrated that the behaviour patterns which result in particular levels of consumption cannot be understood except in terms of the household's total lifestyle. For example, it was found that both past and present circumstances affected householders' satisfaction with the heating system. In conclusion, the study served to generate a perspective from which a more detailed study could be made. It also indicated the importance of descriptive data and the need for further research on a larger scale.

It was therefore decided that an in-depth study of a larger number of households should be conducted (Chapter 4), in conjunction with an investigation of the same householders' window opening habits. This second study (Chapter 5) was felt to be necessary because window opening was considered to be one of the main variables influencing gas consumption. Moreover, it was felt that the structure of window opening as a behaviour pattern, and the way it is influenced by attitudes and beliefs would be illustrative of the way other behaviour patterns may be influenced by such factors.

The first study centred on 113 households on two local authority estates where, although all the dwellings were of similar construction, there were eight basic design types. Analysis of quarterly gas consumption readings showed that design heat loss and terrace position accounted for less than a third of the variance in winter consumption. It was hypothesised that a substantial proportion of the remaining variance could be explained by householders' behaviour patterns. However, although a large number of behaviour patterns thought to relate to consumption were investigated and the motivations underlying their relative frequencies of occurrence were successfully identified, attempts to predict winter consumption from behavioural and social variables did not result in a higher proportion of variance being explained. It was suggested that this was due to considerable interaction between variables, as well as to factors which are difficult to assess and were therefore not measured in the present study (for example, boiler efficiencies, quality of house construction and metering inaccuracies).

The window opening survey was concerned with identifying the objective correlates of window opening on an estate and the subjective motivations for the opening and closing of windows. Occupants were also asked about the effects of specified weather conditions on window opening in three room types in summer and winter. The study made use of three main data sources: a series of systematic window observations, mean hourly metereological data and a postal questionnaire. The questionnaire dealt with underlying motivations and the three factors held to define window opening, namely the likelihood, amount and duration of window opening. A large number of significant results were obtained. They will therefore be briefly reiterated in terms of four main divisions:

a) results of observed weekday data,

b) results of reported data,

c) results of regression analyses, and

d) results of observed weekend and Christmas data.

Principal findings of the observed weekday data

The number of openable windows in a dwelling was found to be an important explanatory variable. Results showed that there were smaller differences between house types with varying numbers of windows when the proportion of open windows was taken as the relative measure than when the absolute number of open windows was considered. All subsequent results were therefore expressed as the proportion of open window observations actually made, in relation to the maximum possible number of open window observations which could have been made.

Preliminary analysis indicated that the variability between households in terms of their total daily window opening was greater than that within households. It was suggested that householders adopted consistent window opening patterns; a hypothesis which received support from the finding of a strong positive relationship between window opening in different room types.

Analysis of the window opening data showed that at both Cowley and Mezen windows in the main bedroom were open more frequently than those in either the sittingroom or kitchen. Examination of the relationships between window opening in certain room types and specified weather parameters indicated that window opening was significantly related to external air temperature for all room types on both estates. The results for other weather parameters differed according to estate and room type.

On the basis of these findings a possible model of window opening was proposed. It was hypothesised that although window opening was primarily a function of external air temperature, relative humidity and windspeed were influential at high values. Examination of the polynomial curves for relative humidity revealed a tendency towards increasing sensitivity to relative humidity with increases in relative humidity. A similar convergence of data points on the polynomial curve at high windspeeds suggested that the relative importance of windspeed increases with the windspeed itself.

It was further hypothesised that all households follow a similar curve of window opening against increases in temperature, but that the threshold temperature marking the foot of the curve varies from one household to another.

Preliminary analysis showed that the frequency distribution of the average percentage of open window observations in each household (N = 113) was skewed to the right, indicating that whilst a small number of householders regularly open a large proportion of windows, many householders only open a very small proportion of windows. Thus, in order to test the proposed model, householders were divided into three groups (high, medium and low) on the basis of their window opening.

The relationship between temperature and the three groups was as predicted - the curves for the low group had the smallest of gradients, those for the medium group had small positive gradients, whilst those for the high group had larger positive gradients. Within the limitations imposed by the restricted range of temperatures experienced during the survey season, these gradients are consistent with the proposed model.

Principal findings of the reported data

The reported data were analysed in terms of three main divisions, namely the demographic characteristics of the questionnaire population, the motivations for the opening and closing of windows and the three parameters (likelihood, amount and duration) which define window opening.

Preliminary analysis of selected demographic variables showed that both the number of household occupants and the household's stage in the lifecycle were significantly related to the proportion of open window observations. Further analysis indicated that within the three lifecycle groups there may have been distinct behavioural or attitudinal differences which influenced their window opening propensities. This hypothesis received support from the finding that two variables (the number of openable windows and the number of occupants) accounted for very different amounts of variance in each of the three lifecycle groups.

Analysis of the questionnaire data showed that of all the window opening motivations in both winter and summer, fresh air received the highest percentage of endorsements in the 'very often the reason' response category. The second highest percentage of 'very often' responses was found for condensation in winter and cooling in summer. Examination of content analyses pertaining to condensation indicated that many householders did not fully understand the causes of condensation. Finally, most other window opening motivations showed little seasonal change in their rank position. Some tentative explanations for this have been proposed.

Inspection of tables for window closing motivations showed that the strength of particular motivations differed according to season. Security and the need to keep rain out were high priorities in both winter and summer. However, most other motivations were less important in summer than in winter. Finally, although group type (high, medium and low groups) was not associated with varying window opening or closing motivational structures, it was postively associated with varying strengths of motives.

Analysis of responses to likelihood, amount and duration questions showed a dominant (from highest to lowest rank) kitchen - main bedroom - sittingroom rank order for the three parameters in all weather conditions in both winter and summer. There were very few exceptions to this order - the two main ones being seen in the data for the reported amount of summer window opening in favourable weather conditions and for the reported duration of summer window opening.

Similarly, a dominant rank order was observed among the seven specified weather conditions. Sunny days almost always received the highest percentage of extreme positive endorsements for each of the three parameters, in all room types in both winter and summer. Mild or humid days were generally ranked second or third depending upon room type, season and window opening parameter. Windy days when the wind is blowing into the house always received the lowest percentage of extreme positive endorsements for each of the three parameters in all room types in both winter and summer.

For all three window opening parameters, higher percentages of householders endorsed the extreme positive response categories in summer than in winter. The largest winter-summer difference was always seen for the sittingroom.

Further analysis revealed a strong relationship between observed and reported data. Large numbers of significant correlations were obtained between group type (high, medium and low; coded 3, 2 and 1) and a measure reflecting a combination of reported likelihood, amount and duration scores for each household in winter and in summer. Similarly, high correlations were found between the three factors, likelihood, amount and duration.

Results of regression analyses

Two types of regression analyses were made - the aim of the first type was to predict estate-wide window opening, the aim of the second, to predict individual householder's window opening.

Analysis revealed that four physical parameters (temperature, relative humidity, windspeed and hour of observation) accounted for 74% and 69% of the variance in estate-wide window opening at Cowley and Mezen respectively. Different regression coefficients were observed for the two estates. Additionally, there was a greater variance in window opening at Cowley than at Mezen. It was suggested that both of these findings reflected differences in window arrangements (in terms of the size, shape and distribution of windows among room types) on the two estates.

Prediction of individual householder's window opening were made from three separate sets of variables. In each case the dependent variable was the total number of open window observations, whilst one of the independent variables was the number of openable windows. In the first analysis the second independent variable was the householder's response to the question "How often is fresh air the reason why you open your windows?" In the second analysis the additional independent variable was the householder's mean response to questions concerning the likelihood of winter window opening. The third regression analysis included as further independent variables: the total number of baths per week and the method of cooking (by gas or electricity). The proportion of variance explained in each of these analyses varied between 31% and 37%. In all three analyses it was found that beyond the first additional variable other variables accounted for only a small proportion of the variance due to correlations between these additional variables. In conclusion, it is suggested that the three regression analyses represent alternative ways of predicting individual householder's window opening levels.

Window opening at weekends and at Christmas

With one exception there were no significant differences between correlation coefficients obtained between weather parameters and window opening on weekdays, and at Christmas and weekends. Highly significant correlations were found between the mean number of total open window observations in each of the three periods. This suggests that the householders adopt characteristic window opening patterns and levels which are consistent even across holiday periods.

Finally, the percentage of householders reporting that they leave windows open longer at weekends than during the week, is larger in summer than in winter. Results show that in both winter and summer, there are more householders who report that the kitchen window is open longer at weekends, than there are householders who report that they leave the sittingroom or main bedroom windows open longer at weekends. This appears to be due to increased amounts of cooking over the weekend period.

6.2. Conclusion

In conclusion, it is suggested that the study successfully identified the motivations underlying a large number of household behaviour patterns. The regression analyses suggest that consumption cannot be determined by a few variables of major significance, but rather that a large number of inter-related variables each exert a small influence on consumption. The detailed analysis of window opening made in Chapter 5 revealed the complexity of structure inherent in any one behaviour pattern.

BIBLIOGRAPHY

Adrian, E.D., The Basis of Sensation, Christophers, London, 1928.

Allen, P., 'Changing patterns of living in homes', in Condensation in Buildings, D. Croome and A.F.C. Sherrat (eds), Applied Science, 1972.

Andersen, I., et al., 'Human response to 78 hour exposure to dry air', Arch. Environ. Health, 29, 1974, pp. 319-324.

Andersen, I., et al., 'Indoor air pollution due to chipboard used as construction material', Atmospheric Environment, 9, 1975, pp. 1121-1127.

Anderson, R.W. and Lipsey, M.W., 'Energy conservation and attitudes towards technology', Public Opinion Quarterly, 41, 1978.

Andersson, L.O., et al., Human Response to Dry, Humidified and Intermittently Humidified Air, Swedish Building Research Department, D11, 1975.

Austwick, P.K.C., The Role of Spores in the Allergies and Mycoses of Man and Animals, Proc. 18th Symposium Colston Research Soc., Butterworths Scientific Publications, London, 1966.

Banham, H., Architecture of the Well Tempered Environment, Architectural Press, 1969.

Baxter, A.J., 'Windows and energy', in Building Energy Management, Pergamon Press, 1981.

Becker, L.J., et al., Relationship Between Attitudes and Residential Energy Use., Dept., of Psych., Princeton University, N.J. 08544.

Bedford, T.,'Warmth and comfort', JIHVE, 37. (4), 1936, pp. 383-402.

Berg-Munch, B., 'The influence of ventilation, humidification and temperature on the sensation of freshness and dryness of air', in Building Energy Management, Pergamon Press, 1981.

Bitter, C. and van Ierland, J.F.A.A., Appreciation of Sunlight in the Home, Proc. of the C.I.E., (Bouwcentrum International, Rotterdam, 1967), pp. 27-37.

Blumstein, C., et al., 'Overcoming social and institutional barriers to energy conservation, Energy, 5, 1980, pp. 355-371.

Bravery, A.F., Origin and Nature of Mould Fungi in Buildings, Proc. of a joint BRE/Paint Research Assoc. Seminar, BRE, 1980.

Brundrett, G.W., Ventilation Requirements in Rooms Occupied by Smokers; A Review, ECRC/M870, 1975.

Brundrett, G.W., Window Opening in Houses: an Estimate of the Reasons and Magnitude of the Energy Wasted, ECRC/M801, 1975.

Brundrett, G.W., Moisture control in buildings: Opportunities for heat pump dehumidifier, International Seminar on 'Heat Transfer in Buildings', 1977.

Brundrett, G.W., Space Heating Consumption Patterns in the Home, CIB 517, Meeting at Holzkirchen, Munich, 28-30 September, 1977.

Brundrett, G.W., 'Ventilation: a behavioural approach', Energy Research, 1, 1977, pp. 289-298.

Brundrett, G.W., Window Ventilation and Human Behaviour, Paper for the International Indoor Climate Symposium in Copenhagen, 1978.

Brundrett, G.W., and Barker, R., Opportunities for Energy Conservation by Heat Pump Dehumidifier and Odour Treatment, ECRC.

Buttena, G., Public Response to the Energy Crisis, A Study of Citizens' Attitudes and Adoptive Behaviors, Scociology Report 130, Ames, Iowa, Iowa State University, 1976.

B.R.E. Working Party Report, Energy Conservation, A Study of Energy Consumption in Buildings and Possible Means of Saving Energy in Housing, CP 56/75.

Brechner, K.C., 'An experimental analysis of social traps', J. of Expt. Psych., 13, 1977, pp. 552-564.

Burton, D.R., Robeson, K.A. and Nevins, R.C., 'The effect of temperature on preferred air velocity for sedentary subjects dressed in shorts', ASHRAE Trans., 81 (2). 1975, pp. 157-168.

Cain, W.S., Odours and Ventilation Requirements, presented at Engineering Foundation Conf.: Ventilation vs Energy Conservation in Buildings, Henniker, NH, 1977.

Carleton, W.M. and Welch, B.E., Fluid Balance in Artificial Environments, USAF School of Aerospace Medicine, NASA report CR-114977, 1971.

Carlyle, J.J. and Gells, S., Behavioral Approaches to Reducing Residential Energy Consumption, Dept. of Psychol., Virginia Poly. Inst. and State University, Blacksburg, VA 24061.

Central Statistical Office, Annual Abstract of Statistics 1981, HMSO, London, 1981.

Chatterjee, S. and Price, B., Regression Aanlysis by Example, John Wiley and Sons, N.Y., 1977.

Cliff, K.D., 'Population exposure to the short lived daughers of radon 222 in Great Britain', Radiological Protection Bulletin No. 22, HMSO, London, 1978, pp. 18-23.

Collingro, C. and Roessler, G., Influence of Window Width on the Communication with the external Environment in a Room with PSALI, Proceedings of C.I.E. Study Group A Symposium, Varna/Bulgaria, 1 and 2, 1972.

Collins, B.L., Windows and People: a Literature Survey, U.S. Nat. Bureau of Standards, 1975.

Condie, S.W., et al., 'Getting blood from collective turnips: volunteer donation in mass blood drives', J. of Appl. Psych., 61, 1976, pp. 290-294.

Conklin, G., The Weather Conditioned House, Reinhold, N.Y., 1958.

Cooper, J.R., et al., Attitudes Towards the Use of Heat Rejecting/Low Light Transmission Glasses in Office Buildings, Proc. of C.I.E. Conf., 'Windows and their function in architectural design', Istanbul, 1973.

Courtney, R.G. and Jackman, P.J., 'A study of three district heating schemes', Heat. and Vent. Engr., 6-14, March 1976.

Croome-Gale, D.J., Air Conditioning and Ventilation of Buildings, Pergamon Press, Oxford, 1975.

Crossley, D.J., Social Factors Affecting Energy Use and Conservation in the Home, School of Australian Environmental Studies, Griffith University, Working Paper, 1980.

Crossley, D.J., 'The role of popularization campaigns in energy conservation', Energy Policy, March 1979.

Curtin, R.T., 'Consumer adaptation to energy shortages', J. of Energy and Development, 2, (1), 1976, pp. 38-59.

DeFronzo, J. and Warkov, S., 'Are female headed households energy efficient: a test of Klausner's hypothesis among Anglo, Spanish speaking and Black Texan households', Human Ecology, 7, (2), 1979.

De Grids, W.F., et al., 'Wind tunnel and on-site pressure distribution measurements on a house and its effects on infiltration, ASHRAE, 85, (2), 1979, pp. 411-427.

Desson, R.A., Energy Conservation: the Intermittent Occupation of Dwellings and Domestic Energy Consumption, BRE Paper CP37/76, 1976.

Dick, J.B. and Thomas, D.A., 'Ventilation research in occupied houses', J.I.H.V.E., 19, 1951, pp. 306-326.

Dickson, D.J., Ventilation with Open Windows, ECRE/M1329, 1980.

Donovan, J.J. and Fischer, W.D., Factors Affecting Residential Heating Energy Consumption, Sloan School Centre for Information Systems, Research Working Paper No. MIT-EL-76-004WP, 1976.

Dunne, M., Thermal Improvements in Old Peoples' Dwellings, Research Inst. for Consumer Affairs (9836), 1977.

Ellis, P. and Gaskell, G., A Review of Social Research on the Individual Energy Consumer, Dept. of Soc. Psych., London School of Ecnomics and Political Science, 1978.

Eichenberger, M.A., 'A comparison of ownership of selected household appliances and residential energy use by employed and non-employed homemakers in the Lansing, Michigan area', in Energy Use and Conservation Incentives, Praeger Special S :dies, 1977.

Enderby, R., 'Practical and economic aspects of mould growth in buildings', in Proceedings of a Joint RE/Paint Research Association Seminar, B.R.E., 1980.

Erikson, B.E., et al., 'Subjektivt bedömd luftkvalitet vid olika uteluftsventilation', VVS, Stockholm, 4, 1978, pp. 53.60. In 'The influence of ventilation, humidification and temperature on the sensation of freshness and dryness of air', B. Berg-Munch, Building Energy Management, Pergamon Press, 1981.

Etheridge, D.W. and Phillips, P., 'The prediction of ventilation rates in houses and the implications for energy conservation', Proceedings of CIB 517 Meeting, Holzkirchen, 1977.

Etheridge, D.W., 'Airflow around buildings', Watson Ho. Bulletin, Jan/Feb. 1979.

Ewert, G., "Mucus flow rate and relative humidity', Int. Rhinology, 4, (25), 1966, pp. 25-32.

Fanger, P.O., Thermal Comfort, McGraw-Hill, NY, 1973.

Field, A.A., 'Review of heating systems', in Condensation in Buildings, D. Croome and A.F.C. Sherrat (eds),Applied Science, 1972.

Field, J. and Hedges, B., National Fuel and Heating Survey. Social and Community Planning Research, National Consumer Council, London, 1977.

Fishman, D.S., 'Subjective effects of air movement around the feet', Proceedings CIBS symposium Man, Environment and Buildings, Loughborough University, 1978.

Fisk, D.J., Domestic Heating Patterns and the 'Comfort-Cost Equation', BRE, 1978.

Fournol, A., 'Ventilation et condensations', CSTB Report 28, 1957, in Window Opening in Houses: an Estimate of the Reasons and Magnitude of the Energy Wasted, G. Brundrett, ECRC/ M801, 1975.

Foxx, R.M. and Hake, D.F., 'Gasoline conservation: a procedure for measuring and reducing the driving of college students', J. of Appl. Behav. Anal., 10, 1977, pp. 61-74.

Gagge, A.P., et al., 'An effective temperature scale based on a sample model of human physiological regulatory response', ASHRAE Trans., 77, 1971, pp. 247-262.

Geller, E.S., et al., Attempts to Promote Residential Energy Conservation: Attitudinal versus Behavioral Outcomes, Dept. of Psych., VPI & SU, Blacksburg, Virginia, 1978.

Gladhart, P.M., 'Energy conservation and lifestyles: an integrative approach to decision making', J. of Consumer Studies and Home Economics, 1, 1977, pp. 265-277.

Gordon, S. (ed), Social Science Energy Review, Inst. of Soc. and Policy Studies, Yale University, 1980.

Goromosov, S.M., in The Physiological Basis of Health Standards for Dwellings, W.H.O., 1968.

Gottlieb, D. and Matre, M., Sociological Dimensions of the Energy Crisis: a Follow-up Study, The Energy Inst., Houston, Texac, 1976.

Grandjean, E., et al., 'Etude sur l'ensoillement d'habitations, EH 53', Proceedings of Int. Conf. on The Sun in the Service of Mankind, Paris, July 1973.

Green, G.H., 'The effect of indoor relative humidity on absenteeism and colds in schools', ASHRAE Trans., 80 (11), 1974.

Gross, G.E., et al.,'Energy Conservation Implications of Master-metering', Kansas City, Mo: Midwest Res. Inst., 1, 1975.

Hamilton, A. and Hardy, H.L., Industrial Toxicology, Publishing Group, Acton, 1974.

Hardin, G., 'The tragedy of the Commons', Science, 162, 1968, pp. 1243-1248.

Harper, C.S., 'The effects of competition, co-operation and communication on management of a group resource', in Social Science Energy Review, S. Gord, 1980.

Hartman, P., Air Change Measurements in Non-air Conditioned Spaces as Affected by Parameters of Design, Climate and Users, EMPA report no. 36630.

Hayes, S.C. and Cone, J.D., 'Reducing residential electricity energy use: payments, information and feedback', J. of Appl. Behav. Anal., 10, 1977, pp. 425-435.

Heap, R.D., 'Heat requirements and energy use in British houses', Energy and Buildings, 1, 1977, pp. 347-366.

Heap, R.D., 'Heating, cooling and weather in Britain', Energy Research, 2, 1978, pp. 47-71.

Hew, The Health Consequences of Smoking, U.S. Dept. Health Education and Welfare, CDC 768704.

H.M.S.O., General Household Survey 1978, HMSO, London, 1980.

Hogan, M.J., Energy Conservation: Family Values, Household Practices and Contextual Variables, Ph.D. diss., Michigan State University, 1976.

Hollowell, C.D., et al., 'Indoor air quality in residential buildings', in Building Energy Management, Pergamon Press, 1981.

Hopkinson, R.G., 'Daylight as a cause of glare', Light and Lighting, 54, 1961, pp. 296-299.

Houghten, F.C., et al., 'Draught temperature and velocities in relation to skin temperature and feeling of warmth', ASHVE Trans., 44, 1938, pp. 289-308.

Huber, G. and Wanner, H.U., Indoor Air Quality as a Criterion for Minimum Ventilation Rate.

Hungerford, N., Relationship of Husband/Wife Ecoconsciousness Value to Direct Household Energy Consumption, Ph.D. Diss., Dept. of Family Ecology, Michigan State University, 1978.

Hunt, D.R.G. and Gidman, M.I., Thermal Comfort in Dwellings: a Report of a 45 Home Pilot Survey, January 1978, BRE, 1979.

Hunt, D.R.G. and Gidman, M.I., Temperatures and Thermal Comfort at Home - Result of a National Field Study, Part I: Temperatures, BRE, 1980.

Imamoglu, V. and Markus, T.A., 'The effect of window size, room proportion and window position on spaciousness evaluation of rooms', Proc. of CIE Conf. on Windows and their Function in Architectural Design, 1973.

Inouye, T., et al., Effect of Relative Humidity on Heat Loss of Men Exposed to Environments of 80, 76, and 72°F, Paper 1480, ASHVE, 1953.

Inui, M. and Miyata, T., 'Spaciousness in interiors', Lighting Research and Technology, 5, 1973, pp. 103-111.

Kaplan, S. and Wendt, J.S., 'Preference and the visual environment; complexity and some alternatives', Proc. of the EDRA 3/ar 8 Conf., University of California at Los Angeles, 1, 1972, pp. 5.8.1-6.8.5.

Keighley, E.C., 'Visual requirements and reduced fenestration in office buildings - a study of window shape', J. of Bldg. Sci., 8, 1973, pp. 321-331.

Kerka, W.F. and Humphreys, C.M., 'Temperature and humidity effect on odour perception', Am. Soc. of Heating Refrigerating and Air Conditioning Engineers Trans., 72, (1), 1956, pp. 531-552.

Kilkeary, R., The Energy Crisis and Decision Making, National Technical Information Service, Washington, D.C., PB-238782, 1975.

Klausner, S., 'Social order and energy consumption in matrifocal households', Human Ecology, 7, (1), 1979, pp. 21-39..

Koch, W., Jennings, B.H. and Humphreys, C.M., 'Sensation responses to temperature and humidity under still air conditions in the comfort range', ASHRAE Trans., 66, 1960, pp. 264-287.

Koch, W., 'Humidity sensations in the thermal comfort range', Archit. Sci. Review, March 1963, pp. 33-34.

Kuehner, R.L., 'Humidity effects on the odour problem', ASHRAE Trans., 62, 1956, pp. 24-256.

Kohlenberg, R., et al., 'A behavioral analysis of peaking in residential electrical energy consumers', J. of Appl. Behav. Anal., 9, Spring 1976, pp. 13-18.

Lacey, J., et al., 'Actinomycete and fungus spores in air as respiratory allergens, in Safety in Microbiology, Shapton, D.A. and Board, R.G. (eds),.Academic Press, London, 1972.

Langkilde, G., et al., 'Mental performance during slight cool or warm discomfort', Archit. Sci. Physiol., 27, (4), 1973.

Langkilde, G., 'The influence of the thermal environment on office work', in Indoor Climate, P.O. Fanger, and O. Valbjøen, Danish Building Research Inst., Copenhagen, 1979.

Leach, G. and Romig, F., Energy for the Built Environment, Paper to the Social Science Research Council Seminar on Energy Utilization Studies, 26th April 1978.

Lipsey, M.W.,'The personal antecedents and consequences of ecologically responsible behavior: a review', in A Review of Social Research on the Individual Energy Consumer, P. Ellis and G. Gaskell, 1978.

Longmore, J. and Neeman, E., 'The availability of sunshine and human requirements for sunlight in building', presented at Conf. on Environmental Research in Real Buildings, NIC Committee TC 3.3, Cardiff, 1973.

Lopreato, S.C. and Meriwether, M.W., 'Energy attitudinal surveys: summary, annotations research recommendations', Final Report, in A Review of Social Research on the Individual Energy Consumer, P. Ellis and G. Gaskell, 1978.

Loudon, A.G., The Effects of Ventilation and Building Design Factors on the Risk of Condensation and Mould Growth in Dwellings, BRS CP 31/71, 1971.

Ludlow, A.M., 'The broad classification of the visual scene: A preliminary study', Vision and Lighting, Report No. 3, (GIB), 1972.

Ludlow, A.M. 'The functions of windows in buildings', Lighting Research and Technology, 1976.

Madsen, Th Lund, Limits for Draught and Asymmetric Radiation in Relation to Human Thermal Well-being, Institut International du Froid, Commissions B1, B2, E1, Belgrade, 1977.

Manning, P., Office Design: A Study of Environment, Liverpool, Pilkington Research Unit, Dept. of Bldg. Sci., Liverpool University, 1965.

Manning, P., 'Windows, environment and people', Interbuild/Arena, 20-25, 1967.

Markus, T.A., 'The function of windows: A reappraisal', Bldg. Sci., 2, 1967, pp. 97-121.

Markus, T.A. and Gray, A., 'Windows in low rise, high density housing - the psychological significance of sunshine, daylight, view and visual privacy', Proc. of C.I.E. Conf. on Windows and their Function in Architectural Design, Instanbul, 1973.

Mathews, W., 'The practical use of energy in the home'. British Gas Communication 1073, presented at 44th Autumn Meeting of Inst. of Gas Engineers, November 1978.

Mazur, A. and Rosa, E.,'Energy and lifestyle', Science, 186, 15th November 1974, pp. 607-610.

McClelland, L.& Cook, S., 'Promoting energy conservation through financial incentives', J. of Soc. Psych., 1978.

McClelland, L., et al., Evaluating Employer Programs Encouraging Use of Alternate Transportation Modes: 2 Studies, Inst. of Behav. Sci., University of Colorado, October 1978.

McClelland, L. and Belsten, L., 'Promoting energy conservation in university dormitories by physical, policy and resident behavior changes', J. of Environ. System, 9, (1), 1979.

McClelland, L. and Cook, S.W., Policy Implications of a Successful Energy Conservation Program in University Buildings and Dormitories, Inst. of Behav. Sci., University of Colorado, March 1979.

McClelland, L. and Carter, R.J., 'Psychological research on energy conservation: context, approaches methods', in Energy Conservation: Psychological Perspectives, Vol. 3, A. Baum and E. Singer (eds), in Press.

McClintock, C.G., 'The conservation of domestic water', Dept. of Psychol., University of California, in A Review of Social Research on the Individual Energy Consumer, P. Ellis and G. Gaskell, 1978.

GcGeevor, P., The Understanding and Use of Controls: A Review, Welsh School of Archit., May 1981.

McIntyre, D.A. and Griffiths, I.D., 'Subjective response to atmospheric humidity', Environ. Res., 5, (1), 1975, pp. 66-75.

McIntyre, D.A., 'Response to atmospheric humidity at comfortable air temperatures: a comparison of 3 experiments', Ann. Occup. Hygiene, 21, 1978, pp. 177-190.

McIntyre, D.A., 'An investigation into the effect of low air speed movement over the body', ECRC/M1262, 1979.

McIntyre, D.A., 'Indoor climate', Appl. Sci., 1980.

McNair, H.P., A Preliminary Study of the Subjective Effects of Vertical Air Temperature Gradients, British Gas Corp., Report No. WH/T/R&D/73/94, London, 1973.

McNair, H.P., Field Studies on Energy Conservation - an Interim Report, British Gas, July/August 1977, Bulletin.

McNair, H.P. and White, M., 'Energy Usages in Dwellings, paper presented to CIBS17 meeting Heating and Climatisation, Holzkirchen, W. Germany, 28-30 September 1977.

McNair, H.P. and Mineur, J.M., 'When not to insulate dwellings', Inst. of Energy Journal, March 1980.

Mercer, J.C., 'On measuring the effect of a window', Archit. Res. and Teaching, 2, 1971, pp. 53-55.

Miller, A.A. and Parry, M., Everyday Meteorology, 2nd edn., Anchor Press Ltd., GB., 1975.

Milstein, J.S., Attitudes, Knowledge and Behavior of American Consumers Regarding Energy Conservation with some Implications for Governmental Action, Federal Energy Administraiton, Washington, D.C., PEA/D-76/466, 1976.

Milstein, J.S. 'How consumers feel about energy: attitudes and behavior during the winter and spring 1976-1977, in Energy Policy in the United States: Social and Behavioral Dimensions, S. Warkov (ed), Praeger, N.Y., pp. 79-90.

Minague, P.J., Occupancy Patterns and Energy Use in Housing, National Inst. for Physical Planning and Construction Research, Dublin 4, 1977.

Minogue, P.J., 'Condensation risk and improved thermal performance of housing', in Building Energy Management, Pergamon Press, N.Y., 1980.

Moncrieff, R.W., The Chemical Senses, International Textbook Co., London (2nd ed), 1967.

Morgan, C.H., 'Sunlight and its effect on human behavior and performance', Proc. of CIE Bouwcentrum, Rotterdam, 1967, pp. 21-26.

Morrison, Bonnie Maas, Socio-physical Factors Affecting Energy Consumption in Single Family Dwellings: an Empirical Test of a Human Ecosystems Model, Ph.D. Diss., Michigan State University, 1975.

Morrison, Bonnie Mass and Gladhart, P.M., 'Energy and families: the crisis and the response', J. of Home Econ., January 1976.

Moser, C.A. and Kalton, G., Survey Methods in Social Investigation, 2nd edn., Heinemann Educational Books Ltd., London, 1971.

Murray, J.R., et al., 'Evaluation of public response to the energy crisis', Science, 184, (4134), 19 April 1974, pp. 257-263.

Ne'eman, E. and Hopkinson, R.G., 'Critical minimum acceptable window size: a study of window design and provision of a view', Lighting Research and Technology, 2, 1970, pp. 17-27.

Nevins, R.G., al., 'A temperature-humidity chart for thermal comfort of seated person', ASHRAE J., April 1966, pp. 55-61.

Nevrala, D.J., 'Effect of insulation, mode of operation and air leakage on the energy demand of dwellings in the U.K.', paper given at 2nd CIBS Conf. on Energy Conservation and the Built Environment, Copenhagen, May/June 1979.

Newman, D.K. and Day, D., The American Energy Consumer, A Report to the Energy Policy Project of the Ford Foundation, Cambridge, Mass., Ballinger, 1975.

Olsen, M.E. and Goodnight, J.A., Social Aspects of Energy Conservation, Northwest Energy Policy Project, Study Module 18, Final Report, 1977.

Ostergaard, J., et al., 'The effect on man's comfort of a uniform air flow from different directions', ASHRAE Trans., 80, (2), 1974, pp. 142-157.

Pallak, M.S. and Cummings, W., 'Commitment and voluntary energy conservation, paper presented at the 83rd Annual Convention of the Am. Psych. Assoc., Chicago, 1975.

Pallak, M.S. and Cummings, W., 'Commitment and voluntary energy conservation', Pers. and Soc. Psych. Bulletin, 2, 1976, pp. 27-30.

Phillips, N. and Nelson, E., 'Energy saving in private households - an integrated research programme, J. of Mkt. Res. Soc., 18, (4), 1976, pp. 180-200.

Raethlisberger, F.J. and Dickson, W.J., Management and the Worker: an Account of a Research Program Conducted by the Western Electric Co., Hawthorne Works, Chicago, Harvard University Press, Cambridge, Mass., 1939.

Ramussen, O.B., 'Man's subjective perception of air humidity', Proc. 5th Int. Congress for Heating, Ventilating and Air Conditioning, Copenhagen, 1, 1971, pp. 79-86.

Richards, S.J., 'Sunlight and buildings', South African Arch. Record, 52, (12), 1967.

Rohles, F.H. and Nevins, R.G., 'The nature of thermal comfort for sedentary man', ASHRAE Trans., 77, (1), 1971, pp. 239-246.

Saeltzer, A., Acoustics and Ventilation, Van Nostrand, N.Y., 1972.

Sansam, R.V., Energy Use in Buildings and Design Requirements, Ph.D. Diss., School of Science and Society, University of Bradford, 1980.

Schipper, L. and Ketoff, A., 'International residential energy use data: analysis of historical and present day structure and dynamics', in Building Energy Management, Pergamon Press, 1981.

Schmeltz, I., et al., 'The influence of tobacco smoke on indoor atmospheres', Preventative Medicine, 4, 1975, pp. 66-82.

Schulte, J.H., 'Sealed environments in relation to health and disease', Archit. Environ. Health, 8, 1964, pp. 438-452.

Seaver, W.B. and Patterson, A.H., 'Decreasing fuel oil consumption through feedback and social commendation', J. of Appl. Behav. Anal., 9, 1976, pp. 147-152.

Seligman, C., et al., 'Behavioral approaches to residential energy conservation', in Saving Energy in the House: Princeton's Experiments at Twin Rivers, R.H. Socolow (ed), Ballinger, Cambridge, Mass., 1978.

Seligman, C., et al., 'Predicting summer energy consumption from homeowners' attitudes', J. of Appl. Soc. Psych., 9, 1979, pp. 170-190.

Siegal, S., Non-parametric Statistics for the Behavioral Sciences, McGraw-Hill, Int. Students edn., Tokyo, 1956.

Siviour, J.B., The Efficiency of Houses in the Use of Solar Energy for Space Heating, ECRC, 1976.

Slavin, R.E. and Wodaeski, J.S., Using Group Contingencies to Reduce Natural Gas Consumption in Master-metered Apartments, John Hopkins University, Baltimore, 1977.

Smith, J.M., et al., 'Research in home humidity control', Project DGR8C Research Series, 106, Purdue University, 1947, in Window Opening in Houses: an Estimate of the Reasons and Magnitude of the Energy Wasted, G. Brundrett, ECRC/ M801, 1975.

Socolow, R.H., 'The coming age of conservation', Annual Review of Energy, 2, 1977, pp. 239-289.

Sonderegger, R.C., 'Movers and stayers: the resident's contribution to variation across houses in energy consumption for space heating, in Saving Energy in the Home: Princeton's Experiments at Twin Rivers, R.H. Socolow (ed), Ballinger, Cambridge, Mass. 1978.

Steinhausler, F., 'Long term measurements of 222Rn, 220Rn, 214Pb and 212Pb concentrations in the air of private and public buildings and their dependence on meteorological parameters', Health Physics, 29, 1975, pp. 705-713.

Stern, P.C., 'Effects of incentives and education on resource conservation decisions in a simulated commons dilemma', J. of Pers. and Soc. Psychol., 34, 1976.

Stern, P.C. and Kirkpatrick, E.M., Energy Behav. Environ, 19, 1977, pp. 10-15.

Stewart, R.D., 'The effects of low concentrations of carbon monoxide in man', Scand. J. of. Respiratory Disease, Supp. No. 91, 1974, pp. 56-62.

Taniguchi, H., Radon 222 and its Daughters in Building at Uranium City, Saskatchewan, Radon Workshop, Energy Research and Development Administration, N.Y., 1977.

Thompson, P.T. and MacTavish, Energy Problems, Public Beliefs, Attitudes and Behaviors, Urban and Environmental Studies Inst., Grand Valley State College, Allendale, Michigan, 1976.

Traynor, G.W., et al., 'Indoor air quality gas stove emissions', submitted to Atmospheric Environment, 1980.

Tredgold, T., The Principles of Warming and Ventilation - Public Buildings, Taylor, London, 1936.

von Pettenkofer in Ventilation - Report of the N.Y. State Commission on Ventilation, Dutton & Co., N.Y., 1923.

Wanner, H.U., 'Comfort and air quality in air conditioned rooms', CIB Commission W 45 - Symposium: Thermal Comfort and Moderate Heat Stress, Building Res. Stn., London, 1972.

Warren, D.I., Individual and Community Effects on Response to the Energy Crisis of Winter 1974: an Analysis of Survey Findings from Eight Detroit Area Communities, Inst. of Labor and Industrial Relations, University of Michigan, 1974..

Warren, D.I. and Clifford, D.I., Local Neighbourhood Social Structure and Response to the Energy Crisis of 1973-74, Inst. of Labor and Industrial Relations, University of Michigan, 1975.

Warren, P.R., 'Natural infiltration routes and their magnitudes in houses - preliminary studies of domestic ventilation', Proc. of Conf. on Controlled Ventilation, Aston University, 1975.

Warren, P.R., 'Pilot study of window opening in office buildings', paper for Research Colloquium Natural Ventilation and Infiltration, BRE, 1980.

Wells, B.W.P., 'Subjective responses to the lighting installation in a modern office building and their design implications', Bldg. Sci., 1, 1965, pp. 57-68.

Weston, J.C., 'Heating research in occupied houses', J. of Inst. Heat and Vent. Engrs., May 1951.

W.H.O.,'Epidemiology and statitistical information on accidental gas poisoning', W.H.O. Chronicle, 16, 1962, pp. 55-58.

Wicker, A.W., 'Attitudes vs Actions: the relationship of verbal and overt behavioral responses to attitude objects', J. of. Marketing, 41, (1), 1977, pp. 24-31.

Winett, R.A. and Nietzel, M.T., 'Behavioral Ecology: contingency management of consumer energy use', Am. J. of Community Pysch., 3, 1975, pp. 123-133.

Winett, R.A., 'Small scale field studies: a microeconomic approach to energy conservation, in Battalio, R.C. and Kagel, J.H., Methods in Experimental Economics, Southern Economic Assoc., 1976.

Winett, R.A., 'Prompting turning out lights in unoccupied rooms', J. Environmental System, 1, 1977, pp. 237-241.

Winett, R.A., et al., 'Effects of monetary rebates, feedback, and information on residential electricity conservation', J. of Appl. Psych., 63, 1978, pp. 73-80.

Winett, R.C., et al., 'Psychological framework for energy conservation in buildings: strategies, outcomes, directions, Energy and Buildings, 1979.

Winett, R.A., et al., 'The effects of self-monitoring and feeback on residential electricity consumption, J. of Appl. Behav. Anal., in press.

Wyon, D.P., et al., 'The mental performance of subjects clothed for comfort at two different air temperatures', Ergonomics, 18, (4), 1975, pp. 359-374.

Zuiches, J.J., Acceptability of Energy Policies to Mid-Michigan Families, Michigan State University, Agricultural Experiment Station, Research Report No. 298.

APPENDIX

LIST OF FIGURES

LIST OF TABLES

FIGURE A1. Interview Questionnaire for Pilot Study at Charnwood

Central Heating Survey

Patterns of Use and Occupants' Attitudes

March 79

House No. ____________ date: ______

time: ______

The House: ____________________

1. (a) end of terrace ______

centre of terrace ______

(b) front door faces:

S	SE
SW	E
W	NE

2. Classification of household

Person	Sex		Age					Occupation	Hours normally in house	Leisure activities	Does he smoke
	M	F	0-4	5-15	16-25	26-55	56+				
1											
2											
3											
4											
5											
6											

3. What type of heating did you have in your previous house?

(i) C.H. ____

(ii) Night storage ____

(iii) Electric underfloor ____

(iv) Warm air ____

(v) Individual space heaters ____

- if yes (a) electric ____

(b) gas fires ____

(c) solid fuel ____

(d) parafin ____

(e) calor gas ____

(f) other (specify) ____

4. What changes have you made to this house since you moved in?

None ____

(i) Structural? Yes ____ No ____

- if yes, elaborate ____

(ii) Decorative? Yes ____ No ____

- if yes, elaborate ____

Did you concentrate on the house as a whole ____ or on particular rooms? ____ Why? ____

(iii) to the heating arrangements? Yes ____ No ____

- if yes, elaborate ____

5. Do you have any pets?

dogs yes ______ no ______

cats yes ______ no ______

mice yes ______ no ______

birds yes ______ no ______

What, if any, special arrangements do you make for them?

____

6. Do you have any of the following appliances?

(i) Washing machine yes ____ no ____

- if yes, is it twin tub yes ____ no ____

hot fill yes ____ no ____

(ii) Dish washer yes ____ no ____

(iii) electric kettle yes ____ no ____

(iv) Fridge yes ____ no ____

(v) Freezer yes ____ no ____

(vi) Colour TV yes ____ no ____

(vii) Extractor fan yes ____ no ____

(viii) Cooker hood yes ____ no ____

(ix) Shower yes ____ no ____

(x) Electric blanket yes ____ no ____

- if yes, how many ____________

7. I can see you have C.H., but do you have any additional appliances for heating?

A. (i) Gas room heaters yes ____ no ____

(ii) Parafin heaters yes ____ no ____

(iii) Electric fire yes ____ no ____

(iv) Calor gas yes ____ no ____

(v) Fan heaters yes ____ no ____

B. In which rooms do you use these appliances and how often?

Room	never	rarely	frequently	always	why
Sitting					
dining					
hall					
bathroom					
bedroom 1					
bedroom 2					
bedroom 3					
bedroom 4					
bathroom					

C. Do you turn the individual radiators on and off:

often ________ seldom ______ never ________

Why? ____

- if yes, how often in each of these rooms?

Room	never on	seldom on	generally on	always on
Sitting				
dining				
hall				
bathroom				
bedroom 1				
bedroom 2				
bedroom 3				
bedroom 4				

D. (i) How have you got your time clock set now? a.m. ____ p.m. ___

(ii) and at the weekends? a.m. ____ p.m. ___

(iii) Who sets it? ______________________

(iv) Who else knows how to set it? ______________

(v) Do you ever over-ride it? Yes ____ No ____

- if yes regularly ______

depending on weather ______

hardly ever ______

When has this been? when we get up ______

during the morning ______

at lunch time ______

afternoon ______

early evening ______

late evening ______

night ______

Why? ______

E. (i) What is the setting on your thermostat? ______

(ii) Measured temperature is ______

(iii) Who sets the thermostat? ______

(iv) Who else knows how to set it? ______

(v) Do you ever change it? Yes ____ No ______

How? ______

Has this been - regularly ______

depending on weather ______

hardly ever ______

When has this been - when we get up ______

during morning ______

lunch time ______

afternoon ______

each evening ______

late evening ______

night ______

Why? ______

F. Were you shown how to use the controls when you first moved into the house? Yes ____ No ______

- if yes, to your satisfaction? Yes _____ No ____

- if no, what did you find difficult? ____________________

G. In summer, how often do you have the radiators on?

	bathroom	sitting	dining	hall	bedroom	1	2	3	4
always									
usually but not always									
rarely									
never									

Why? ____

H. What do you think are the good points about your present heating arrangement? ____

____

I. What do you feel are the bad points? ____________________

____

J. What do you feel about the controls? ____________________

____

8. Do you have any condensation? Yes ____ No _____

sitting ________ bedroom 1 ________

dining ________ bedroom 2 ________

kitchen ________ bedroom 3 ________

bathroom ________ bedroom 4 ________

hall ________

What do you think is the cause? ______________________________

What do you do to help it? ______________________________

9. When you are in the house, where do you spend most of your time?

	Morning	Afternoon	Evening
Wife			
Husband			
Child 1			
Child 2			
Child 3			
Child 4			

10. The sittingroom - curtains

(i) Do you draw them? Yes _____ No _____

(ii) - if yes, before it's dark __________

when it is dark __________

on sunny winter days _______

(iii) What material are they made of? ______________________

(iv) Are they lined? Yes ____ No _______

(v) Do you change the furniture around? Yes _____ No _____

- if yes, why? ______________________________________

11

11. Windows -

Do you ever open windows? Yes _____ No _______

- if yes, why? ______________________________________

Room	never open	seldom often	always open	time
Sitting				
dining				
kitchen				
bathroom				
toilet				
bedroom 1				
bedroom 2				
bedroom 3				
bedroom 4				

12. Doors :

Are they ever left open? Yes ____ No ____

- if yes, why? ________________________________

Room	never open	seldom open	often open	always open
Sitting				
dining				
kitchen				
bathroom				
toilet				
bedroom 1				
bedroom 2				
bedroom 3				
bedroom 4				

13. (a) Thinking of your house in general, have there been times when yo you've felt a bit too cold? Yes ____ No ____

if, yes, why? ________________________________

(b) What do you do when you're too cold?

____

(c) Have there been times when you've been too hot?

____

(d) What have you done when you're too hot?

____

14. Insulation - Do you have any extra loft insulation ____

draught stripping on doors ____

draught stripping on windows ____

cylinder jacket ____

draught excluders ____

other (specify) ____

- if yes, what encouraged you to put it in? ____

____

When did you put it in? ______________________________

- if no, what has discouraged you from putting in some form of extra insulation? ______________________________

____

15. How many baths would you say, the family as a whole, have in an average? ______________________________

Is there any one in the family who tends to use more water than others? ______________________________

Why? ______________________________

16. Cooking

(a) Gas __________electric ______________

(b) How many meals do you cook on

(i) weekdays ______________ (ii) weekends ____________

(c) Where do you eat? kitchen _____dining ___ sitting______

(d) Do you all eat together as a family? Yes_____ No______

- if no, why not? ______________________________

(e) Baking/home cooking: do you do

a little but not much __________________

quite a bit __________________

a lot __________________

17. Dishwashing - do you wash the dishes - after each meal __________

as you use them __________

once a day __________

in sink ______________

in bowl ______________

under tap ______________

18. (a) Clothes washing - on average, how often do you use your washing machine:

every day ____________

every second day ____________

twice a week ____________

once a week ____________

less often ____________

(b) On average, how many loads do you do at a time?

One ______

Two ______

Three ______

Four ______

(c) Do you ever wash clothes by hand? Yes ______ No ______

- if yes, what proportion of total clothes washing do you do by hand? less than 1/4 ______ 1/4 ____ 1/2 ____ 3/4 ____

(d) In winter, where do you dry your clothes?

radiators ________ garden ________

clothes horse ________ tumble drier ______

bathroom ________ - if yes, where does the exhaust air go? ________

PART TWO

19. (a) Comfort - do different members of the family feel the cold more than others? Yes ______ No ______

- if yes, why? ______________________________

(b) Which rooms do you feel it is most important to heat?

(list in order of preference)

sitting ______ bedroom 1 ____

dining ______ bedroom 2 ____

kitchen ______ bedroom 3 ____

bathroom ______ bedroom 4 ____

hall ______

(c) Are there any rooms or areas which you feel don't need heat?

____

Why? ____

20. How long does it take to warm up the house if you've been away for a weekend in the winter and the heating has been off? __________

Why is that? ____________________________

21. (a) Economics - do you feel the heating system is running efficiently? Yes______No __________

- if no, why not?

(b) How do you pay? quarterly______monthly __________

regular monthly payments ________

other (specify) __________

(c) How would you like to pay? quarterly ______ monthly ______

regular monthly ________

other (specify) ____________

Why? ____________________________________

(d) Do you regard the cost of gas as:

far too expensive __________

expensive but worth it ________

fairly reasonable for what you get __________

relatively cheap __________

Have you tried to cut down this winter? Yes______ No ______

Do you feel you have used .... more ________

the same amount ________

less ________ than last year?

Has it cost you - more __________

the same ________

less ________

Why? ____________________________________

(e) Do you know what your neighbours or friends spend on gas?

Yes _____ No ____________

(f) Thinking about last winter, were you worried about the cost of heating? Yes _____ No ___________

- if yes, would you say

(i) you were not as comfortable as you would have liked _________

(ii) you took care but were always comfortable _________

(iii) you did not have as much hot baths you would have liked ______

(iv) you had enough hot water but had to be careful _______

22. How often do you shop? every day ______ every 2nd day ______

twice a week _____once a week _________

23. (a) Conservation: do you believe there is an energy crisis? Yes_____

No _____

(b) Do you feel you as an individual can do anything about it? Yes _____ No _______

(c) Do you feel the government have acted responsibly? Yes ___ No ___

Why? __________________________

(d) What do you think about the "save it" campaign? ________________

(e) Do you ever discuss energy and heating problems with others? Yes ___

No ____

- if yes, who? ______________________________________

(f) Do you see energy conservation as

(i) energy saved by you __________________

(ii) fuel saved by the country ____________

24. Do you have a weekly routine? Yes _____ No _______

(i) Where would you put it along this line?

very predictable ______________________________ very variable

(ii) Is you income this year -

very predictable ______________________________ very variable

(iii) Last year

very predictable ______________________________ very variable

25. Which of the following statements best describes your feelings?

"The heating arrangements are:

(a) adequate and we keep as warm as we want to _____________

(b) adequate but it's too expensive to keep it as warm as we'd like _____________

(c) not really adequate, but we keep reasonably warm _________

(d) not adequate and we cannot keep warm enough ___________

26. How do you feel about each of these statement?

	agree	strongly agree	neither	disagree	strongly disagree	don't know
(a) It's not generally necessary to heat bedrooms						
(b) Older people often get ill because they haven't enough heating						
(c) We can't afford to keep our home as warm as we'd like						
(d) People who keep their homes very warm get lots of coughs and colds						
(e) It's very important to keep your home warm even if the cost means saving on other things						

FIGURE A2. Interview questionnaire for main survey at Cowley and Mezen

HOUSE NO.
ESTATE

DATE
INTERVIEW NO.
EXTERNAL TEMPERATURE

HOUSE ORIENTATION
HOUSE TERRACE POSITION
FLOOR AREA

1. HOUSEHOLD CLASSIFICATION

M	F	0-4	5-15	16-25	26-55	56-65	66+	OCCUPATION	CLO	SMOKES

SEX/AGE

TOTAL

CLO

LIFE CYCLE

AT WHAT TIMES IS THERE NORMALLY SOMEONE IN THE HOUSE ?

MON
TUES
WED
THURS

FRI
SAT
SUN

TOTAL HRS p.w.	
W/DAYS	
W/ENDS	

2. <u>THE HOUSE</u>

(a)

ROOMS	NO. OF DOORS	NO. OF WINDOWS	NO. OF RADS
KITCHENETTE			
SITTING ROOM			
HALL			
TOILET			
BATHROOM			
BEDROOM 1			
BEDROOM 2			
BEDROOM 3			
BEDROOM 4			
total			

NO. OF FLOORS [ ]

(b) INSULTATION

METHOD	ROOM	WHY	SATIS FIED	WHY

3. DO YOU HAVE ANY OF THE FOLLOWING APPLIANCES ?

a) an electric kettle

b) a dish washer

c) a freezer

d) a fridge-freezer

e) hoover

f) colour TV

g) tumble drier

h) shower

i) extractor fan — if yes, where ?

j) electric blanket — if yes, No. [ ] and where ?

bedroom 1 2 3 4

WHY ?

k) a car [ ] if yes, No. [ ]

is it, BIG [ ] MEDIUM [ ] SMALL [ ]

is it, more than five years old ? [ ]

l) any form of additional heat ? [ ]

gas room heaters [ ]

parafin heaters [ ]

electric fires [ ]

fan heaters [ ]

TOTAL INDEX [ ]

ROOM	WHEN	WHY
KITCHENETTE		
SITTING ROOM		
HALL		
BATHROOM		
BEDROOM 1		
BEDROOM 2		
BEDROOM 3		
BEDROOM 4		

4. CONTROLS

(a) DO YOU TURN THE INDIVIDUAL RADIATORS ON AND OFF ?

NEVER ☐ SELDOM ☐ OFTEN ☐

If never, why?

If yes,

ROOM	WHY	NEVER ON	SELDOM ON	GEN. ON	HRS OFF WHEN CH. IS ON

INDEX ☐

(b) ARE THERE ANY ROOMS WHICH YOU FEEL DO'NT NEED A RADIATOR ? ☐

If yes, where ?

ROOM	WHY

If no, why ?

(c) WHEN DID YOU FIRST PUT YOUR HEATING ON THIS WINTER ?

WHY ?

At what setting ? TIMES

THERMOSTAT

(d) DO YOU USE YOUR TIME CLOCK ? [ ]

WHY ?

When is your C.H. on ? Weekdays am

pm

Weekends am

pm

Index W/Day [ ]

W/End [ ]

P.W. [ ]

Who put the clock in its present setting ?

Male [ ] Female [ ]

Who else knows how to set it ?

Male [ ] Female [ ] Child 1 2 3 4

Do you ever over ride it ? [ ]

If yes,

Regularily because of personal circumstances [ ]

At weekends [ ]

Depending on the weather [ ]

Hardly ever [ ]

When ?

When we get up	
During the morning	
Lunchtime	
Afternoon	
Early evening	
Late evening	
Night	

If yes, why ?

If no, why ?

(e) THERMOSTAT SETTING day [ ] night [ ]

ROOM	MEASURED TEMPERATURE
KITCHENETTE	
SITTING ROOM	
HALL	
BATHROOM	
BEDROOM 1	
BEDROOM 2	
BEDROOM 3	
BEDROOM 4	

Who put the thermostat at its present position ?

Male ☐ Female ☐ Child 1 2 3 4

Who else knows how to set it ?

Male ☐ Female ☐ Child 1 2 3 4

Do you ever over ride it ?

If yes,

- Regularily ☐
- Depending on the weather ☐
- Hardly ever ☐

When ?

- When we get up ☐
- During the morning ☐
- Lunchtime ☐
- Afternoon ☐
- Early evening ☐
- Late evening ☐
- Night ☐

Why yes ?

Why no ?

5. SUMMER HEATING

(a)

ROOM	NEVER ON	SELDOM	OFTEN	ALWAYS	HRS.	WHY
KITCHENETTE						
SITTING ROOM						
HALL						
BATHROOM						
BEDROOM 1						
BEDROOM 2						
BEDROOM 3						
BEDROOM 4						

(b) What sort of heating did you have in your last house?

Gas fires ☐ Fan heaters ☐

Parafin ☐ C.H. ☐

Coal fires ☐

Electric heaters ☐

How did you find (i) the system itself ?

Inadequate ☐ Reasonable ☐

Good ☐ V.Good ☐

(ii) the cost ?

Too expensive ☐ A bit too costly ☐ Reasonable ☐

Cheap ☐

INDEX ☐

(c) the present system ?

Inadequate ☐ Reasonable ☐ Good ☐

V.Good ☐

Cost?

Too expensive ☐ A bit too costly ☐ Reasonable ☐

Cheap ☐

6. SATISFACTION

(a) were you shown how to use the controls when you came into the house ? ☐

Did you understand the demonstration ? ☐

Had you ever used a central heating system before ? ☐

At the begining, what did you find difficult about the controls ?

Time Clock

Thermostat

(b)

What do you find difficult now ?

Time Clock

Thermostat

What do you think are the good points about your present heating arrangements ?

What do you feel are the bad points ?

(c) Thinking of your house in general, have there been times when you've felt a bit too cold ? ☐

Why ?

What do you do when you are too cold ?

Have there been times when you've been too hot ? ☐

Why ?

What do you do when you're too hot ?

(d) Is there anyone in the family who feels the cold more than the others ? ☐

Who ?

What effect does this have on the heating arrangements ?

7. COOKING GAS

Estimated no. of hrs. cooking p.w.

Hot H_2O Clock used

Times

Total No. of baths p.w.

Total No. of washing loads p.w.

Method of clothes drying

Radiators Tumble Dryer

Garden Bathroom

8. WINDOWS

Do you ever open windows during the winter ?

Why ?

Why do you close them ?

ROOM	NEVER OPEN	SELDOM	OFTEN	ALWAYS	HRS W/DAYS	HRS W/END
KITCHENETTE						
SITTING ROOM						
TOILET						
BATHROOM						
BEDROOM 1						
BEDROOM 2						
BEDROOM 3						
BEDROOM 4						

(b) Condensation

ROOM	NONE	A LITTLE	QUITE ALOT	ALOT
KITCHENETTE				
SITTING ROOM				
BATHROOM				
BEDROOM 1				
BEDROOM 2				
BEDROOM 3				
BEDROOM 4				

What do you think is the cause ?

What do you do to help it?

(c) Internal doors

ROOM	NEVER	OPEN	SELDOM	FREQUENTLY	ALWAYS
KITCHENETTE					
SITTING ROOM					
TOILET					
BATHROOM					
BEDROOM 1					
BEDROOM 2					
BEDROOM 3					
BEDROOM 4					

Why are they open ?

Why are they closed ?

9. PAYMENT

How do you pay ? Quarterly
Regular Monthly
Monthly

How would you like to pay ?
Quarterly
Regular Monthly
Monthly

Why ?

How much would you say you spend on heating in a week ?

What proportion of the total family income is this ?

Are you trying to cut down on the amount of gas you use ?

How ?

Why ?

FIGURE A3. Gas consumption readings for six quarters (N = 113 households at Cowley and Mezen)

Row	"ACON"	"BCON"	"CCON"	"DGON"	"ECON"	"FCON"
1	250	245	83	93	270	245
2	127	149	78	63	121	127
3	74	101	46	74	93	88
4	183	222	78	160	183	200
5	176	194	146	19	206	185
6	147	158	45	40	204	158
7	342	229	298	10	16	0
8	200	291	67	0	0	0
9	380	125	125	0	0	0
10	212	238	195	148	222	222
11	145	89	100	48	311	125
12	137	150	49	80	160	161
13	123	117	47	203	103	35
14	0	0	0	0	0	0
15	185	192	59	480	135	135
16	134	158	68	61	197	85
17	151	149	7	100	208	167
18	218	228	150	97	218	109
19	185	174	65	79	231	174
20	205	223	99	115	232	186
21	128	115	45	58	131	76
22	167	258	165	44	285	258
23	266	288	300	70	250	258
24	187	200	19	0	0	0
25	107	119	45	59	180	75
26	201	187	45	60	203	274
27	144	159	55	68	173	153
28	258	241	114	126	359	150
29	196	191	75	97	213	204
30	105	111	35	58	262	85
31	193	100	69	91	145	0
32	68	142	100	85	158	142
33	214	231	81	85	234	195
34	148	183	85	32	0	0
35	149	129	46	35	200	200

cont'd

FIGURE A3. continued

Row	"ACON"	"BCON"	"CCON"	"DGON"	"ECON"	"FCON"
36	230	91	211	200	230	197
37	100	113	100	100	169	113
38	33	33	245	220	225	210
39	323	300	106	172	305	271
40	304	240	112	104	304	240
41	224	163	117	110	224	163
42	213	245	87	81	215	200
43	108	134	41	51	157	124
44	236	250	95	106	256	243
45	100	237	49	192	100	0
46	188	184	65	82	188	210
47	303	290	0	0	0	0
48	330	324	102	0	0	0
49	0	80	19	15	0	0
50	0	165	166	61	242	162
51	179	166	69	69	153	166
52	0	0	0	0	0	0
53	100	100	79	298	100	100
54	145	207	172	110	271	207
55	148	187	44	45	148	147
56	191	212	41	34	191	182
57	45	94	17	37	86	105
58	117	152	41	80	146	166
59	136	147	39	124	154	172
60	99	98	48	0	120	146
61	51	51	27	28	61	111
62	138	145	35	18	138	131
63	133	126	29	44	176	198
64	100	153	100	163	100	148
65	331	355	132	143	352	398
66	241	271	113	135	326	234
67	184	220	57	82	209	153
68	135	118	127	92	167	269
69	245	305	32	14	0	0
70	298	270	144	154	298	228
71	184	183	23	0	0	0
72	208	285	131	134	287	259
73	166	172	0	0	0	0

cont'd

FIGURE A3. continued

ROW	"ACON"	"BCON"	"CCON"	DCON"	"ECON"	"FCON"
74	257	238	116	97	257	238
75	205	303	124	125	301	303
76	162	180	86	102	204	179
77	79	127	17	28	110	103
78	122	150	45	49	149	138
79	126	150	55	23	191	150
80	135	218	27	17	0	0
81	144	172	50	238	144	174
82	37	3	10	7	37	0
83	155	178	63	62	169	160
84	100	100	2	185	100	100
85	0	0	0	0	0	0
86	222	299	50	75	222	281
87	141	135	70	79	148	111
88	0	197	41	73	192	197
89	27	29	20	14	44	43
90	167	173	51	22	179	219
91	142	100	40	40	142	100
92	100	138	34	31	74	46
93	0	174	155	100	204	215
94	126	145	32	58	136	115
95	2	303	100	50	45	303
96	319	364	94	147	376	337
97	262	234	119	140	262	313
98	163	248	94	156	163	248
99	297	68	392	100	140	266
100	0	0	0	0	0	0
101	265	53	55	75	75	53
102	257	275	101	67	331	275
103	464	321	81	123	285	321
104	159	203	59	69	208	186
105	204	224	84	80	273	171
106	70	113	131	15	70	45
107	184	220	40	70	120	220
108	77	83	28	41	49	115
109	315	108	196	125	202	208
110	156	97	93	81	156	162
111	0	190	104	50	50	0
112	256	287	143	153	294	266
113	271	257	93	116	273	257

TEXT BOUND CLOSE TO THE SPINE IN THE ORIGINAL THESIS

ORTANT TO BE COMPLETED BY THE HOUSEWIFE OR HEAD OF THE HOUSEHOLD

CENTRAL HEATING SURVEY

1. CLASSIFICATION OF RESPONDENT

1.1. Sex: MALE ☐ FEMALE ☐

.ate 1.2 Age: 16-25 ☐ 26-55 ☐ 56-65 ☐ 66-90 ☐

2 THE CENTRAL HEATING SYSTEM

2.1. If you want to get the front room warm quickly, do you

e iate EACH the n

		Yes	No
(a)	turn the room thermostat up and turn it down later	☐	☐
(b)	turn the room thermostat up and leave it at that setting	☐	☐
(c)	turn the hot water thermostat up	☐	☐
(d)	check that the front room window is closed	☐	☐
(e)	check that the vent in the front room window is closed	☐	☐
(f)	other - please state overleaf	☐	☐

2.2 Does the thermostat in your front room cut out when

le :iate EACH the on

		Yes	No
(a)	the radiators are at the set temperature	☐	☐
(b)	the hot water supply is at the set temperature	☐	☐
(c)	the front room is at the set temperature	☐	☐

2.3 Imagine that the central heating is on. The room thermostat is set to number 2. Will the front room temperature

		Yes	No
(a)	always stay exactly the same	☐	☐
(b)	stay roughly the same	☐	☐
(c)	change with the temperature of the hot water supply	☐	☐

<u>USE OF THE CENTRAL HEATING</u>

3. 1. Is your central heating usually on for longer during the day at the weekends, than during the weekdays?

- longer ☐
- the same ☐
- not as long ☐

3.2. Do you ever leave your central heating on when the house is empty for periods of an hour or more?

- never ☐
- seldom ☐
- quite often ☐
- very often ☐

3.3. Do any of the following reasons explain why you leave your central heating on when the house is empty for an hour or more?

	never the reason	seldom the reason	quite often the reason	very ofte[n] the reason
(a) because it is difficult to turn off				
(b) because you forget to turn it off				
(c) because the savings are not enough to make it worthwhile				
(d) because you want the house to be warm when you come in				
(e) because of animals in the house				
(f) because it is too troublesome to turn it off				
(g) because you might forget to turn it on again				

(h) other - overleaf

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).4. WINDOW OPENING AND USE OF CENTRAL HEATING

4.1. Do you ever open your front room window(s) when your central heating is on?

: the
·opriate

never ☐

seldom ☐

quite often ☐

very often ☐

4.2. Do you ever open your main bedroom window(s) when your central heating is on?

: the
:opriate

never ☐

seldom ☐

quite often ☐

very often ☐

4.3. Do you ever open your kitchen window(s) when your central heating is on?

k the
ropriate

never ☐

seldom ☐

quite often ☐

very often ☐

REASONS FOR OPENING WINDOWS

5.1 In the winter, do any of the following reasons explain why you open your windows? (please answer all the questions)

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on

	never the reason	seldom the reason	quite often the reason	very often the reason
(a) to let fresh air in				
(b) to cool the house				
(c) to get rid of tobacco smoke				
(d) to stop condensation				
(e) to make the room atmosphere less dry				
(f) because it is humid or close				
(g) because it looks better				
(h) to clean the windows				
(i) to let domestic animals in/out				
(j) to let out smells				
(k) because it is stuffy				

(l) other - please state overleaf

5.2 In the winter, do any of the following reasons explain why you close your windows? (please answer all the questions)

	never the reason	seldom the reason	quite often the reason	very often the reason
(a) to keep out the rain				
(b) for privacy				
(c) to keep out dust or dirt				
(d) for security				
(e) to prevent draughts				
(f) to keep the house warm				
(g) because it looks better				
(h) because they are difficult to open				
(i) because there is no need for them to be open				

(j) other - please state overleaf

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5.3 In the summer, do any of the following reasons explain why you open your windows? (please answer all the questions)

	never the reason	seldom the reason	quite often the reason	very ofte the reason
(a) to let fresh air in				
(b) to cool the house				
(c) to get rid of tobacco smoke				
(d) to stop condensation				
(e) to make the room atmosphere less dry				
(f) because it is humid or close				
(g) because it looks better				
(h) to clean the windows				
(i) to let domestic animals in/out				
(j) to let out smells				
(k) because it is stuffy				
(l) other - please state overleaf				

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5.4. In the summer, do any of the following reasons explain why you would close your windows? (please answer all the questions)

	never the reason	seldom the reason	quite often the reason	very often the reason
(a) to keep out the rain				
(b) for privacy				
(c) to keep out dust and dirt				
(d) for security				
(e) to prevent draughts				
(f) to keep the house warm				
(g) because it looks better				
(h) because they are difficult to open				
(i) because there is no need for them to be open				

(j) other - please state overleaf

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THE WEEKEND

6.1. In the winter, are your windows open for longer at the weekend than during the week?

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	Open longer at weekends	No Difference	Open less at weekends
(a) front room window			
(b) main bedroom window			
(c) Kitchen window			

6.2. In the summer, are your windows more likely to be open at the weekend than during the week?

the opriate for EACH of the tion

	Open longer at weekends	No Difference	Open less at weekends
(a) front room window			
(b) main bedroom window			
(c) kitchen window			

6.3 In <u>winter</u>, do any of the following reasons explain why you open your windows more often at the weekend than in the week?

		never the reason	seldom the reason	quite often the reason	very often the reason
(a)	because the house gets stuffier at the weekend				
(b)	because of cleaning at the weekend				
(c)	because I have more time at the weekend				
(d)	because they are not open much/at all during the week				
(e)	because more cooking is done at the weekend				
(f)	because more clothes washing is done at the weekend				
(g)	because there is more tobacco smoke than during the week				
(h)	because there are more people in the house at the weekend				
(i)	because I am at home to shut them when I want to at the weekend				
(j)	Other - please state overleaf				

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THE WEATHER

7.1. In winter, how likely are you to open your front room window(s) on a

	very unlikely	fairly unlikely	quite likely	very likely
(a) sunny day				
(b) wet day				
(c) humid or close day				
(d) mild day				
(e) cold day				
(f) windy day, when the wind is not blowing into the house				
(g) windy day, when the wind is blowing into the house				

7.2. In winter, how likely are you to open your main bedroom window on a

	very unlikely	fairly unlikely	quite likely	very likely
(a) sunny day				
(b) wet day				
(c) humid or close day				
(d) mild day				
(e) cold day				
(f) windy day, when the wind is not blowing into the house				
(g) windy day, when the wind is blowing into the house				

7.3 In winter, how likely are you to open your kitchen window(s) on a

	very unlikely	fairly unlikely	quite likely	very likely
(a) sunny day				
(b) wet day				
(c) humid or close day				
(d) mild day				
(e) cold day				
(f) windy day, when the wind is not blowing into the house				
(g) windy day, when the wind is blowing into the house				

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7.4 In summer, how likely are you to open your front room

	very unlikely	fairly unlikely	quite likely	very likely
(a) sunny day				
(b) wet day				
(c) humid or close day				
(d) mild day				
(e) cold day				
(f) windy day, when the wind is not blowing into the house				
(g) windy day, when the wind is blowing into the house				

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7.5 In summer, how likely are you to open your main bedroom window(s)

	very unlikely	fairly unlikely	quite likely	very likely
(a) sunny day				
(b) wet day				
(c) humid or close day				
(d) mild day				
(e) cold day				
(f) windy day, when the wind is not blowing into the house				
(g) windy day, when the wind is blowing into the house				

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7.6. In summer, how likely are you to open your kitchen window(s)

	very unlikely	fairly unlikely	quite likely	very likely
(a) sunny day				
(b) wet day				
(c) humid or close day				
(d) mild day				
(e) cold day				
(f) windy day, when the wind is not blowing into the house				
(g) windy day, when the wind is blowing into the house				

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Q.8

EXTENT OF WINDOW OPENING

8.1 In winter, how wide do you open your front room window(s) on a

	not at all	a tiny bit	a little bit	half open	fully open
(a) sunny day					
(b) wet day					
(c) humid or close day					
(d) mild day					
(e) cold day					
(f) windy day, when the wind is not blowing into the house					
(g) windy day, when the wind is blowing into the house					

Tick the appropriate box for EACH part of the question

8.2 In winter, how wide do you open your main bedroom window(s)

	not at all	a tiny bit	a little bit	half open	fully open
(a) sunny day					
(b) wet day					
(c) humid or close day					
(d) mild day					
(e) cold day					
(f) windy day, when the wind is not blowing into the house					
(g) windy day, when the wind is blowing into the house					

Tick the appropriate box for EACH part of the question

8.3 In winter, how wide do you open your kitchen window(s) on a

		not at all	a tiny bit	a little bit	half open	fully open
(a)	sunny day					
(b)	wet day					
(c)	humid or close day					
(d)	mild day					
(e)	cold day					
(f)	windy day, when the wind is not blowing into the house					
(g)	windy day, when the wind is blowing into the house					

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8.4 In summer, how wide do you open your front room window(s)

		not at all	a tiny bit	a little bit	half open	fully open
(a)	sunny day					
(b)	wet day					
(c)	humid or close day					
(d)	mild day					
(e)	cold day					
(f)	windy day, when the wind is not blowing into the house					
(g)	windy day when the wind is blowing into the house					

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8.5 In <u>summer</u>, how wide do you open your <u>main bedroom</u> window(s) on a

k the ropriate for EACH t of the stion

	not at all	a tiny bit	a little bit	half open	fully open
(a) sunny day					
(b) wet day					
(c) humid or close day					
(d) mild day					
(e) cold day					
(f) windy day, when the wind is not blowing into the house					
(g) windy day, when the wind is blowing into the house					

8.6 In <u>summer</u>, how wide do you open your <u>kitchen</u> window on a

k the propriate k for EACH rt of the estion

	not at all	a tiny bit	a little bit	half open	fully open
(a) sunny day					
(b) wet day					
(c) humid or close day					
(d) mild day					
(e) cold day					
(f) windy day when the wind is not blowing into the house					
(g) windy day when the wind is blowing into the house					

Q.9 LENGTH OF WINDOW OPENING

9.1. In winter, how long do you leave your windows open for? (if your house does not have a particular window e.g. bathroom, cross out that line).

t the ropriate for EACH t of the stion

	not open	about an hour	a few hours	most of the day	all day	all night	all day and all night
(a) front room window							
(b) dining room window							
(c) kitchen window							
(d) main bedroom window							
(e) bathroom window							
(f) toilet window							

9.2 In winter, does the weather make a difference to how long you leave the windows open for?

k the ropriate for EACH t of the stion

	makes no difference	makes very little difference	makes some difference	makes a lot of difference
(a) front room window				
(b) dining room window				
(c) kitchen window				
(d) main bedroom window				
(e) bathroom window				
(f) toilet window				

9.3 In summer, how long do you leave your windows open for?

	not open	about an hour	a few hours	most of the day	all day	all night	all day and all night
(a) front window							
(b) dining room window							
(c) kitchen window							
(d) main bedroom window							
(e) bathroom window							
(f) toilet window							

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9.4 In summer, does the weather make a difference to how long you leave the windows open for?

	makes no difference	makes very little difference	makes some difference	makes a lot of difference
(a) front window				
(b) dining room window				
(c) kitchen window				
(d) main bedroom window				
(e) bathroom window				
(f) toilet window				

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2.10 MECHANICS

10.1 Our boiler is a

(a) Thorn ☐

the (b) Glow worm ☐
priate

(c) Other - please state overleaf

10.2 The boiler is in the

(a) kitchen ☐

the (b) outside shed ☐
priate

(c) front room ☐

(d) other - please state overleaf

10.3 At this moment the hot water thermostat is set at

____

10.4 The extractor fan in the bathroom is

(a) never switched on ☐

the (b) sometimes switched on ☐
priate

(c) always switched on ☐

Have you answered all the questions? Please check back through the questionnaire to see that you have not skipped a page.
Thank you.

THE HOUSEHOLD

11.1 It is helpful to relate the information you have given, to certain household characteristics. Could you please fill in this chart for each member of the household

	HOUSEHOLD MEMBER'S SEX (M or F)	MEMBER'S AGE						DOES HE/ SHE SMOKE (✓or X)	OCCUP-ATION	FULL/PA[RT] TIME (F or P
		0-4	5-15	16-25	26-55	56-65	66+			
1.										
2.										
3.										
4.										
5.										
6.										
7.										
8.										

11.2 For what times is the central heating generally on, in the winter?

from ____________ to ____________ and

from ____________ to ____________

11.3. Do you use the time clock to control the central heating?

Yes ☐

No ☐

FIGURE A5. Postal questionnaire covering letter

Brunel University

Department of Building Technology
Uxbridge, Middlesex UB8 3PH
Telephone: Uxbridge 37188 Extension

Domestic Heating Project
Gillian Conan

April 1980

Dear Sir/Madam,

I am from Brunel University. We are conducting a survey on central heating and window opening. We would be very grateful if you would fill in the enclosed questionnaire. Do not be put off by the number of pages. The printing is large and it will not take very long.

Please answer all the questions. In order to make an accurate estimate of window opning habits we need to know what <u>you</u> do with your windows. The back of each page has been left blank for any comments you want to make. Please return the questionnaire in the enclosed envelope. All responses will be treated confidentially. Thank you.

Yours faithfully

Gillian Conan

Brunel University

Department of Building Technology

Uxbridge, Middlesex UB8 3PH
Telephone: Uxbridge 37188 Extension

Domestic Heating Project

Gillian Conan

May 1980

Dear Sir/Madam

We are disappointed not to have received your completed questionnaire. We would like to know how window opening varies in different households. Could you please return your questionnaire so that we can include your views in our study.

All replies will be treated confidentially.

Thank you.

Yours faithfully

Gillian Conan

FIGURE A7. Letter sent to householders who returned and completed the postal questionnaire

Brunel University

Department of Building Technology

Uxbridge, Middlesex UB8 3PH
Telephone: Uxbridge 37188 Extension

Domestic Heating Project
Gillian Conan

May 1980

Dear Sir/Madam

This is to thank you for completing and returning the questionnaire to me. I appreciate your giving up your time to do it for me.

Many thanks,

Yours faithfully

Gillian Conan

FIGURES A8-A11. Relationships between temperature and window opening in the low group at Cowley

Figure A8

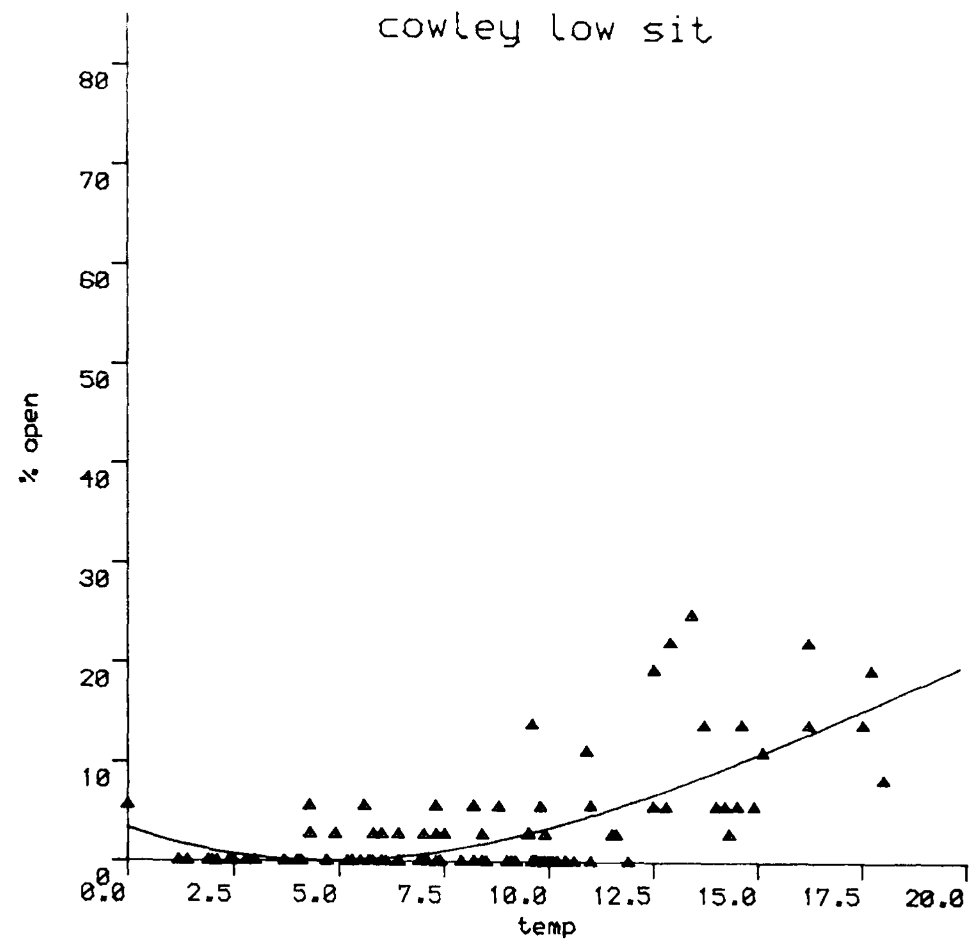


Figure A9

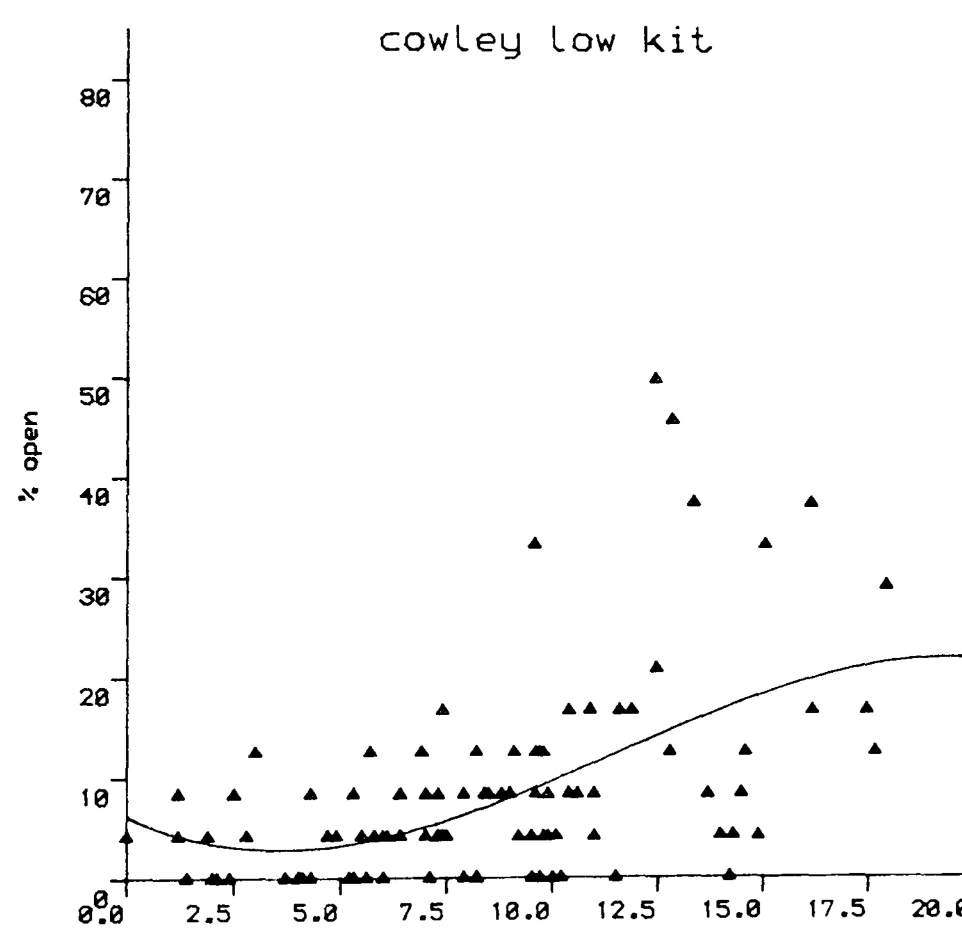


Figure A10

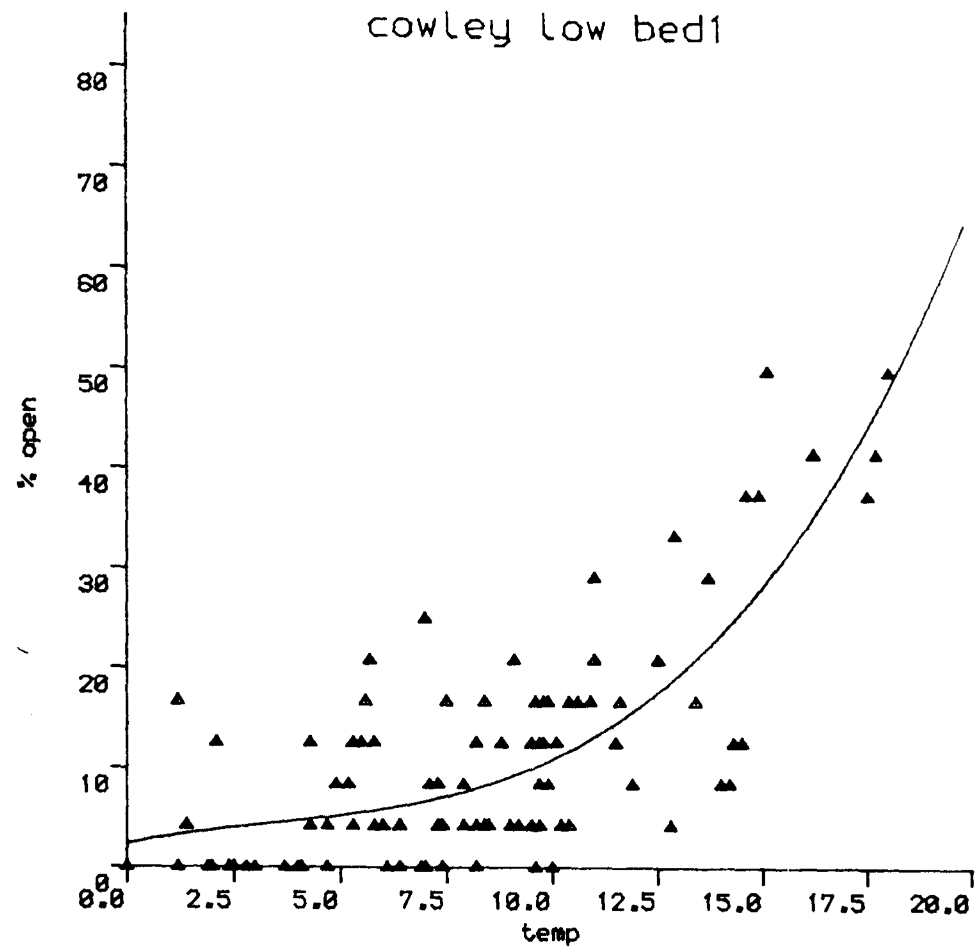
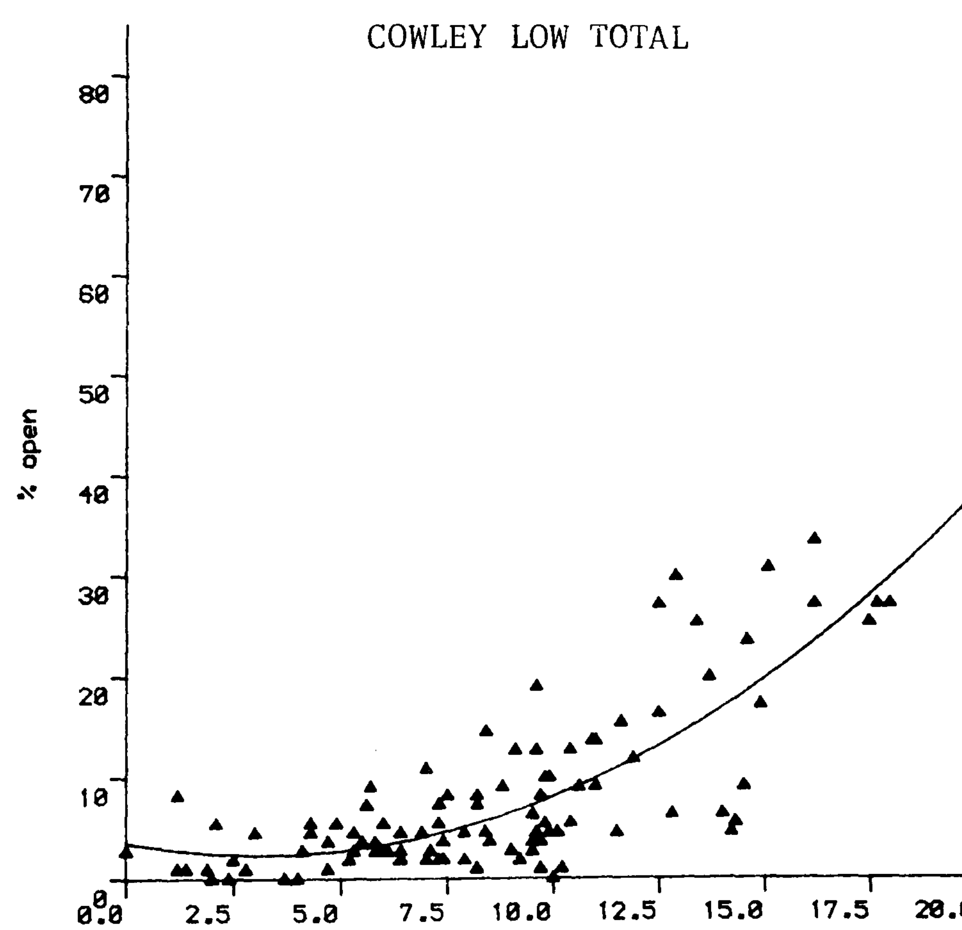


Figure A11



FIGURES A12-A15. Relationships between temperature and window opening in the medium group at Cowley

FIGURE A12

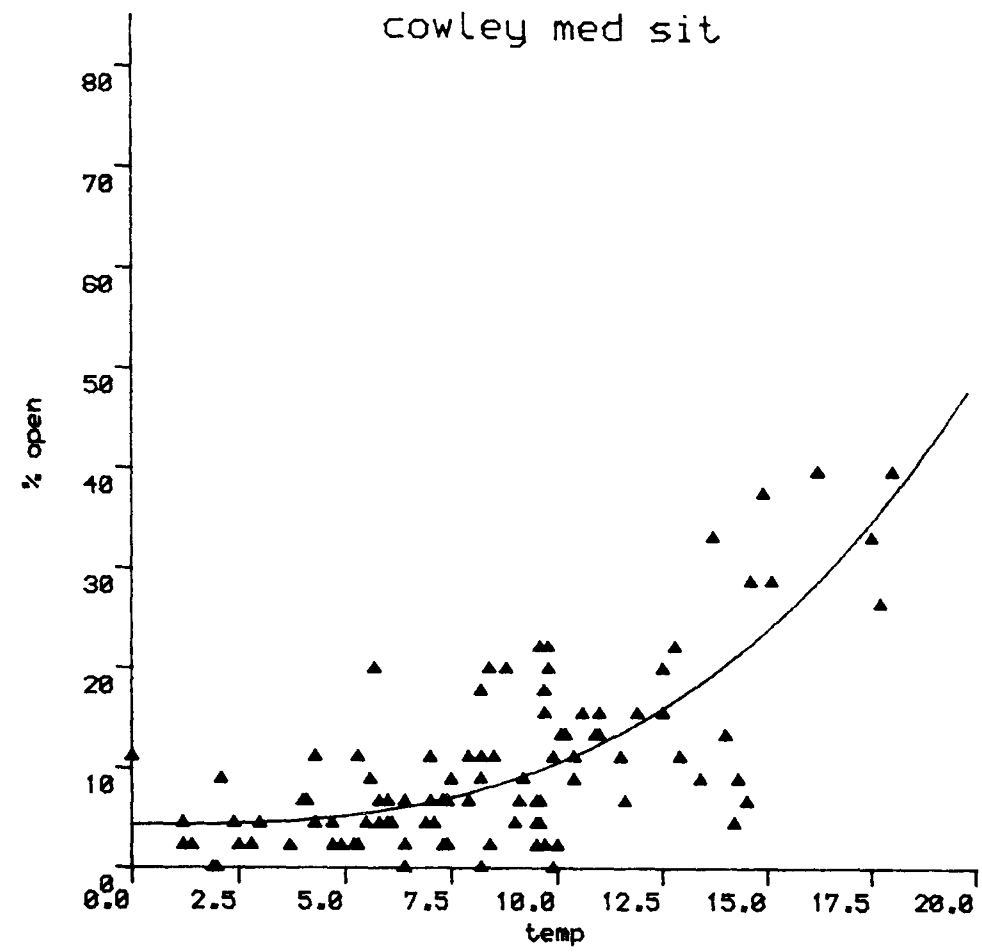


FIGURE A13

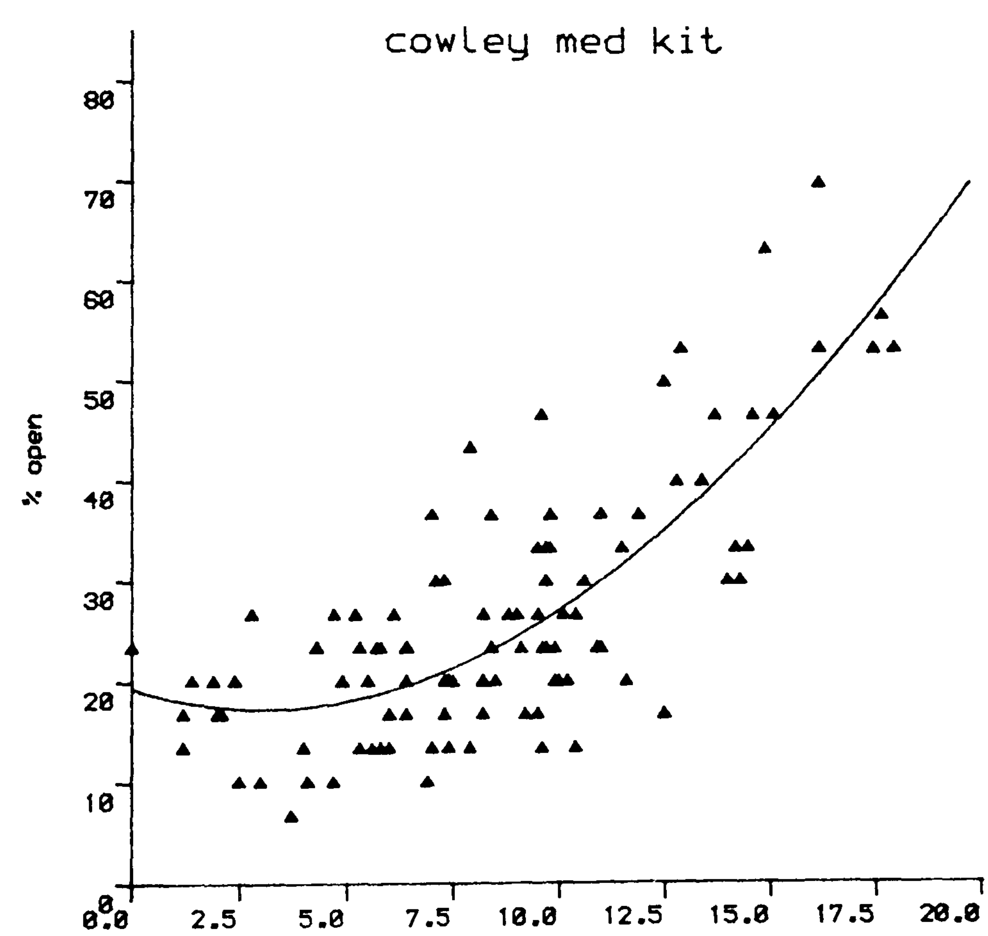


FIGURE A14

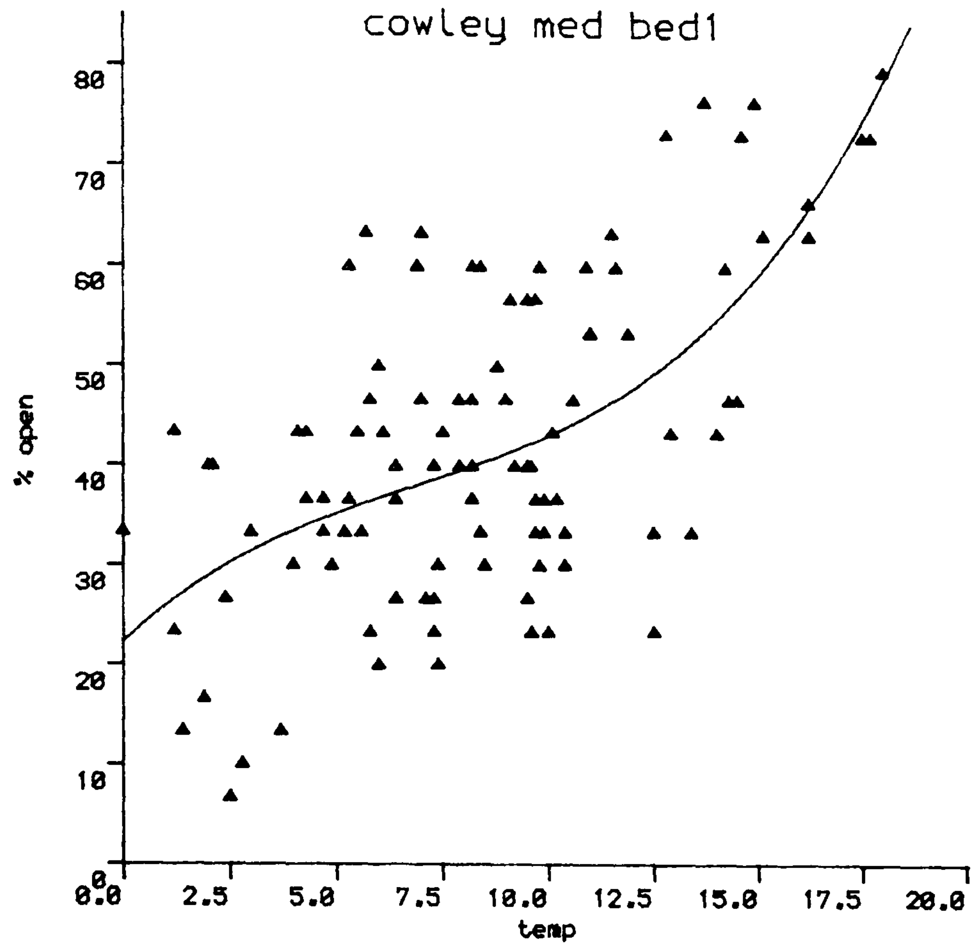
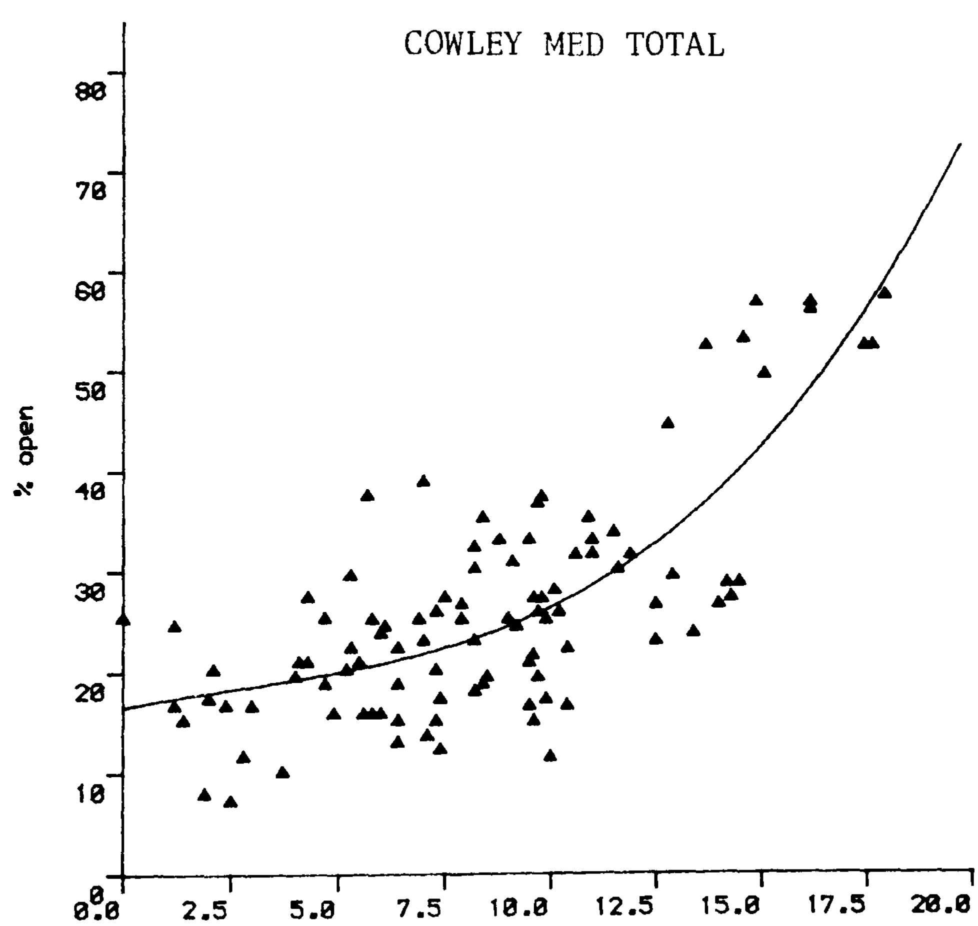


FIGURE A15



FIGURES A16-A19. Relationships between temperature and window opening in the high group at Cowley

FIGURE A16

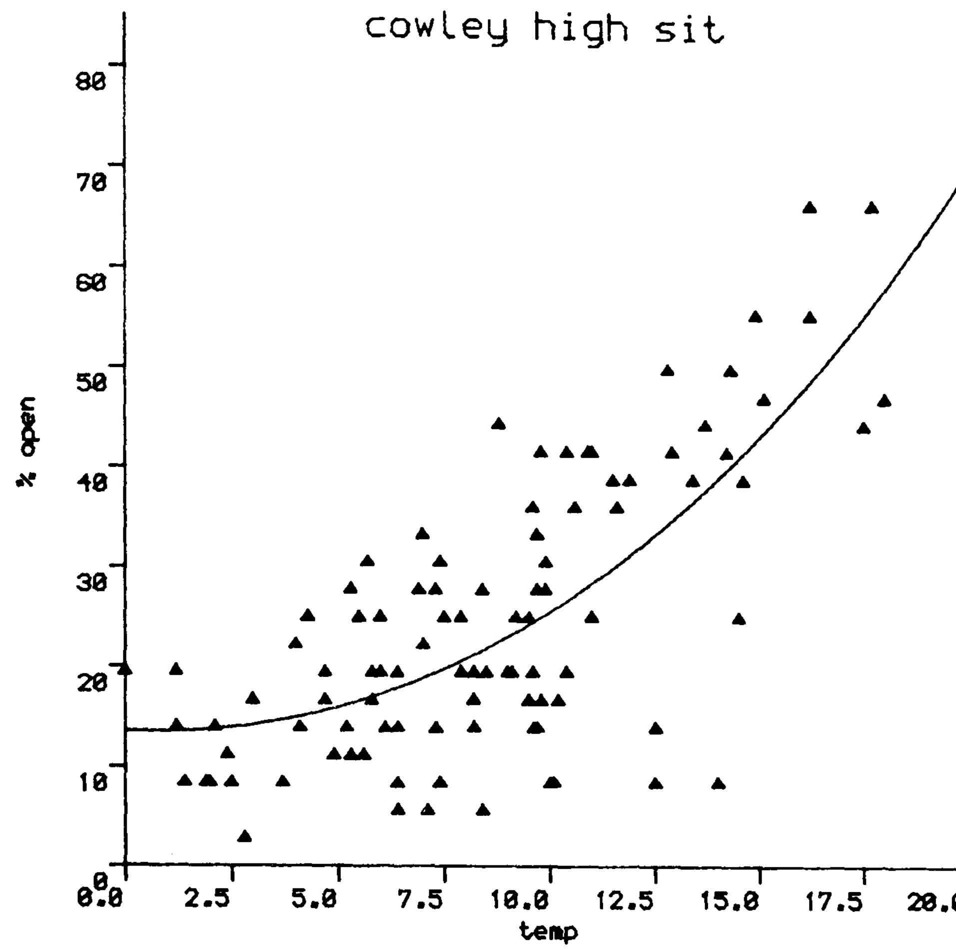


FIGURE A17

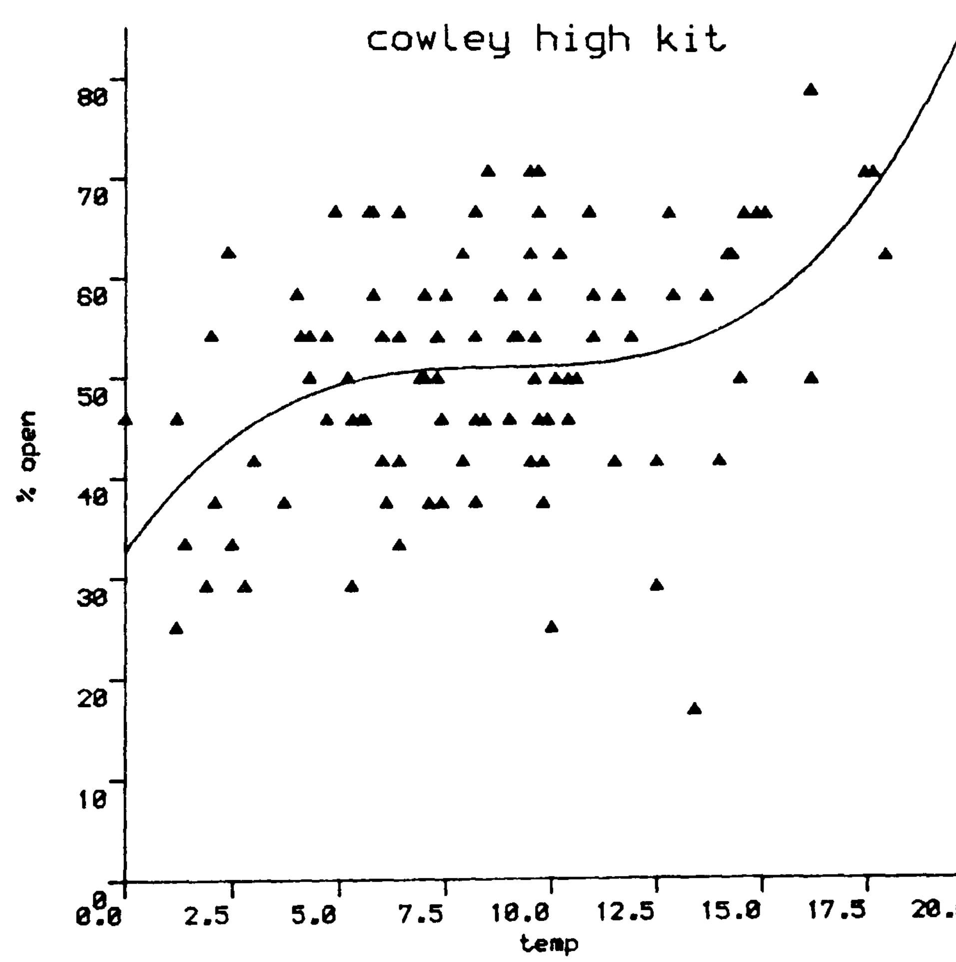


FIGURE A18

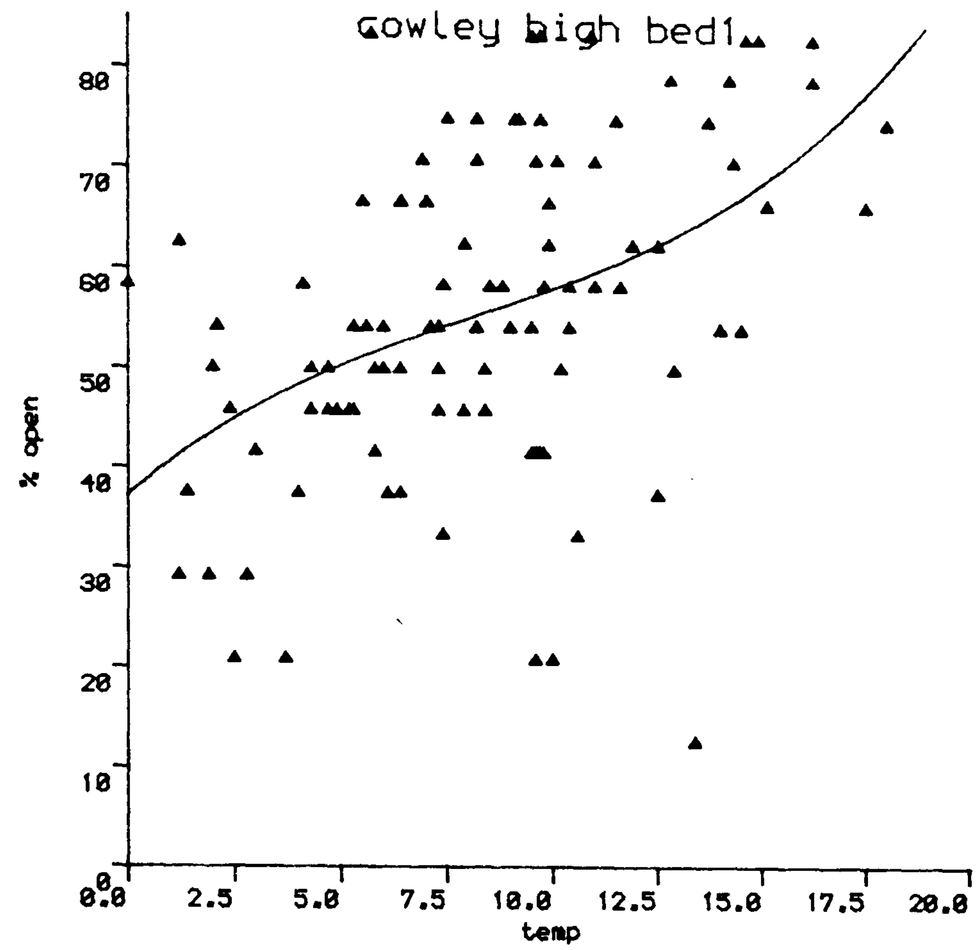
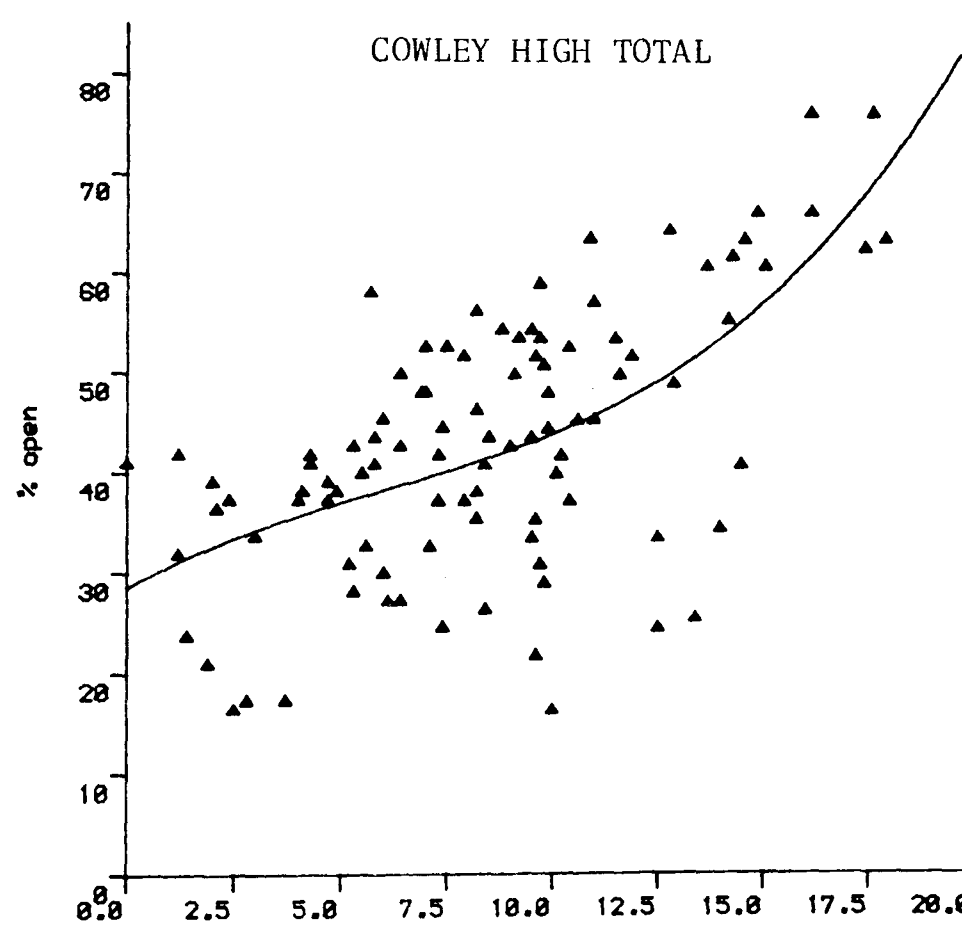


FIGURE A19



FIGURES A20-A23. Relationships between temperature and window opening in all groups at Cowley

FIGURE A20

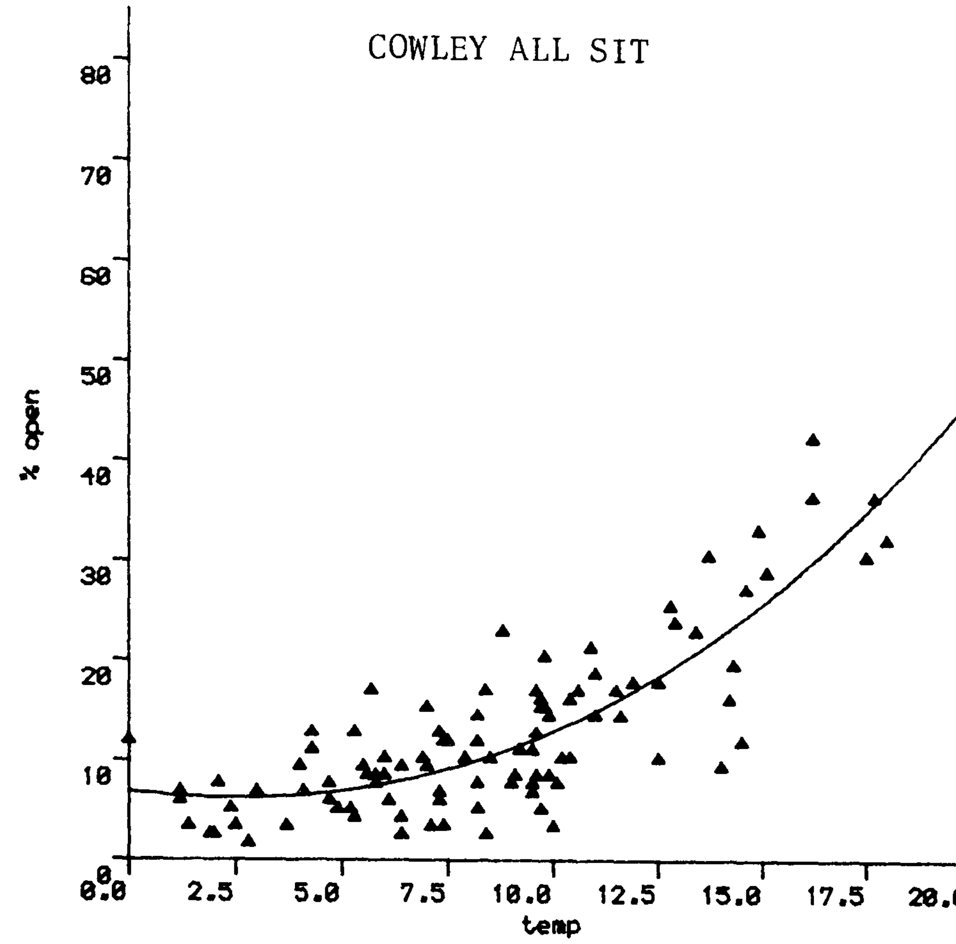


FIGURE A21

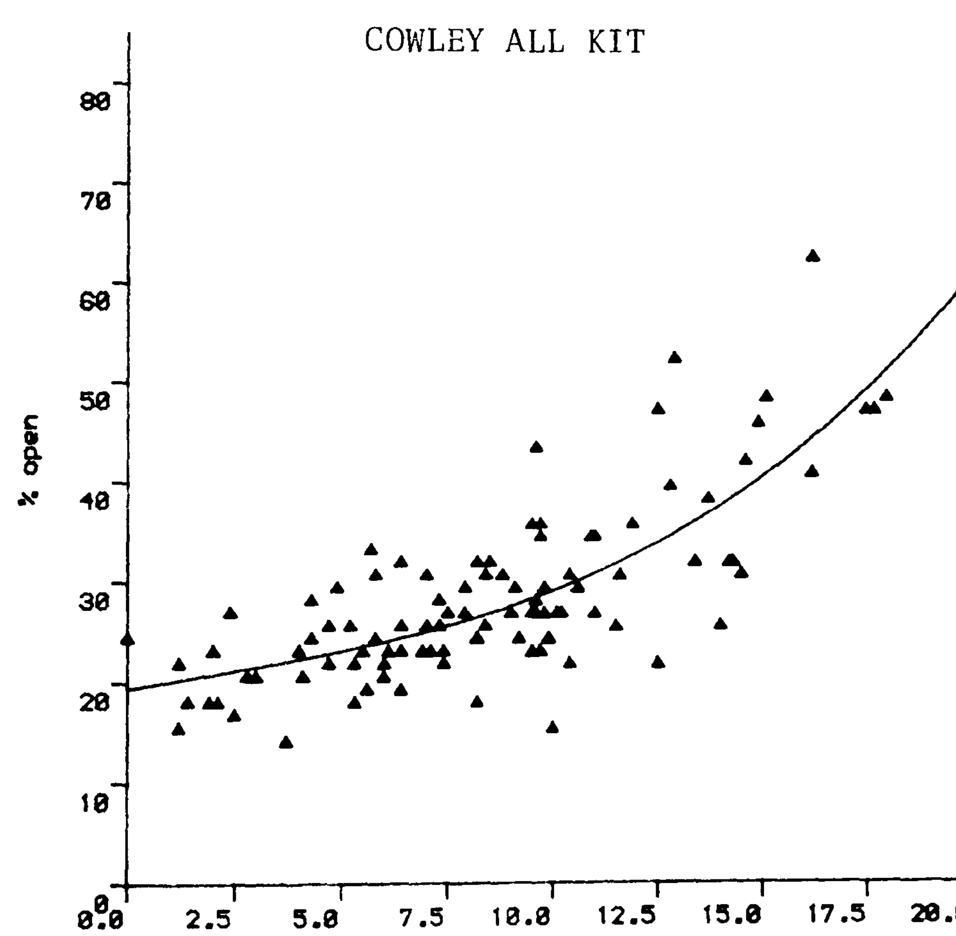


FIGURE A22

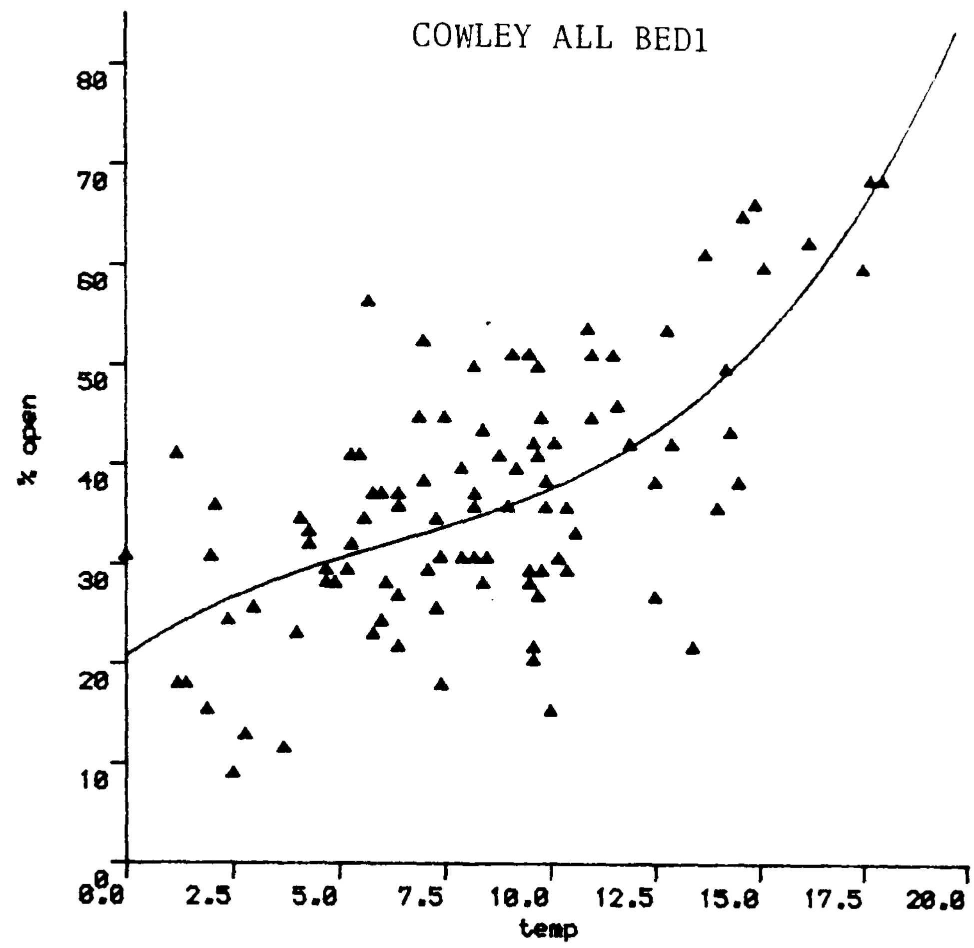
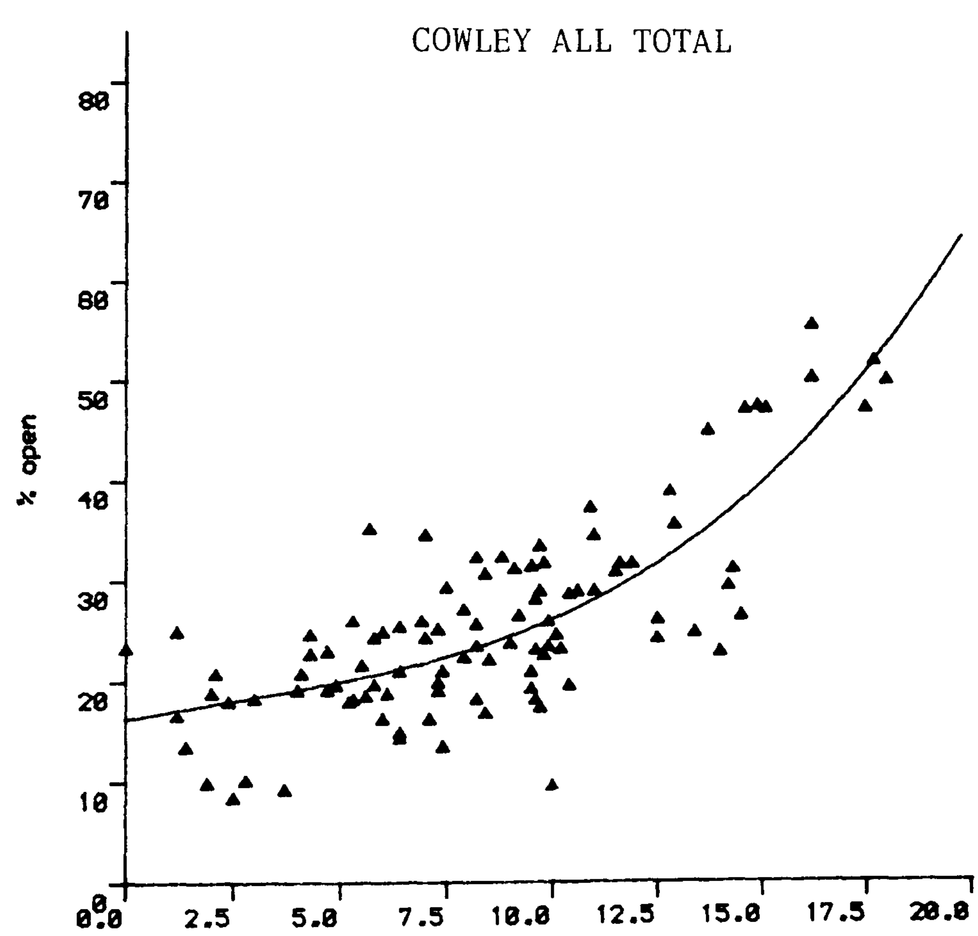


FIGURE A23



FIGURES A24-A27. Relationship between temperature and window opening in the low group at Mezen

FIGURE A24

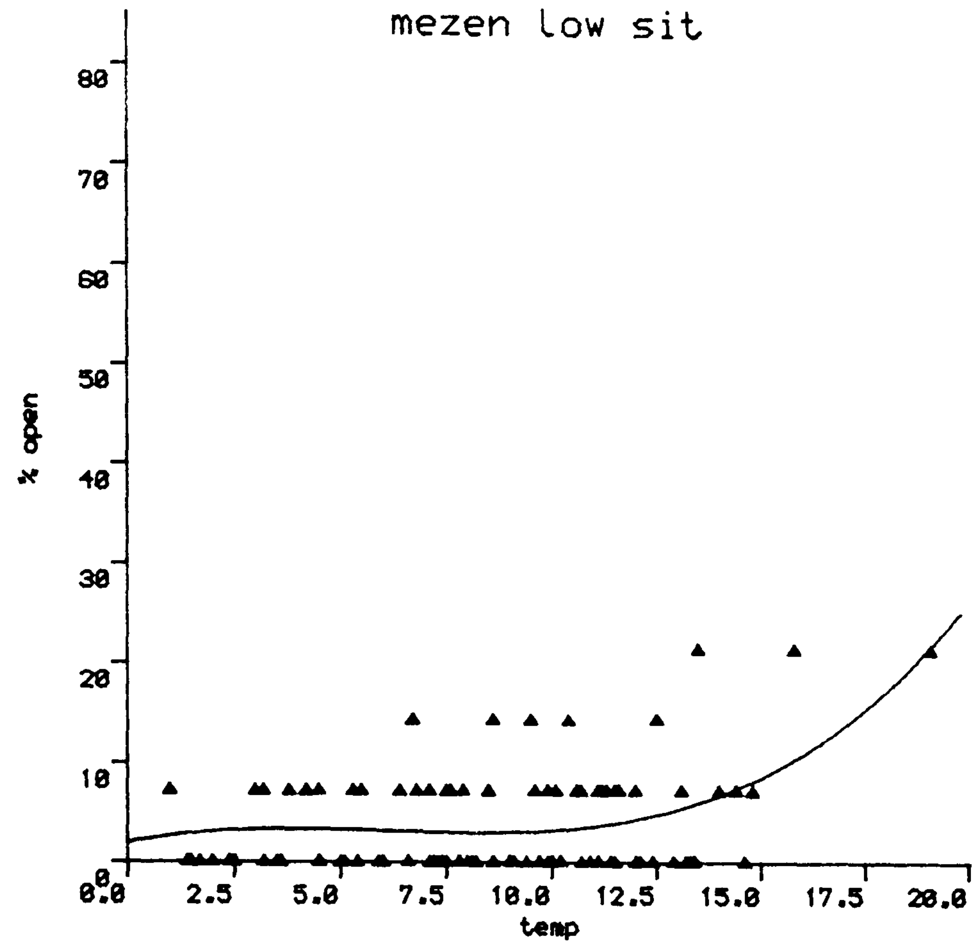


FIGURE A25

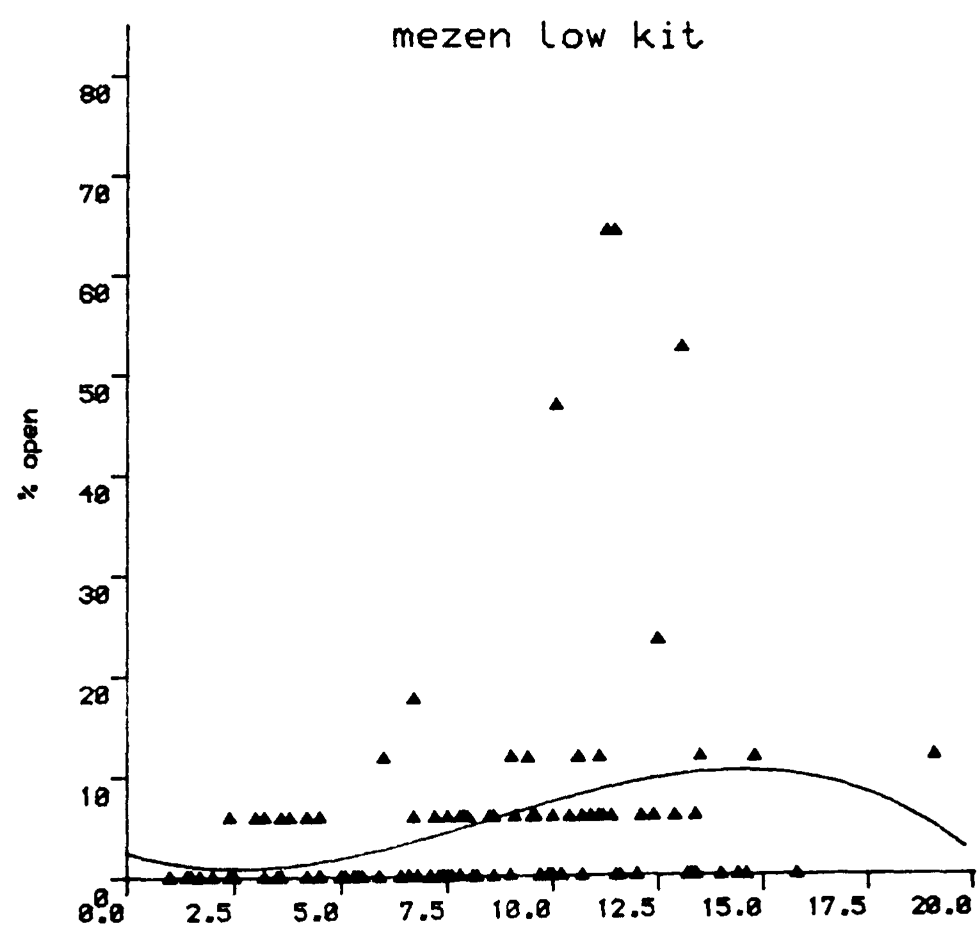


FIGURE A26

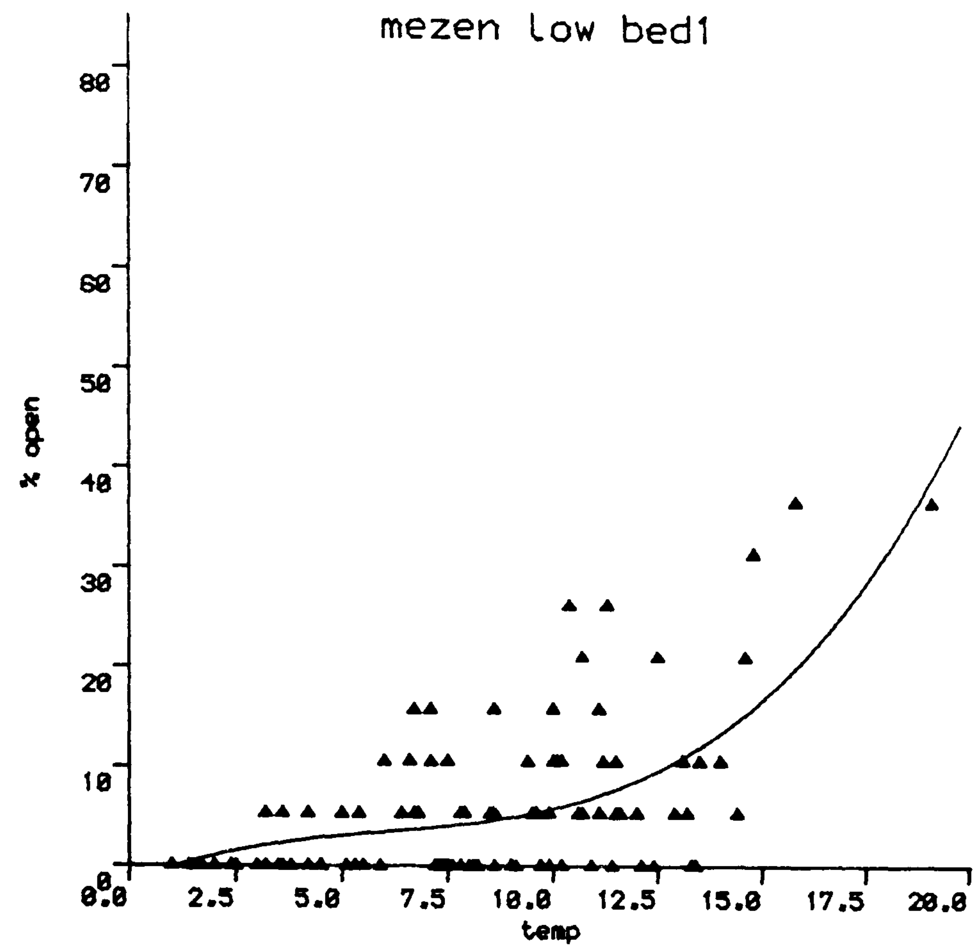
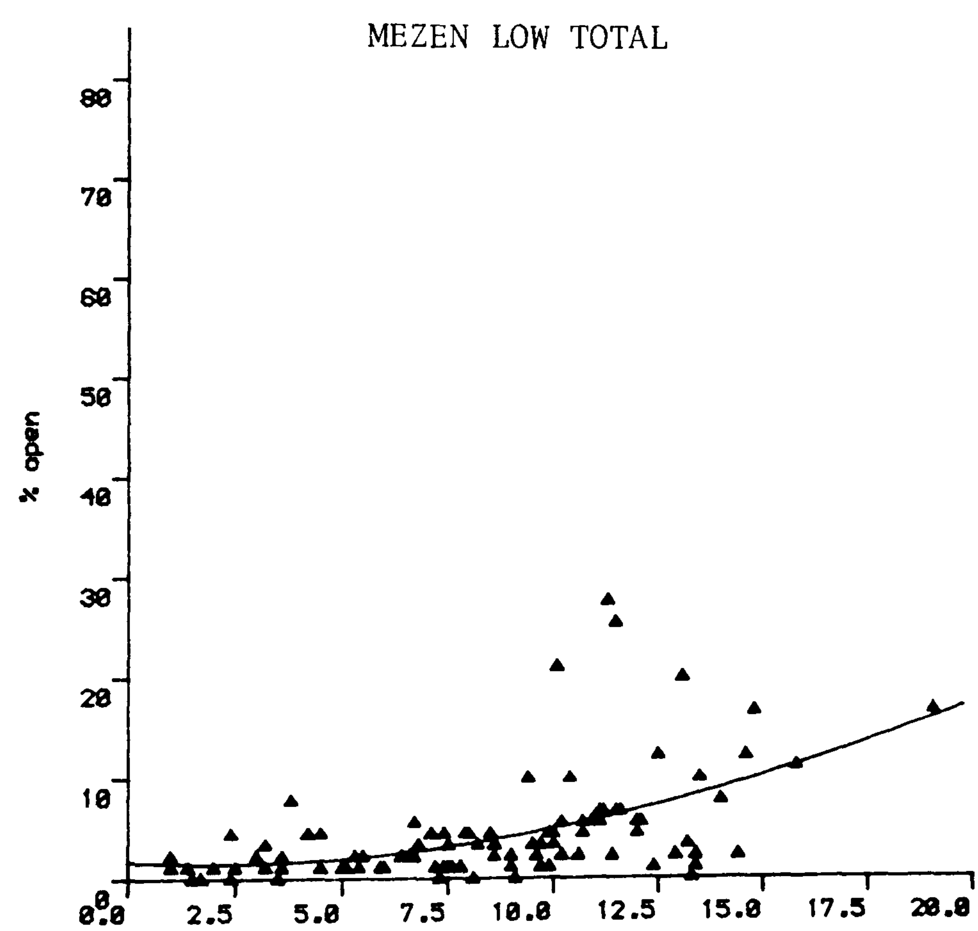
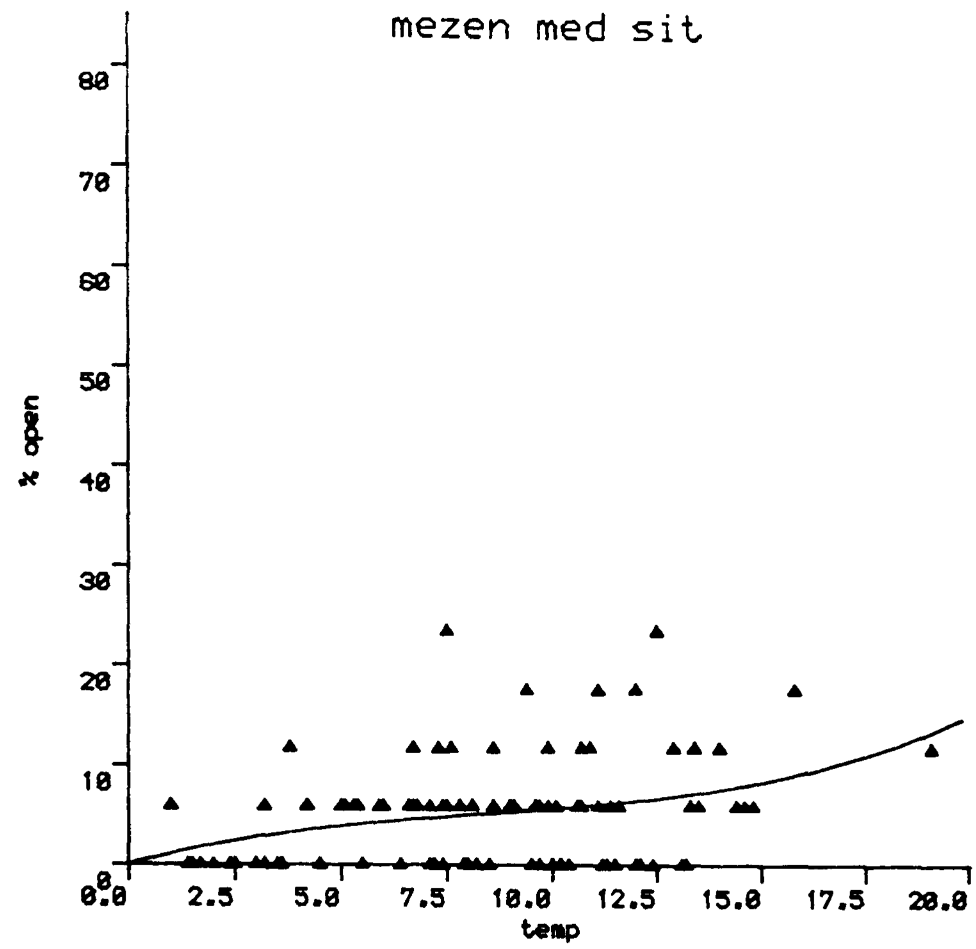


FIGURE A27



FIGURES A28-A31. Relationships between temperature and window opening in the medium group at Mezen

FIGURE A28



FIGURES A29

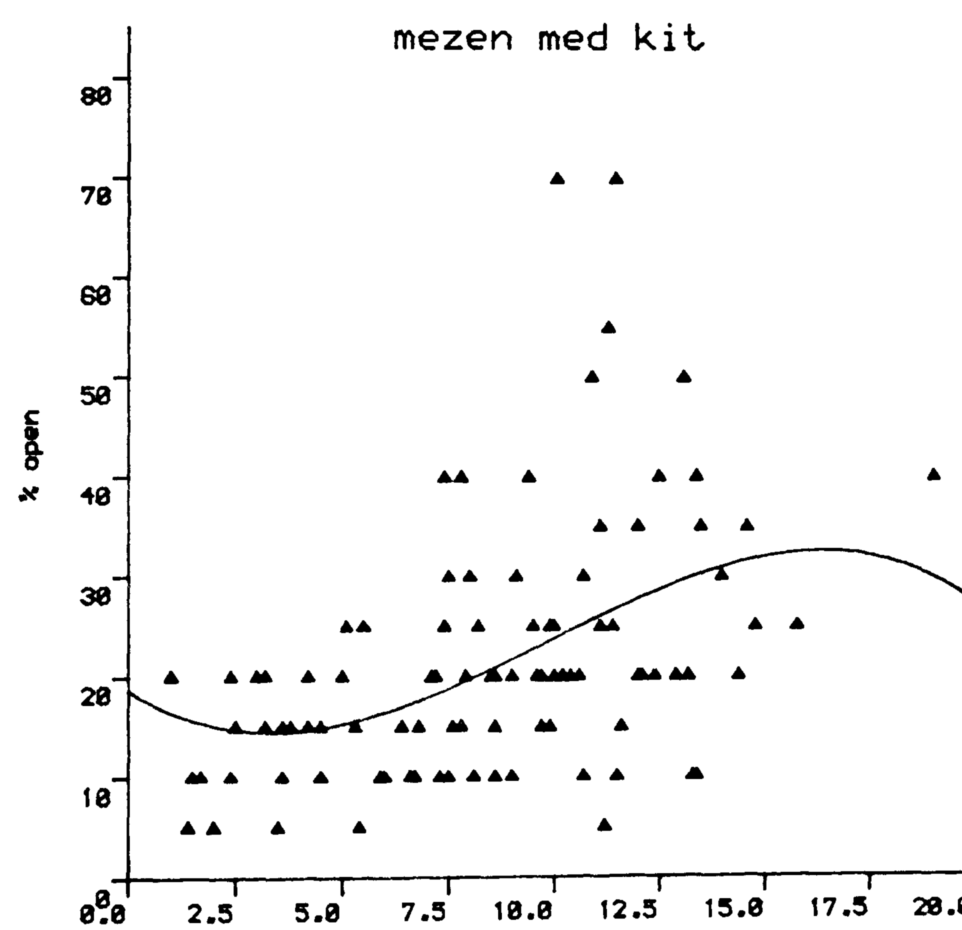


FIGURE A30

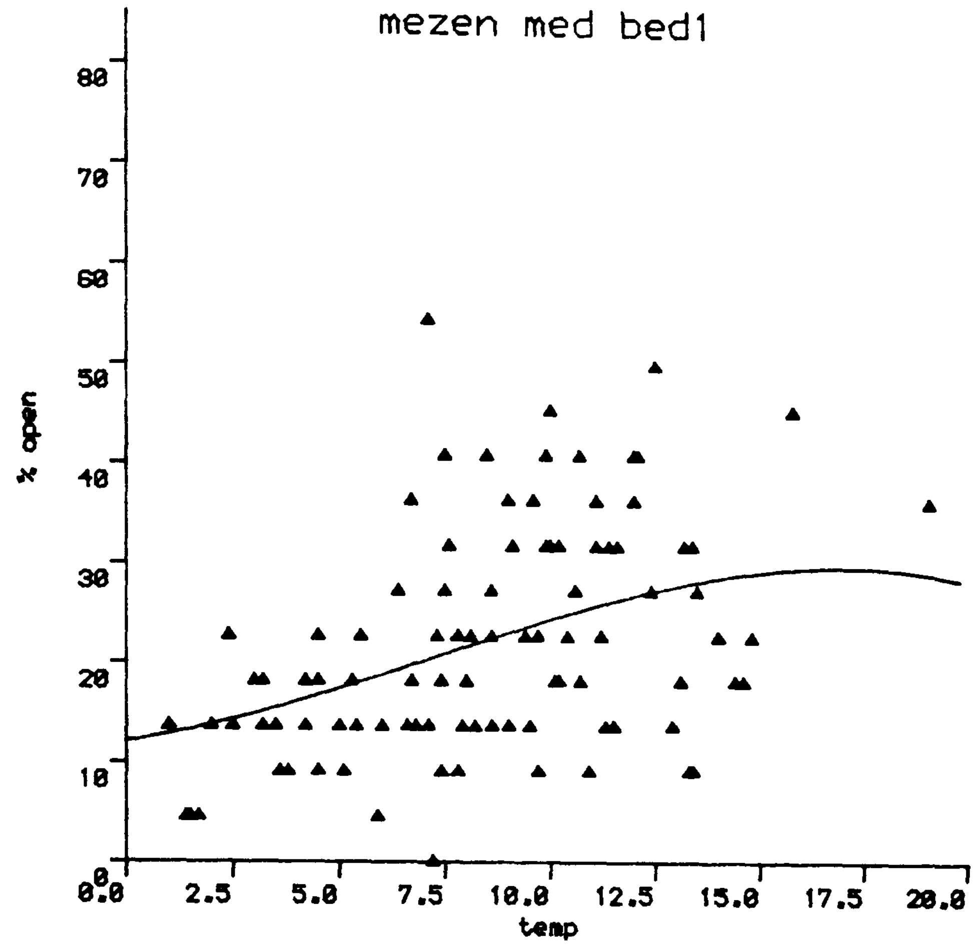
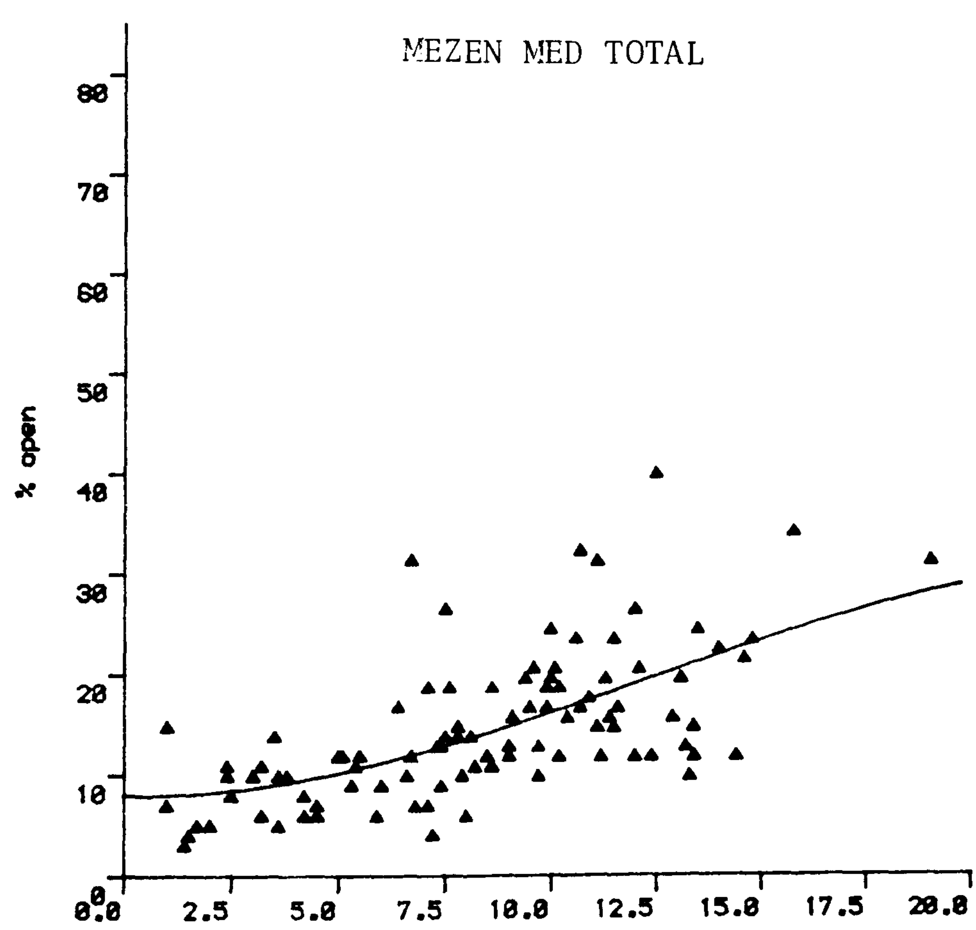


FIGURE A31



FIGURES A32-A35. Relationships between temperature and window opening in the high group at Mezen

FIGURE A32

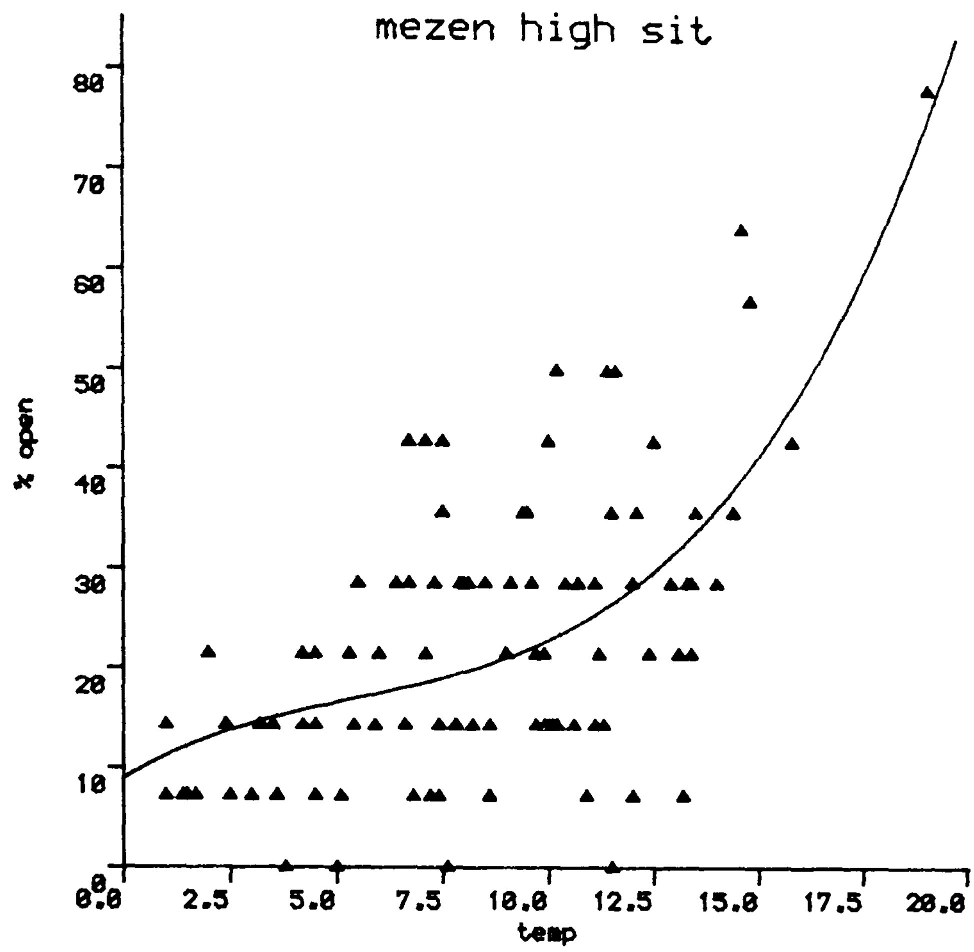


FIGURE A33

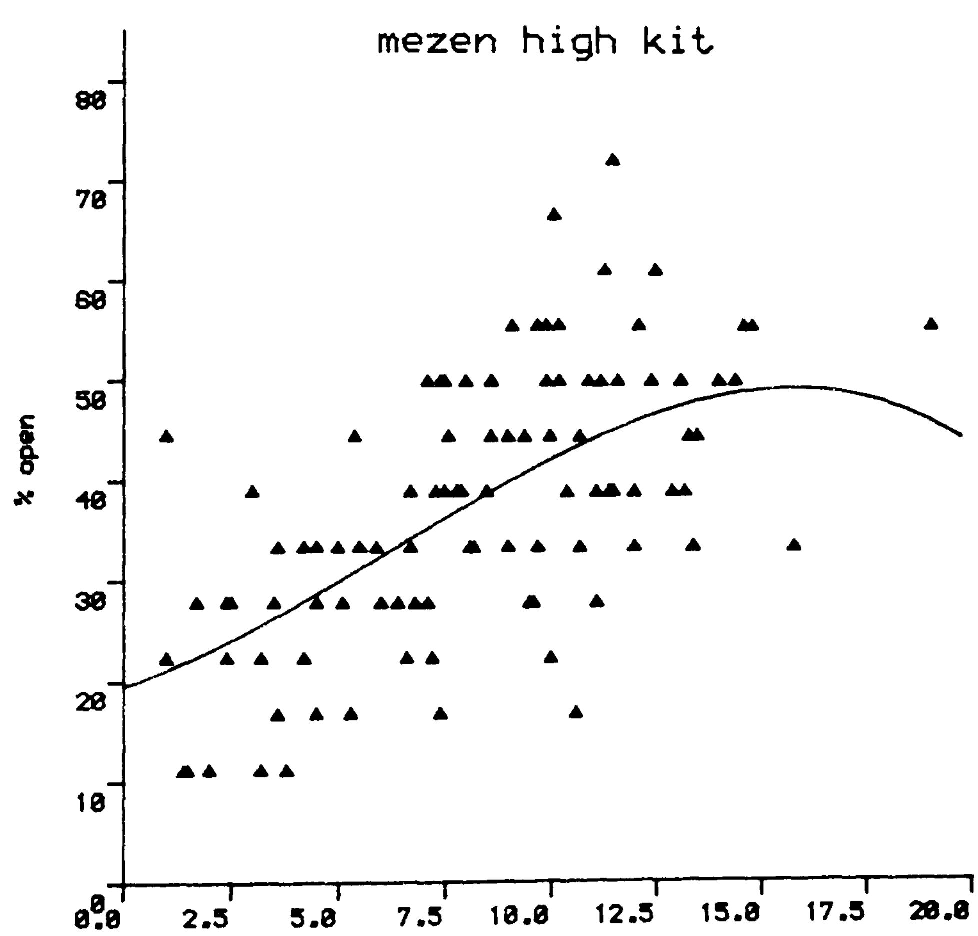


FIGURE A34

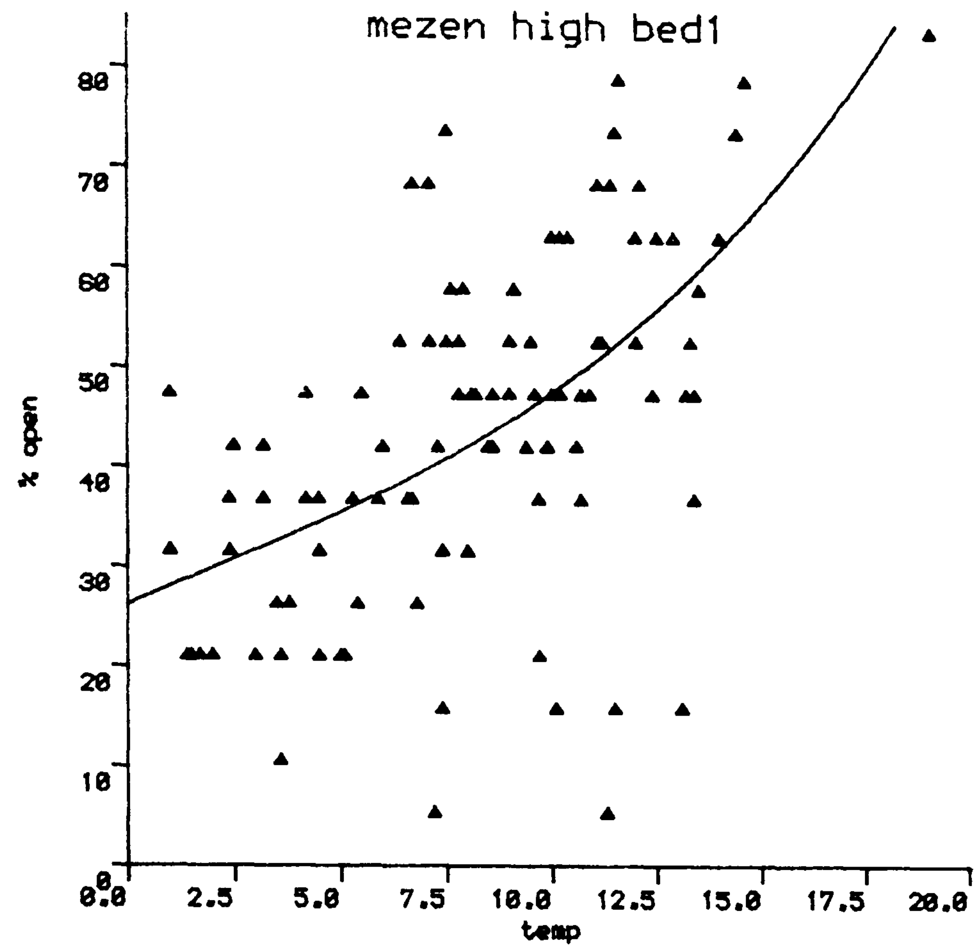
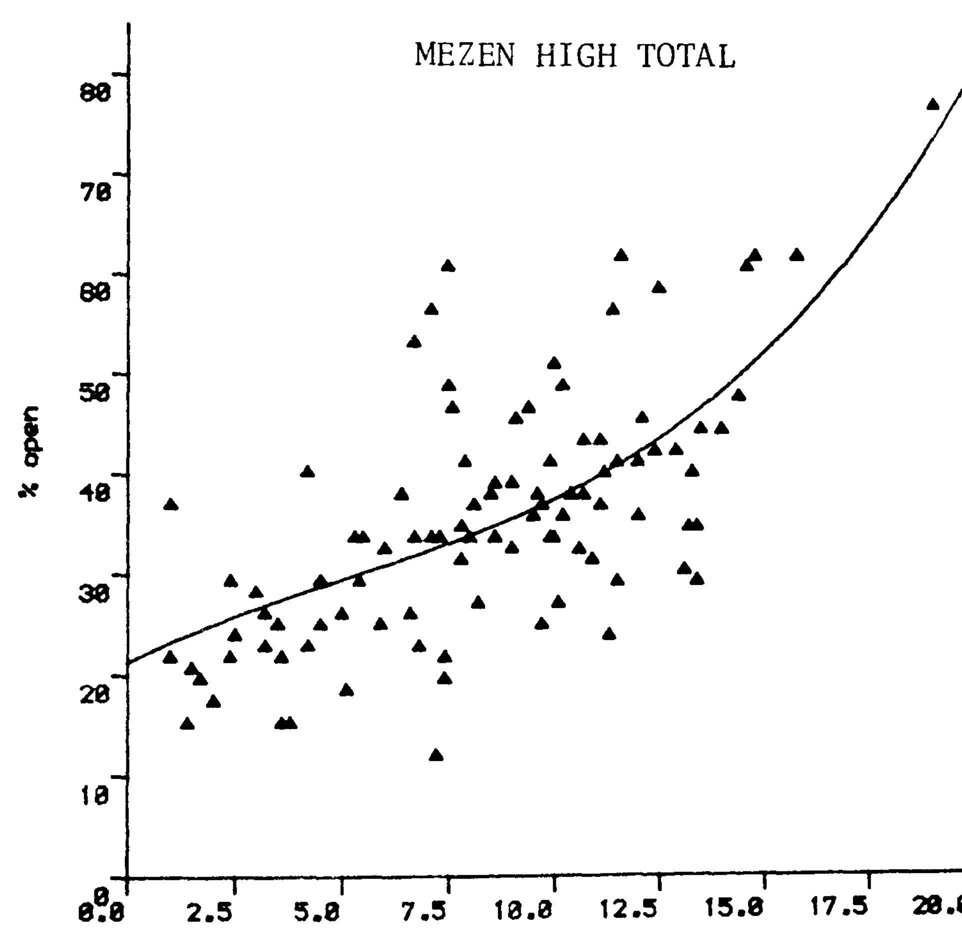


FIGURE A35



FIGURES A36-A39. Relationships between temperature and window opening in all groups at Mezen

FIGURE A36

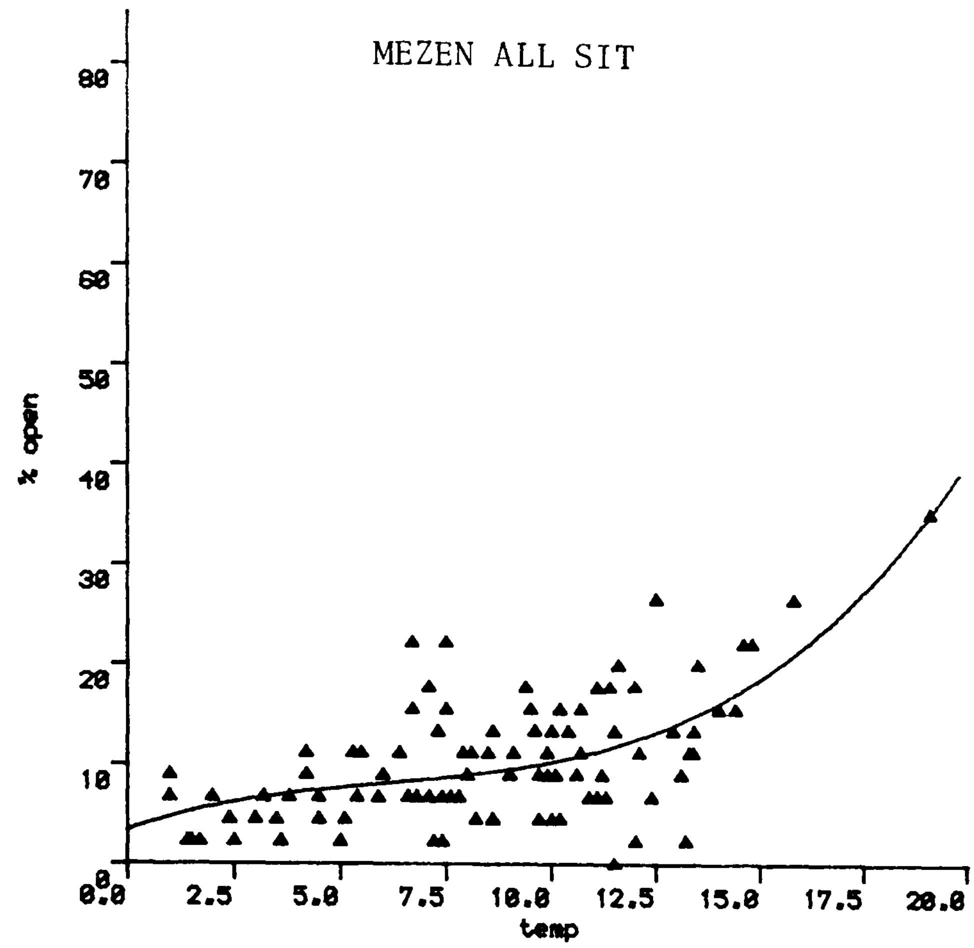


FIGURE A37

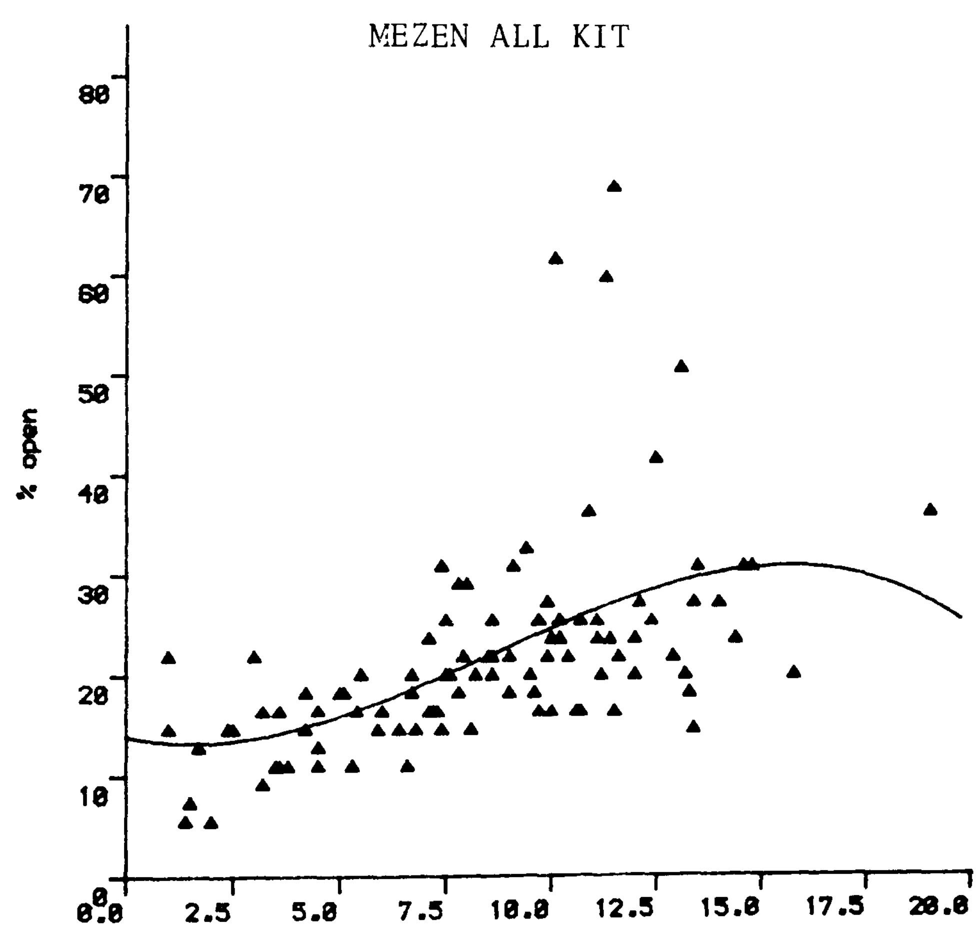


FIGURE A38

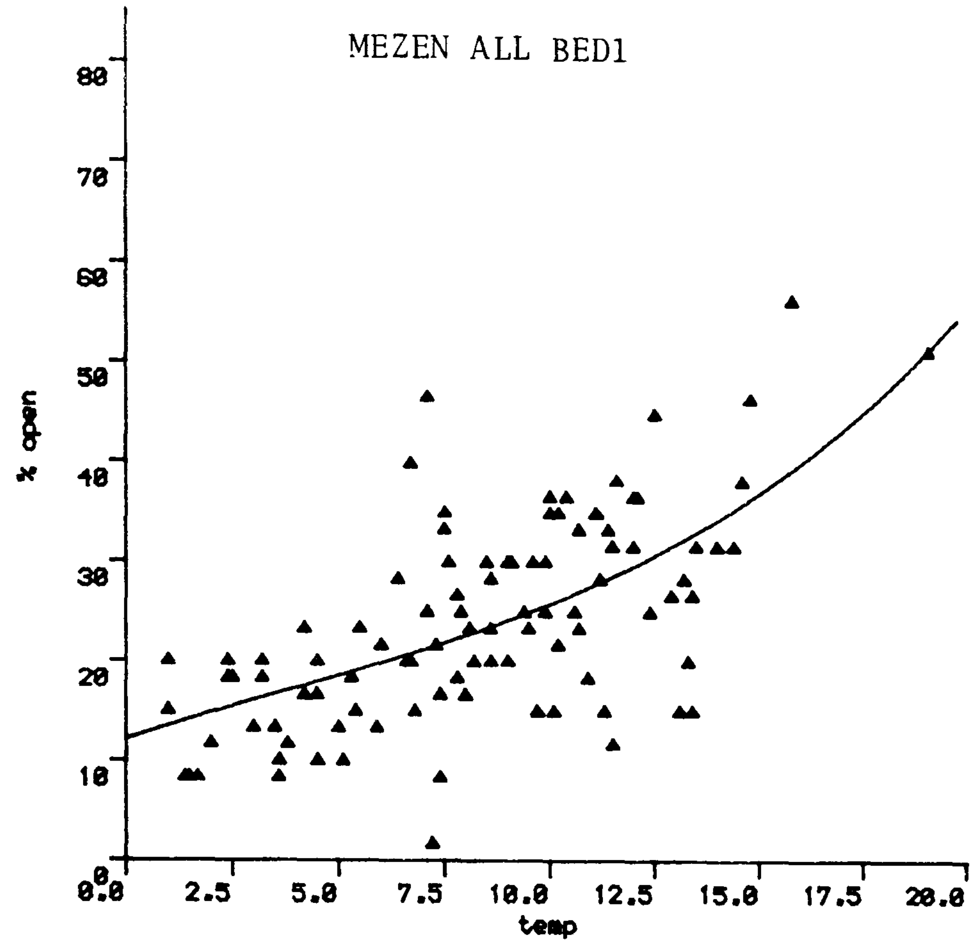
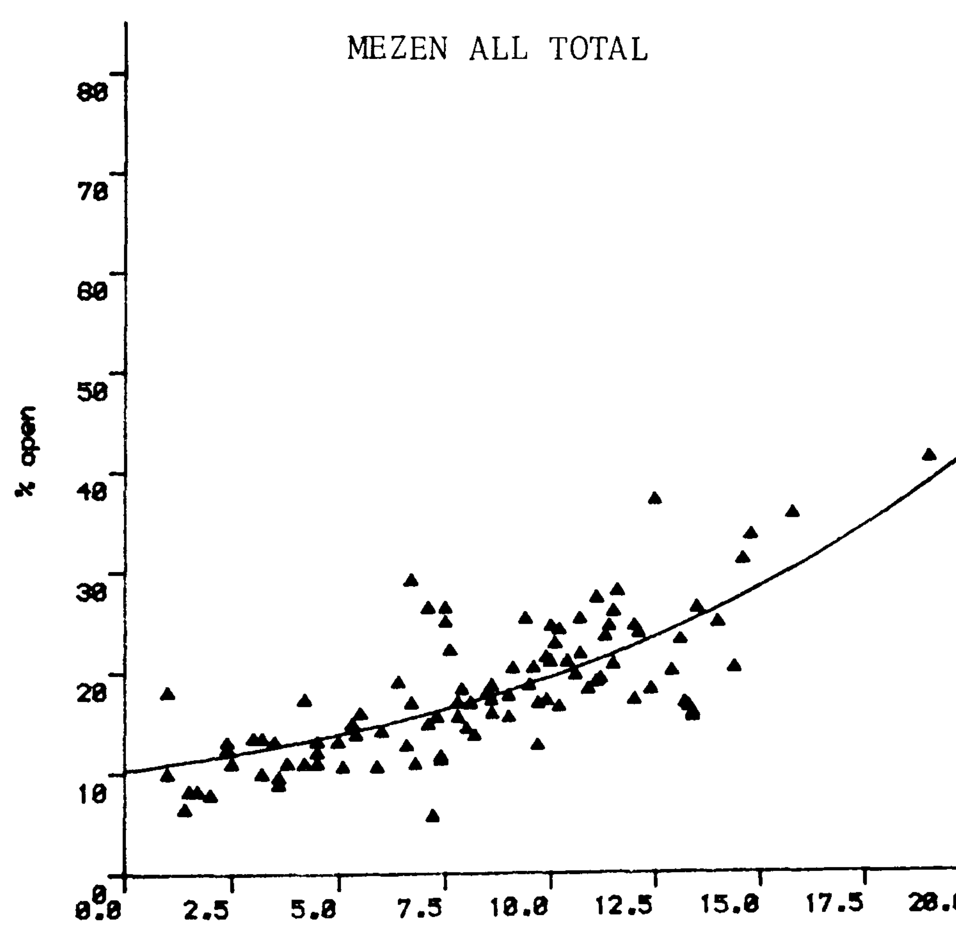


FIGURE A39



FIGURES A40-A43. Relationships between relative humidity and window opening in the low group at Cowley

FIGURE A40

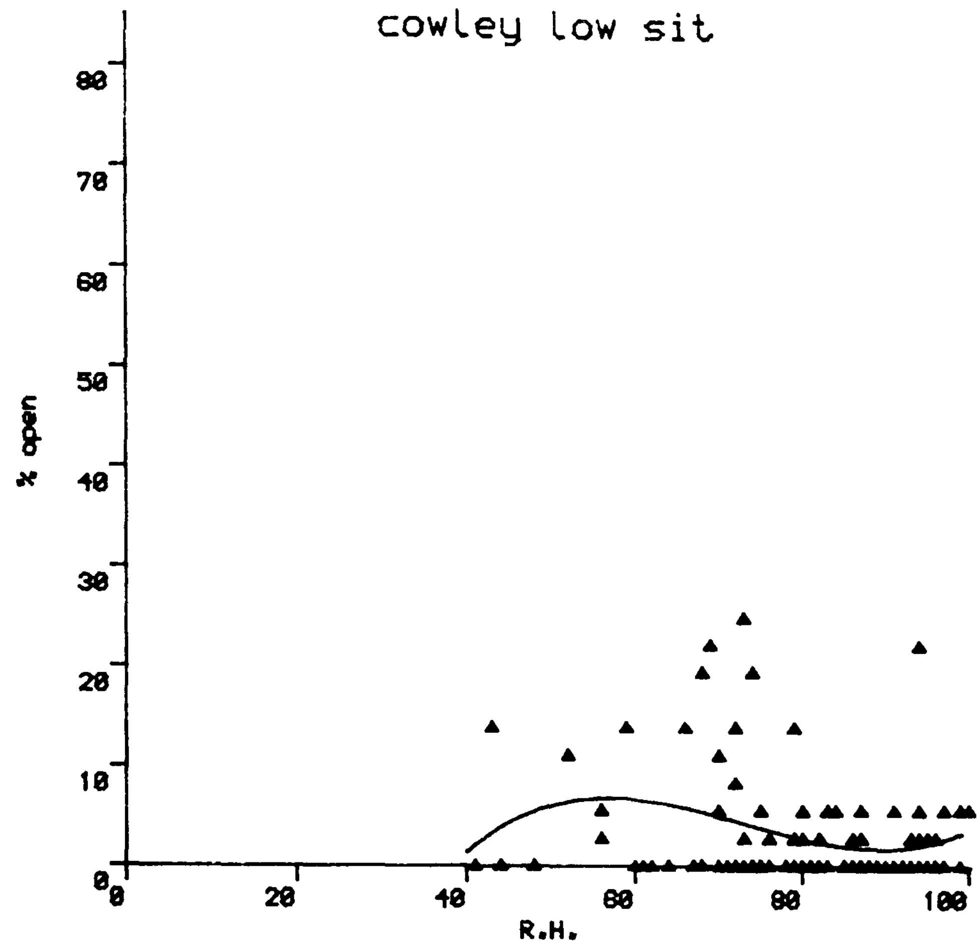


FIGURE A41

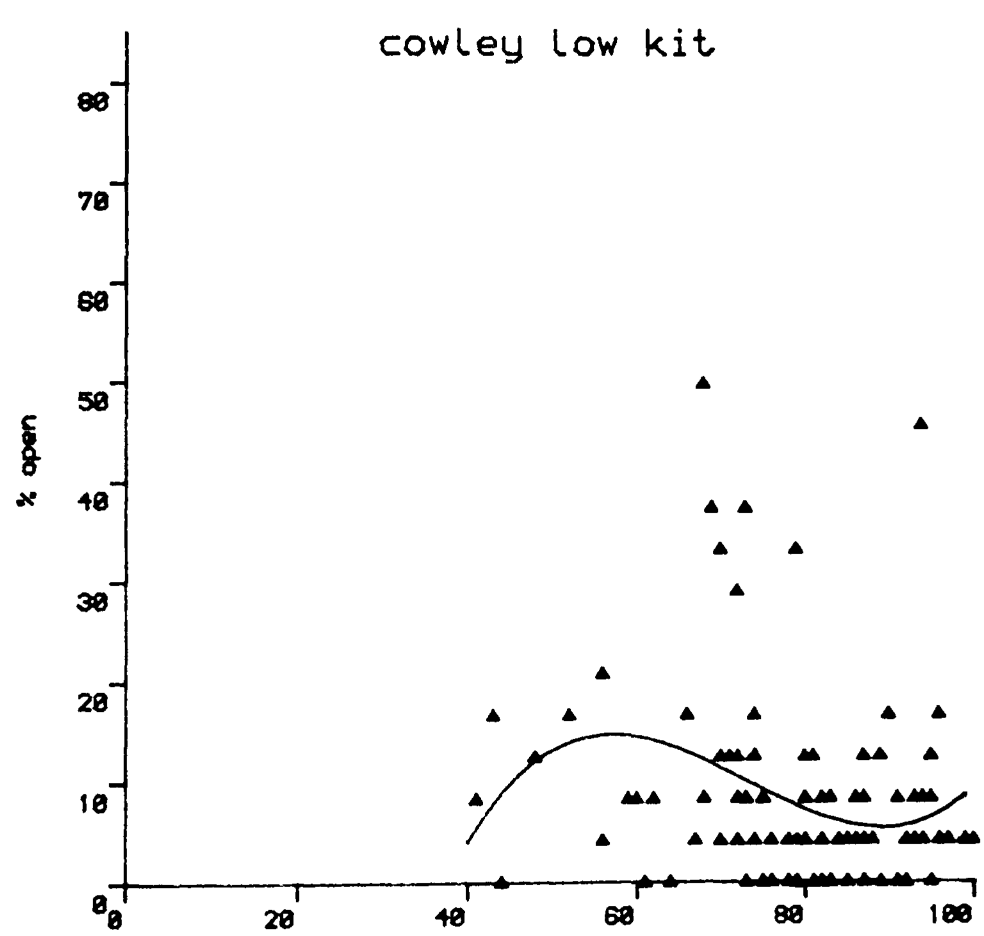


FIGURE A42

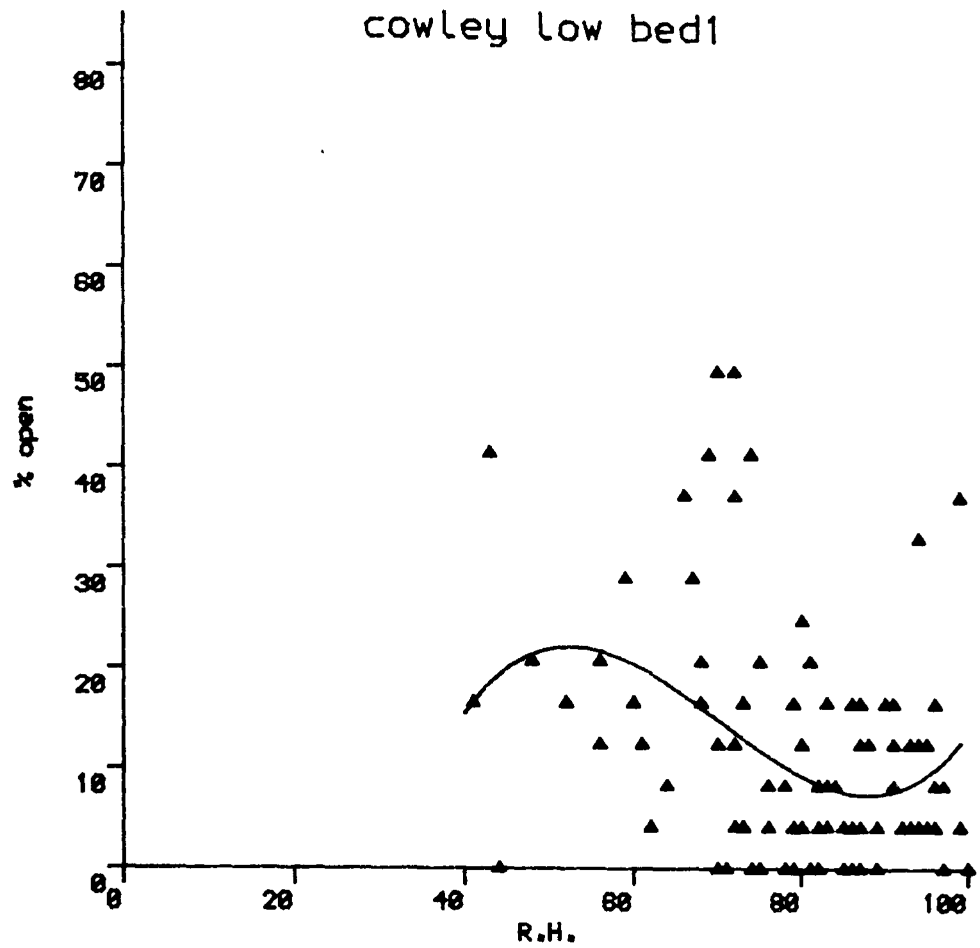
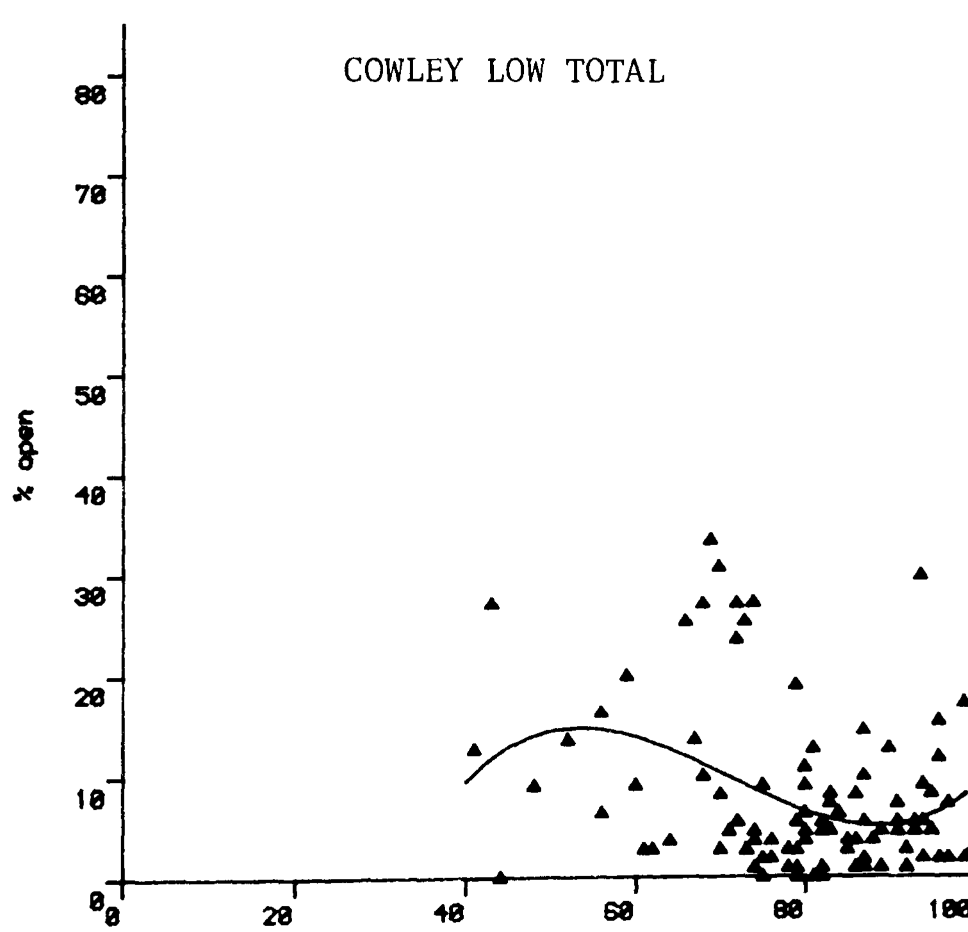


FIGURE A43



FIGURES A44-A47. Relationships between relative humidity and window opening in the medium group at Cowley

FIGURE A44

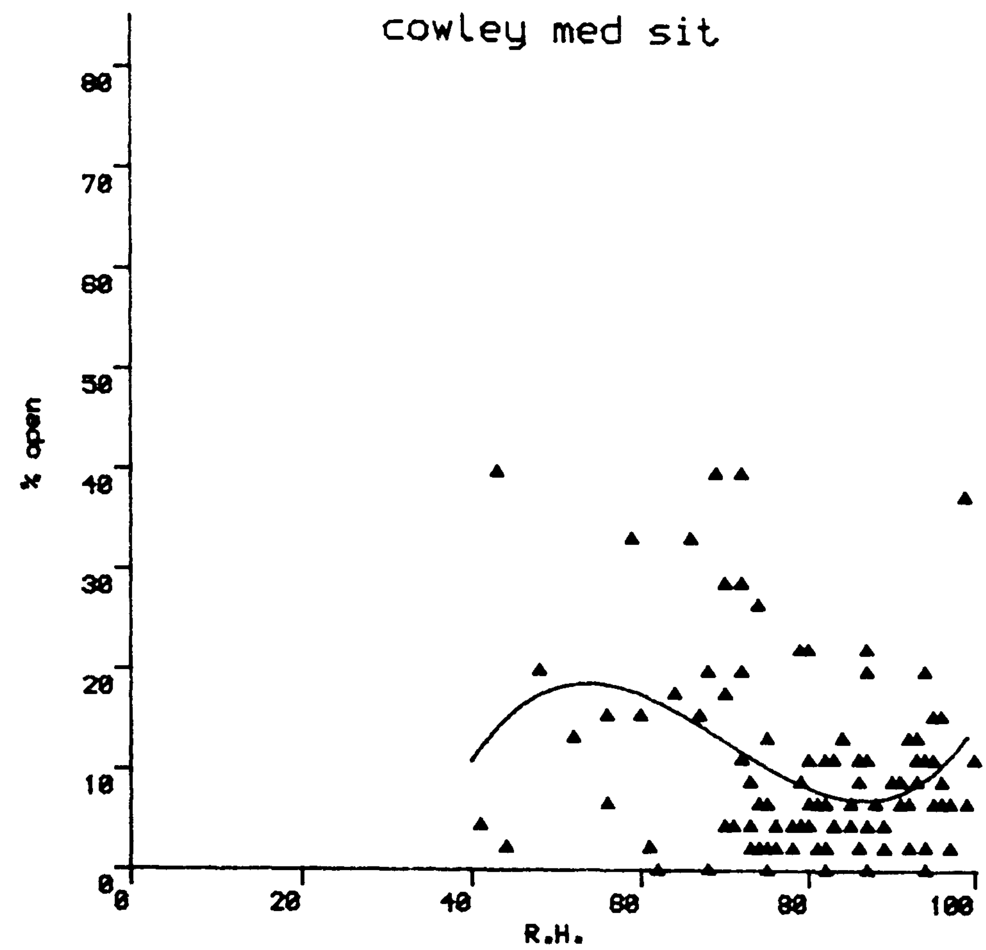


FIGURE A45

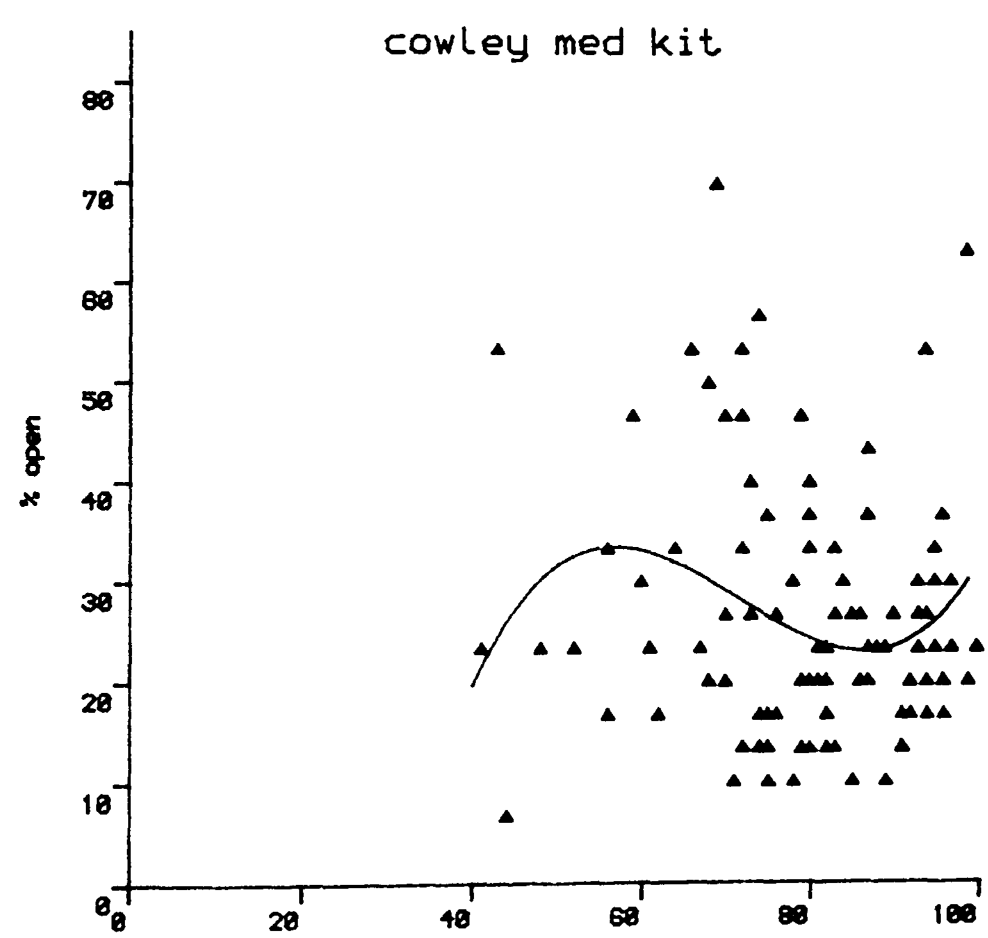


FIGURE A46

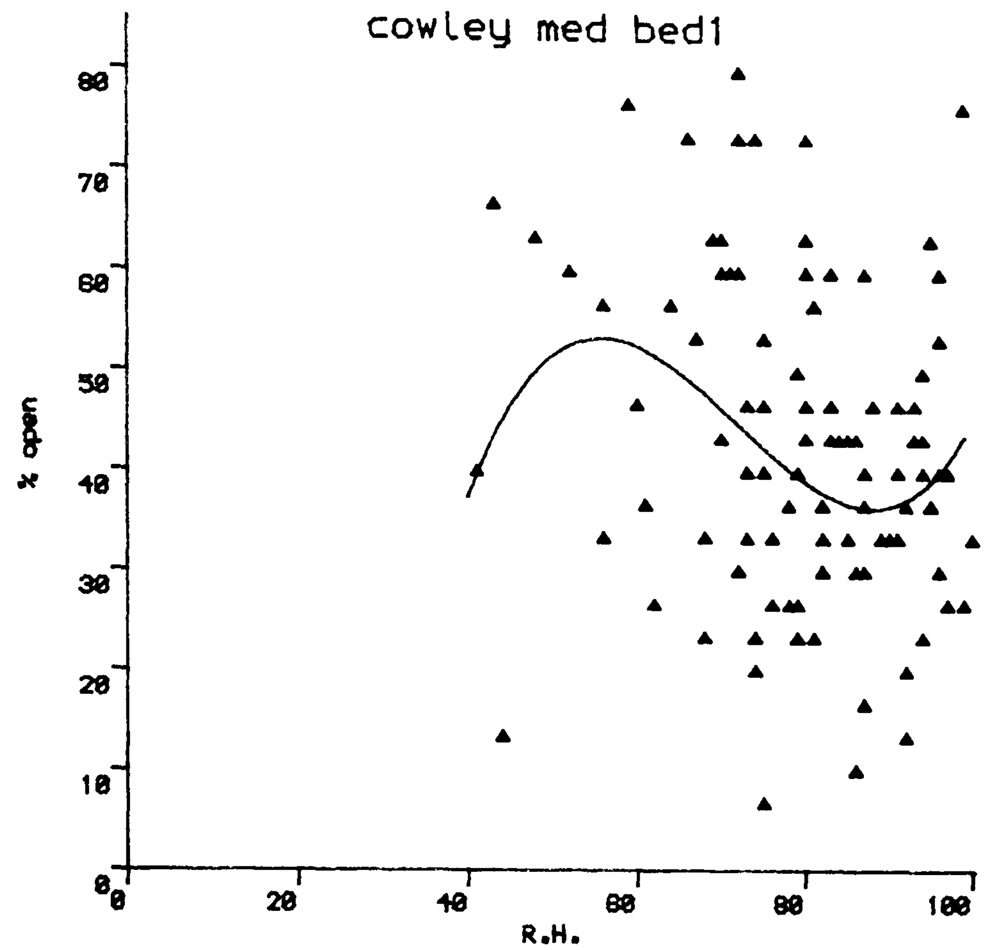
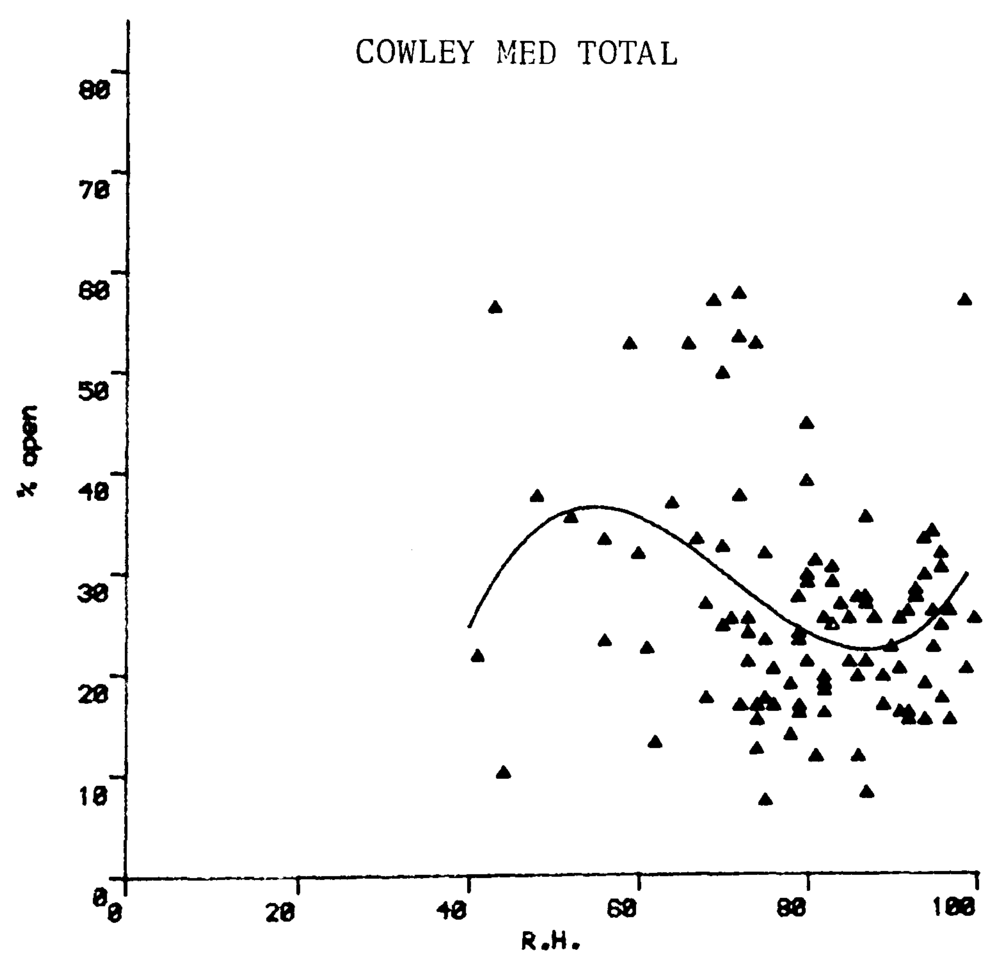
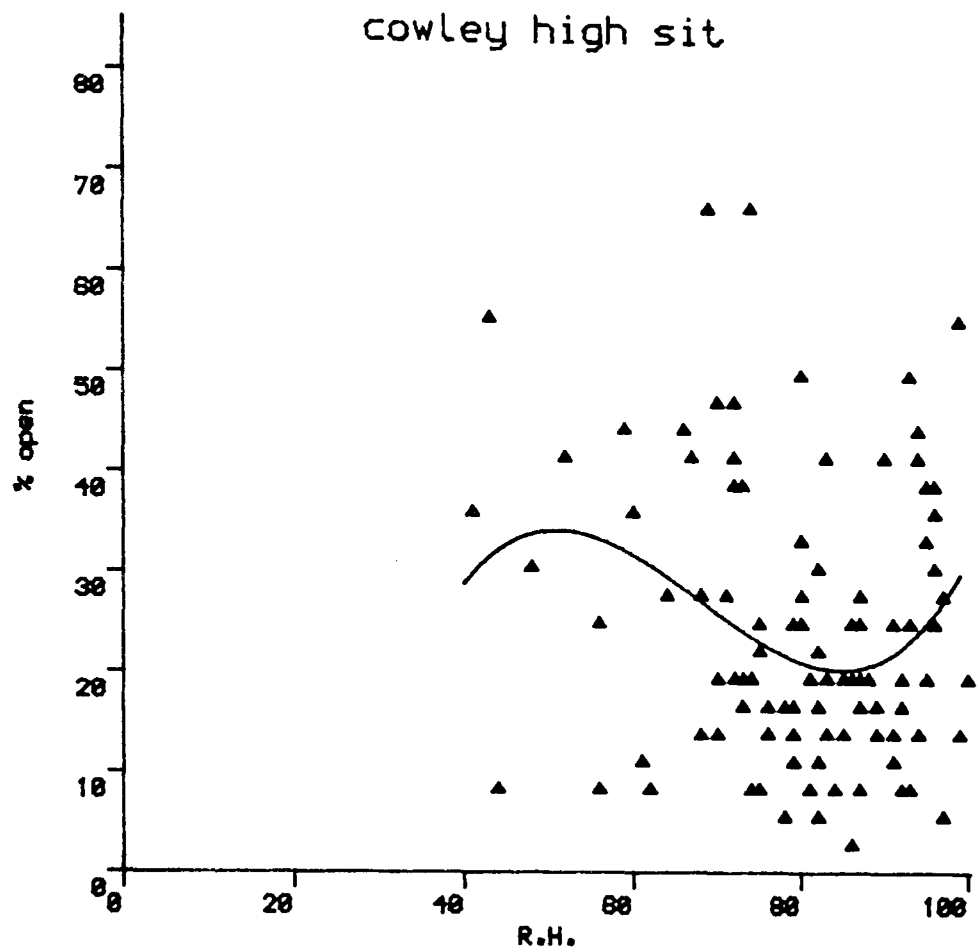


FIGURE A47



FIGURES A48-A51. Relationships between relative humidity and window opening in the high group at Cowley

FIGURE A48



FIGUREA A49

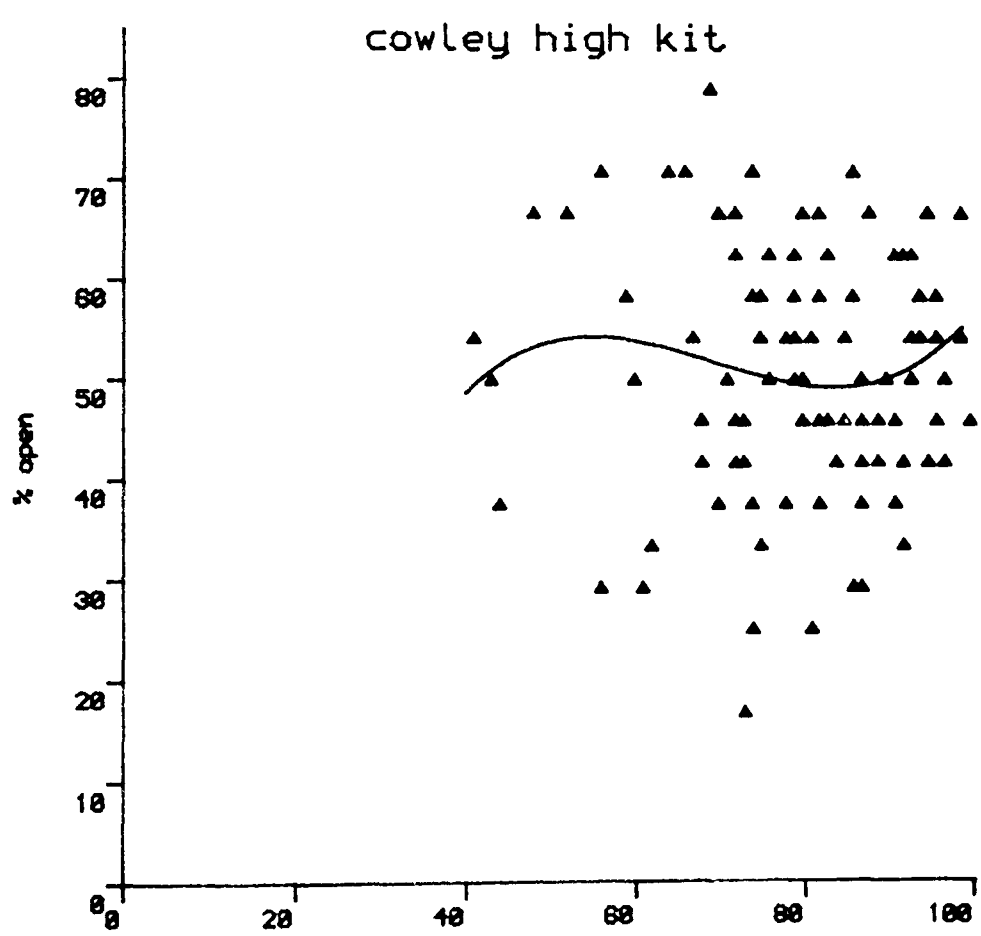


FIGURE A50

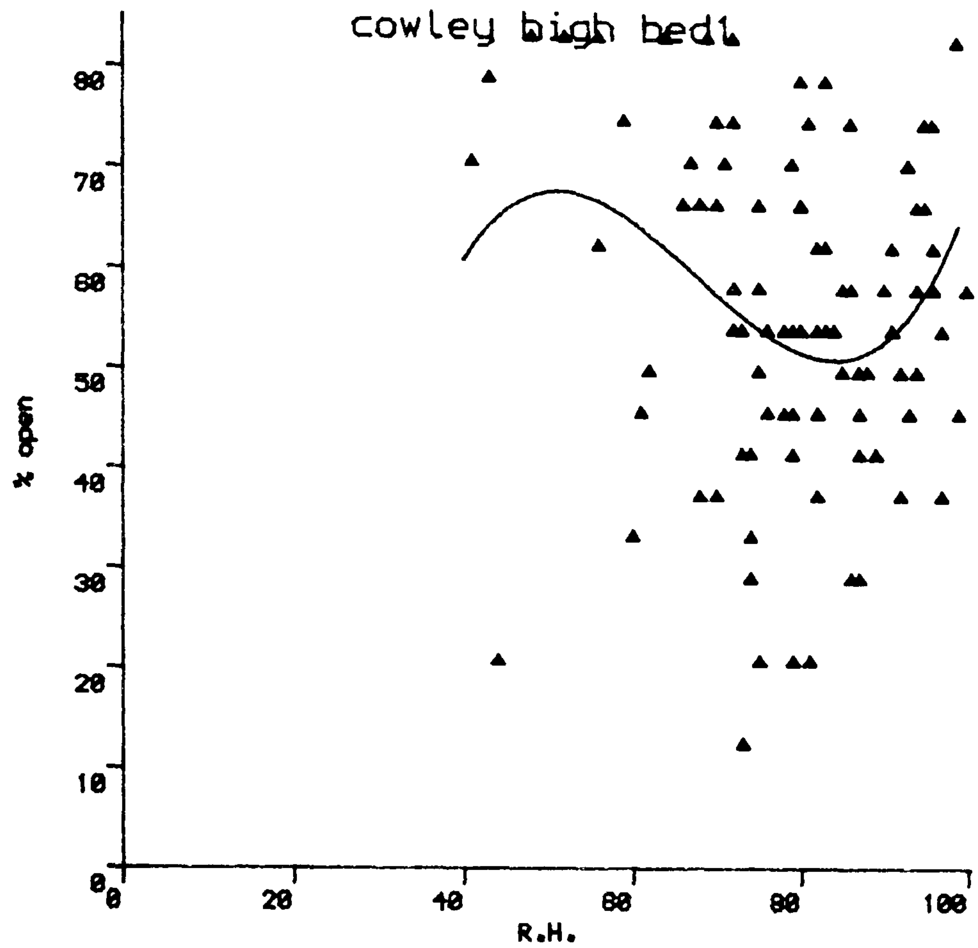
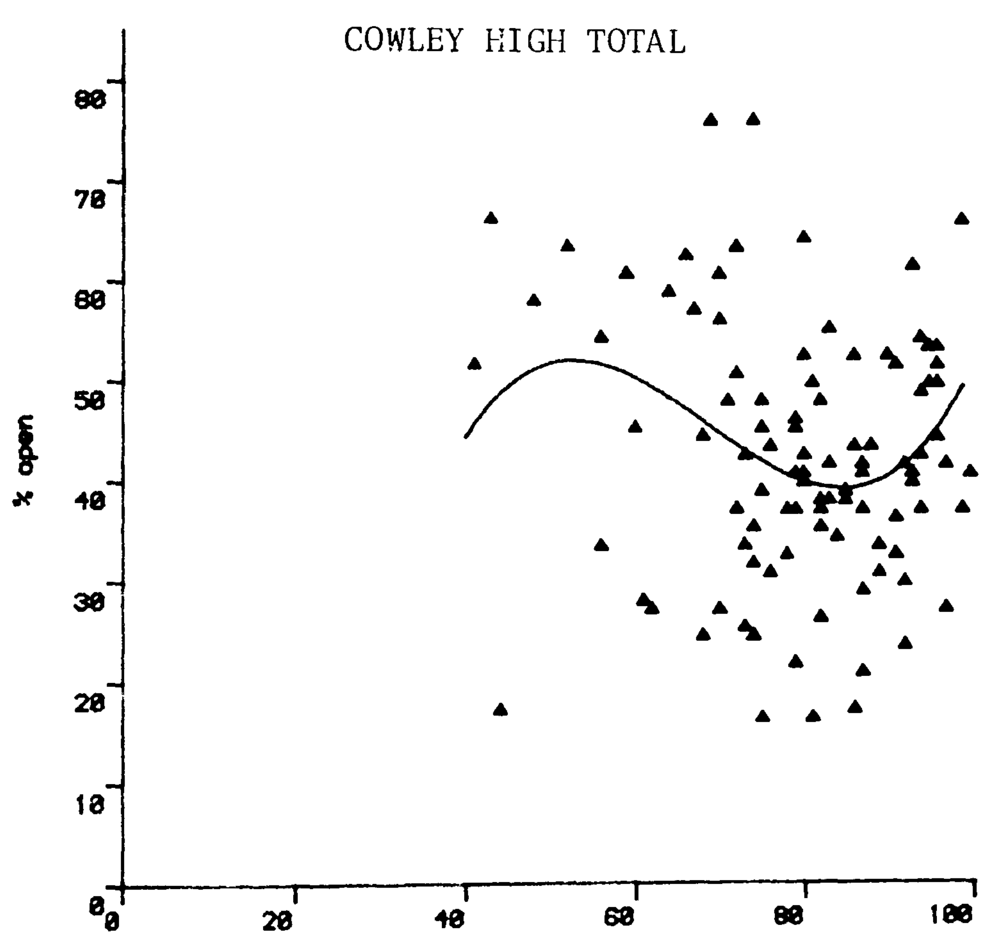


FIGURE A51



FIGURES A52-A55. Relationships between relative humidity and window opening in all groups at Cowley

FIGURE A52

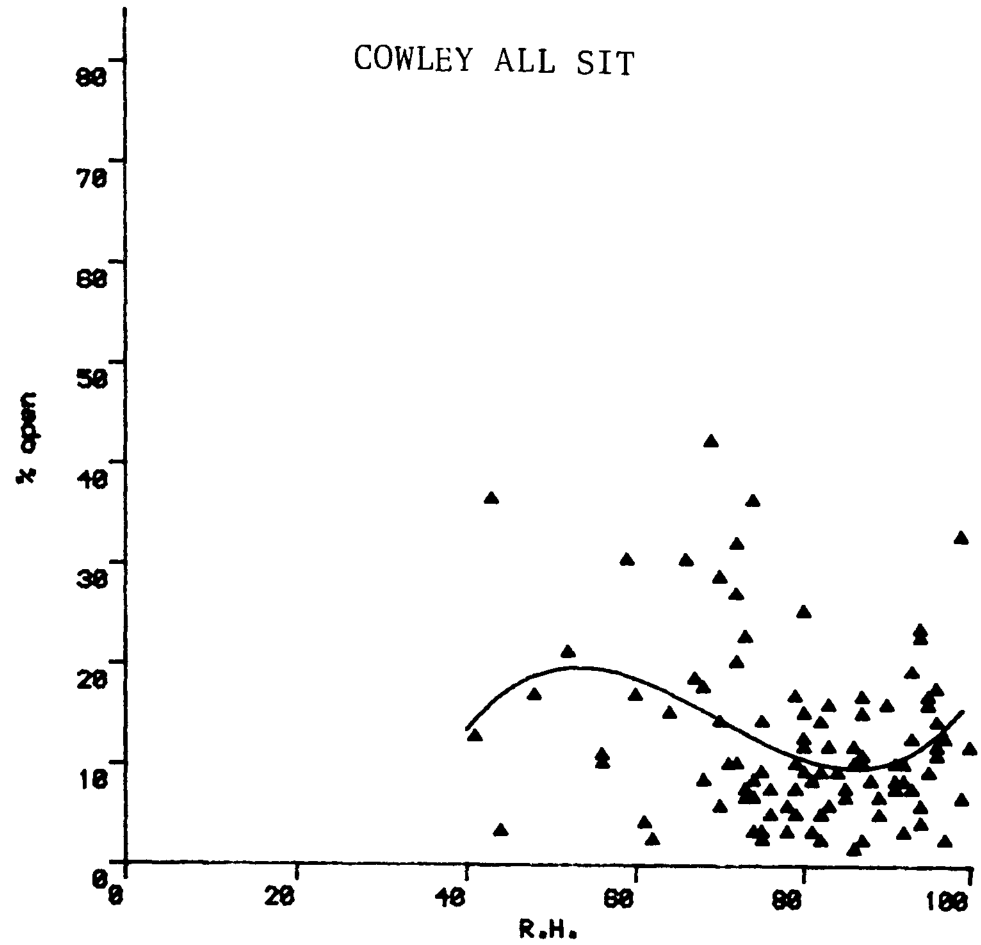


FIGURE A53

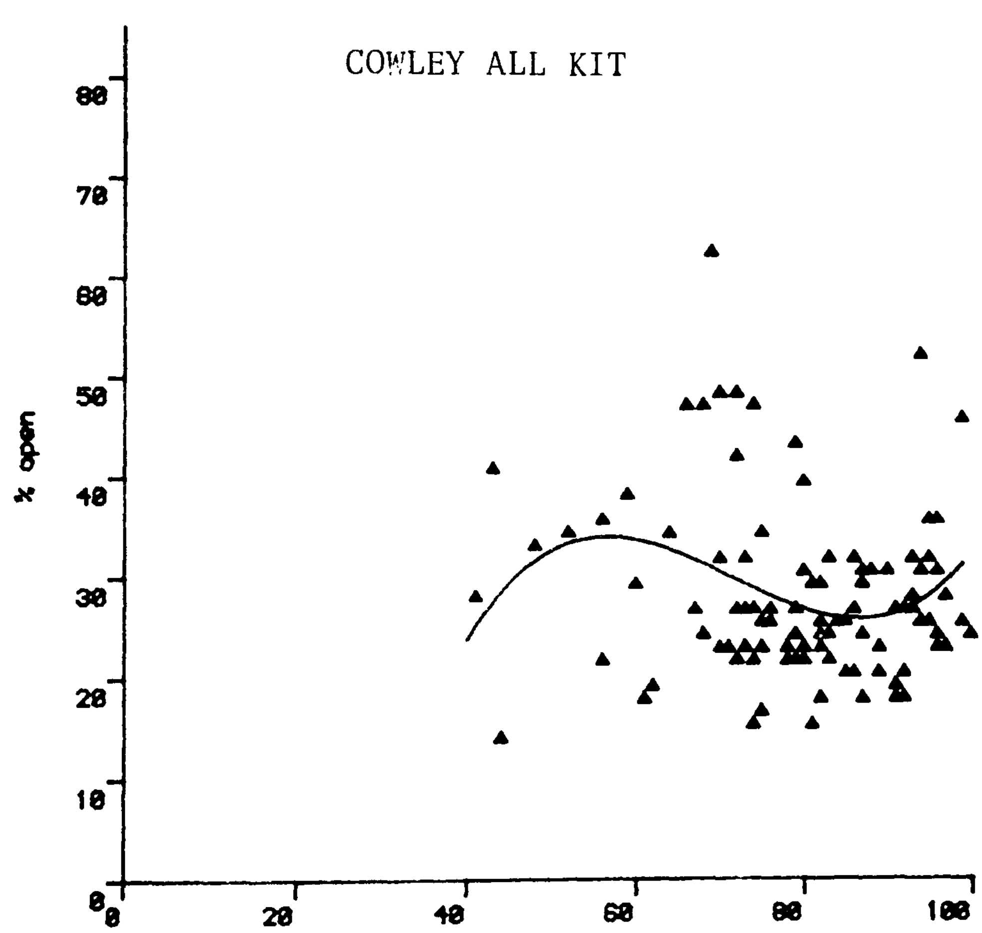


FIGURE A54

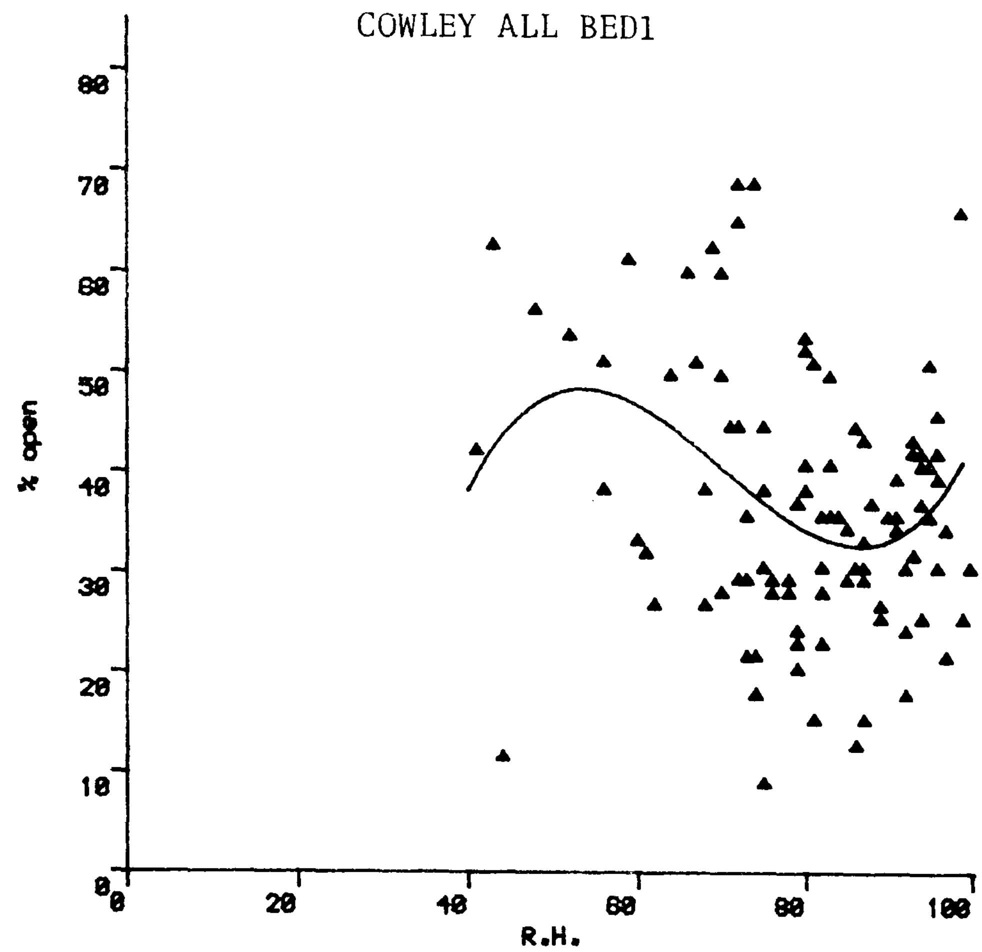
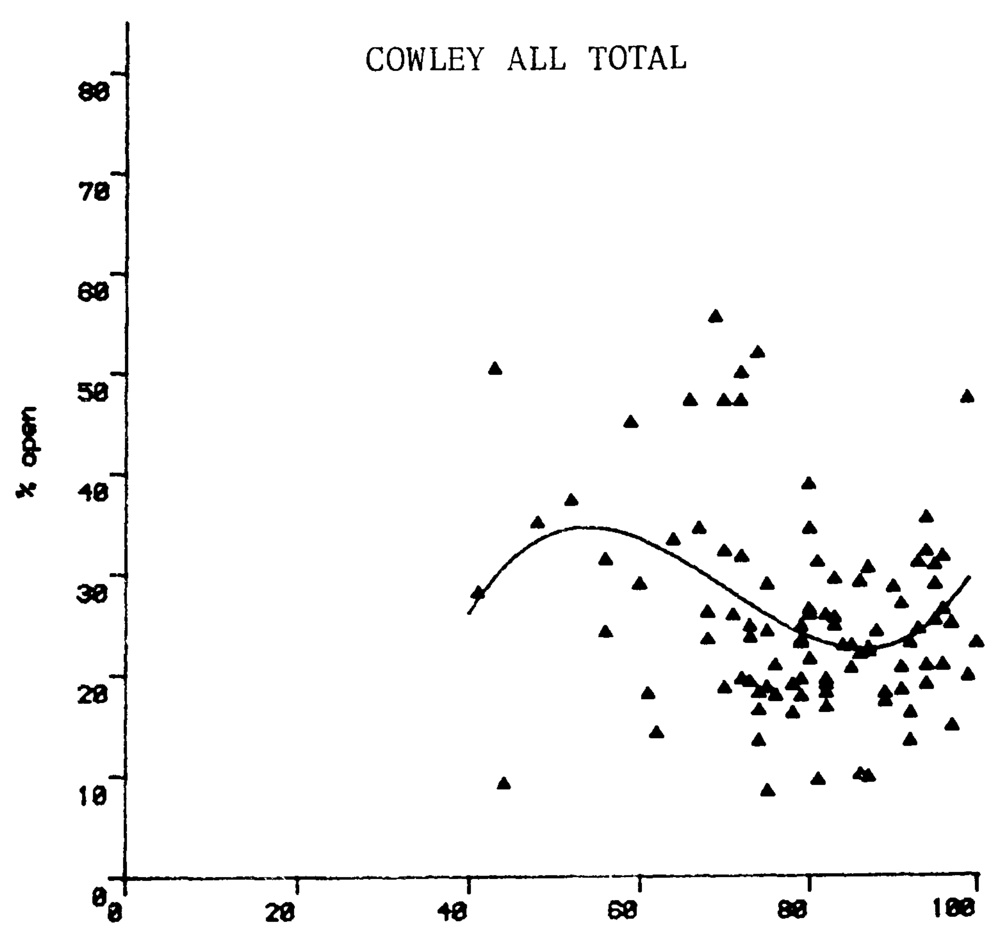


FIGURE A55



FIGURES A56-A59. Relationships between relative humidity and window opening in the low group at Mezen

FIGURE A56

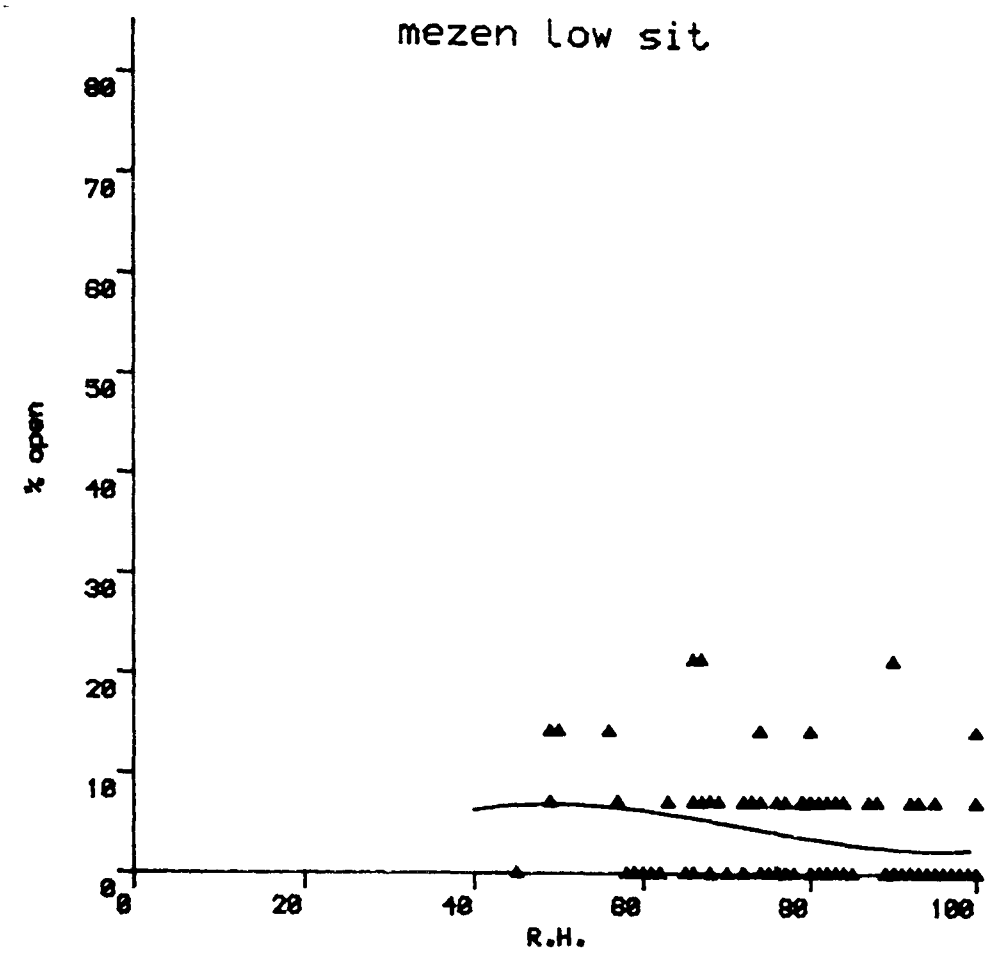


FIGURE A57

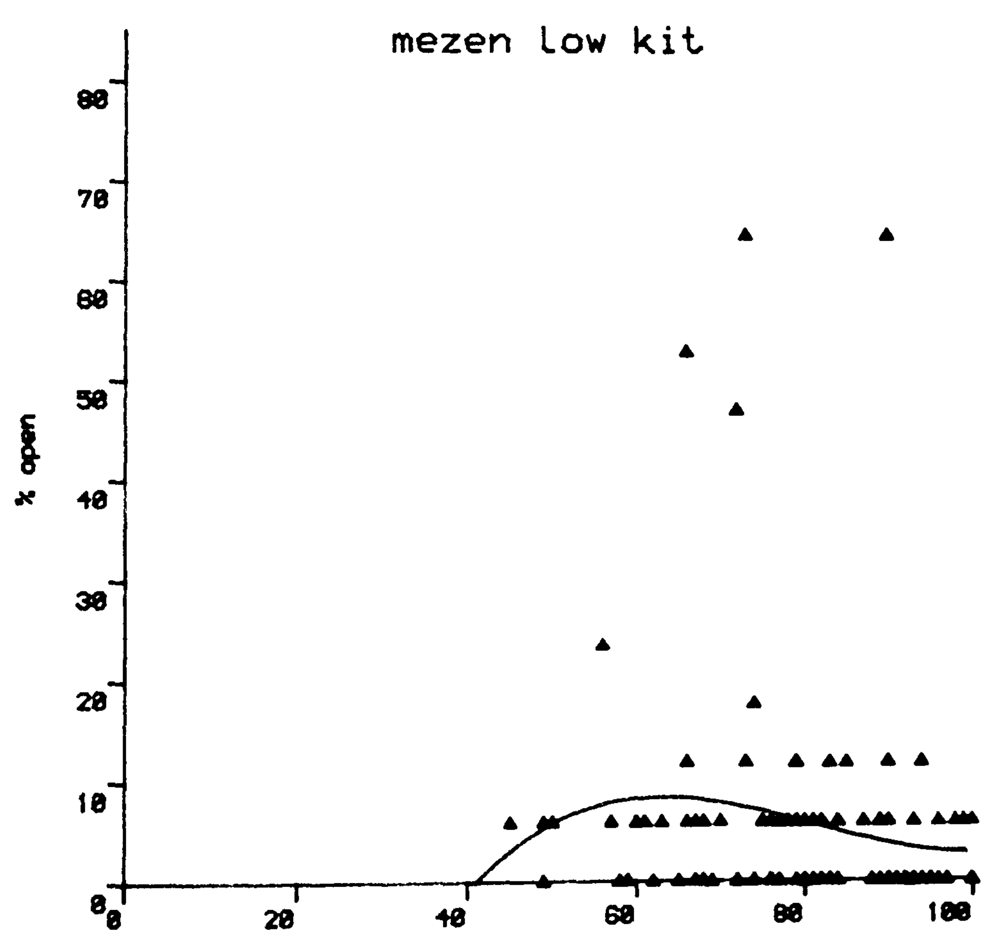


FIGURE A58

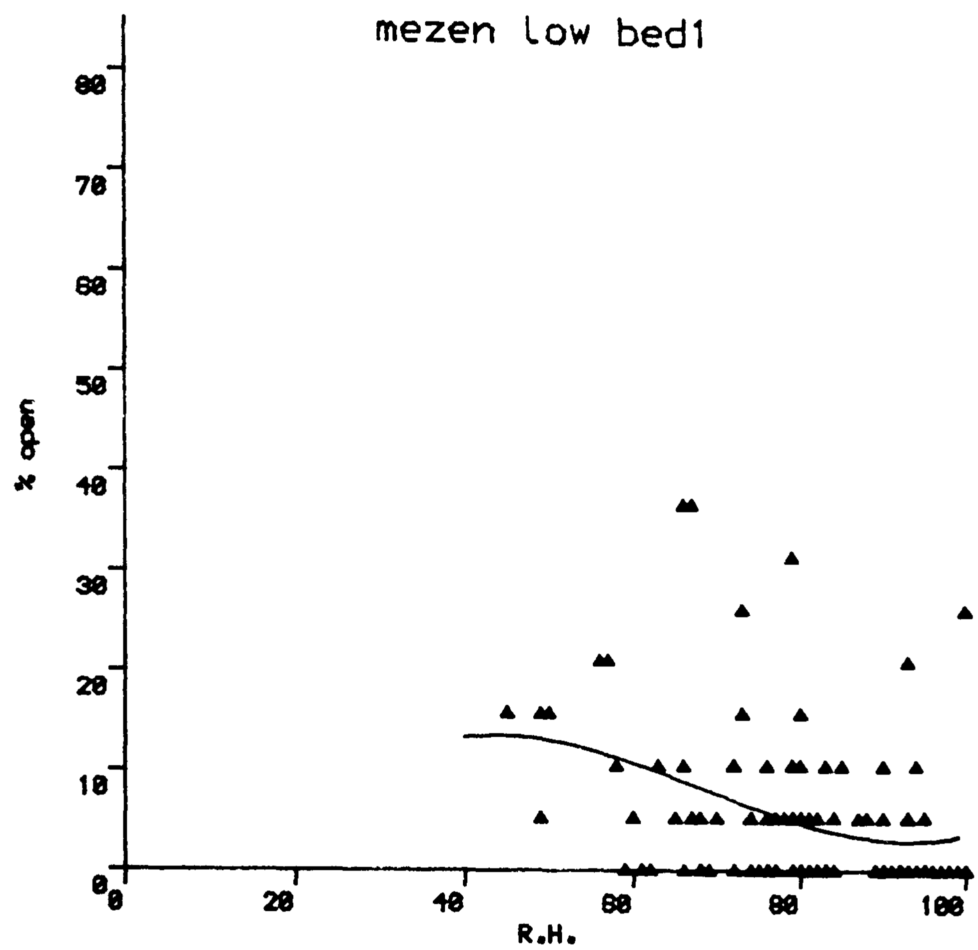
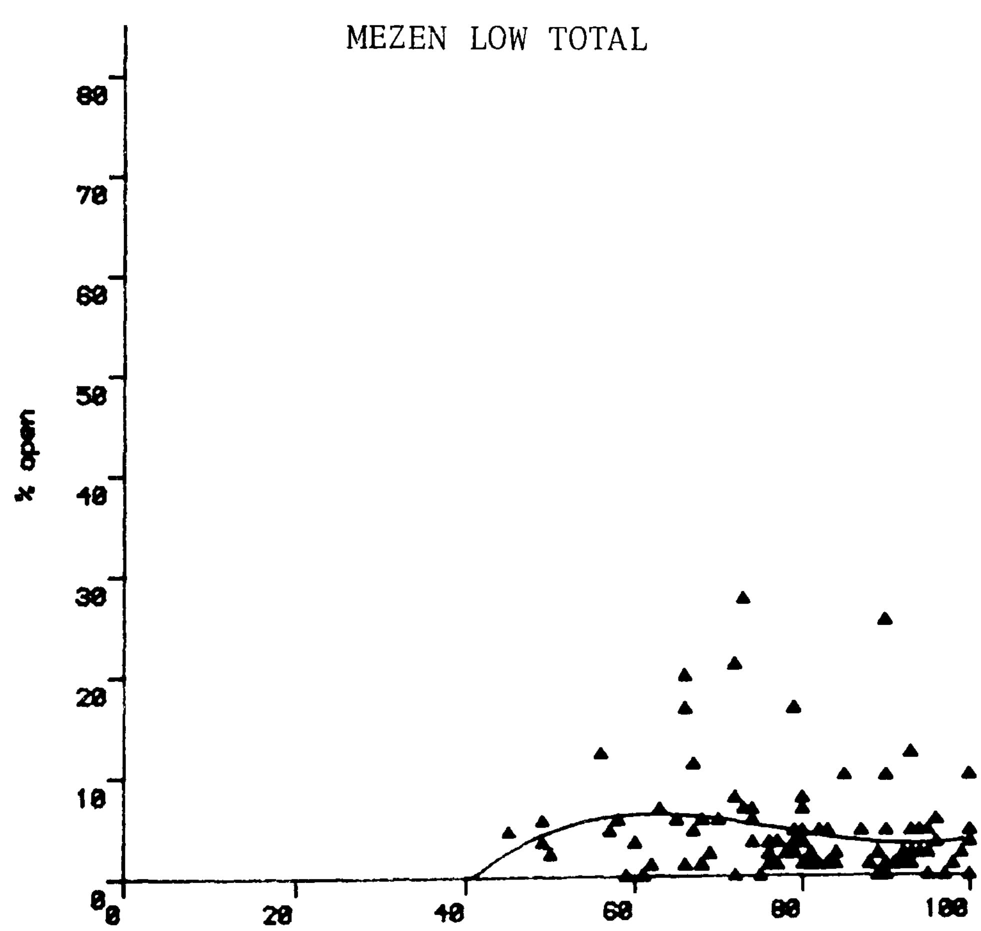


FIGURE A59



FIGURES A60-A63. Relationships between relative humidity and window opening in the medium group at Mezen

FIGURE A60

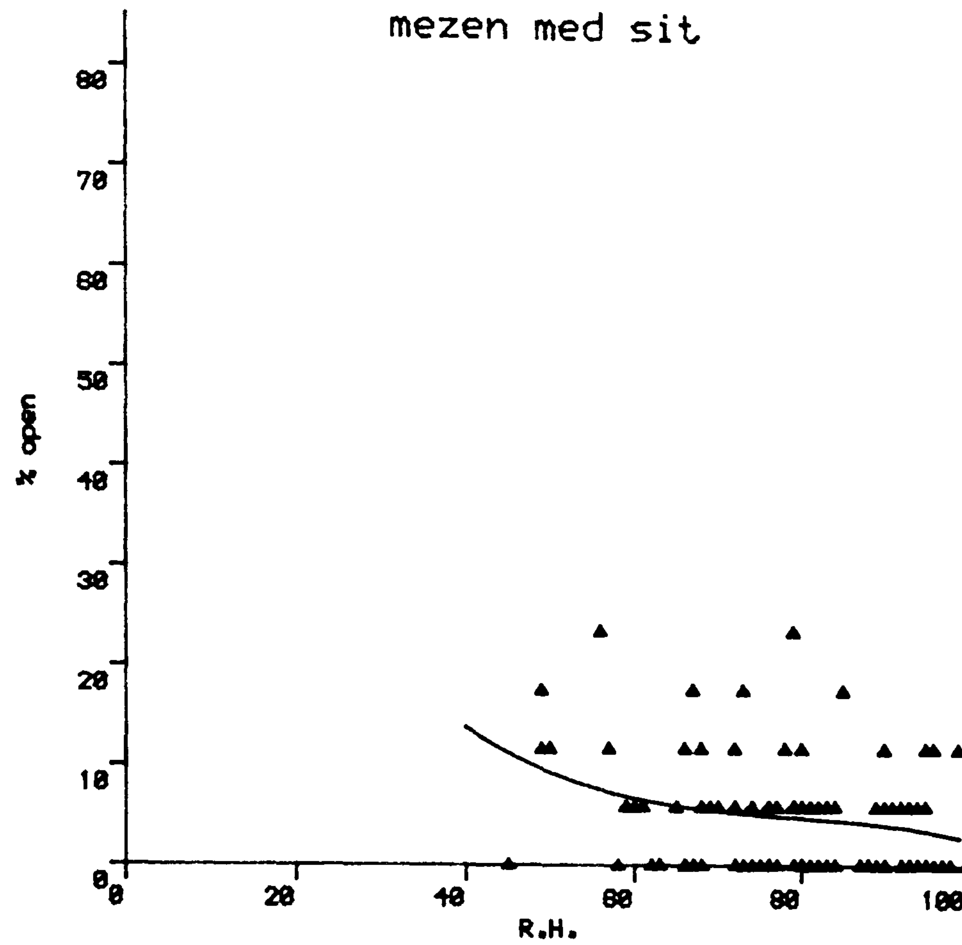


FIGURE A61

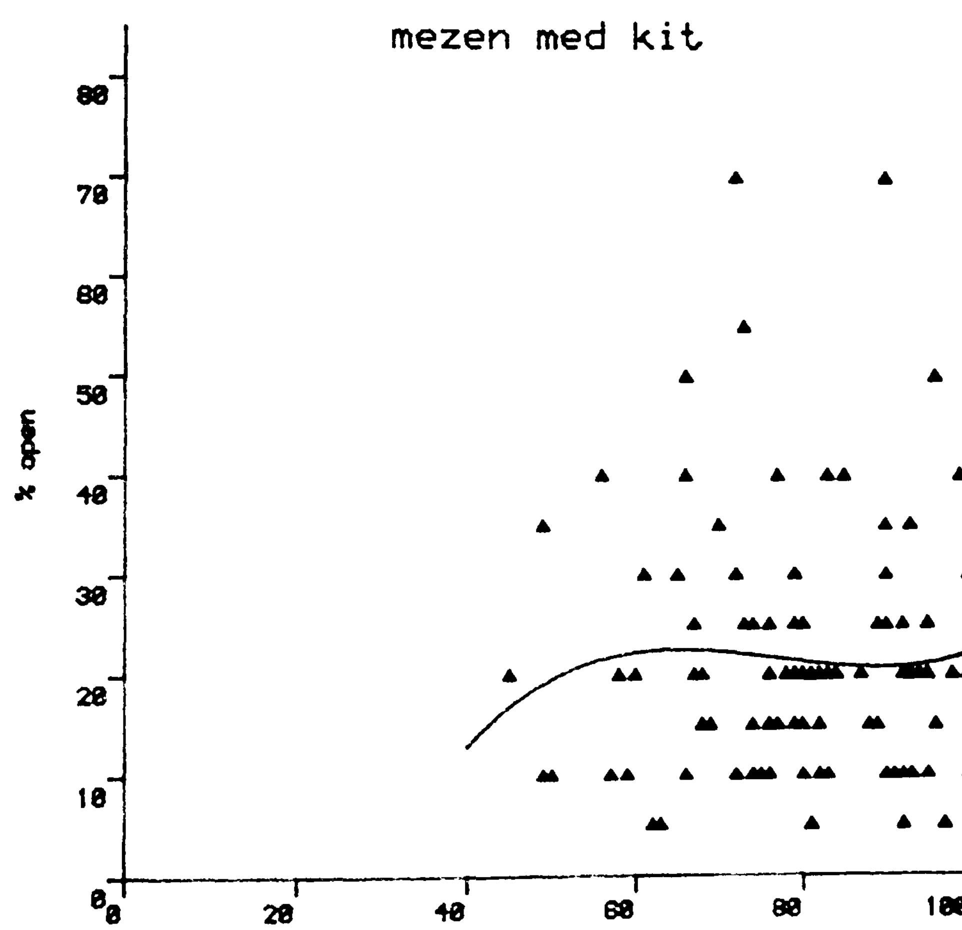


FIGURE A62

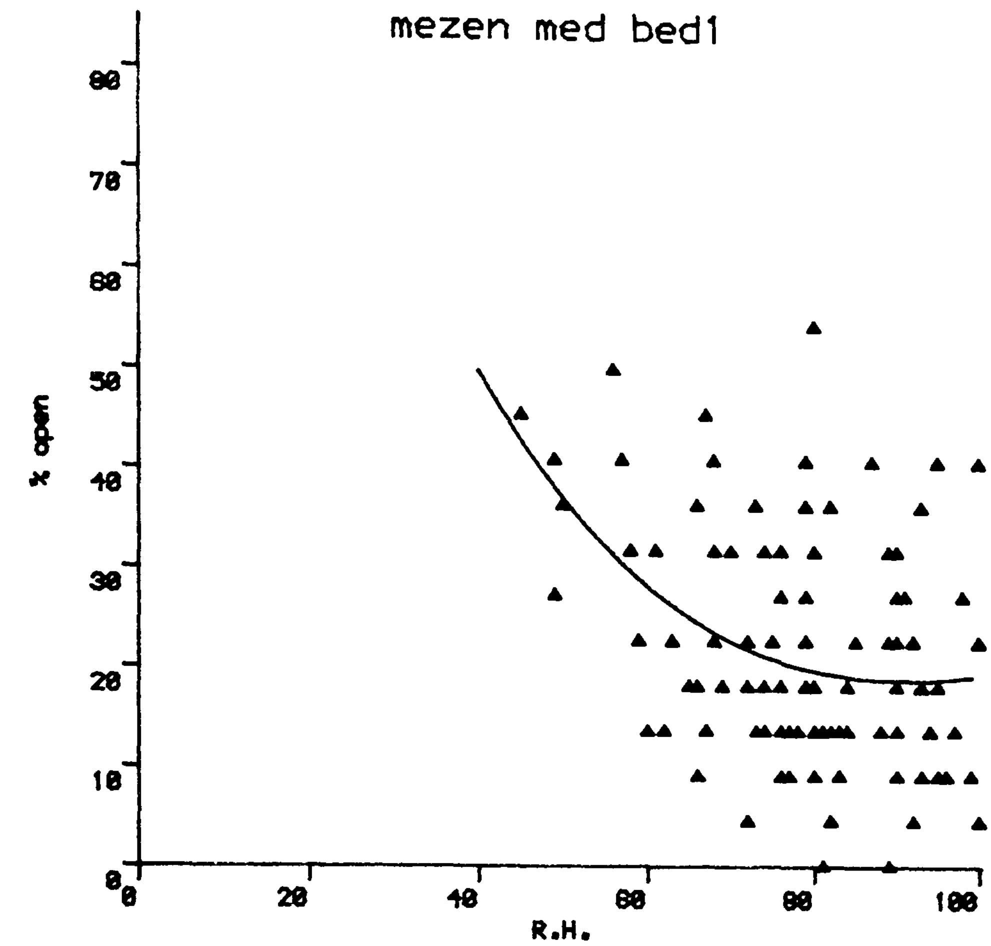
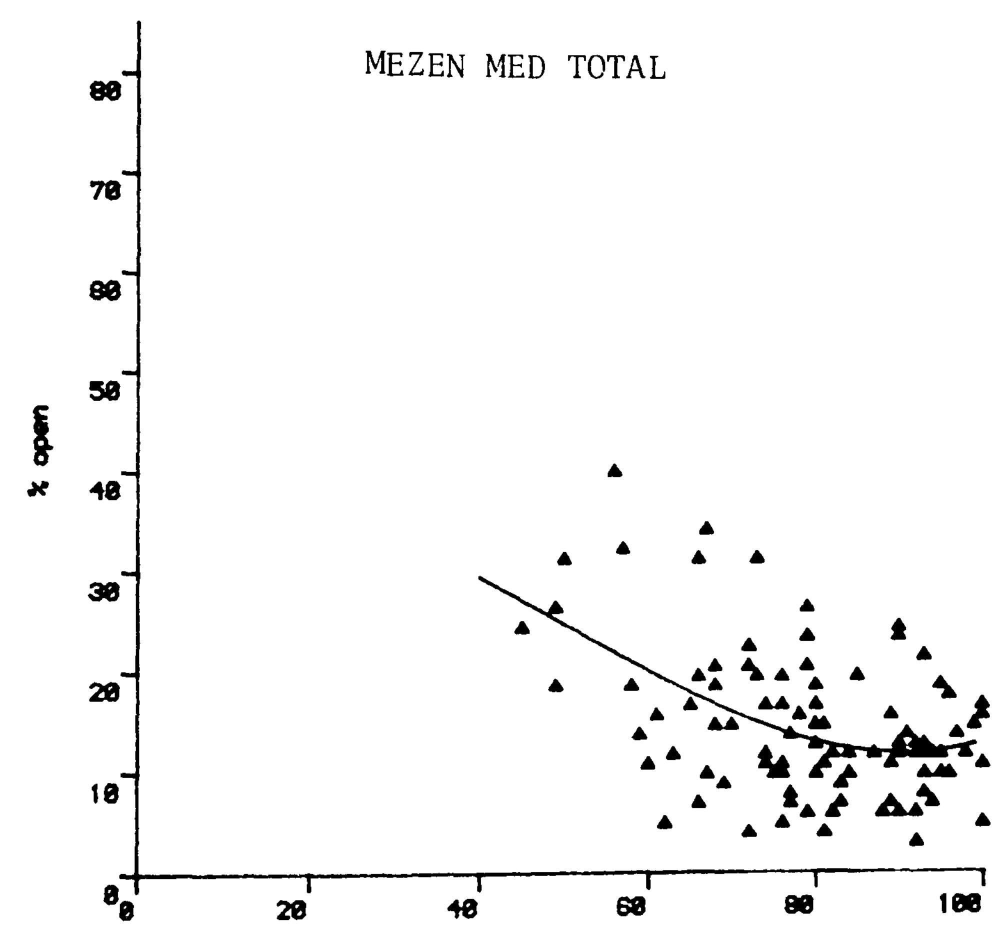


FIGURE A63



FIGURES A64-A67. Relationships between relative humidity and window opening in the high group at Mezen

FIGURE A64

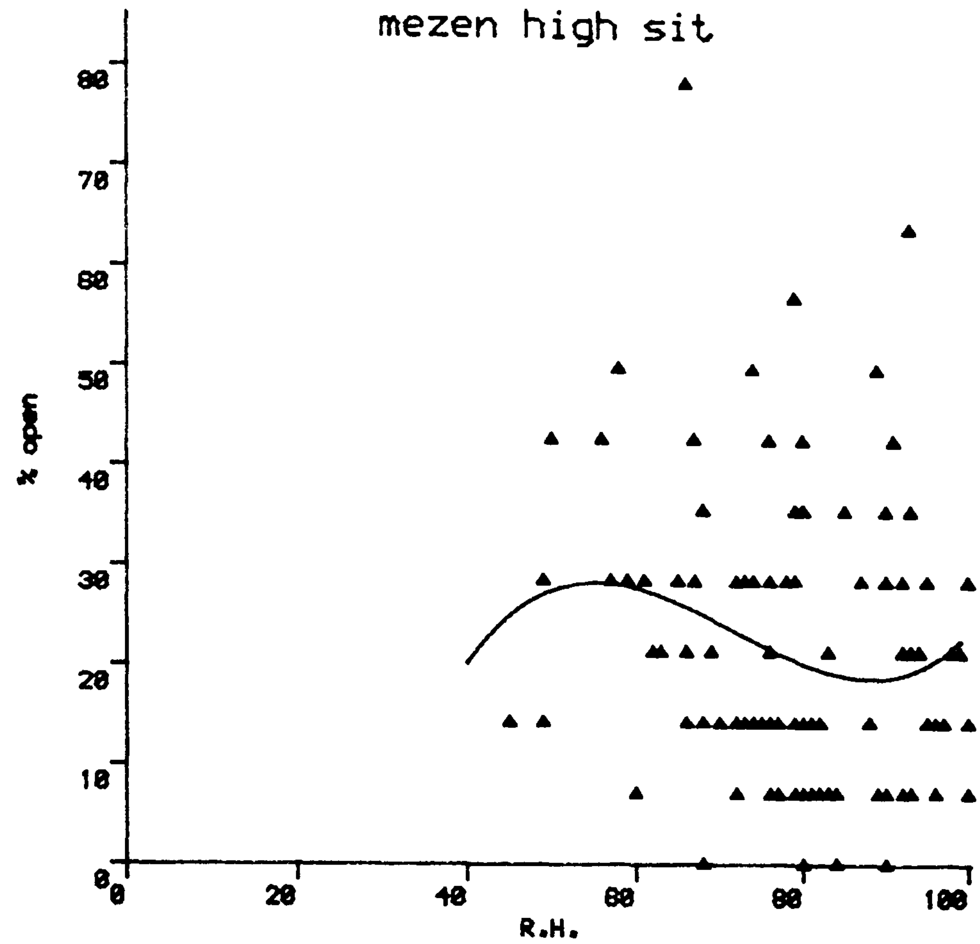


FIGURE A65

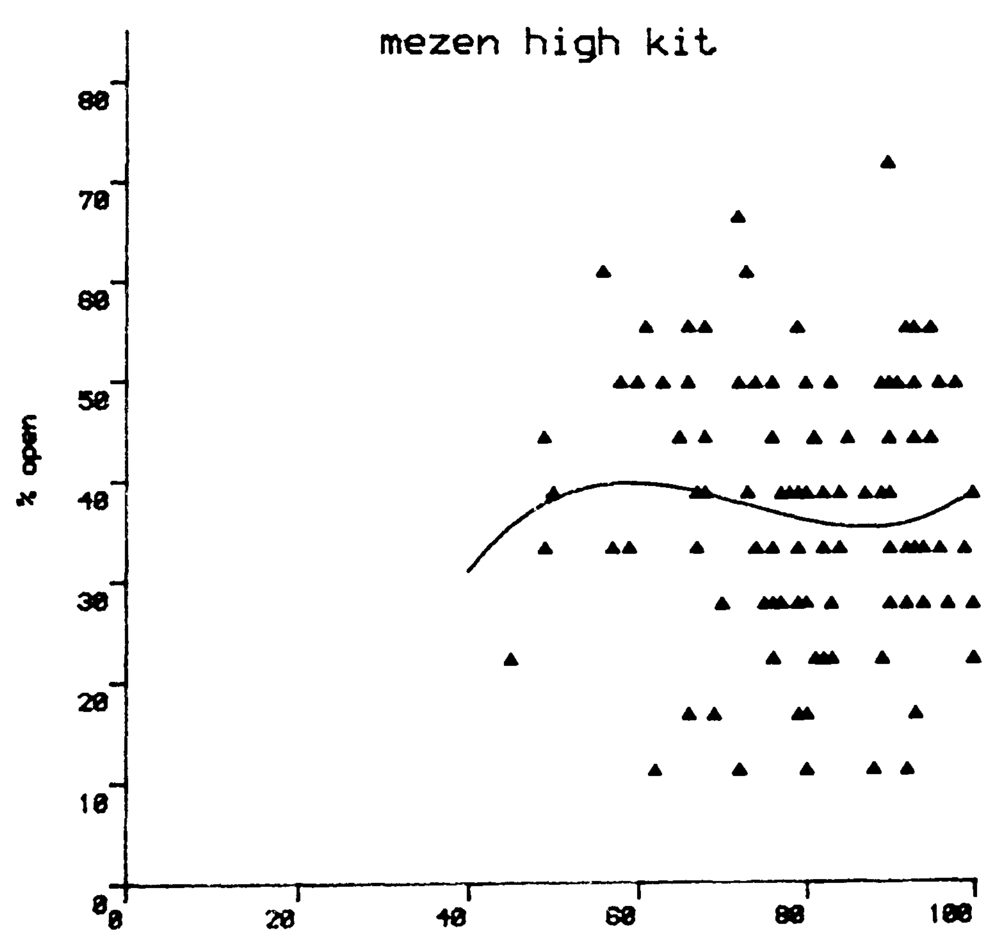


FIGURE A66

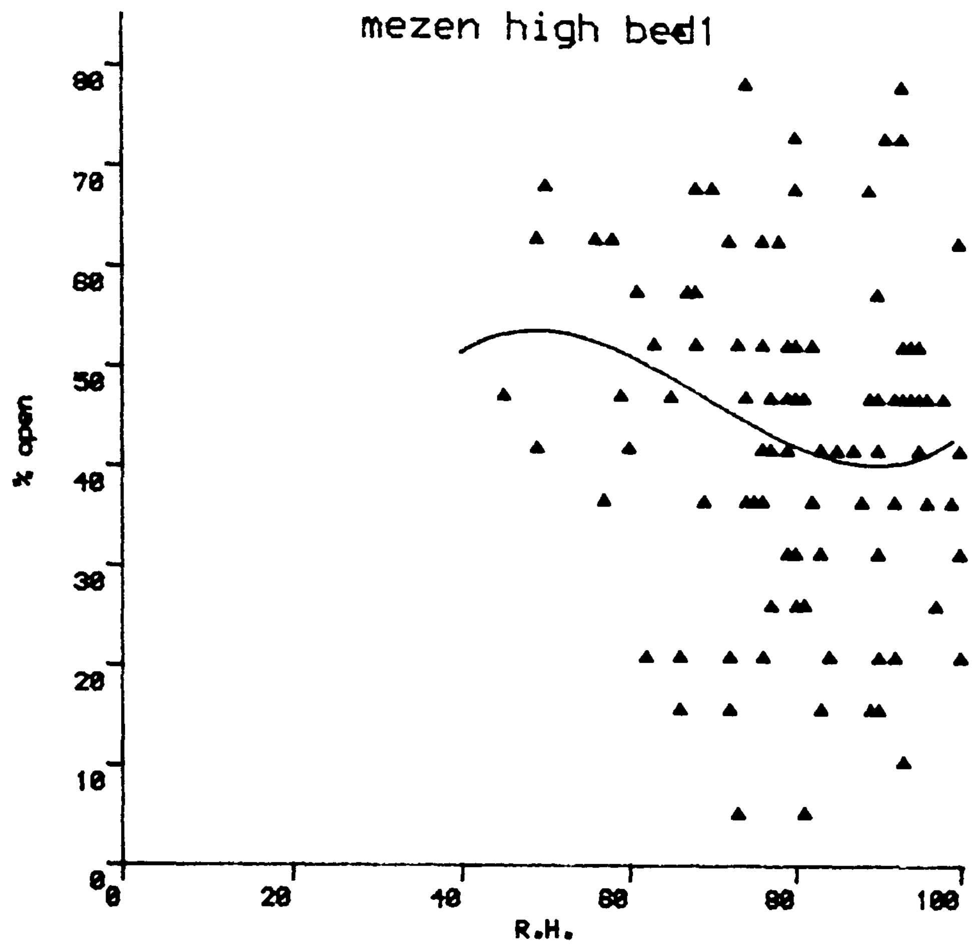
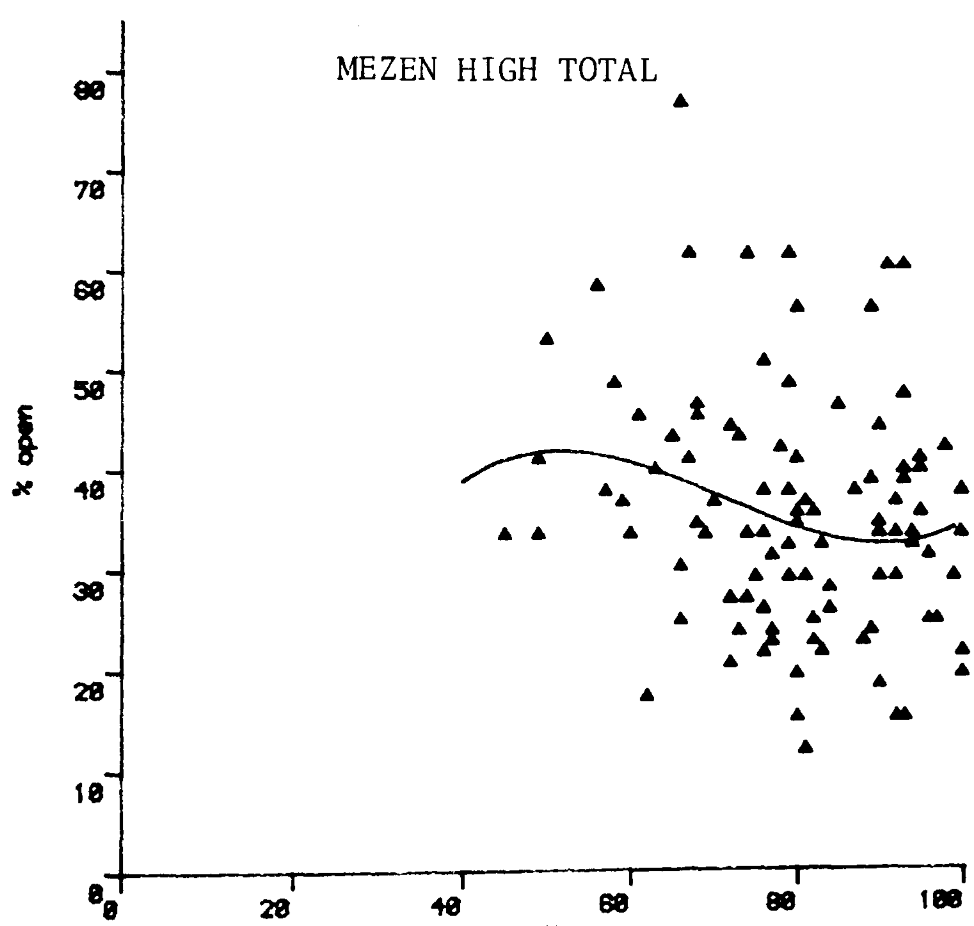


FIGURE A67



FIGURES A68-A71. Relationships between relative humidity and window opening in all groups at Mezen

FIGURE A68

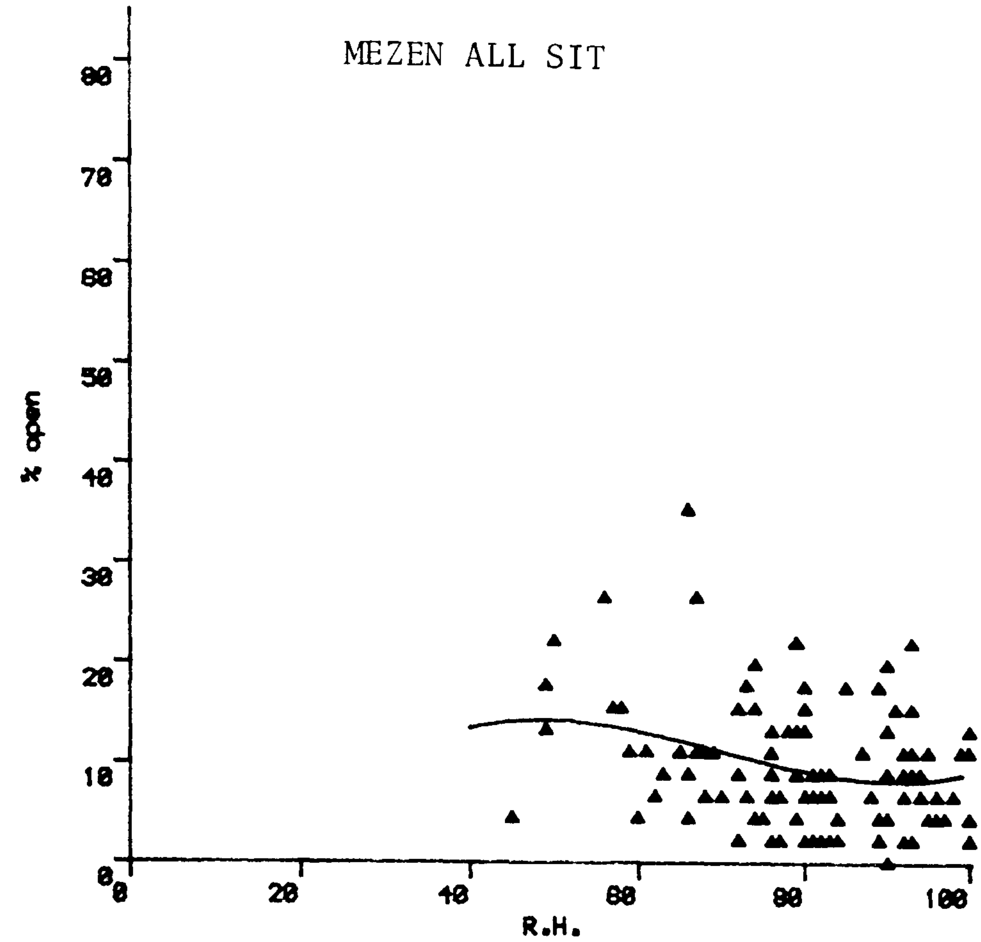


FIGURE A69

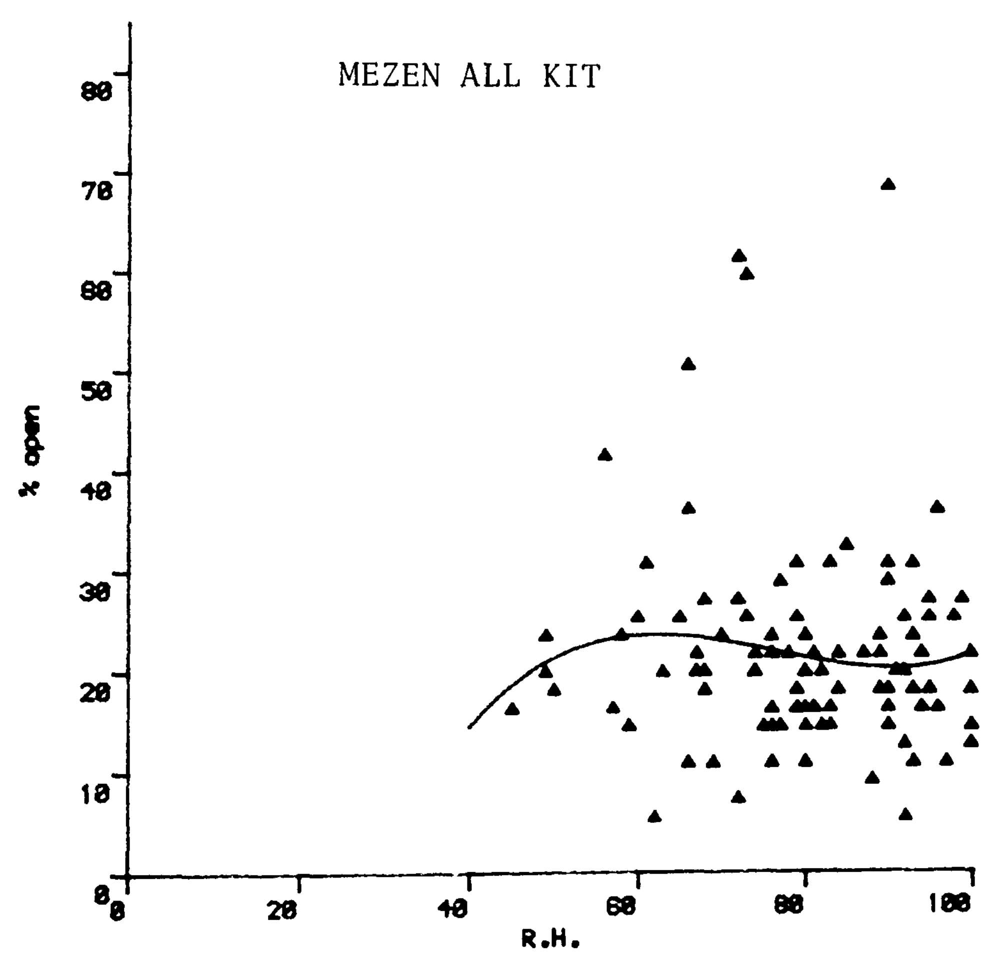


FIGURE A70

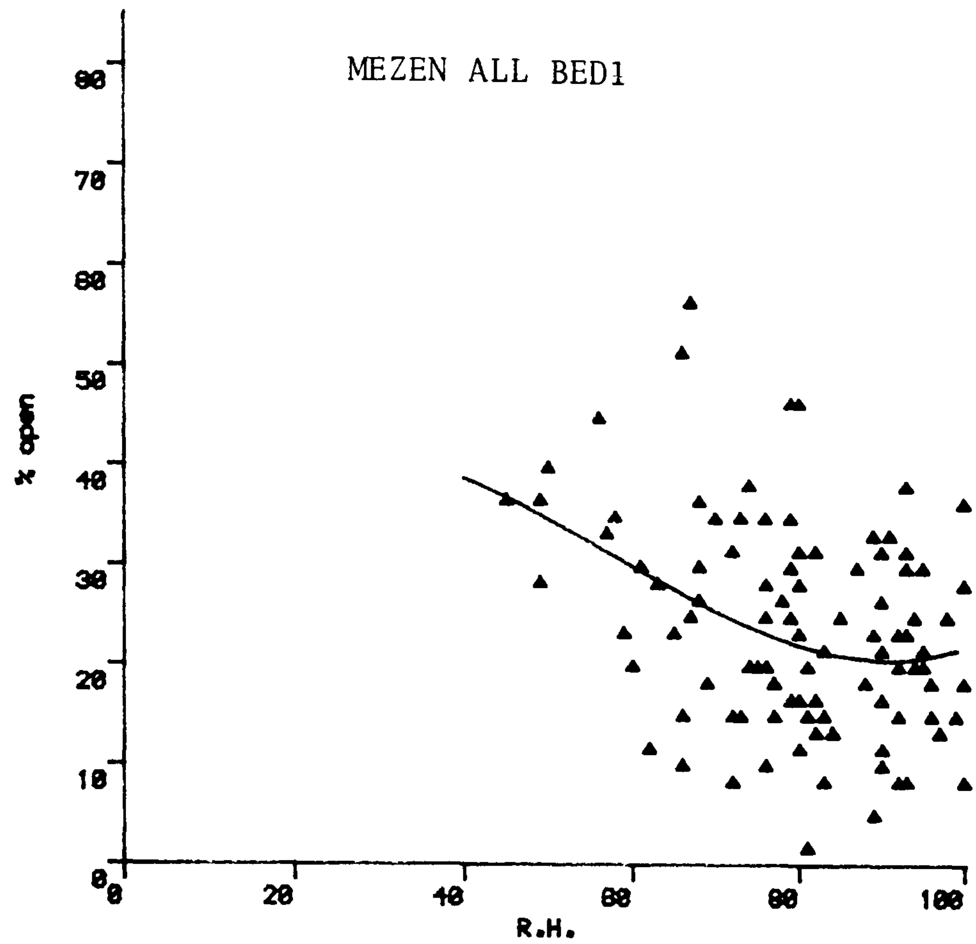
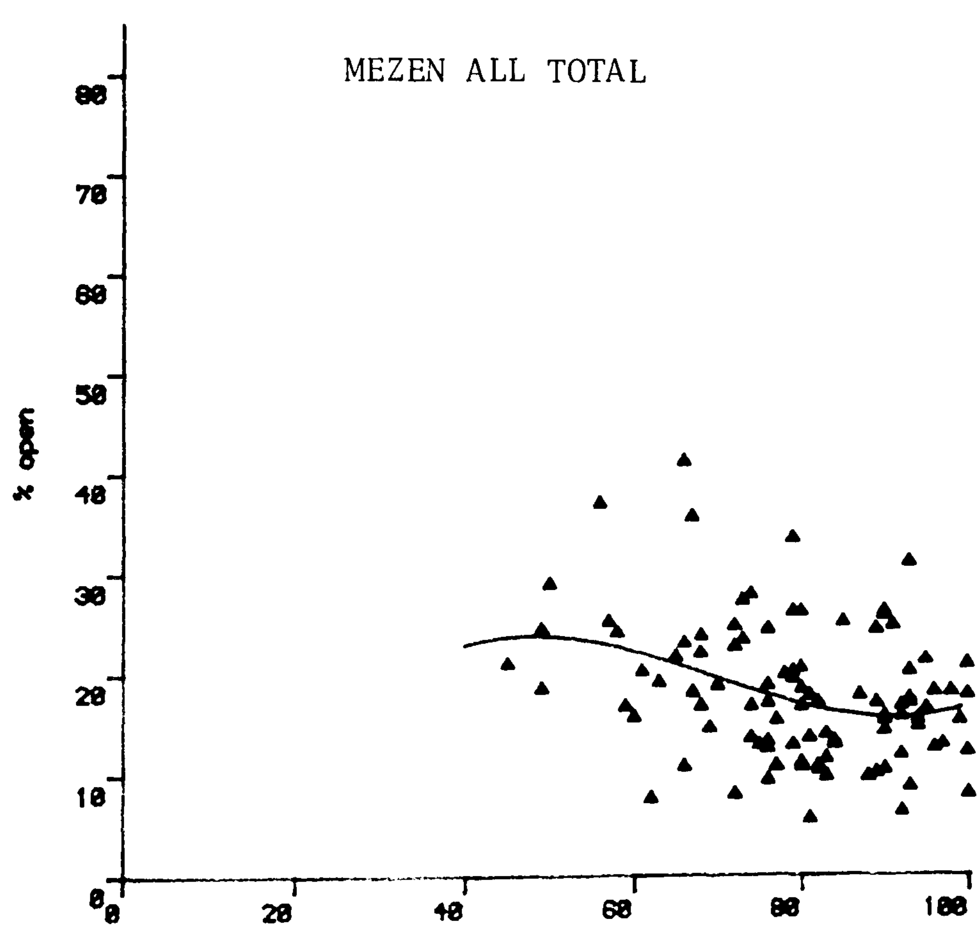


FIGURE A71



FIGURES A72-A75. Relationships between windspeed and window opening in the low group at Cowley

FIGURE A72

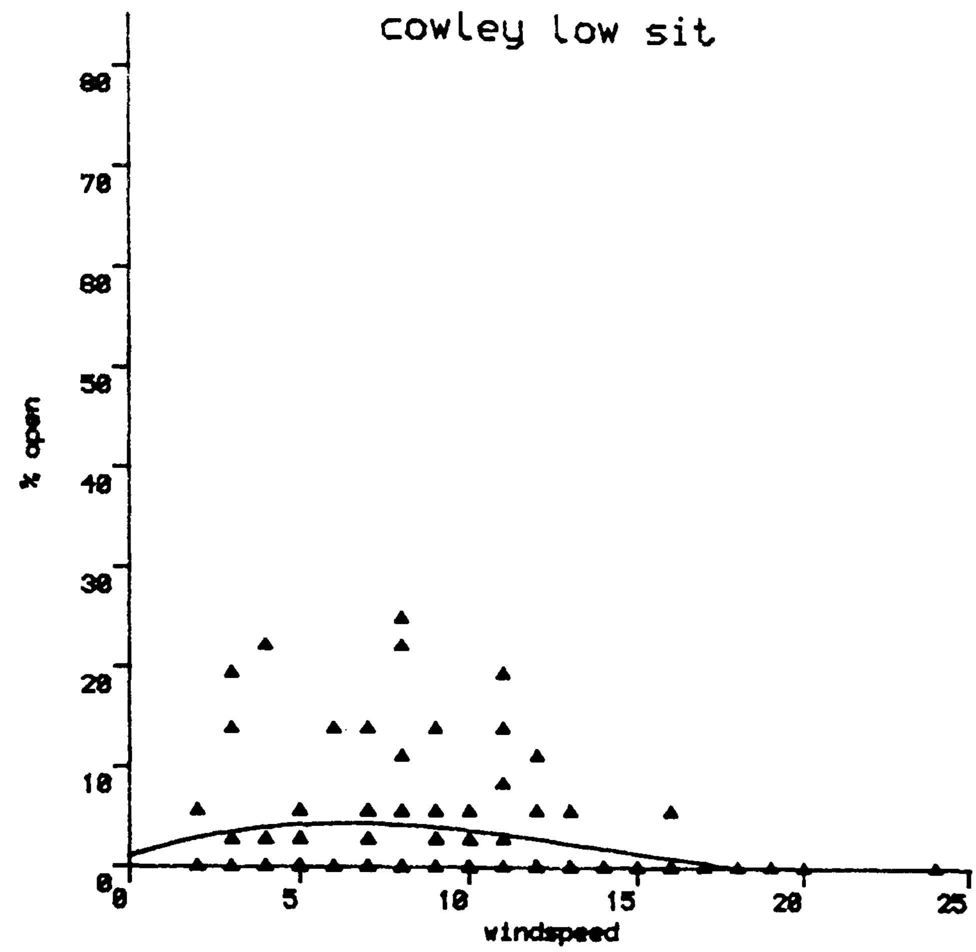


FIGURE A73

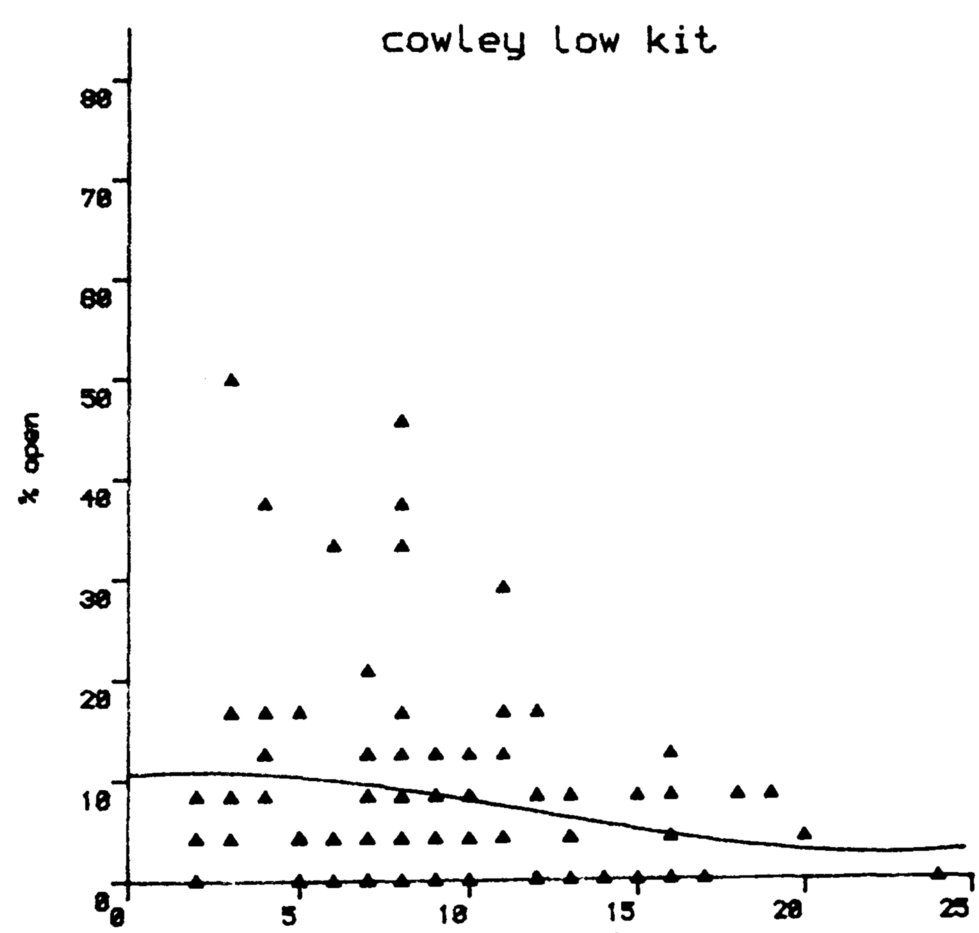


FIGURE A74

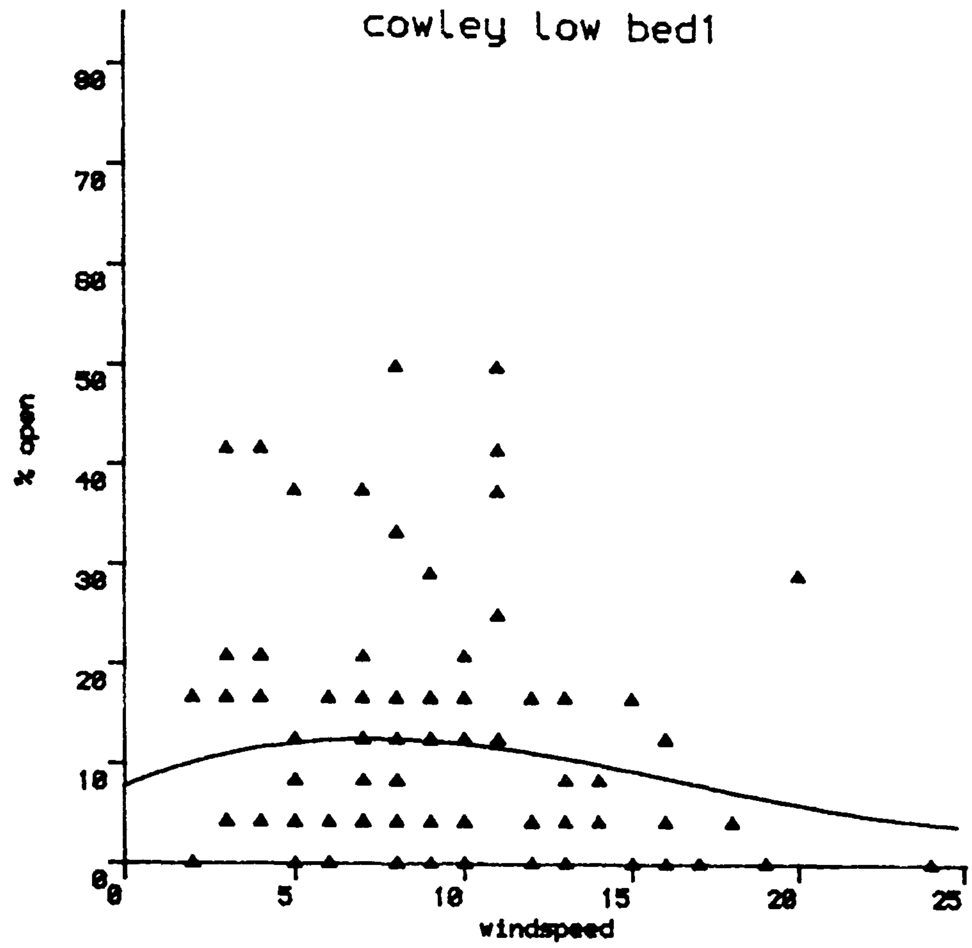
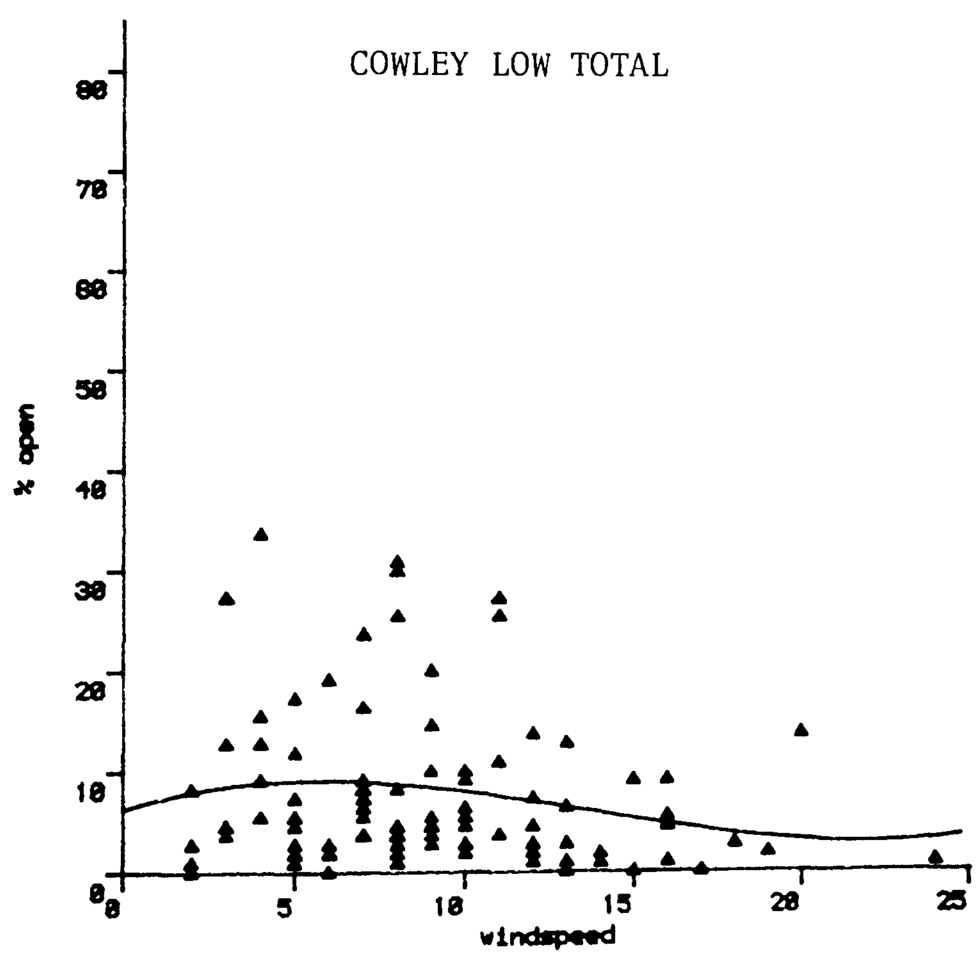


FIGURE A75



FIGURES A76-A79. Relationships between windspeed and window opening in the medium group at Cowley

FIGURE A76

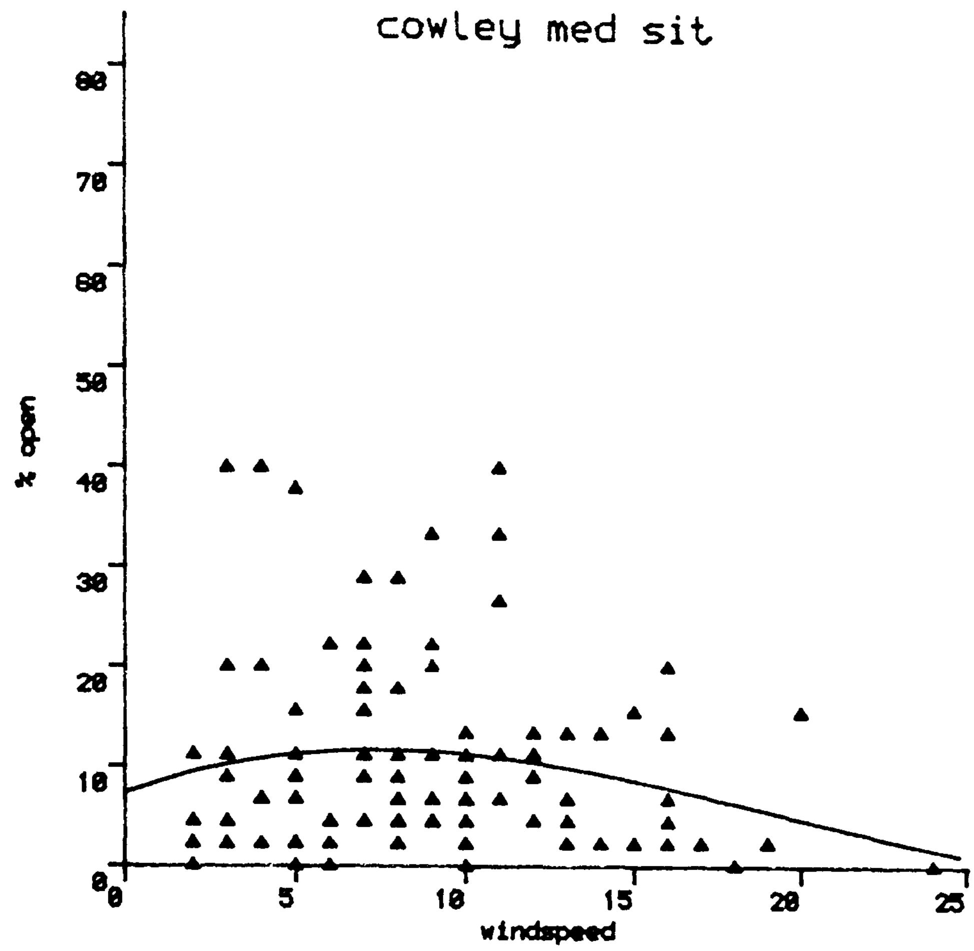


FIGURE A77

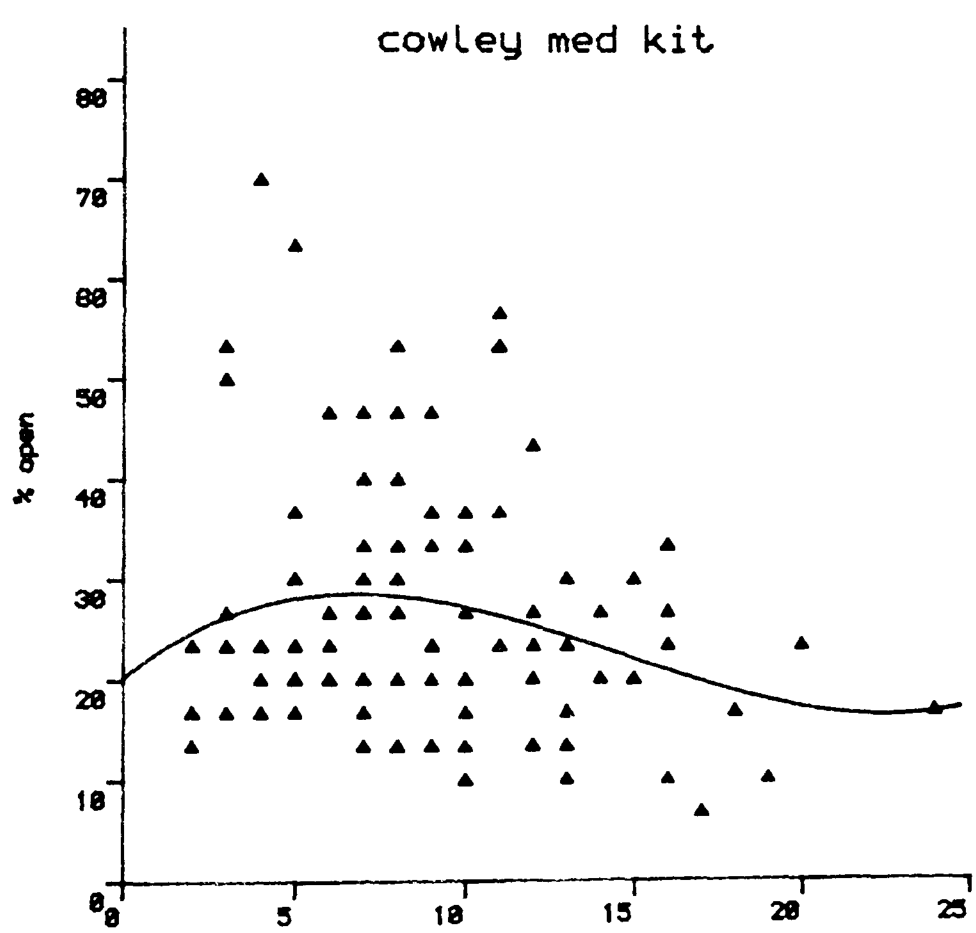


FIGURE A74

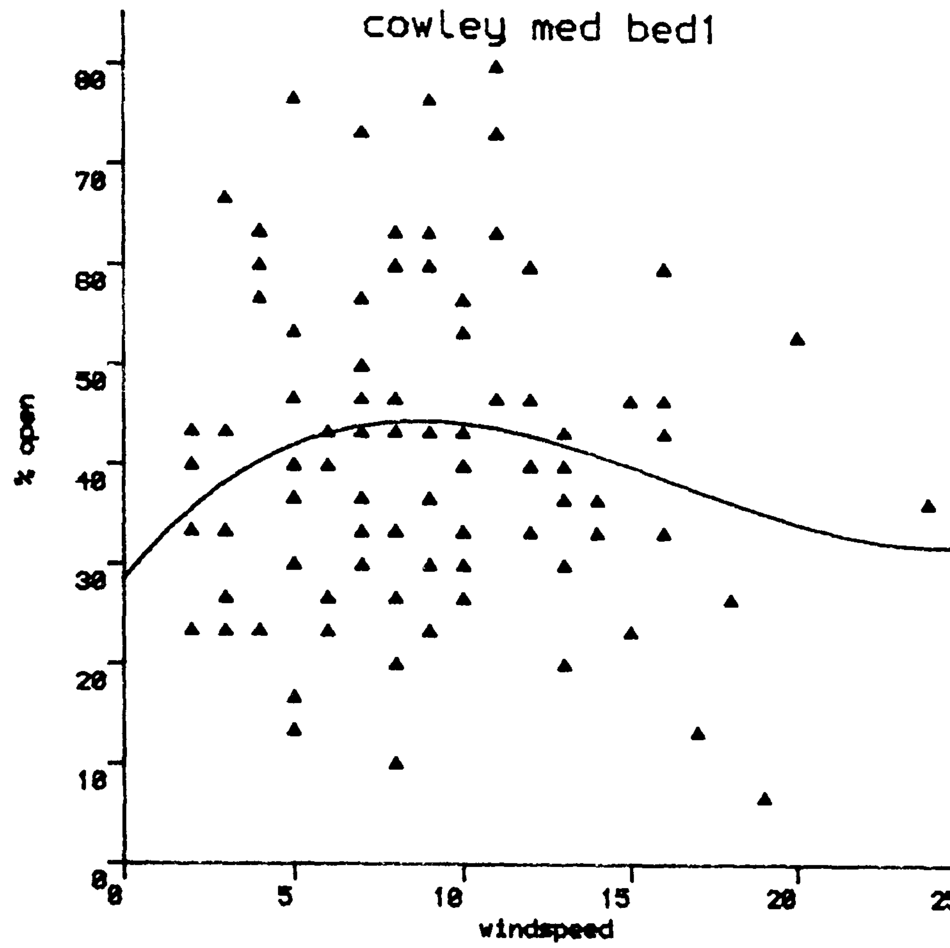
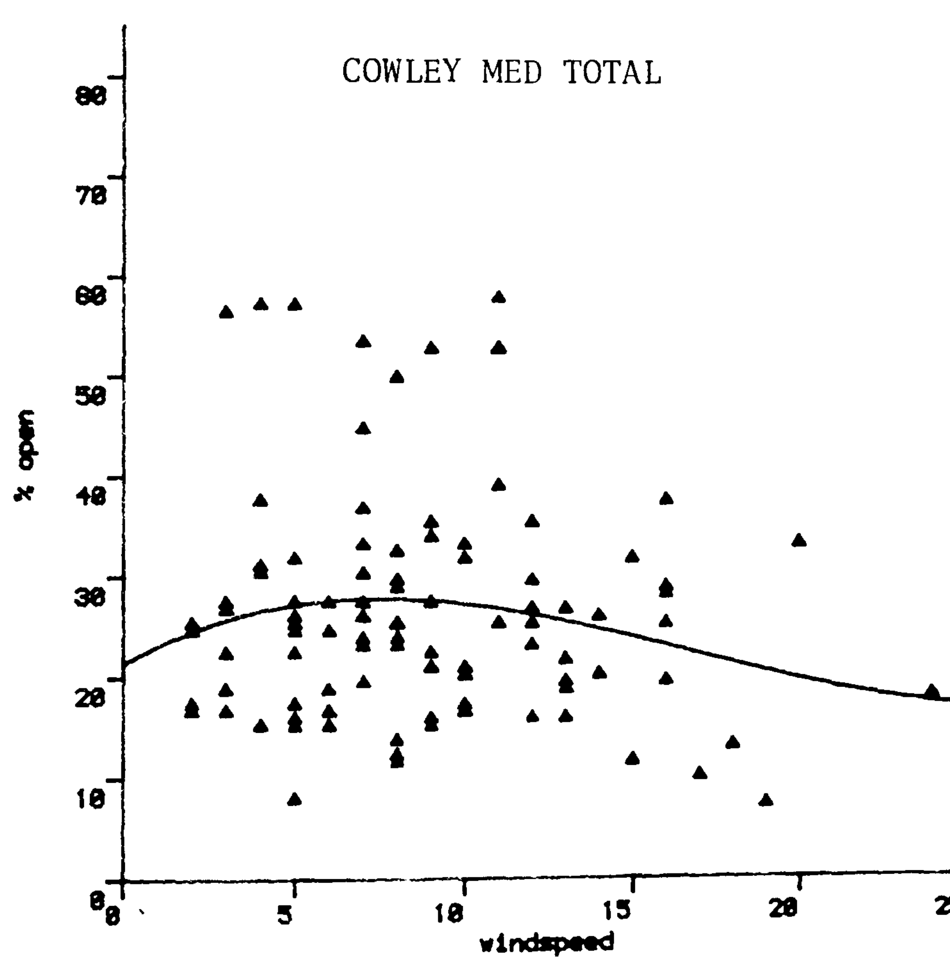


FIGURE A75



FIGURES A80-A83. Relationships between windspeed and window opening in the high group at Cowley

FIGURE A80

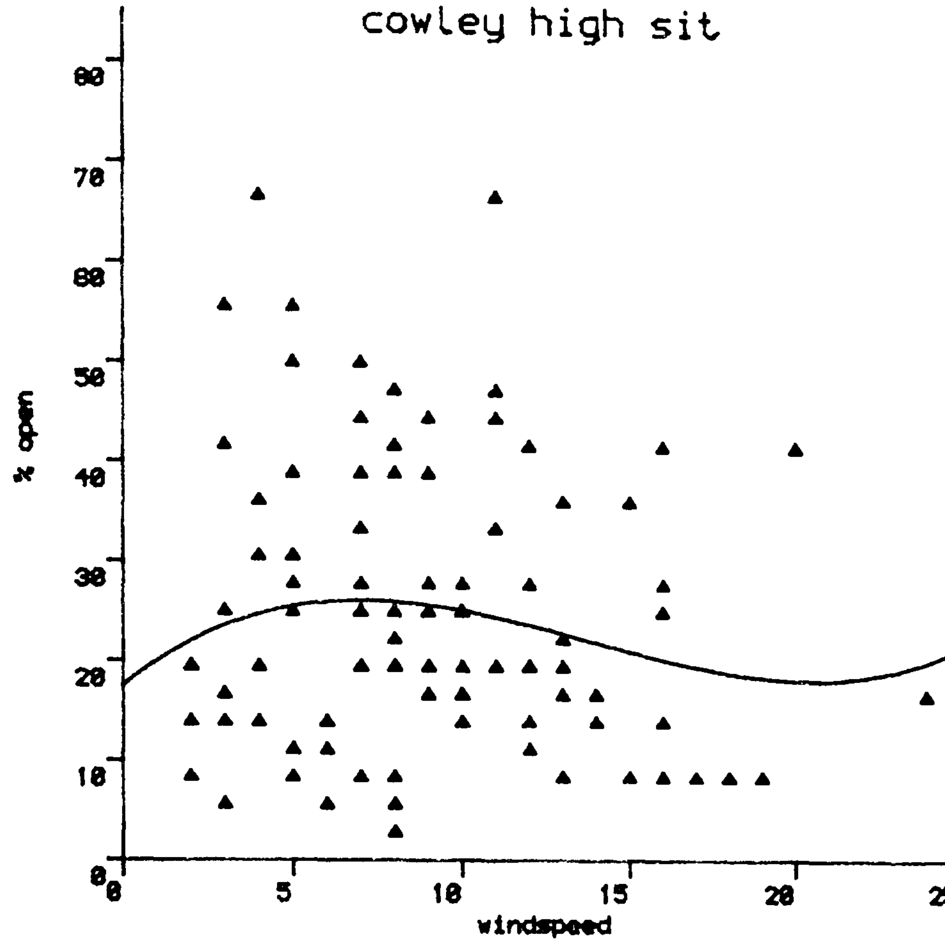


FIGURE A81

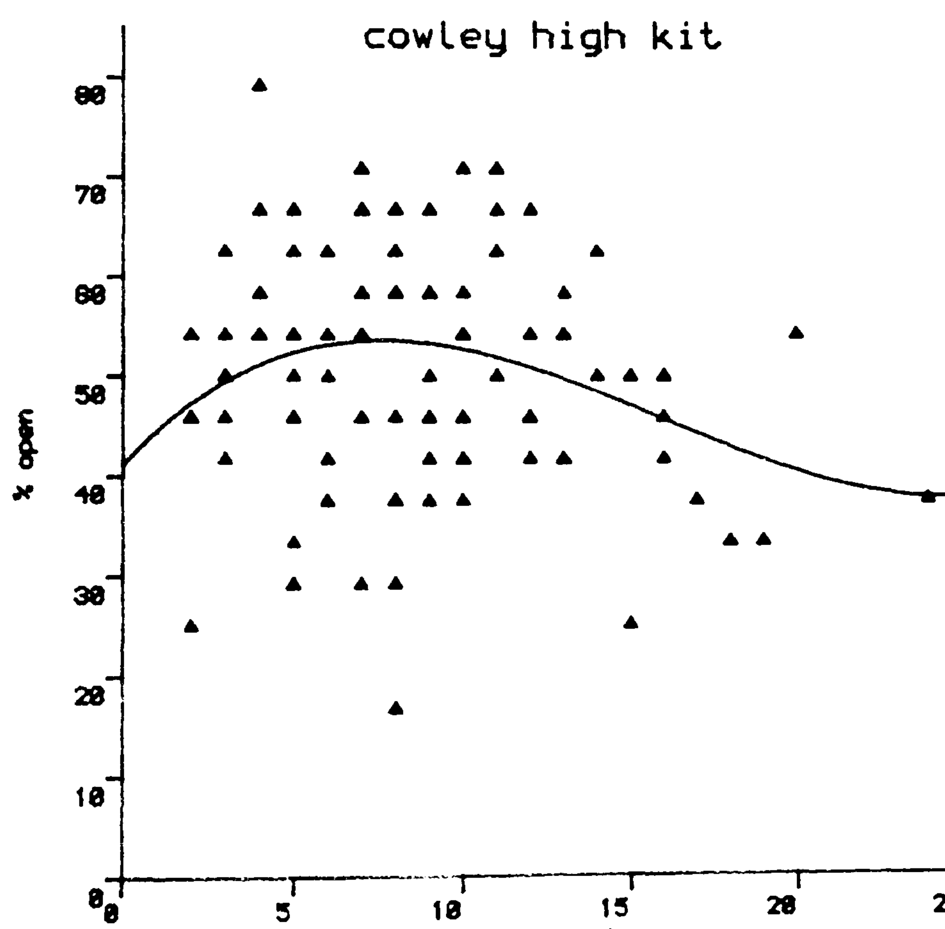


FIGURE A82

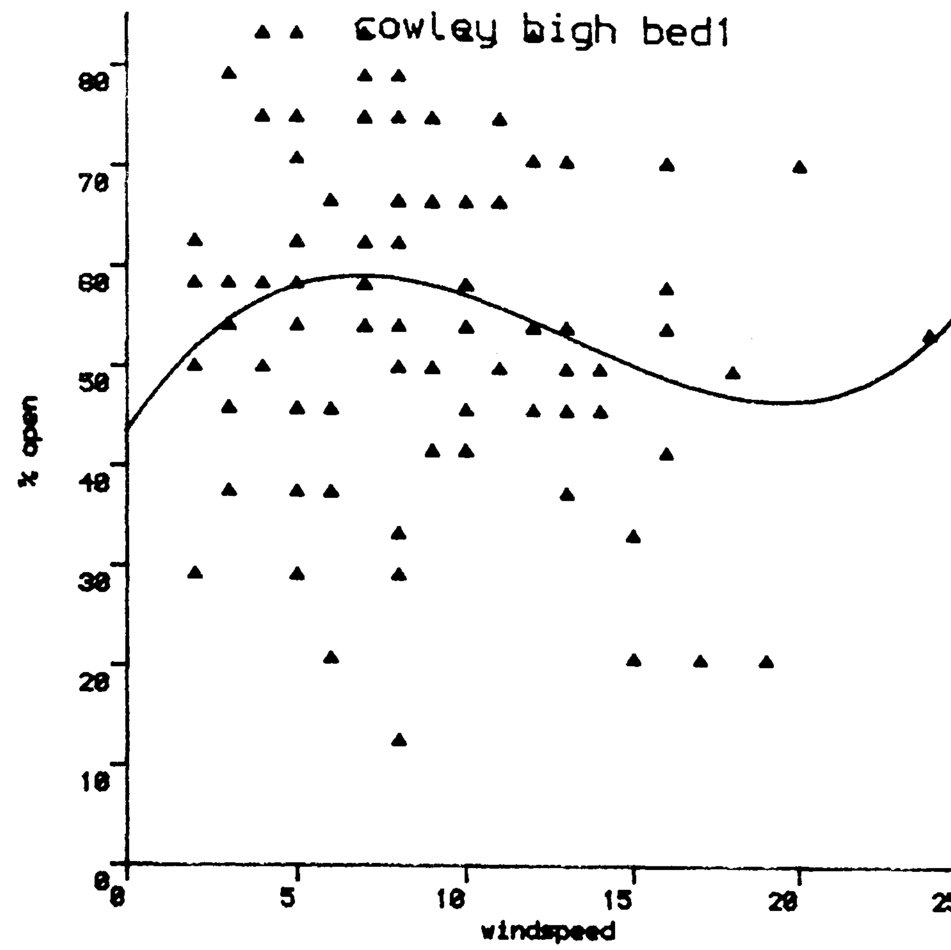
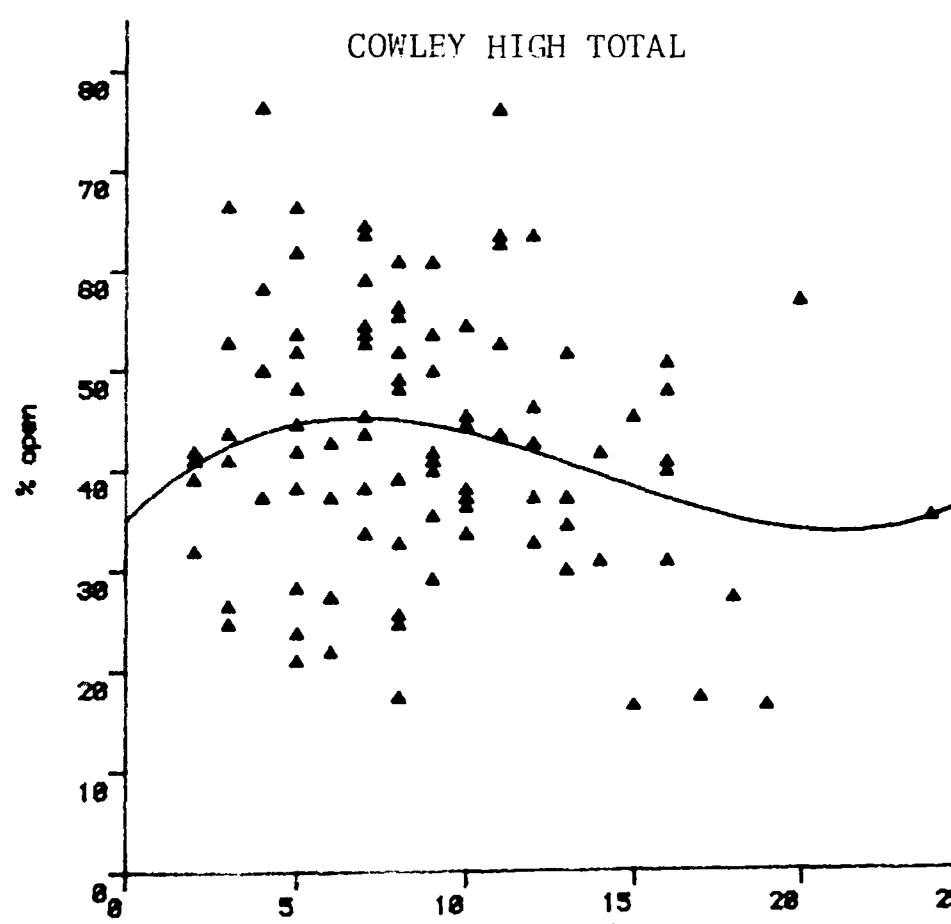


FIGURE A83



FIGURES A84-A87. Relationships between windspeed and window opening in all groups at Cowley

FIGURE A84

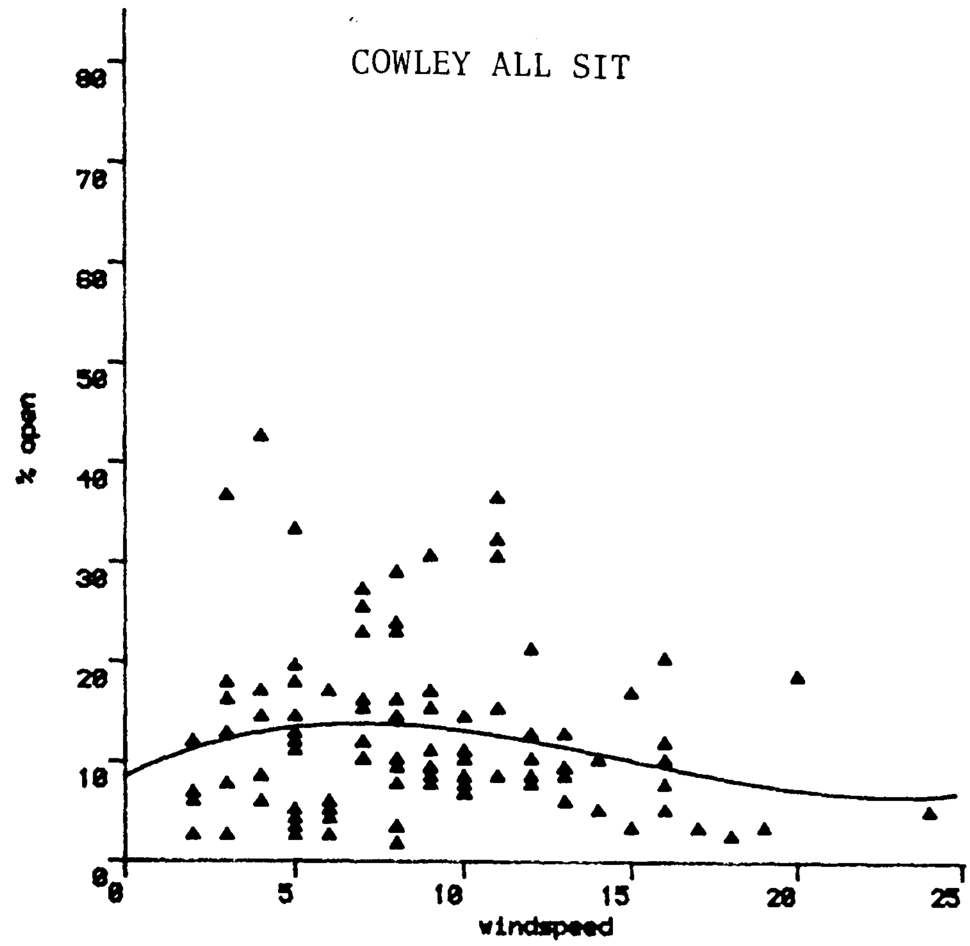


FIGURE A85

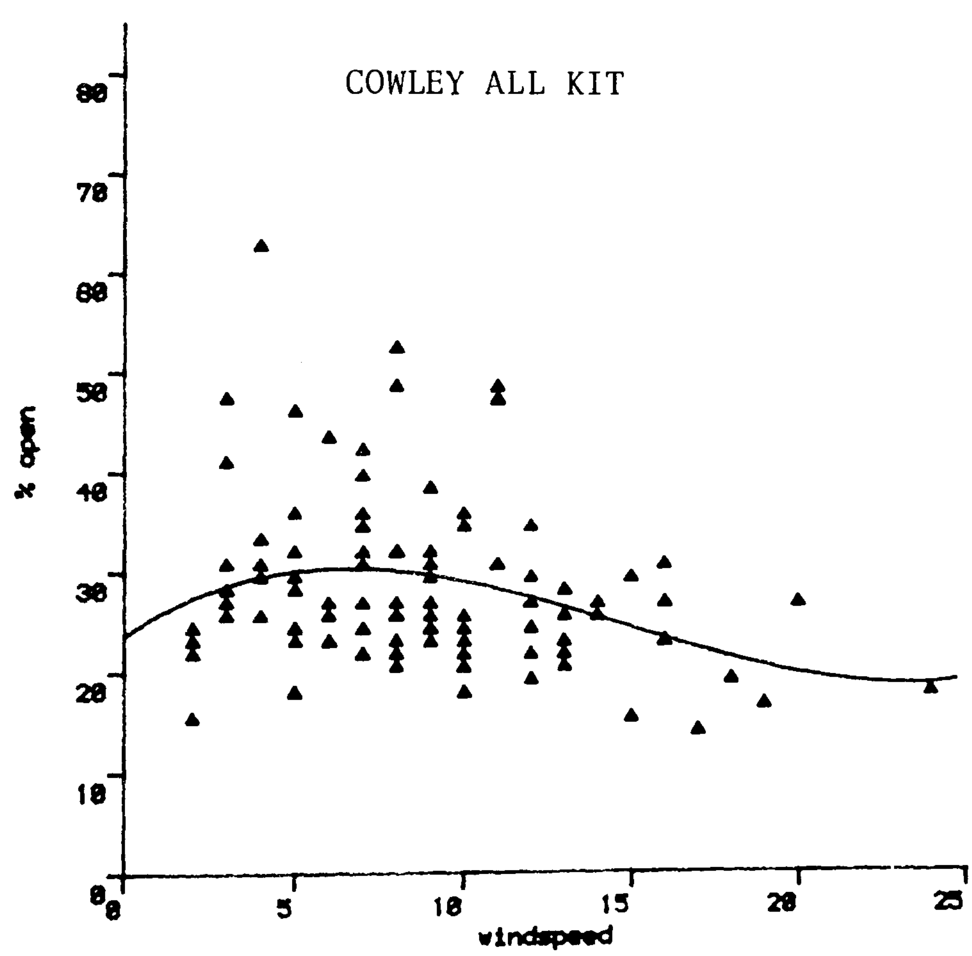


FIGURE A86

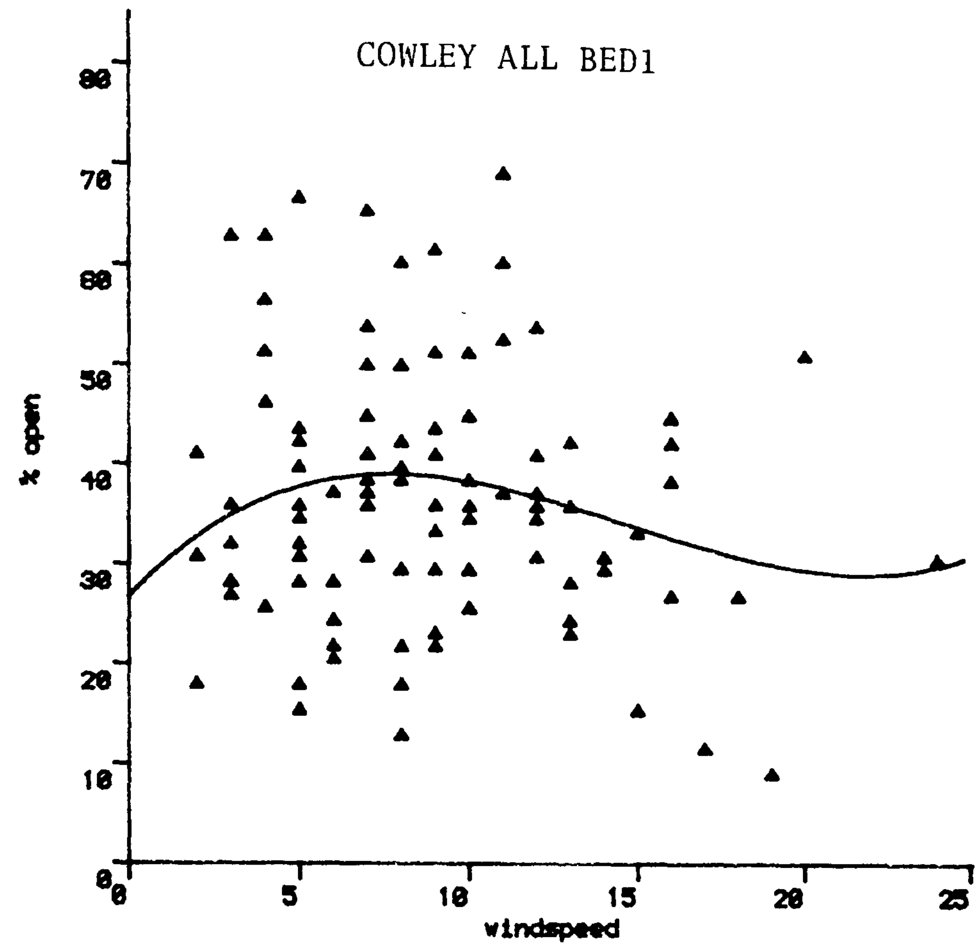
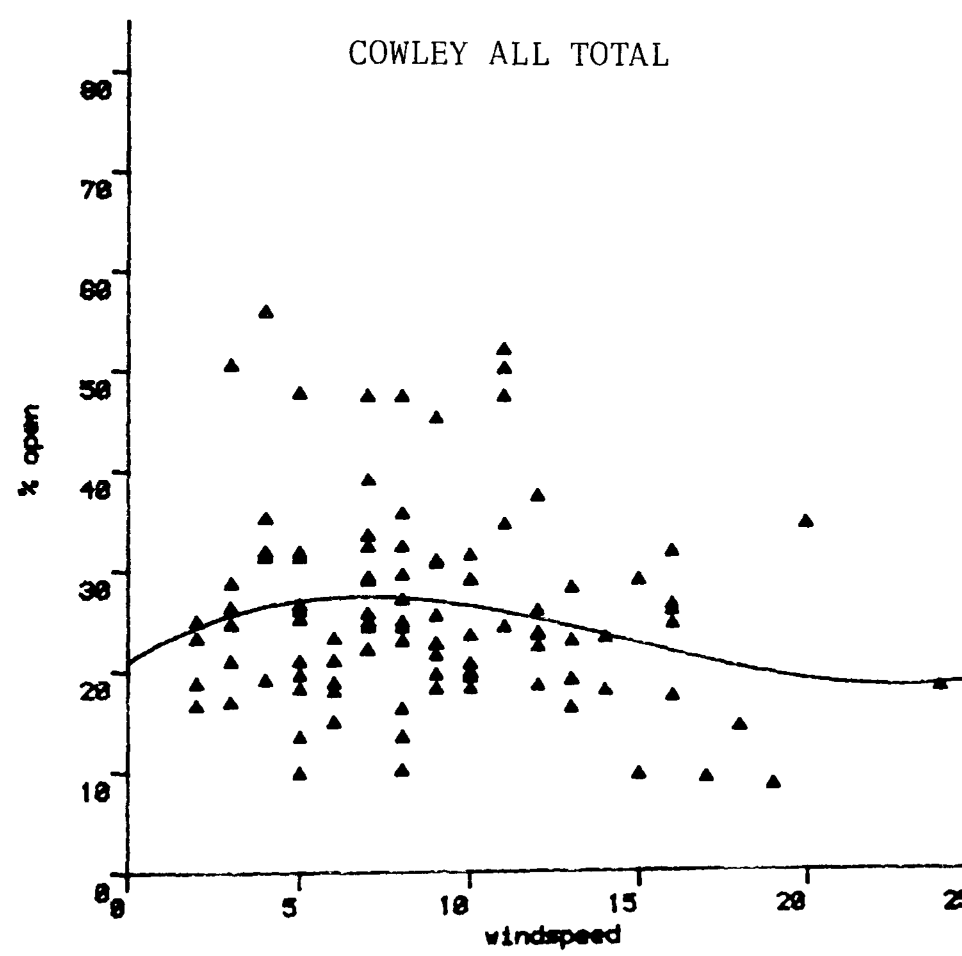


FIGURE A87



FIGURES A88-A91. Relationships between windspeed and window opening in the low group at Mezen

FIGURE A88

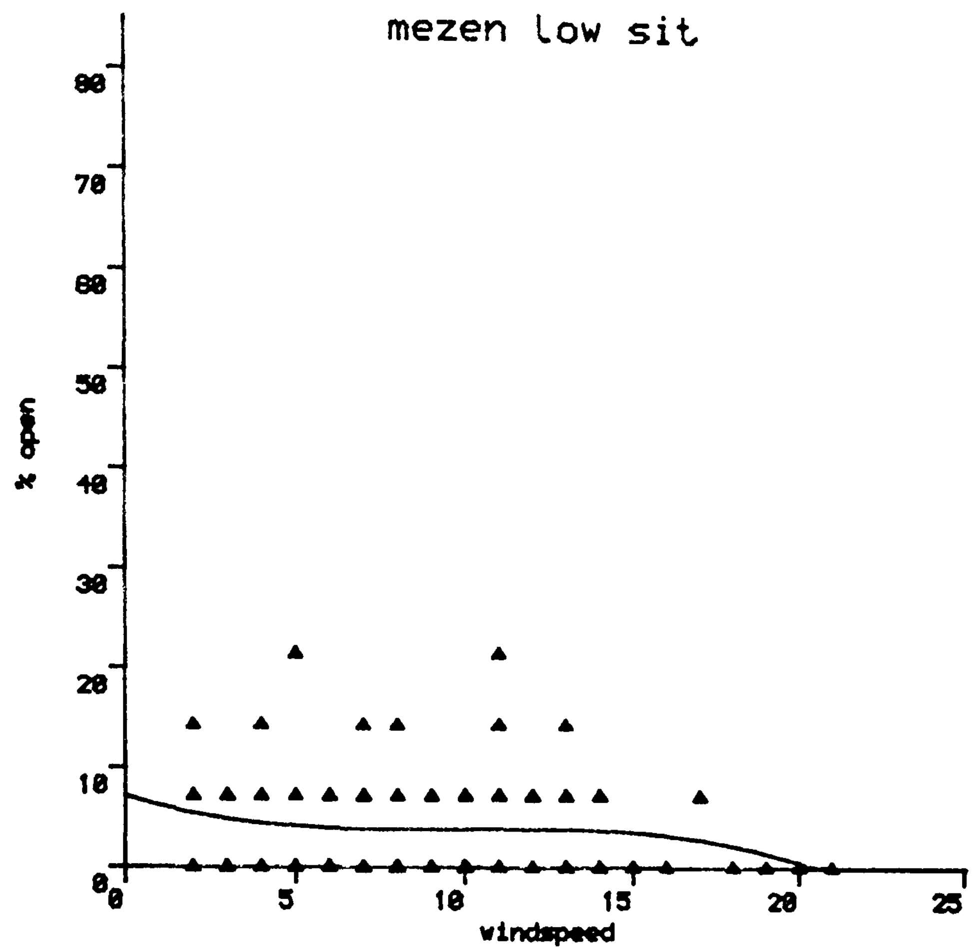


FIGURE A89

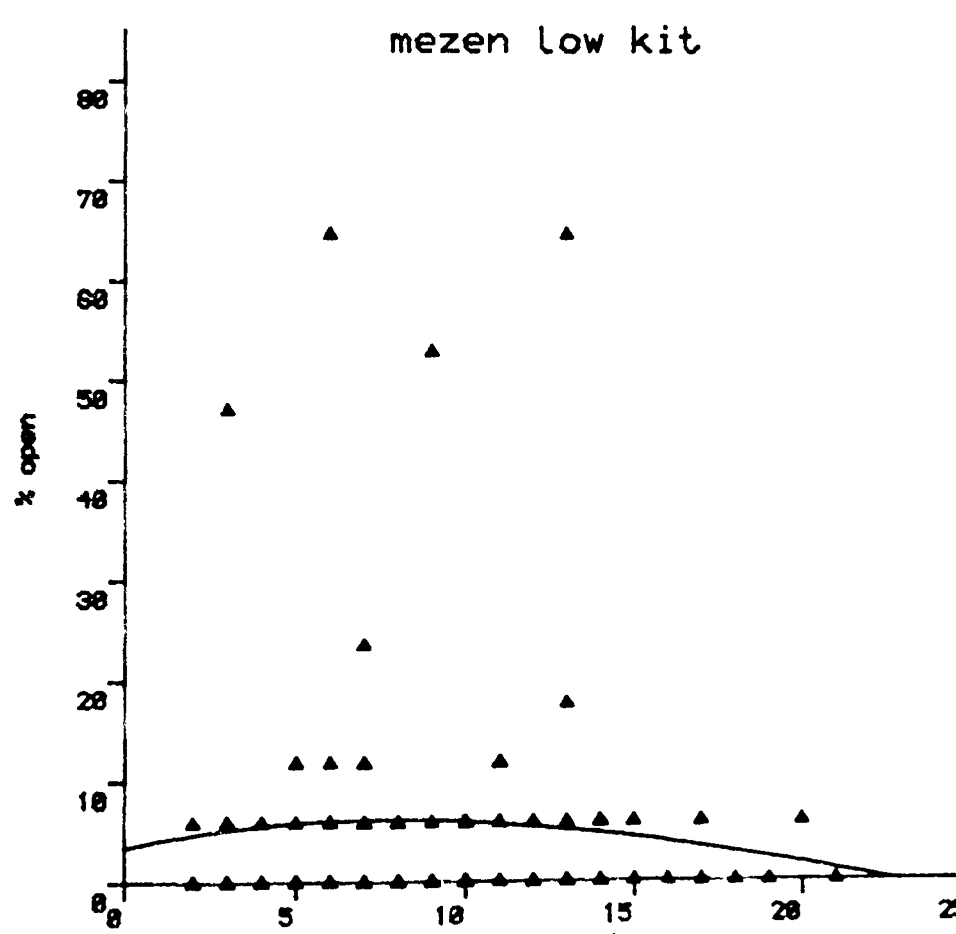


FIGURE A90

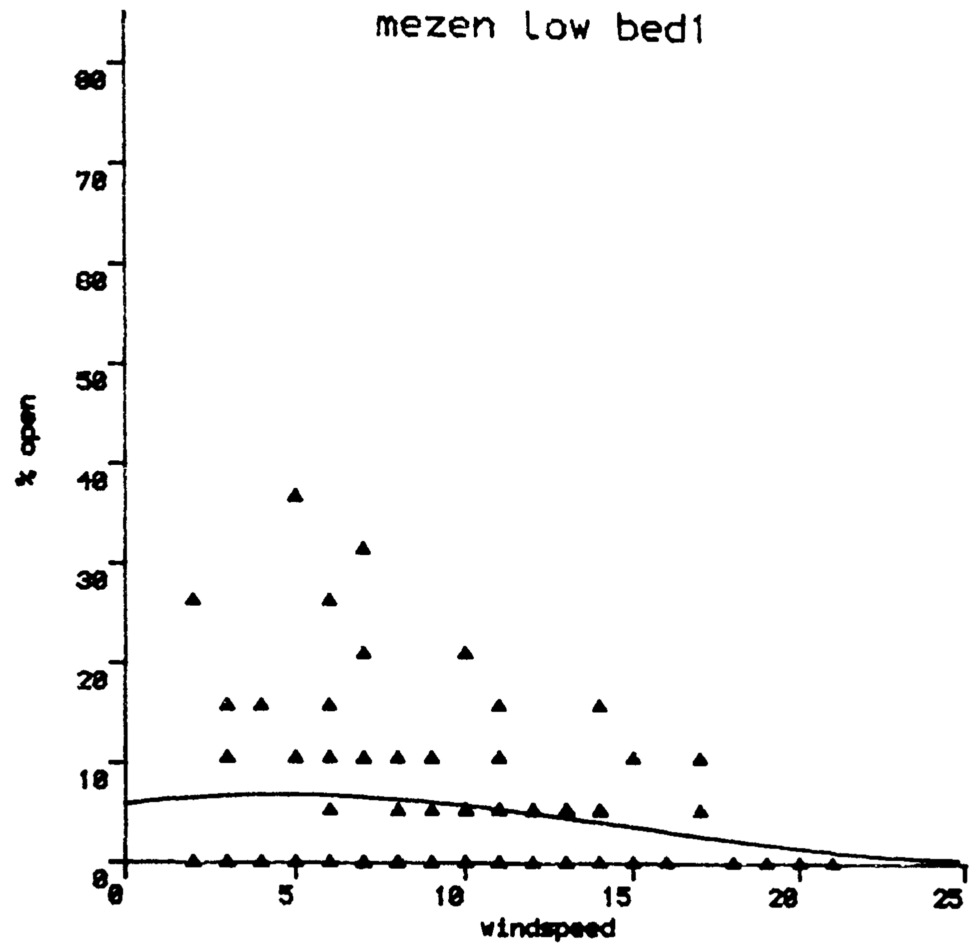
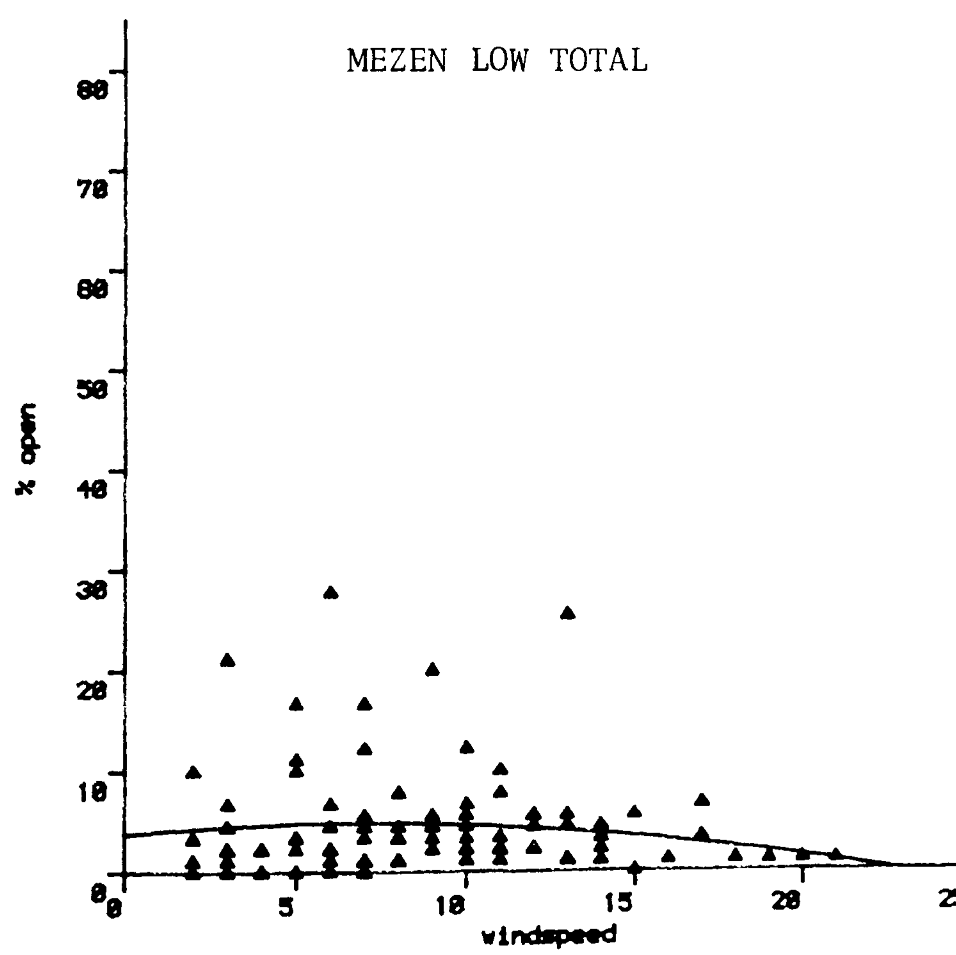


FIGURE A91



FIGURES A92-A95. Relationships between windspeed and window opening in the medium group at Mezen

FIGURE A92

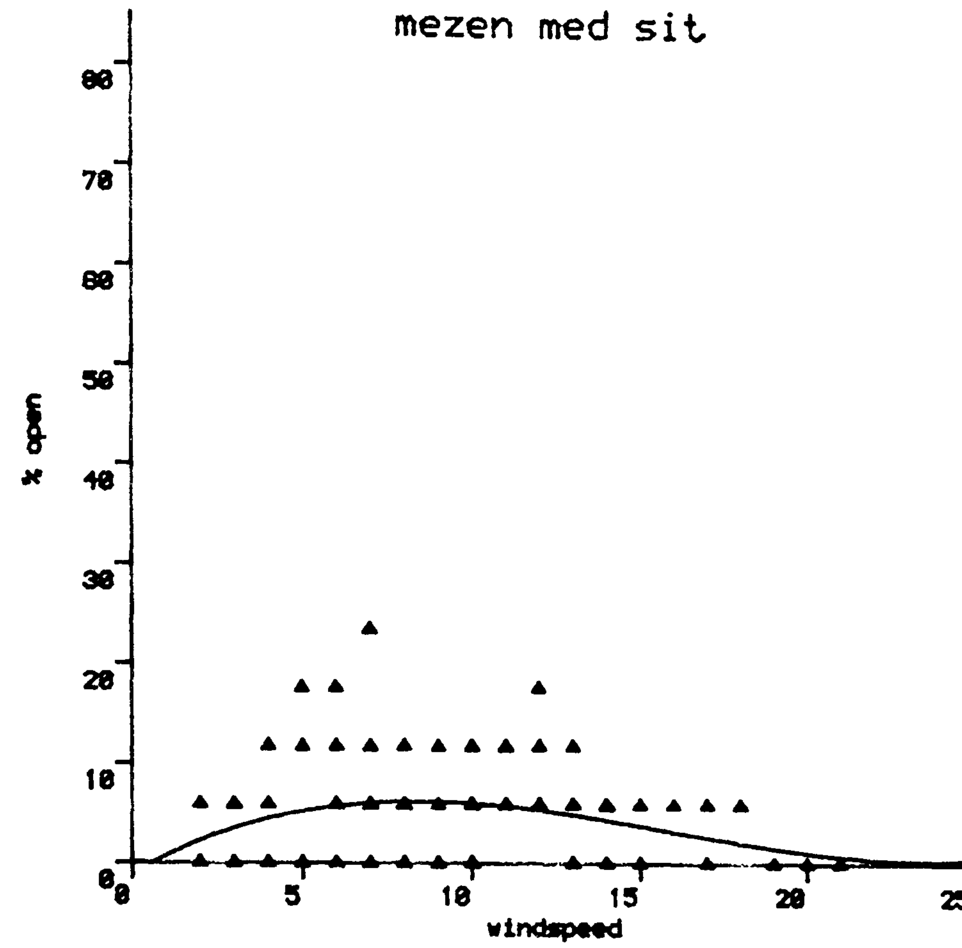
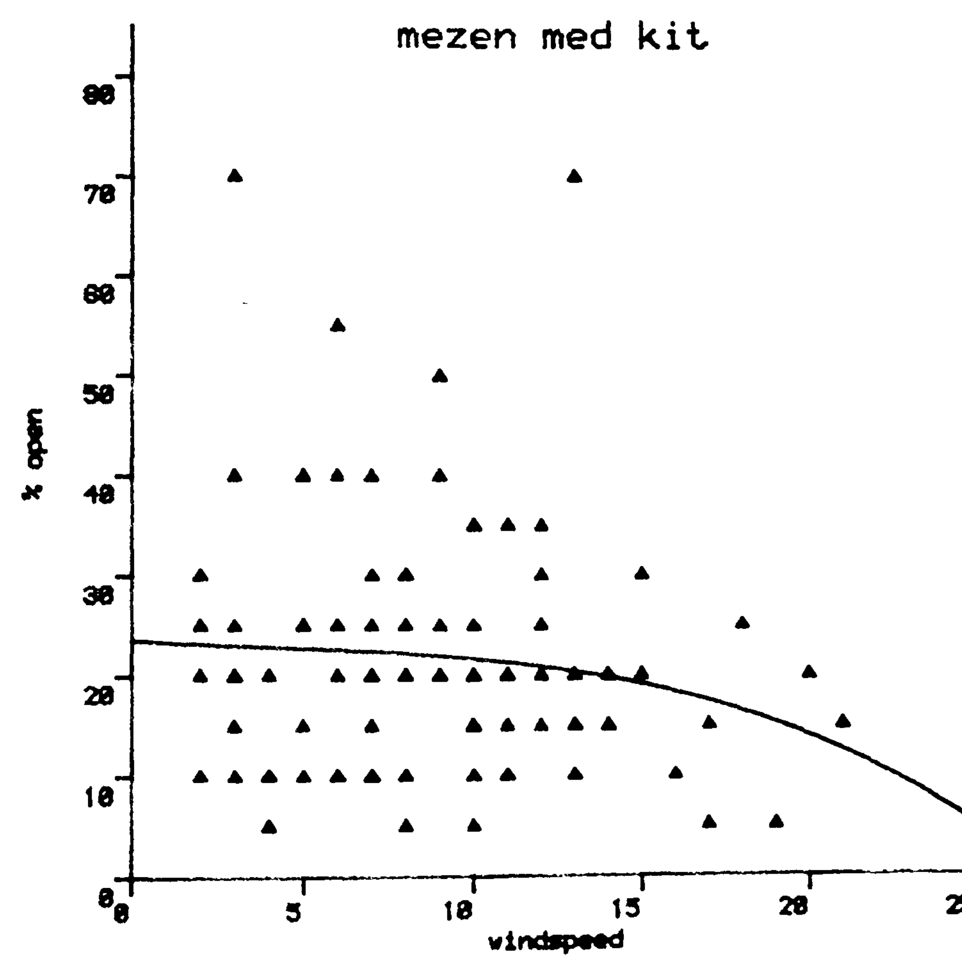


FIGURE A93



FIGURES A94

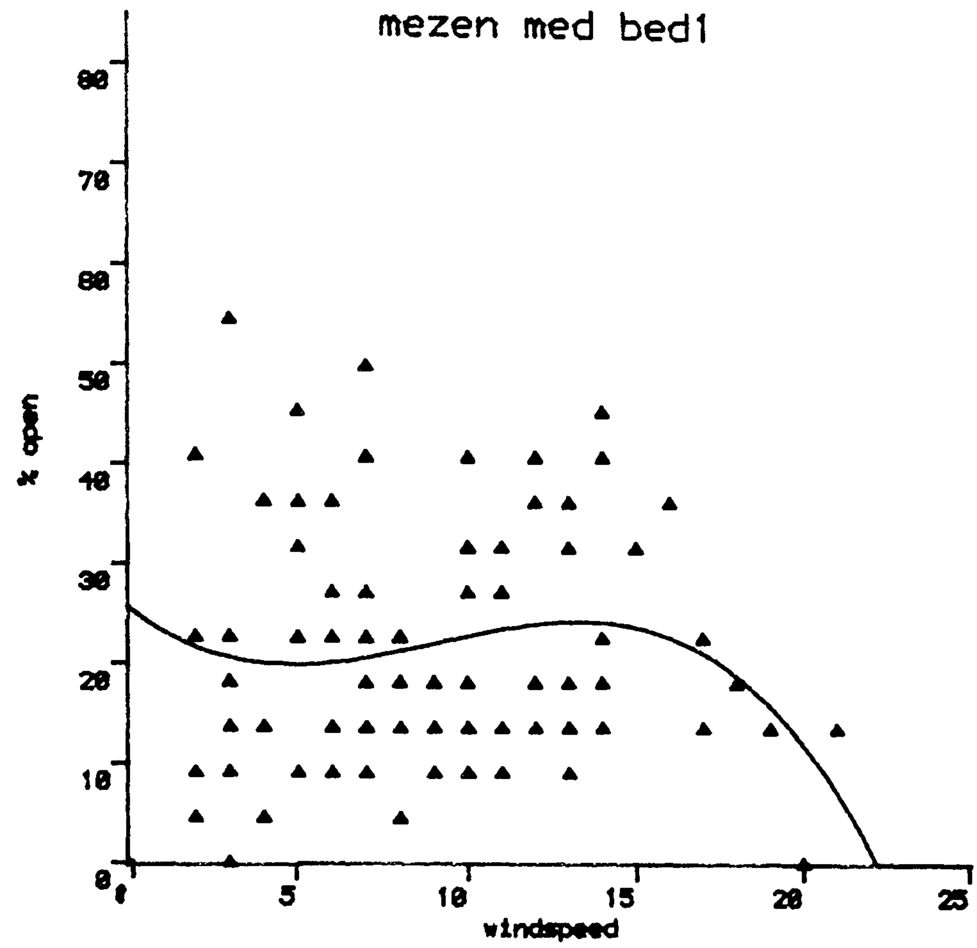
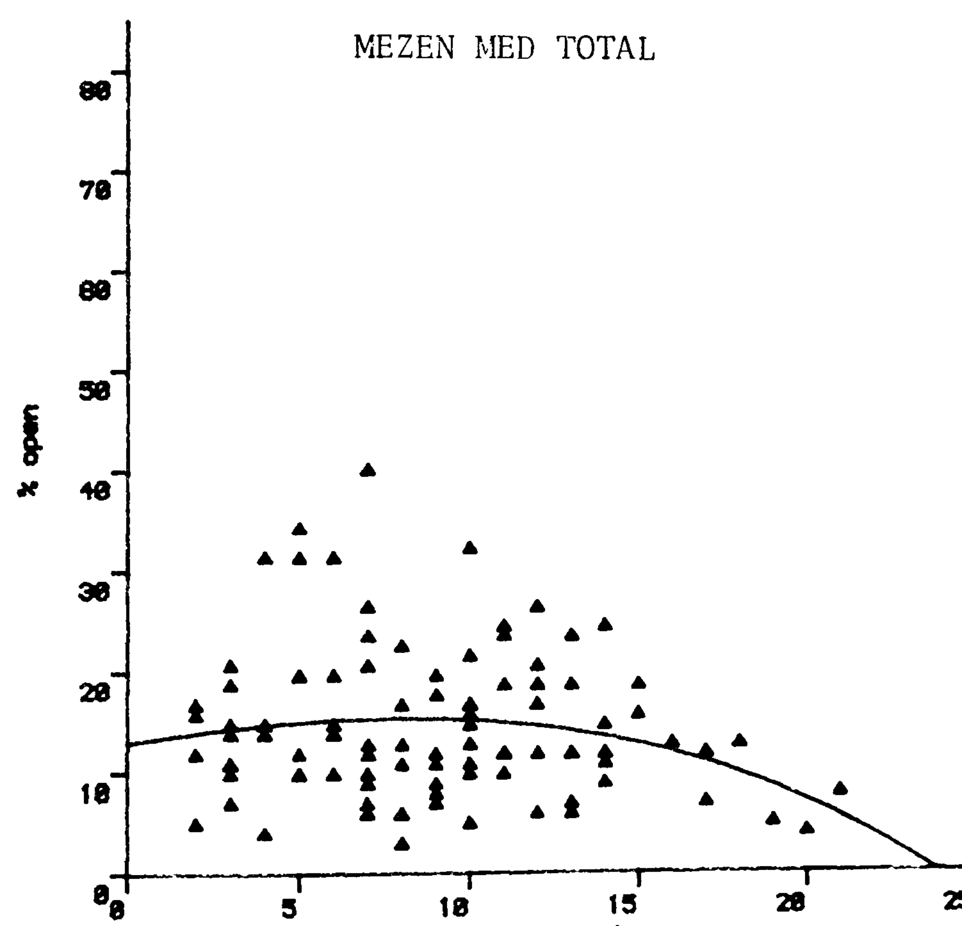


FIGURE A95



FIGURES A96-A99. Relationships between windspeed and window opening in the high group at Mezen

FIGURE A96

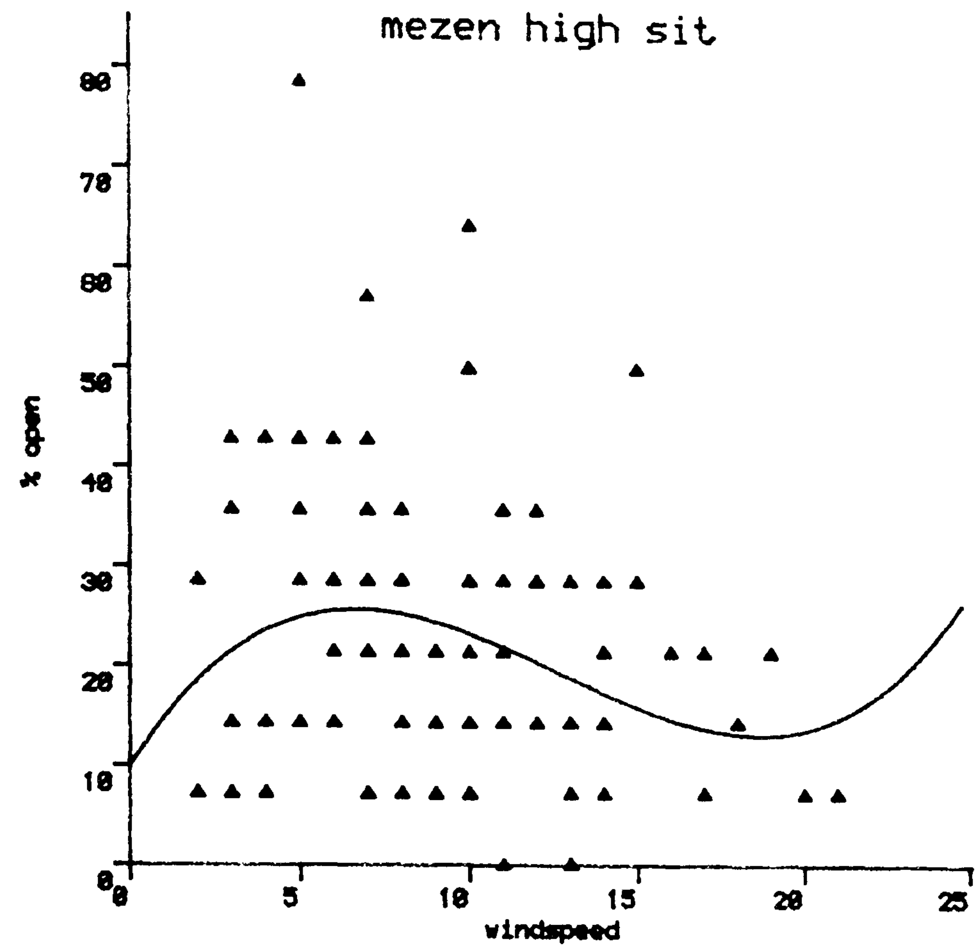


FIGURE A97

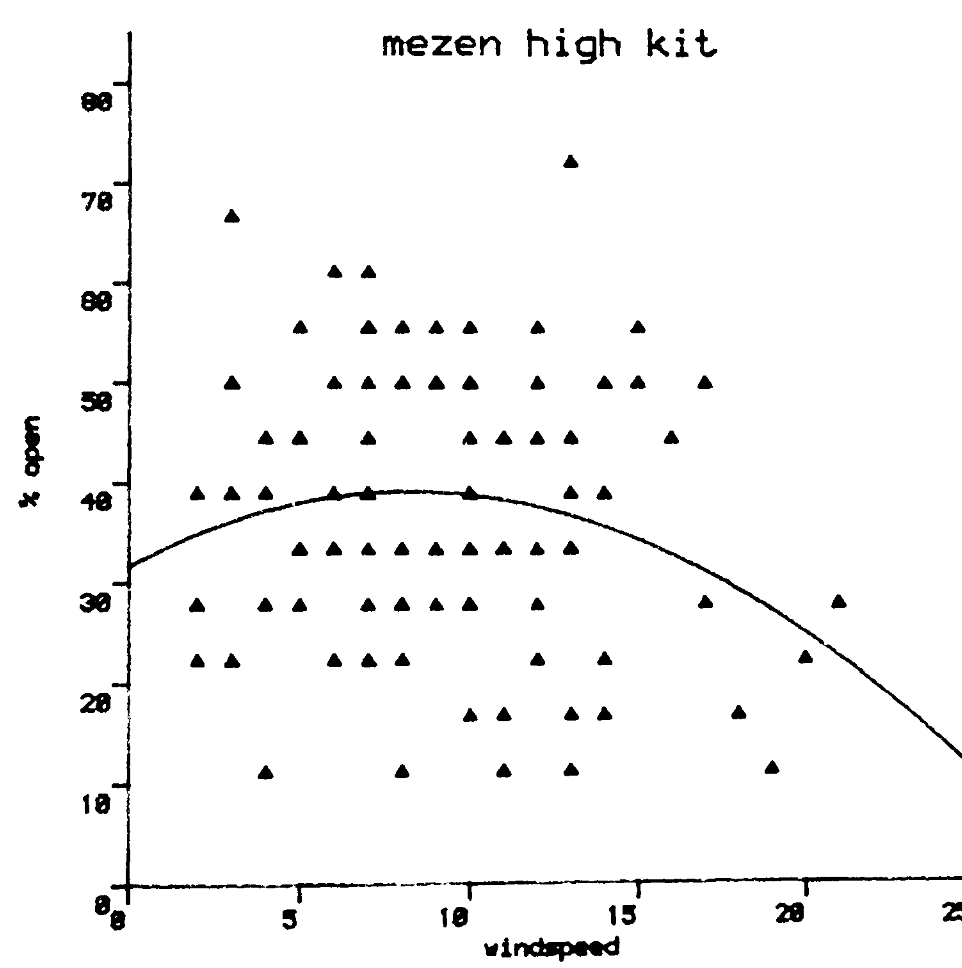


FIGURE A98

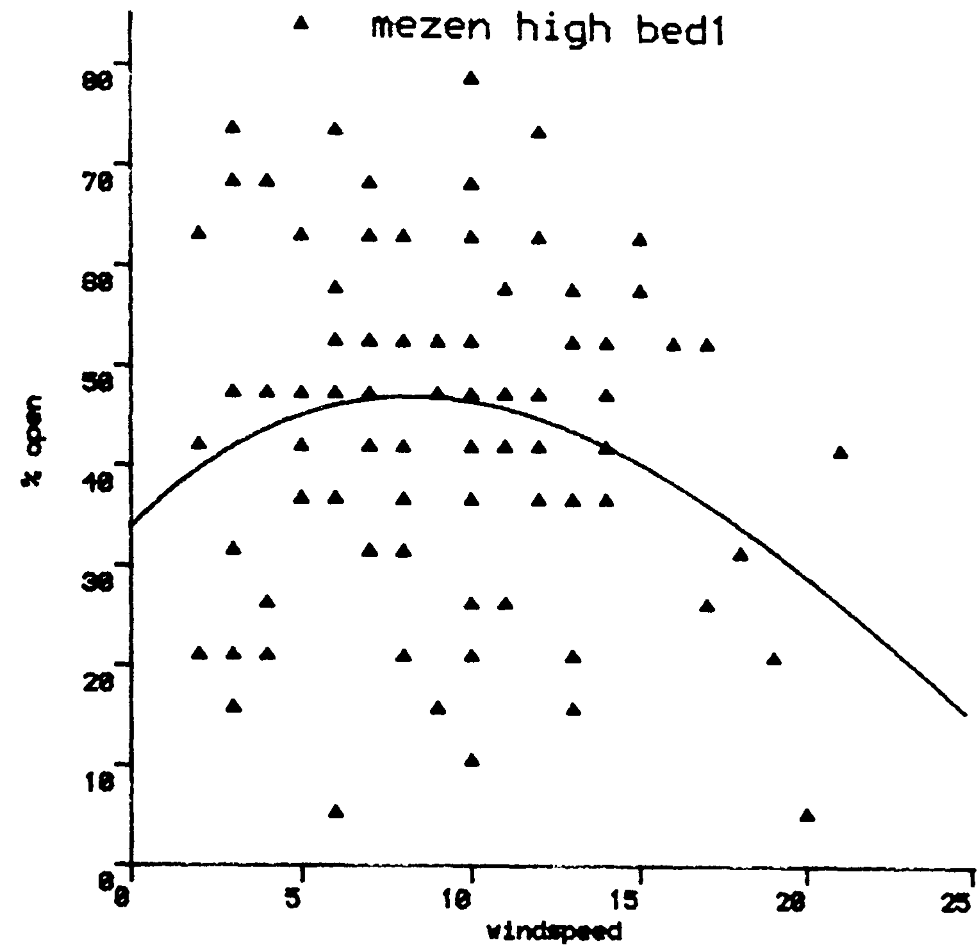
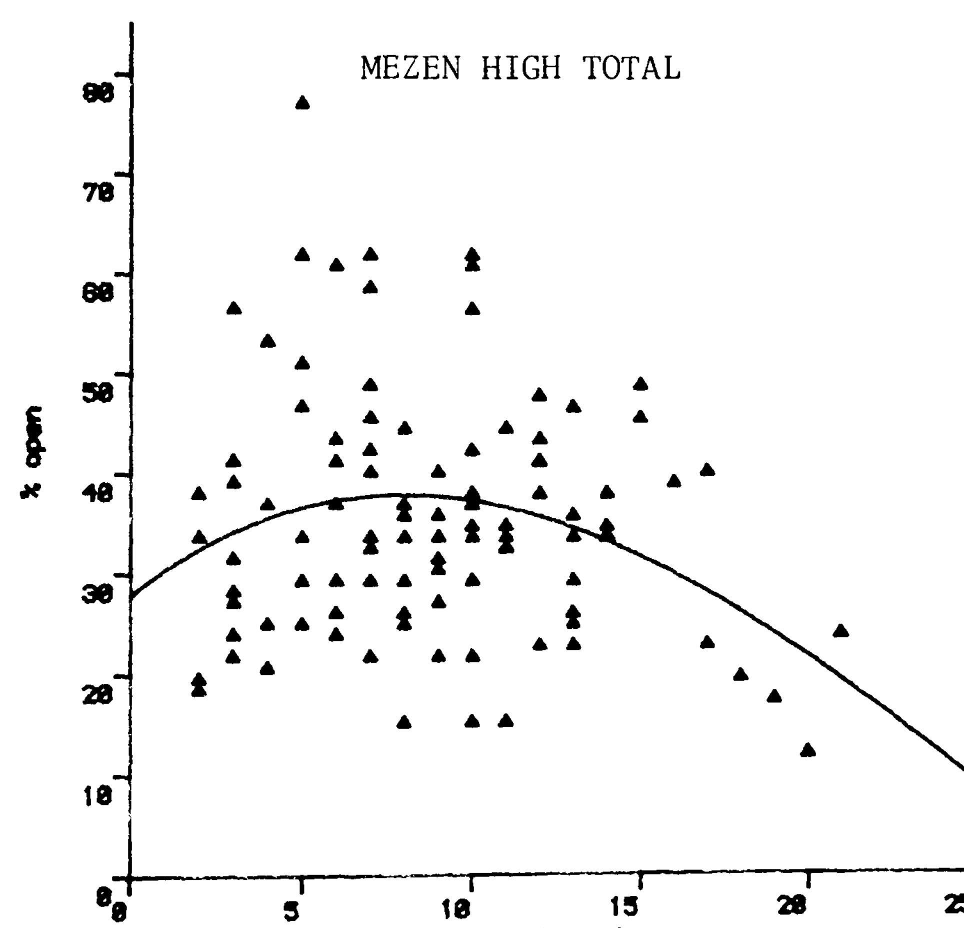


FIGURE A99



FIGURES A100-A103. Relationships between windspeed and window opening in all groups at Mezen

FIGURE A100

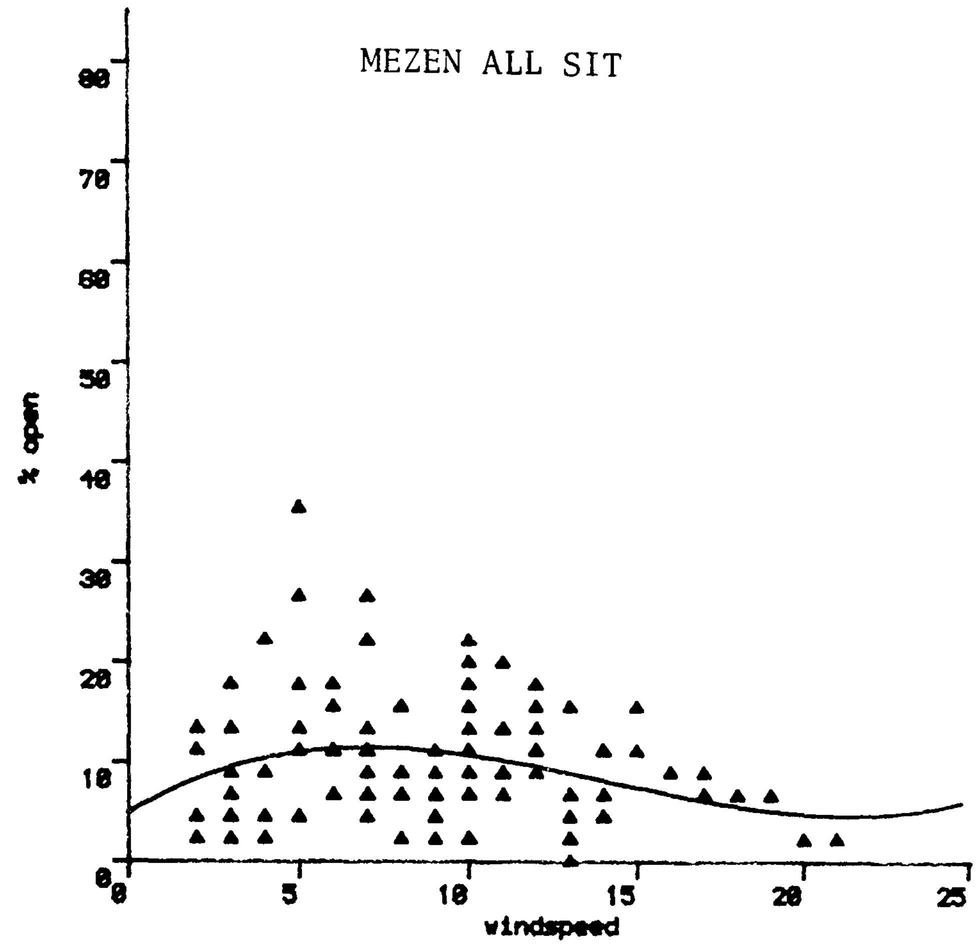


FIGURE A101

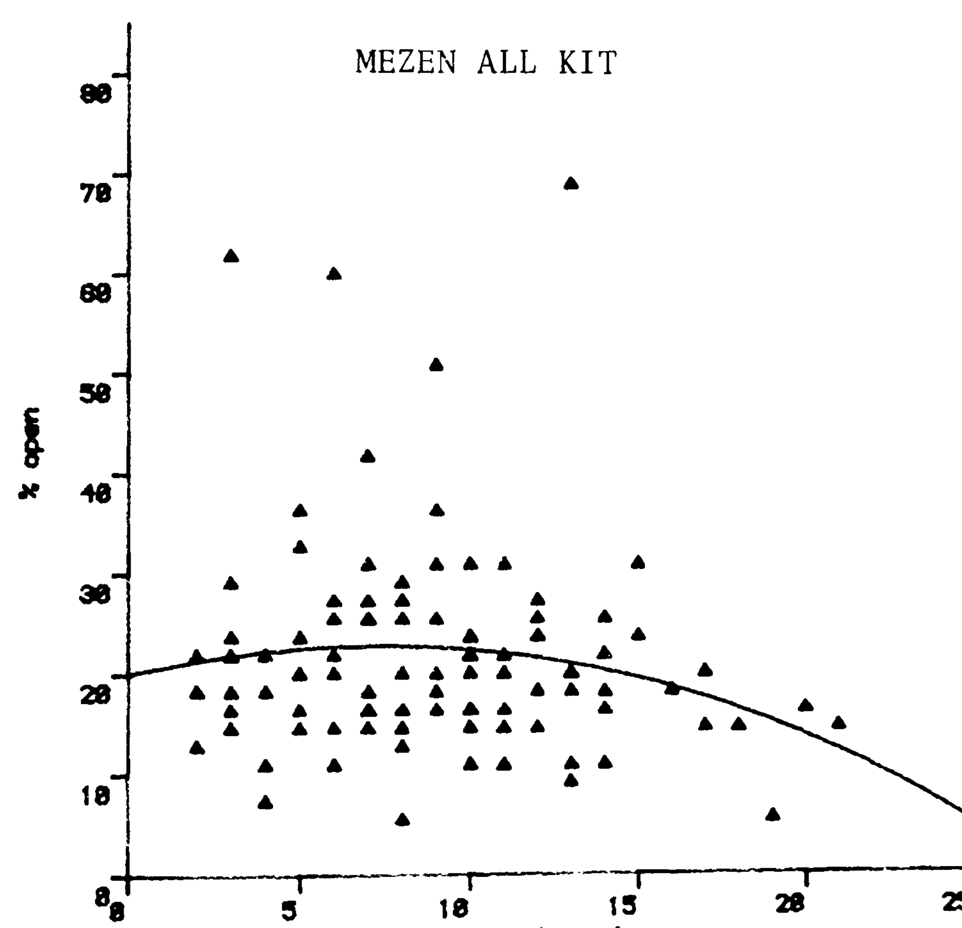


FIGURE A102

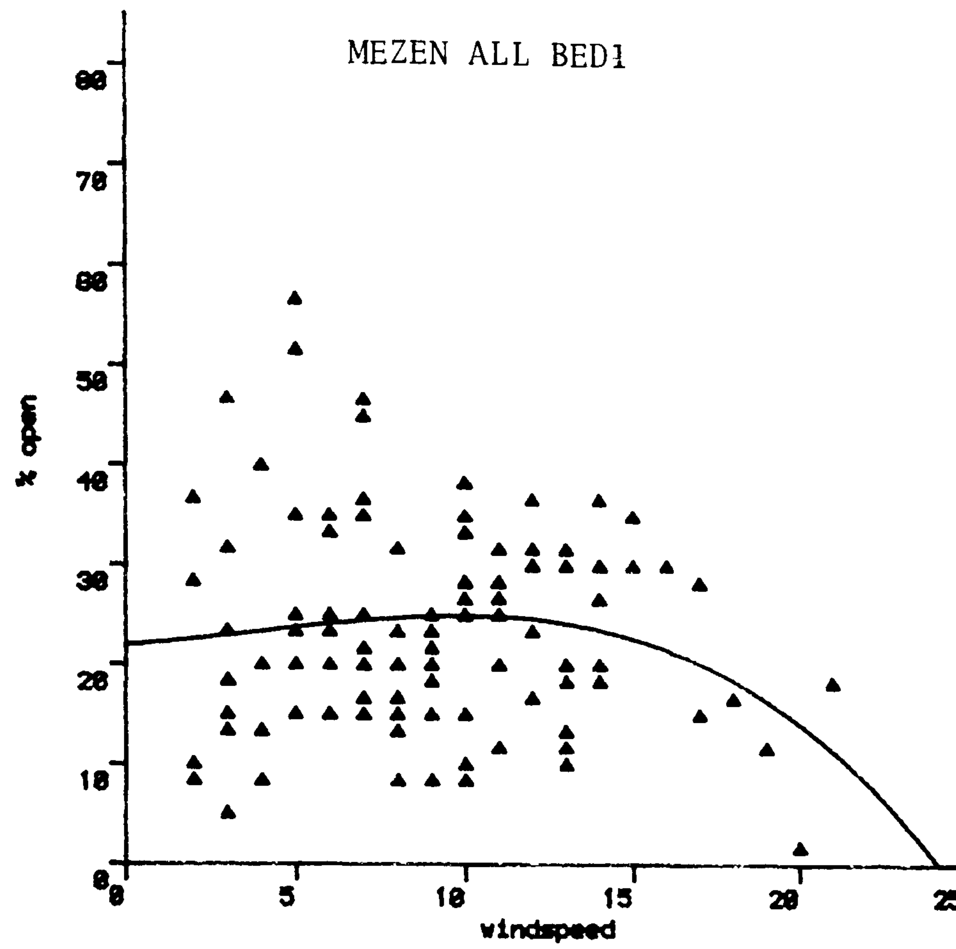
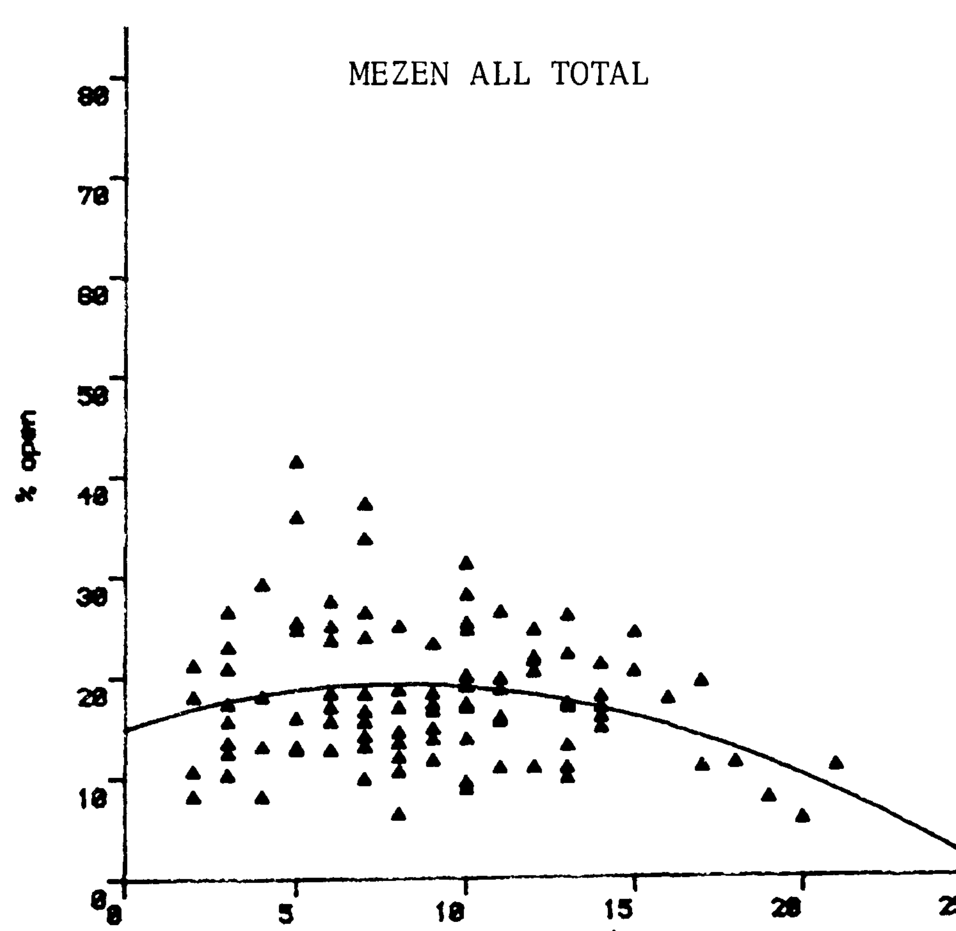


FIGURE A103



FIGURES A104-A107. Relationships between sunshine duration and window opening in the low group at Cowley

FIGURE A104

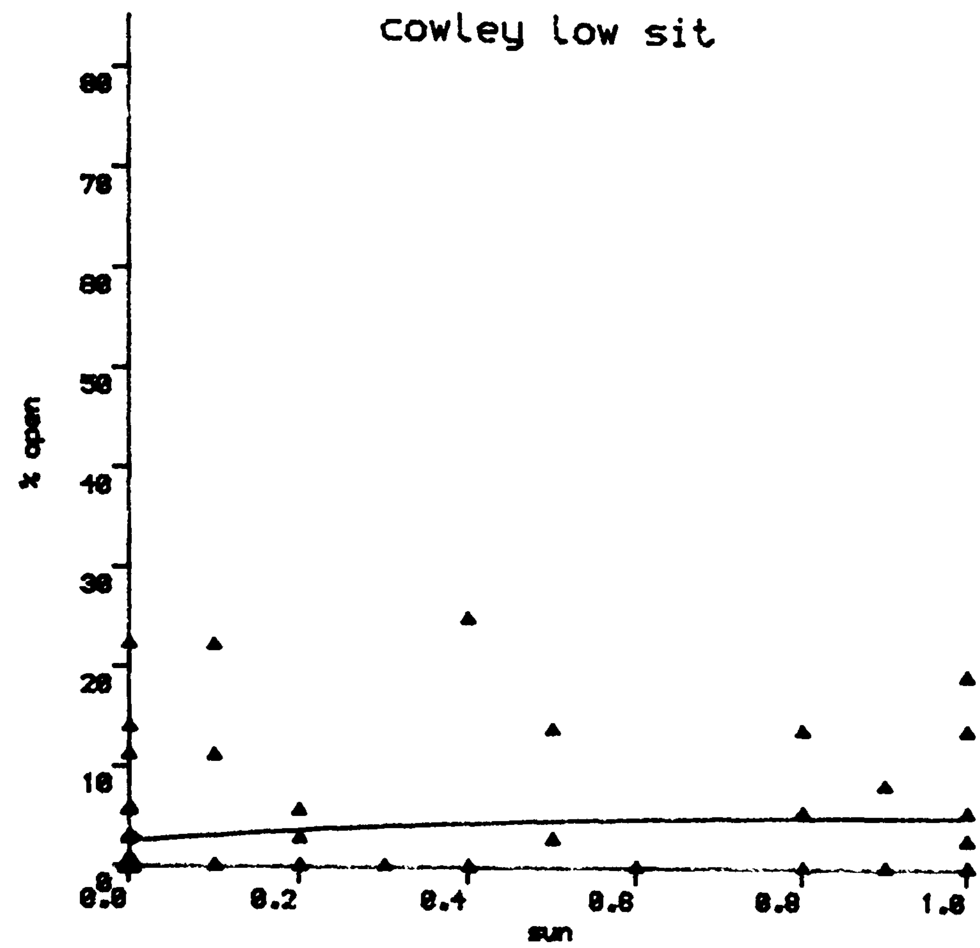


FIGURE A105

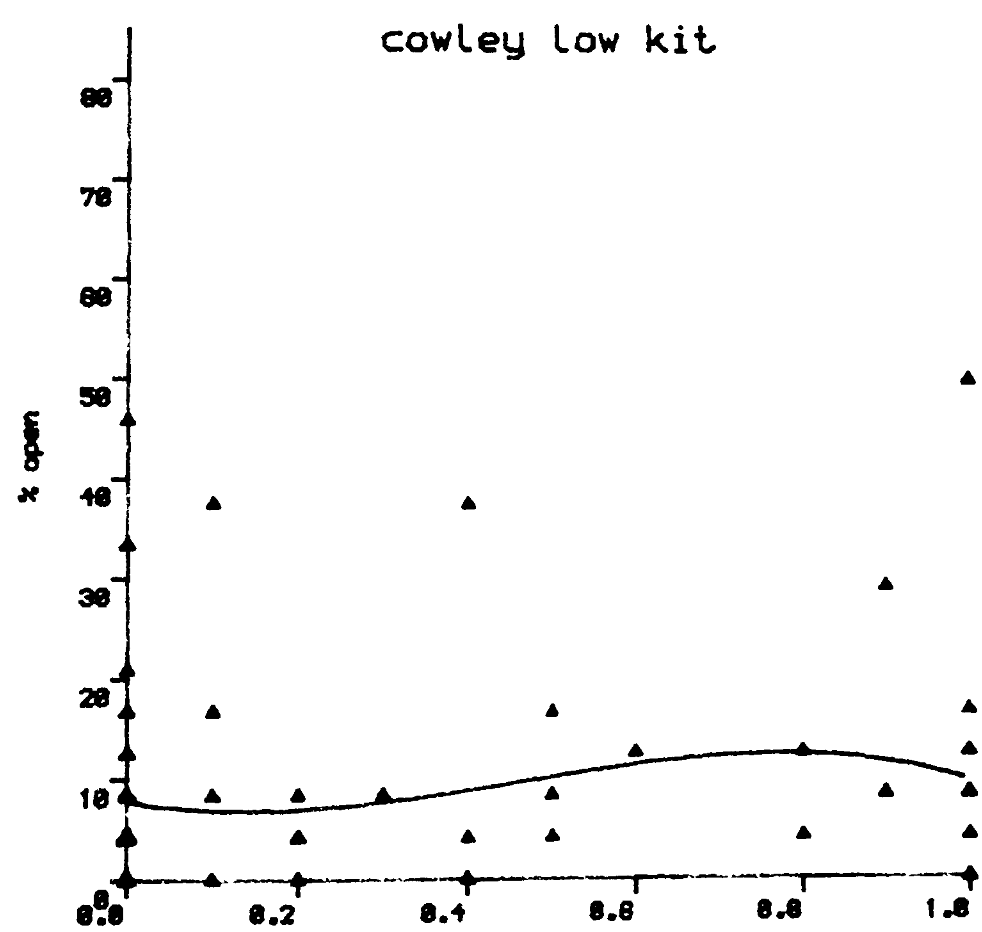


FIGURE A106

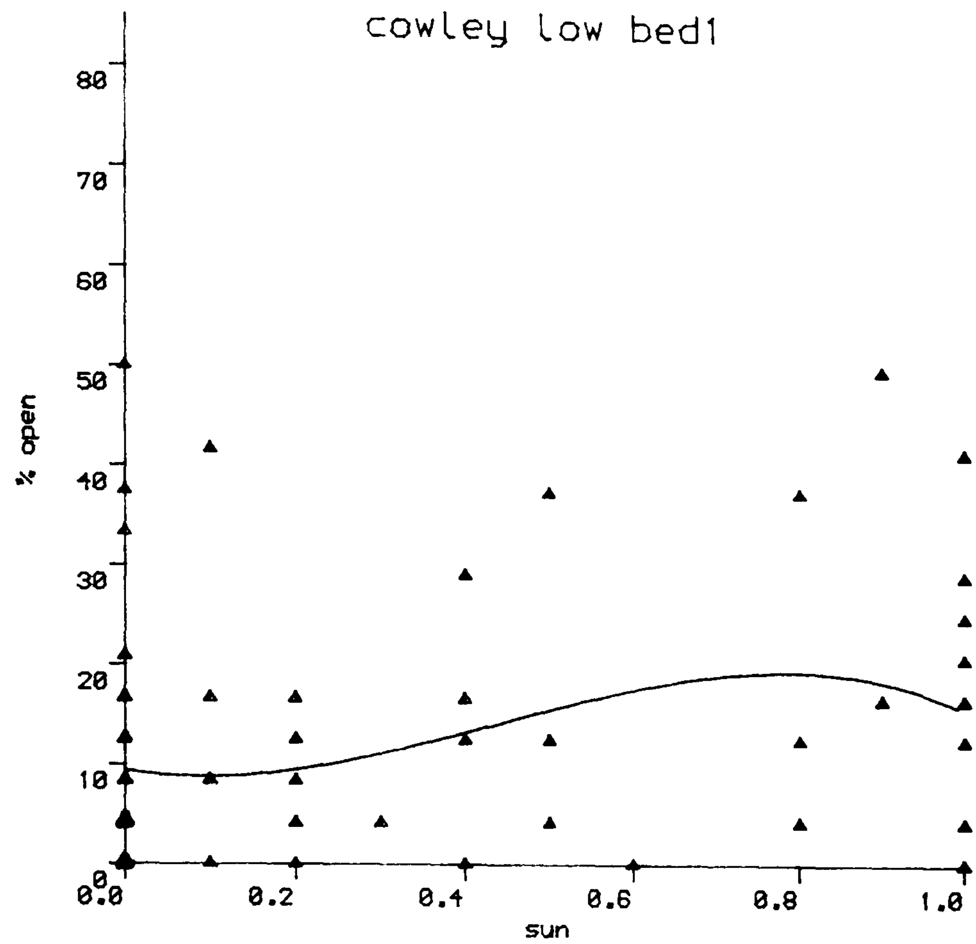
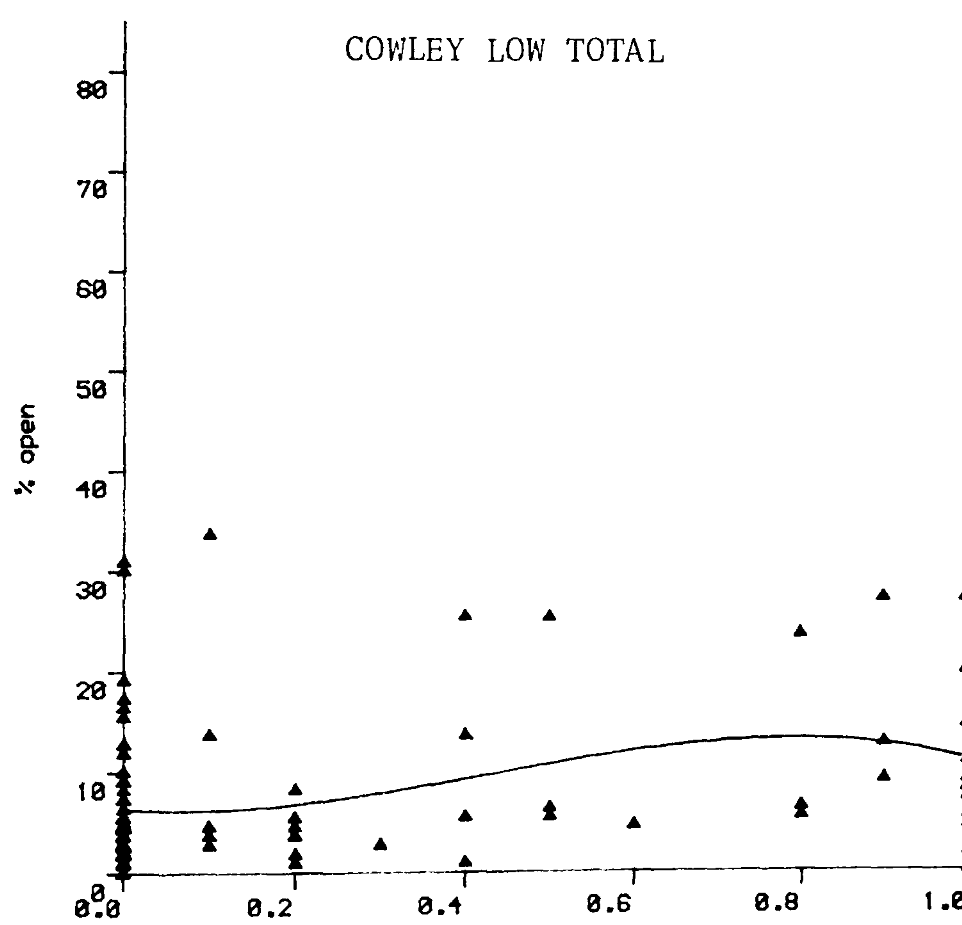


FIGURE A107



FIGURES A108-A111. Relationships between sunshine duration and window opening in the medium group at Cowley

FIGURE A108

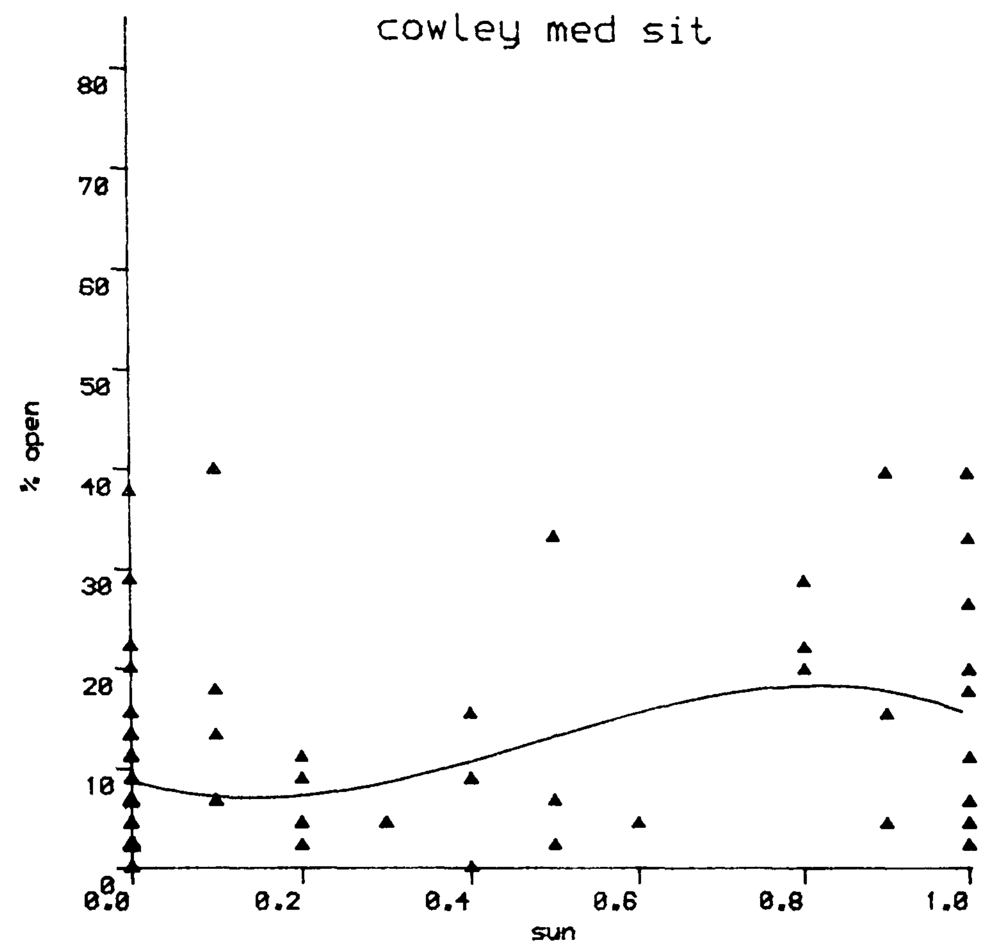


FIGURE A109

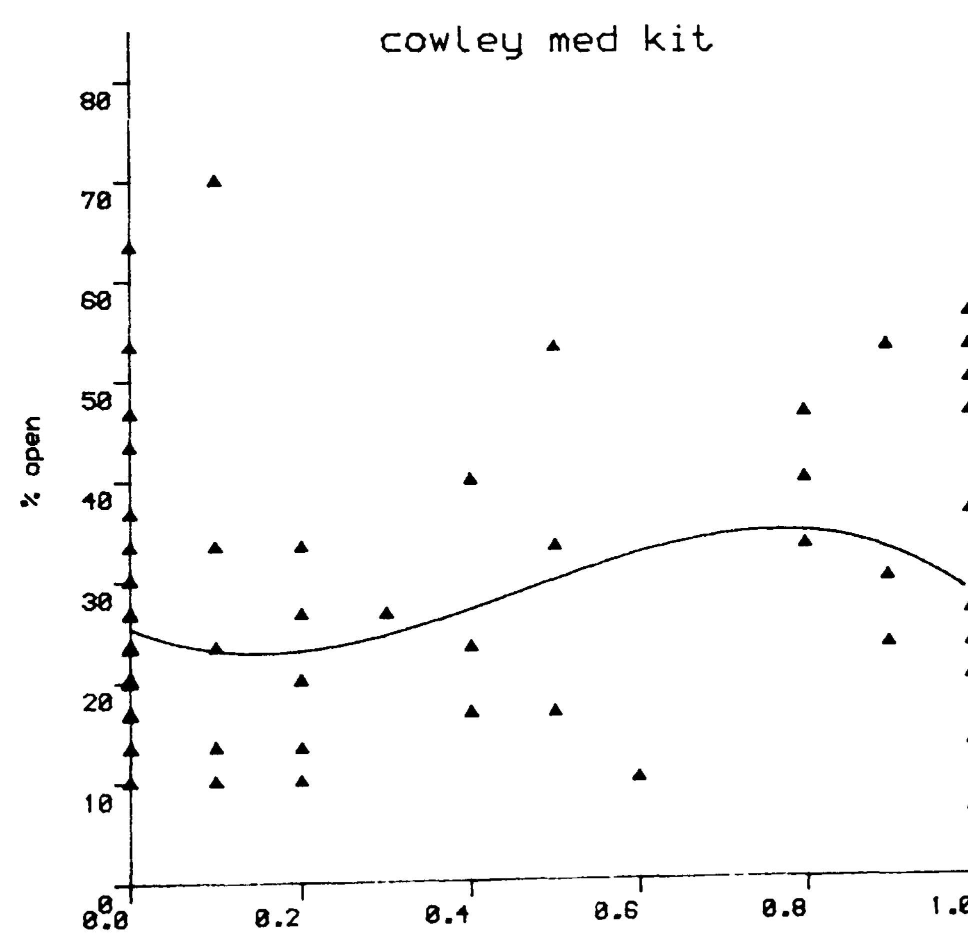


FIGURE A110

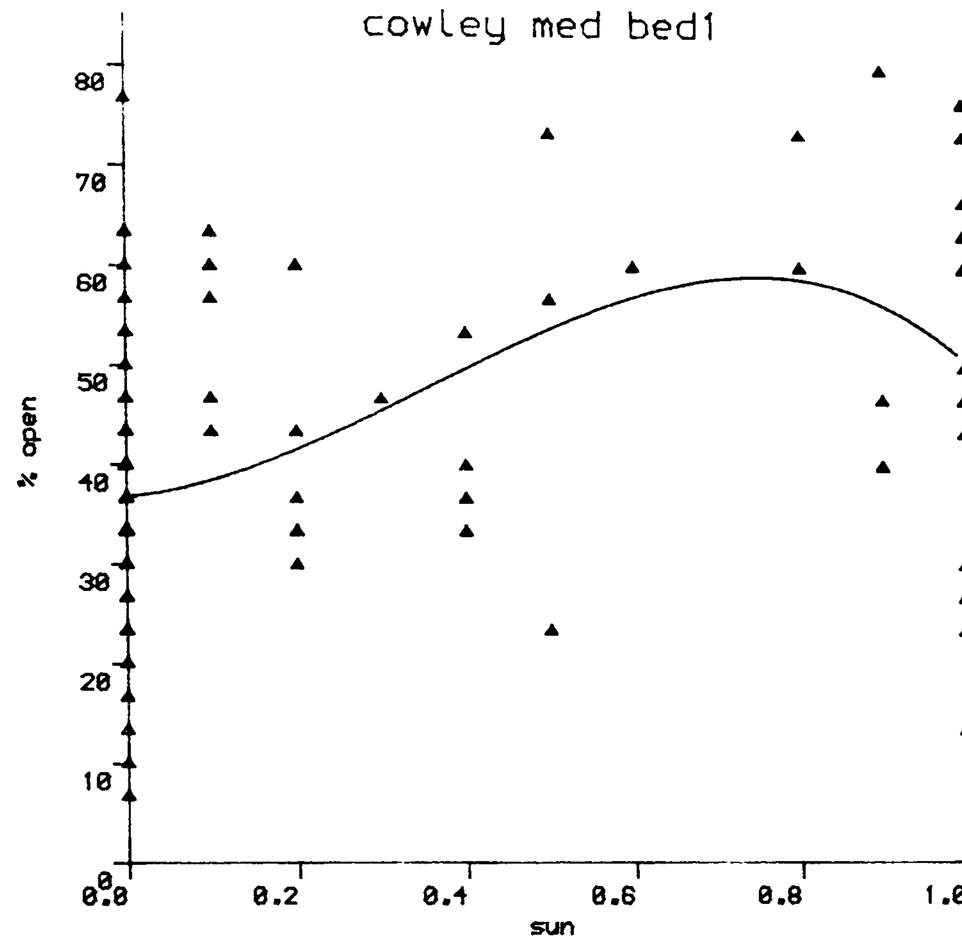
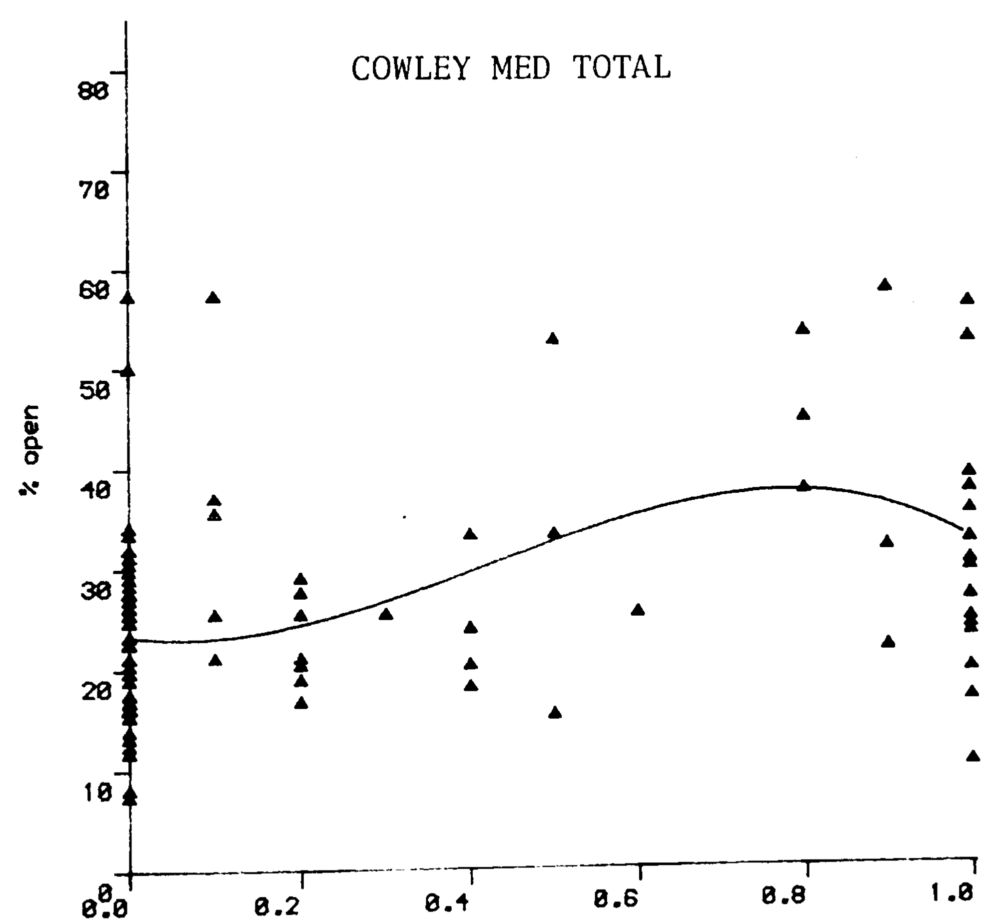


FIGURE A111



FIGURES A112-A115. Relationships between sunshine duration and window opening in the high group at Cowley

FIGURE A112

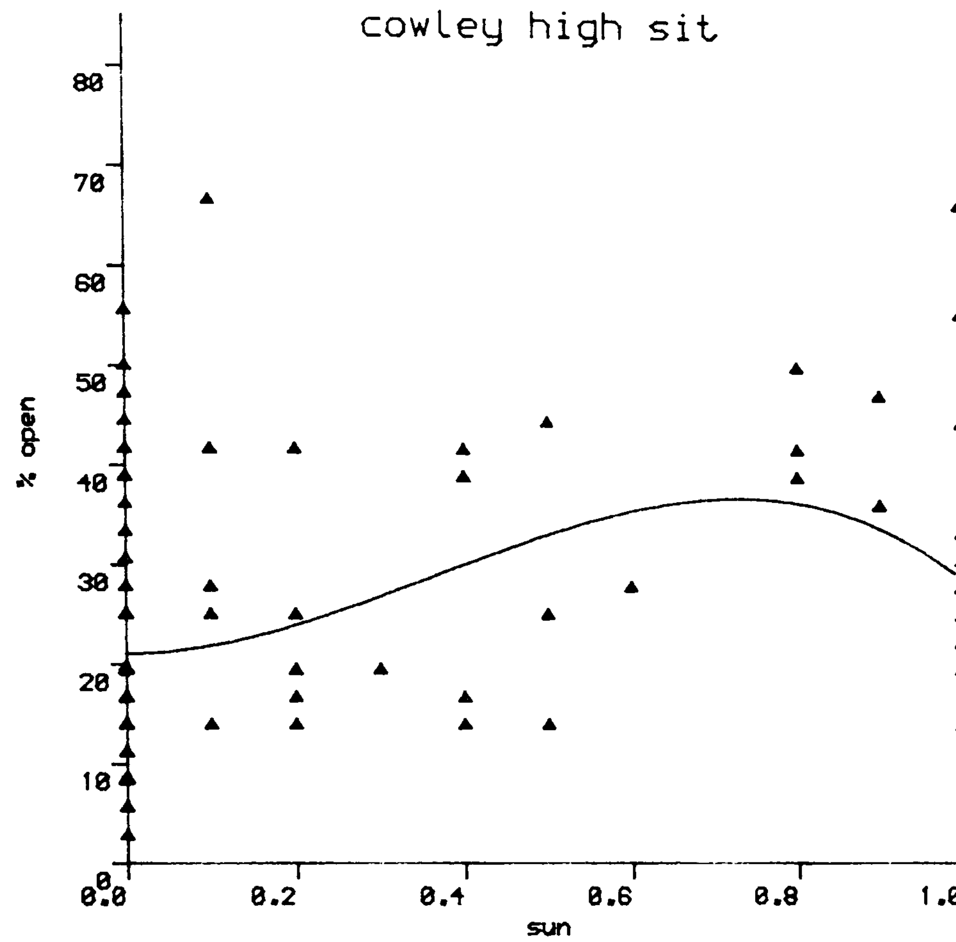


FIGURE A113

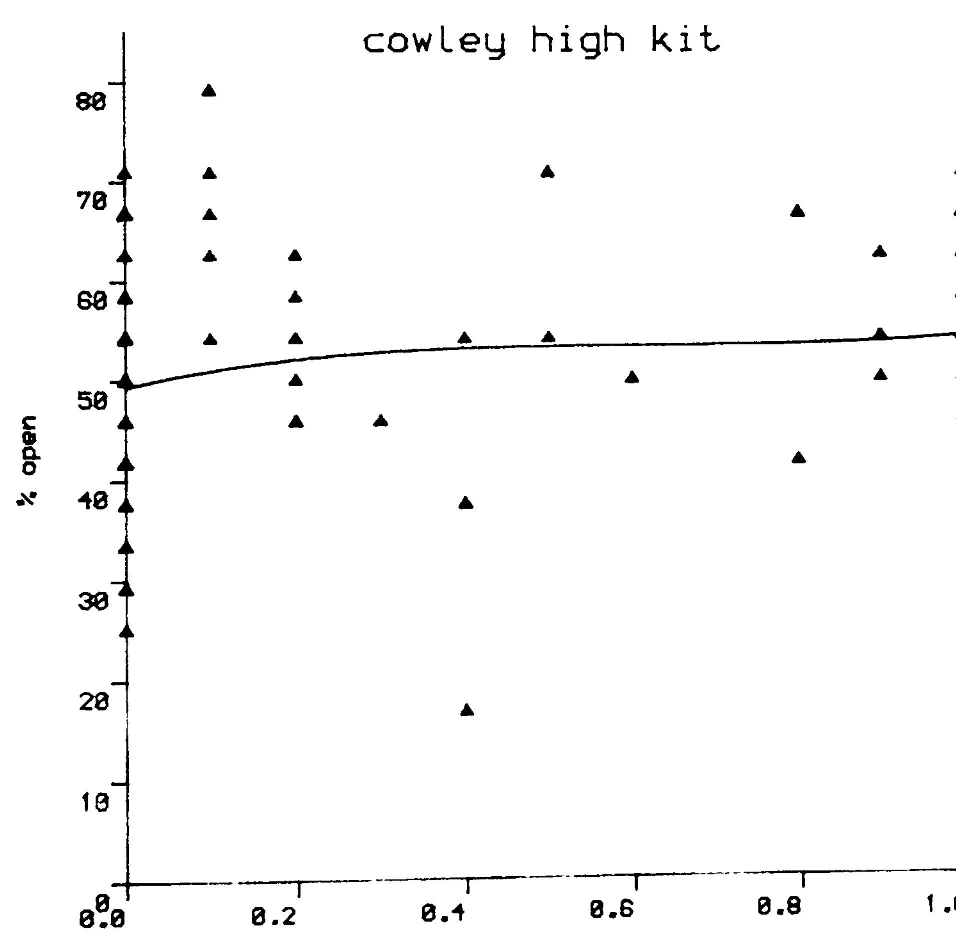


FIGURE A114

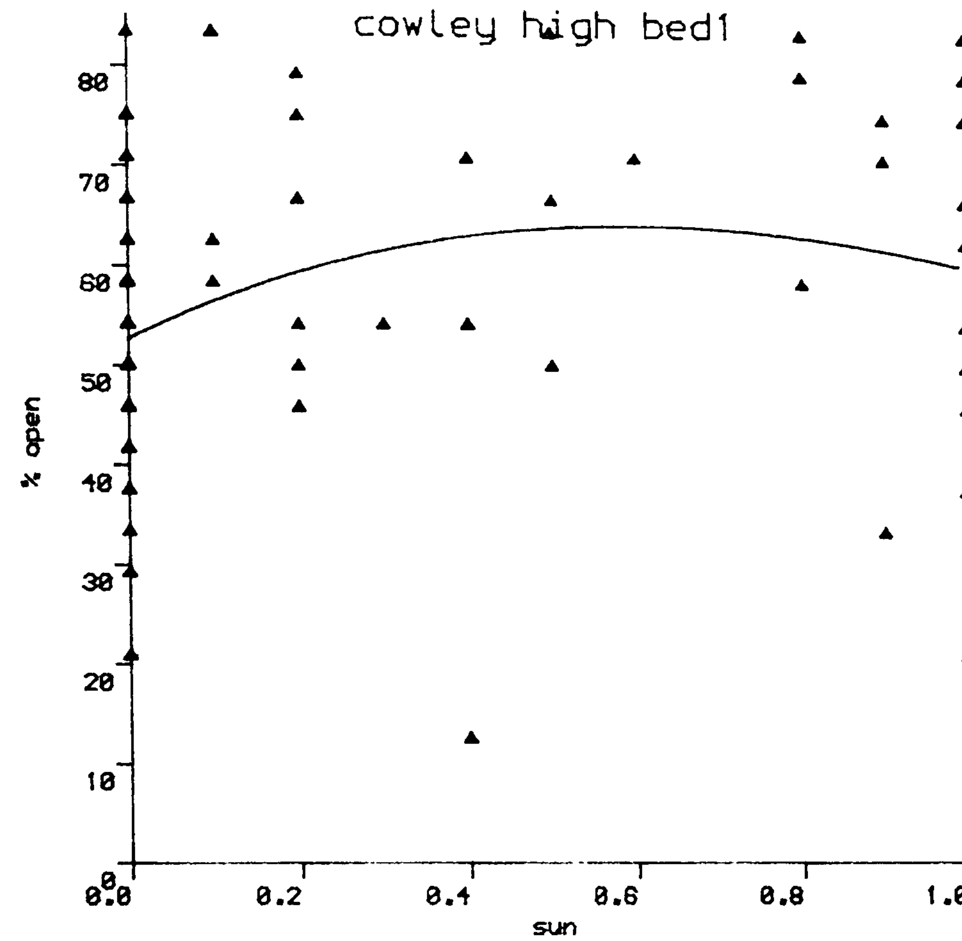
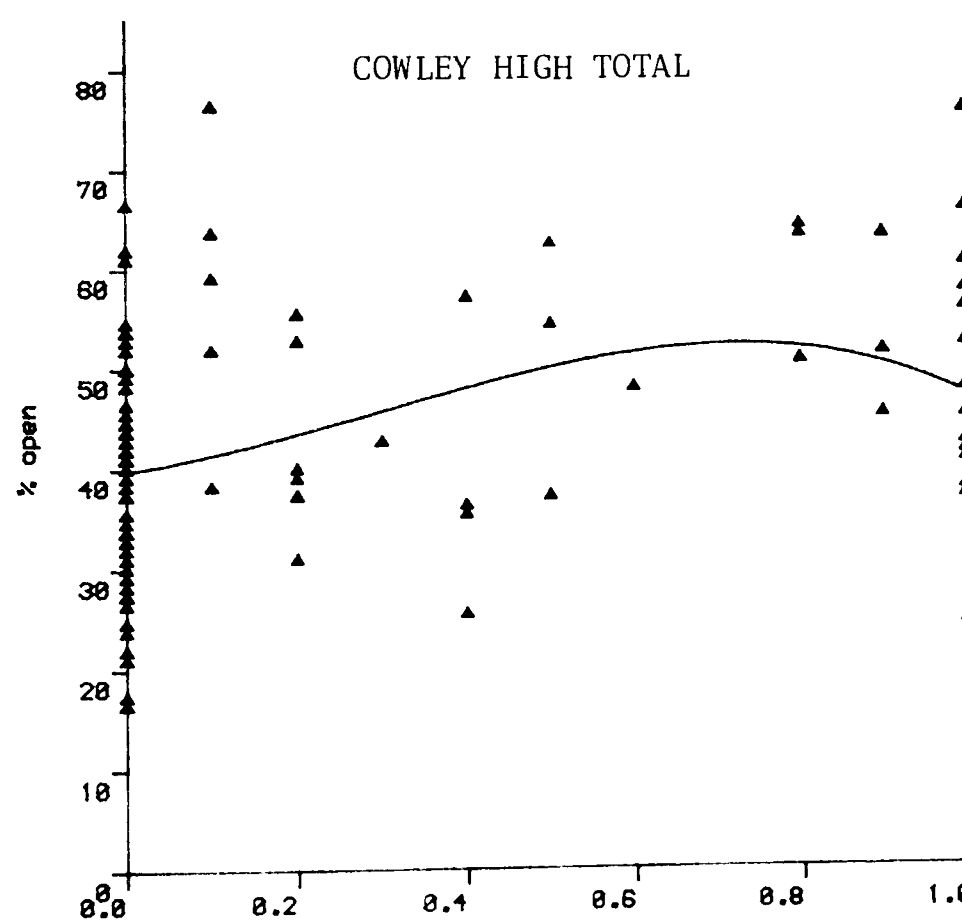


FIGURE A115



FIGURES A116-A119. Relationships between sunshine duration and window opening in all groups at Cowley

FIGURE A116

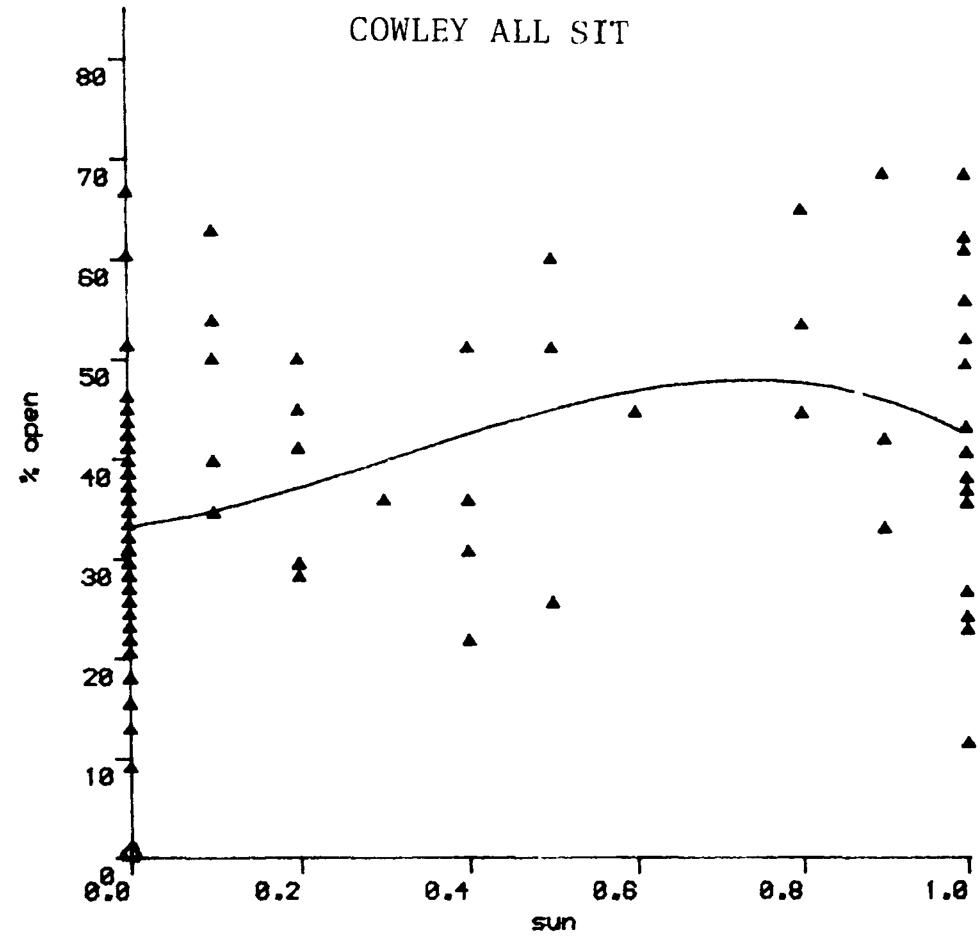


FIGURE A117

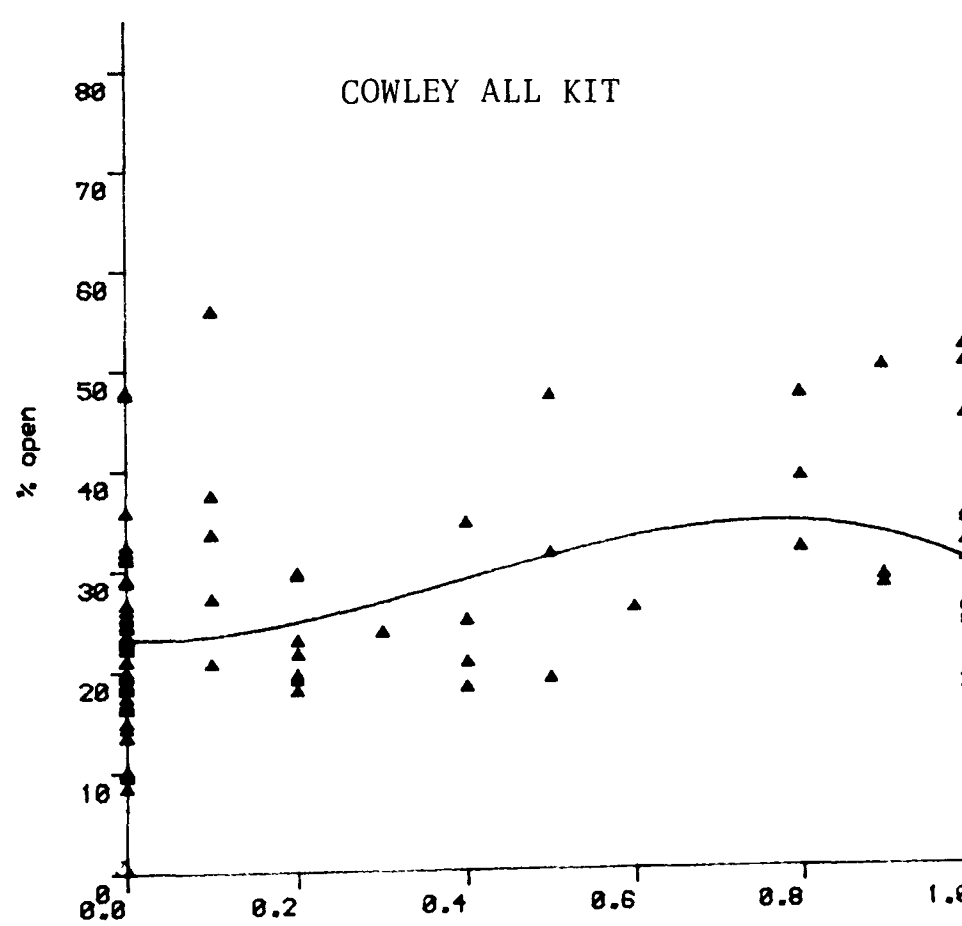


FIGURE A118

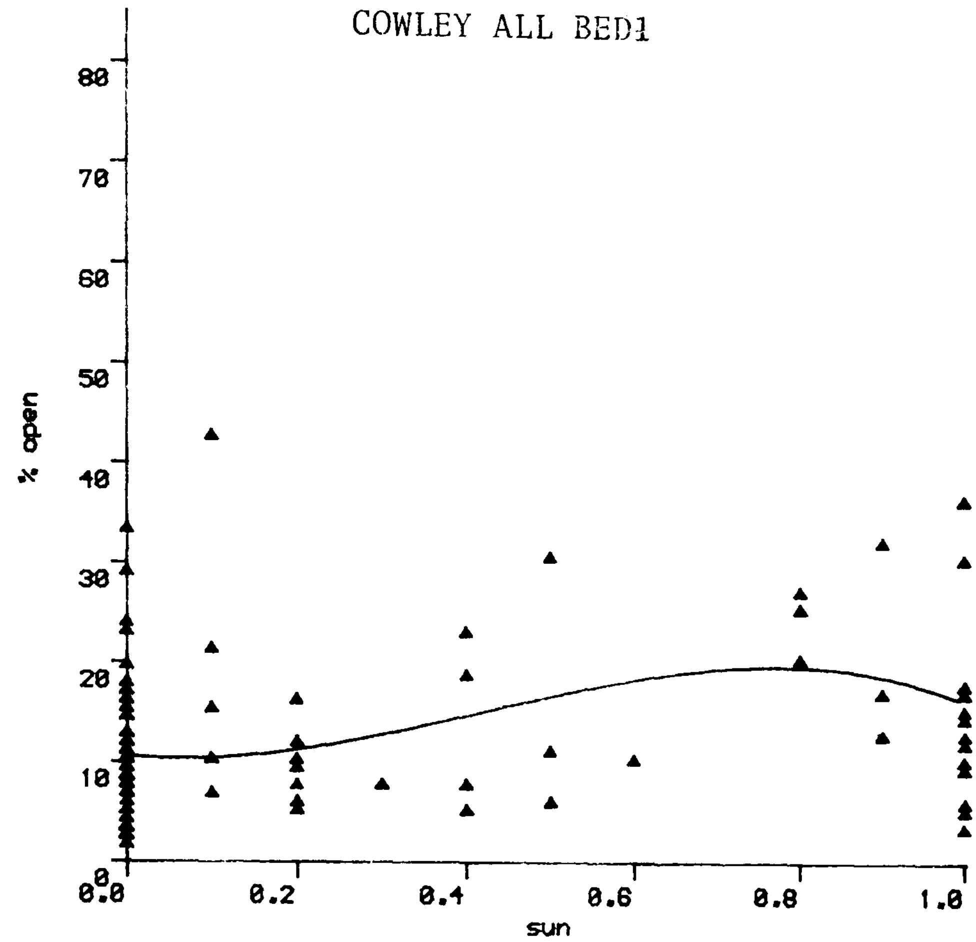
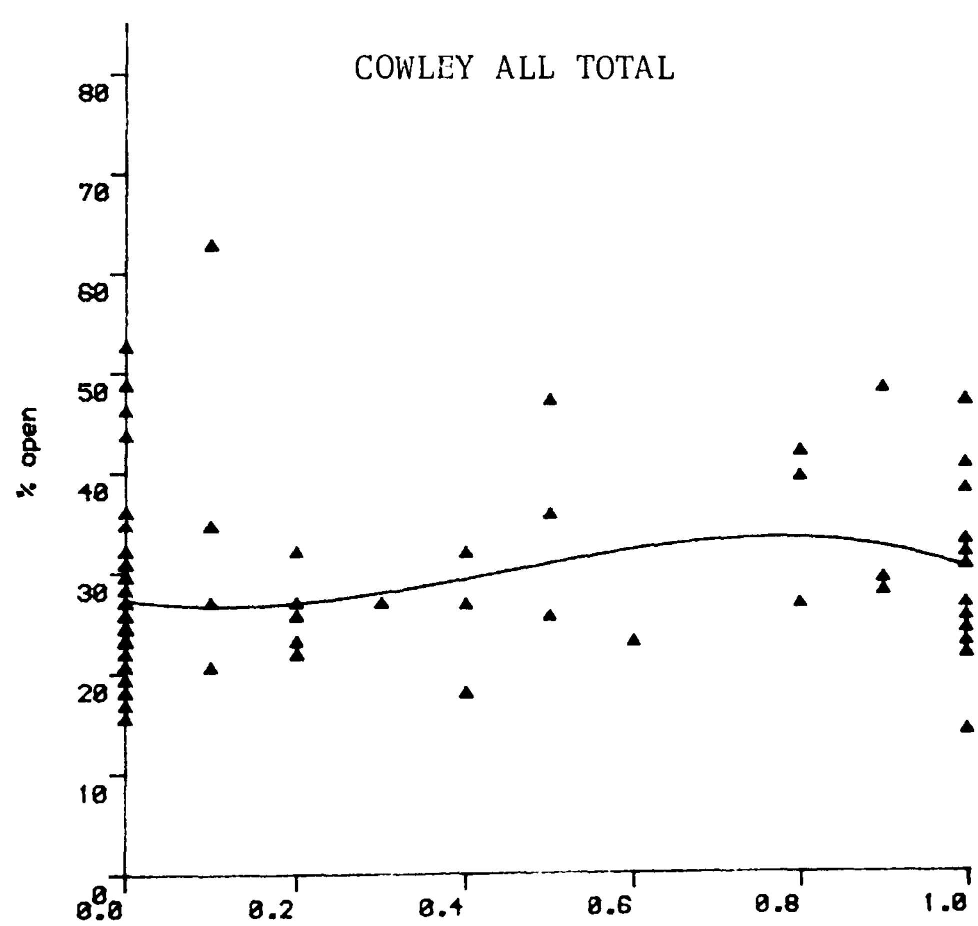


FIGURE A119



FIGURES A120-A123. Relationships between sunshine duration and window opening in the low group at Mezen

FIGURE A120

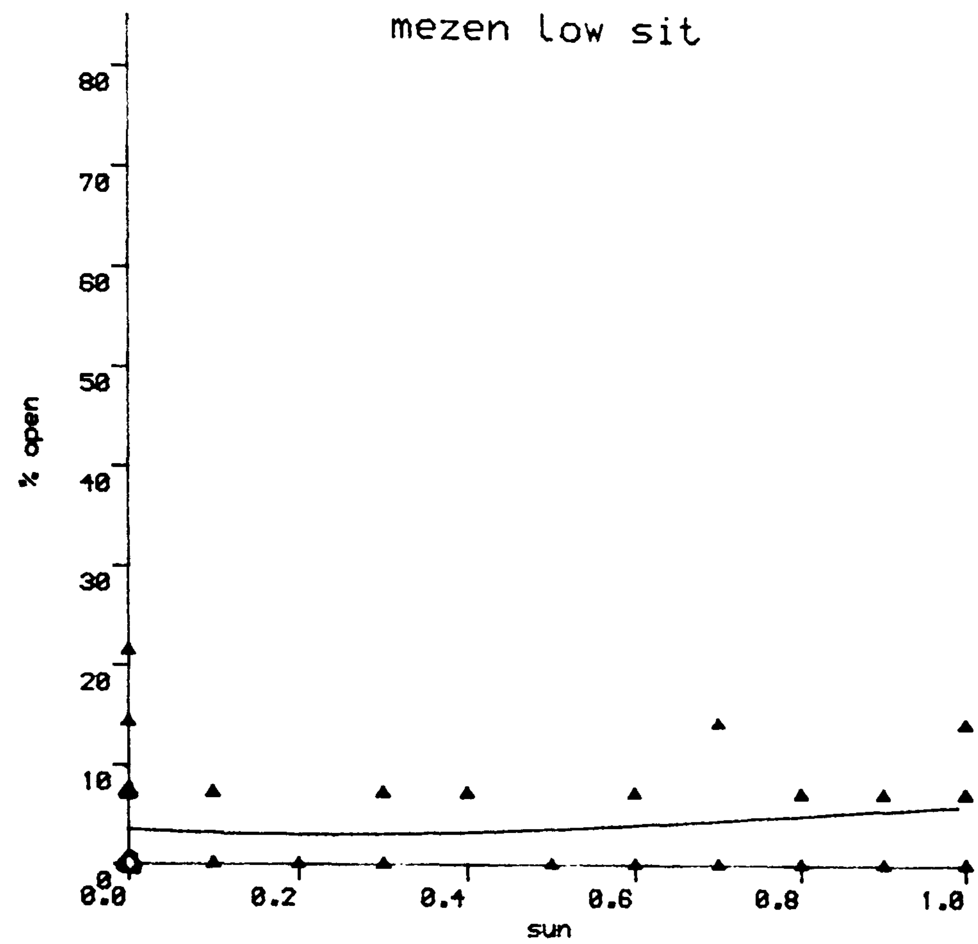


FIGURE A121

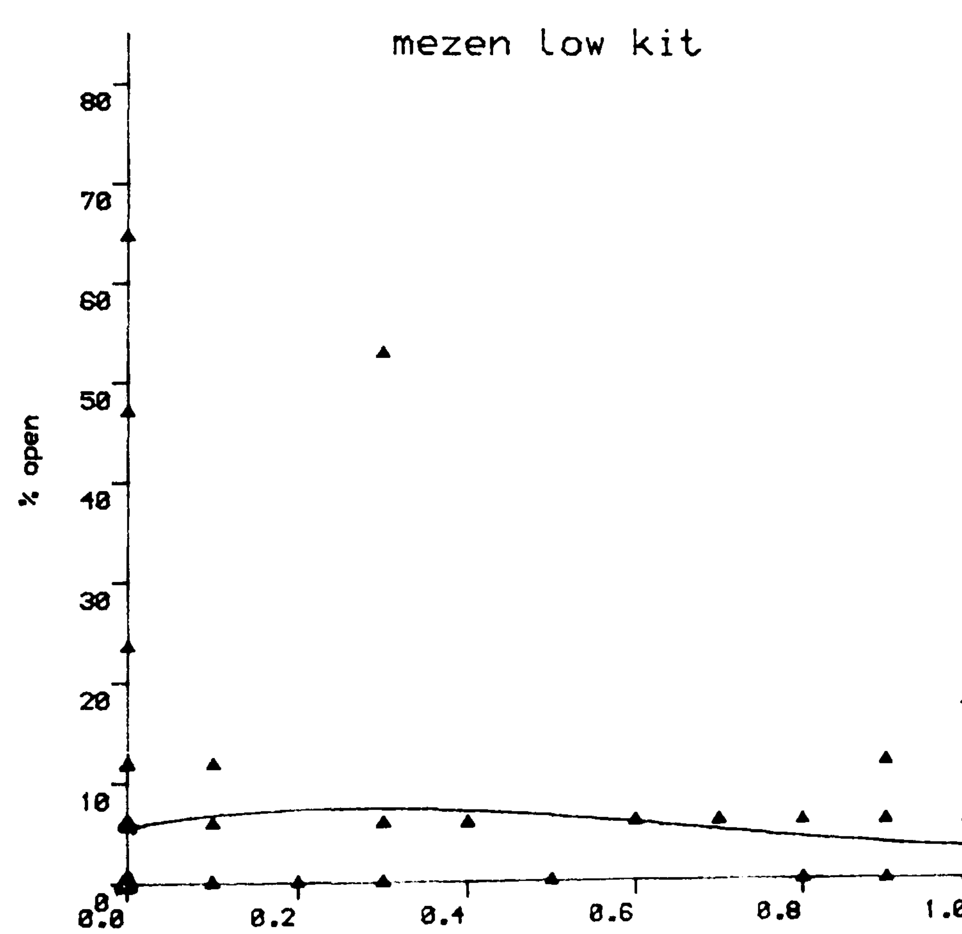


FIGURE A122

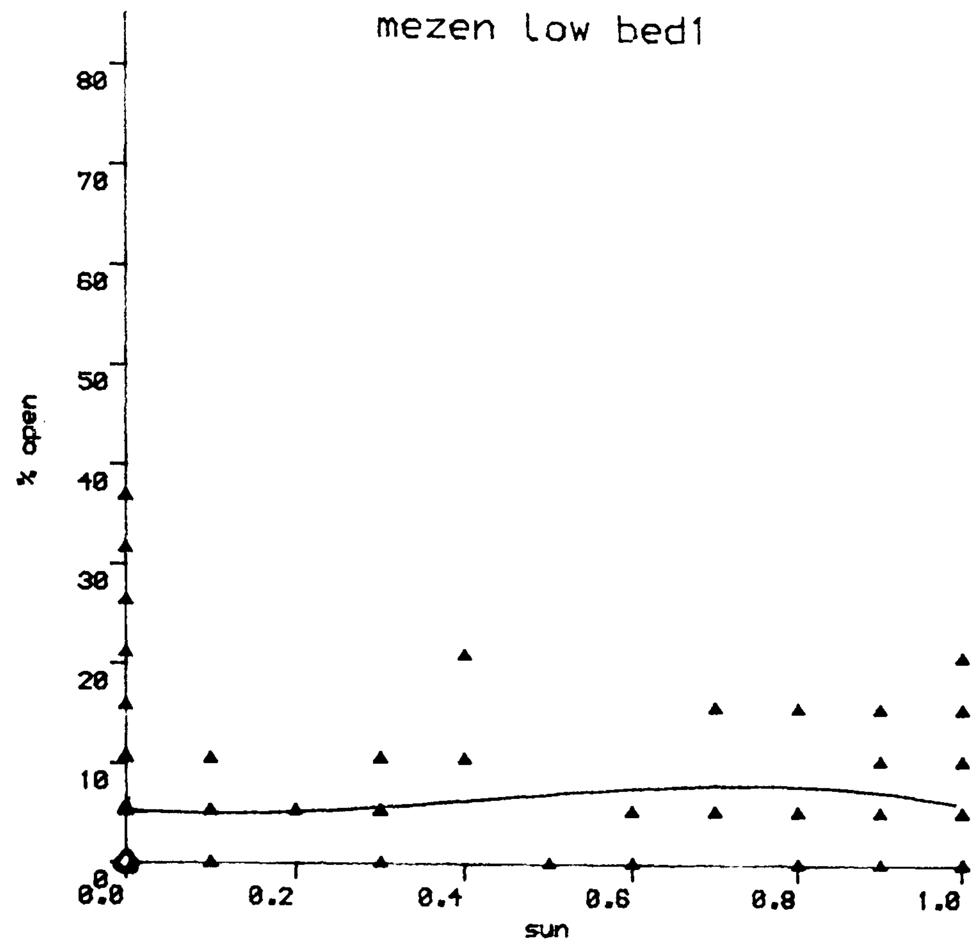
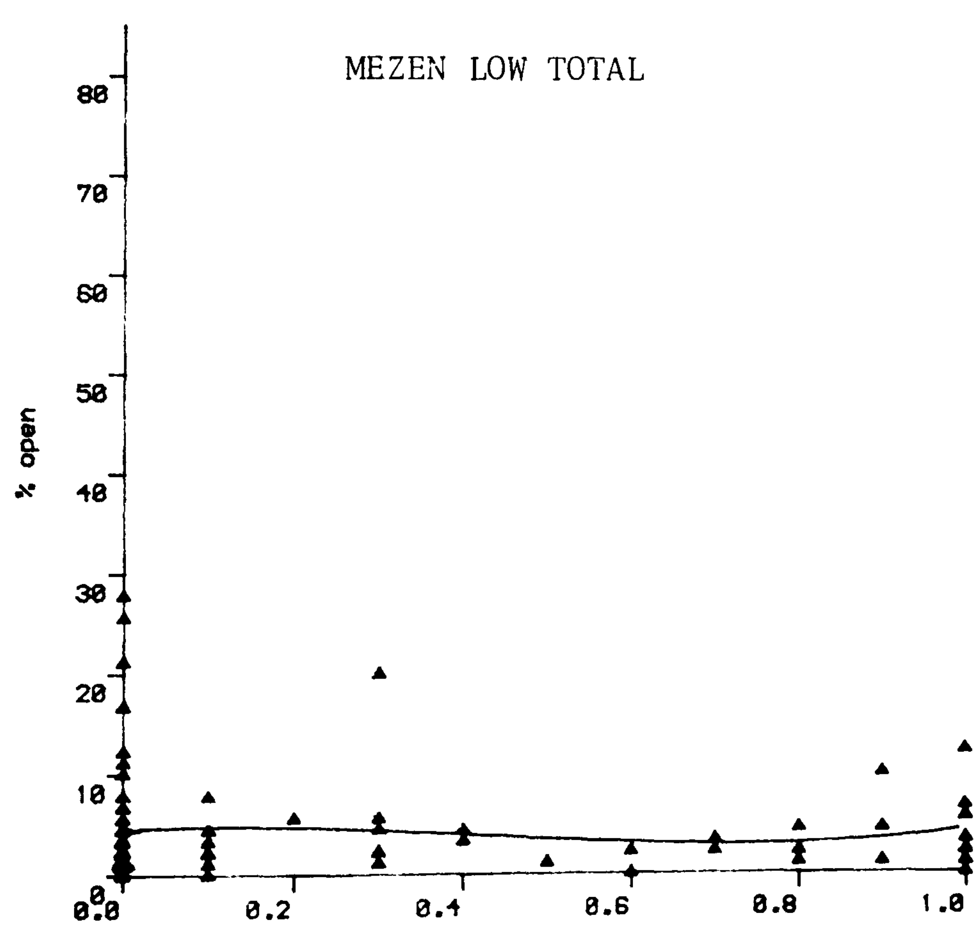


FIGURE A123



FIGURES A124-A127. Relationships between sunshine duration and window opening in the medium group at Mezen

FIGURE A124

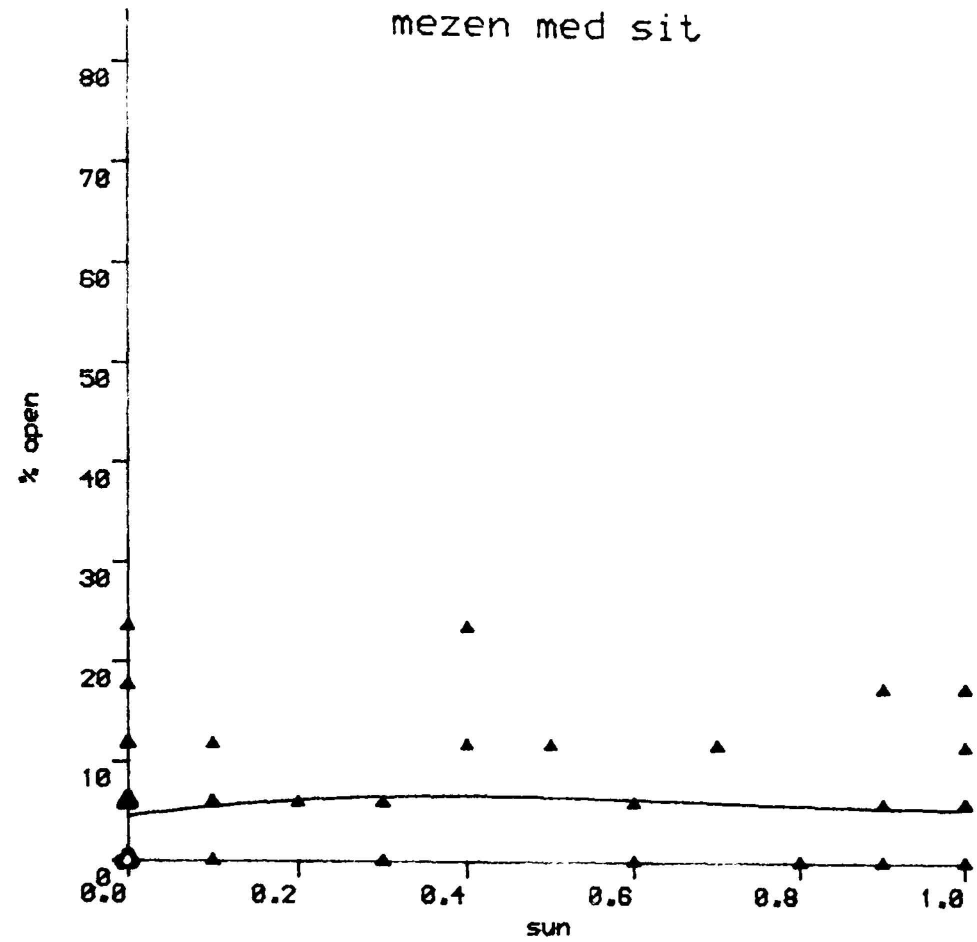


FIGURE A125

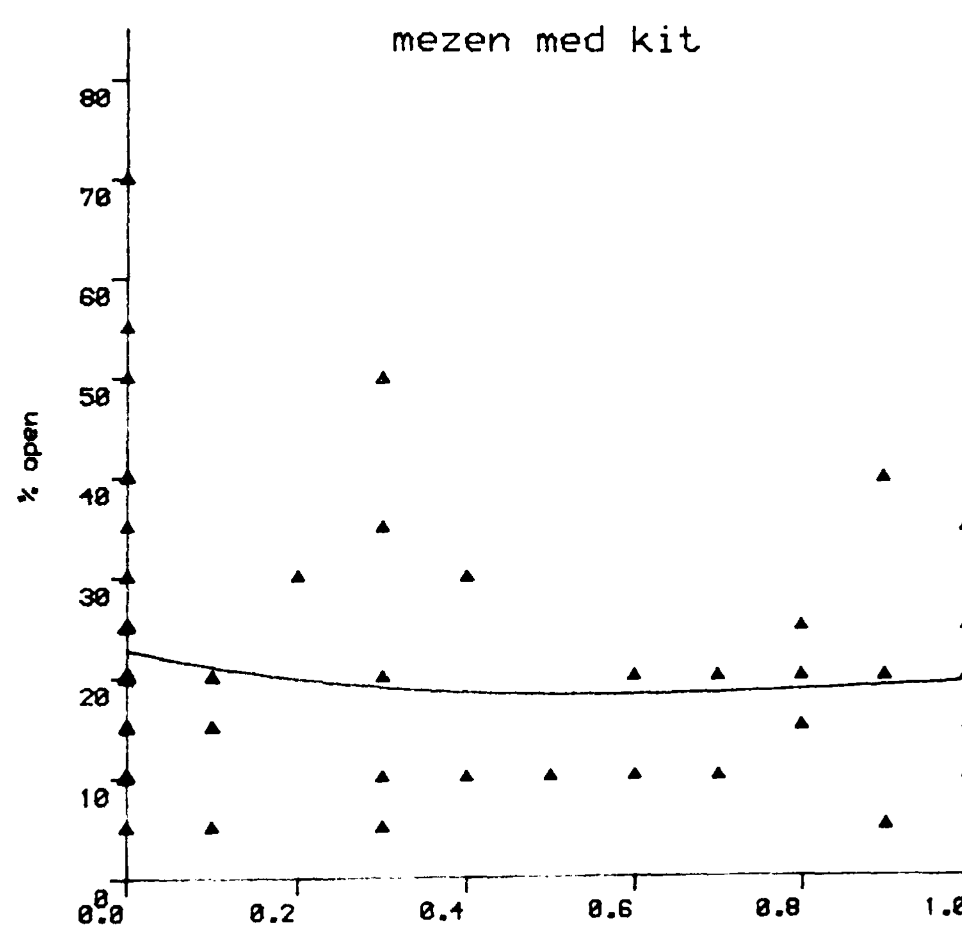


FIGURE A126

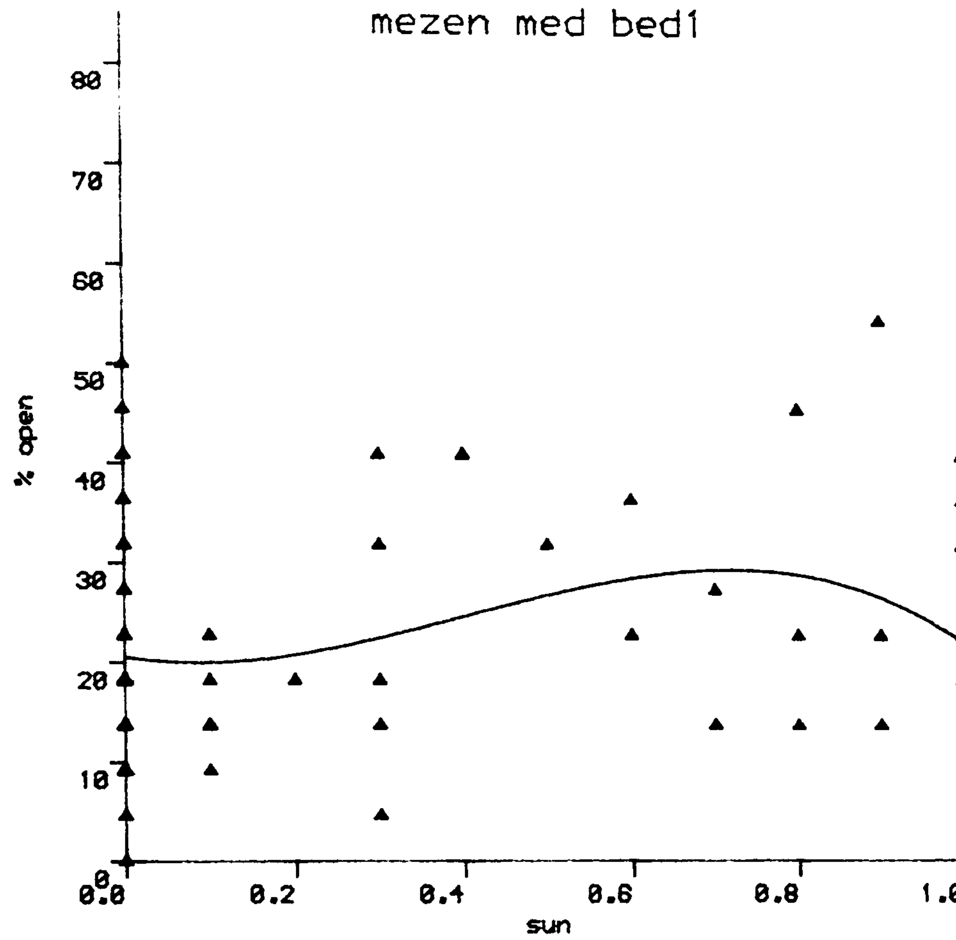
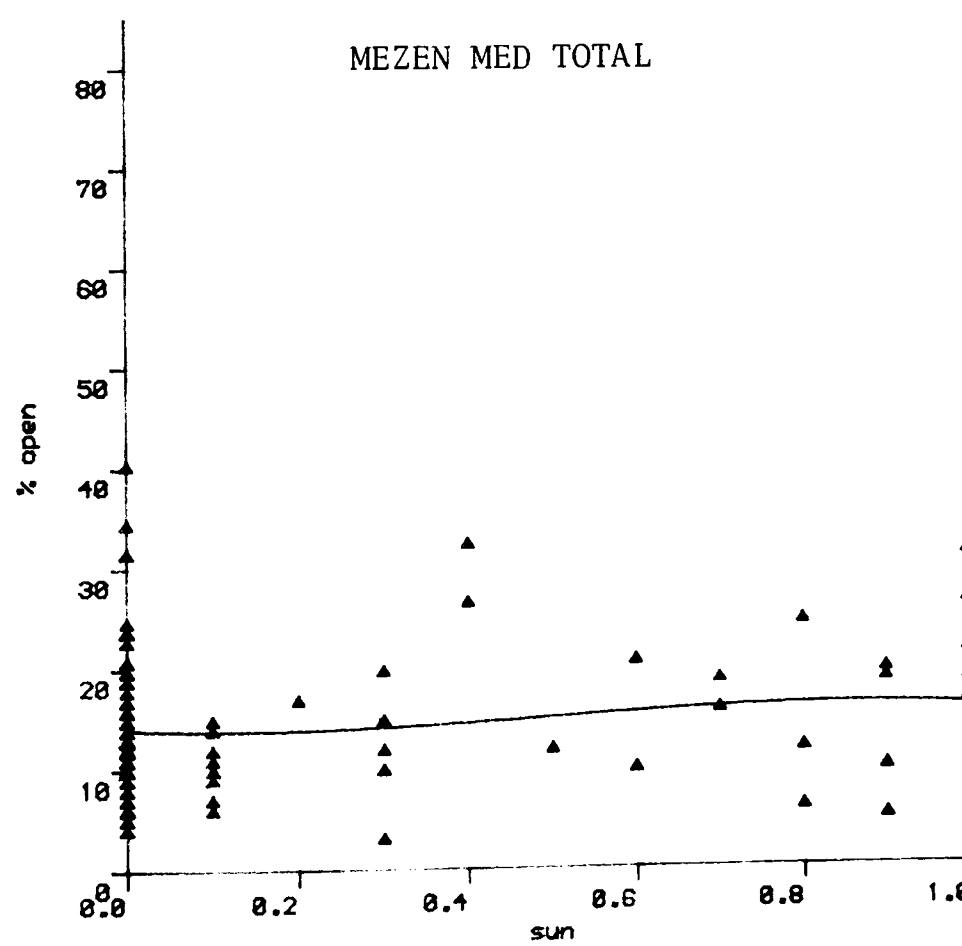


FIGURE A127



FIGURES A128-A131. Relationships between sunshine duration and window opening in the high group at Mezen

FIGURE A128

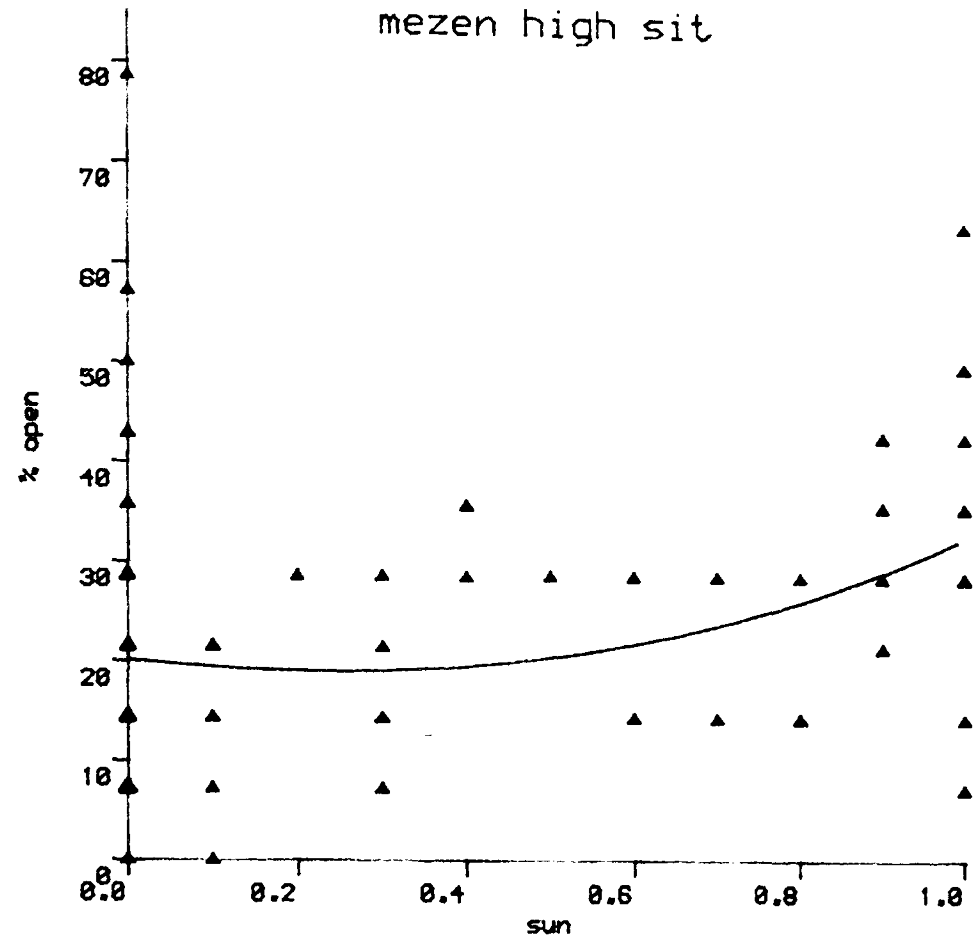


FIGURE A129

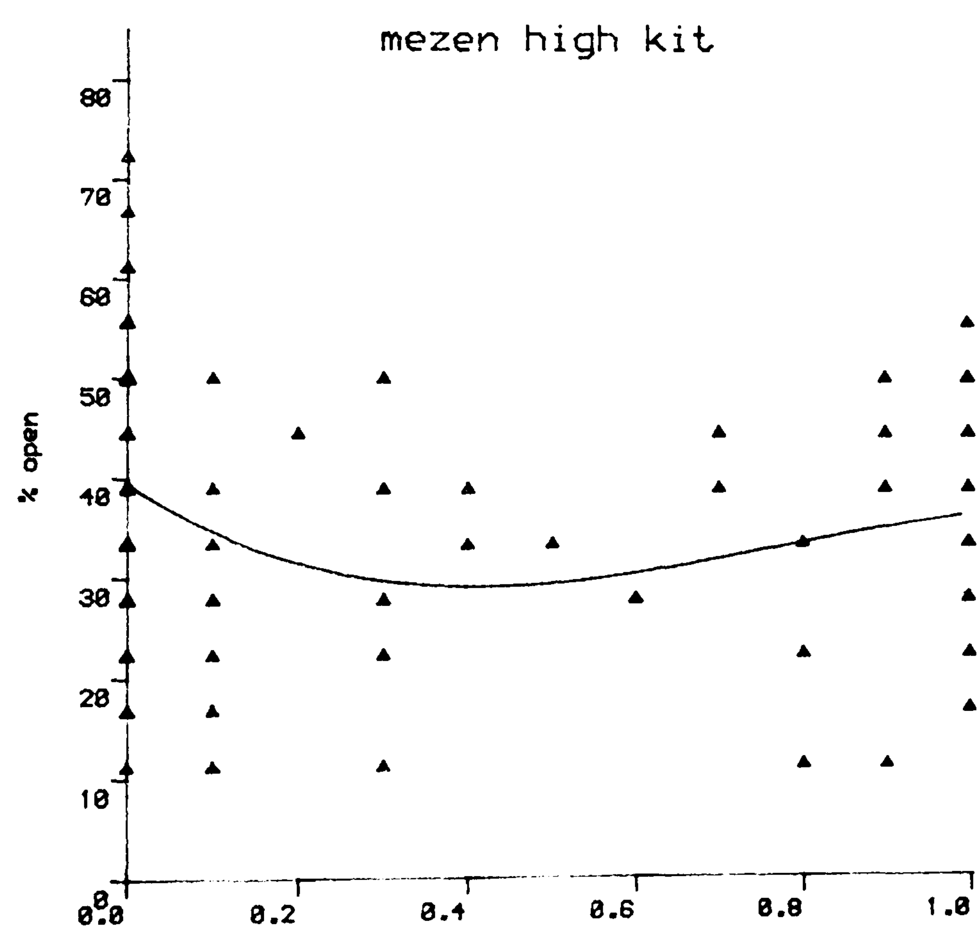


FIGURE A130

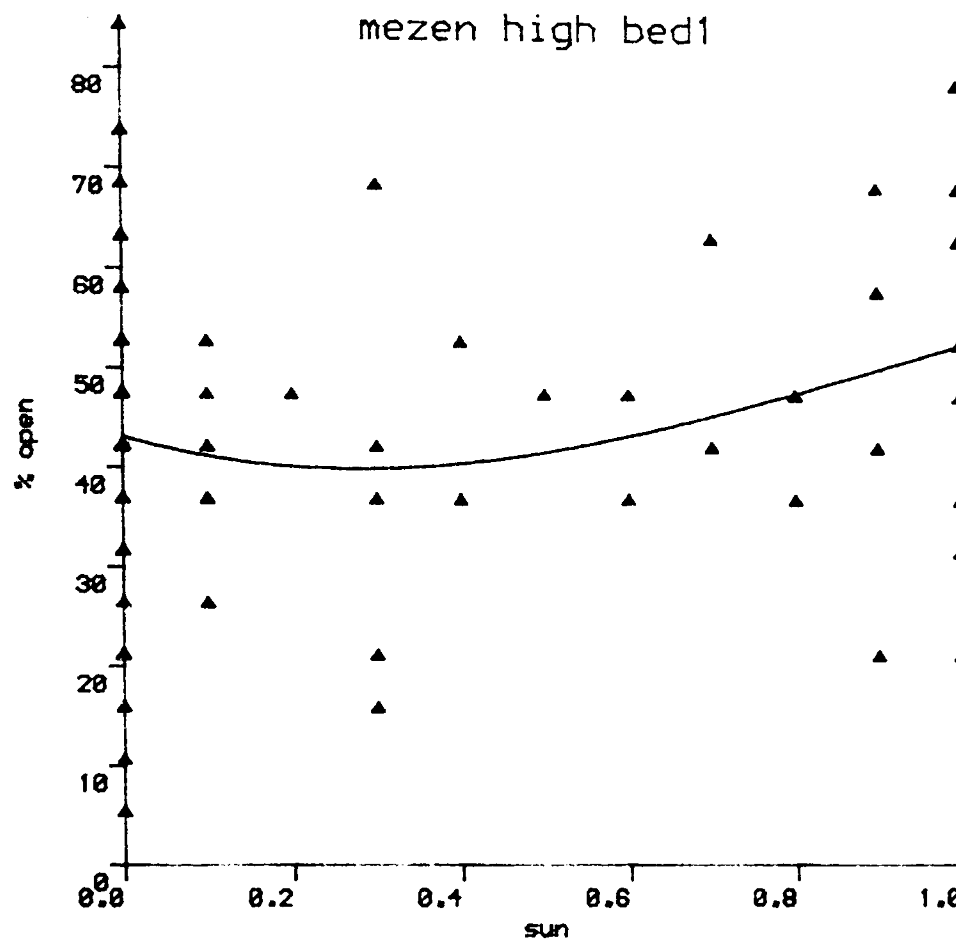
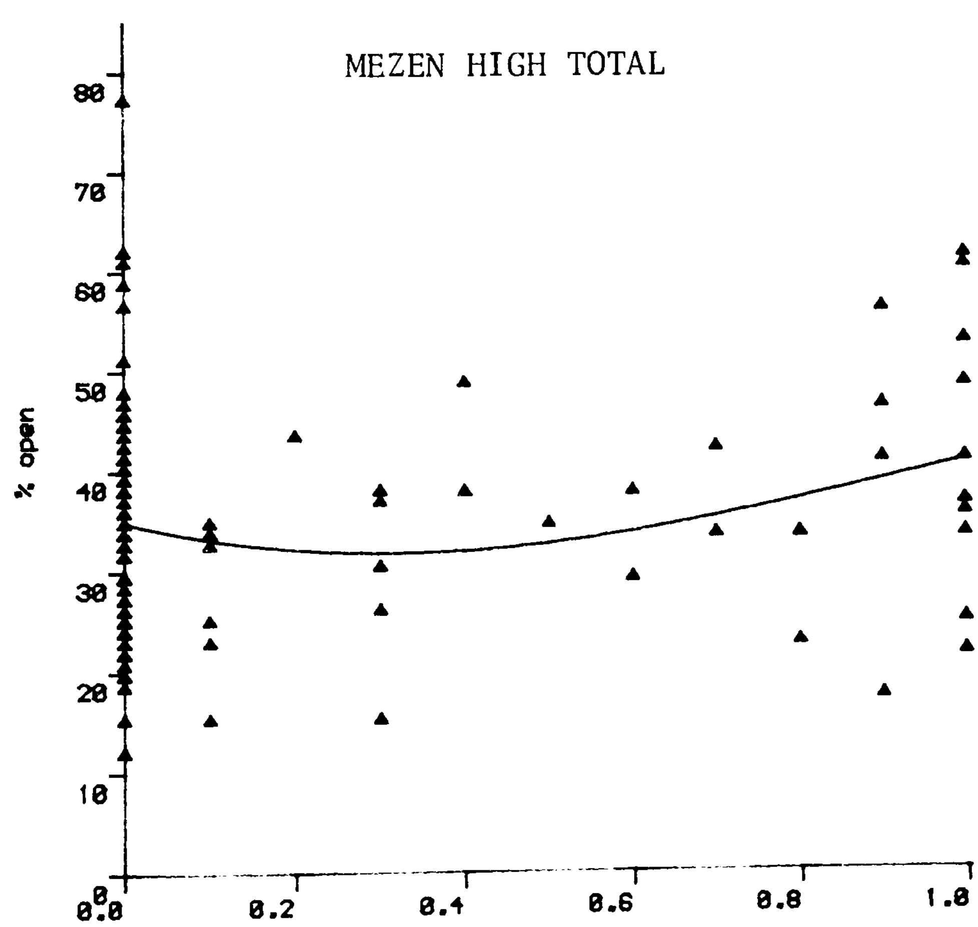


FIGURE A131



FIGURES A132-A135. Relationships between sunshine duration and window opening in all groups at Mezen

FIGURE A132

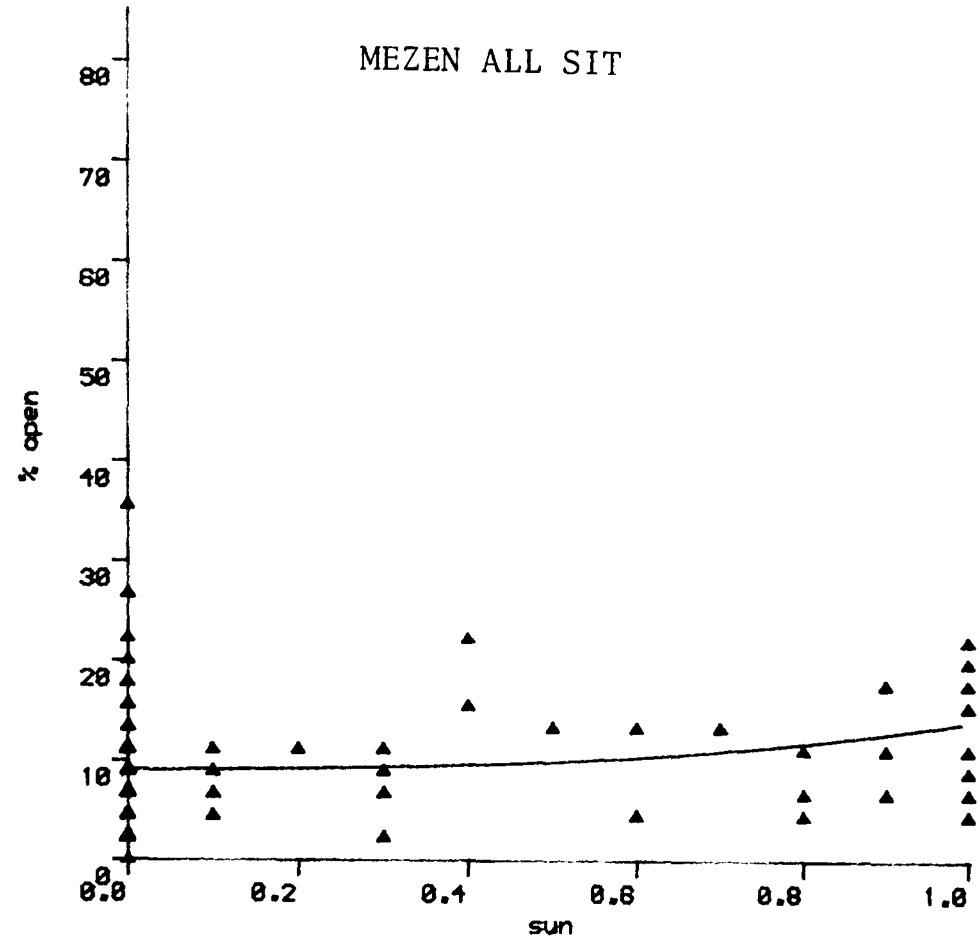


FIGURE A133

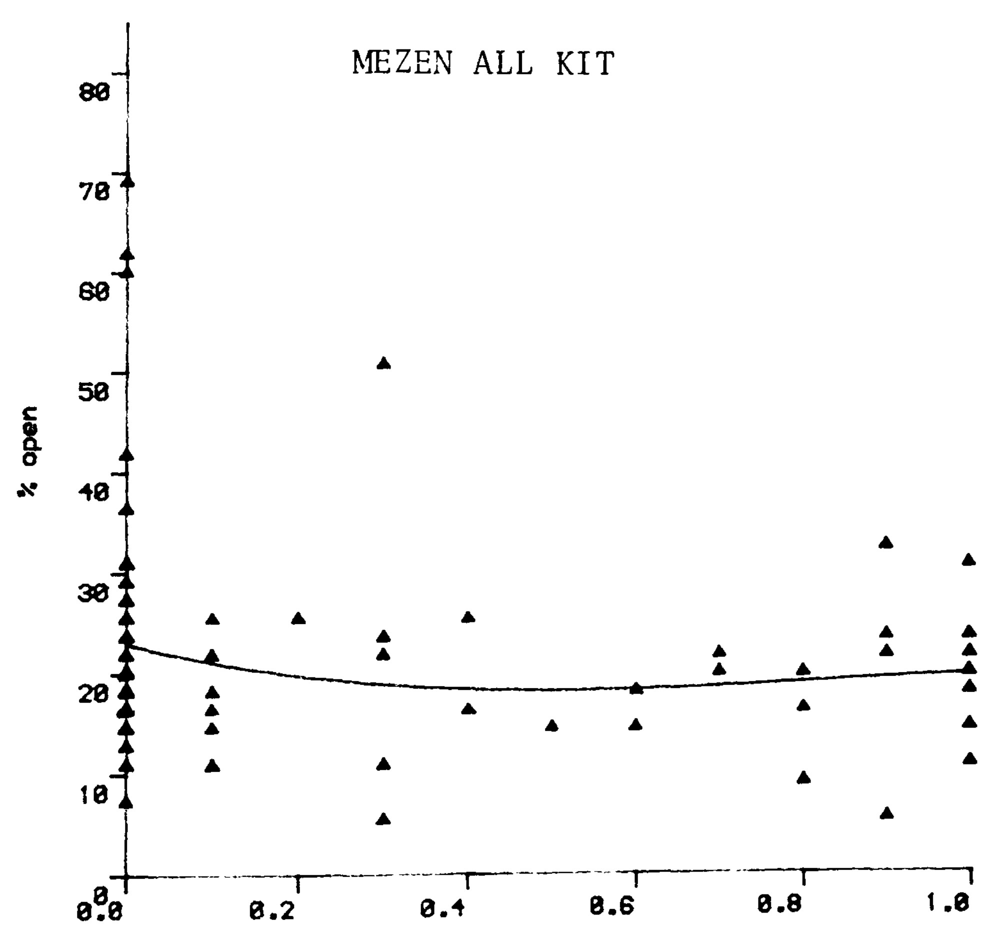


FIGURE A134

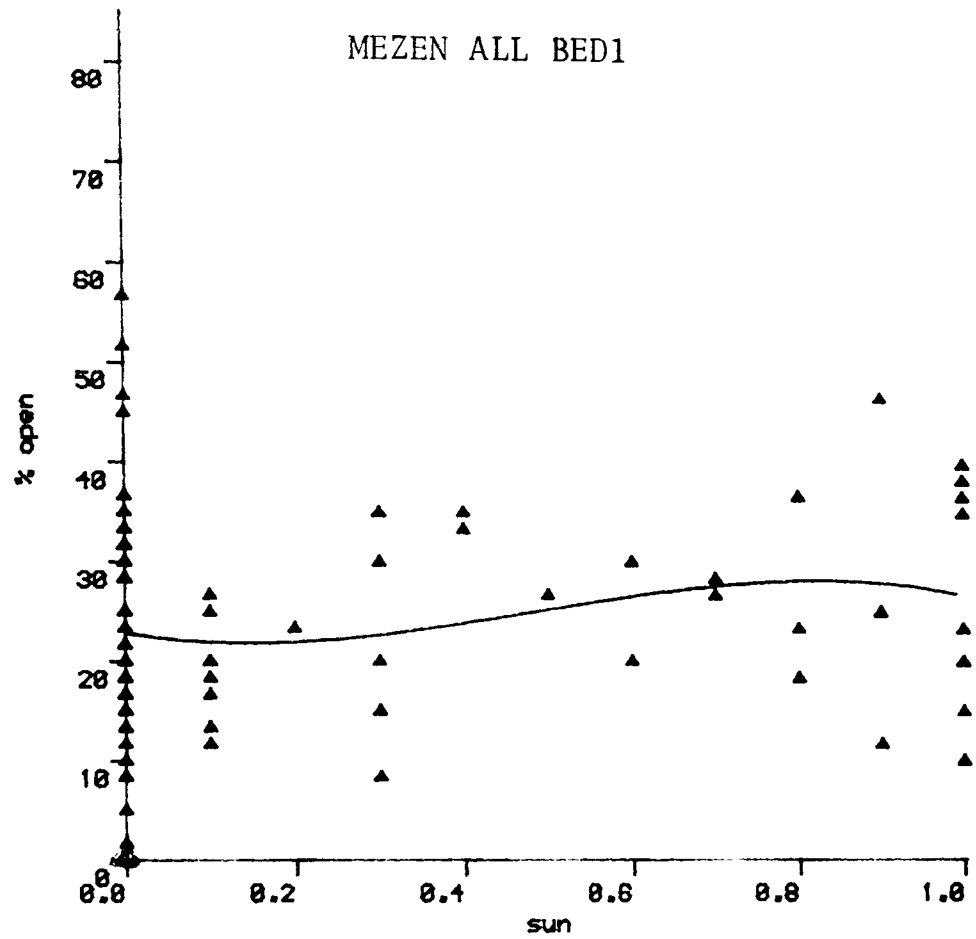
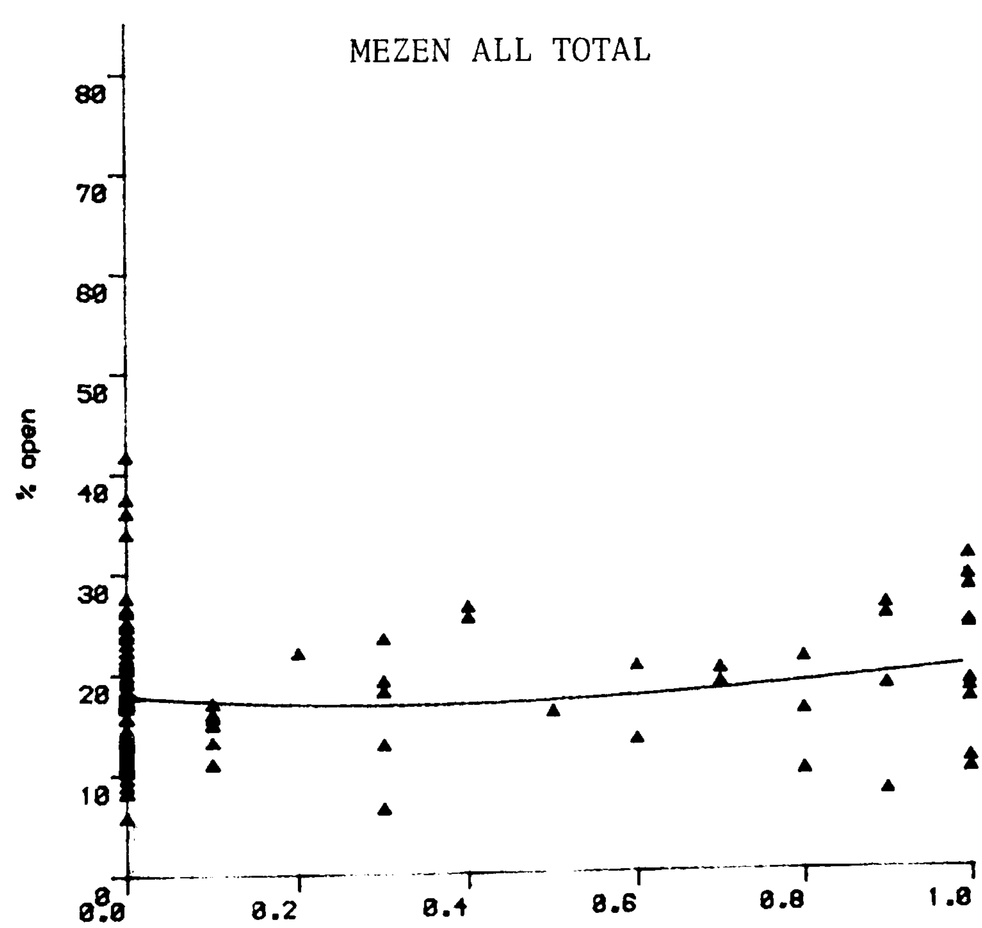


FIGURE A135



FIGURES A136-A139. Relationships between rainfall and window opening in the low group at Cowley

FIGURE A136

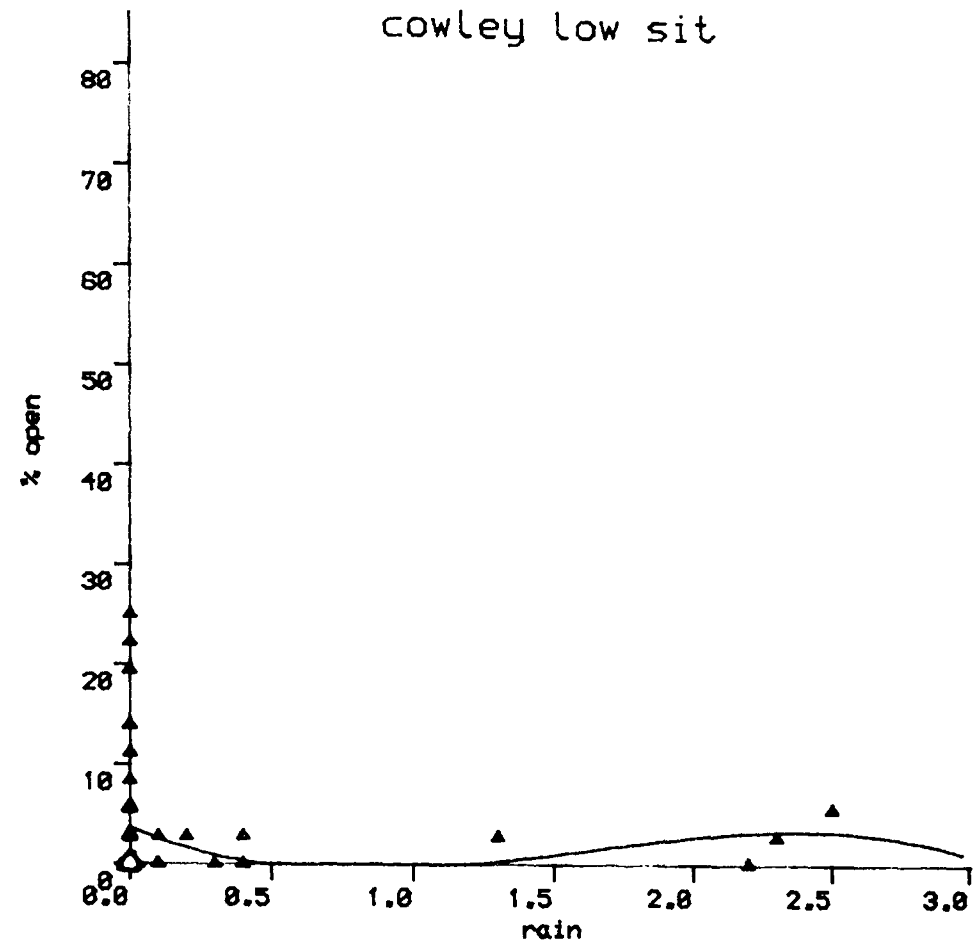


FIGURE A137

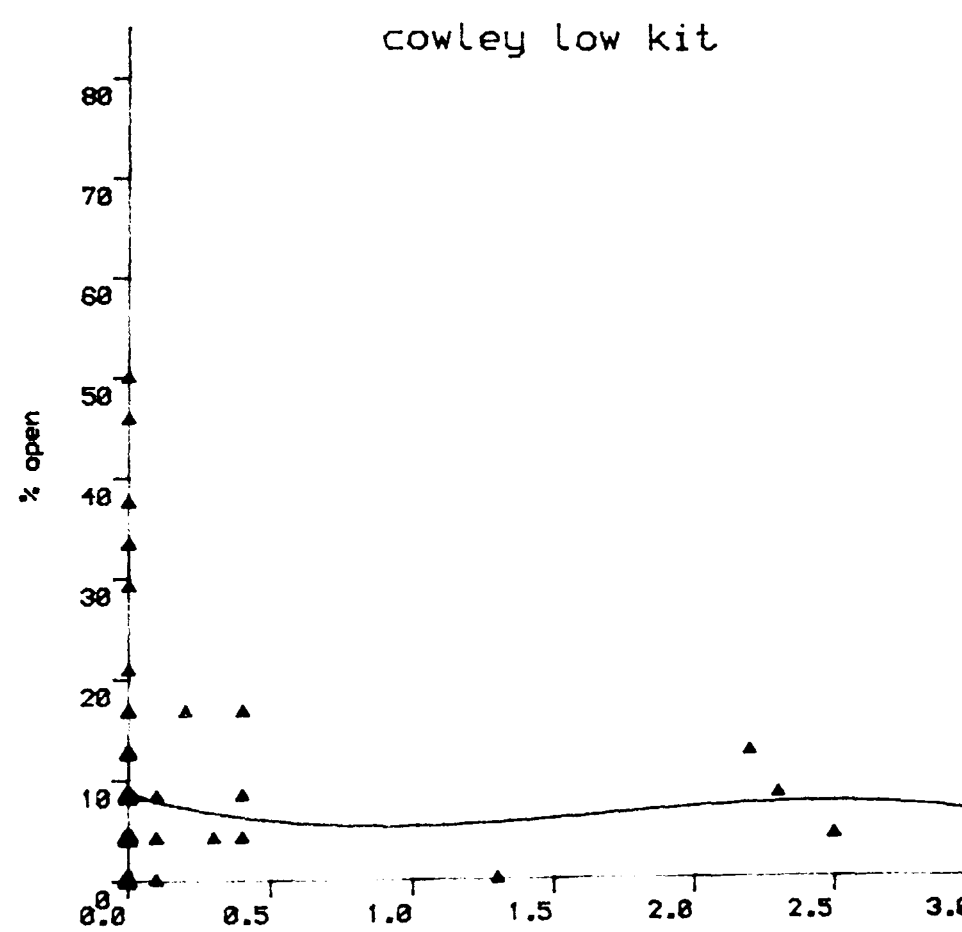


FIGURE A138

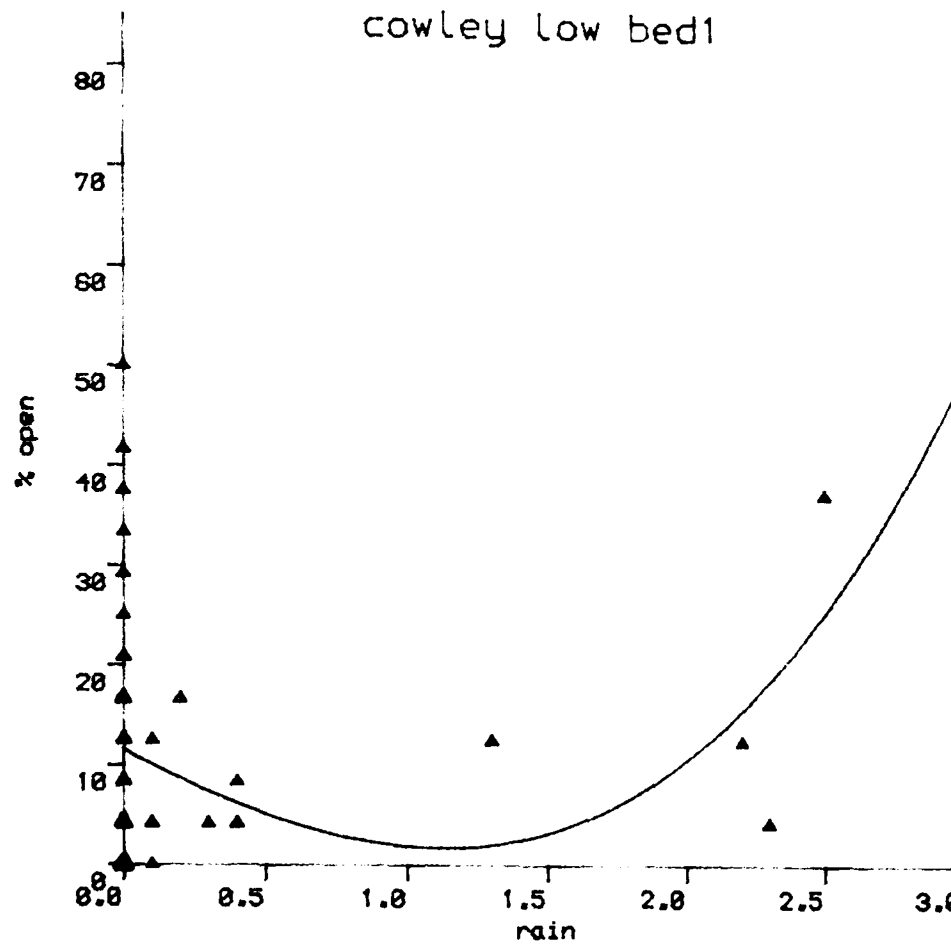
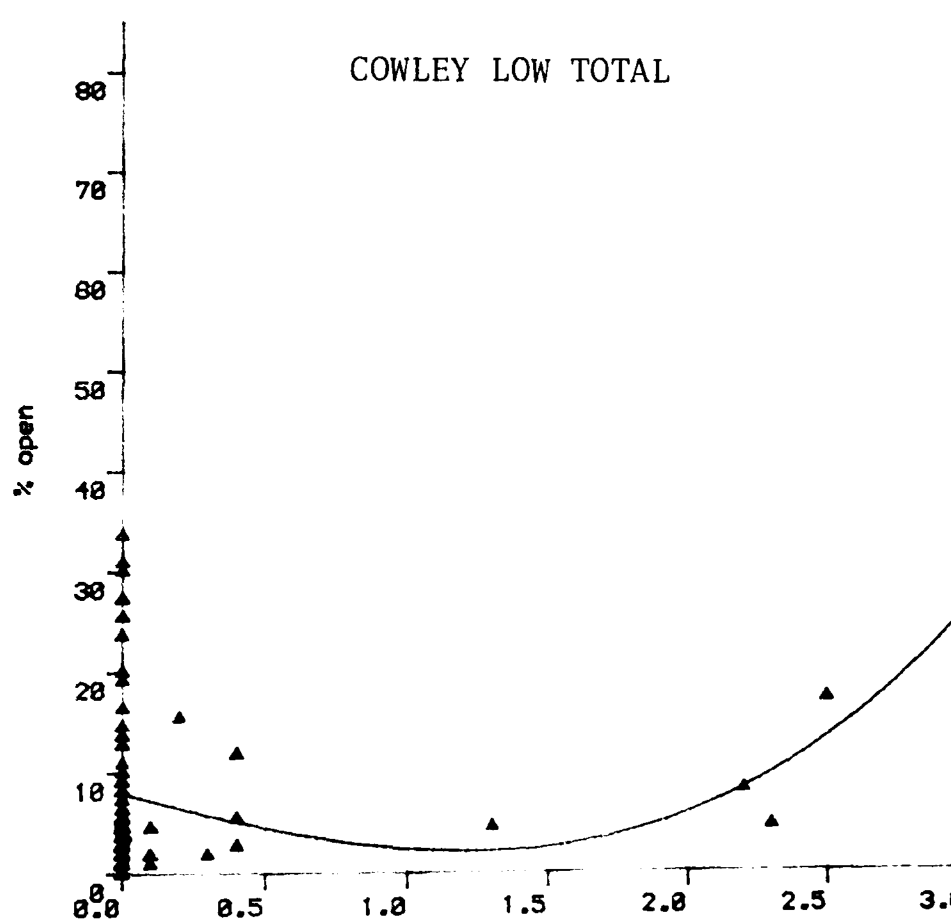


FIGURE A139



FIGURES A140-A143. Relationships between rainfall and window opening in the medium group at Cowley

FIGURE A140

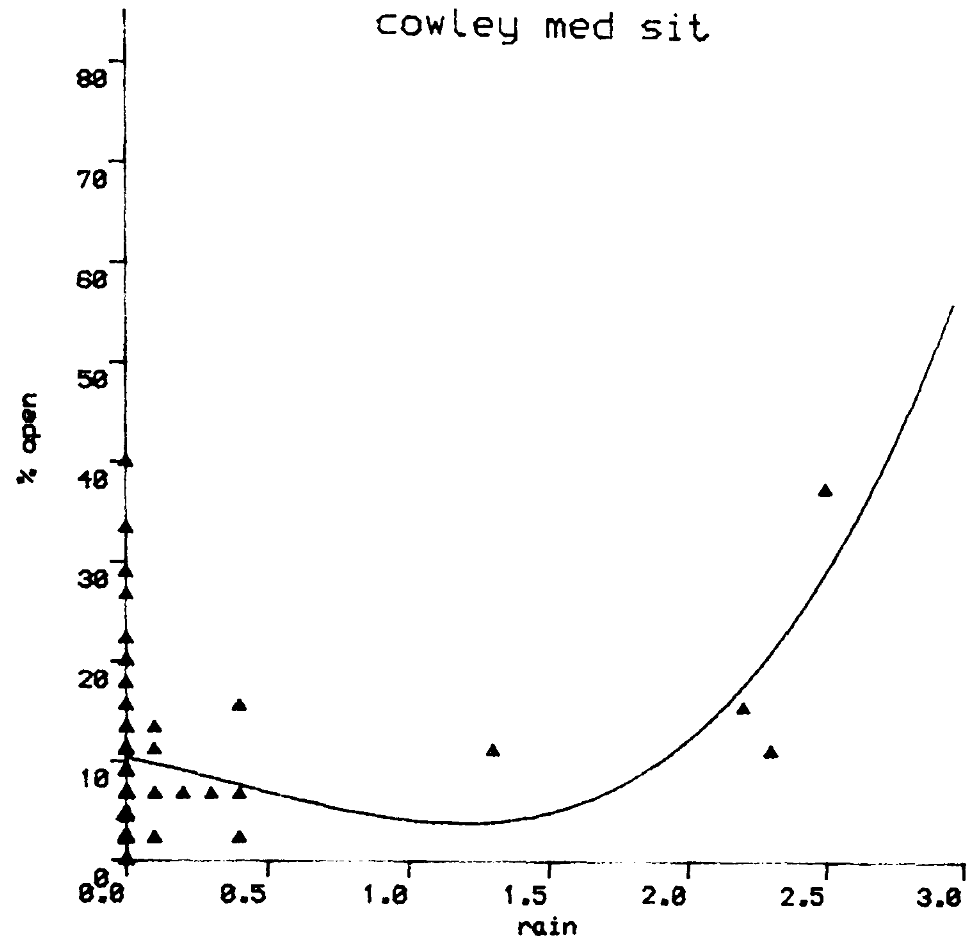


FIGURE A141

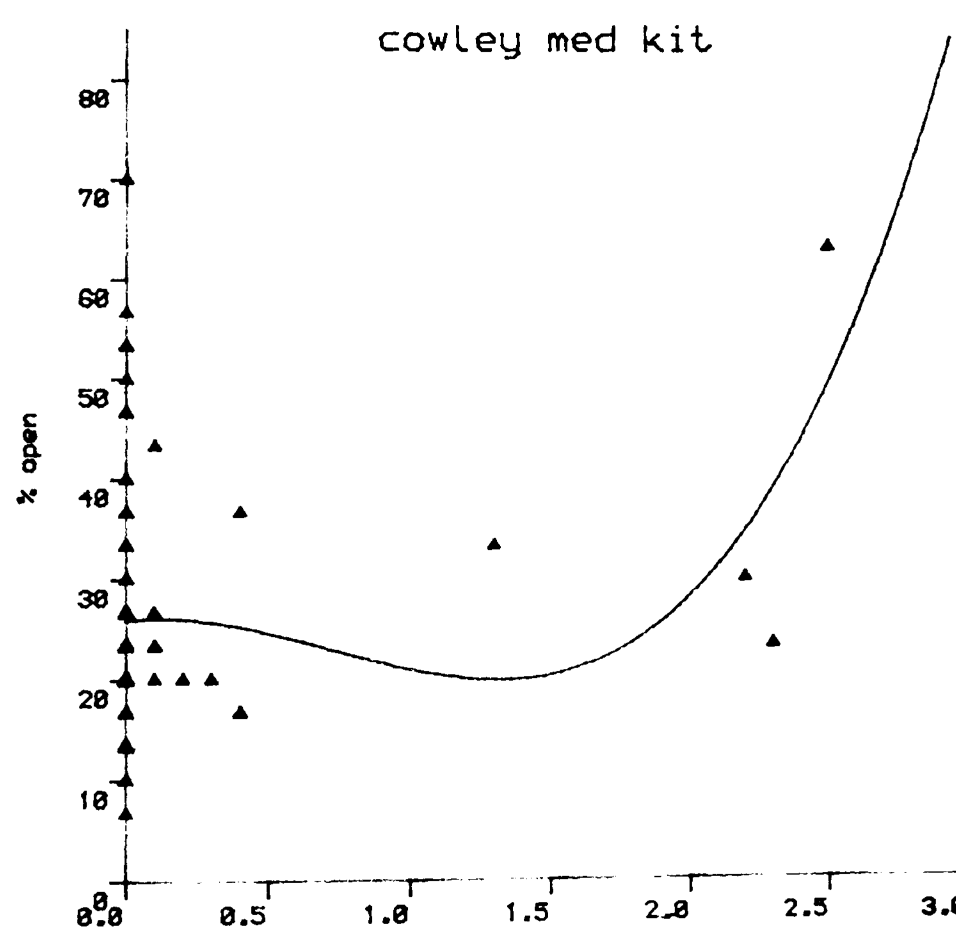


FIGURE A142

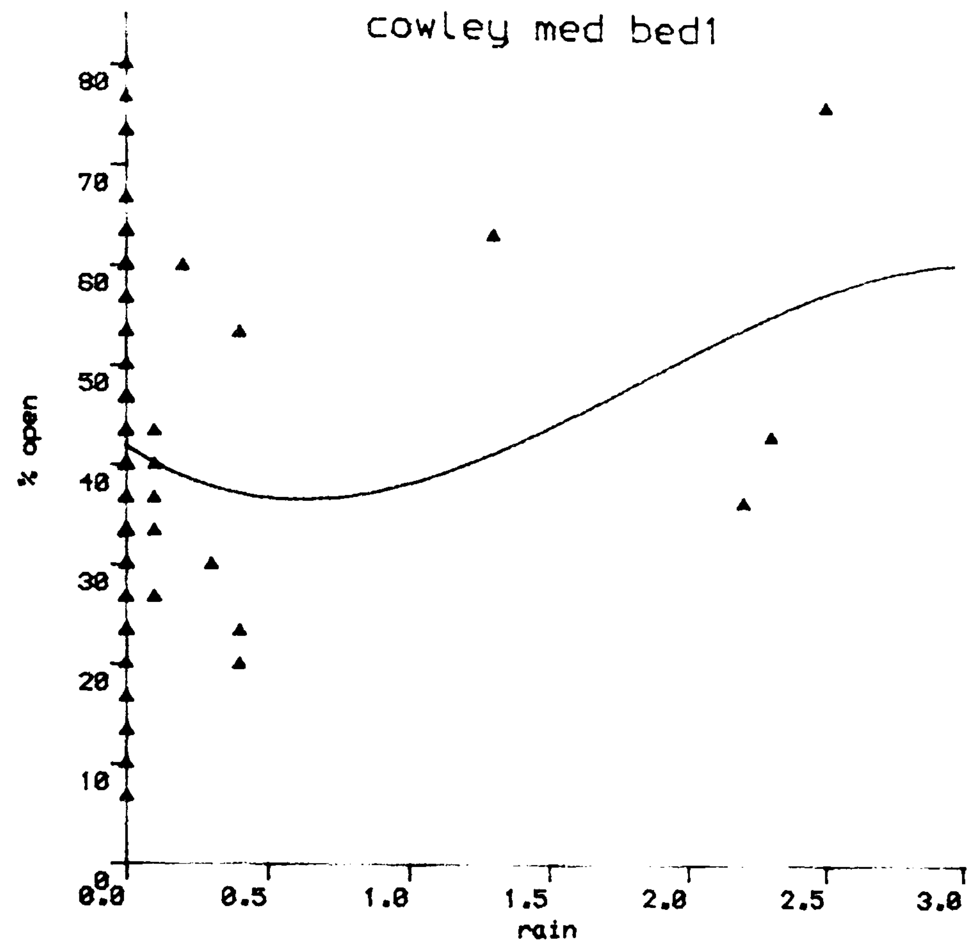
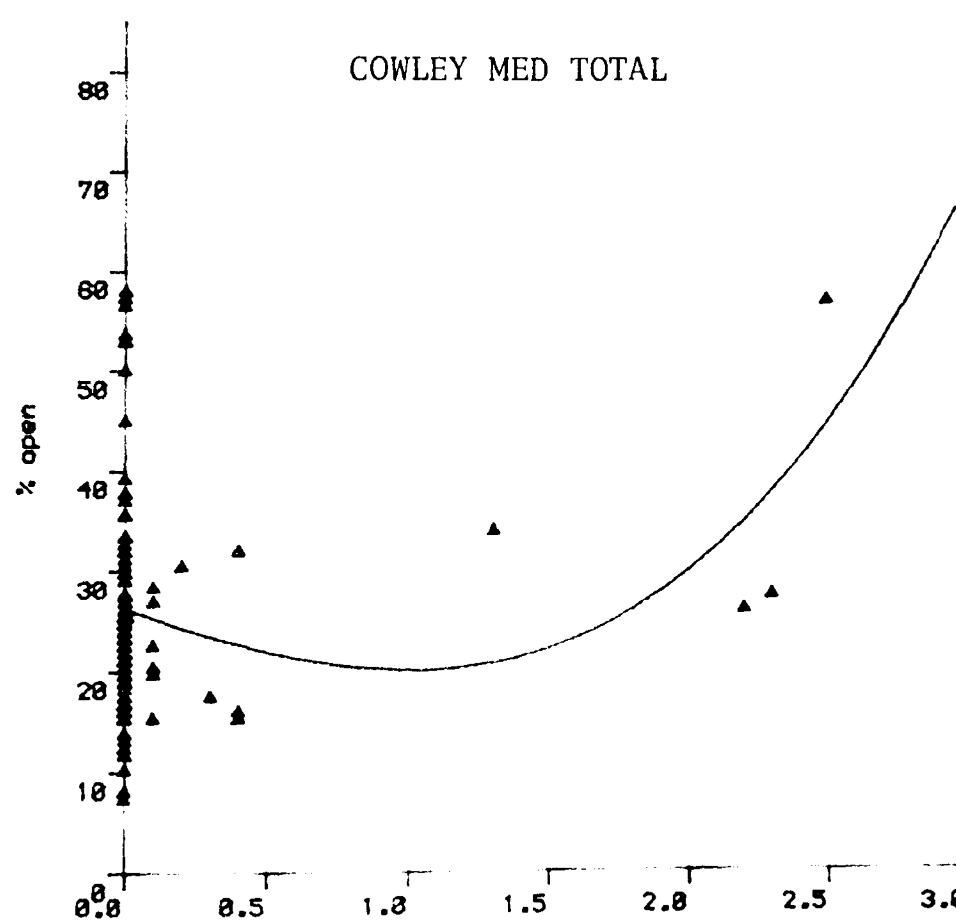


FIGURE A143



FIGURES A144-A147. Relationships between rainfall and window opening in the high group at Cowley

FIGURE A144

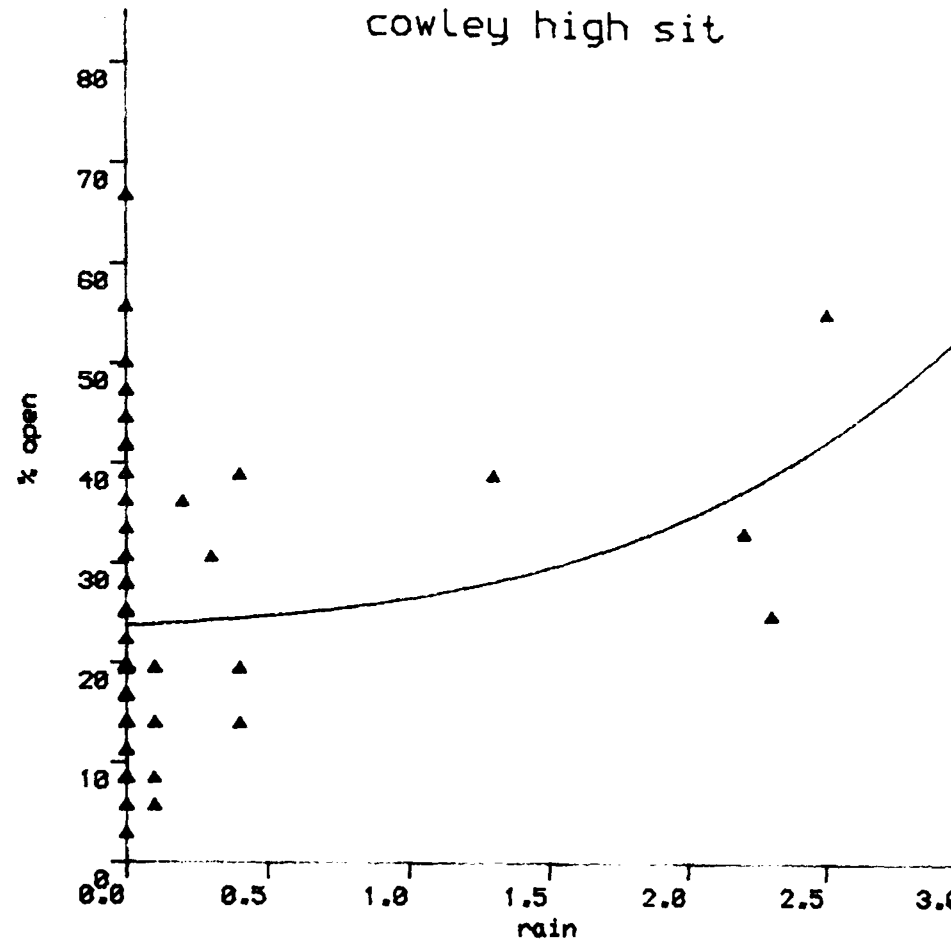


FIGURE A145

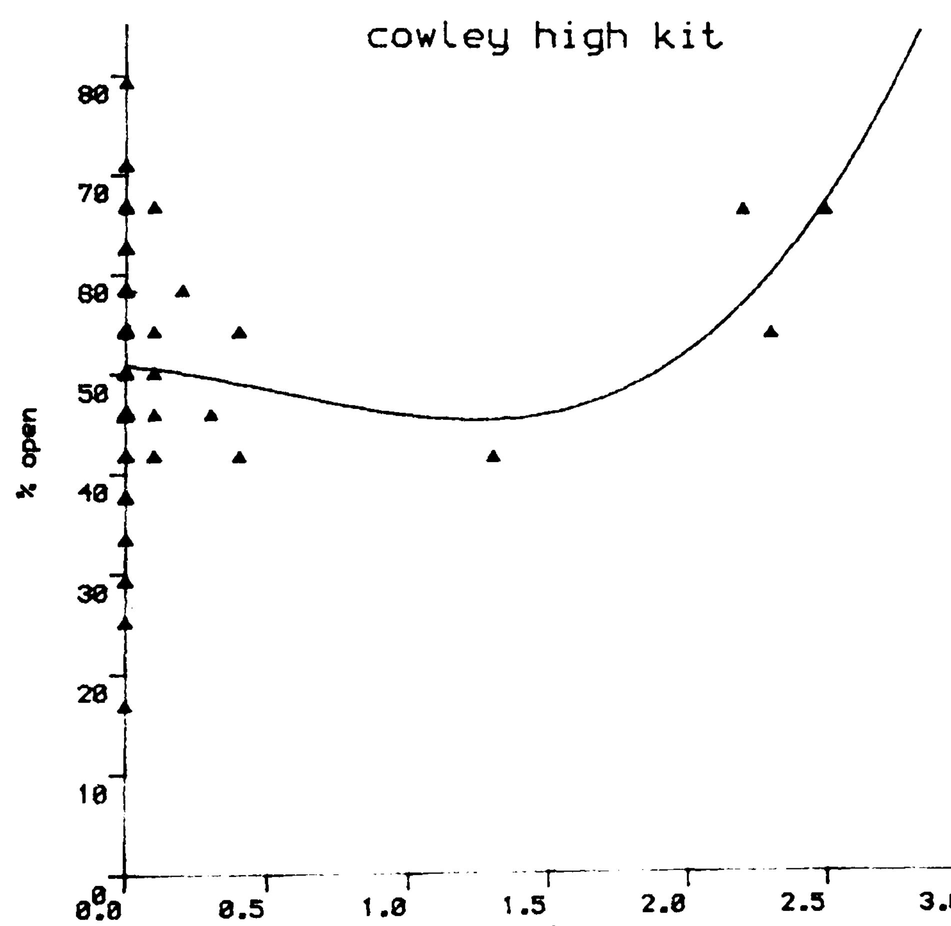


FIGURE A146

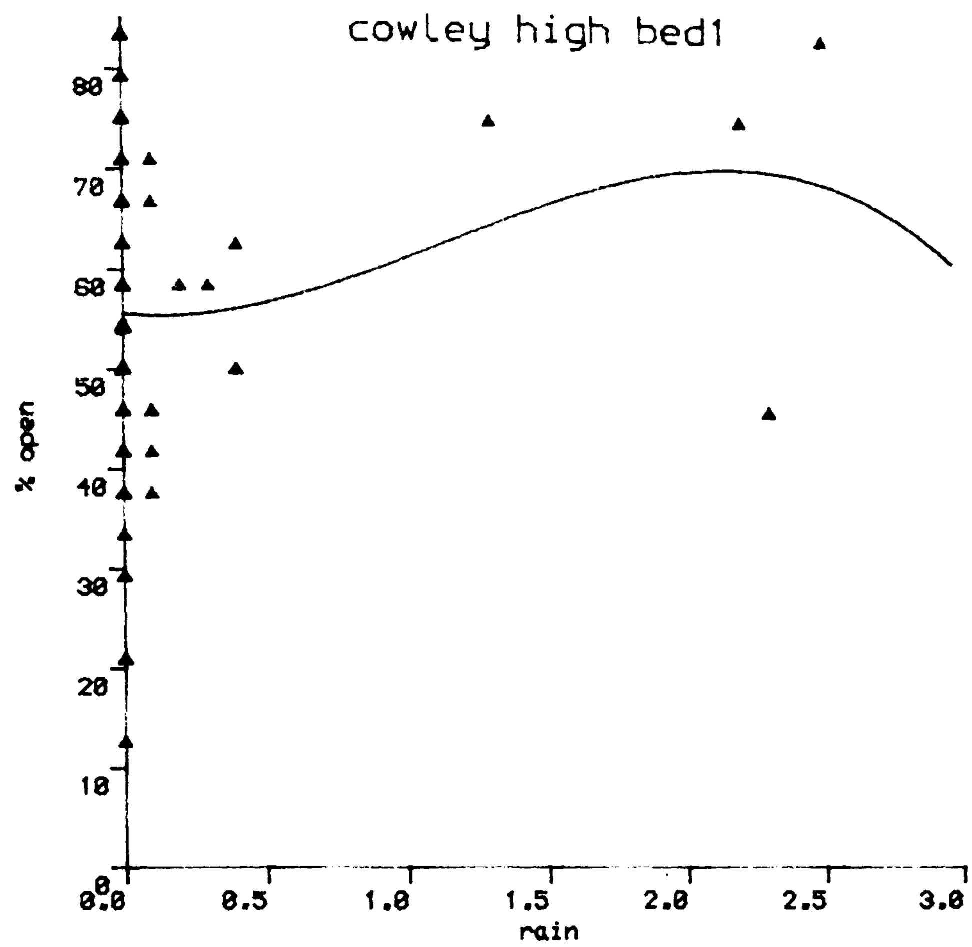
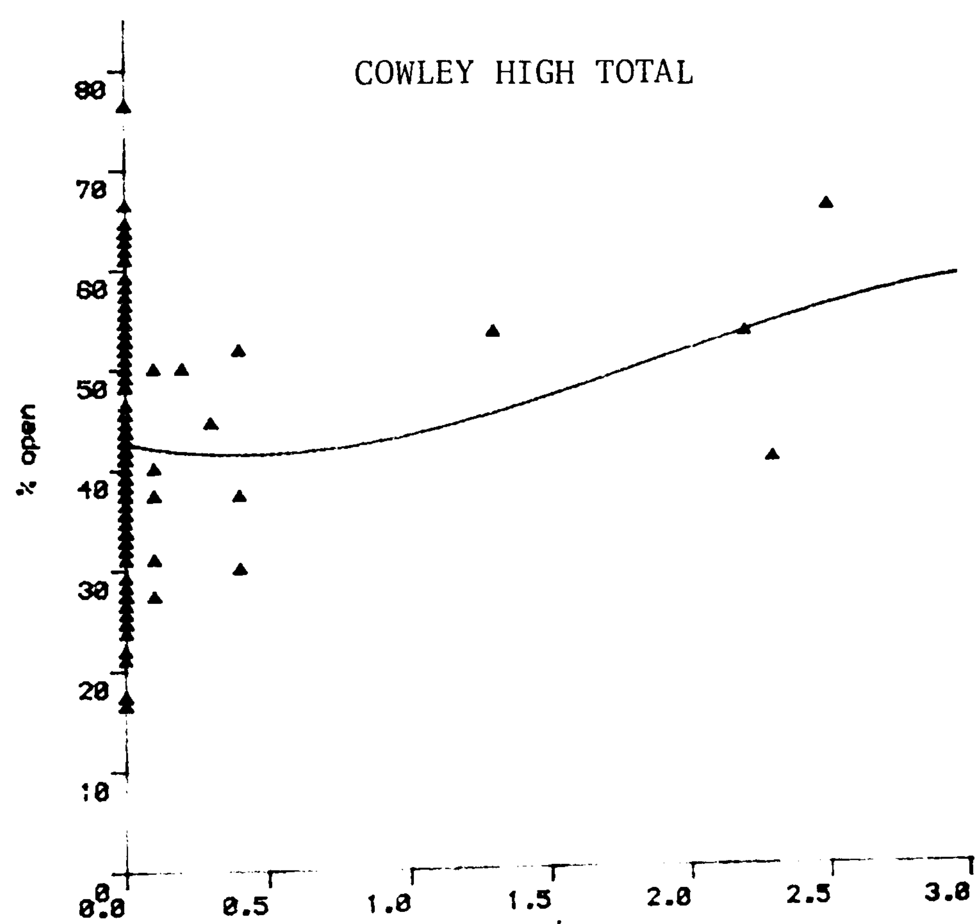


FIGURE A147



FIGURES A148-A151. Relationships between rainfall and window opening in all groups at Cowley

FIGURE A148

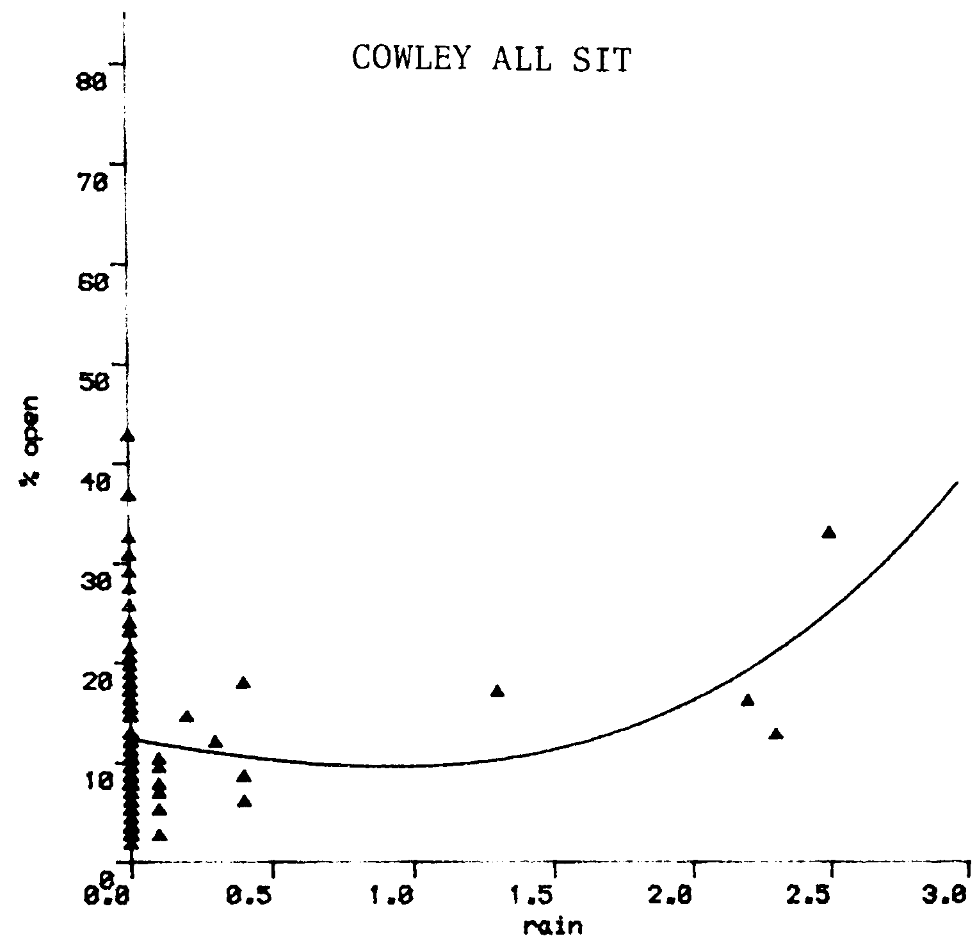


FIGURE A149

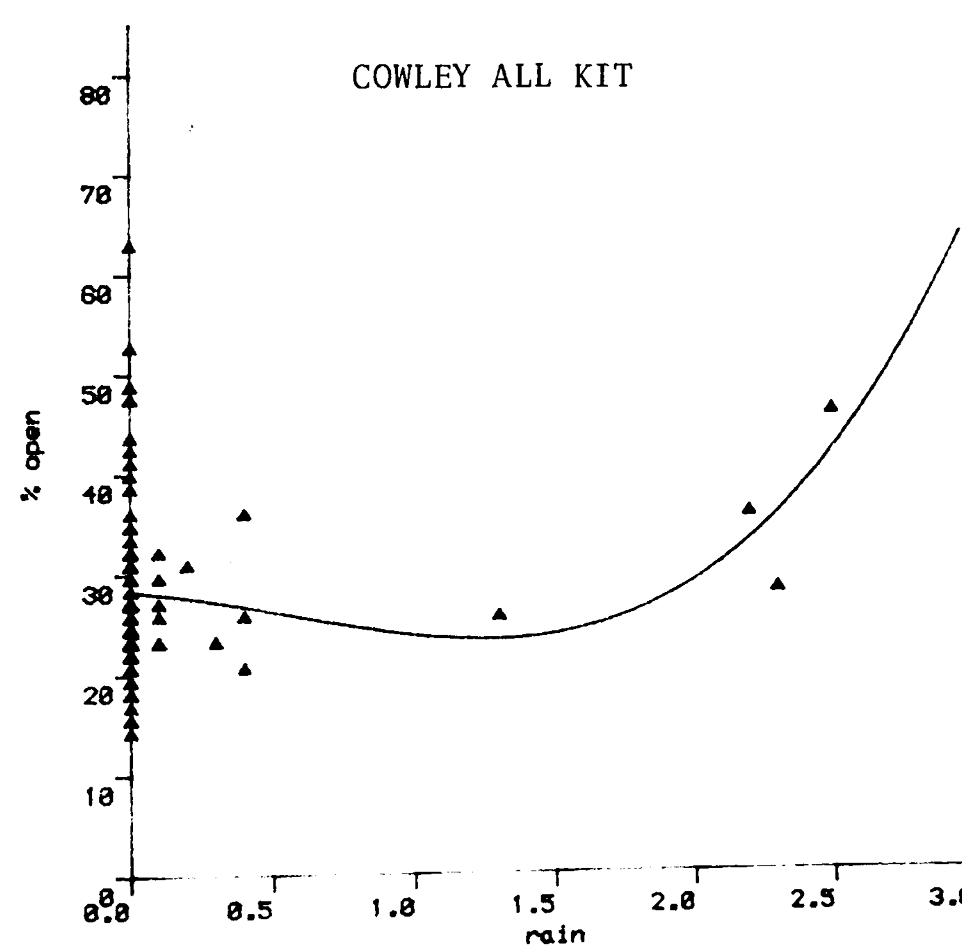


FIGURE A150

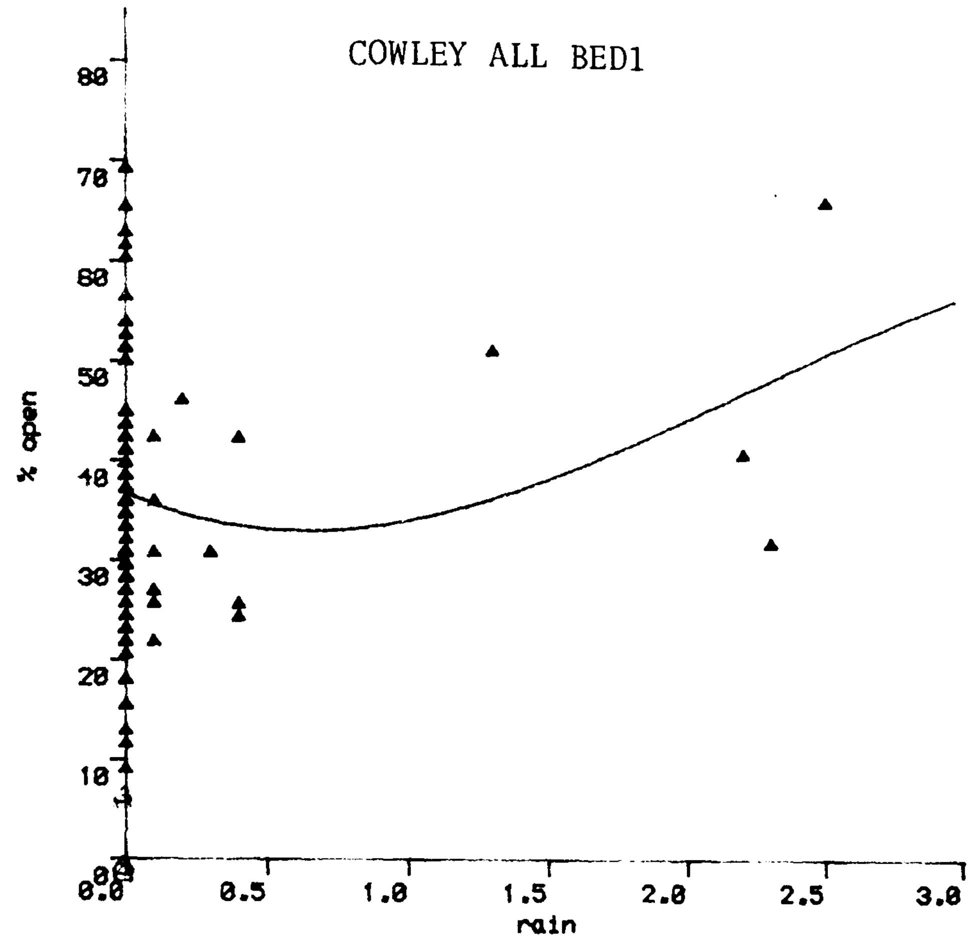
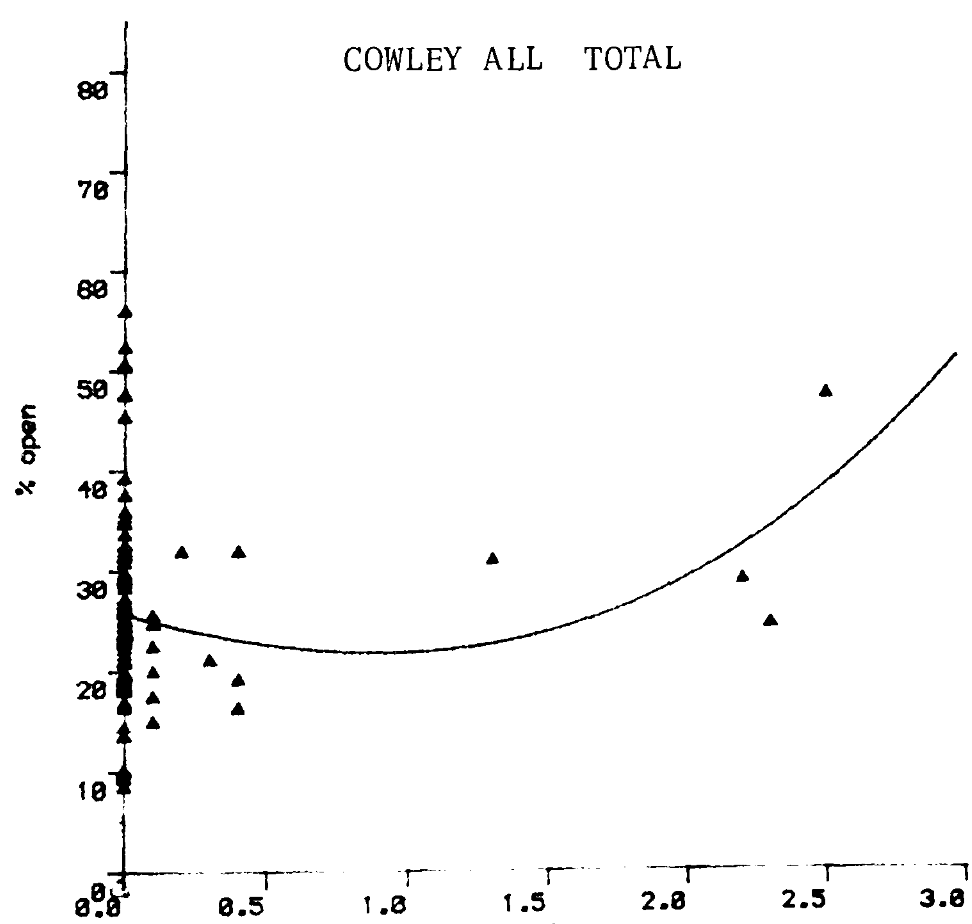


FIGURE A151



FIGURES A152-A155. Relationships between rainfall and window opening in the low group at Mezen

FIGURE A152

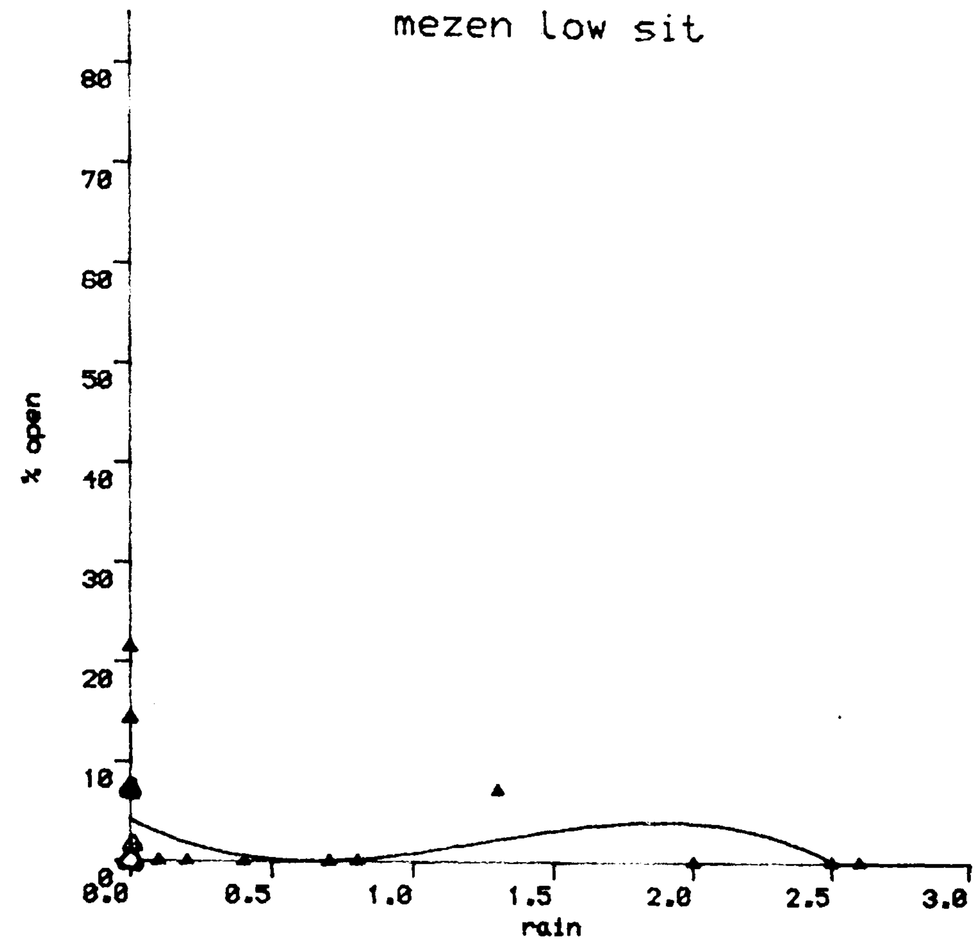


FIGURE A153

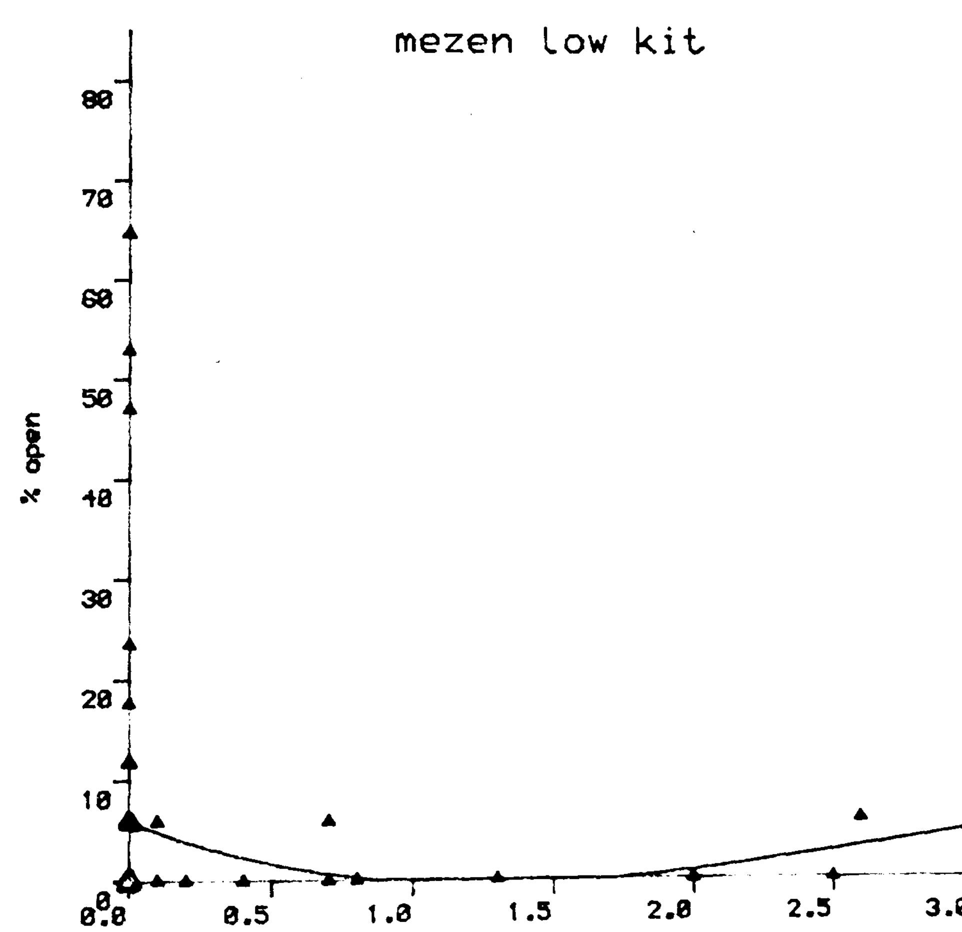


FIGURE A154

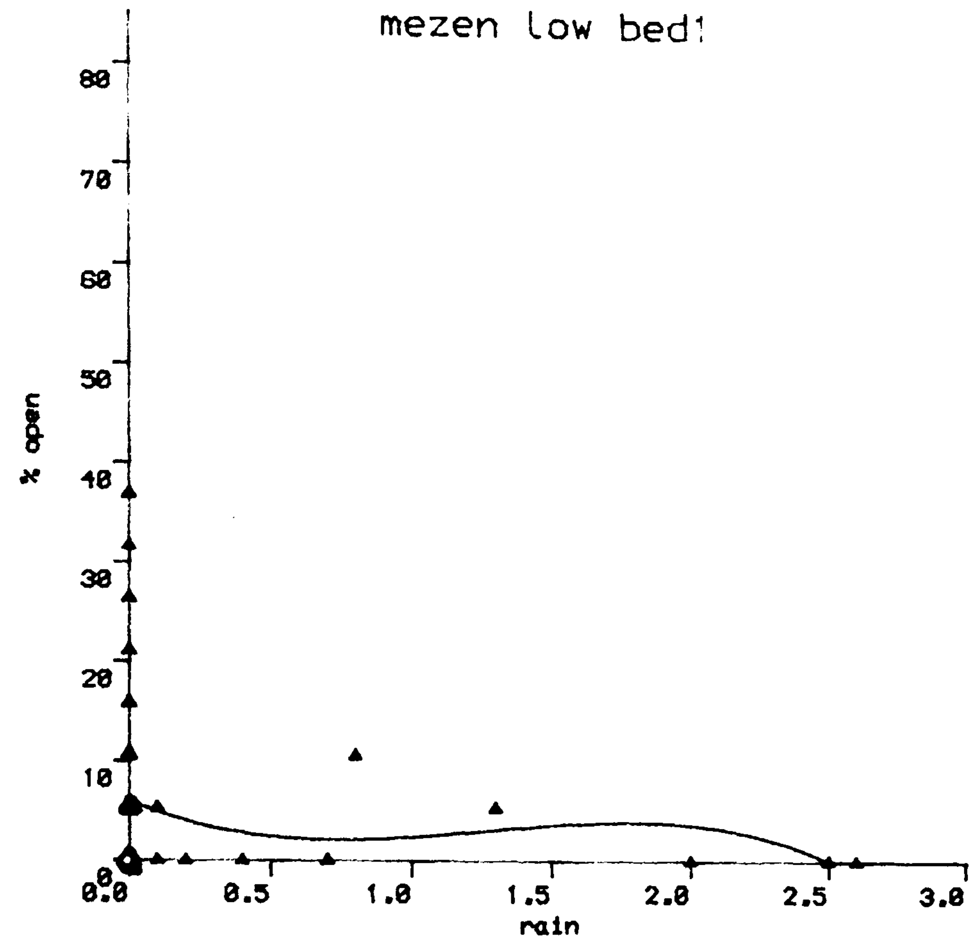
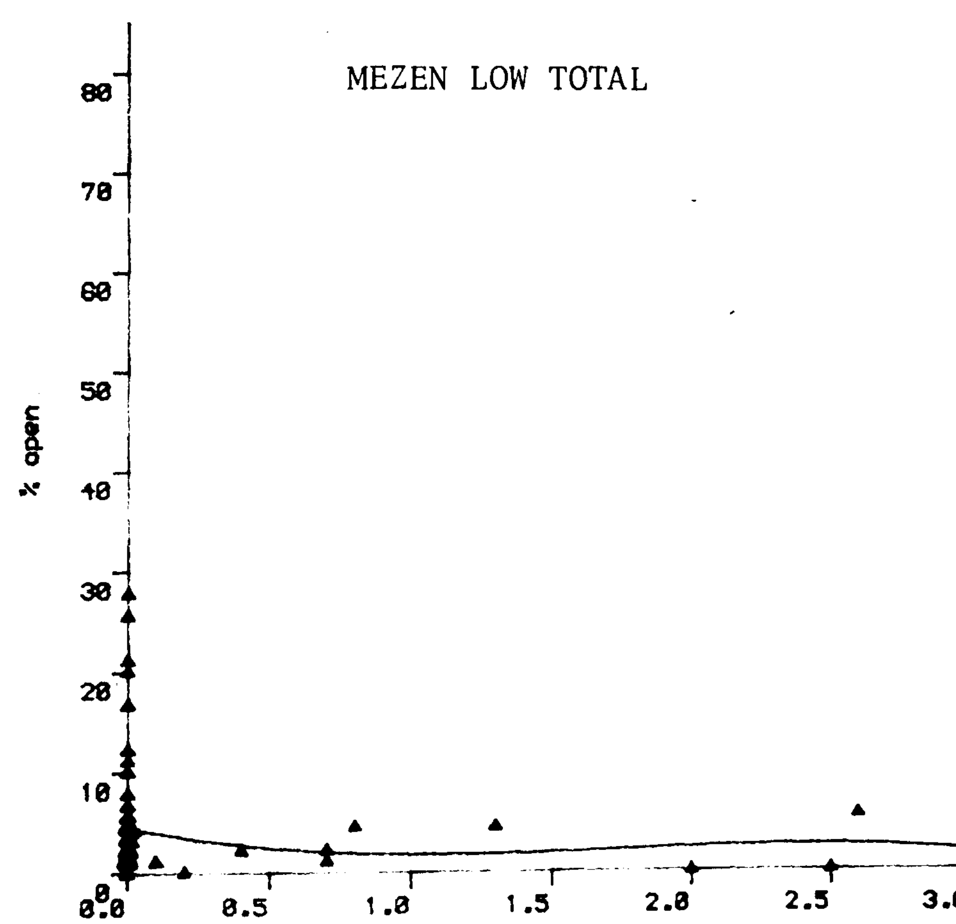


FIGURE A155



FIGURES A156-A159. Relationships between rainfall and window opening in the medium group at Mezen

FIGURE A156

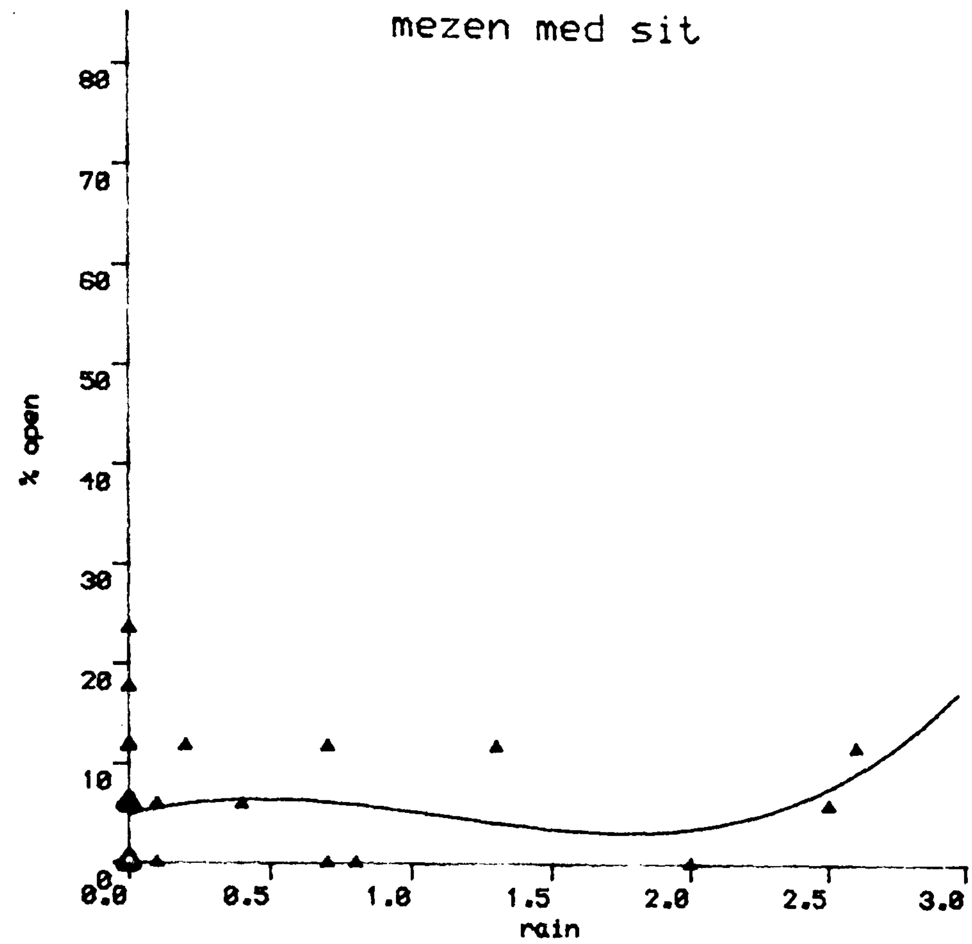


FIGURE A157

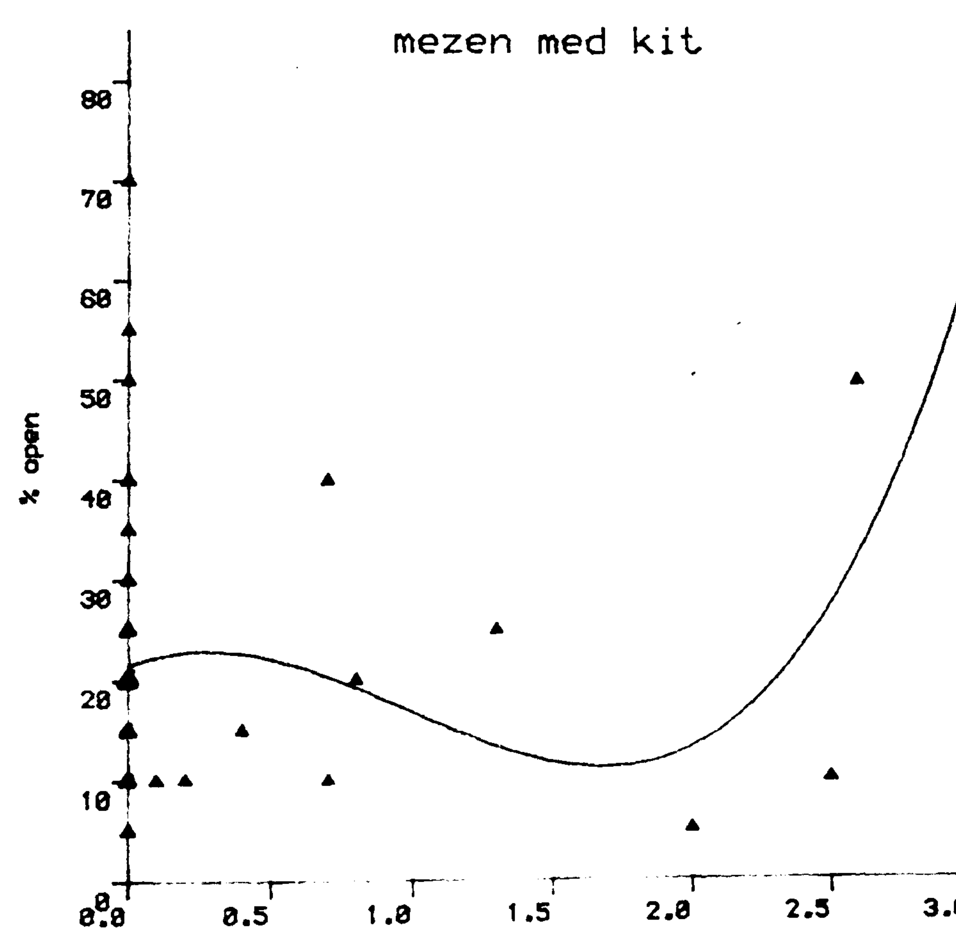


FIGURE A158

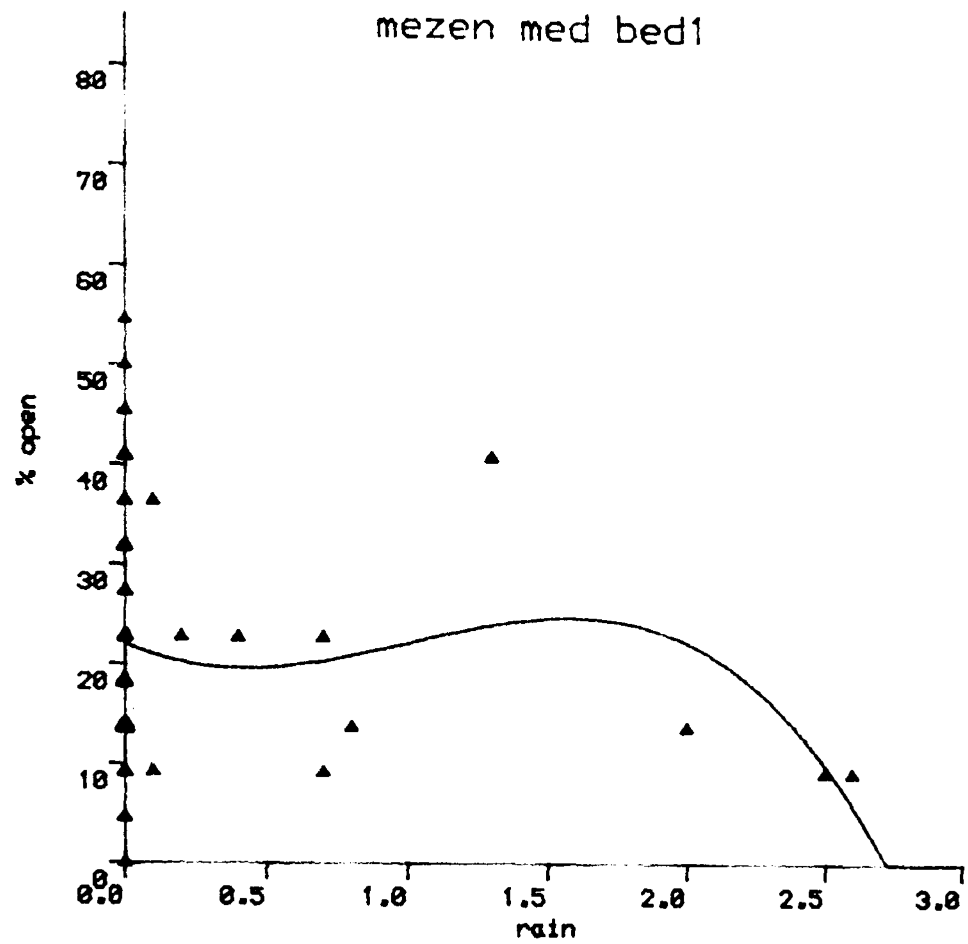
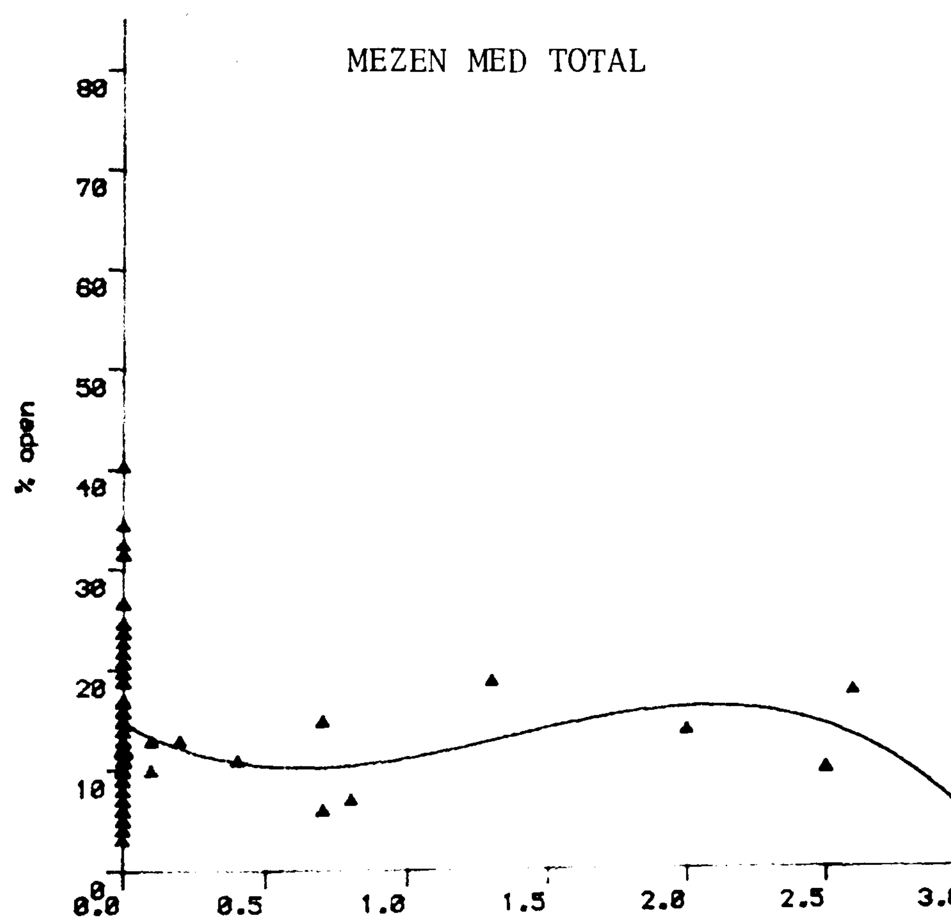


FIGURE A159



FIGURES A160-A163. Relationships between rainfall and window opening in the high group at Mezen

FIGURE A160

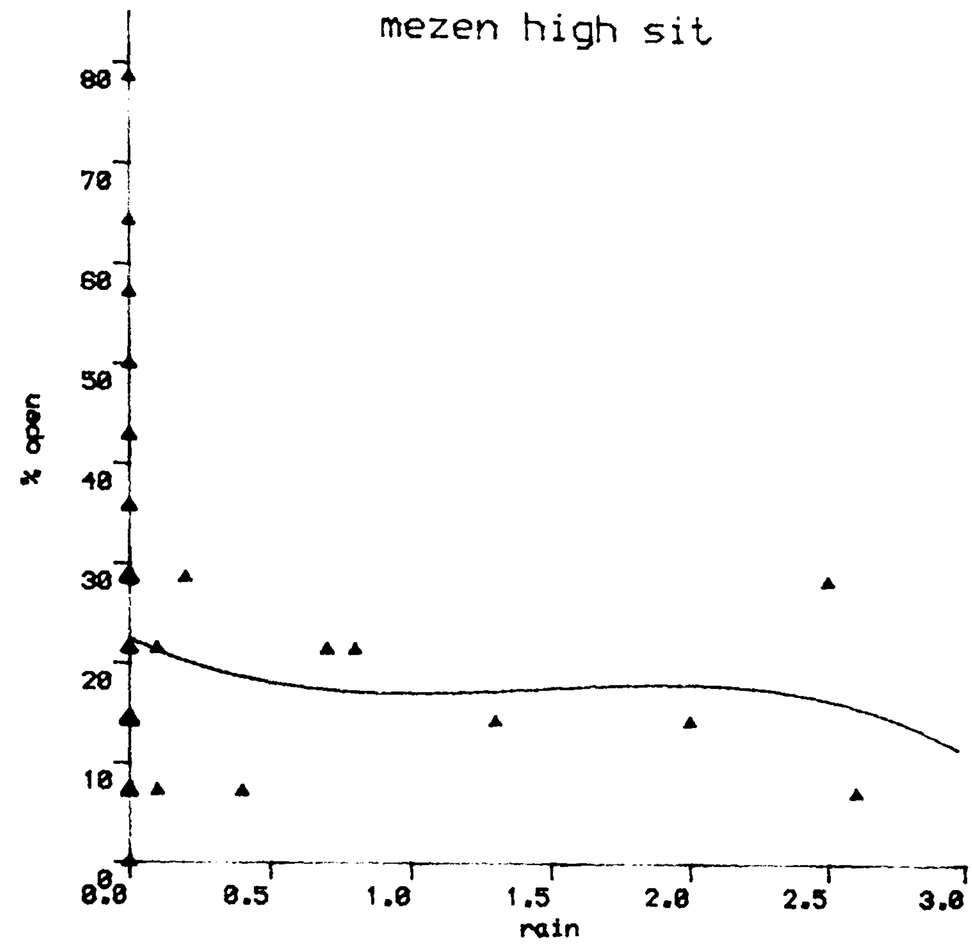


FIGURE A161

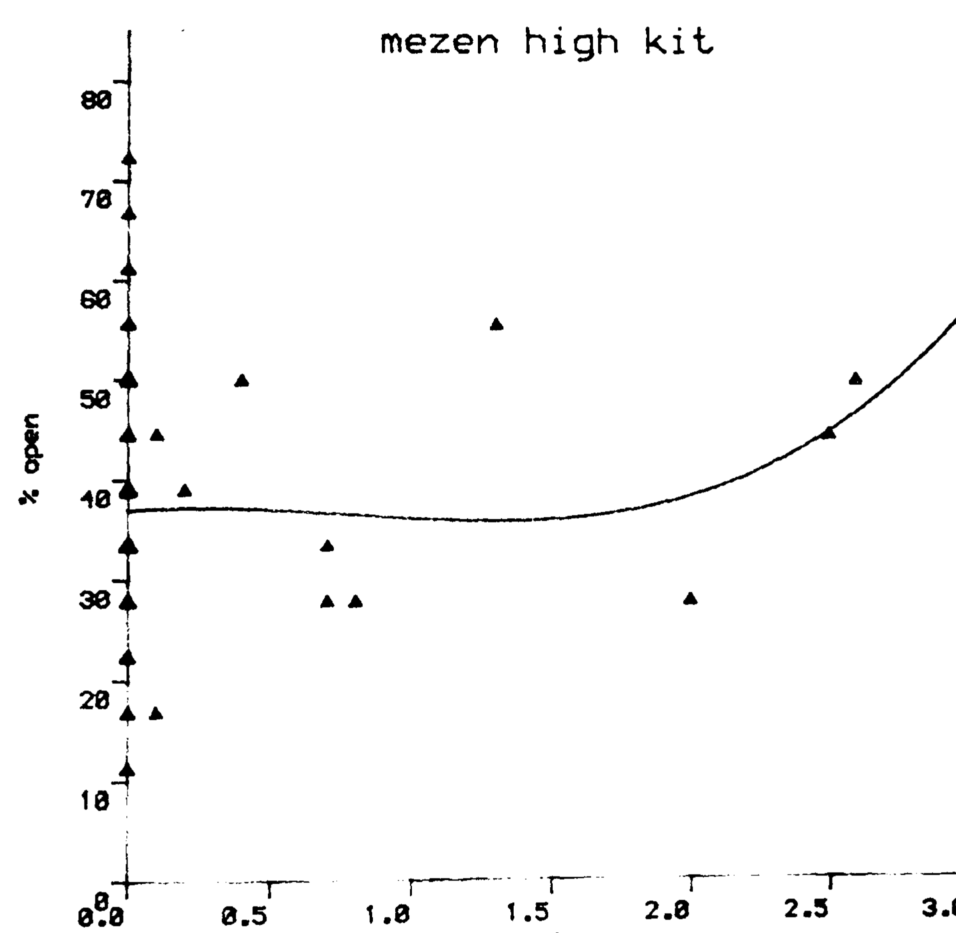


FIGURE A162

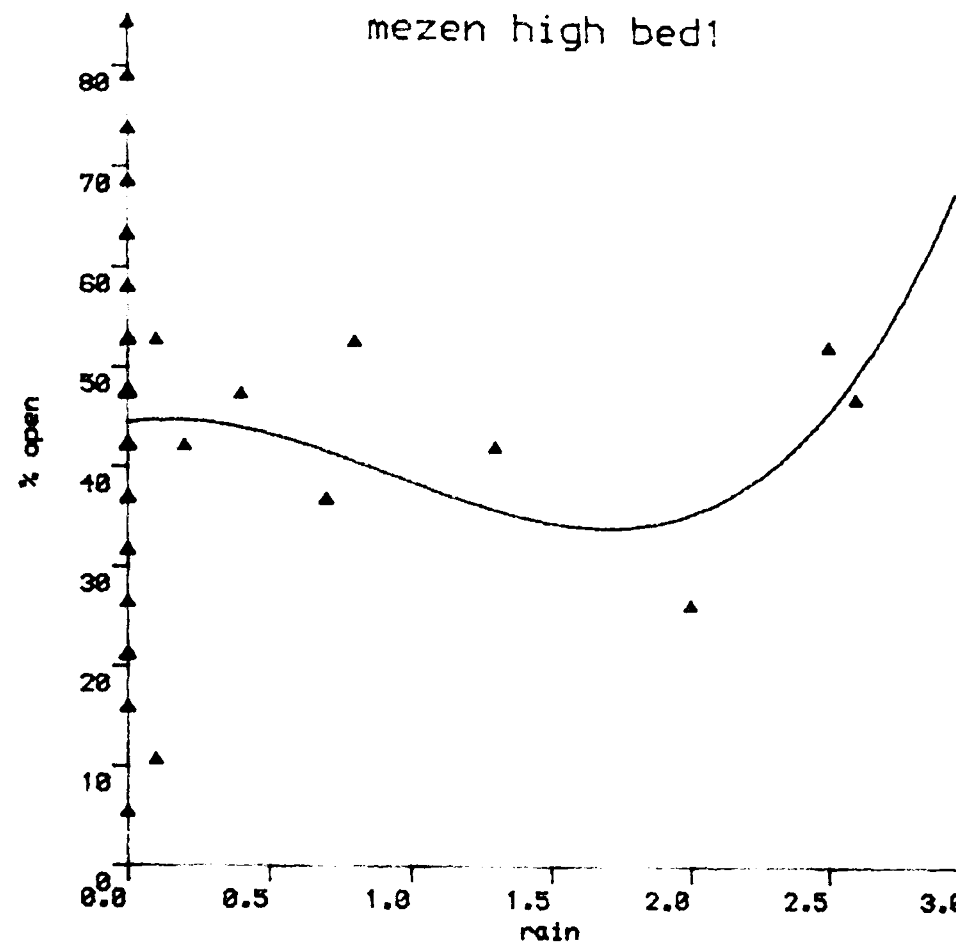
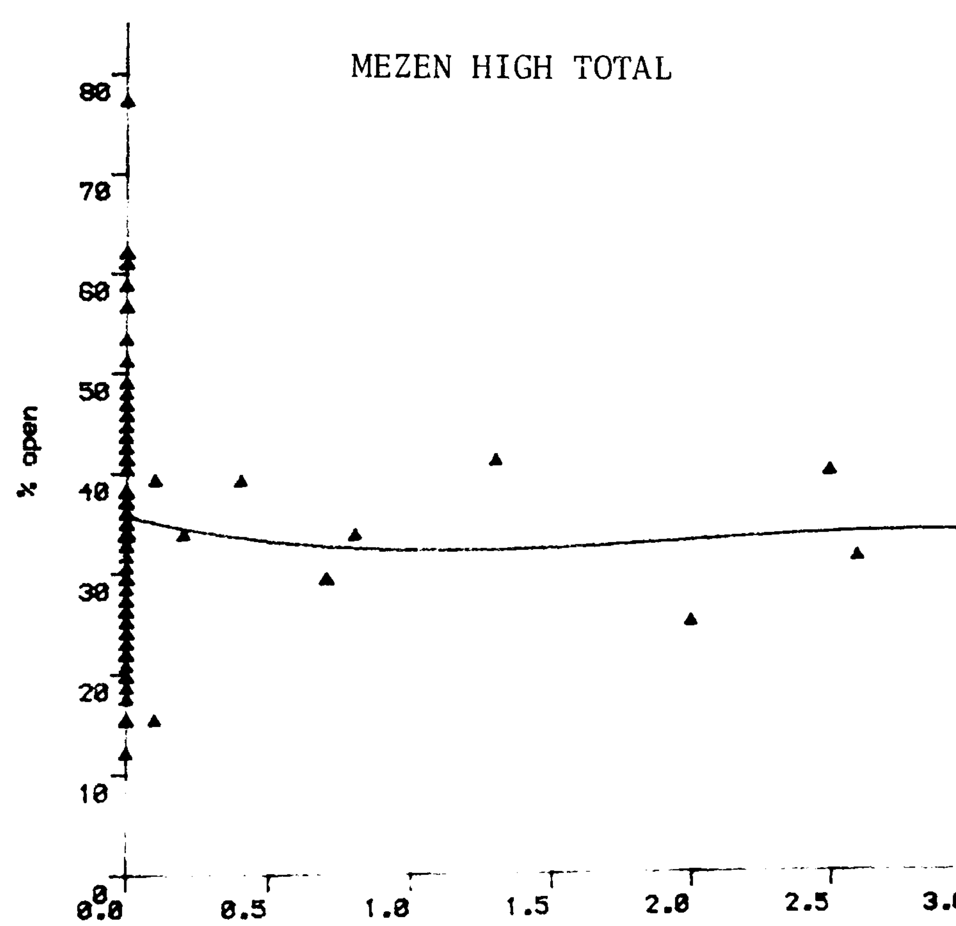


FIGURE A163



FIGURES A164-A167. Relationships between rainfall and window opening in all groups at Mezen

FIGURE A164

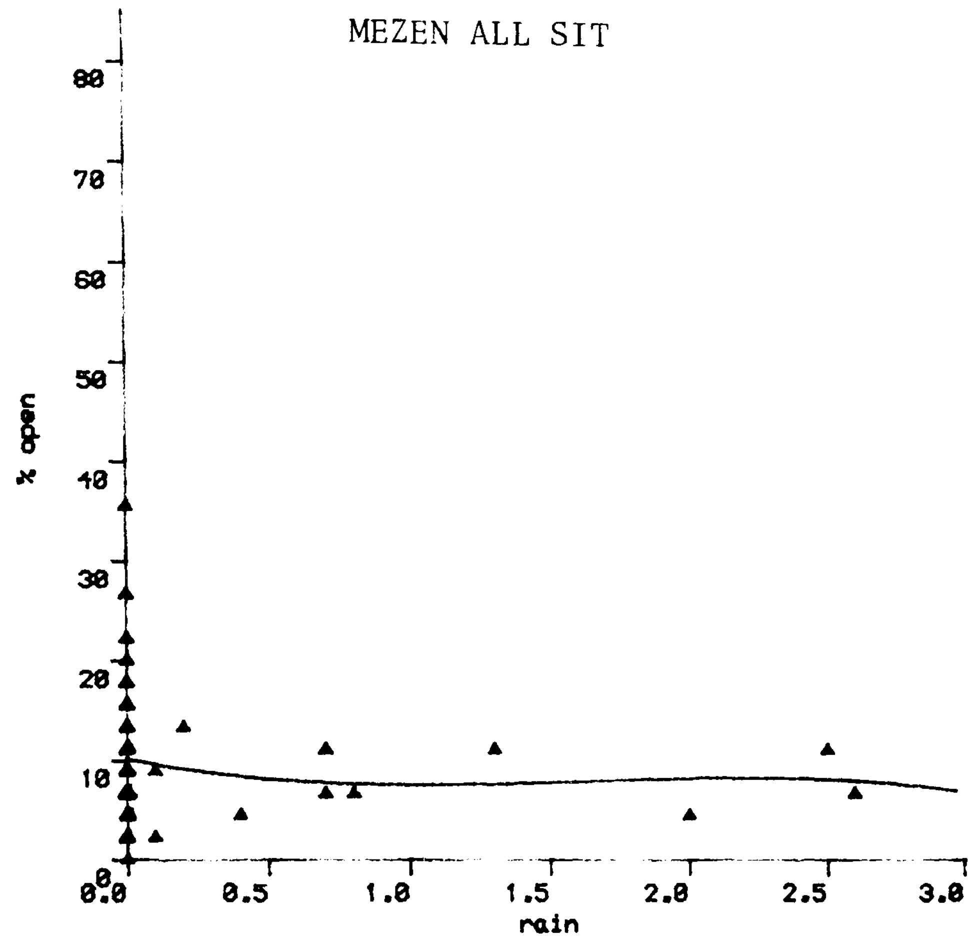


FIGURE A165

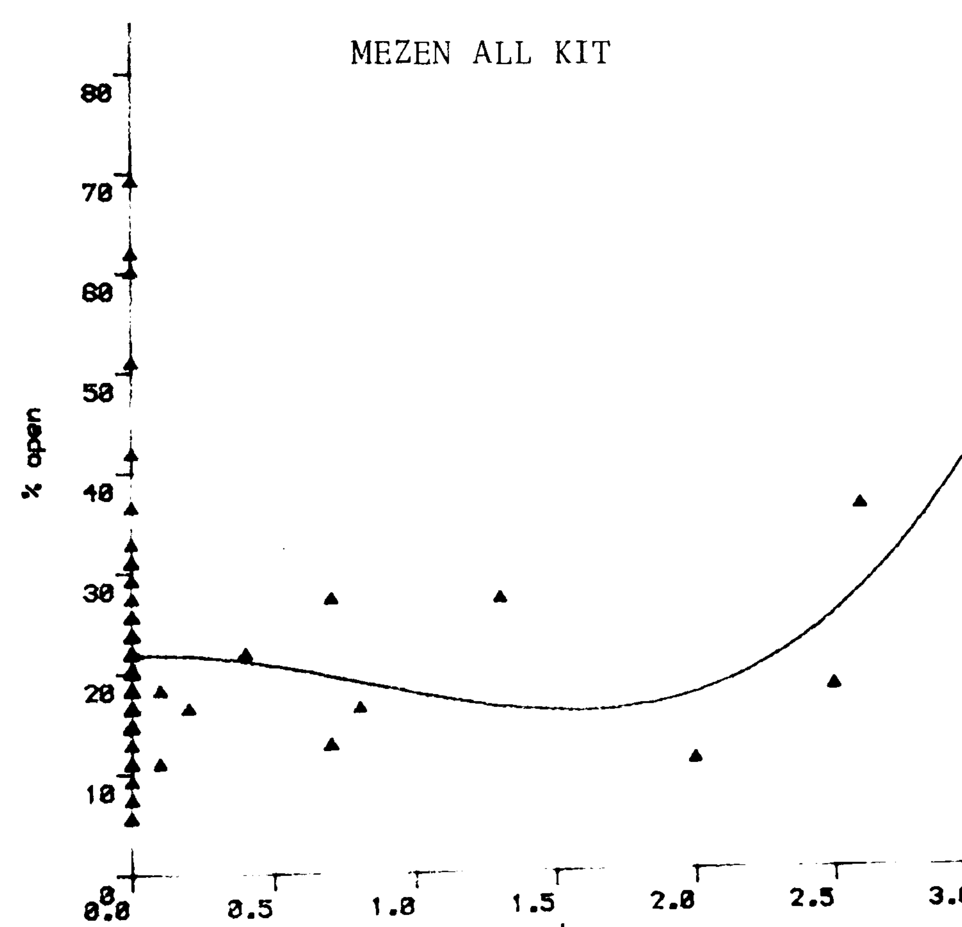


FIGURE A166

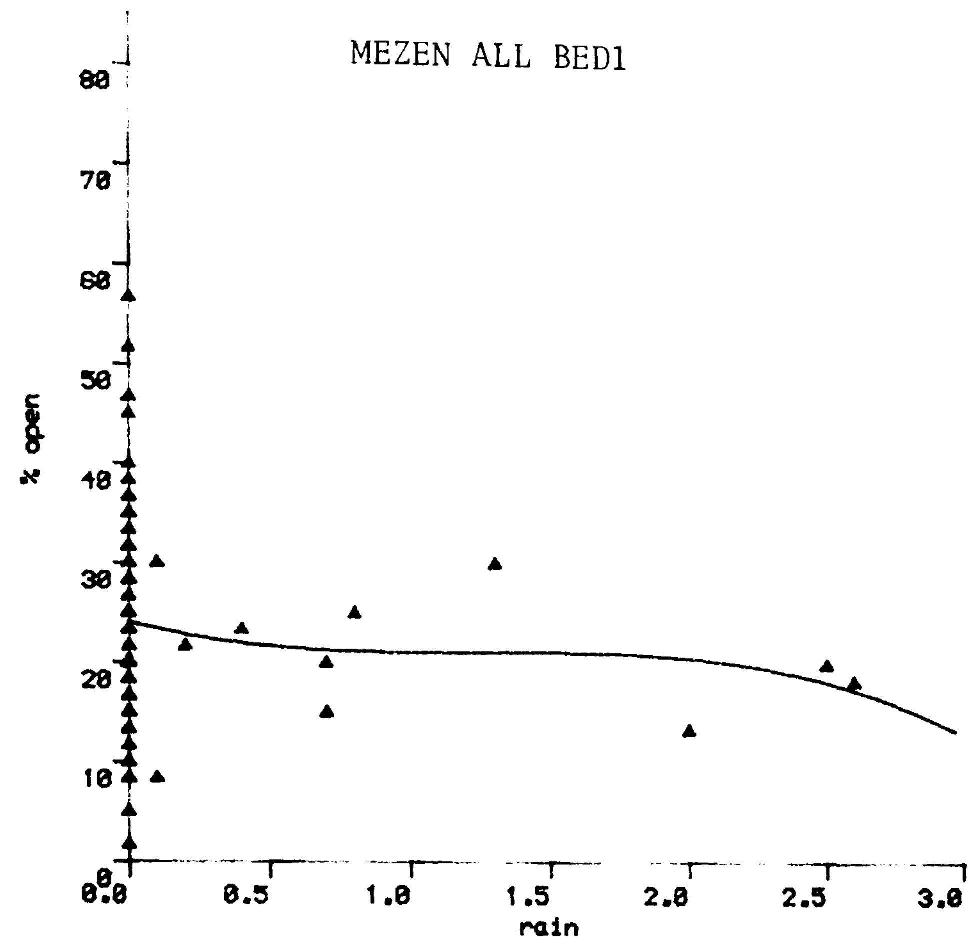


FIGURE A167

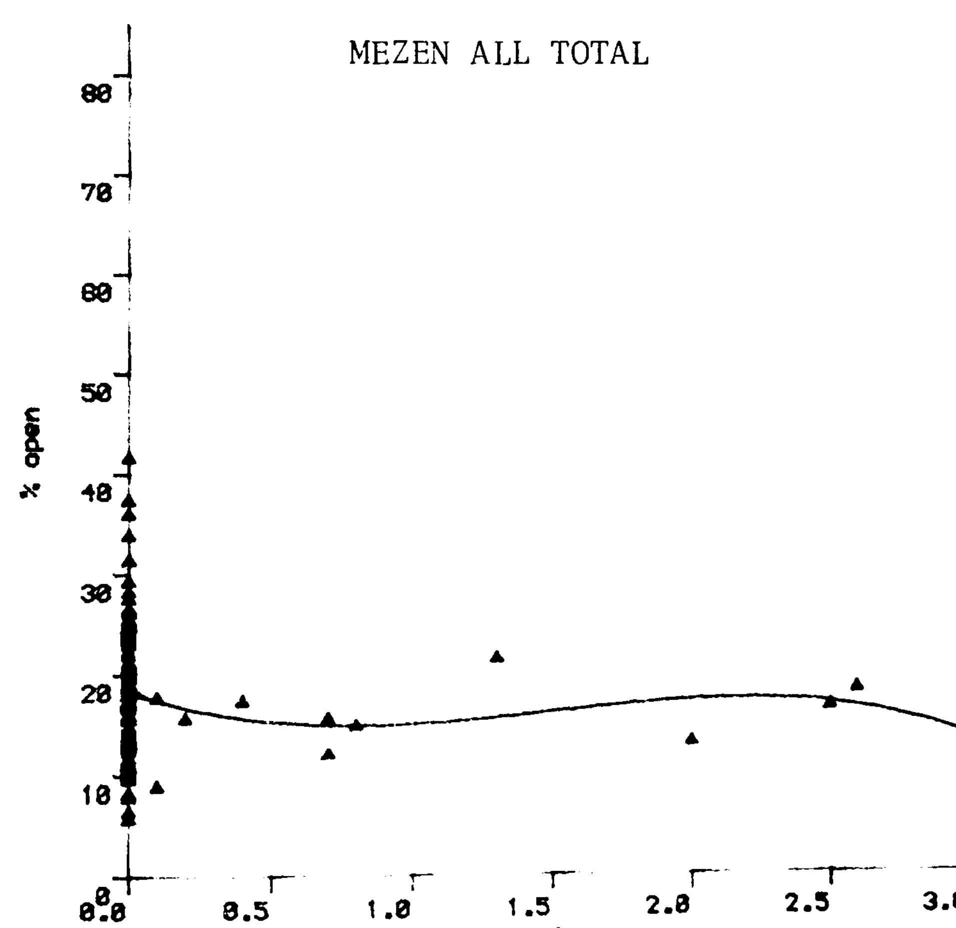


TABLE A1. Frequency distribution of the number of household occupants

No. of occupants	Absolute frequency
1	16
2	32
3	27
4	20
5	5
6	1

TABLE A2. Frequency distribution of household lifecycle stage

Stage	Absolute frequency
1 (extremes)	58
2 (middle)	43

TABLE A3. Frequency distribution of number of occupants going out to work

No. going out to work	Absolute frequency
1	6
2	35
3	19
4	15
5	2
7	2
8	1
No one/retired/ unemployed	21

TABLE A4. Frequency distribution of the number of hours per week for which the house is occupied

No. of hours p.w.	Absolute frequency
111 - 120	4
121 - 130	7
131 - 140	11
141 - 150	15
151 - 160	22
161 - 170	32

TABLE A5. Frequency distribution of total nett weekly income

Income (£)	Absolute frequency
20 - 50	21
51 - 80	23
81 - 110	24
111 - 140	8
no response	3

Table A6. Chart for recording window observations at Cowley.

Estate: COWLEY

Time:

Date:

St. Ivanhoe 18 – 25

FLATS

	Front			Back				
	G	1st		G		1st		
No.	B 1	B 1	B 2	SIT	KIT	SIT A	SIT B	KIT
24								
25								
23								
22								
20								
21								
19								
18								

St. Ivanhoe 1 – 10

FOUR PERSON, THREE STOREY HOUSES

	Front			Back		
	2nd		3rd	1st	2nd	3rd
No.	SIT A	SIT B	B 1	KIT	B 2	LND
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						

St. Helens 24 - 31 & 23 - 21

FLATS

	Front			Back				
	G	1st		G		1st		
No.	B 1	B 1	B 2	SIT B	KIT	SIT A	SIT B	KIT
30								
31								
29								
28								
26								
27								
25								
24								

SIX PERSON, THREE STOREY HOUSES

	Front		Back			
	2nd	3rd	G	2nd		3rd
No.	B 1	B 2	KIT	SIT A	SIT B	B 3
23						
22						
21						

FLATS

	Front			Back				
	G	1st		G		1st		
No.	B 1	B 1	B 2	SIT	KIT	SIT A	SIT B	KIT
19		■	■			■	■	■
20	■			■	■			
18	■			■	■			
17		■	■			■	■	■
15		■	■			■	■	■
16	■			■	■			
14	■			■	■			
13		■	■			■	■	■

FOUR PERSON, TWO STOREY HOUSES

	Front		Back	
	G	1st	G	1st
No.	KIT	B 1	SIT	B 2
12				
11				

SIX PERSON, THREE STOREY HOUSES

	Front		Back			
	2nd	3rd	1st	2nd		3rd
No.	B 1	B 2	KIT	SIT A	SIT B	B 3
10						
9						
8						
7						
6						
5						
4						
3						

FOUR PERSON, TWO STOREY HOUSES

	Front		Back	
	G	1st	G	1st
No.	KIT	B 1	SIT	B 2
2				
1				

FLATS

	Front			Back				
	G	1st		G		1st		
No.	B 1	B 1	B 2	SIT	KIT	SIT A	SIT B	KIT
40								
41								
43								
42								
44								
45								
47								
46								

SIX PERSON, THREE STOREY HOUSES

	Front		Back			
	2nd	3rd	1st	2nd a	2nd b	3rd
No.	B 1	B 2	KIT	SIT A	SIT B	B 3
48						
49						

St. Martins 20, 18, 16, 14.

FOUR PERSON, TWO STOREY HOUSES

	Front		Back	
	G	1st	G	1st
No.	KIT	B 1	SIT	B 2
20				
18				
16				
14				

Table A7. Chart for recording window observations at Mezen.

Estate: MEZEN

Date:

Time:

FLATS

	Front			Side					Back		
No.	B 2	B 1A	B 1B	B 1A	B 1B	BTH	KT A	KT B	KT C	SIT A	SIT B
1											
2											

FOUR PERSON HOUSES

	Front				Back					
	G	1st			G		1st			
No.	KT	LND	BTH	WC	DIN	SIT	B 1A	B 1B	B 2A	B 2B
3										
4										
5										
6										
7										

FLATS

	Side					Side	Back		
No.	KT A	KT B	BTH	B 1A	B 1B	B 2	KT C	SIT A	SIT B
8									
9									

FLATS

	Side 1					Side 2			
No.	KT A	KT B	BTH	B 1A	B 1B	LND	B 2	SIT A	SIT B
10									
11									

FLATS

	Side					Side	Back		
No.	KT A	KT B	BTH	B 1A	B 1B	B2	KT C	SIT A	SIT B
12									
13									

FOUR PERSON HOUSES

	Front				Back					
	G	1st			G		1st			
No.	KT	LND	BTH	WC	DIN	SIT	B 1A	B 1B	B 2A	B 2B
14										
15										
16										
17										
18										

FLATS

	Front			Side					Back		
No.	B 2	B 1A	B 1B	B 1A	B 1B	BTH	KT A	KT B	KT C	SIT A	SIT B
19											
20											

FLATS

	Side 1				Side 2				
No.	LND	B 2	SIT A	SIT B	KT A	KT B	BTH	B 1A	B 1B
21									
22									

FLATS

	Side 1				Side 2					Back
No.	LND	B 2	SIT A	SIT B	KT A	KT B	BTH	B 1A	B 1B	KT C
23										
24										
25										
26										

FLATS

	Side 1					Side 2	Side 3		
No.	B 1A	B 1B	BTH	KT A	KT B	B 2	SIT A	SIT B	KT C
27									
28									

FOUR PERSON HOUSES

	Front				Back					
	G	1st			G		1st			
No.	KT	LND	BTH	WC	DIN	SIT	B 1A	B 1B	B 2A	B 2B
29										
30										

FLATS

	Front			Side				Back		
No.	LND	B 1A	B 1B	B 2	KT B	BTH	B 1	SIT A	SIT B	KT A
31										
32										

FOUR PERSON HOUSES

	Front				Back					
	G	1st			G		1st			
No.	KT	LND	BTH	WC	DIN	SIT	B 1A	B 1B	B 2A	B 2B
33										
34										
35										

Table A8. Weather parameter values, hour of observation and window opening scores on days 1 - 100 for a) Cowley & b) Mezen

Cowley

day	temp	rel. hum.	wind speed	sun	rain	time		no. open windows Sit	Kit	Bed 1
1	17.7	74	11	1	0	12	low	7	3	10
							medium	12	17	22
							high	24	17	22
							all	43	37	54
2	15.2	43	3	1	0	12	low	5	4	10
							medium	18	16	20
							high	20	12	19
							all	43	32	49
3	14.9	90	5	0	2.5	15	low	2	1	9
							medium	17	19	23
							high	20	16	20
							all	39	36	52
4	18	72	11	0.9	0	11	low	3	7	12
							medium	18	16	24
							high	17	15	18
							all	38	38	54
5	16.2	69	4	0.1	0	14	low	8	9	10
							medium	18	21	19
							high	24	19	20
							all	50	49	49
6	14.6	72	7	0.3	0	13	low	5	3	9
							medium	13	14	22
							high	14	16	20
							all	32	33	51
7	15.1	70	8	0	0	16	low	4	3	12
							medium	13	14	19
							high	17	16	16
							all	34	33	47
8	13.7	59	9	1	0	11	low	5	2	7
							medium	15	14	23
							high	16	14	18
							all	36	30	48
9	17.5	66	11	0.5	0	16	low	5	4	9
							medium	15	16	22
							high	16	17	16
							all	36	37	47
10	11	67	20	0.4	0	10	low	0	1	7
							medium	7	7	16
							high	15	13	17
							all	22	21	40
11	10.6	60	15	0.9	0	12	low	0	2	4
							medium	7	9	14
							high	13	12	8
							all	20	23	26
12	10.4	90	3	0	0	10	low	0	4	4
							medium	4	8	10
							high	15	12	14
							all	19	24	28
13	11.9	96	5	0	0.4	15	low	0	4	2
							medium	7	11	16
							high	14	13	15
							all	21	28	33
14	11.6	96	4	0	0.2	9	low	1	4	4
							medium	3	6	18
							high	13	14	14
							all	17	24	36
15	8.4	37	9	1	0	9	low	1	2	4
							medium	9	11	18
							high	10	11	12
							all	20	24	34

16	12.9	94	3	0	0	18	low	8	11	8
							medium	5	16	13
							high	15	14	12
							all	28	41	33
17	13.4	73	8	0.4	0	16	low	9	9	4
							medium	4	12	10
							high	14	4	3
							all	27	25	17
18	9.6	79	6	0	0	17	low	5	8	4
							medium	10	14	7
							high	5	12	5
							all	20	34	16
19	12.5	68	3	1	0	13	low	7	12	5
							medium	9	15	7
							high	5	10	9
							all	21	37	21
20	9.1	81	4	0	0	13	low	0	3	5
							medium	3	7	17
							high	7	13	18
							all	10	23	40
21	7	80	11	1	0	10	low	1	1	6
							medium	5	11	19
							high	12	12	16
							all	18	24	41
22	6.1	70	6	0	0	16	low	0	1	0
							medium	2	3	13
							high	5	9	9
							all	7	18	22
23	5.3	61	5	0	0	16	low	0	0	3
							medium	1	7	11
							high	4	7	11
							all	5	14	25
24	5.8	83	11	0	0	13	low	0	1	3
							medium	3	7	14
							high	7	16	12
							all	10	24	29
25	4.3	37	9	0	0	9	low	2	0	3
							medium	2	7	11
							high	9	12	12
							all	13	19	26
26	5.6	91	12	0	0	14	low	2	0	4
							medium	4	4	10
							high	4	11	13
							all	10	15	27
27	8.4	82	3	0	0	18	low	0	2	1
							medium	1	7	10
							high	2	11	11
							all	3	20	22
28	6.4	94	6	0	0	15	low	0	1	1
							medium	0	6	12
							high	5	13	16
							all	5	20	29
29	0	100	2	0	0	9	low	2	1	0
							medium	5	7	10
							high	7	11	14
							all	14	19	24
30	7.3	97	5	0	0	10	low	2	1	2
							medium	3	9	12
							high	10	12	13
							all	15	22	27
31	11	75	10	0	0	15	low	2	2	5
							medium	6	11	16
							high	9	14	14
							all	17	27	35

32	14.5	80	16	0	0	11	low	2	2	3
							medium	3	10	14
							high	9	12	13
							all	14	24	30
33	14.2	83	5	0.2	0	14	low	2	0	2
							medium	2	10	18
							high	15	15	19
							all	19	25	39
34	12.8	80	7	0.8	0	14	low	2	3	1
							medium	10	12	22
							high	18	16	19
							all	30	31	42
35	9.8	87	9	0	0	18	low	2	3	4
							medium	10	11	9
							high	6	9	10
							all	18	23	23
36	8.8	94	7	0	0	9	low	2	2	3
							medium	9	8	15
							high	16	14	14
							all	27	24	32
37	14.3	93	5	0	0	15	low	1	1	3
							medium	4	9	14
							high	18	15	17
							all	23	25	34
38	11.5	95	9	0	1.3	10	low	1	0	3
							medium	5	10	19
							high	14	10	18
							all	20	20	40
39	9.8	72	16	0.8	0	11	low	0	1	3
							medium	9	10	18
							high	15	10	14
							all	24	21	35
40	10	81	15	0	0	17	low	0	0	0
							medium	1	6	7
							high	3	6	5
							all	4	12	12
41	9.9	82	5	0	0	16	low	1	1	2
							medium	5	7	11
							high	11	11	15
							all	17	19	28
42	7.1	78	8	0	0	17	low	0	0	2
							medium	2	9	8
							high	2	9	13
							all	4	18	23
43	6.4	62	18	0	0	16	low	0	2	1
							medium	0	5	8
							high	3	8	12
							all	3	15	21
44	5.5	80	9	0.2	0	10	low	0	1	3
							medium	2	6	13
							high	9	11	16
							all	11	18	32
45	5.2	76	14	0.2	0	14	low	0	0	2
							medium	1	8	10
							high	5	12	11
							all	6	20	23
46	2.1	91	10	0.4	0	9	low	0	0	3
							medium	4	5	12
							high	5	9	13
							all	9	14	28
47	4.1	85	10	0.1	0	12	low	0	0	0
							medium	3	3	13
							high	5	13	14
							all	8	16	27

48	1.9	87	5	0	0	18	low	0	1	0
							medium	0	6	5
							high	3	7	7
							all	3	14	12
49	1.4	92	5	0	0	13	low	0	0	1
							medium	1	6	4
							high	3	8	9
							all	4	14	14
50	2.4	79	6	1	0	13	low	0	0	0
							medium	2	6	8
							high	4	15	11
							all	6	21	19
51	2.8	86	3	0	0	17	low	0	1	0
							medium	1	3	3
							high	1	7	7
							all	2	16	10
52	4.7	78	13	0.2	0	11	low	0	1	0
							medium	1	3	11
							high	6	13	11
							all	7	17	22
53	4	82	13	1	0	11	low	0	0	0
							medium	3	4	9
							high	3	14	9
							all	11	18	18
54	1.2	74	2	0	0	11	low	0	1	0
							medium	1	5	7
							high	7	6	7
							all	8	12	14
55	8.2	82	24	0.4	0	12	low	0	0	0
							medium	0	5	11
							high	6	9	13
							all	6	14	24
56	6.9	71	16	0.6	0	11	low	0	3	0
							medium	2	3	18
							high	10	12	17
							all	12	18	35
57	5.3	80	12	1	0	10	low	0	2	1
							medium	5	4	18
							high	10	11	13
							all	15	17	32
58	6	79	7	1	0	12	low	1	0	1
							medium	2	4	15
							high	9	13	13
							all	12	17	29
59	7	75	8	1	0	13	low	0	2	0
							medium	3	4	14
							high	8	14	16
							all	11	20	30
60	3	89	10	0	0	9	low	0	3	0
							medium	2	3	10
							high	6	10	10
							all	8	16	20
61	7.4	74	8	0	0	18	low	0	4	0
							medium	1	4	6
							high	3	9	8
							all	4	17	14
62	9	73	12	0.3	0	10	low	0	2	1
							medium	2	8	14
							high	7	11	13
							all	9	21	28
63	2	75	2	0	0	17	low	0	0	0
							medium	0	5	12
							high	3	13	12
							all	3	18	24

64	6.4	97	6	0	0.1	17	low	0	1	0
							medium	1	7	8
							high	2	10	9
							all	3	18	17
65	9.7	89	16	0	0.1	12	low	0	0	1
							medium	1	7	10
							high	5	11	10
							all	6	13	21
66	7.3	99	10	0	0.1	15	low	0	1	1
							medium	3	6	8
							high	5	13	11
							all	8	20	20
67	10.2	92	14	0	0	12	low	0	0	1
							medium	6	6	11
							high	6	15	12
							all	12	21	24
68	7.9	91	8	0.1	0	10	low	0	2	2
							medium	3	4	14
							high	9	15	15
							all	12	21	31
69	7.5	86	7	0.2	0	11	low	1	1	4
							medium	4	6	13
							high	9	14	18
							all	14	21	35
70	8.5	86	7	0	0	17	low	0	2	1
							medium	5	6	9
							high	7	17	14
							all	12	25	24
71	9.2	96	5	0	0	9	low	0	1	1
							medium	4	5	12
							high	9	13	18
							all	13	19	31
72	14	84	13	0	0	15	low	2	1	2
							medium	6	9	13
							high	3	10	13
							all	11	20	28
73	9.5	56	10	0.5	0	13	low	1	1	3
							medium	3	10	17
							high	9	17	20
							all	13	28	40
74	9.5	73	10	0	0	16	low	1	0	1
							medium	1	8	12
							high	6	10	10
							all	8	18	23
75	7.3	94	4	0.5	0.4	16	low	1	2	1
							medium	1	5	7
							high	5	13	12
							all	7	20	20
76	6.4	95	9	0	0.1	15	low	1	2	1
							medium	3	7	11
							high	7	16	16
							all	11	25	28
77	4.9	82	5	0	0	17	low	1	1	2
							medium	1	6	9
							high	4	16	11
							all	6	23	22
78	5.8	79	9	0	0	17	low	1	1	1
							medium	2	4	7
							high	6	14	10
							all	9	19	18
79	9.5	76	3	0	0	18	low	1	1	1
							medium	2	5	8
							high	6	15	13
							all	9	21	22

80	8.2	70	8	1	0	13	low	2	3	[illegible]
							medium	8	6	13
							high	7	16	13
							all	17	25	39
81	5.7	48	4	1	0	12	low	0	3	5
							medium	9	7	19
							high	11	16	20
							all	20	26	44
82	1.2	33	2	1	0	9	low	0	2	4
							medium	2	4	13
							high	5	11	15
							all	7	17	32
83	4.7	85	8	0.2	0	9	low	0	1	1
							medium	2	8	10
							high	7	11	12
							all	9	20	23
84	7.4	96	5	0	0.3	14	low	0	1	1
							medium	3	6	9
							high	11	11	14
							all	14	18	24
85	7.9	87	12	0	0.1	14	low	0	0	1
							medium	5	13	12
							high	7	10	11
							all	12	23	24
86	8.2	79	12	0	0	14	low	0	0	0
							medium	4	6	12
							high	5	13	17
							all	9	19	29
87	9.7	64	7	0.1	0	14	low	0	0	2
							medium	8	10	17
							high	10	17	20
							all	18	27	39
88	10.1	93	16	0	0.1	12	low	0	1	3
							medium	6	8	13
							high	3	12	17
							all	9	21	33
89	4.3	93	3	0	2.3	13	low	1	2	1
							medium	5	7	13
							high	9	13	11
							all	15	22	25
90	6	92	13	0	0.4	11	low	0	1	1
							medium	3	5	6
							high	7	10	12
							all	10	16	19
91	2.5	75	19	0	0	18	low	0	2	0
							medium	1	3	2
							high	3	8	5
							all	4	13	7
92	3.7	44	17	1	0	14	low	0	0	0
							medium	1	2	4
							high	3	9	5
							all	4	11	9
93	10.4	72	10	0.2	0	15	low	0	2	1
							medium	5	4	9
							high	7	11	13
							all	12	17	23
94	8.2	83	7	1	0	10	low	2	0	1
							medium	5	8	14
							high	7	11	13
							all	14	19	28
95	10.9	52	12	0.1	0	13	low	4	4	4
							medium	6	7	18
							high	15	16	20
							all	25	27	42

96	9.6	74	9	0	0	18	low	0	3	0
							medium	3	4	7
							high	7	14	10
							all	10	21	17
97	9.7	95	7	0	2.2	15	low	0	3	3
							medium	7	9	11
							high	12	16	18
							all	19	28	32
98	12.5	56	7	0	0	17	low	2	5	5
							medium	7	5	10
							high	3	7	15
							all	12	17	30
99	9.6	41	13	0.9	0	14	low	0	2	4
							medium	2	7	12
							high	13	13	17
							all	15	22	33
100	9.9	68	10	0	0	18	low	0	2	4
							medium	0	6	10
							high	10	11	16
							all	10	19	30

mezen

day	temp	rel. hum.	wind speed	sun	rain	time	no. open windows	Sit	Kit	Bed 1
1	19.1	66	5	0	0	17	low	3	2	7
							medium	2	8	8
							high	11	10	16
							all	16	20	31
2	14.3	79	7	0	0	18	low	1	2	6
							medium	1	5	5
							high	3	10	17
							all	10	17	28
3	14.6	93	10	1	0	9	low	0	0	4
							medium	1	7	4
							high	9	10	15
							all	10	17	23
4	10.4	100	2	0	0	10	low	2	1	5
							medium	0	4	5
							high	4	7	12
							all	6	12	22
5	14	72	8	0	0	18	low	1	0	2
							medium	2	6	5
							high	4	9	12
							all	7	15	19
6	11.5	80	3	0	0	9	low	1	0	2
							medium	0	2	3
							high	5	7	14
							all	6	9	19
7	11.6	74	10	1	0	9	low	1	0	1
							medium	1	3	7
							high	7	9	15
							all	9	12	23
8	11.2	63	17	0	0	16	low	1	1	2
							medium	0	1	5
							high	3	9	10
							all	4	11	17
9	8.2	74	9	0	0	13	low	0	0	0
							medium	0	5	3
							high	2	6	9
							all	2	11	12
10	12.9	73	10	0.7	0	15	low	0	1	1
							medium	2	4	3
							high	4	7	12
							all	6	12	16

11	13.3	95	7	0	2.5	10	low	0	0	0
							medium	1	2	2
							high	4	8	10
							all	5	10	12
12	8.6	89	3	0	0.4	16	low	0	0	0
							medium	1	3	5
							high	1	9	9
							all	2	12	14
13	3.5	97	4	0.1	2	16	low	0	0	0
							medium	0	1	3
							high	2	5	5
							all	2	6	8
14	1	81	4	1	0	10	low	1	0	0
							medium	1	4	3
							high	2	8	9
							all	4	12	12
15	14.4	93	12	0	0	14	low	1	0	1
							medium	1	4	4
							high	5	9	14
							all	7	13	19
16	9.4	85	5	0.9	0	11	low	0	2	2
							medium	3	8	5
							high	5	8	8
							all	8	18	15
17	11.5	90	13	0	0	13	low	0	11	1
							medium	0	14	3
							high	0	13	3
							all	0	38	7
18	11.3	73	6	0	0	18	low	1	11	5
							medium	0	11	3
							high	2	11	1
							all	3	33	9
19	13.1	66	9	0.3	0	13	low	1	9	2
							medium	0	10	4
							high	3	9	3
							all	4	28	9
20	10.1	72	3	0	0	17	low	1	8	2
							medium	1	14	4
							high	2	12	3
							all	4	34	9
21	5.4	81	10	0	0	17	low	0	0	1
							medium	1	1	3
							high	2	8	5
							all	3	9	9
22	3.6	93	10	0	0.1	17	low	0	1	1
							medium	0	2	2
							high	1	3	2
							all	1	6	5
23	5.1	90	2	0	0	18	low	0	0	0
							medium	1	5	2
							high	1	5	4
							all	2	10	6
24	5.5	92	5	0.8	0	9	low	1	0	0
							medium	0	5	5
							high	4	6	9
							all	5	11	14
25	2.4	100	3	0	0	9	low	0	0	0
							medium	0	4	5
							high	2	4	6
							all	2	8	11
26	1.7	100	2	0	0	16	low	0	0	0
							medium	0	2	1
							high	1	5	4
							all	1	7	5

27	9.7	95	5	0	0	15	low	0	0	0
							medium	0	3	2
							high	2	6	7
							all	2	9	9
28	10.6	79	11	0	0	10	low	1	2	1
							medium	1	4	6
							high	2	3	3
							all	4	9	15
29	13.4	99	6	0	0.7	13	low	0	1	0
							medium	2	8	2
							high	3	6	7
							all	5	15	9
30	13.2	80	10	0	0	16	low	0	0	1
							medium	0	4	7
							high	1	7	9
							all	1	11	17
31	11.4	89	10	0	0	10	low	0	1	0
							medium	1	5	7
							high	7	7	13
							all	8	13	20
32	13.4	90	11	0.5	0	10	low	0	0	0
							medium	2	2	7
							high	4	6	9
							all	6	3	16
33	12.1	68	7	0	0	15	low	0	1	0
							medium	0	4	9
							high	5	10	13
							all	5	15	22
34	12	82	13	0	0	16	low	0	0	1
							medium	0	4	8
							high	1	7	10
							all	1	11	19
35	12.4	98	7	0	0	10	low	0	1	0
							medium	0	4	6
							high	3	9	9
							all	3	14	15
36	13.5	90	11	0	0	14	low	3	2	2
							medium	1	7	6
							high	5	8	11
							all	9	17	19
37	10.7	65	12	0.2	0	14	low	0	0	1
							medium	1	6	4
							high	4	8	9
							all	5	14	14
38	7.4	83	9	0	0	17	low	0	0	0
							medium	0	8	2
							high	1	9	3
							all	1	17	5
39	9.5	80	3	1	0	11	low	2	1	1
							medium	0	5	3
							high	5	5	10
							all	7	11	14
40	6.7	74	13	1	0	11	low	2	3	1
							medium	1	2	4
							high	4	6	7
							all	7	11	12
41	6.8	77	17	0	0	10	low	1	0	1
							medium	1	3	3
							high	1	5	5
							all	3	8	9
42	5.9	82	3	0	0	14	low	0	0	0
							medium	1	2	1
							high	2	6	7
							all	3	8	3

43	3.2	83	13	0.3	0	9	low	1	0	1
							medium	0	3	3
							high	2	2	7
							all	3	5	11
44	4.2	82	12	0.1	0	12	low	1	1	0
							medium	1	3	3
							high	2	4	7
							all	4	8	10
45	3.8	80	11	0.1	0	11	low	1	1	0
							medium	2	3	2
							high	0	2	5
							all	3	6	7
46	6	33	7	0	0	12	low	0	2	2
							medium	1	2	3
							high	3	5	8
							all	4	9	13
47	3.6	76	10	0	0	16	low	0	0	0
							medium	0	3	2
							high	1	6	4
							all	1	9	6
48	3.2	76	8	0	0	12	low	0	1	0
							medium	1	4	4
							high	2	4	8
							all	3	9	12
49	3	84	3	0	0	12	low	1	1	0
							medium	0	4	4
							high	1	7	4
							all	2	12	8
50	-0.5	89	3	0	0	16	low	0	1	0
							medium	0	5	0
							high	1	4	3
							all	1	10	3
51	5.3	69	14	0.1	0	14	low	1	0	0
							medium	1	3	4
							high	3	3	7
							all	5	6	11
52	4.5	66	13	1	0	14	low	0	1	0
							medium	0	2	2
							high	2	3	4
							all	2	6	6
53	1.5	72	4	0	0	15	low	0	0	0
							medium	0	2	1
							high	1	2	4
							all	1	4	5
54	7.2	81	20	0	0	17	low	0	1	0
							medium	0	4	0
							high	1	4	1
							all	1	9	1
55	7.8	68	14	0.1	0	15	low	0	0	1
							medium	1	3	5
							high	2	7	10
							all	3	10	16
56	7.9	67	6	0.9	0	14	low	1	1	1
							medium	0	4	3
							high	4	7	11
							all	5	12	15
57	1	83	7	1	0	9	low	1	0	0
							medium	1	4	3
							high	1	4	6
							all	3	8	9
58	4.5	79	7	0	0	13	low	1	0	0
							medium	0	3	4
							high	1	6	6
							all	2	9	10

59	6.6	76	6	0.3	0	12	low	0	0	2	[illegible]
							medium	1	2	3	1
							high	2	4	7	2
							all	3	6	12	3
60	9.6	79	12	0.6	0	11	low	1	1	1	[illegible]
							medium	1	4	3	[illegible]
							high	4	5	9	[illegible]
							all	6	10	18	[illegible]
61	7.1	94	9	0.1	0.8	15	low	0	0	2	4
							medium	0	4	3	7
							high	3	5	10	3
							all	3	9	15	4
62	2.4	75	5	0.6	0	13	low	0	1	0	0
							medium	0	2	5	1
							high	2	5	7	2
							all	2	8	12	3
63	9	93	16	0	0.1	9	low	0	0	0	1
							medium	1	2	8	1
							high	3	8	10	3
							all	4	10	18	5
64	7.5	91	6	0	0	10	low	0	0	0	1
							medium	1	2	6	1
							high	6	9	14	5
							all	7	11	20	7
65	4.2	93	9	0	0	9	low	1	0	1	4
							medium	1	4	4	8
							high	3	6	9	3
							all	5	10	14	4
66	10.2	95	9	0	0	17	low	0	0	0	2
							medium	0	4	4	1
							hich	2	10	9	3
							all	2	14	13	4
67	11.1	70	10	0.3	0	15	low	0	1	1	5
							medium	1	7	7	1
							high	2	5	13	3
							all	3	13	21	5
68	9.9	76	10	0	0	13	low	0	0	0	1
							medium	1	3	7	1
							high	3	9	8	3
							all	4	12	15	4
69	8	90	8	0	0	13	low	0	1	0	4
							medium	0	6	4	6
							high	4	9	6	[illegible]
							all	4	16	10	4
70	7.1	80	3	0.9	0	11	low	1	0	3	4
							medium	1	4	12	[illegible]
							high	6	9	13	9
							all	3	13	28	[illegible]
71	-0.3	100	2	0	0	10	low	1	0	0	
							medium	0	6	9	
							high	4	4	8	
							all	5	10	17	
72	6.4	76	10	0	0	13	low	1	0	1	
							medium	0	3	6	
							high	4	5	10	
							all	5	8	17	
73	7.3	77	3	0	0	13	low	0	1	0	
							medium	1	8	2	
							high	2	7	9	
							all	3	16	11	
74	10	76	5	0	0	12	low	0	0	2	
							medium	0	5	7	
							high	6	8	12	
							all	6	13	21	

75	6.7	50	4	1	0	14	low	2	1	3
							medium	2	2	9
							high	6	7	13
							all	10	10	24
76	8.1	59	6	1	0	12	low	0	0	0
							medium	1	2	5
							high	4	6	9
							all	5	8	14
77	7.6	63	13	0	0	12	low	1	0	0
							medium	2	3	7
							high	0	8	11
							all	3	11	18
78	9.7	92	3	0	0	17	low	0	0	0
							medium	1	4	5
							high	3	10	4
							all	4	14	9
79	7.3	90	7	0	0.2	16	low	0	0	0
							medium	2	2	5
							high	4	7	8
							all	6	9	13
80	8.5	87	14	0.3	0	12	low	1	1	1
							medium	0	4	9
							high	4	7	8
							all	5	12	18
81	1.4	92	3	0.3	0	11	low	0	0	0
							medium	0	1	1
							high	1	2	4
							all	1	3	5
82	8.6	60	14	0.1	0	15	low	0	1	1
							medium	1	4	3
							high	1	9	8
							all	2	14	12
83	7.5	79	7	0.4	0	11	low	1	1	2
							medium	4	6	9
							high	5	7	10
							all	10	14	21
84	9.9	95	12	0	1.3	15	low	1	0	1
							medium	2	5	9
							high	2	10	8
							all	5	15	18
85	8.6	49	11	0.7	0	16	low	2	1	3
							medium	2	2	6
							high	2	8	8
							all	6	11	17
86	5	84	13	0	0	13	low	0	0	1
							medium	1	4	3
							high	0	6	4
							all	1	10	8
87	4.5	92	3	0	0.7	9	low	0	0	0
							medium	0	2	5
							high	3	5	7
							all	3	7	12
88	7.4	80	18	0	0	14	low	0	0	0
							medium	1	5	4
							high	2	3	6
							all	3	8	10
89	2.5	77	21	0	0	17	low	0	0	0
							medium	0	3	3
							high	1	5	8
							all	1	8	11
90	2	62	17	0.9	0	11	low	0	0	0
							medium	0	1	3
							high	3	2	4
							all	3	3	7

91	9	94	11	0.1	0	13	low	0	2	0
							medium	1	4	3
							high	3	5	9
							all	4	12	12
92	12	42	12	1	0	13	low	1	2	1
							medium	3	7	9
							high	4	6	12
							all	8	13	22
93	9.1	61	15	0	0	13	low	0	1	0
							medium	1	6	7
							high	4	10	11
							all	5	17	18
94	10.9	96	9	0	2.6	18	low	0	1	0
							medium	2	10	2
							high	1	9	9
							all	3	20	11
95	10.2	58	15	1	0	11	low	0	0	2
							medium	0	4	7
							high	7	9	12
							all	7	13	21
96	12.5	56	7	0	0	17	low	2	4	4
							medium	4	8	11
							high	6	11	12
							all	12	23	27
97	10	45	14	0.3	0	15	low	0	1	3
							medium	0	4	10
							high	2	4	9
							all	2	9	22
98	10.7	57	10	0.4	0	13	low	1	1	4
							medium	2	2	9
							high	4	6	7
							all	7	9	20
99	15.8	67	5	0	0	12	low	3	0	7
							medium	3	5	10
							high	6	6	17
							all	12	11	34
100	11.1	73	6	0	0	14	low	1	2	3
							medium	3	5	8
							high	4	7	10
							all	8	14	21

Table A9. Window Opening in Individual households over 100 Days at a) Cowley and b) Mezen

Estate : COWLEY

HOUSE NO.	TOTAL	SIT	DIN	KIT	BTH only	WC/ BTH & WC	B1	B2	B3	LND
St. Ivanhoe.										
24	22	1		17			4			
25	136	27		61			34	14		
23	17	3		11			3	0		
22	16	1		11			4			
20	32	2		29			1			
21	6	0		3			1	2		
19	143	30		52			50	7		
18	14	2		9			3			
1	104	12		13			70	9		0
2	231	55		36			76	63		1
3	42	6		7			24	5		0
4	78	2		3			31	42		0
5	68	22		4			24	18		0
6	266	99		5			81	83		2
7	199	66		10			66	58		1
8	125	44		13			23	44		1
9	172	62		21			46	42		1
10	149	20		3			49	78		1
11	188	4		65			61	58		
12	31	5		9			10	7		
13	54	3		21			16	14		
14	27	1		11			9	6		
15	160	14		15			74	57		
16	149	7		13			70	59		
17	65	4		4			51	6		
St. Helens.										
39	164	31		36			50	47		
38	73	1		5			53	14		
37	32	3		3			11	15		
36	121	12		11			55	43		
35	56	3		10			16	27		
34	193	7		64			70	52		

continued over -

Estate : COWLEY

HOUSE NO.	TOTAL	SIT	DIN	KIT	BTH only	WC/ BTH & WC	B1	B2	B3	LND
St. Helens.										
33	218	16		85			73	44		
32	156	10		28			96	22		
30	7	0		2			5			
31	29	0		24			2	3		
29	166	8		63			52	43		
28	5	0		1			4			
26	21	14		2			5			
27	132	26		14			67	25		
25	159	29		51			60	19		
24	8	0		3			5			
23	208	7		12			59	72	58	
22	67	9		14			13	17	14	
21	6	1		2			0	2	1	
19	68	2		26			40			
20	53	31		12			8	2		
18	75	5		28			39	3		
17	71	15		13			43			
15	49	1		28			20			
16	47	15		20			6	6		
14	146	18		20			69	39		
13	7	1		2			4			
12	120	14		18			51	37		
11	187	14		64			52	57		
10	192	23		9			51	56	53	
9	191	35		13			42	42	59	
8	315	64		61			56	70	64	
7	201	24		49			52	36	40	
6	29	1		9			1	7	11	
5	64	3		18			11	14	18	
4	284	39		7			84	79	75	
3	221	44		39			44	57	37	
2	232	48		80			51	53		
1	268	65		84			76	43		
40	121	51		65			5			
41	176	20		96			30	30		
43	129	9		73			39	8		

continued over -

Estate : COWLEY

HOUSE NO.	TOTAL	SIT	DIN	KIT	BTH only	WC/ BTH & WC	B1	B2	B3	LND
St. Helens.										
42	13	4		5			4			
44	28	2		25			1			
45	357	154		95			91	17		
47	97	16		45			30	6		
46	17	3		12			2			
48	218	11		40			63	46	58	
49	360	47		77			76	82	78	
St. Martins.										
20	51	4		7			14	26		
18	141	4		75			24	38		
16	163	6		67			55	35		
14	213	5		72			69	67		

Estate : MEZEN

HOUSE NO.	TOTAL	SIT	DIN	KIT	BTH only	WC/ BTH & WC	B1	B2	B3	LND
1	188	34		66		45	43			
2	21	0		8	5	5	2	1		
3	270	8	24	61	5	9	102	53		8
4	339	45	44	23	0	57	80	85		5
5	93	1	4	10	4	12	19	34		9
6	352	13	26	77	13	80	100	29		14
7	43	1	1	2	0	8	16	14		1
8	17	2		12		1	2	0		
9	26	5		2		1	18			
10	9	0		7		0	1	0		1
11	22	4		5		8	5			
12	92	4		9		22	57			
13	17	5		8		0	2	2		
14	143	13	3	5	28	10	71	6		7
15	38	0	0	8	1	17	6	6		0
16	139	3	2	24	9	13	37	48		3
17	141	1	3	41	2	7	40	24		23
18	138	15	6	24	0	37	22	24		10
19	163	24		91		44	6			
20	115	10		35		1	52	17		
21	213	6		49		28	117	1		12

continued over -

Estate : MEZEN

HOUSE NO.	TOTAL	SIT	DIN	KIT	BTH only	WC/ BTH & WC	B1	B2	B3	LND
22	122	2		60		48	12			
23	316	7		101		75	107	10		16
24	198	14		69		55	60			
25	237	44		83		42	48	3		17
26	39	22		10		2	5			
27	86	4		25		15	42			
28	30	3		21		2	3	1		
29	172	7	8	44	7	61	20	17		8
30	156	8	5	8	13	66	18	19		19
31	226	6		38		5	126	51		0
32	190	79		50		40	21			
33	48	0	1	6	6	7	10	13		5
34	224	23	13	25	27	41	52	32		11
35	509	35	34	73	45	91	102	52		77

Table A10. Summary Statistics of Individual Householders' Window Opening at a) Cowley and b) Mezen

ESTATE	HOUSE NO.	Max. possible no. of open window observations.	Mean Daily no. of total open window observations.	Standard deviation.
COWLEY	St. I.			
	24	300	0.22	0.6
	25	500	1.36	1.3
	23	500	0.17	0.5
	22	300	0.16	0.4
	20	300	0.32	0.5
	21	500	0.06	0.2
	19	500	1.43	1.3
	18	300	0.14	0.4
	1	600	1.04	0.9
	2	600	2.31	1.6
	3	600	0.42	0.8
	4	600	0.78	0.9
	5	600	0.68	1.1
	6	600	2.66	1.3
	7	600	1.99	1.5
	8	600	1.25	1.3
	9	600	1.72	1.5
	10	600	1.49	0.8
	11	400	1.88	1.0
	12	400	0.31	0.7
	13	400	0.54	0.9
	14	400	0.27	0.7
	15	400	1.60	1.0
	16	400	1.49	1.0
	17	400	0.65	0.6
	St. H.			
	39	400	1.64	1.5
	38	400	0.73	0.9
	37	400	0.32	0.7
	36	400	1.21	1.1
	35	400	0.56	0.8
	34	400	1.93	1.1

continued over -

ESTATE	HOUSE NO.	Max. possible no. of open window observations.	$\bar{X}$ no. of total open window observations.	Standard deviation.
COWLEY	St. H.			
	33	400	2.18	0.8
	32	400	1.56	0.9
	30	300	0.07	0.3
	31	500	0.29	0.5
	29	500	1.66	1.3
	28	300	0.05	0.2
	26	300	0.21	0.5
	27	500	1.32	1.0
	25	500	1.59	1.0
	24	300	0.08	0.4
	23	600	2.08	1.3
	22	600	0.67	1.3
	21	600	0.06	0.2
	19	300	0.68	0.8
	20	500	0.53	0.9
	18	500	0.75	0.9
	17	300	0.71	0.8
	16	500	0.49	0.9
	15	300	0.47	0.7
	14	500	1.46	1.0
	13	300	0.07	0.3
	12	400	1.20	1.1
	11	400	1.87	1.2
	10	600	1.92	1.7
	9	600	1.91	1.4
	8	600	3.15	1.8
	7	600	2.01	1.5
	6	600	0.29	0.5
	5	600	0.64	1.0
	4	600	2.84	1.3
	3	600	2.21	1.9
	2	400	2.32	1.5
	1	400	2.68	1.4
	40	300	1.21	0.8
	41	500	1.76	1.2
	43	500	1.29	0.9

continued over -

ESTATE	HOUSE NO.	Max. possible no. of open window observations.	$\overline{X}$ no. of total open window observations.	Standard deviation.
COWLEY	St. H.			
	42	300	0.13	0.5
	44	300	0.28	0.5
	45	500	3.57	1.0
	47	500	0.97	1.2
	46	300	0.17	0.5
	48	600	2.18	1.5
	49	600	3.60	1.3
	St. M.			
	20	400	0.51	0.9
	18	400	1.41	1.0
	16	400	1.63	1.1
	14	400	2.13	1.1
MEZEN	1	400	1.88	1.4
	2	900	0.21	0.7
	3	1000	2.70	1.6
	4	1000	3.39	1.7
	5	1000	0.93	1.2
	6	1000	3.52	1.9
	7	1000	0.43	0.9
	8	900	0.17	0.7
	9	400	0.26	0.5
	10	900	0.09	0.5
	11	400	0.22	0.7
	12	400	0.92	0.8
	13	900	0.17	0.7
	14	1000	1.43	1.3
	15	1000	0.38	0.8
	16	1000	1.39	1.6
	17	1000	1.41	1.6
	18	1000	1.38	1.7
	19	400	1.63	0.9
	20	900	1.15	1.3
	21	900	2.13	1.5
	22	400	1.22	0.9

continued over -

ESTATE	HOUSE NO.	Max. possible no. of open window observations.	$\overline{X}$ no. of total open window observations.	Standard deviation.
MEZEN	23	1000	3.16	1.6
	24	500	1.98	1.4
	25	1000	2.37	1.9
	26	500	0.39	0.6
	27	400	0.86	1.0
	28	900	0.30	0.7
	29	1000	1.72	1.4
	30	1000	1.56	1.6
	31	900	2.26	1.5
	32	400	1.90	1.2
	33	1000	0.48	1.0

TABLE A11. Correlation coefficients obtained between external air temperature and different room types at five times of day

Time of day	Estate	Correlations with temperature				
		TOTAL	SIT	DIN	KIT	B1
Hour of observation	COWLEY	.737 xx	.763 xx		.733 xx	.657 xx
	MEZEN			.415 xx	.527 xx	.622 xx
8 a.m	COWLEY	.558 xx	.612 xx		.538 xx	.491 xx
	MEZEN	.494 xx	.423 xx	.336 xx	.346 xx	.423 xx
12 Noon.	COWLEY	.745 xx	.770 xx		.691 xx	.667 xx
	MEZEN	.704 xx	.575 xx	.393 xx	.520 xx	.614 xx
Total - day of observation	COWLEY	.724 xx	.767 xx		.678 xx	.651 xx
	MEZEN	.693 xx	.585 xx	.375 xx	.481 xx	.601 xx
Total - previous day	COWLEY	.755 xx	.773 xx		.666 xx	.694 xx
	MEZEN	.690 xx	.560 xx	.358 xx	.465 xx	.606 xx

Time of day	Estate	B2	B3	BATH	WC	
Hour of observation	COWLEY	.598 xx	.403 xx			
	MEZEN	.408 xx		.428 xx	.624 xx	
8 a.m	COWLEY	.453 xx	.320 xx			
	MEZEN	.210 x		.232 xx	.446 xx	
12 Noon	COWLEY	.630 xx	.488 xx			
	MEZEN	.424 xx		.331 xx	.590 xx	
Total - day of observation	COWLEY	.602 xx	.435 xx			
	MEZEN	.380 xx		.360 xx	.596 xx	
Total - previous day	COWLEY	.648 xx	.472 xx			
	MEZEN	.425 xx		.311 xx	.615 xx	

xx $p < .01$ x $p < .05$

TABLE A12. Correlation coefficients obtained between relative humidity and different room types at five times of day.

Time of day	Estate	Correlations with relative humidity: TOTAL	SIT	DIN	KIT	B1
Hour of observation	COWLEY	-.232 xx	-.204 x		-.131	-.222 x
	MEZEN	-.319 xx	-.242 xx	-.179 x	-.069	-.312 xx
8 a.m	COWLEY	.089	.108		.193 x	.053
	MEZEN	.098	-.002	-.006	-.230 xx	.029
12 Noon	COWLEY	-.245 xx	-.196 x		-.078	-.247 xx
	MEZEN	-.375 xx	-.338 xx	-.250 xx	-.071	-.356 xx
Total - day of observation	COWLEY	-.079	-.042		.111	-.112
	MEZEN	-.248 xx	-.227 x	-.202 x	.062	-.306 xx
Total previous day	COWLEY	-.040	.025		.040	-.060
	MEZEN	-.138	-.121	.040	-.017	-.154

Time of day	Estate	B2	B3	BATH	WC	
Hour of observation	COWLEY	-.233 xx	-.209 x			
	MEZEN	-.454 xx		-.111	-.213 x	
8 a.m	COWLEY	.038	.008			
	MEZEN	-.013		.144	.117	
12 Noon	COWLEY	-.293 xx	-.336 xx			
	MEZEN	-.467 xx		-.164 x	-.247 xx	
Total - day of observation	COWLEY	-.139	-.197 x			
	MEZEN	-.384 xx		.027	-.169 x	
Total - previous day	COWLEY	-.092	-.076			
	MEZEN	-.267 xx		.052	-.073	

xx $p < .01$ x $p < .05$

TABLE A13. Correlation coefficients obtained between windspeed and different room types at five times of day

Time of day	Estate	Correlations with windspeed: TOTAL	SIT	DIN	KIT	B1
Hour of observation	COWLEY	-.147	-.133		-.232 xx	-.083
	MEZEN	-.165 x	-.169 x	.037	-.123	-.089
8 a.m	COWLEY	-.226 x	-.200 x		-.244 xx	-.187 x
	MEZEN	-.202 x	-.091	-.006	-.096	-.193 x
12 Noon	COWLEY	-.143	-.113		-.212 x	-.101
	MEZEN	-.176 x	-.175 x	.036	-.080	-.141
Total - day of observation	COWLEY	-.248 xx	-.197 x		-.295 xx	-.189 x
	MEZEN	-.259 xx	-.181 x	-.033	-.141	-.205 x
Total - previous day	COWLEY	-.194 x	-.150		-.250 xx	-.141
	MEZEN	-.151	-.148	-.150	-.037	-.110

Time of day	Estate	B2	B3	BATH	WC
Hour of observation	COWLEY	-.168	-.097		
	MEZEN	-.160		-.261 xx	-.116
8 a.m	COWLEY	-.232 xx	-.220 x		
	MEZEN	-.226 xx		-.255 xx	-217 x
12 Noon	COWLEY	-.162	-.091		
	MEZEN	-.181		-.203 x	-.162
Total - day of observation	COWLEY	-.279 xx	-.165 x		
	MEZEN	-.256 xx		-.323 xx	-.218 x
Total - previous day	COWLEY	-.225 x	-.084		
	MEZEN	-.114		-.225 x	-.153

xx $p < .01$ x $p < .05$

TABLE A14. Correlation coefficients obtained between sunshine duration and different room types at five times of day

Time of day	Estate	Correlations with sunshine duration: TOTAL	SIT	DIN	KIT	B1
Hour of observation	COWLEY	.356 xx	.323 xx		.188 x	.346 xx
	MEZEN	.123	.259 xx	.155	-.129	.150
8 a.m	COWLEY	.308 xx	.296 xx		.195 x	.289 xx
	MEZEN	.272 xx	.210 x	.050	.154	.151
12 Noon	COWLEY	.290 xx	.298 xx		.203 x	.236 xx
	MEZEN	.252 xx	.249 xx	.084	.164 x	.179 x
Total - day of observation	COWLEY	.349 xx	.325 xx		.189 x	.329 xx
	MEZEN	.351 xx	.340 xx	.168 x	.163	.273 xx
Total - previous day	COWLEY	.225 x	.146		.248 xx	.180 x
	MEZEN	.183 x	.051	-.016	.159	.128

Time of day	Estate	B2	B3	BATH	WC
Hour of observation	COWLEY	.407 xx	.289 xx		
	MEZEN	.183 x		-.030	.090
8 a.m	COWLEY	.339 xx	.202 x		
	MEZEN	.341 xx		.173 x	.244 x
12 Noon	COWLEY	.292 xx	.245 xx		
	MEZEN	.326 xx		.103	.151
Total - day of observation	COWLEY	.385 xx	.313 xx		
	MEZEN	.411 xx		.161	.244 xx
Total - previous day	COWLEY	.248 xx	.178 x		
	MEZEN	.261 xx		.048	.146

xx $p < .01$ x $p < .05$

TABLE A15. Correlation coefficients obtained between rainfall and different room types at five times of day.

Time of day	Estate	Correlations with rainfall: TOTAL	SIT	DIN	KIT	B1
Hour of observation	COWLEY	.142	$.173^{x}$		.145	.135
	MEZEN	-.064	-.079	.009	.015	-.097
8 a.m	COWLEY	-.052	-.053		-.035	-.047
	MEZEN	-.148	-.073	-.004	-.063	-.153
12 Noon	COWLEY	-.059	-.013		-.020	-.102
	MEZEN	-.085	.008	-.031	-.062	-.082
Total - day of observation	COWLEY	.055	.090		.102	.035
	MEZEN	.038	.131	.084	.132	-.044
Total - previous day	COWLEY	.000	.046		.009	.054
	MEZEN	.102	.156	.146	.037	.097

Time of day	Estate	B2	B3	BATH	WC
Hour of observation	COWLEY	.083	.112		
	MEZEN	-.098		-.053	-.008
8 a.m	COWLEY	-.019	-.062		
	MEZEN	-.129		-.124	$-.165^{x}$
12 Noon	COWLEY	-.035	$-.164^{x}$		
	MEZEN	-.121		-.097	-.072
Total - day of observation	COWLEY	.019	.006		
	MEZEN	-.073		-.046	-.001
Total - previous day	COWLEY	-.003	-.032		
	MEZEN	.033		-.075	.073

$^{xx}p < .01$ $^{x}p < .05$

Table A16. Differences in correlations between window opening and temperature at (a) the hour of observation and (b) other times of day.

Time of day	Estate	RoomTypes TOTAL	SIT	DIN	KIT	B1
Hour of observation	COWLEY	.737	.763		.733	.657
	MEZEN	.726	.568	.415	.527	.522
8 a.m	COWLEY	-	-		-	-
	MEZEN	-	-	-	-	-
12 Noon	COWLEY	+	+		-	+
	MEZEN	-	+	-	-	-
Total - day of observation	COWLEY	-	+		-	-
	MEZEN	-	+	-	-	-
Total - previous day	COWLEY	+	+		-	+
	MEZEN	-	-	-	-	-

Time of day	Estate	RoomTypes B2	B3	BATH	WC
Hour of observation	COWLEY	.598	.403		
	MEZEN	.408		.428	.624
8 a.m	COWLEY	-	-		
	MEZEN	-		-	-
12 Noon	COWLEY	+	+		
	MEZEN	+		-	-
Total - day of observation	COWLEY	+	+		
	MEZEN	-		-	-
Total - previous day	COWLEY	+	+		
	MEZEN	+		-	-

+ correlation higher than at hour of observation.

- correlation lower than at hour of observation.

Table A17. Differences in correlations between window opening and relative humidity at (a) the hour of observation and (b) other times of day.

Time of day	Estate	Room Types				
		TOTAL	SIT	DIN	KIT	B1
Hour of observation	COWLEY	-.232	-.204		-.131	-.222
	MEZEN	-.319	-.242	-.179	-.069	-.312
8 a.m	COWLEY	-	-		+	-
	MEZEN	-	-	-	+	-
12 Noon	COWLEY	+	-		-	+
	MEZEN	+	+	+	+	+
Total - day of observation	COWLEY	-	-		-	-
	MEZEN	-	-	+	-	-
Total - previous day	COWLEY	-	-		-	-
	MEZEN	-	-	-	-	-

Time of day	Estate	Room Types			
		B2	B3	BATH	WC
Hour of observation	COWLEY	-.232	-.209		
	MEZEN	-.454		-.111	-.213
8 a.m	COWLEY	-	-		
	MEZEN	-		+	-
12 Noon	COWLEY	+	+		
	MEZEN	+		+	+
Total - day of observation	COWLEY	-	-		
	MEZEN	-		-	-
Total - previous day	COWLEY	-	-		
	MEZEN	-		-	-

\+ correlation higher than that at hour of observation.

\- correlation lower than that at hour of observayion.

Table A18. Differences in correlations between window opening and windspeed at (a) the hour of observation and b) other times of day.

Time of day	Estate	Room Types TOTAL	SIT	DIN	KIT	B1
Hour of observation	COWLEY	-.147	-.133		-.232	-.083
	MEZEN	-.165	-.169	.037	-.123	-.059
8 a.m	COWLEY	+	+		+	+
	MEZEN	+	-	-	-	+
12 Noon	COWLEY	-	-		-	+
	MEZEN	+	+	-	-	+
Total - day of observation	COWLEY	+	+		+	+
	MEZEN	+	+	-	+	+
Total - previous day	COWLEY	+	+		+	+
	MEZEN	-	-	+	-	+

Time of day	Estate	Room Types B2	B3	BATH	WC
Hour of observation	COWLEY	-.168	-.097		
	MEZEN	-.160		-.261	-.116
8 a.m	COWLEY	+	+		
	MEZEN	+		-	+
12 Noon	COWLEY	-	-		
	MEZEN	+		-	+
Total - day of observation	COWLEY	+	+		
	MEZEN	+		+	+
Total - previous day	COWLEY	+	-		
	MEZEN	-		-	+

\+ correlation higher than that at hour of observation.

\- correlation lower than that at hour of observation.

Table A19. Differences in correlations between window opening and sunshine duration at (a) hour of observation and b) other times of day.

Time of day	Estate	Room Types TOTAL	SIT	DIN	KIT	B1
Hour of observation	COWLEY	.356	.323		.188	.346
	MEZEN	.123	.259	.155	-.129	.150
8 a.m	COWLEY	–	–		+	–
	MEZEN	+	–	–	+	+
12 Noon	COWLEY	–	–		+	–
	MEZEN	+	–	–	+	+
Total - day of observation	COWLEY	–	+		+	–
	MEZEN	+	+	+	+	+
Total - previous day	COWLEY	–	–		+	–
	MEZEN	+	–	–	+	–

Time of day	Estate	Room Types B2	B3	BATH	WC
Hour of observation	COWLEY	.407	.289		
	MEZEN	.183		-.030	.090
8 a.m	COWLEY	–	–		
	MEZEN	+		+	+
12 Noon	COWLEY	–	–		
	MEZEN	+		+	+
Total - day of observation	COWLEY	–	+		
	MEZEN	+		+	+
Total - previous day	COWLEY	–	–		
	MEZEN	+		+	+

\+ correlation higher than at hour of observation.

– correlation lower than at hour of observation.

Table A20. Differences in correlations between window opening and rainfall at (a) the hour of observation and b) other times of day.

Time of day	Estate	Room Types				
		TOTAL	SIT	DIN	KIT	B1
Hour of observation	COWLEY	.142	.173		.145	.135
	MEZEN	-.064	-.079	.009	.015	-.097
8 a.m	COWLEY	-	-		-	-
	MEZEN	+	-	-	+	+
12 Noon	COWLEY	-	-		-	-
	MEZEN	+	-	+	+	-
Total - day of observation	COWLEY	-	-		-	-
	MEZEN	-	+	+	+	-
Total - previous day	COWLEY	-	-		-	-
	MEZEN	+	+	+	+	-

Time of day	Esate	Room Types			
		B2	B3	BATH	WC
Hour of observation	COWLEY	.083	.112		
	MEZEN	-.098		-.033	-.008
8 a.m	COWLEY	-	-		
	MEZEN	+		+	+
12 Noon	COWLEY	-	+		
	MEZEN	+		+	+
Total - day of observation	COWLEY	-	-		
	MEZEN	-		+	-
Total - previous day	COWLEY	-	-		
	MEZEN	-		+	+

\+ correlation higher than at hour of observation.

\- correlation lower than at hour of observation.

TABLE A21. Results of one-way analysis of variance test for the significance of differences in prorportion of window opened when households are grouped according to the number of occupants

	all data	level 1	2	3	4	5	6
-	1		1				
-	1			1			
60. +	2				2		
-	3		1		1	1	
-	7		1	3	2	1	
-	6		3	1	2		
-	11			6	4		1
30. +	11	1	3	4	2	1	
-	10	2	8				
-	8		1	4	3		
-	14	1	4	2	5	2	
-	20	6	6	7	1		
0. +	7	5	2				

analysis of variance

due to	df	ss	ms=ss/df	f-ratio
factor	5	4957.	991.	3.91
error	95	24100.	254.	
total	100	29057.		

level	n	mean	st. dev.
1	15	8.9	9.6
2	30	22.4	16.7
3	28	25.2	16.6
4	22	30.9	16.4
5	5	31.9	19.8
6	1	33.5	0.0

pooled st. dev. = 15.9

individual 95 percent c. i. for level means
(based on pooled standard deviation)

```
         +---------+---------+---------+---------+---------+---------+
1        i*****i*****i
2                    i***i***i
3                      i***i***i
4                         i****i****i
5                      i********i**********i
6         i*********************i*********************i
         +---------+---------+---------+---------+---------+---------+
         0.        15.       30.       45.       60.       75.
```

TABLE A22. Results of one-way analysis of variance to test for the significance of differences in proportion of windows opened when households are grouped according to stage in the lifecyc

		all data	level 1	level 2	level 3
	-	1		1	
	-	1		1	
60.	+	2		2	
	-	3	1	2	
	-	7	4	2	1
	-	6	2	2	2
	-	11	3	7	1
30.	+	11	3	3	5
	-	10	1	2	7
	-	8	5	2	1
	-	14	6	6	2
	-	20	4	8	8
0.	+	7			7

analysis of variance

due to	df	ss	ms=ss/df	f-ratio
factor	2	2496.	1248.	4.60
error	98	26561.	271.	
total	100	29057.		

level	n	mean	st. dev.
1	29	25.0	15.2
2	38	28.5	19.3
3	34	16.9	13.8

pooled st. dev. = 16.5

individual 95 percent c. i. for level means
(based on pooled standard deviation)

```
     +---------+---------+---------+---------+---------+---------
1                   i***********i***********i
2                           i**********i**********i
3       i**********i**********i
     +---------+---------+---------+---------+---------+---------
   10.0      15.0      20.0      25.0      30.0      35.0
```

TABLE A23. Results of one-way analysis of variance test for the significance of differences in proportion of window opened when households are grouped according to the number of occupants going out to work

		level							
	all data	1	2	3	4	5	7	8
-	1				1			
-	1			1				
60. +	2		2					
-	3			3				
-	7	1	3	1	1			
-	6		3	1				
-	11		5	3	1	1	1	
30. +	11		3	2	2	1		
-	10	1	3		3			
-	8	1	4	2			1	
-	14		9	3	1			
-	20	1	3	2	5	1		1
0. +	7			1				

analysis of variance

due to	df	ss	ms=ss/df	f-ratio
factor	7	2887.	412.	1.47
error	93	26169.	281.	
total	100	29057.		

level	n	mean	st. dev.
1	4	22.9	18.1
2	35	26.1	15.4
3	19	29.4	19.2
4	14	24.0	19.4
5	3	24.9	18.1
7	2	27.3	12.8
8	1	4.8	0.0
9	23	15.2	14.8

pooled st. dev. = 16.8

individual 95 percent c. i. for level means
(based on pooled standard deviation)

```
      +---------+---------+---------+---------+---------+---------+
1                               i**********i**********i
2                                        i**i***i
3                                         i****i****i
4                                    i*****i******i
5                               i************i************i
7                             i***************i***************i
8      i***********************i************************i
9                                i****i****i
      +---------+---------+---------+---------+---------+---------+
   -30.      -15.        0.       15.       30.       45.
```

TABLE A24. Results of one-way analysis of variance to test for the significance of differences in proportion of windows opened when households are grouped according to the number of occupants who smoke

	all data	level 1	level 2	level 4	level 9
-	1	1			
-	1	1			
60. +	2	2			
-	3	1	2		
-	7	1	4		2
-	6	3	2		1
-	11	7	1		3
30. +	11	7	3		1
-	10	3	4		3
-	8	2	4		2
-	14	5	4		5
-	20	9	5	1	5
0. +	7	6			1

analysis of variance

due to	df	ss	ms=ss/df	f-ratio
factor	3	733.	244.	0.84
error	97	28323.	292.	
total	100	29057.		

level	n	mean	st. dev.
1	48	24.0	18.9
2	29	26.0	16.1
4	1	4.8	0.0
9	23	20.6	14.0

pooled st. dev. = 17.1

individual 95 percent c. i. for level means
(based on pooled standard deviation)

```
        +---------+---------+---------+---------+---------+-------
1                                       i**i**i
2                                       i***i****i
4        i********************i**********************i
9                                    i****i***i
        +---------+---------+---------+---------+---------+-------
      -30.      -15.        0.       15.       30.       45.
```

TABLE A25. Results of one-way analysis of variance to test for the significance of differences in proportion of windows opened when households are grouped according to the number of hours for which the central heating is reported to be on

		all data	level 1	level 2	level 3	level 4
	-	1		1		
	-	1		1		
60.	+	2	1	1		
	-	3	1	2		
	-	7		6	1	
	-	6	2	2	2	
	-	11	3	6	2	
30.	+	11	1	6	4	
	-	9	2	5	2	
	-	8	2	5	1	
	-	14		14		
	-	20	9	6	2	3
0.	+	7	1	3	2	1

analysis of variance

due to	df	ss	ms=ss/df	f-ratio
factor	3	1684.	561.	1.97
error	96	27371.	285.	
total	99	29055.		

level	n	mean	st. dev.
1	22	20.9	17.8
2	58	25.5	17.6
3	16	25.0	14.4
4	4	5.6	2.3

pooled st. dev. = 16.9

individual 95 percent c. i. for level means
(based on pooled standard deviation)

```
      +---------+---------+---------+---------+---------+---------
1                                       i*****i*****i
2                                             i***i***i
3                                          i******i******i
4               i**************i**************i
      +---------+---------+---------+---------+---------+---------
    -20.      -10.        0.       10.       20.       30.
```

TABLES A26(a)-(h). Reported amount of winter window opening in three room types - percentages of respondents endorsing each response category

(a) "Sunny day"

Reponse category	Room Type		
	SIT	KIT	B1
not at all	7.4	3.7	2.5
tiny bit	11.1	8.6	17.3
little bit	51.9	45.7	49.4
half open	17.3	28.4	19.8
fully open	12.3	13.6	11.1

(b) "Wet day"

Response category	Room type		
	SIT	KIT	B1
not at all	48.1	24.7	32.1
tiny bit	18.5	19.8	24.7
little bit	28.4	37.0	35.8
half open	4.9	12.3	7.4
fully open	0.0	6.2	0.0

(c) "Humid day"

Response category	Room type		
	SIT	KIT	B1
not at all	9.9	6.2	4.9
tiny bit	11.1	11.1	17.3
little bit	43.2	50.6	48.1
half open	22.2	21.0	18.5
fully open	13.6	11.1	11.1

(d) "Mild day"

Response category	Room type		
	SIT	KIT	B1
not at all	12.3	3.7	2.5
tiny bit	16.0	9.9	18.5
little bit	44.4	55.6	51.9
half open	19.8	19.8	19.8
fully open	7.4	11.1	7.4

(e) "Cold day"

Response category	Room type		
	SIT	KIT	B1
not at all	64.2	36.2	46.9
tiny bit	16.0	26.2	23.5
little bit	16.0	28.8	24.7
half open	3.7	6.3	4.9
fully open	0.0	2.5	0.0

(f) "Windy day when wind is not blowing into the house"

Response category	Room type		
	SIT	KIT	B1
not at all	38.7	22.2	25.9
tiny bit	37.5	32.1	30.9
little bit	17.5	35.8	35.8
half open	3.7	6.2	4.9
fully open	2.5	3.7	2.5

(g) "Windy dah when wind is blowing into the house"

Respone category	Room type		
	SIT	KIT	B1
not at all	80.2	54.5	65.4
tiny bit	8.6	22.8	17.3
little bit	8.6	16.5	14.8
half open	2.5	5.1	2.5
fully open	0.0	1.3	0.0

(h) Grand mean

Reponse category	Room type		
	SIT	KIT	B1
not at all	12.3	7.4	7.4
tiny bit	54.3	40.7	44.4
little bit	25.9	34.6	38.3
half open	6.2	13.6	8.6
fully open	1.2	3.7	1.2

TABLES A27(a)-(h). Reported amount of summer window opening in three room types - percentages of respondents endorsing each response category

(a) "Sunny day"

Response category	Room type		
	SIT	KIT	B1
not at all	1.2	3.7	0.0
tiny bit	3.7	2.5	4.9
little bit	21.0	21.0	27.2
half open	39.5	45.7	43.2
fully open	34.6	27.2	24.7

(b) "Wet day"

Response category	Room type		
	SIT	KIT	B1
not at all	24.7	17.3	19.8
tiny bit	16.0	21.0	24.7
little bit	40.7	40.7	37.0
half open	13.6	13.6	12.3
fully open	4.9	7.4	6.2

(c) "Humid day"

Response category	Room type		
	SIT	KIT	BL
not at all	1.2	3.7	0.0
tiny bit	6.2	8.6	8.6
little bit	28.4	29.6	38.3
half open	40.7	34.6	29.6
fully open	23.5	23.5	23.5

(d) "Mild day"

Response category	Room type		
	SIT	KIT	B1
not at all	2.5	5.0	2.5
tiny bit	7.4	3.7	7.4
little bit	33.3	36.2	38.3
half open	38.3	37.5	37.0
fully open	18.5	17.5	14.8

(e) "Cold day"

Response category	Room type		
	SIT	KIT	B1
not at all	35.8	27.2	32.1
tiny bit	19.8	28.4	23.5
tiny bit	19.8	28.4	23.5
little bit	34.6	30.9	34.6
half open	7.4	9.9	7.4
fully open	2.5	3.7	2.5

(f) "Windy day when wind is not blowing into the house"

Response category	Room type		
	SIT	KIT	B1
not at all	19.8	14.8	17.3
tiny bit	22.2	23.5	22.2
little bit	35.8	43.2	40.7
half open	14.8	12.3	16.0
fully open	7.4	6.2	3.7

(g) "Windy day when wind is blowing into the house"

Response category	Room type		
	SIT	KIT	B1
not at all	59.3	45.7	45.7
tiny bit	13.6	24.7	25.9
little bit	19.8	19.8	21.0
half open	6.2	7.4	6.2
fully open	1.2	2.5	1.2

(h) Grand mean

Response category	Room type		
	SIT	KIT	B1
not at all	3.7	4.9	2.5
tiny bit	25.9	23.5	29.6
little bit	48.1	46.9	45.7
half open	19.8	19.8	18.5
fully open	2.5	4.9	3.7

TABLE A28. Summary results of regression analysis on Cowley data (N = 100 days): prediction of proportion of open window observations on estate from temperature data

```
--    regr 'perc'   1   'temp'
the regression equation is
y = 10.4 + 1.82 x 1

                                        st. dev.     t-ratio =
           column       coefficient     of coef.     coef/s.d.
           --             10.368         1.564         6.63
x1         temp           1.8223         0.1672       10.90
the st. dev. of y about regression line is
s = 6.675
with (100- 2) = 98 degrees of freedom
r-squared = 54.8 percent
r-squared = 54.3 percent, adjusted for d.f.
analysis of variance
 due to       df         ss          ms=ss/df
regression     1       5290.75       5290.75
residual      98       4366.97         44.56
total         99       9657.72
```

TABLE A29. Summary results of regression analysis on Cowley data (N = 100 days): prediction of proportion of open window observations on estate from temperature + relative humidity

```
-- regr 'perc' 2 'temp' 'rh'
the regression equation is
y = 14.9 + 1.79 x1 - 0.0535 x 2
```

	column	coefficient	st.dev. of coef.	t-ratio = coef/s.d.
	--	14.938	4.738	3.15
x1	temp	1.7851	0.1711	10.43
x2	rh	-0.05347	0.05233	-1.02

the st. dev. of y about regression line is

s = 6.674

with (100 - 3) = 97 degrees of freedom

r-squared = 55.3 percent

r-squared = 54.3 percent, adjusted for d.f.

analysis of variance

due to	df	ss	ms=ss/df
regression	2	5337.26	2668.63
residual	97	4320.47	44.54
total	99	9657.72	

TABLE A30. Summary results of regression analysis on Cowley data (N = 100 days): prediction of proportion of open window observations on estate from temperature, relative humidity and windspeed

```
-- regr 'perc'3 'temp' 'rh' 'ws'

teh regression equation is

y = 22.0 + 1.80 x 1 - 0.0869 x 2
    - 0.503 x 3
```

	column	coefficient	st.dev. of coef.	t-ratio = coef/s.d.
	--	21.955	4.944	4.44
x1	temp	1.7986	0.1625	11.07
x2	rh	-0.08689	0.05062	-1.72
x3	ws	-.5035	0.1473	-3.42

the st. dev. of y about regression line is

s = 6.334

with (100 - 4) = 96 degrees of freedom

r-square = 60.1 percent

r-square = 58.9 percent, adjusted for d.f.

analysis of variance

due to	df	ss	ms=ss/df
regression	3	5805.78	1935.26
residual	96	3851.94	40.12
total	99	9657.72	

TABLE A31. Summary results of regression analysis on Mezen data (N = 100 days): prediction of proportion of open window observations on estate from temperature

```
-- regr 'perc' 1 'temp'

the regression equation is

y = 7.77 + 1.26 x 1
```

	column	coefficient	st. dev. of coef.	t-ratio = coef/s.d.
	--	7.769	1.088	7.14
x1	temp	1.2594	0.1199	10.50

the st. dev. of y about regression line is

s = 4.728

with (100 - 2) = 98 degrees of freedom

r-squared = 53.0 percent

r-squared = 52.5 percent, adjusted for d.f.

analysis of variance

due to	df	ss	ms=ss/df
regression	1	2466.26	2466.26
residual	98	2190.28	22.35
total	99	4656.54	

TABLE A32. Summary results of regression analysis on Mezen data (N = 100 days): prediction of proportion of open window observations on estate from temperature and relative humidity

```
--   regr 'perc' 2 'temp' 'rh'

the regression equation is

y = 16.8 + 1.20 x 1 - 0.107 x 2

                                          st. dev.      t-ratio =
        column      coefficient           of coef.      coef/s.d.

        --              16.799             3.194           5.26

x1      temp            1.2003             0.1170         10.26

x2      rh             -0.10731            0.03586        -2.99

the st. dev. of y about regression line is

s = 4.547

with (100 - 3) = 97 degrees of freedom

r-squared = 56.9 percent

r-squared = 56.1 percent, adjusted for d.f.


analysis of variance

  due to          df         ss          ms=ss/df

regression         2       2651.38       1325.69

residual          97       2005.16         20.67

total             99       4656.54
```

TABLE A33. Summary results of regression analysis on Mezen data (N = 100 days): prediction of proportion of open window observations on estate from temperature, relative humidity and windspeed

```
-- regr 'perc' 3 'temp' 'rh' 'ws'

the regression equation is

y = 24.4 + 1.22 x 1 - 0.150 x 2
    - 0.476 x 3

                                     st. dev.     t-ratio =
      column       coefficient       of coef.     coef/s.d.

      --             24.371            3.297         7.39
x1    temp           1.2174            0.1058       11.50
x2    rh            -0.15035           0.03366      -4.47
x3    ws            -0.4765            0.1001       -4.76

the st. dev. of y about regression line is
s = 4.111
with (100 - 4) = 96 degrees of freedom
r-squared = 65.2 percent
r-squared = 64.1 percent, adjusted for d.f.


analysis of variance

   due to          df          ss        ms=ss/df
regression          3        3034.28     1011.43
residual           96        1622.26       16.90
total              99        4656.54
```

TABLE A34. Outliers generated by regression equations for the predicti[on] of estate-wide window opening

Estate	Day	Weather parameter			Hour of observation	Proportion of open window observations on estate	
		Temp	RH	WS		Observed	Predicted
Cowley	3	14.9	99	5	15	47.8	35.8
Cowley	5	16.2	69	4	14	55.9	43.9
Cowley	17	13.4	73	8	16	47.5	36.6
Cowley	19	12.5	68	3	13	26.3	39.1
Cowley	40	10.0	81	15	17	9.5	20.0
Mezen	3	14.6	93	10	9	35.8	25.5
Mezen	12	8.6	89	3	16	16.5	24.6
Mezen	33	12.1	68	7	15	15.8	23.6
Mezen	71	-0.3	100	2	10	18.0	9.4
Mezen	96	12.5	56	7	17	37.3	26.8

Temp = temperature

RH = relative humidity

WD = windspeed

TABLE A35. Weather parameter values, hour of observation and total open window scores on weekend days 1-7 for Cowly

		Cowley						Total No open window obs.
Day	Month	Temp	RH	WD	SUNDUR	RAIN	TIME	
1	Oct.	14.3	64	15	0.0	0.0	14	176
2	Nov.	8.3	67	7	0.8	0.0	14	103
3	Dec.	9.2	67	15	1.0	0.0	12	161
4	Jan.	0.5	98	9	0.2	0.0	13	86
5	Feb.	6.4	95	10	0.0	0.1	15	94
6	Mar.	11.0	46	20	0.8	0.0	15	68
7	Apr.	11.8	56	9	1.0	0.0	15	88

TABLE A36. Weather parameter values, hour of observation and total open window scores on weekend days 1-7 for Mezen

		Mezen						Total No open window obs
Day	Month	Temp	RH	WD	SUNDUR	RAIN	TIME	
1	Oct.	13.7	66	16	0.0	0.0	16	85
2	Nov.	7.9	67	5	0.0	0.0	16	45
3	Dec.	9.9	61	14	0.8	0.0	14	69
4	Jan.	2.0	69	3	0.3	0.0	14	39
5	Feb.	6.1	94	8	0.0	0.0	13	62
6	Mar.	10.8	53	33	0.9	0.0	14	55
7	Apr.	14.3	48	11	1.0	0.0	11	71

Temp = temperature (°C)

RH = relative humidity (%)

WD = windspeed (knots)

SUNDUR = sunshine duration (1/10 hour)

RAIN = rainfall (mm)

TABLE A37. Weather parameter values, hour of observation and total open window scores at Christmas, days 1-9 for Cowley

	Cowley						
Day	TEMP	RH	WS	SUNDUR	RAIN	TIME	Total No open window observatio
1	2.1	93	2	0.0	0.0	9	36
2	-3.4	97	2	0.8	0.0	10	57
3	7.0	78	13	0.0	0.0	11	58
4	4.8	74	6	0.0	0.0	17	52
5	2.0	80	5	0.0	0.0	16	50
6	0.8	82	7	0.0	0.0	15	61
7	2.2	64	10	0.7	0.0	14	56
8	4.9	92	21	0.0	0.5	13	47
9	9.1	88	15	0.0	0.0	12	48

TABLE A38. Weather parameter values, hour of observation and total open window s ores at Christmas, days 1-10 for Mezen

	Mezen						
Day	TEMP	RH	WS	SUNDUR	RAIN	TIM	Total No open window observati
1	2.1	93	2	0.0	0.0	9	39
2	-3.4	97	2	0.8	0.0	10	28
3	7.0	78	13	0.0	0.0	11	21
4	9.8	99	24	0.0	1.4	18	15
5	4.8	74	6	0.0	0.0	17	16
6	0.4	87	7	0.0	0.0	12	26
8	0.8	74	8	0.0	0.0	16	32
9	5.1	97	17	0.0	1.0	15	22
10	9.2	76	16	0.9	0.0	14	51

TEMP = temperature (°C)
RH = relative humidity (%)
WS = windspeed (knots)
SUNDUR = sunshine duration (1/10 hour
RAIN = rainfall (mm)

TABLE A39. Mean number of total open window observations for three observation periods at Cowley

House No.	Observation period		
	Main survey (N = 100)	Weekends (N = 7)	Christmas (N = 9)
24	0.22	0.43	0.11
25	1.36	1.57	0.33
23	0.17	0.14	0.00
22	0.16	0.29	0.22
20	0.32	0.29	0.44
21	0.06	0.00	0.00
19	1.43	1.29	0.89
18	0.14	0.14	0.22
1	1.04	0.86	0.67
2	2.31	2.86	0.33
3	0.42	0.29	0.00
4	0.78	1.14	0.22
5	0.68	1.29	0.00
6	2.66	3.00	2.67
7	1.99	1.57	0.00
8	1.25	0.86	1.22
9	1.72	2.57	0.22
10	1.49	1.71	0.22
11	1.88	1.43	0.89
12	0.31	2.00	0.67
13	0.54	0.29	0.11
14	0.27	1.57	0.22
15	1.60	1.86	1.00
16	1.49	2.14	1.00
17	0.65	1.14	0.33
39	1.64	2.57	2.11
38	0.73	1.00	0.44
37	0.32	1.14	0.00
36	1.21	1.43	0.11
35	0.56	1.43	0.11
34	1.93	1.86	1.56
33	2.18	2.00	1.33
22	1.56	2.00	0.89
30	0.14	0.07	0.11

House No	Observation period		
	Main survey (N = 100)	Weekends (N = 7)	Christmas (N = 9)
31	0.29	0.29	0.00
29	1.86	1.66	0.33
28	0.00	0.05	0.11
26	0.00	0.21	0.11
27	1.14	1.32	0.78
25	1.14	1.59	0.44
24	0.29	0.08	0.22
23	1.86	2.08	1.78
22	2.00	0.67	0.11
21	0.14	0.06	0.00
19	0.57	0.68	0.22
20	1.14	0.53	0.22
18	0.71	0.75	0.00
17	1.57	0.71	0.00
15	0.86	0.49	0.44
16	0.57	0.47	0.22
14	1.71	1.46	0.78
13	0.29	0.07	0.00
12	1.00	1.20	1.00
11	2.86	1.87	1.00
10	1.92	3.00	1.44
9	1.91	2.00	0.89
8	3.15	3.29	2.67
7	2.01	2.14	0.89
6	0.29	0.14	0.00
5	0.64	0.86	0.00
4	2.84	3.86	1.67
3	2.21	1.57	0.33
2	2.32	2.14	2.67
1	2.68	3.43	1.22
40	1.21	1.29	0.56
41	1.76	2.14	0.33
43	1.29	2.14	0.33
42	0.13	0.14	0.22
44	0.28	0.29	0.33
45	3.57	3.29	1.78
47	0.97	1.29	0.33
46	0.17	0.29	0.00

House No	Observation period		
	Main survey (N = 100)	Weekend (N = 7)	Christmas (N = 9)
48	2.18	1.71	1.67
49	3.60	3.71	2.00
20	0.51	1.14	0.89
18	1.41	1.29	1.44
16	1.63	2.71	1.00
14	2.13	2.71	2.67

TABEL A40. Mean number of total open window observations for three observation periods at Mezen

House No.	Observation period		
	Main survey (N = 100)	Weekends (N = 7)	Christmas (N = 10)
1	1.88	2.14	1.4
2	0.21	0.29	0.0
3	2.70	2.86	1.2
4	3.39	4.29	1.6
5	0.93	1.00	0.0
6	3.52	3.71	2.1
7	0.43	1.14	0.7
8	0.17	0.86	0.4
9	0.26	0.43	0.1
10	0.09	0.00	0.0
11	0.22	1.71	0.1
12	0.92	1.43	0.4
13	0.17	0.00	0.0
14	1.43	1.14	0.3
15	0.38	0.00	0.0
16	1.39	1.43	0.8
17	1.41	1.86	2.5
18	1.38	1.43	0.2
19	1.63	2.00	0.9
20	1.15	2.71	0.4
21	2.13	2.29	2.1
22	1.22	1.29	0.8
23	3.16	3.00	2.5
24	1.98	1.57	0.9
25	2.37	3.00	0.8
26	0.39	0.00	0.1
27	0.86	1.00	0.9
28	0.30	1.14	0.1
29	1.72	2.29	1.3
30	1.56	2.29	0.8
31	2.26	2.14	0.8
32	1.90	1.86	0.8
33	0.48	1.00	0.1
34	2.24	3.00	0.8
35	5.09	4.57	2.1