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THE DISPERSAL OF CABBAGE ROOT FLY IN RELATION TO AGRICULTURAL PRACTICE

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THE DISPERSAL OF CABBAGE ROOT FLY IN RELATION TO AGRICULTURAL PRACTICE.

Kir K . I . ALEXANDER

This thesis was submitted to the Council for National Academic Awards in partial fulfilment of the degree of Doctor of Philosophy, in collaboration with the Agricultural, Development & Advisory Service (Starcross) and the National Vegetable Research Station.

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ABSTRACT

The study aimed to estimate the dispersal rate of wild cabbage root flies in agricultural systems,to test a migration hypothesis and the predictions of a computer simulation model.

The dispersal rate was determined by a new method,from the age-grouping of wild flies instead of releasing marked culture flies. The mean distance dispersed was calculated from the slope of density of captured flies on distance;the mean age was calculated from laboratory measurements of development at constant temperatures.

A new method of male age determination was developed,based on the changes in pupal fat and testes colour.The published method of female age determination was improved to allow more rapid separation of nulliparous and parous flies.

The values of the slope and intercept fitted to the density-distance data were strongly correlated.A computer simulation demonstrated that random noise causes a progressive underestimation of the slope,as the catch decreases.The slope for gravid females reaches a limiting value of approxiamately 0.2,indicating a mean distance dispersed of 500m.A numerical integration suggests that 95% of the flies move less than 580m.There was no evidence of the female migratory phase,proposed by Finch & Skinner(1975),which was probably an artefact of the use of ANCS attractant.The dispersal rate was estimated at 49-165 m/day,compared with 29-87 m/day predicted by the simulation model.

There was little evidence that dispersal alters with agricultural practice.A proportion of the first generation were found to delay emergence on one site,which may be connected with the planting of fodder brassica crops at midsummer.

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SECTION ONE

INTRODUCTION

CHAPTER I

(a) The cabbage root fly

The cabbage root fly (Delia radicum L., Diptera; Anthomyiidae) (Pont, 1981) is a major pest of cruciferous crops in Europe and North America. In Britain, the insect causes the most serious damage on cauliflowers and cabbage, but also attacks broccoli, Brussels sprouts, kale, mustard, radish, rape, swedes and turnips (Coaker & Finch, 1971; Anon., 1973; Thompson, 1978). The pest can also develop on a wide range of cruciferous weeds (Finch & Ackley, 1977).

The eggs are laid in the soil around the base of the stem of a host plant, although a small proportion of eggs may be laid in the developing buttons of Brussels sprouts (Coaker, 1967). The larvae emerge to feed on the root tissue, passing through three instars, until pupating in the soil around the roots. The cabbage root fly overwinters as a pupa, entering diapause in the autumn when subjected to low temperatures and short day lengths (Coaker & Finch, 1971; Soni, 1976). The diapause development is completed by exposure to low temperatures (e.g. 4-5 months at 3-5°C; Coaker & Finch, 1971). The emergence of adults in the spring can be predicted from the day degree accumulation from February 1st (Coaker & Finch, 1963; Finch, 1977), and coincides with the flowering of a common hedgerow plant, Anthriscus sylvestris (Coaker & Finch, 1971; Anon., 1973).

The adult forces its way to the surface, using the ptilinum situated on the anterior surface of the head. The percentage of adults emerging from the pupae does not depend on the depth in the soil, but while 70% successfully reached the surface from a depth of 3.75-15 cm., only 20% were successful from 30 cm. (Finch & Skinner, 1980). The farm cultural practices (ploughing, etc.) can significantly affect the emergence of adult cabbage root flies (Finch & Skinner, 1980).

The females usually feed on the 2nd and 3rd days after emergence under laboratory conditions, mate on the 4th day and commence oviposition on the 5th and 6th days (Hawkes, 1972b). The females usually mate only once, but the males can mate up to 40-70 times from two days after emergence until they die (Coaker & Finch, 1971; Price, 1973). A source of carbohydrate is required for the development of the first batch of eggs, and protein is also required for the second and subsequent batches (Finch & Coaker, 1969b; Finch, 1971a). The majority of flies in a large field cage were found to feed only on carbohydrates, with chromatographic analysis indicating that only 3-6% of females had matured or were capable of maturing a second batch of eggs (Finch, 1971b). A wide range of flowers are capable of supplying the carbohydrate requirements (Finch, 1974b), and the availability of flowers is thought to aggregate the flies at the hedgerows (Hawkes, 1972b, 1973; Finch & Skinner, 1973b). The females move away from the hedgerows to search for suitable host plants for oviposition, as they become gravid (Hawkes, 1972b, 1973). The gravid females are responsive to host plant odour, and will move upwind to a host crop from up to 30 m. downwind (Hawkes, 1974, 1975). The host plant odour, and possibly also visual stimuli, bring the fly into contact with the leaves. If the fly receives a suitable contact chemostimulus, it moves down the plant and searches with its extended ovipositor for a suitable crevice in which to lay the eggs (Traynier, 1967).

The larvae burrow through the roots of the host plant, allowing the entry of pathogenic soft rot bacteria and fungi. The plants can be attacked at all stages, although the young plants are the most vulnerable. Plants attacked at the seedling stage, or soon after transplantation, often wilt and die, and in severe cases, the plant

collapses due to the destruction of the entire root system. The more mature plants can tolerate quite large populations of flies, with few obvious symptoms, although there may be a reduction in the yield (Wheatley & Coaker, 1969; Harcourt, 1970; Strandberg & Denton, 1976; Getzin, 1978). In crops grown for their roots (e.g. swede, radish) even slight superficial damage can seriously impair the quality for human consumption. The eggs laid in the buttons of Brussels sprouts are a problem, particularly in crops grown for freezing (Coaker, 1967). There are normally two generations in northern Britain, with three generations in southern Britain (Smith, 1927; Shaw, 1971; Finch, 1977). The most concentrated attack generally arises from the overwintering (first) generation (Anon., 1973).

(b) The agricultural production of brassicas in S. W. England.

The cruciferous crops are grown in a variety of cropping patterns, which have consequences for the control of cabbage root fly. The summer maincrops (Brussels sprouts, cabbage, cauliflower) form the bulk of cruciferous vegetable production, and are planted in the autumn or spring to be ready for consumption in the following spring, summer or autumn (Lockhart & Wiseman, 1978; Halley, 1982). A smaller area of early maincrops are grown to provide vegetables when fresh supplies are limited. These crops are either planted in spring for winter consumption, or in the autumn for spring consumption. They require a mild frost-free winter to avoid damage to the young or maturing plants. Large areas of fodder brassicas (e.g. turnips, swede, rape, kale) are grown for winter animal feed. These are normally grown as catch crops, planted in the late spring or summer for winter consumption. There are also specialised crops, such as oil-

TABLE 1

A comparison of the average areas of brassica crops grown in S.W. England and in England&Wales.

	Area grown(hectares)		
	S.W. England	England& Wales	Proportion grown in S.W. (%)
Winter cauliflower	1701	5952	28.6
Winter cabbage	207	3486	5.9
Spring cabbage	1190	8743	13.6
Summer & autumn cauliflower	355	8225	4.3
Summer & autumn cabbage	306	5357	5.7
Brussels sprouts	642	13893	6.7
Turnips&swedes (for stockfeeding)	467750	3118360	15.0
Turnips&swedes (for human consumption)	1171	4641	25.2
Kale	119700	355640	33.6

Source : MAAF Agricultural statistics

The South West is defined as the counties of Avon,Cornwall, Devon,Dorset,Gloucestershire,Somerset,Wiltshire.

Average 1975-1978

seed rape for oil extraction and mustard for condiment manufacture.

The S. W. England is an important producer of early vegetables (Table 1), because of the mild winters. The bulk of the region's production comprises spring cabbage and winter cauliflower, which can be conveniently fitted into the predominantly dairying or livestock rearing pattern (Leat, 1980). There is a concentration of intensive horticultural production in S. W. Cornwall and in the South Hams of Devon, because of their favourable southerly aspect.

The South West is generally not a major source of maincrop production, which is largely concentrated in Eastern England. The maincrop brassicas are bulky crops of relatively low value, which cannot bear heavy transport costs and are most economically produced by large-scale mechanised production. The growing of Brussels sprouts has become concentrated close to the packing or freezing factories (Wheatley, 1972). Large areas of swedes and turnips are grown on the red sandstone soils of Devon and Somerset (Table 1). These red soils produce large, well-shaped and well-flavoured swedes, which can remain in the ground throughout the winter. The fodder brassicas are widely grown in the region (Table 1) to provide winter feed for the dairy and livestock farms.

Brassica crops are commonly grown throughout the year on intensive horticultural holdings, so insecticide has to be applied to all crops to prevent a build up of pests. The fodder brassicas are normally planted at midsummer during the second generation of cabbage root fly. These farms often do not grow any other brassica crops, so the first generation is controlled by the lack of suitable host plants and control measures are not required. A small population of cabbage root fly can survive on the wild crucifers in the hedgerows, or by

long-distance dispersal. The population will only increase slowly during the second and third generations, but some damage is acceptable in a crop grown for animal consumption.

(c) The agricultural control of cabbage root fly

The cabbage root fly is currently controlled by routine applications of insecticide at the time of sowing or transplantation (Anon., 1973; Thompson, 1978). The insect has developed widespread resistance to the organochlorine insecticides (Coaker, Mowat & Wheatley, 1963; Gostick & Baker, 1966), and today control is reliant on the organophosphorus and carbamate insecticides (Anon., 1983a). These later insecticides require careful and accurate placement for effective control (Bevan & Kelly, 1975; Mowat, 1975), and are more toxic to both the operators and crop plants. Some of the insecticides (e.g. chlorfenvinphos) are less toxic to the predatory ground beetles (Mowat & Coaker, 1967), which are responsible for the death of a large proportion of cabbage root fly eggs (Coaker, 1965; Freuler, 1975; Mowat & Martin, 1981). The organophosphorus and carbamate insecticides are considerably more expensive than the organochlorine types, and are broken down more rapidly in the soil, so will not provide effective protection throughout a season (Beynon, Hudson & Wright, 1973). In practice, it is only necessary to protect the crop during the critical few weeks after transplantation, because the established plants can tolerate quite high populations with little effect on the final yield (Wheatley & Coaker, 1970). The developing buttons of Brussels sprouts require treatment, since even a low level infestation can lead to the rejection of a crop grown for packing or freezing (Coaker, 1967; Wheatley, 1972).

The dependence of agriculture on synthetic insecticides could be a vulnerable position, if the cabbage root fly develops resistance to the limited range of available insecticides. The synthetic pyrethroids are the only new insecticides that have been introduced in recent years, and they are relatively ineffective when applied to the soil. The spiralling costs of development of new pesticides makes it unlikely that any significant new compounds will appear in the near future (Brown, 1977). There is currently no evidence for the development of resistance in cabbage root fly (Thompson, 1979), but the organophosphorus insecticides are known to induce resistance more slowly than the organochlorine types, although severe cross-resistance can develop even to unrelated compounds (O'Brien, 1967).

Some of the newer cropping policies are encouraging pest problems by demanding high levels of control. The insect is increasingly exposed to the insecticide, which may be foreshortening its useful life (Luck, van den Bosch & Garcia, 1977). There is a need to develop methods to replace or augment the conventional insecticides. The development of resistance can be slowed by lowering insecticide dose levels, or applying insecticides only when the population exceeds a threshold level, or by the intentional retention of susceptible individuals in noncrop areas or in untreated segments of the crop (Georghiou & Taylor, 1977). These simple changes in dosage or treatment schedule may result in higher pest populations, which may be currently unacceptable to the processor or the consumer. Nevertheless the insecticides are expensive, and any reduction in their usage could be both biologically and economically valuable. A recent development has been the transplantation of plants raised in peat blocks, to which insecticide can be added (Saynor, Davies & Brown, 1982). The

method allows an accurately controlled dose of insecticide to be applied to the roots, and permits a reduced rate of insecticide application and better establishment of the plants.

(d) Modern trends in agricultural practice

Modern development in agronomic techniques and changes in consumer demand have led to altered cropping policies, which have aggravated old pest problems and introduced new ones.

The farms and their fields show a continuing trend towards increased size, for greater efficiency in production (Gair, 1972; Strickland, 1972). The higher labour costs have led to increased mechanization and a reduction in the labour force employed (Strickland, 1972). The high capital costs force the growers to specialise, so that crops are grown in shorter rotations, which can lead to a build up of soil pest problems (Strickland, 1972).

Modern herbicides eliminate the need for mechanical weeding and removes many of the traditional restrictions on crop spacing. The spatial arrangement of the crop can be used to adjust the size and quantity of the crop. A high plant density allows the production of small uniform vegetables for packing, and can ameliorate the effects of pest attack (Finch & Skinner, 1976; Finch, Skinner & Freeman, 1976). The development of precision drilling allows very uniform stands to be grown, with the possibility of 'once over' harvesting, which requires a high degree of control over pest populations (Wheatley, 1972).

There is a trend towards earlier planting of brassica crops to provide a longer growing season and higher yields. The extension of brassica availability, particularly in the first generation of cabbage root fly, could lead to higher fly populations and increased pesticide

usage. The growing of swedes and turnips for animal consumption is declining as farmers switch to grass ensilage, or leaf brassicas which can be ensiled or grazed off the field.

An increasing proportion of vegetables are being grown for packing or freezing, which has led to a concentration of production close to the factories (Strickland, 1972; Wheatley, 1972). The produce is required to conform to sophisticated specifications for uniformity of size and freedom from pest damage (Wheatley, 1972). The emphasis on aesthetic considerations has undoubtedly led to an increased use of insecticides. The producer has a very large investment in the crop (seed, herbicides, mechanical equipment), and the insecticide treatments represent only a small proportion of the total cost (Wheatley & Coaker, 1970; Cruger, 1980). The producer dare not omit any treatment, and such insurance treatment probably leads to considerable unnecessary use of pesticides.

(e) Alternatives to chemical control

The insecticides kill the eggs and newly-emerged larvae, but the cabbage root fly might equally be controlled by the prevention of egg development or disruption of host plant location.

The female flies require carbohydrate for egg production (Finch, 1971a), which is normally obtained from hedgerow flowers (Finch, 1971b, 1974b). The removal of the hedgerow flowers would be expected to prevent egg development, but in a field experiment there was no significant reduction in the number of eggs laid (Finch, 1971c). The experiment was designed on the basis of an underestimate of the dispersal range of the flies, so females were able to disperse in from surrounding untreated areas.

The development of viable eggs can be prevented by the sterilization of the males or the females. The wild population of flies can be sterilised using the chemical TEPA, contained in an attractive bait. Chemosterilization was effective in preliminary laboratory and field cage trials, producing 70% egg sterility (Coaker & Smith, 1970). The egg sterility rarely exceeded 30% in an open field experiment, which was attributed to immigration of unsterilised males and females, the emigration of the sterilised females, a reduction in the competitiveness of the sterilised males and a failure by the males to disperse once sterilised (Finch & Skinner, 1973a).

Hawkes & Coaker (1977) developed a model relating egg sterility to parameters of mating and reproduction. The combined effects of dispersal and reduced male competitiveness could not account for the low observed sterility, and they suggest that the baits were located in suboptimal positions, so the treatment was relatively ineffective against females. The model suggests that a maximum of 68-83% sterility could be achieved with an efficient chemosterilant and isolation from untreated flies.

The laboratory-reared cabbage root flies can be sterilised by irradiation, and in a field trial a yield of marketable curds was 80% of that obtained from a control crop treated with insecticide (Hertveldt, van Keymeulen & Pelerents, 1980). The release of sterile insects is theoretically capable of more effective control than the use of chemosterilants. The chemosterilant affects a constant proportion of the population, and will become less effective as the population size decreases (Finch, 1980). The release of a constant number of sterile insects, while the natural population is declining, will become increasingly effective as the ratio of sterile to normal

insects increases with each generation. The method is capable of eliminating a pest in an ideal isolated situation (La Chance, Schmidt & Bushland, 1967). In practice, the effectiveness depends on the release of sufficient sterile individuals relative to the wild population, and on the immigration from outside the area. The mass rearing of flies is an expensive and labour-intensive process, so it will be difficult to release sufficient sterile flies in a full scale agricultural environment.

The cabbage root flies might be controlled by capture in yellow water traps, especially with the use of attractive chemicals such as allylisothiocyanate (ANCS)(Finch & Skinner, 1974a, 1982a; Finch, 1980). The ANCS is particularly attractive to gravid females, which respond by upwind orientation (Hawkes & Coaker, 1979). The traps were found to be ineffective in reducing the population level (Finch & Skinner, 1971c), because the traps were capable of attracting flies from a short distance (Hawkes, 1973; Finch & Skinner, 1974a; 1982b) and capture only a small proportion of the flies present in the attractive radius (Finch & Skinner, 1974a, 1982a). Hawkes (1980) proposed that the high concentration of ANCS close to the trap may inhibit the positive anemotaxis of gravid females, and that the catch might be enhanced by the separation of the ANCS dispenser and the trap, but this was found to not increase the catch of flies (Finch & Skinner, 1982b). A variety of natural and synthetic isothiocyanates have been tested for their attractive ability, but none were found to be more effective than ANCS (Finch & Skinner, 1982a). There is the possibility of protecting the individual crop plants by anti-attractants (repellents)(Finch, 1980; den Ouden, 1980; Finch & Skinner, 1982a).

The application of insecticides against cabbage root fly also reduces the insect predators and parasites, so there is a tendency for pest resurgence because of the slower recovery by the predator and parasite populations (Coaker, 1966). The predators and parasites provide an important check on the cabbage root fly population, the ground beetles alone consuming 90-95% of the eggs (Hughes, 1959; Mukerji, 1971; Freuler, 1975; Mowat & Martin, 1981). The key factor (Varley, Gradwell & Hassell, 1973) of cabbage root fly population dynamics has been identified as the failure of females to attain their maximum potential egg production, which may be caused, at least partially, by the emigration of females away from the host crop (Benson, 1973; Jones et al., 1980). The population level is stabilised by density-dependent pupal mortality, due to predators and parasites in Canada, but to the death of the host plant in England (Benson, 1973). Bromand (1980) found that Aleochara spp. are capable of destroying a large proportion of a cabbage root fly population, but this control varies widely for different sites and years. A field experiment with a parasitic nematode produced some reduction in pest damage, but less than that achieved by a control insecticide treatment (Welch & Briand, 1961). The classic biological control of predators and parasites cannot provide the certain and almost complete pest control, required by high productivity farming.

The control of cabbage root fly through plant resistance is particularly attractive to the growers, because there are no constraints on cultural practice. The plant resistance is often bought at the expense of final yield. The basis of resistance in cruciferous crops is either a reduction in attractiveness to the egg-laying females (Ellis et al., 1976; Finch & Skinner, 1982a), or an

increase in tolerance to damage to the roots (Hardman & Ellis, 1978).

The uniform monoculture of a modern crop provides an ideal habitat for the expansion of a pest population, and an increase in diversity could improve the pest population regulation (Dempster & Coaker, 1972). An undersowing of clover was found to reduce oviposition (Tukahiriwa & Coaker, 1982) and increase the predator population (Ryan, Ryan & McNaeidhe, 1980).

The females could be prevented from laying their eggs by physical barriers around the base of the stem of the host plant (Coaker & Finch, 1971). Foam rubber discs were found to be as effective as insecticides in protecting brassica plants from attack by cabbage root fly (Finch & Wheatley, 1980). The cost is comparable with standard insecticide treatments, and the method would be suitable for small-scale use. The discs work by reducing the number of eggs laid, and also provide a sheltered habitat for predatory ground beetles.

It is clear that, at the moment, the non-chemical alternatives for cabbage root fly control are incapable of replacing the chemical insecticides. The short-term aim must be to ensure a more rational usage of the insecticides. An insecticide treatment should only be applied when it is likely to cause an economic reduction in pest damage, and not as a routine application. A system of hazard assessment (c.f. cereal disease management, Anon., 1983b) is required for the decisions of whether to apply insecticide. The optimal timing of spray applications depends on reliable methods of forecasting cabbage root fly emergence and development (Finch, 1977). Preliminary estimates for the economic thresholds of cabbage root fly have been determined (e.g. Wheatley & Coaker, 1969; Cruger, 1980; El Titi, 1980; Freuler, 1982; Vincent, 1982). The key factor for mobile

organisms will usually be the distance between the sites of successive host crops. It is important that dispersal of cabbage root fly is quantitatively described, so that eventually it will be possible to predict the proportion of a population expected to invade a new crop.

(f) Dispersal and migration

Dispersal can be defined as any movement away from an aggregation (Southwood, 1978), which leads to insect populations becoming distributed over a larger area than that occupied during development (Johnson, 1969).

Dispersal is brought about by two types of flight; migratory flights or movement associated with appetitive behaviour. A flight is called 'appetitive' if they can be interrupted by stimuli which cause insects to feed or lay eggs, and 'migratory' if they are unaffected by such stimuli. Locomotory behaviour is enhanced in migration, whereas feeding and reproductive behaviour are inhibited (Kennedy, 1961). Migration produces persistent 'straightened-out' movement and greater dispersal, which would be advantageous where the habitat is only transiently fit for breeding (Southwood, 1962, 1977).

(g) The dispersal of cabbage root fly

The dispersal ability of cabbage root fly was originally assessed from the spread of damage from known sources of infestation (Read, 1958), and from the spread of an insecticide-resistant strain (Mowat & Coaker, 1968). Both studies conclude that cabbage root fly has little innate tendency to disperse, although neither method directly measures dispersal. The apparent level of damage depends

on the soil and climate (Coaker & Finch, 1971), while the spread of resistance depends on the relative fitness of the genes and the selection pressures operating within the study area.

Dispersal can be directly studied by the release and recapture of marked individuals (Southwood, 1978). The low recapture rate of most trapping methods requires the release of large numbers of individuals. It is costly to obtain large numbers of wild cabbage flies (Finch & Skinner, 1980), so it is usual practice to use laboratory-reared flies. It is never certain that the cultured insects behave as the wild insects, because of the unusual selection pressures present in a culture (Finch & Skinner, 1975; Price & Thompson, 1979). The high density of flies at the release point may cause initially high rates of dispersal (Wallace, 1966). The small proportion of flies recaptured may not represent an unbiased sample of the total population (Finch & Skinner, 1974a, 1975; Nair & McEwen, 1974).

Hawkes (1972a) marked culture flies by feeding them for three days on a diet containing radioactive phosphorus. These flies were released when 6-7 days old and recaptured using yellow water traps located at a maximum distance of 100 m. from the release point.

The relationship between the number caught and distance was best described by the empirical equation (1) (Hawkes, 1972a).

$$\log_e y = a - b\sqrt{x} \qquad (1)$$

where y = number of flies caught

x = distance from release point

The individual flies vary in the distance travelled from the release point, and the arithmetic mean would be misleading because no allowance is made for individuals that pass beyond the trapping area.

The fitted model can be used to estimate the number of flies passing beyond the outer traps, and allow calculation of a true mean distance dispersed. The fitting of the model will smooth out sampling errors, and the estimate of the mean distance dispersed will be independent of the details of the sample plan.

The number of flies at any distance (x) from the release point is proportional to the number caught multiplied by the circumference of a circle of radius x (2).

$$N_x \propto y.2\pi x \qquad (2)$$

where $y = \exp(a - b\sqrt{x})$

The total number of flies could then be estimated by the integration of (2).

$$\Sigma N = \int_0^\infty K.\ y.\ 2\pi x.\ dx \qquad (3)$$

The constant (K) is required because the yellow water traps capture only a proportion of the available flies. The sum of all the distances dispersed by all the flies can be estimated by multiplying the total number of flies by the distance (x) from the release point (4).

$$\Sigma d = \int_0^\infty K.\ x.\ y.\ 2\pi x.\ dx \qquad (4)$$

The mean distance dispersed can then be calculated by dividing the sum of the distances dispersed (4) by the total number of flies (3), which can be shown to reduce to equation (5) (Appendix 1).

$$\bar{d} = 20/b^2 \quad \text{(Hawkes, 1972a)} \qquad (5)$$

The relationships established in equations (3) and (4) are not strictly correct, because they treat the trap catch as a point source and not as the capture of flies available within the attractive radius (Finch & Skinner, 1974a, 1982b). The density of flies at a

point (= the probability of locating a fly at that point) would be expected to be proportional to the density of flies within the attractive radius. The mean distance dispersed can be validly estimated from equation (5), because of the cancelling of the constant of proportionality.

The above method was used by Hawkes (1972a) to estimate the dispersal rate of cabbage root fly at 8-20 m/day. The flies were released in a small plot of cabbages within a fallow field, and for the first two experiments the flies were released away from the hedge. The initial high rates of dispersal (56-102 m/day) of the male flies were thought to result from a directional movement to the hedge. Slower initial rates of dispersal were observed in the third and fourth experiments, when the flies were released at the hedgerows. The rate of dispersal was found to gradually decrease with time (Hawkes, 1972a, 1974, 1975). All movement at the start of the experiment must necessarily be away from the release point, but as the flies disperse with time, the chance of individuals moving back towards the release point will increase, causing the apparent decline in dispersal rate.

The gravid females were found to be the most active stage in laboratory experiments (Hawkes, 1972b), and the brassica crop was thought to have an arresting effect on the dispersal of females. This hypothesis was tested by releasing 4-7 day old flies at the hedgerow in a fallow area downwind of a cabbage crop (Hawkes, 1974). The males were found to disperse at 10-27 m/day, although there was one anomalous estimate of 52 m/day, which was attributed to avoidance of a shaded area. The non-gravid females dispersed at 20-30 m/day, but the gravid females moved upwind to the host crop at

40-80 m/day.

The flies were strongly aggregated at the hedge in these experiments, so dispersal was almost exclusively in one dimension along the hedgerow. When the flies were released at the hedge downwind of a cabbage crop, but in a field planted with barley and not fallow, there was no aggregation of flies at the hedgerow (Hawkes, 1975). The flies probably moved into the barley, because of the availability of feeding sites (Hawkes, 1973). The males and non-gravid females initially dispersed at very high rates (170-290 m/day) for the first few hours after release, decreasing to 36-57 m/day over the next two days. The flies disperse 2-3 times faster over the barley, than when the flies were released at a hedge adjacent to a brassica crop or a fallow area. This would appear to be caused by dispersal in two dimensions, rather than along the single dimension of the hedgerow. The gravid females were found to disperse at 35-95 m/day, which is comparable to the earlier estimates of 40-80 m/day. It was calculated that populations more than 800 m apart would be unlikely to intermix over the adult lifetime (Hawkes, 1968).

Experimental attempts to control cabbage root fly by removal of the hedgerow flowers (Finch & Skinner, 1971c), and chemosterilization (Finch & Skinner, 1973), failed to achieve satisfactory control, because of inadequate isolation of the treated from untreated areas. The estimates of Hawkes (1972a, 1974, 1975) were suggested to be solely a measure of appetitive flight, and that there could be an earlier migratory flight in the younger flies before the gonads are fully mature (Johnson, 1969).

An improved method of marking the flies was developed, to allow the study of dispersal from the time of emergence. The flies can

be marked on the head by fluorescent dust, which is trapped in the ptilinal suture during emergence from the pupa, or they can be marked on the body using oil-soluble dyes (Finch & Skinner, 1974b).

Nair & McEwen (1974) released large numbers of two-day old cabbage root flies, marked either on the head or on the body. The flies were trapped with baited live traps, but less than 0.3% of the marked flies were recaptured. The nearest traps were located 305 m from the release point, and only a small proportion of the flies would be expected to disperse to this distance, because of the exponential decline in number with distance. A detailed analysis of such a small number of recaptures is not possible, but one marked fly was recaptured 915 m from the release point after seven days, indicating a dispersal rate of 131 m/day.

Finch & Skinner (1975) investigated the dispersal of cabbage root fly in a series of three experiments, where the mean distance dispersed was estimated from the slope of density on distance. The flies were marked by a combination of head and body marks. In the 1971 experiment, 0-1 day-old flies were released and recaptured by a grid of yellow water traps arranged around the release site. A number of other trap sites were also established up to c. 2000 m from the release point, to determine whether flies could be recaptured so far from the release point. The males were found to disperse at 51.3-62.5 m/day, but the mean distance dispersed by the females could not be calculated because of the recapture of only a small proportion of the females. The arrangement of the traps did not appear to sample the major part of the female population since 6% (n = 3) and 9% (n = 5) of the recaptured females were caught at 305 m and 1300 m respectively from the release point.

The yellow water traps were replaced in the later experiments by a yellow trap dispensing the attractant allylisothiocyanate (ANCS), which will increase the catch of male and female flies (Finch & Skinner, 1974a; Hawkes, 1980). The 1972 experiment sought to determine whether flies would disperse when released in a host crop. The flies were released in five separate cauliflower plots, and recaptured by a group of nine ANCS traps in each plot. The results indicate that considerable emigration occurs from the host crop, with the maximum distance between plots (660 m) being crossed by 2-3% of the males and 4-5% of the females recaptured.

The flies released in the 1973 experiment were derived from field-collected (wild) pupae and laboratory-reared (culture) pupae. Dispersal was estimated across both a host crop (Brussels sprouts) and across non-host areas (corn stubble). The ANCS traps were arranged along the eight cardinal compass points, to a maximum distance of 400 m from the release point. The flies were found to move little during the first two days of adult life, and by the third day the two sexes had dispersed to an average of c. 100 m from the release point. The males continued to disperse at c. 100 m/day for the three subsequent days. The wild females were estimated to have dispersed to a mean distance of 2678 m by the sixth day, but the culture females had moved to an average of only 870 m. It was suggested that the wild females undergo a migratory flight at c. 1000 m/day during the fifth and sixth days. It was found that 2 of the 6296 culture females and 14 of the 3235 wild females released across the non-host area were recaptured in the Brussels sprout crop locating 1300-1900 m from the release points.

Freeman (1977) reanalysed the data from the 1973 experiment of Finch & Skinner (1975) using a model (6), which allows the intercept

and slope to alter with time.

$$\text{Log}_e Y = a - b\sqrt{x} - ht - cx \log_e t \qquad (6)$$

where t = time

x = distance

a, b, h, c = constants

The models make no provision for a migratory phase, although the fitted values of the slope indicate a mean distance dispersed ranging from 255-2126 m.

A computer simulation model of the dispersal of female cabbage root fly has been developed based on measurements of flight length, flight frequency and flight orientation, made in a wind tunnel (Hawkes, Patten & Coaker, 1979), or from direct observation in the field (Hawkes, pers. comm.). The simulation proceeds in a series of one minute periods, with the flight parameters being generated with the observed means, standard errors and distributions. The position of each fly was calculated after each flight, and movement rates were calculated over 2-6 hour periods. The mean movement rate was calculated from thirty runs, since each run will differ because of the stochastic elements.

The model predicts a dispersal rate of 65 m/day for culture gravid females and 250 m/day for the wild gravid females in the presence of host plant odour (Hawkes, Patton & Coaker, 1978). A dispersal rate of 29.4-87.0 m/day was predicted for wild non-gravid females and gravid females in the absence of host plant odour (Hawkes, pers. comm.).

Taylor (1978) has shown that a significantly greater proportion of the variance can be explained by allowing the exponent (c) of distance to vary (7), instead of using the square root.

$$\text{Log}_e\ y = a - bx^c \qquad (7)$$

The equation provides a generalisation of a series of specific models fitted to a range of insect species. The improved fit is a simple consequence of employing a third variable, but he suggests that the value of c provides a biologically useful measure of the randomness of dispersal. A diffusion model, where the movement of individuals occurs at random, would have a value for c of two (Scotter, Lamb & Hassan, 1971). A value for c of less than two, is suggested to indicate repulsion of the individuals, whereas a value for c greater than two, would indicate attraction of the individuals. This would not necessarily be true, because the value of c is influenced by the heterogeneity of individual dispersal (Skellam, 1951), or by the integration of trap catch over time (Hawkes, 1972a).

A problem arises in equation (7) as the value of c approaches zero, since N = exp(a + b) = a constant. Taylor (1980) proposes that equation (8) would be a more appropriate model.

$$N = \exp(a + bx^c + d \log_e x) \qquad (8)$$

The $\log_e x$ term clearly becomes dominant when either b or c approaches zero. The model was found to provide a good description for a wide range of data.

The present models are merely empirical mathematical descriptions of the change in density with distance, and the parameters are unlikely to be of biological significance (Freeman, 1977). The observed distribution could be produced by a variety of different movement patterns. Taylor (1981) suggests that the spatial distribution of animals arises from the balance of two opposing forces, the repulsion and the attraction behaviours. He describes an

explanatory model which is capable of generating the exponential form of the density-distance curves.

The migration of female cabbage root fly on the fifth and sixth days after emergence, proposed by Finch & Skinner (1975), may be an artefact of the use of ANCS in the traps (Hawkes, pers. comm.). In a migration, the insect would be expected to become less responsive to vegetative stimuli. The ANCS traps have been shown to capture the greatest number of females 5-6 days after release (Finch & Skinner, 1974a), so it is likely that the females become more responsive.

The greater catch of males and non-gravid females in ANCS traps is caused by increased activity in the presence of high concentrations of ANCS, which develop in the close proximity of the trap (Hawkes, Patton & Coaker, 1979; Hawkes, 1980). The ANCS stimulates gravid females at much lower concentrations, and induces upwind movement (Hawkes, Patton & Coaker, 1979). The ANCS has an attractive radius of about 5 m (Finch & Skinner, 1982b).

At normal summer temperatures the females will develop to the gravid stage and commence oviposition, within 5-6 days (Hawkes, 1972b). The migration proposed by Finch & Skinner (1975) is probably caused by the selective action of ANCS on gravid females. The host plant odour will attract the gravid females upwind at higher rates of dispersal (Hawkes, Patton & Coaker, 1979). The trap arrangement may also have influenced the fitted value of the slope of density on distance. The traps were arranged at equal intervals along the cardinal compass points leading away from the release point. The traps closest to the release point could interfere with the traps in other trap lines, reducing the number of flies caught and leading to an underestimate of the slope (Begon, 1976a; Jones et al., 1980). The

simulation model indicates that such interference is capable of causing a significant underestimate of the slope (Hawkes, pers. comm.) The estimates of the slope on the 5th and 6th days were based on the recapture of a small number of flies (e.g. on the 6th day, only 38 culture females and 16 wild females were caught in all the traps). The slope estimated from such a small number of observations is unlikely to be statistically very reliable, and there may be a significant underestimation of the slope (see Ch. III.2).

The migration hypothesis could be tested by the description of the dispersal of wild flies using yellow water traps (without ANCS). The slope of density on distance could then be determined for the various female age-groups (Hawkes, 1975). A migratory phase for the gravid females would be expected to produce a significantly smaller slope for the gravid age-group than for younger females.

(h) Dispersal and life history strategy

The life history strategy of an individual is the relative energetic effort devoted to reproduction, growth or dispersal (Southwood, 1977, 1981). The strategy is determined by the habitat (including competition for limiting resources), and is optimised by natural selection to provide the maximum number of successful offspring. The cabbage root fly must necessarily reproduce each generation, but there is freedom to vary the effort devoted to dispersal, either by changing the proportion of the population dispersing, or by altering the distance attained by the dispersing individuals.

Dispersal is clearly advantageous if the habitat is unstable and offers many empty patches, so the pests of annual crops would be expected to be well-adapted for dispersal and the location of new

host plants (Southwood, 1962). There would appear to be no advantage in changing location in a stable environment, but there are the obvious disadvantages of the energy expended and mortality during dispersal. A better strategy might be to reduce dispersal, and concentrate on competing for the available resources. This would not be an 'evolutionary stable strategy', since a genotype which keeps only one offspring 'at home', but uses the remainder for dispersal, will always possess an advantage over other genotypes keeping more of their offspring 'at home' (Hamilton & May, 1977). The offspring which do not disperse must compete with related genotypes, and the dispersal of at least some of the offspring reduces the chance of total reproductive failure and increases the probability of competition with an unrelated genotype.

The fraction programmed to disperse could be expected to depend on the mortality suffered by the dispersing individuals. When dispersal mortality is high, then a smaller proportion of the offspring would be committed to dispersal. Even in a stable environment where the dispersal mortality is very high, it would be still advantageous to commit at least half the offspring to dispersal (Hamilton & May, 1977).

Habitats are not stable nor uniform, but differ in their favourability for reproduction in both time and space (Southwood, 1977). The organism is faced with decisions on whether to breed 'here' or 'elsewhere', and 'now' or 'later'. Dispersal to close patches can be achieved by appetitive behaviour, but longer range dispersal could be better achieved by migration (Dingle, 1974; Southwood, 1977). A patch remaining favourable for a long period of time (relative to the generation time) would be expected to select for continuous breeding

(Southwood, 1977). Population regulation would result from density-dependent competition selecting for individuals capable of efficiently securing resources, and that tend to devote effort to growth and maintenance rather than immediate reproduction (K-selection, Horn, 1978; Grime, 1979; Southwood, 1981). In a patch which is less stable in time, the onset of unfavourable conditions prevents continuous breeding. The population must be able to expand rapidly to utilise the transiently available resources (r-selection).

The unfavourable periods can be avoided by either dispersal to another patch, or the organism can enter a dormant phase to await the return of favourable conditions (Southwood, 1977). The cabbage root fly avoids the regular unfavourable season of winter through diapause, which is controlled by temperature and photoperiod (Coaker & Finch, 1971). The flies will need to disperse to locate the available host crops, which are rotated for control of the clubroot fungus. The different cropping practices might select for different dispersal ability. The constant availability of brassica crops on intensive market gardens might select for reduced dispersal. The brassica crop on livestock rearing farms normally plant the brassica crop at midsummer during the second generation of cabbage root fly. The flies could be selected for longer range dispersal, or the first generation might delay emergence until the host crop is available.

Research objectives

The relationship between density and distance for wild flies will be quantitatively described, to test the predictions of a computer model.

The flies will be separated into age-groups to test the migration hypothesis of Finch & Skinner (1975). It would be desirable to devise a method for male age determination, so that the males and females can be investigated independently. The mean distance dispersed can be estimated from the slope of density on distance, and the mean age of the age-groups can be estimated from laboratory experiments. The dispersal rate will be calculated by the division of mean distance by mean age.

Experiments will be carried out on a range of sites, to determine whether dispersal varies with the stability of the habitat.

SECTION TWO

THE DETERMINATION OF THE AGE OF MALE AND FEMALE CABBAGE ROOT FLIES

CHAPTER II.1

Introduction to insect age determination

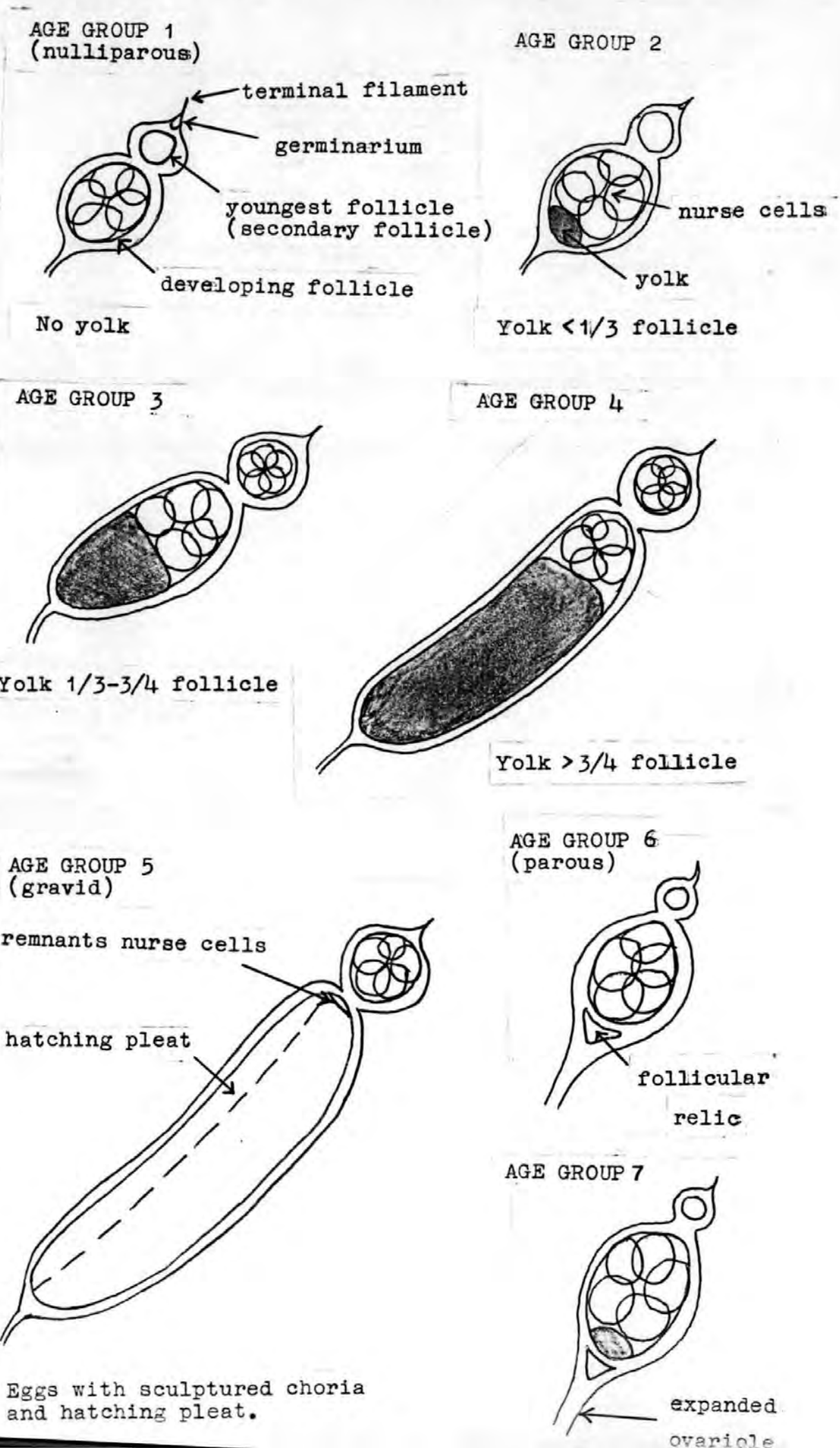
The age is an important attribute of an individual, because the action of many ecological processes depends on the age. Adult mortality is obviously an age-related process (Finch, 1974a) and so is the mean distance dispersed (Hawkes, 1972a; Finch & Skinner, 1975; Freeman, 1977). The behavioural pattern of cabbage root fly alters with age (Hawkes, 1972b, 1975; Hawkes & Coaker, 1979), which has important consequences on their response to the traps (Finch & Skinner, 1974a) and in their field distribution (Hawkes, 1973).

The life span of an insect can be divided into a series of 'physiological' age-groups, based on observable changes with age. An absolute age can be estimated for these age-groups, by allowing for the changes in the rate of development caused by the fluctuations in environmental conditions (Tyndale-Biscoe & Hughes, 1969; Vogt, Woodburn & Tyndale-Biscoe, 1974; Kitching, 1977).

The age-grouping of a population is a prerequisite of life-table analysis. The construction of a series of life tables allows the population size to be estimated, allowing for the dynamics caused by natality, mortality and dispersal (Southwood, 1978). The recognition of recently-emerged adults can be valuable in the location of the adult emergence sites, and the age structure can further provide an indication of whether a population is expanding or declining. Such information can be of practical importance in the timing and placement of control measures.

The age-grouping of female insects has been extensively developed, originally for mosquito species (Detinova, 1968), but more

FIG. 1 THE AGE GROUPS FOR FEMALE CABBAGE ROOT FLY



recently the technique has been applied to a wide range of other species (e.g. Saunders, 1962; Anderson, 1964; Hawkes, 1975; Tyndale-Biscoe & Hughes, 1968; Vogt et al., 1974). When an egg is laid, the empty follicle (corpus luteum) remains in the ovariole and only gradually degenerates. The number of batches of eggs (ovarian cycles) that have been produced, can be determined by counting the number of follicular relics in the ovariole (Fig. 1). This technique was particularly useful in those species which pass through many ovarian cycles (e.g. mosquitoes). The majority of insect species produce only a few batches of eggs, which has prompted the subdivision of each cycle based on the degree of development of the egg. The large translucent nurse cells can be readily differentiated from the developing dark granular yolk (Fig. 1).

A scheme of physiological age-groups has been devised for female cabbage root flies (Fig. 1)(Hawkes, 1975). The cabbage root fly differs from most other dipteran species in requiring only carbohydrate for the development of the first batch of eggs, but a source of protein is necessary for the production of subsequent batches (Finch & Coaker, 1969b; Finch, 1971a). In laboratory conditions the cabbage root fly is capable of passing through many ovarian cycles (Finch, 1974a), but in the field 94-97% of the females feed only on carbohydrate and would not produce a second batch of eggs (Finch, 1971b). It is only necessary to be able to separate nulliparous and parous cabbage root fly females. It can be difficult to locate the follicular relics in specimens that have been stored in a deep freeze for a long period, so it would be useful to identify additional characters for the separation of nulliparous and parous flies. Anderson (1964) suggests that the pupal fat and the ovarial tracheation could also

provide useful characters.

The age-grouping of male insects has been rarely attempted, and there is no published method of age determination for male cabbage root flies. The males usually mature rapidly and there are few obvious developmental changes. The production of the sperm requires only small quantities of nutrients, and does not have the profound effects on the physiology of the individual as egg production. The males are usually assumed to behave similarly to the females, although the two sexes have been shown to differ in their behaviour (Hawkes, 1973, 1975; Finch & Skinner, 1975). It was considered desirable to devise an age determination method for male cabbage root flies, allowing the independent study of the dispersal of the two sexes.

CHAPTER II.2

Obtaining flies of known age

Introduction

A source of flies of accurately known age, is required for the investigation of the changes in a character with time. A heterogeneous population would be obtained from the collection of flies at a fixed time each day, the individuals ranging in age from recently-emerged to one day old. It would be desirable to collect a uniformly aged population, which has completed the minimum of development.

Most insect species exhibit a definite rhythm in the emergence from the pupa (e.g. Pittendrigh, 1966; Dean, Wilson & Wortham, 1968; Thompson & Price, 1979). The emergence pattern can be determined by collecting the emerged flies at regular intervals during the day. This method requires frequent attention and cannot be conveniently collected during the night. A number of devices have been designed for the automatic collection of the emerged flies (e.g. Miller & Treece, 1968; Kempton, 1975; Honegger, 1977), but they rely on the positive phototaxis of the adults to attract them into the collection cages. The flies will not necessarily move into the cages during the night, and will contaminate the later collections. A constant light regime may produce significant changes in the emergence rhythm. Thompson & Price (1979) resolved this problem by extending the light phase using artificial lighting, and then simply collected only during the light phase.

Methods

The emergence rhythm of cabbage root fly was investigated using a large batch of laboratory-reared pupae. The pupae were mixed with an equal volume of moist vermiculite, and this mixture was thinly spread out in a perspex rearing cage at 20°C, in a 18 hours light/6 hours dark cycle. The emerged flies were removed at two hour intervals for three consecutive days.

Results & Discussion

The emergence occurs with a definite peak soon after the start of the light cycle (Fig. 2). A similar result was found for wild and laboratory-reared cabbage root flies at Wellesbourne (Thompson & Price, 1979). The emergence could be a direct response to the light stimulus, or it could be controlled by a circadian rhythm which would cause emergence to occur at a similar time even in constant conditions. Experiments with other insect species have shown that eclosion does follow an endogeneous rhythm, but the rhythm is often entrained to the prevailing light regime (e.g. Pittendrigh, 1966; Dean et al., 1968). The exact time of peak emergence appears to vary with both year and the source of flies (Fig. 2). The emergence of the flies at Plymouth extends over a longer part of the day, and there is a less definite peak in emergence (Fig. 2). This may be an artefact of the method, since it was necessary to briefly switch on the lights during the dark phase, to collect the emerged flies. The pupae were thereby exposed to short periods of light during the dark phase, which may have been sufficient to affect the eclosion pattern.

FIG. 2

ECLOSION PATTERNS OF LABORATORY-REARED CABBAGE ROOT FLIES.

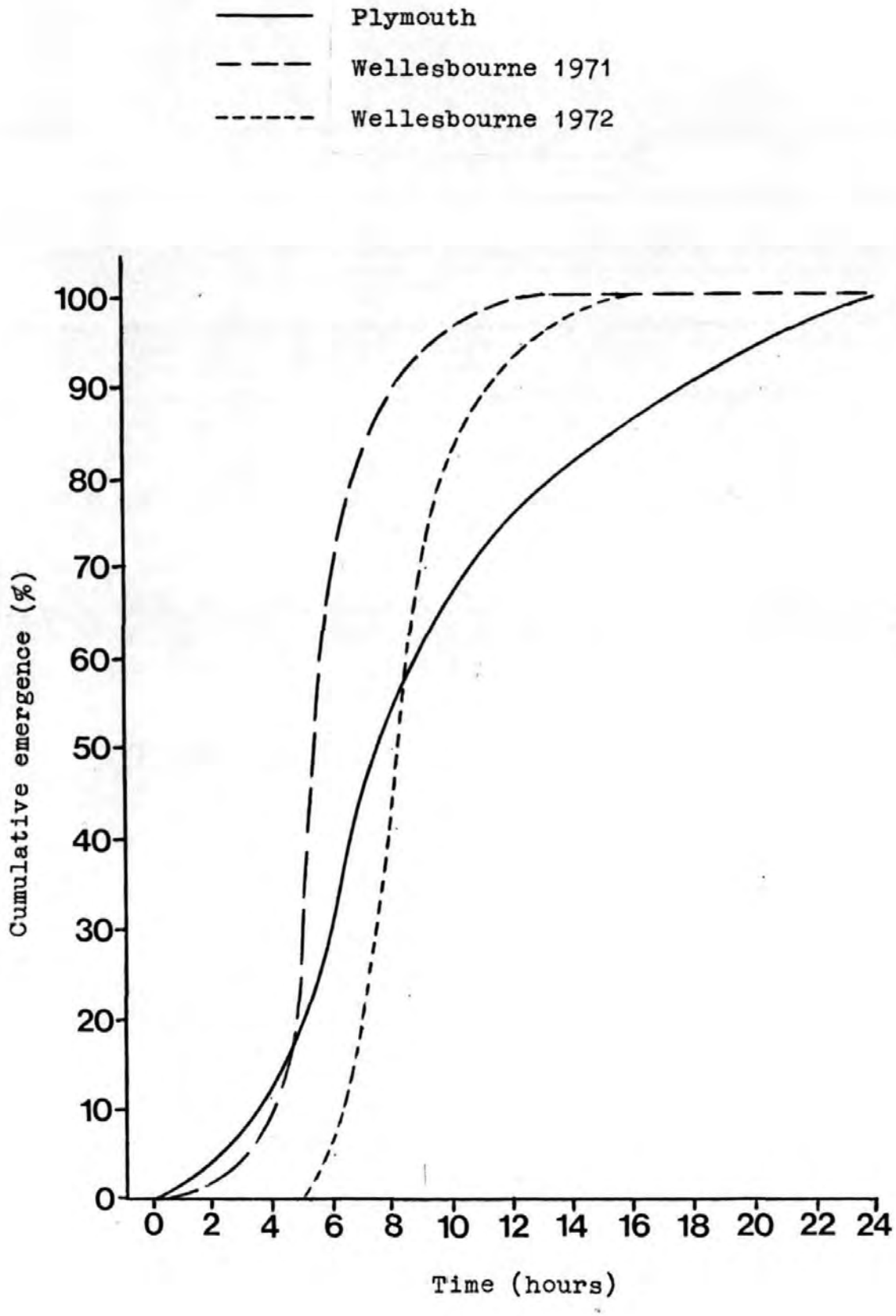


TABLE 2

The emergence of cabbage root flies during certain periods of the day.

Time	Percentage emergence		
	Plymouth 1980	Wellesbourne 1971	Wellesbourne 1972
0400-1000	68.2	97.0	82.5
1000-1800	20.3	3.0	17.5
1800-0400	21.4	0	0

Conclusion

The simple technique of collecting the emerged flies at 10 a.m. and 6 p.m. each day, enables the collection of the maximum number of flies at 10 a.m. but the majority of these flies will be less than six hours old (Table 2).

CHAPTER II.3

A review of methods for male age determination

Introduction

The literature contains a range of potential characters for male age determination, and these will be reviewed and their practicability assessed for *Λ* cabbage root fly. The main objective of this preliminary study is to establish that the character exists in *Λ* cabbage root fly, and then to determine whether there are any changes with age. This can be easily achieved from a small number of observations on flies of known age. The results will not be reported in detail as they are not intended to be statistically rigorous. Any suitable characters discovered will be investigated in detail in later experiments, when quantitative descriptions of the changes with age will be made.

(a) Pupal fat body

The newly-emerged adults of cyclorrhaphous Diptera have been widely noted as containing numerous pupal fat cells free in the abdominal haemolymph (e.g. Evans, 1935; Wigglesworth, 1949; Cwilich & Mer, 1954; Anderson, 1964; Adams & Nelson, 1969; Tyndale-Biscoe & Hughes, 1969; Spradbery & Sands, 1981). The pupal and adult fat are embryologically distinct, being derived from different groups of cells in the embryo. The adult fat usually develops as a loose meshwork beneath the cuticle and a central layer around the gut. The two types of fat cell both contain deposits of glycogen and lipid, although the pupal fat cells additionally contain proteinaceous granules (Butterworth, Bodenstein & King, 1965). The pupal fat is derived originally from the larval fat body, which can be found

extending throughout the larva. The cells of the larval fat body separate during pupation, and many are histolysed. The remaining fat cells survive into the adult, but are normally rapidly degenerated as the adult fat body develops (Adams & Nelson, 1969).

The disappearance of the pupal fat cells in females correlates with ovary development, with the fat cells probably forming a nutrient source for the ovaries. If ovary development is prevented by removal of the corpora allata, then there is no loss of the pupal fat (Munro & Bailey, 1965; Adams & Nelson, 1969). The pupal fat of both sexes disappears more rapidly when the adults are fed on a diet containing protein (Evans, 1935). The protein allows ovary development in the females, so presumably the loss of pupal fat in males in connected with reproductive development.

The number and diameter of the pupal fat cells decreases with age in both males and females (Cwilich & Mer, 1954; Spradbery & Sands, 1981). The individual variation prevents the precise determination of the age of any single fly, although Anderson (1964) suggests that females could be separated into young, medium and old-age groups. The volume of pupal fat depends on the body size of the individual (Wigglesworth, 1949; Spradbery & Sands, 1981). The time taken for the elimination of the pupal fat depends on the temperature and the quality of the larval food (Tyndale-Biscoe & Hughes, 1969; Spradbery & Sands, 1981). The better quality larval food probably allows a larger larva to develop, which will result in a larger adult.

(b) Other pupal remnant characters

The abdomens of recently-emerged mosquitoes contain a mass of transparent muscle tissue, which is the degenerating remains of the

larval abdominal musculature (Rosay, 1961). The mosquitoes also contain a coloured semi-solid mass (meconium) in the midgut, which is expelled soon after emergence from the pupa (Rosay, 1961).

(c) Adult teneral characters

The cyclorrhaphous flies with subterranean pupae emerge through the soil by means of a ptilinum. Blood is pumped in and out of this cuticular sac on the anterior surface of the head, forcing a passage through the soil. Once at the soil surface, the ptilinum is withdrawn into the head and is gradually broken down (Laing, 1935). The adult cuticle is soft and pale immediately after emergence, and the wings have to be expanded. The cuticle is usually rapidly hardened by enzymic tanning of the proteins, and there is often associated melanin deposition. In some Heteroptera the cuticle darkens more slowly, so a series of pigmentation stages can be recognized (Young, 1965).

(d) Cuticular development

The adult cuticle continues to grow for some time after emergence by the deposition of further layers of chitin. Cuticular bands have been demonstrated in a wide range of insect species and would appear to form the basis of an accurate method of age determination (Table 3). The bands are caused by permanent changes in chitin orientation at the time of deposition (Neville, 1965; Dingle, Caldwell & Haskell, 1969). The chitin laid down during the dark 'night' phase is organised into several lamellae, but during the light 'day' phase a layer of non-lamellate chitin is grown.

TABLE 3

Summary of published work on postmetamorphic development.

Author(s)	Insect(s)	Body sites investigated	Method
Neville (1963,1967)	ORTHOPTERA *Schistocerca*	Tibia	Razor blade sections+ phase contrast and polarising microscopy.
Dingle *et al* (1969)	HEMIPTERA *Oncopeltus*	Femur,tibia+ antennae	Cryostat sections+ polarising microscopy.
Menzel *et al* (1969)	HYMENOPTERA *Apis*		
Schlein(1967)	DIPTERA *Aedes*,*Culex*, *Calliphora*, *Glossina*, *Musca* etc.	Cuticle+ apodemes	Dissection+compound microscopy
Schlein (1972a,b)	DIPTERA *Sarcophaga*	Thoracic apodemes+ aedegus	..
Sclein & Gratz(1972)	DIPTERA *Aedes*,*Culex*, *Calliphora*, *Glossina*; *Sarcophaga*	..	Stained+compound microscopy
Zelazny & Neville(1972)	COLEOPTERA *Oryctes*	Femur,elytra, abdomen,pronotum	Razor blade sections+ polarising microscopy
Veron(1073)	ODONATA *Austrolectes*, *Ischnura*	Tibia	Cryostat+polarising microscopy
Tyndale-Biscoe & Kitching(1974)	DIPTERA *Lucilia*	Thoracic apodemes	Dissection+compound microscopy

The band formation has been shown, in two species, to be controlled by an endogenous circadian rhythm, which is normally phased to the daily environmental changes (Neville, 1965; Dingle et al., 1969). The bands are formed independently of temperature and with a free-running period of roughly 24 hours under constant conditions. In a Coleopteran Oryctes band formation was found to be controlled by a non-circadian rhythm; the bands were produced independently of environmental changes and the rate of formation was strongly dependant on the temperature (Zelazny & Neville, 1972). In the Dipteran Lucilia band formation was not controlled by any innate rhythm, since no bands were formed in constant conditions. The bands were grown as a direct response to the temperature rising above a threshold (Tyndale-Biscoe & Kitching, 1974).

The rate of cuticle growth depends directly on the prevailing temperature (Dingle et al., 1969; Schlein, 1972; Tyndale-Biscoe & Kitching, 1974). At high temperatures the cuticle will grow rapidly to its maximum size, and no further bands can then be formed. The number of bands will not then be a true indicator of age. At low temperatures the cuticle grows slowly and the bands will be difficult to distinguish. Light does not appear to be an important influence on band formation, since bands are laid down normally in constant light or constant dark (Neville, 1965; Dingle et al., 1969; Tyndale-Biscoe & Kitching, 1974).

The cuticular bands can be seen at a variety of sites (Table 3), although the number of bands may differ at the various sites within an individual (Dingle et al., 1969; Schlein & Gratz, 1972).

(e) Wear and tear

The insect cuticle and its appendages become damaged through abrasion with the environment, and the degree of damage would be expected to increase with age. The ventral thoracic hairs of grasshoppers were found to become increasingly worn with age (Launois & Launois-Luong, 1980). The number of tears in the wings has been found to correlate well with other age indices (Jackson, 1946; Saunders, 1962).

(f) Chemical changes

The quantity of many chemical constituents and the activity of enzymes have been found to alter with age (Rockstein & Baker, 1972). They presumably form the underlying mechanisms governing the visible structural and physiological changes.

(g) The male reproductive system

(i) Testes

The size of the testes varies with age in many insect species (e.g. Haydak, 1957; Clift & McDonald, 1971; Ganesalingam, 1975; Reissig & Kamm, 1975; Begon, 1976b; Eguagie, 1976). The increase in size is probably caused by sperm development, and there is often a later shrinkage in older flies which may result from cessation of sperm production. The colour and appearance of the testes commonly alters with age (e.g. Clift & McDonald, 1971; Begon, 1976b; Shorrocks, 1979). The testes of cabbage root flies are orange in recently-emerged flies, but change to a dark red-brown colour within a few days (Price, 1977).

The sperm generally develop soon after emergence (e.g. Ganesalingam, 1975; Shorrocks, 1979). Midttun (1974) made a detailed histological examination of different ages of dragonflies, but could find only slight differences in sperm orientation and later senile changes, such as vacuolation and necrotic granules. Ascerno, Hower & Smilowitz (1978) developed an age index using a brief microscopic examination to separate the males by the degree of development and the motility of the sperm.

(ii) Accessory glands

The size of the accessory glands varies with age (e.g. Thomsen, 1943; Ganesalingam, 1975; Begon, 1976b; Eguagia, 1976). The glands are thought to provide a bulking agent for the transfer of sperm, and they may have an important role in the nutrition of the sperm. The glands probably initially swell with the accumulated secretion, and the later decrease in size may result from depletion after repeated mating.

(iii) Vas deferens

The vas deferens carries the mixture of sperm and accessary gland secretion to the aedegus during mating. Ascerno et al. (1978) separated males into three categories based on the whiteness and visibility of the vas deferens. They recommend this as a method of determining whether a fly has mated (i.e. a crude index of age) because of its convenience and ease of observation. Fenemore (1971) recognized three age-groups on the basis of the size of the vas deferens, but this is likely to be specifically applicable to Costelytra because the vas deferens is specially adapted for sperm storage before mating.

Results

The number and diameter of the pupal fat cells decrease with age in both male and female cabbage root flies, being eliminated within 5-10 days at 20°C. The adult fat is very variable in quantity, generally forming a thin layer beneath the abdominal cuticle. The larval abdominal musculature and the meconium do not survive into the adult stages of cabbage root flies.

The ptilinum is withdrawn within minutes of emerging at the surface. The wings are fully expanded within about one hour, and the darkening of the body is largely complete within four hours at 20°C.

It was impossible to discover whether cuticular bands exist in the tibiae of cabbage root fly, because the thinnest sections obtainable using a cryostat (approximately 5 μ) were opaque to light. It might be possible to achieve thinner sections with embedded tibiae and a microtome, but this would greatly increase the time necessary for each tibia. The thoracic apodemes could be dissected out after the muscle has been macerated in 10% KOH for 24 hours (Tyndale-Biscoe & Kitching, 1974). The cuticular bands could be seen under x100 magnification, once the adhering muscle has been carefully removed with watchmakers' forceps.

The dimensions of the male reproductive organs alter with age, although it will be necessary to determine the importance of overall body size in the explanation of the observed changes. Motile sperm are present in the testes within one day of emergence at 20°C. The lumen of the vas deferens often appears as a dark stripe in 5-10 day old flies, probably because of the passage of sperm after mating.

Discussion

A number of requirements have to be satisfied before a character can be successfully used in age determination. The character must be a necessary stage in development and not an optional character that develops only under certain conditions. The adult fat body is extremely variable in quantity, depending on the larval and adult nutrition. The females may develop large adult fat reserves, if ovary development is prevented by the absence of protein in the diet (Evans, 1935).

The age-groups should ideally follow in a continuous series, but in practice, delays of variable length may arise between the developmental stages. In most insect species the female requires protein for ovary development, so any protein shortage will lengthen the developmental time (Vogt, Woodburn & Tyndale-Biscoe, 1974). The cabbage root fly female is unusual in not requiring protein for the production of the first batch of eggs (Finch & Coaker, 1969b), and in the field few individuals produce a second batch of eggs (Finch, 1971b). The female needs also to locate a suitable host plant for oviposition. The development of the male reproductive system is less demanding of nutrients, and is little affected by nutrient shortage (Wigglesworth, 1966).

The character must change sufficiently with age, to avoid being obscured by the individual variation. The characters should also develop at the same rate in different populations, otherwise the interpopulation comparisons are not valid (Ascerno et al., 1978).

The dimensions of the organs (e.g. pupal fat, testes) depend partially on the overall body size of the individual. The use of characters independent of body size would have the advantage of

eliminating the additional measurements.

The design of the sample program imposes further constraints on the selection of usable characters. The cabbage root flies are to be collected from the yellow water traps at weekly intervals, so characters requiring recently-killed specimens will not be practicable (Ascerno et al., 1978). The teneral characters are lost too rapidly, and consequently will be rarely sampled.

The main objective of the sample program is to obtain a statistically reliable description of the change in density with distance. It will be necessary to process a large number of flies, so any method of age determination will need to be rapid. The methods based on chemical changes or the cuticular bands are too complex and could be applied to only a small number of flies. The cuticular bands are not necessarily an accurate indicator of age, particularly once the maximum size of the cuticle has been reached.

Conclusion

The changes in pupal fat, testes colour and in the dimensions of the reproductive organs would merit further detailed study for the development of a male age determination method.

CHAPTER II.4

The relationship between age and the changes in the pupal fat and the dimensions of the male reproductive organs

Introduction

The preliminary considerations indicate that the pupal fat, the testes' colour and the dimensions of the reproductive system, alter sufficiently with age to justify further detailed study. A quantitative description of the changes with age, are now required for the assessment of how useful the characters would be in assigning an age to an unknown individual. The value of a character in age determination depends on the relative separation of the different ages. Small differences could be useful if there were also low individual variation. The proportion of the variance explained (R^2) will be an important criterion in the judgement of practical value. A low R^2 would indicate that the differences between ages are small in comparison with the individual variation (Lindeman, 1974).

Methods

The flies were collected at 10 a.m. using a pooter, and transferred to 15 cm. diameter perspex rearing cages. They were provided with 10% sucrose solution on cotton wool plugs, which were replenished daily to minimise mortality. A slice of swede on a layer of sand was available as an oviposition site (Finch & Skinner, 1969a). This site was renewed every two days, because the swede dries out and becomes less attractive to the females. The cages were kept at $20 \pm 1^{\circ}C$ in a light regime of 16 hours light/8 hours dark. The long light phase is essential to prevent the pupae from entering diapause

(Coaker & Finch, 1971), or the adults from reproductive diapause (Begon, 1976b).

The flies were killed in tap water to which a trace of detergent had been added, and were then transferred to a 0.75% saline solution (Anderson, 1964; Miller & Treece, 1968; Jones, 1971). All dissections were carried out on the day of killing.

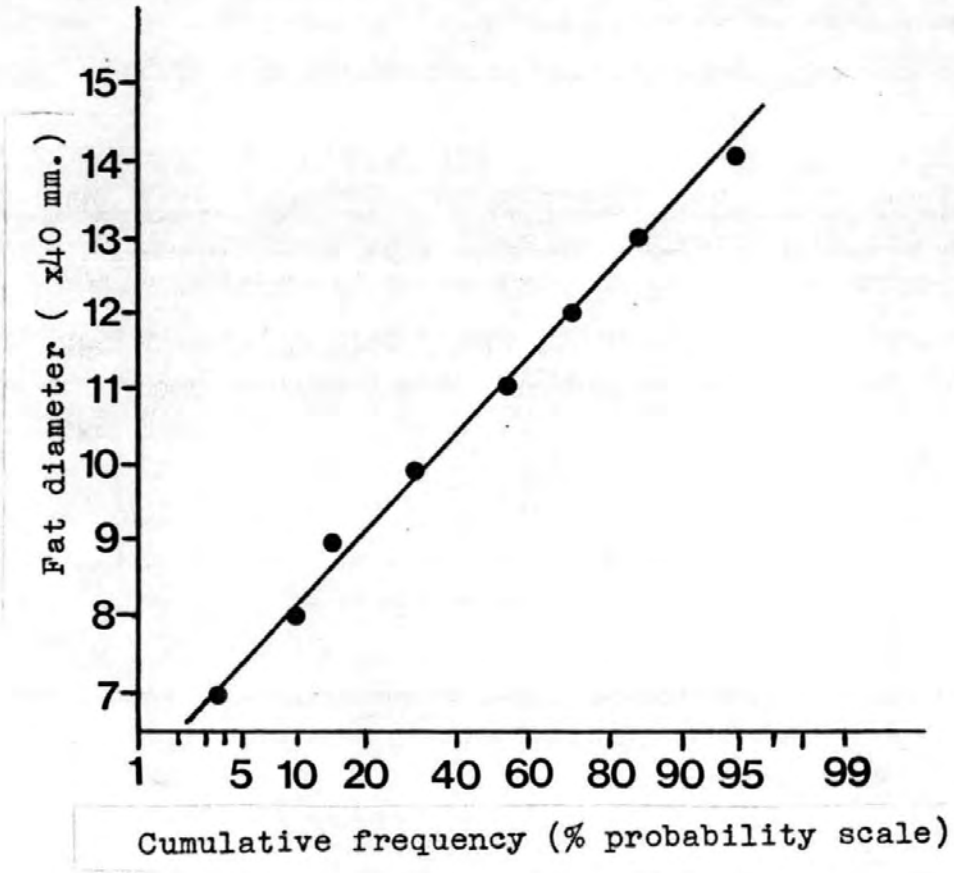
The preliminary observations indicate that the changes in the characters are completed within ten days at 20°C. This covers the most important stages in the female life cycle, and it is likely that only a small proportion of adults in the field survive beyond this physiological age. The main body of observations were made on ten males and ten females for each day from recently-emerged to ten days old.

The body size was measured as the head and the thorax width using a micrometer eyepiece at x 10 magnification. The abdomen of the fly was then separated from the rest of the body in 2 cm^3 of 0.75% saline solution in a 4 cm. diameter Petri dish. The pupal fat cells adhering to the thorax were removed by gentle agitation, and the thorax was discarded. The abdomen was then torn apart using watchmakers' forceps to liberate the free-floating pupal fat cells. A total count of the fat cells was made at x 10 magnification, using a stage grid to facilitate the count and side illumination to contrast the whitish fat cells. Only cells with a diameter greater than 0.05 mm. were counted. This limit was necessary to separate the fat cells from the large number of small gobules, which are probably the breakdown remnants of the fat cells (Fig. 11).

The diameter of the individual fat cells varies with a normal distribution (Fig. 3), so it is only necessary to measure a sample

FIG. 3

The testing of the normality of the size distribution of fat diameter using probability paper.



for the calculation of a mean value. The required sample size can be estimated from the expression (1) (Elliot, 1977; Southwood, 1978).

$$n = (S/\bar{x}.p)^2 \quad (1)$$

where S = standard deviation

$\bar{x}$ = mean

p = required precision (10% = 0.1)

A small number of preliminary observations suggest that thirty cells should be measured for each individual (Table 4a). In a similar experiment, Spradbery & Sands (1981) measured only ten cells. The cells are usually spherical and would be adequately represented by measurement across their greatest dimension (at x 40 magnification).

The ovarian stage of the female was determined according to the scheme of Hawkes (1975). The oviduct was checked for follicular relics under a compound microscope at x 100-400 magnification.

A more detailed description of the various organs was made for the male flies. The colour of the testes was matched to a standard set of colour charts (Kornerup & Wanscher, 1963). This provides a very detailed classification, which was simplified into five subjective groups (Table 4b). The length and width of both testes and both accessory glands were measured along their greatest dimension using a micrometer eyepiece at x 40 magnification. A description of the external appearance of both organs was also made, noting in particular any changes in shape and visible evidence (e.g. granulation) of the onset of secretory activity. The vas deferens was measured at the point of exit from the junction of the testes and the accessory glands, using the micrometer eyepiece.

TABLE 4

The preliminary observations of fat diameter in male cabbage root fly.

4a

Age(days)	Mean fat diameter (X40 mm)	Standard deviation	Required sample size
0	11.13	4.05	12.8
2	8.23	4.46	29.4
4	7.00	7.00	6.0
8	5.70	0.78	1.9

4b

The subjective groups used in the classification of testes colour.

Group	Colour	Kornerup & Wanscher categories
1	orange	Plate 6,a+b
2	orange-red	P8,a-c
3	brown	P6,c-f ; P7,d-f
4	red	P9,a-c,P10,a-c
5	dark red	P8,d-f ; P9,d-f ; P10,d-f

Results

A detailed summary of the male and female measurements are presented in Appendices 2 and 3.

The head and thorax width are very highly correlated (for the females $r = 0.919$, $N = 110$, $p < 0.001$), so in future analyses the head width will be used as the measure of the overall body size, because it was the easier to measure accurately.

(a) Pupal fat

The fat number and mean fat diameter of both males and females clearly do not decline linearly with age (Figs 4 - 9). The relationship can be empirically described by polynomial equations, fitted by multiple regression (Kleinbaum & Kupper, 1978). The high proportion of the variance explained (R^2) and the random residual pattern indicate that the models are good statistical descriptions of the data. The importance of body size as a determinant of the quantity of pupal fat was tested by including head width as an additional variable in the multiple regression. The body size explains a relatively small, but statistically very significant proportion of the variance in fat number and mean fat number of both males and females.

It is of interest to compare the slope and intercept of the fitted male and female regressions. This can be elegantly achieved by means of a dummy variable in a multiple regression of the combined data (Kleinbaum & Kupper, 1978). The female flies are significantly larger ($t = 4.06$, $N = 220$, $p < 0.05$) than the males, so the head width will be included as a covariate. A single dummy variable is necessary for the definition of two groups, coding zero for the males and unity for the females. A third order polynomial provides the best

FIG. 4

The relationship between fat number and age for female cabbage root flies.

	SS	DF	MS	F	
x	22049074.	1	22049074.	555.1	***
x^2	534941.	1	534941.	13.5	***
x^3	904797.	1	904797.	22.8	***
Head width	548563.	1	548563.	13.8	***
Residual	4289973.	108	39722.		
Total	28327338.	112			

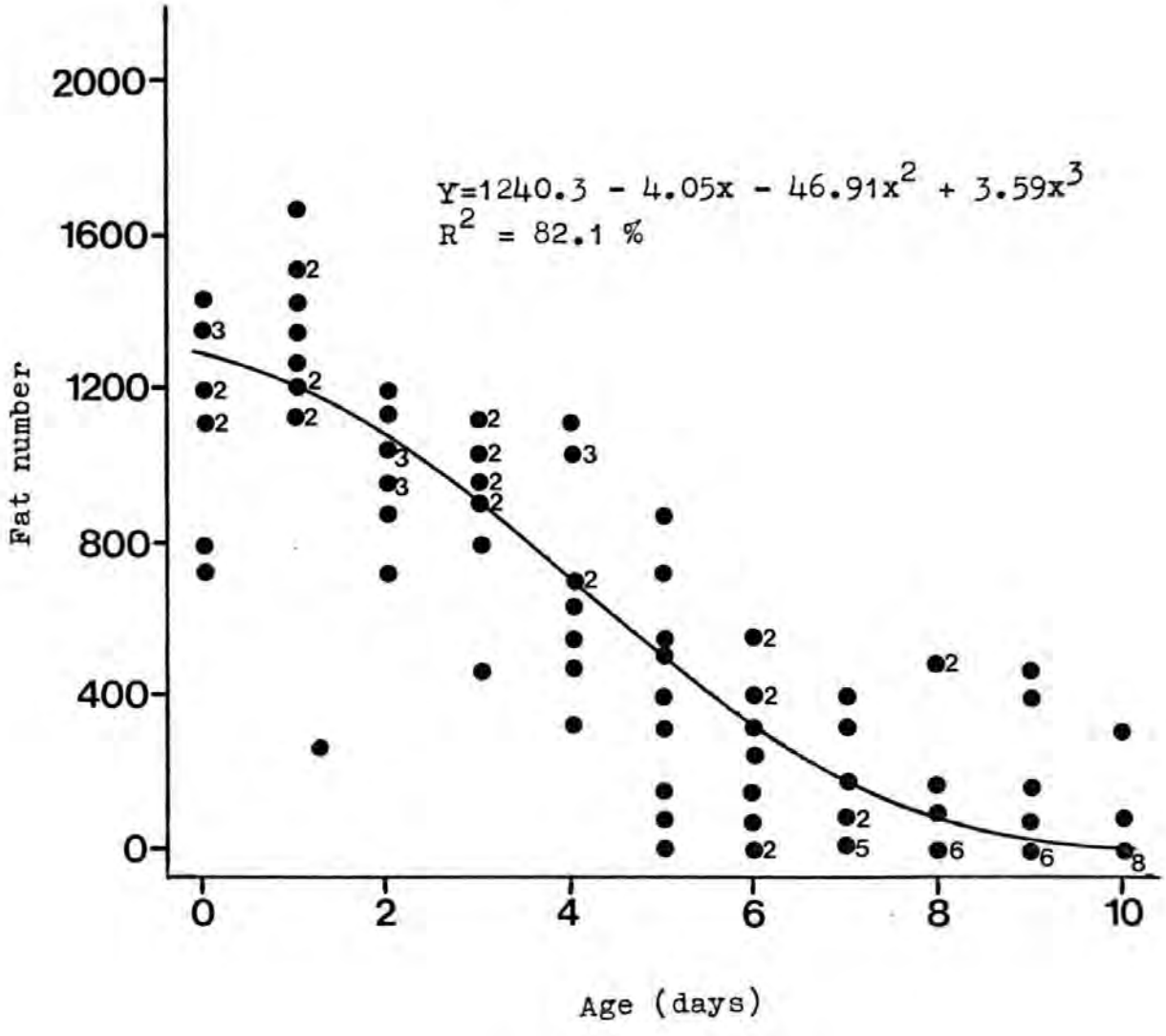


FIG. 5

The relationship between mean fat diameter and age for female cabbage root flies.

	SS	DF	MS	F	
x	0.32018	1	0.32018	539.9	***
x^2	0.01499	1	0.01499	25.3	***
x^3	0.00283	1	0.00283	4.8	*
Head width	0.01312	1	0.01312	22.1	***
Residual	0.06409	108	0.00059		
Total	0.41521	112			

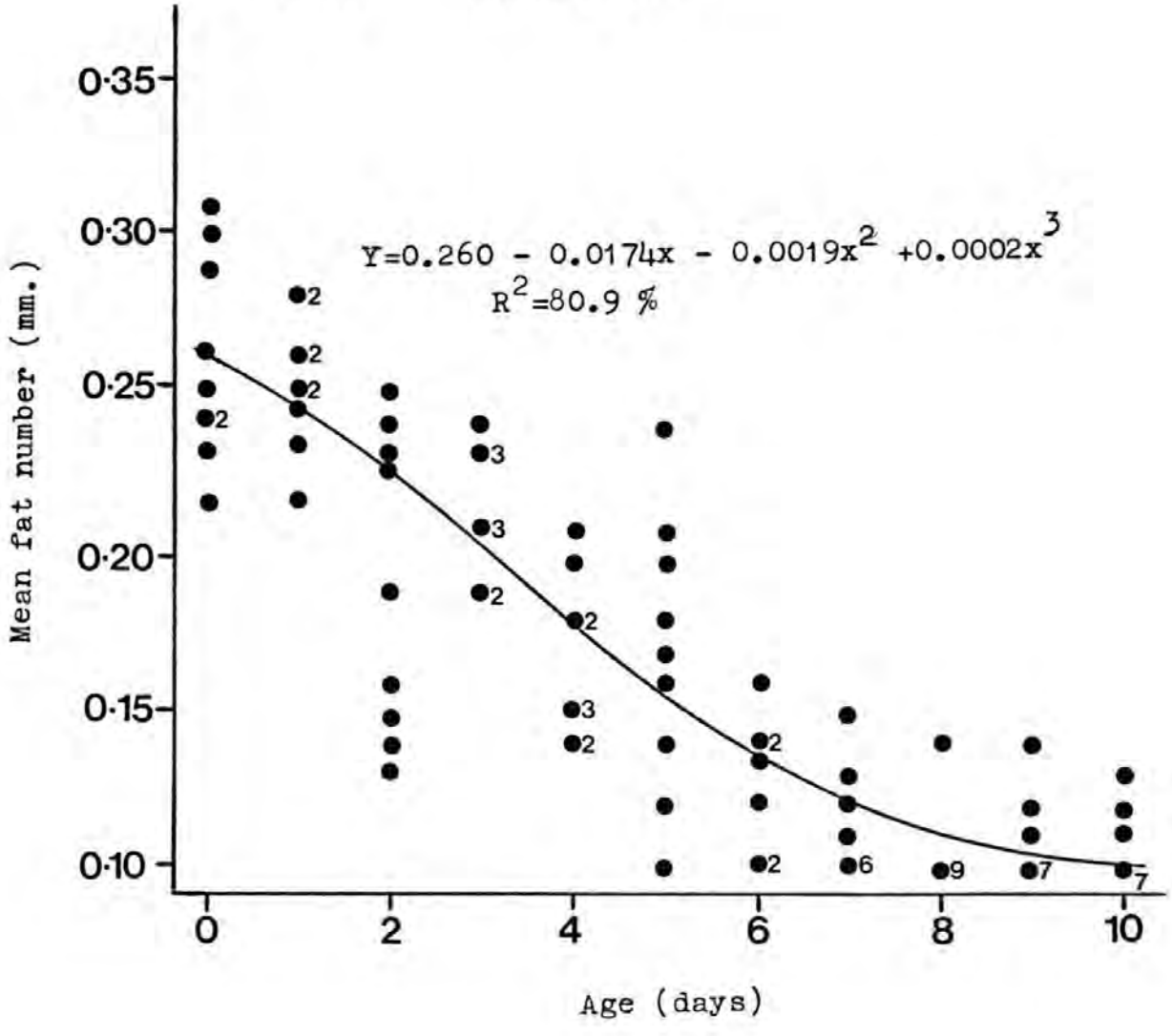


FIG. 6

The relationship between fat number and mean fat diameter for female cabbage root flies.

	SS	DF	MS	F	
x	22049074.	1	22049074.	555.1	***
x^2	534941.	1	534941.	13.5	***
x^3	904797.	1	904797.	22.8	***
Head width	51184.	1	51184.	1.0	
Residual	5787178.	109	53093.		
Total	28327068.	112			

$Y = -1290. + 15696.x - 23497.x^2$

$R^2 = 79.0\ \%$

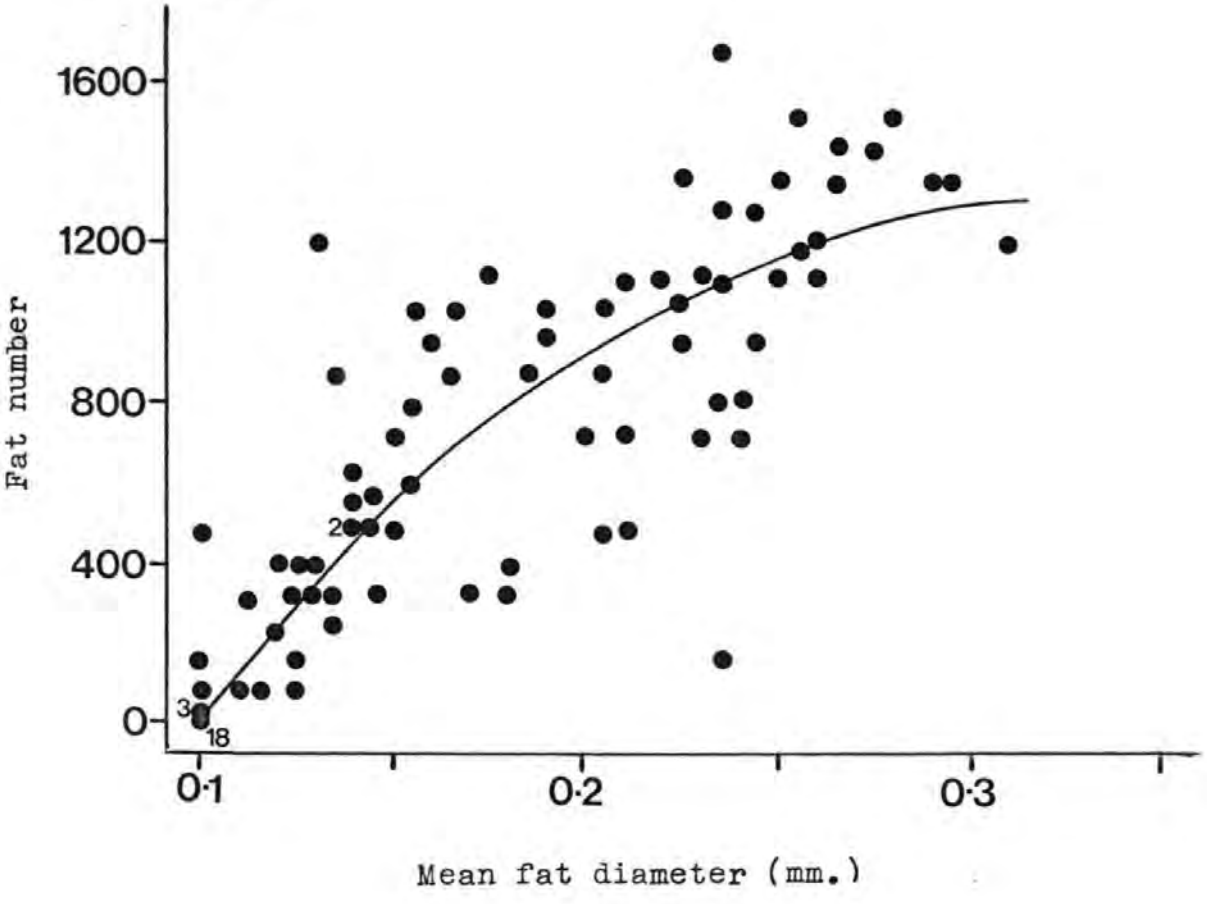


FIG. 7

The relationship between fat number and age for male cabbage root flies.

x	16785922.	1	16785922.	443.8 ***
x^2	177727.	1	177727.	4.7 *
x^3	218183.	1	218183.	5.8 *
Head width	215596.	1	215696.	5.8 *
Residual	3971651.	105	37825.	
Total	21369173.	109		

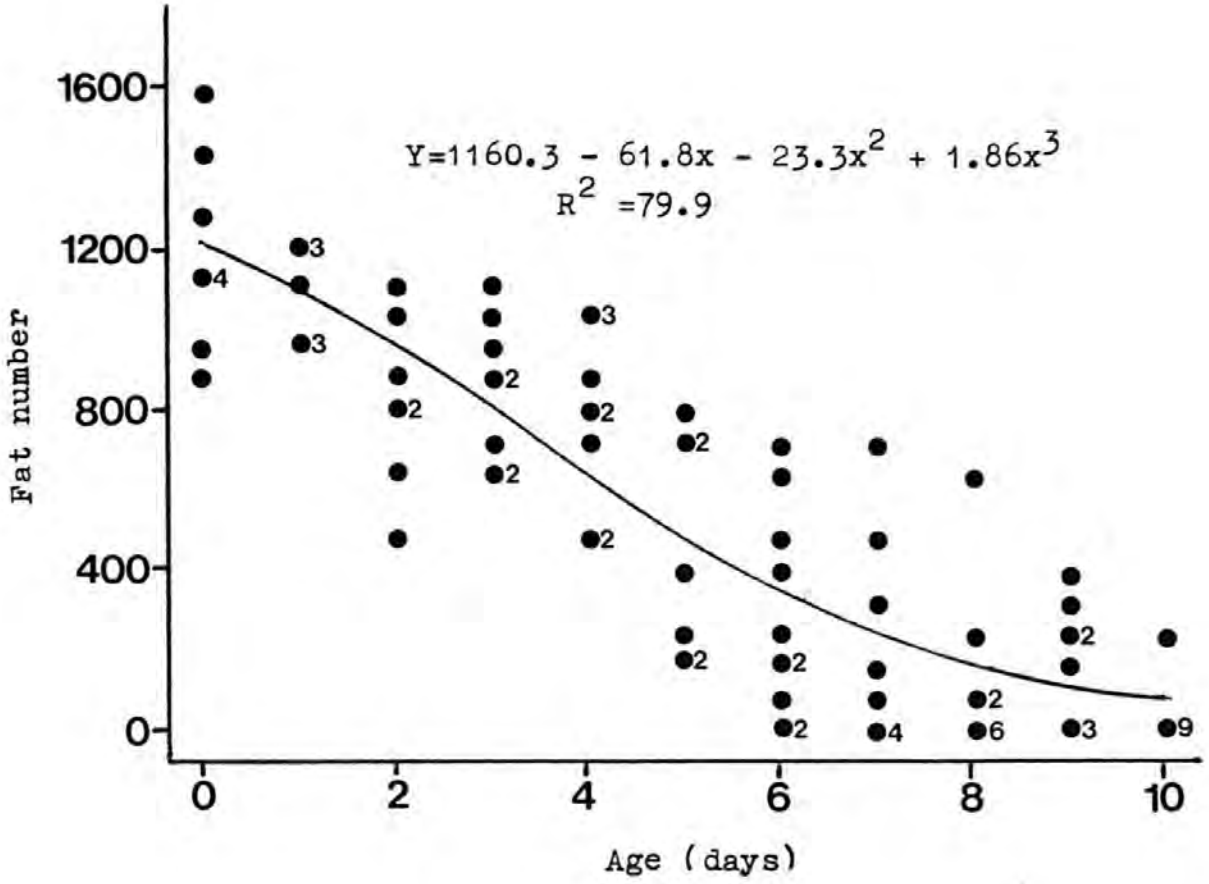


FIG. 8

The relationship between mean fat diameter and age for male cabbage root flies.

	SS	DF	MS	F	
x	0.1916	1	0.1916	361.4	***
x^2	0.0121	1	0.0121	22.8	***
Head width	0.0109	1	0.0109	20.5	***
Residual	0.0560	105	0.0005		
Total	0.2705	108			

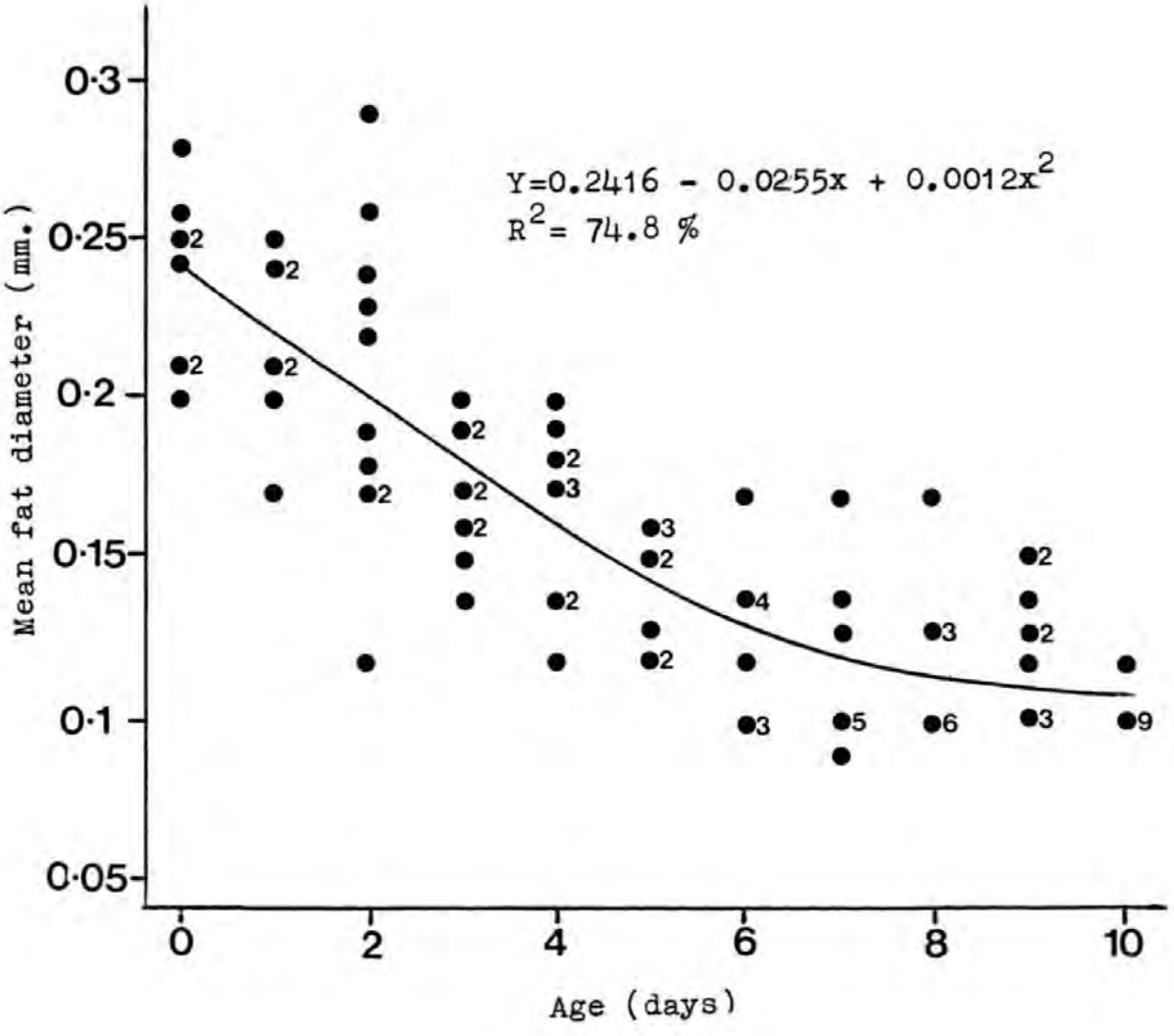


FIG. 9

The relationship between fat number and mean fat diameter for male cabbage root flies.

	SS	DF	MS	F	
x	16538090.	1	16538090.	544.4	***
x^2	1028067.	1	1028067.	33.8	***
Head width	138015.	1	138015.	4.5	*
Residual	3189795.	105	30379.		
Total	20893959.	108			

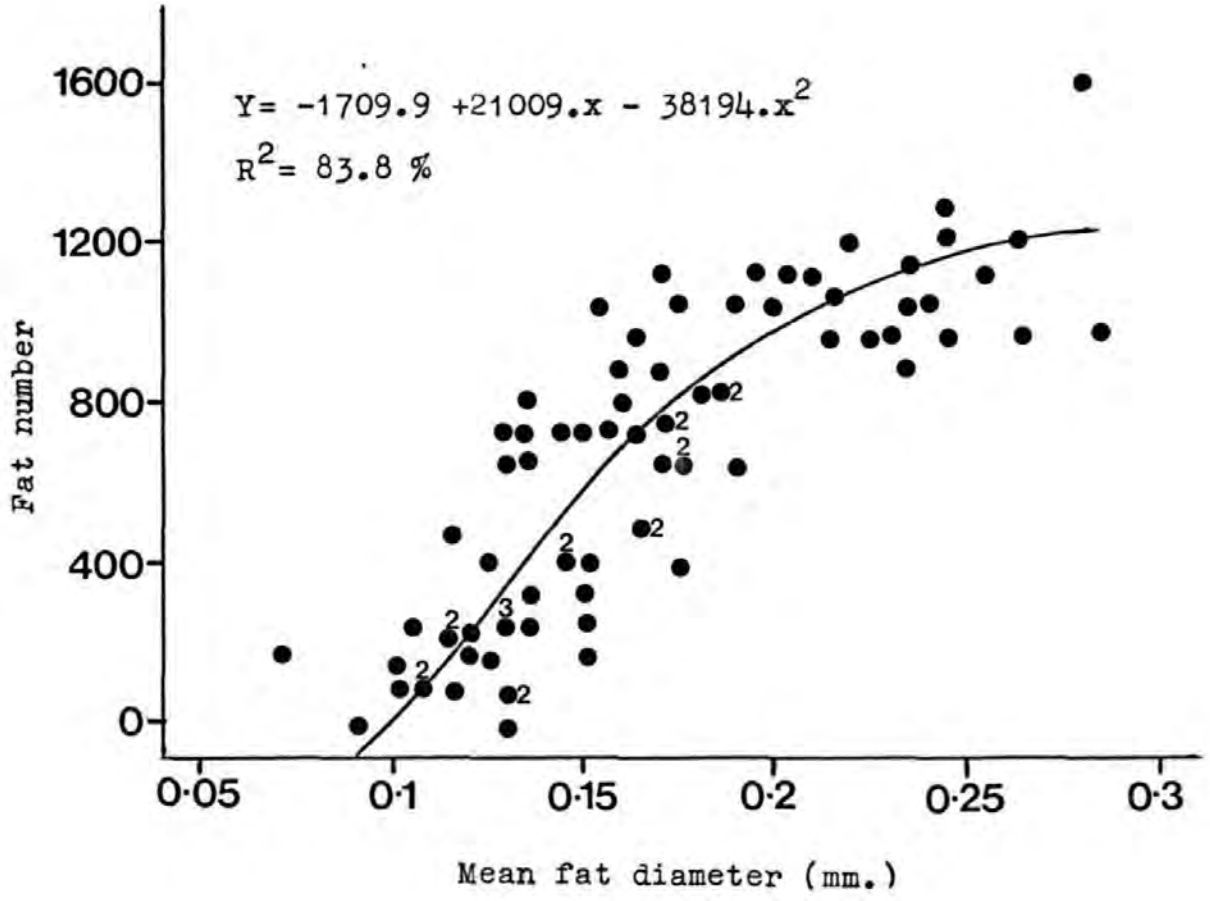


FIG. 10

The relationship between fat volume and age for male cabbage root flies.

	SS	DF	MS	F
x	693.40	1	693.40	261.6 ***
x^2	159.97	1	159.97	60.3 ***
Head	52.77	1	52.77	19.9 ***
Residual	286.32	108	2.65	
Total	1192.45	111		

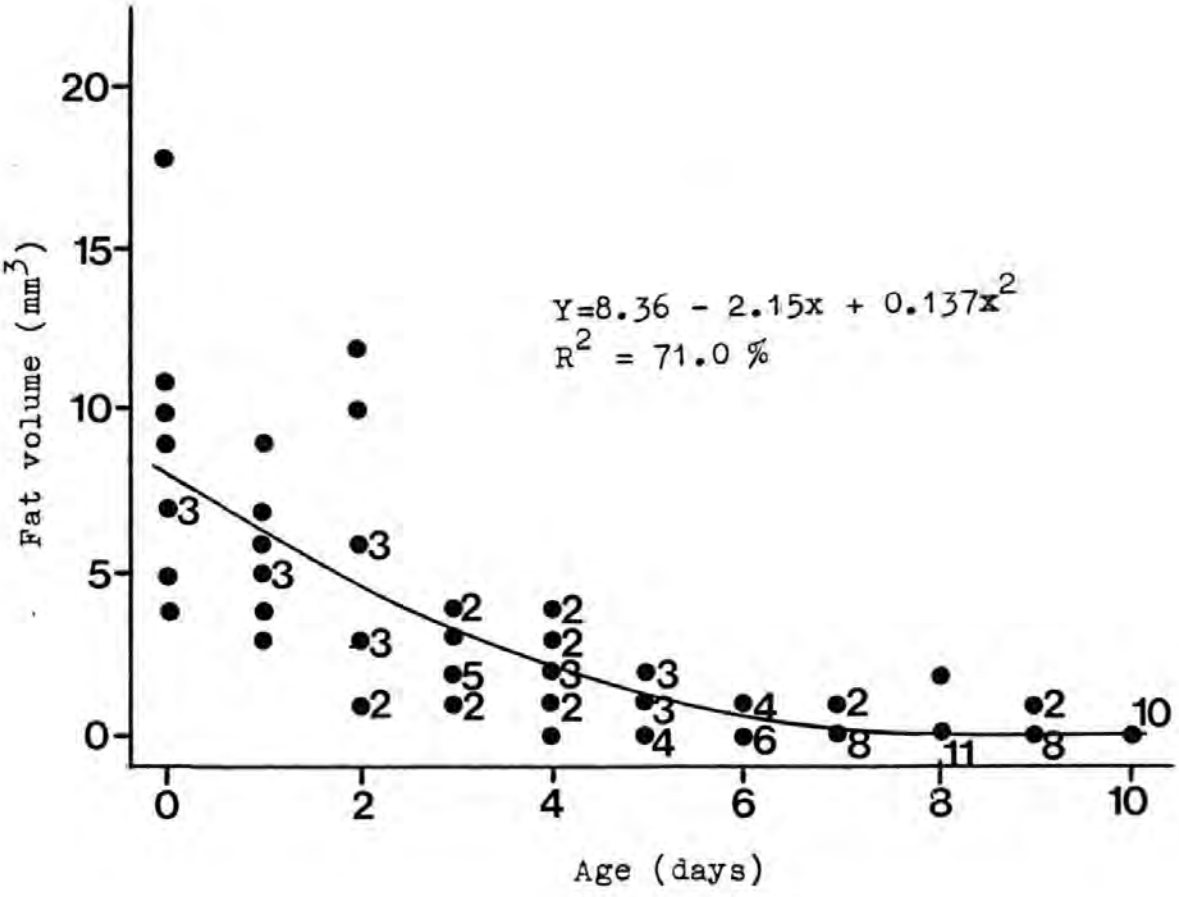
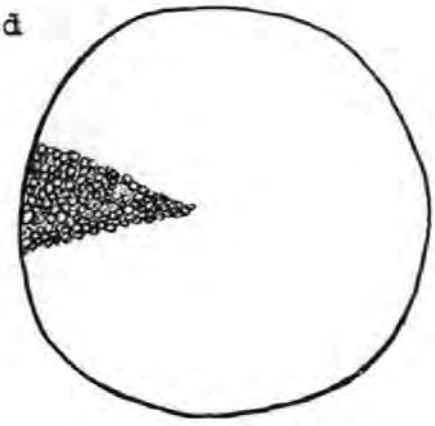


FIG. 11

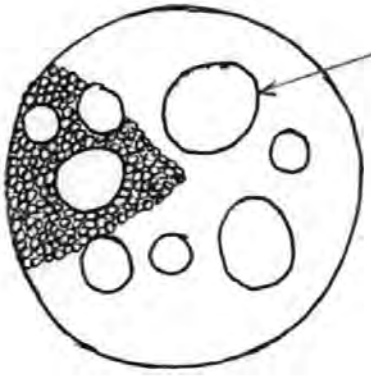
The changes in appearance with age in the pupal fat cells.

Recently emerged

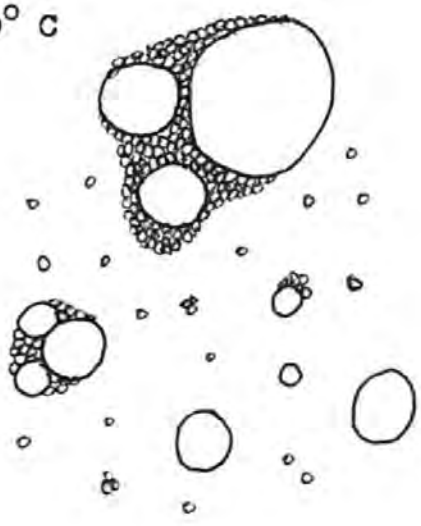


0·1mm

3 days at 20° C



5 days at 20° C



The membrane disintegrates releasing the globules.

explanation of the change in fat number with age for both males and females (Figs 4 & 7). The two sexes can then be compared by fitting the multiple regression model (2).

$$Y = a + b_1x + b_2x^2 + b_3x^3 + b_4H + b_5z + b_6xz + b_7x^2z + b_8x^3z \quad (2)$$

where x = age (days)

H = head width

z = dummy variable

For males ($z = 0$)

$$Y = a + b_1x + b_2x^2 + b_3x^3 + b_4H$$

For females ($z = 1$)

$$Y = (a + b_5) + (b_1 + b_6)x + (b_2 + b_7)x^2 + (b_3 + b_8)x^3 + b_4H$$

The males and females differ significantly in both the first and third power of age, for both fat number and mean fat diameter (Table 5). The males appear to lose the pupal fat more rapidly in the initial two days after emergence, after which the females show a rapid loss of fat.

In previous studies the pupal fat has usually been expressed as a volume, which decreases exponentially with age (Adams & Nelson, 1969; Olson, 1980; Spradbery & Sands, 1981). The volume is a concise summary of the changes in both number and diameter, and can be estimated using equation (3) by assuming the fat cells are truly spherical (Fig. 10).

$$\text{Volume} = \frac{4}{3} (\bar{d}/2)^3 N \quad (3)$$

where $\bar{d}$ = mean fat diameter

N = fat number

This expression will not accurately estimate the true volume of pupal fat, because the cubic power will relatively underestimate the

TABLE 5

The comparison of the regression of fat number and mean fat diameter on age of the male and female cabbage root flies.

Fat number

	DF	SS	MS	F	P
Regression	8	41442661.	5180332.	134.7	c
Age(x)	1	38670000.	38670000.	1005.1	c
x^2	1	688123.	688123.	17.9	c
x^3	1	999386.	999386.	26.0	c
Head width	1	640729.	640729.	11.7	c
Z	1	5911.	6911.	0.2	
xZ	1	224917.	224817.	5.9	a
x^2Z	1	9071.	9071.	0.2	
x^3Z	1	204555.	204555.	5.3	a
Residual	216	8310115.	38473.		
Total	224	49752779.			

Mean fat diameter

	DF	SS	MS	F	P
Regression	8	0.58059	0.07257	127.3	c
Age(x)	1	0.51677	0.51677	914.6	c
X^2	1	0.02763	0.02763	48.9	c
x^3	1	0.00207	0.00207	3.7	
Head width	1	1.00277	0.00277	4.9	a
Z	1	0.02075	0.02075	36.7	c
xZ	1	0.00805	0.00805	14.2	c
x^2Z	1	0.00008	0.00008	0.1	
x^3Z	1	0.00246	0.00246	4.4	a
Residual	216	0.12200	0.00057		
Total	224	0.70259			

a = $P < 0.05$

b = $P < 0.01$

c = $P < 0.001$

volume of cells larger than the mean.

The fat number and mean fat diameter both decline simultaneously with age, and it would be necessary to measure only one variable if they were closely correlated. A second order polynomial provides a good empirical description of the male data (Fig. 9) and was also fitted to the female data to facilitate comparison between the sexes, even though the second power does not explain a significant amount of female variance (Fig. 6). The use of a multiple regression model is not strictly valid since both variables were measured with error. A type II regression should be applied, but multiple regression procedures are only available for type I regression (Sokal & Rohlf, 1969). The error will not be independant of the variables, which could have serious consequences for the significance tests although the fitted parameters should be less seriously affected (Glass, Peckham & Saunders, 1972; Lindeman, 1974).

The pupal fat cells alter in appearance with age (Fig. 11), the component globules gradually increasing in size until the whole cell disintegrates into a large number of smaller globules (Evans, 1935). These globules were too numerous to count, and were excluded from the estimate of the mean fat diameter. The apparent decline in mean diameter (Figs 5 & 8) to a minimum, is caused by this disintegration of the cells which are not then measured.

(b) Male reproductive organs

The testes length and width both alter significantly with age, although only a relatively small proportion of the variance is explained (Table 6). The large number of observations produce the high statistical significance, but the variables would not be practicably useful in age determination. The length and width are

TABLE 6

The results of the regression of the dimensions of the male reproductive organs on age.

	N	Intercept	Slope	R^2	PARTIAL F Age	PARTIAL F Head width
Testes length	108	1.075	-0.019	21.1	29.6[c]	0.03
Testes width	108	0.524	-0.020	59.9	173.2[c]	9.7[b]
Testes lengthXwidth	108	0.559	-0.028	61.7	184.0[c]	6.0[a]
Accessory gland length	107	0.816	-0.008	5.2	7.3[b]	7.9[b]
Acc. gl. width	107	0.273	+0.003	7.7	10.4[c]	5.9[a]
Acc. gland lengthXwidth	107	0.224	+0.005	10.3	15.9[c]	11.9[c]
Vas deferens	95	-	-	-	0.3	3.2

a = $P < 0.05$
b = $P < 0.01$
c = $P < 0.001$

FIG. 12

The relationship between testes length x width for male cabbage root flies.

	SS	DF	MS	F
x	0.8279	1	0.8279	184.0 ***
Head width	0.0269	1	0.0269	6.0 *
Residual	0.4800	106	0.0045	
Total	1.3348	108		

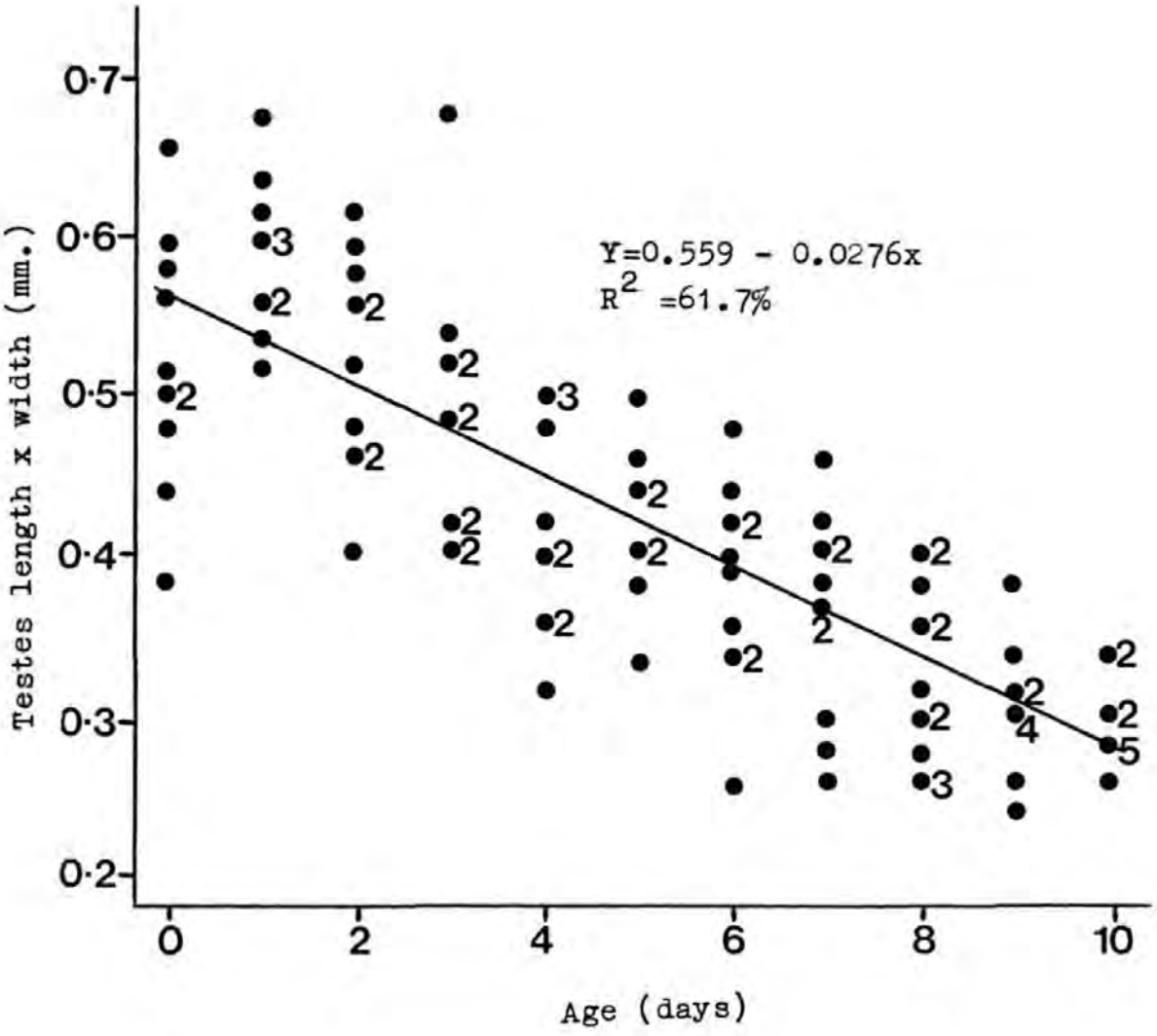


FIG. 13

The relationship between testes colour and age for male cabbage root flies.

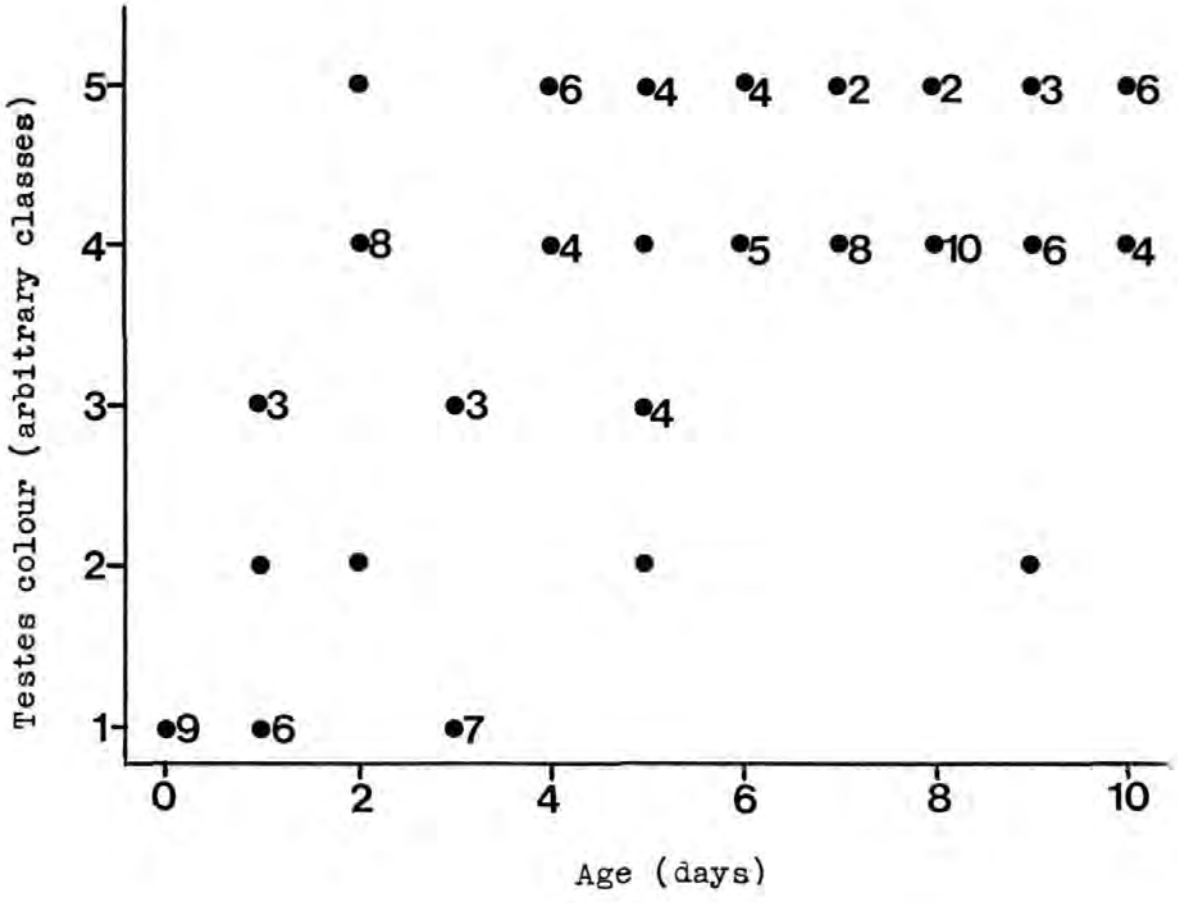


FIG. 14

The relationship between accessory gland length x width for male cabbage root flies.

	SS	DF	MS	F
x	0.02728	1	0.02728	14.6 ***
Head width	0.02223	1	0.02223	11.9 ***
Residual	0.19615	105	0.00187	
Total	0.24567	107		

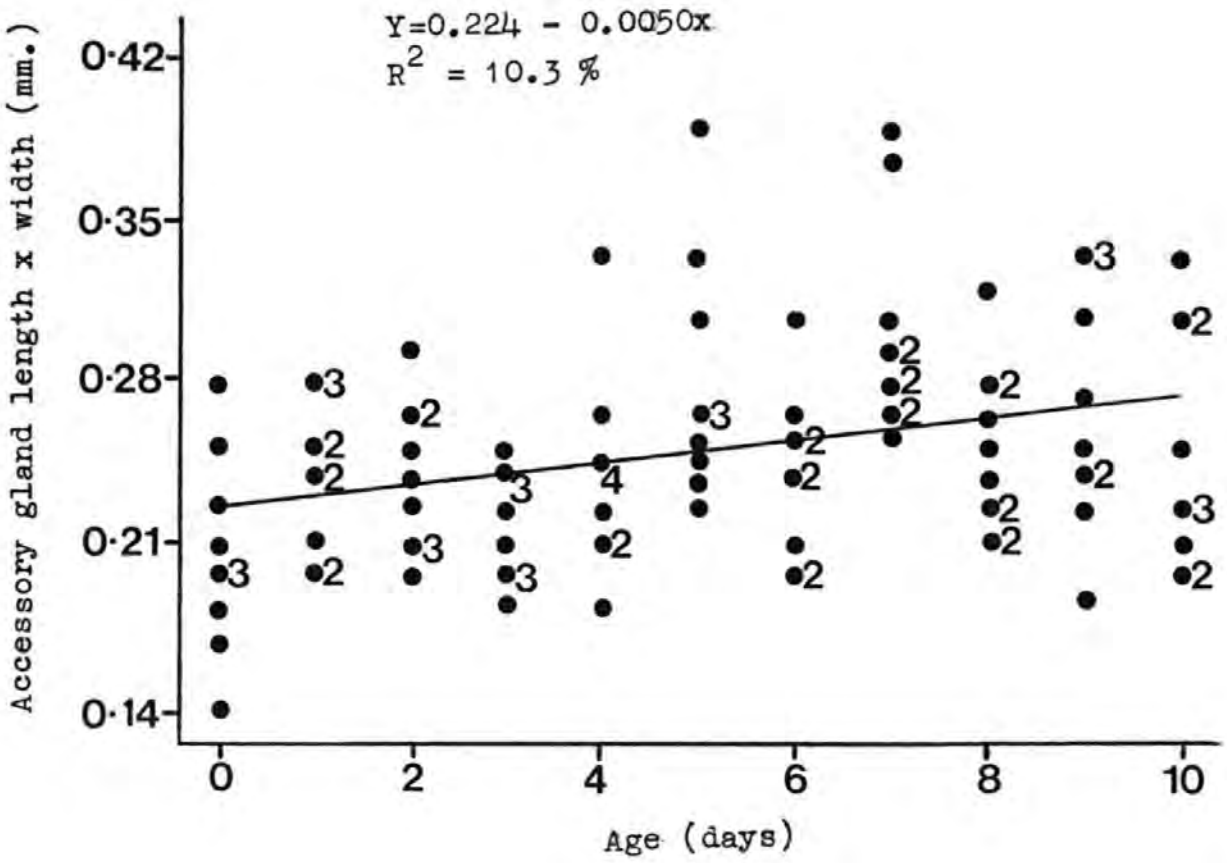
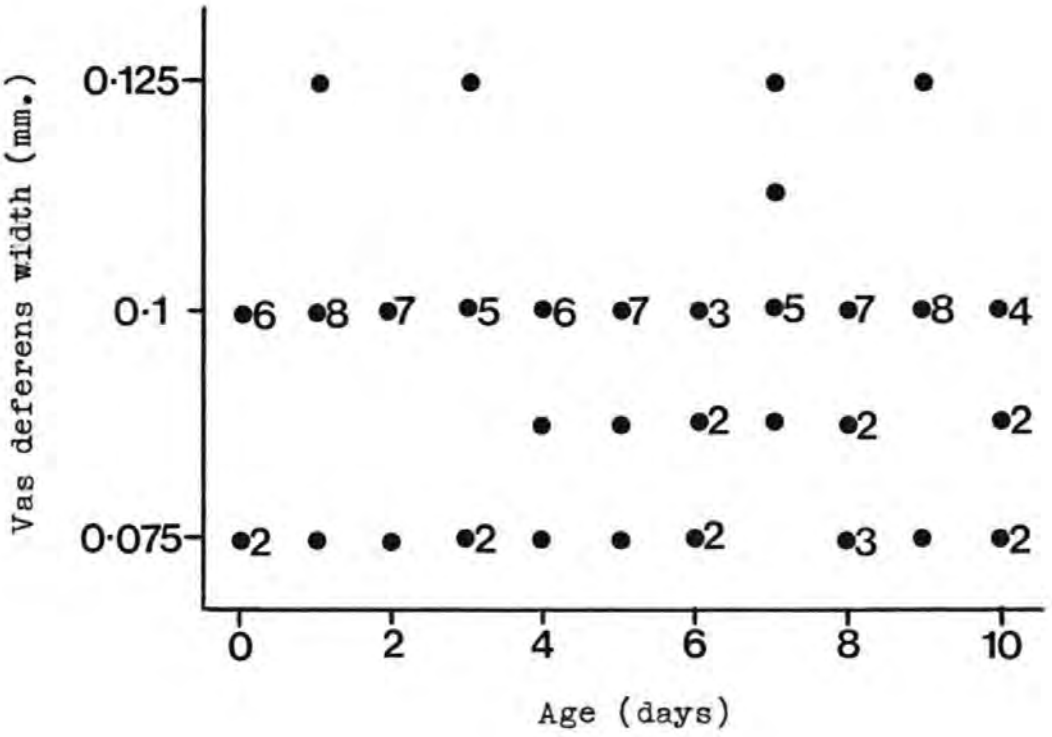


FIG. 15

The relationship between vas deferens width and age for male cabbage root flies.

	SS	DF	MS	F
x	0.096	1	0.096	0.5
Residual	19.038	94	0.210	
Total	19.833	95		



statistically very highly correlated ($r = 0.322$, $N = 108$, $p < 0.001$), but they are not good predictors of each other because of the high individual variation. The two variables both decline with age and could be combined to produce a more useful new variable. The multiplication of length and width will enhance the separation of the different ages and explains a larger proportion of the variance (Table 6; Fig. 12). The overall body size explains a statistically significant proportion of the variance, but this explanation is small compared to that achieved by age. The body size could be ignored with only a small loss of precision. The testes colour changes rapidly with age and could be useful in the recognition of recently-emerged males (Fig. 13).

The accessory gland length and width both alter significantly with age, although the explanation of variance is very low even if the two dimensions are combined (Table 6; Fig. 14). The small differences between the ages are obscured by the large individual variation. The vas deferens width does not alter with age (Fig. 15).

Discussion

The rate of pupal fat loss differs between the males and females. The males initially lose fat more rapidly, but after 2 days at 20°C, the females undergo a rapid increase in the rate of fat loss. The disappearance of the pupal fat in females has been experimentally related to ovary development (e.g. Munro & Bailey, 1965). The fat body provides a source of nutrients for the high demand caused by the developing ovaries. What drives the pupal fat loss in males is uncertain, but it may be under hormonal control with the fat passing to the forming adult fat body (Adams & Nelson, 1969). The adult

diet could have an important effect on the rate of disappearance of the pupal fat (see later).

It is only necessary to measure one variable, as the changes in fat number and mean fat diameter are closely correlated. The enumeration of fat number is unlikely to be as accurately measured as mean fat diameter, which can be rapidly assessed from a small number of random measurements.

The pupal fat, testes colour and the testes dimensions alter significantly with age, and would seem to offer useful characters in age determination of males. The body size explains only a small proportion of the variance and can be omitted with little loss of precision, but would reduce the cost of data collection.

CHAPTER II.5

The use of pupal fat and reproductive organs for male age determination

Introduction

The preceding experiments have identified the fat number, mean fat diameter, testes colour and testes dimensions, as useful candidates for male age determination. These variables all demonstrate a clear trend with age, but the individual variation prevents the accurate prediction of age from any one variable. The variables are all mutually correlated, so they should all be considered together as a multivariate problem. It is necessary to discover the optimal combination of characters to distinguish between the different ages. Discriminant analysis was specifically designed for the separation of groups on the basis of multivariate observations. A linear discriminant function is calculated to describe the discontinuous (nominal) dependent variable using the set of continuous independent variables. This can be contrasted with regression analysis where a continuous dependent variable is described by any mixture of continuous or discontinuous variables. The two methods are based on different statistical assumptions; regression analysis requires normality of the dependent variable, whereas discriminant analysis requires multivariate normality of the independent variable. This multivariate normality can be ensured by the specification of the groups in advance of data collection (Kleinbaum & Kupper, 1978). The daily collection of flies represent discrete groups, as the adult emergence is a discontinuous process (Ch. II.2) and these groups are the basis for all the measurements of aging characters.

Methods

The data collected previously for the 0-10 day old male flies will be used for the discriminant analysis, providing a basic data set of 112 cases. The computation was performed using the DISCRIMINANT subroutine of the SPSS package (Nie et al., 1975).

Results & Discussion

A summary of the observations of the pupal fat and the reproductive system are given in Appendices 2 and 3.

(a) The relative discriminant ability of the variables

The initial step is to identify those variables which demonstrate significant power of discrimination. A stepwise procedure was chosen with one variable being added into the analysis at each step. The variable is selected to maximise the partial F, after adjusting for the variables already included in the analysis.

The Wilks' lambda statistic is an inverse measure of the discriminatory power of a variable; the larger the value of lambda, the smaller the power of discrimination shown by that variable. The lambda can be converted into a X^2 statistic for a convenient test of statistical significance. All the variables are found to show significant power of discrimination (Table 7a), though fat number and testes colour are responsible for the majority of the decrease in the value of lambda. The mean fat diameter and testes size do not greatly enhance discrimination, and they could reduce the separation of the groups through interaction between the variables.

(b) Deriving the discriminant function

A discriminant function is a weighted linear combination of the variables (1).

TABLE 7

A

The results of the discriminant analysis of the daily age-groups of the males .

Step	Enter	Wilks' Lambda	Significance
1	FAT NUMBER	0.17735	P < 0.001
2	TESTES COLOUR	0.05144	..
3	MEAN FAT DIAMETER	0.03963	..
4	TESTES L x W	0.03100	..

B

Function	%Variance explained	After function	Wilks' Lambda	Chi^2	DF
		0	0.0310	359.6^c	40
1 *	85.8	1	0.3236	116.8^c	27
2 *	10.8	2	0.7071	35.9^c	16
3 *	2.3	3	0.08836	12.9	7
4	1.2				

*= functions used in remaining analysis

C

Standardised discriminant function coefficients

	Function 1	Function 2	Function 3
Mean fat diameter	0.293	0.078	1.193
Testes colour	-0.645	0.767	0.020
Fat number	0.480	0.464	-0.823
Testes L x W	0.282	0.292	-0.303

D

		Predicted group										
	N	0	1	2	3	4	5	6	7	8	9	10
Actual group												
0	10	10	0	0	0	0	0	0	0	0	0	0
1	10	4	5	0	1	0	0	0	0	0	0	0
2	10	0	0	7	1	2	0	0	0	0	0	0
3	10	2	0	1	7	0	0	0	0	0	0	0
4	10	0	0	1	0	7	1	1	0	0	0	0
5	10	0	0	0	1	1	5	2	0	0	1	0
6	10	0	0	0	0	2	0	1	2	3	1	1
7	10	0	0	0	0	1	0	1	3	2	2	1
8	12	0	0	0	0	1	0	0	1	5	0	5
9	10	0	0	0	0	0	1	0	0	1	6	2
10	10	0	0	0	0	0	0	0	0	1	0	9

58% correctly classified

$$L = a + b_1\bar{x}_1 + b_2x_2 \ldots b_nx_n \qquad (1)$$

The discriminant score (L) is used to assign an unknown individual to a group that it most resembles, based on the distance (in multivariate space) from the centre of the group, and the probability of observing a distance of that magnitude (Kleinbaum & Kupper, 1978; Lindeman, Merenda & Gold, 1980).

It is possible to generate a virtually limitless series of functions, but of decreasing discriminatory ability. The functions are tested, after they each have been calculated, to determine whether a statistically significant amount of discriminant information remains (Table 7b). The first three functions account for the majority of the variance, and will be used for classification. The right hand side of the table indicates the change in Wilks' lambda as the information in successive functions is removed.

(c) <u>The standardised discriminant coefficients</u>

The standardised coefficients could be used for the calculation of the discriminant score, if the variables were transformed to a standardised scale. The coefficients are of analytical interest, since they represent the relative contribution of each variable to the function. They can be used to identify the dominant variable which can be used to 'name' that function. The testes colour is dominant in the first function (Table 7c) making a negative contribution. In the second function, testes colour is again dominant, but now making a positive contribution. The third function is dominated by the mean fat diameter. The discrimination between the different ages is thus largely dependent on the testes colour and mean fat diameter.

(d) The classification phase

The effectiveness of the discriminant functions can be investigated by classifying the original individuals on the basis of their discriminant scores. It was found that only 58% of the cases were correctly classified to the group to which they actually belong (Fig. 7d). The discrimination between groups is statistically very significant, but the groups cannot be adequately separated because of the wide individual variation. The overlap of the different ages can be clearly seen in the plots of fat number and mean fat diameter against age (Figs 4-9) (Cwilich & Mer, 1952; Anderson, 1964). However, there is an indication that a smaller number of age-groups might be recognized, after combining individual days. This can be illustrated by the zero and one day old flies, where only 75% were correctly classified to the correct day (Fig. 7d), but 95% were allocated between the two days.

(e) Cluster analysis

The groups are specified a priori for discriminant analysis, and any attempt to search for meaningful groups a posteriori requires the use of clustering techniques. The objective is to locate groups in the data, where the variation between groups is greater than the variation within the groups. The cluster analysis was calculated using the recommended procedure of the CLUSTAN III package (Wishart, 1978). The data were standardised and the principal components were calculated. A similarity matrix was created between the individual cases using the error sum of squares criterion. A hierarchical clustering was then performed by Ward's method, producing a dendrogram summary (Fig. 16). This classification is a robust, global solution as a reclassification phase (RELOCATE, Wishart, 1978) causes no significant changes.

The clustering identifies three distinct groups, which correspond strongly with the ages of the individuals (Fig. 16). The first group contains the zero and one day old flies; the second group contains the 2-4 day old flies; and the third group contains the 5-10 day old flies. Overall, 87.5% of the cases were classified to the correct age-group.

(f) Definition of the new age-groups

The numerical boundaries of the age-groups were estimated from the plots of fat number, mean fat diameter and testes colour against age (Table 8). The original data were then recoded and a discriminant analysis calculated, where 78.6% of the individuals were correctly classified. In practice, the precise measurement of fat number and mean fat diameter is time-consuming, so it would be desirable to simplify the procedure. The fat number and diameter are closely correlated, so only one need be measured. The mean fat diameter can be rapidly assessed from a small random sample, and will be given the greatest weight in classification. There is a small improvement in classification, with 91.1% of the individuals being correctly assigned to their age-group.

(g) An independent test of the discriminant function

It is better practice to test the discriminant model with independent data, rather than with the data used in its derivation (Lindeman, Merenda & Gold, 1980). An additional 46 male flies were dissected and scored for fat number, fat diameter and testes colour (Appendix 4), and 82.6% were classified correctly.

FIG. 16

The hierarchical clustering of the male flies on the basis of pupal fat number, mean fat diameter, testes colour and testes size.

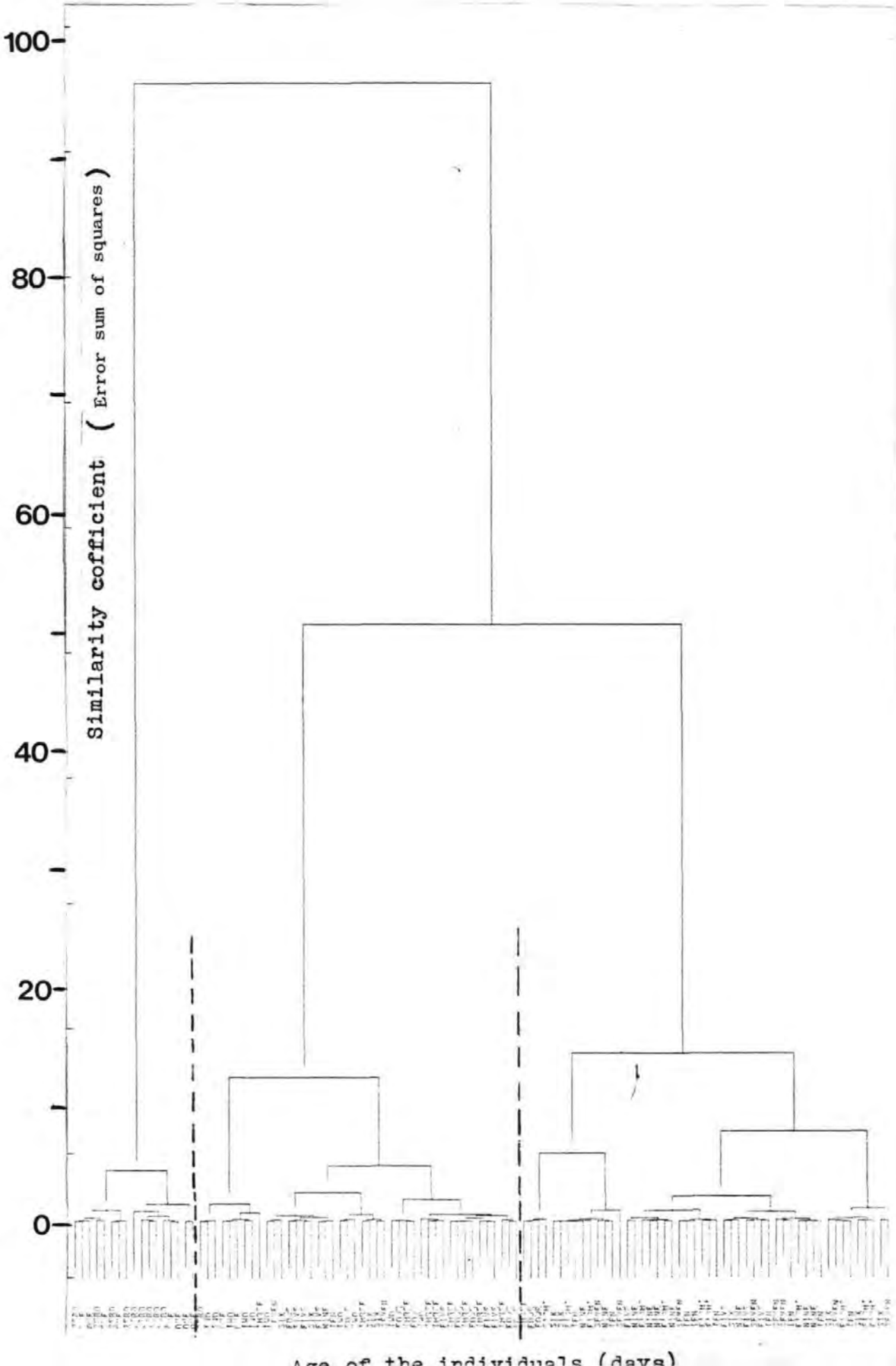


TABLE 8

The definition of the male age-groups.

AGE GROUP	AGE (days 20°C)	FAT NUMBER	MEAN DIAMETER (mm)	TESTES COLOUR
1	0,1	> 900	> 0.225	Orange
2	2-4	600-900	0.150-0.225	Orange-red + red
3	5-10	< 600	< 0.150	Red

AGE-GROUP	AGE (days 20°C)	MEAN FAT DiAMETER (x_1)	MEAN TESTES COLOUR (x_2)	MEAN FAT NUMBER (x_3)
1	0,1	1.500	1.200	1.000
2	2-4	2.067	1.700	1.700
3	5-10	2.887	2.000	2.887

FUNCTION 1

$$L_1 = -8.3756 + 0.7108x_1 + 1.5945x_2 + 1.7125x_3$$

FUNCTION 2

$$L_2 = -3.1201 + 0.4818x_1 + 2.9542x_2 - 1.4760x_3$$

AGE-GROUP	MEAN DISCRIMINANT SCORE ($\bar{L}_1+\bar{L}_2$)
1	-4.0119
2	-0.8957
3	+2.4223

The methods of assigning an individual to a group are desribed in Kleinbaum & Kupper (1978) and Lindeman,Merenda & Gold (1980) The simplest method is to use a cut-off point of $\frac{1}{2}(\bar{L}_n+\bar{L}_{n+1})$

Conclusions

Any method of age determination will have its associated advantages and disadvantages, and it is necessary to reconcile these with the requirements of the experiment. The method based on pupal fat and testes colour has the major advantages of being rapid and applicable to flies that have been stored for long periods in a deep freeze. The major disadvantage of the method is the error rate (at least 10%) due to individual variation. The method allows the recognition of only three age-groups, which are not of equal duration. In a small proportion of cases, the abdomen becomes detached from the fly which cannot then be classified.

A major requirement of the present study is the ability to process a large number of flies, so the need is for a rapid method of age assessment. The larger number of flies used will partially offset the classification errors. The small number of age-groups means that the age cannot be precisely established, but the larger number of flies in each age-group will improve the statistical reliability. The loss of the abdomen was only a significant problem for flies that had been stored in a deep freeze for six months or more. The method of male age determination is adequate for the requirements of the present study.

CHAPTER II.6

An improved method of female age determination

Introduction

The detection of follicular relics for the recognition of parous females, is often difficult and requires a microscopic examination. Anderson (1964) proposed that the pupal fat would provide a useful character for the rapid separation of nulliparous and parous females. The relationship between pupal fat number and mean fat diameter with ovary stage, can be investigated using the data previously gathered in connection with the description of the age-related changes.

Results

There is a clear separation between nulliparous and parous females (Figs 17 & 18), and the dividing line can be estimated as a fat number of 600, and a mean fat diameter of about 0.19 mm. These criteria together will correctly classify 97.3% of the individuals.

Discussion

The pupal fat provides a fast and accurate method of separating nulliparous and parous females. There are a small number of ambiguous individuals, which cannot be classified with certainty by their pupal fat. In these cases, a check can be made for follicular relics, expansion of the ovariole or the distance between the most mature follicle and the junction of the ovariole and the paired oviducts (Hawkes, 1975).

FIG. 17

The relationship between fat number and the age-class for female cabbage root flies.

	SS	DF	MS	F	
x	20556807.	1	20556807.	330.6	***
x^2	132393.	1	132393.	2.0	
x^3	430918.	1	430918.	6.9	**
Head width	491347.	1	491347.	7.9	**
Residual	6715825.	109	62184.		
Total	28327281.	112			

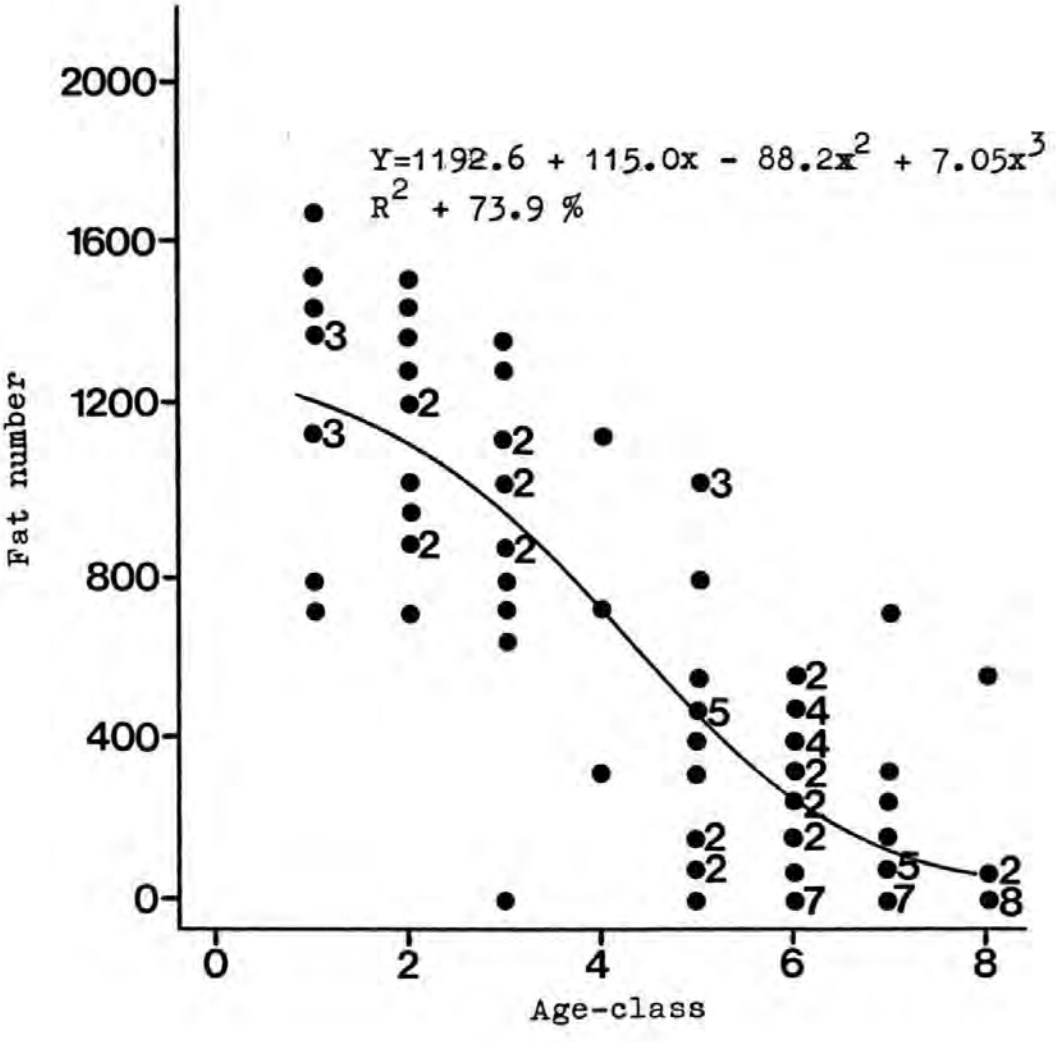
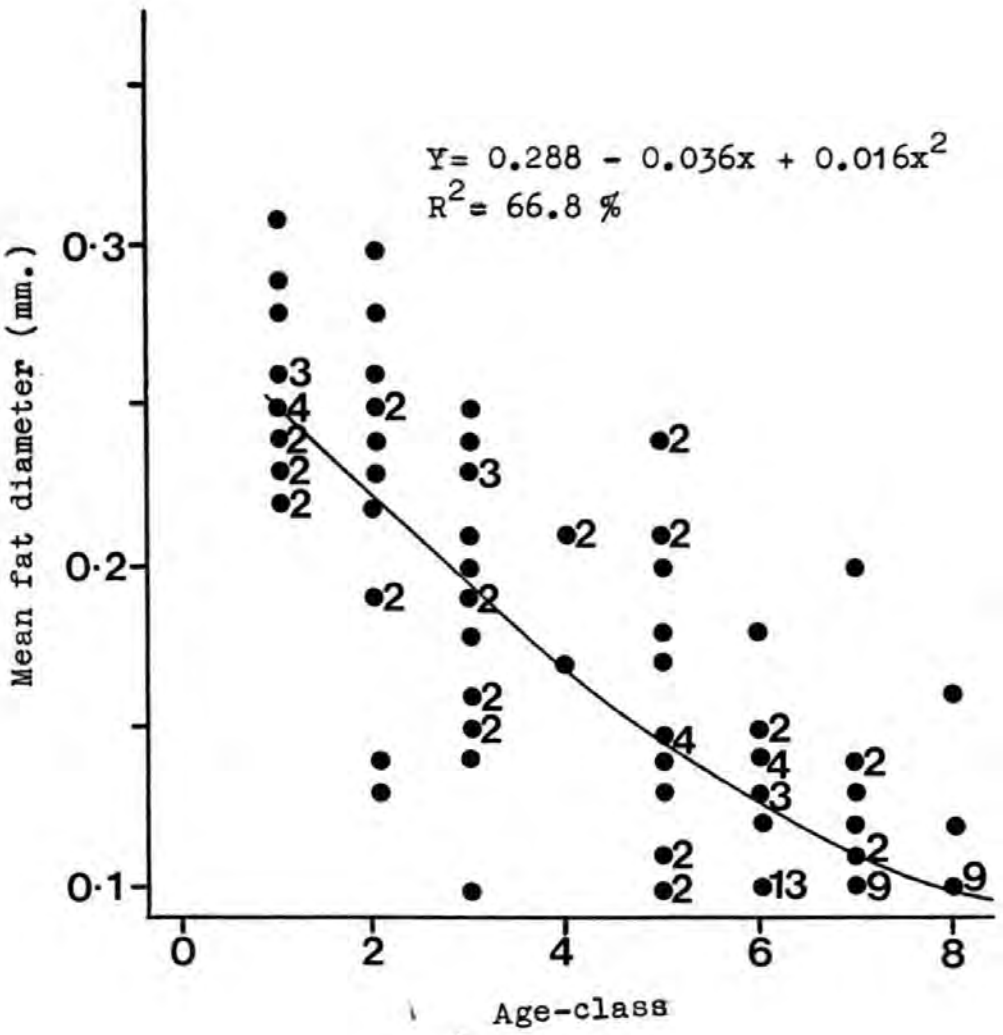


FIG. 18

The relationship between mean fat diameter and the age-class for female cabbage root flies.

	SS	DF	MS	F
x	0.27461	1	0.27461	249.6 ***
x^2	0.00504	1	0.00504	4.5 *
Head width	0.01276	1	0.01276	11.6 ***
Residual	0.12279	109	0.00113	
Total	0.41520	112		



CHAPTER II.7

The comparison of the age determination in two independent populations

Introduction

The method of age determination has been derived from measurements of laboratory-reared flies. There are quite different selection pressures in a laboratory culture than the natural environment, so it is uncertain whether the method can be applied to wild flies. The culture flies are provided with a high quality diet in abundance, so competition may be reduced, and there is no predation or host plant finding hazard. The small population could allow significant genetic drift. The wild and cultured flies have been observed to differ in their rates of dispersal (Finch & Skinner, 1975; Hawkes, Patten & Coaker, 1979), but not in their eclosion pattern (Thompson & Price, 1979).

Ideally wild flies of known age should be collected for comparison with the culture flies, which would require either the trapping of emerging adults in the field, or the field collection of pupae for emergence in the laboratory. The two alternatives were impracticable because of the high cost of collection, so the method will be tested by the comparison of two independent cultures.

Methods

A batch of approximately 200 pupae were obtained from the cabbage root fly culture of the National Vegetable Research Station (Wellesbourne). The emerged adults were collected at 10 a.m. and transferred to perspex rearing cages. The flies were supplied with 10% sucrose solution on a cotton wool plug, and kept at 20 $\pm$ 1°C under a 16 hour light/8 hour dark photophase. The flies were

dissected after an interval of 0-7 days, and scored for fat number, mean fat diameter, testes colour and testes dimensions.

Results

A summary of the results is given in Appendix 4. The relationship between the pupal fat and age differs between the two cultures. The Plymouth data were best described by a second order polynomial for mean fat diameter (Fig. 8), and a third order polynomial for fat number (Fig. 7). The Wellesbourne data are adequately described by a linear regression for both fat number and fat diameter (Figs 19 & 20); the higher order terms do not explain significant additional variance. The quantity of pupal fat was dependent on body size for the Plymouth males, but independent of body size for the Wellesbourne males. This difference could be caused by the measurement of a smaller sample of males from Wellesbourne. No measurements were made on 8-10 day old Wellesbourne males, so the curvature of the plots against age are less obvious, which reduces the significance of the higher powers of age.

The two populations can be directly compared by means of dummy variables in a multiple regression model fitted to the combined data (Kleinbaum & Kupper, 1978). The Wellesbourne males are significantly larger ($t = 6.41$, $n = 135$, $p < 0.001$) than the Plymouth males, so head width will be included as a covariate in the model. The two populations differ significantly in their intercepts for the regression of fat number on age, and differ significantly in their slopes for the regression of mean fat diameter on age (Table 9; Fig. 21). The Wellesbourne males contain slightly fewer fat cells, and the mean diameter decreases slightly more rapidly with age than the Plymouth males.

FIG. 19

The relationship between mean fat diameter and age for male cabbage root flies from the Wellesbourne culture.

	SS	DF	MS	F
x	0.20277	1	0.20277	321.9 ***
Head	0.00063	1	0.00063	0.9
Residual	0.03891	58	0.00067	
Total	0.24231	60		

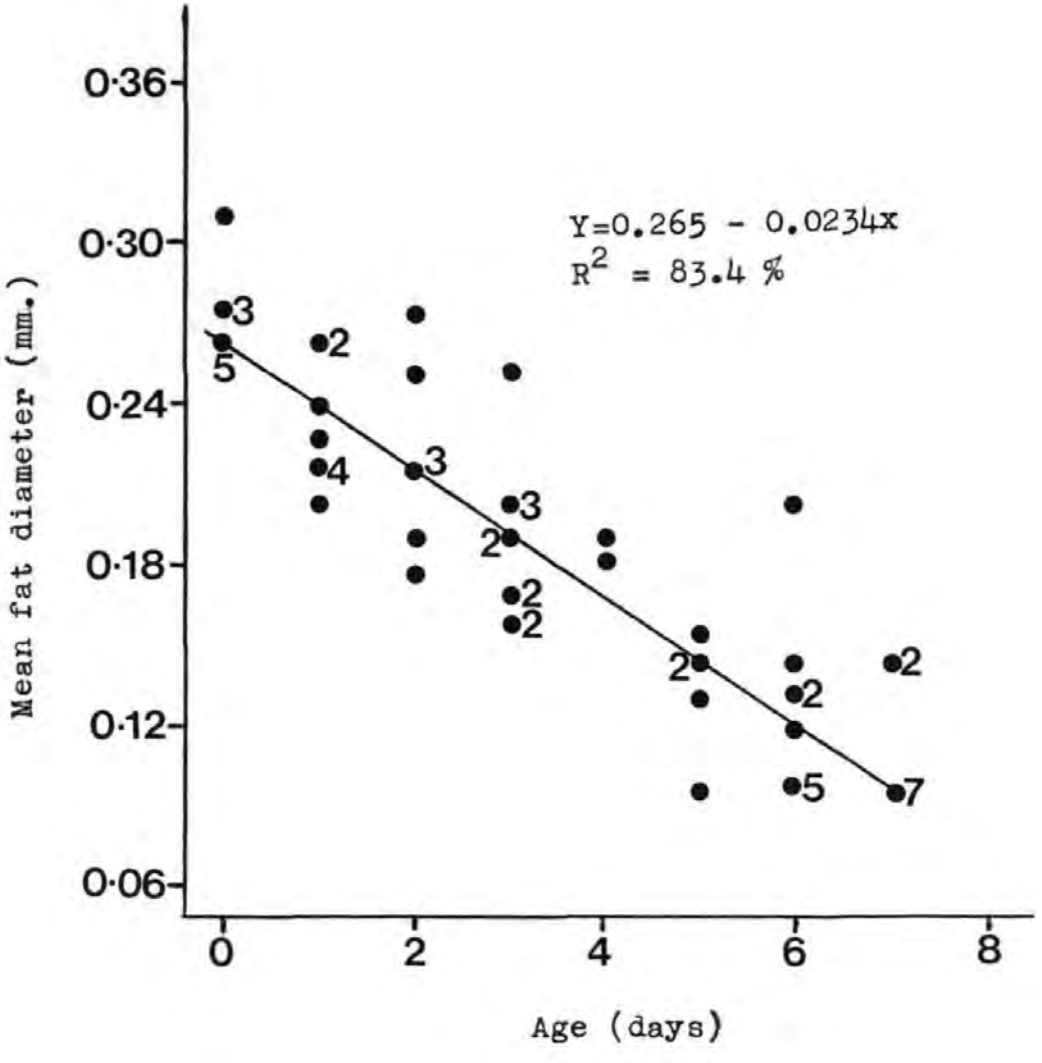


FIG. 20

The relationship between fat number and age for male cabbage root flies from the Wellesbourne culture.

	SS	DF	MS	F	
x	9755867.	1	9755867.	209.2	***
Head	33374.	1	33374.	0.7	
Residual	2705101.	58	46640.		
Total	12494342.	60			

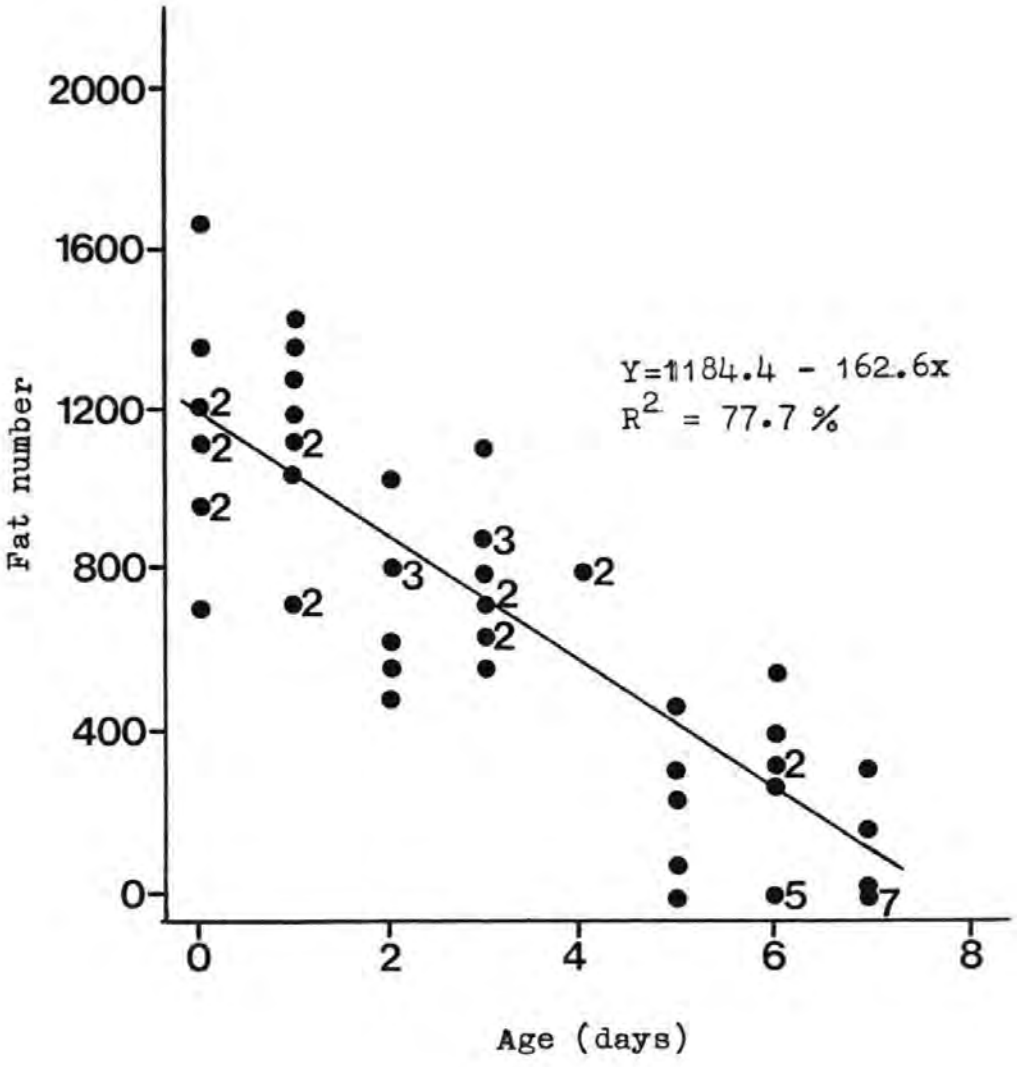


TABLE 9

The comparison of the regressions of male fat number and mean fat diameter on age betwwen Plymouth and Wellesbourne flies.

Fat number

	DF	SS	MS	F	P
Regression	8	27619419.	3452427.	85.6	c
Age(x)	1	25828108.	25828108.	650.3	c
x^2	1	537950.	537950.	13.3	c
x^3	1	483635.	483635.	12.0	c
Head width	1	369008.	369008.	9.1	b
Z	1	314759.	314759.	7.8	b
xZ	1	68157.	68157.	1.7	
x^2Z	1	513.	513.	0.01	
x^3Z	1	17303.	17303.	0.4	
Residual	164	6615433.	40338.		
Total	172	34234857.			

Mean fat diameter

	DF	SS	MS	F	P
Regression	8	0.46297	0.07716	130.8	c
Age(x)	1	0.41173	0.41173	697.8	c
x^2	1	0.03158	0.03158	53.5	c
Head width	1	0.00955	0.00955	16.2	c
Z	1	0.00197	0.00197	3.3	
xZ	1	0.00786	0.00786	13.3	c
x^2Z	1	0.00028	0.00028	0.5	
Residual	166	0.0983	0.00059		
Total	172	0.56127			

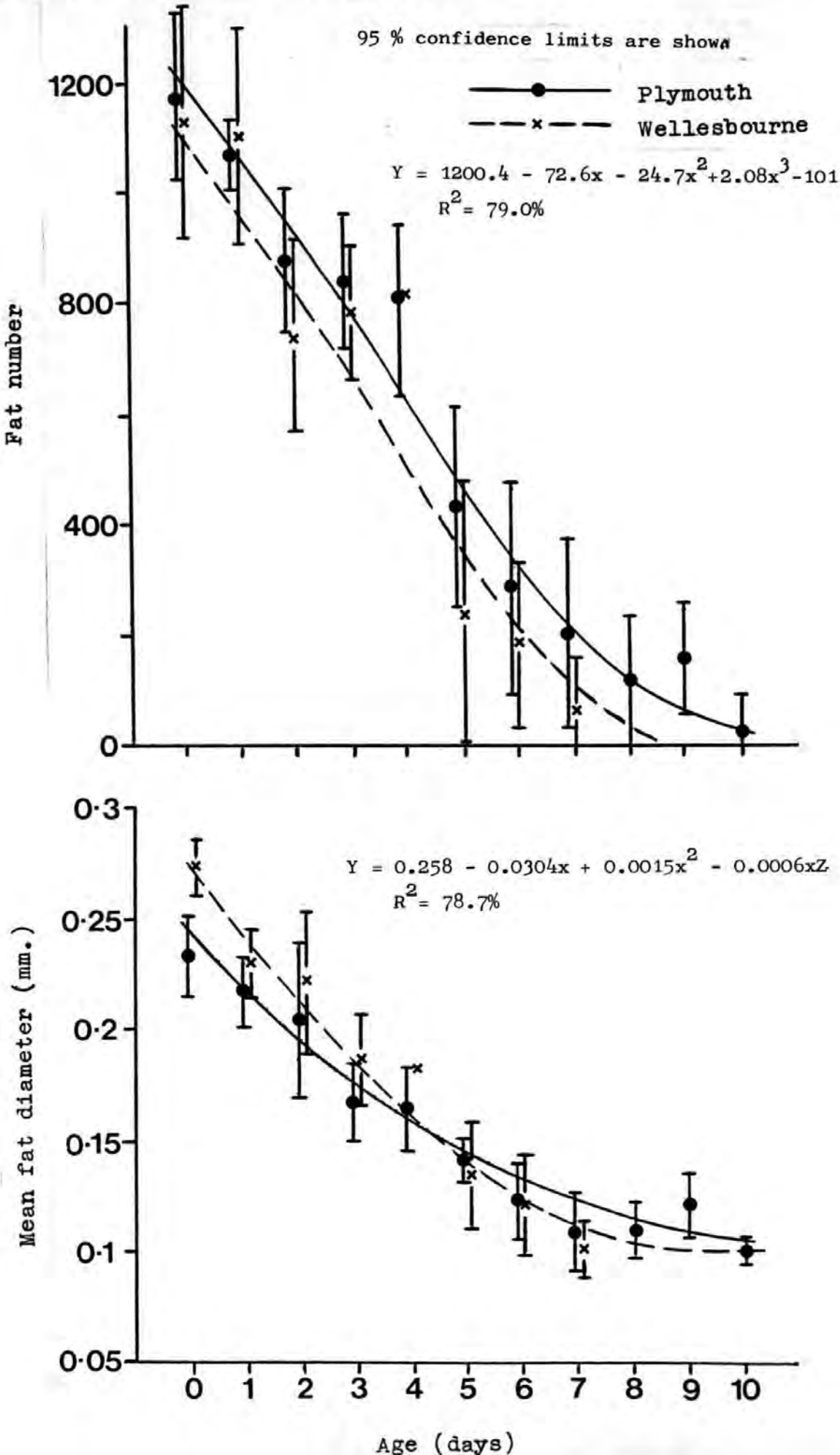
a = $P < 0.05$

b = $P < 0.01$

c = $P < 0.001$

FIG. 21

The comparison of the age-related changes in the fat number and mean fat diameter of laboratory-reared cabbage root fly males from Plymouth and Wellesbourne.



Discussion

The flies from the two cultures differ in the quantity and rate of change of the pupal fat. These differences will cause errors in the classification of the Wellesbourne males according to criteria derived from measurements on the Plymouth males. The differences are small, so 86.9% of the individuals were correctly classified by the discriminant function.

The changes in fat quantity and testes colour occur in the same sequence in both populations, so the age-groups can be used as a physiological age indicator. All the flies of a particular age-group will have reached the same developmental stage and will be directly comparable, although they will differ in actual chronological age.

CHAPTER II.8

The use of age determination methods for field populations

Introduction

The age determination methods have been shown to reflect the changes in age in laboratory experiments, and can be applied to the field samples. The age structure would be expected to change with time (e.g. Davies, 1963; Detinova, 1968; Jones, 1971; Begon, 1976b), and also with distance from the emergence site. The age structure can provide a useful indication of the location of the sources of emerging flies, and whether the population is increasing or declining. The age-groups will also form the basis for the estimation of rates of dispersal in this study.

Methods

All the flies caught at the various sample times in the different experiments (Ch. III.3) were dissected and assigned to one of the age-groups. The small numbers of flies with missing abdomens were apportioned to the age-groups in proportion to the classified flies. The relative changes in age structure can be best seen after the total catch has been standardised to a constant value.

It was thought that the flies might delay emergence on the live-stock rearing farms, where the brassica crops are not planted until the second generation of cabbage root fly. This possibility was investigated at Great Englebourne Farm by continuing the sampling with yellow water traps through the second generation at the site of emergence of the first generation. The details of the site and trap layout are given in Ch. III.3. In 1980, the site of the first

generation emergence was isolated (over 600 m.) from all other potential sources of flies, which would prevent any significant input of flies (Finch & Skinner, 1975). The hedgerows contain very few wild crucifers, so there will be very few flies emerging from this source. In 1981, the emergence site of the first generation was less isolated (240 m.) from other sources of cabbage root flies, but only a small population of cabbage root fly developed at these other sources.

Results & Discussion

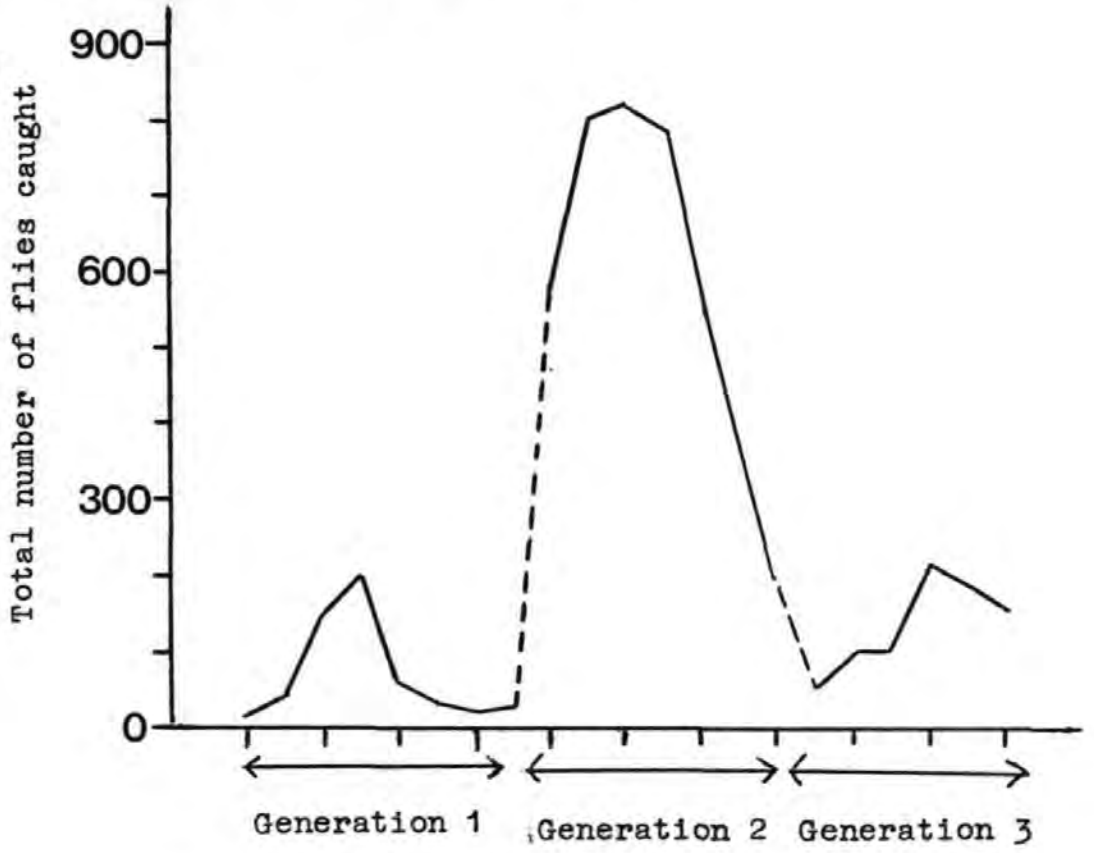
The three generations per year can be clearly identified (Finch, 1977). The number of flies caught rises to a sharp peak due to emergence, followed by a rapid decline as the flies gradually die (Figs 22 & 23). The smaller scale fluctuations on this pattern may be caused by changes in the weather (e.g. temperature, rainfall) affecting the trap catch (Miles, 1954; Finch & Skinner, 1975).

The maximum catch of males occurs earlier than for females, because of their earlier emergence from the pupae (Finch, 1977). The maxima of the different age-groups occur at different times; the younger age-groups generally reaching a maximum before the older age-groups (Figs 22-27). The proportion of the older age-groups gradually increase through the generation, and the age structure provides useful additional information for the separation of the generations (Figs 22-25). The emergence of a new generation is clearly marked by the appearance of young flies.

There is some evidence for delayed emergence of the first generation at Great Englebourne. There was a peak in the catch at week 10 (in 1980) for the traps at the first generation emergence site, that can only be attributed to delayed emergence of first generation flies

FIG. 22

The change in the age structure of the female population with time at Venn Farm in 1980.



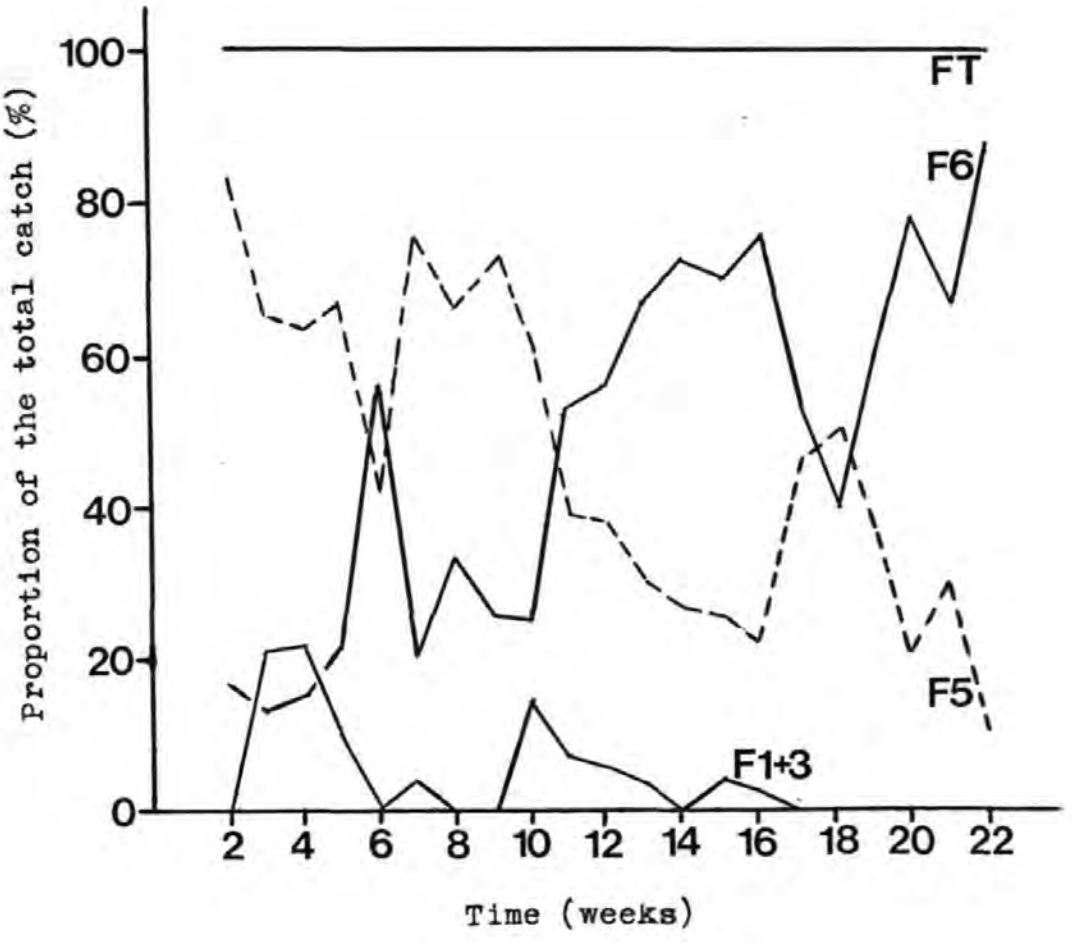
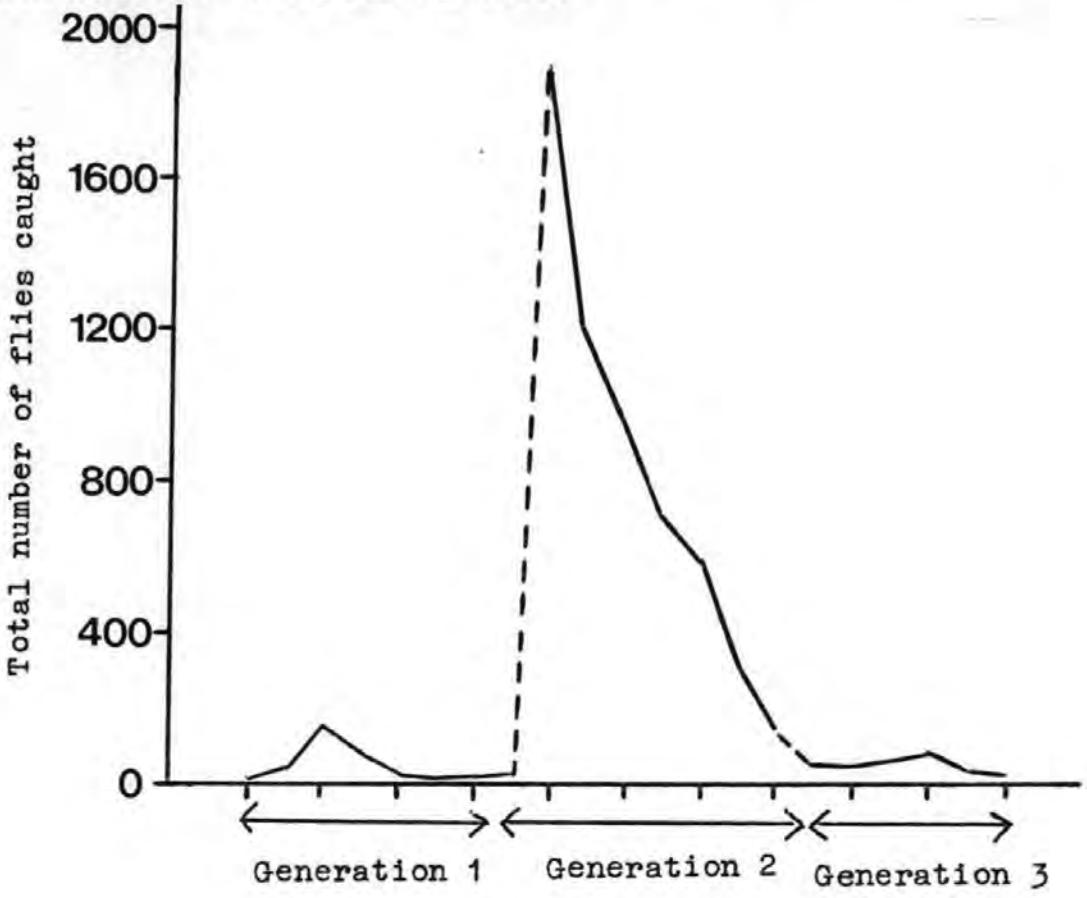


FIG. 23

The change in the age structure of the male population with time at Venn Farm in 1980.



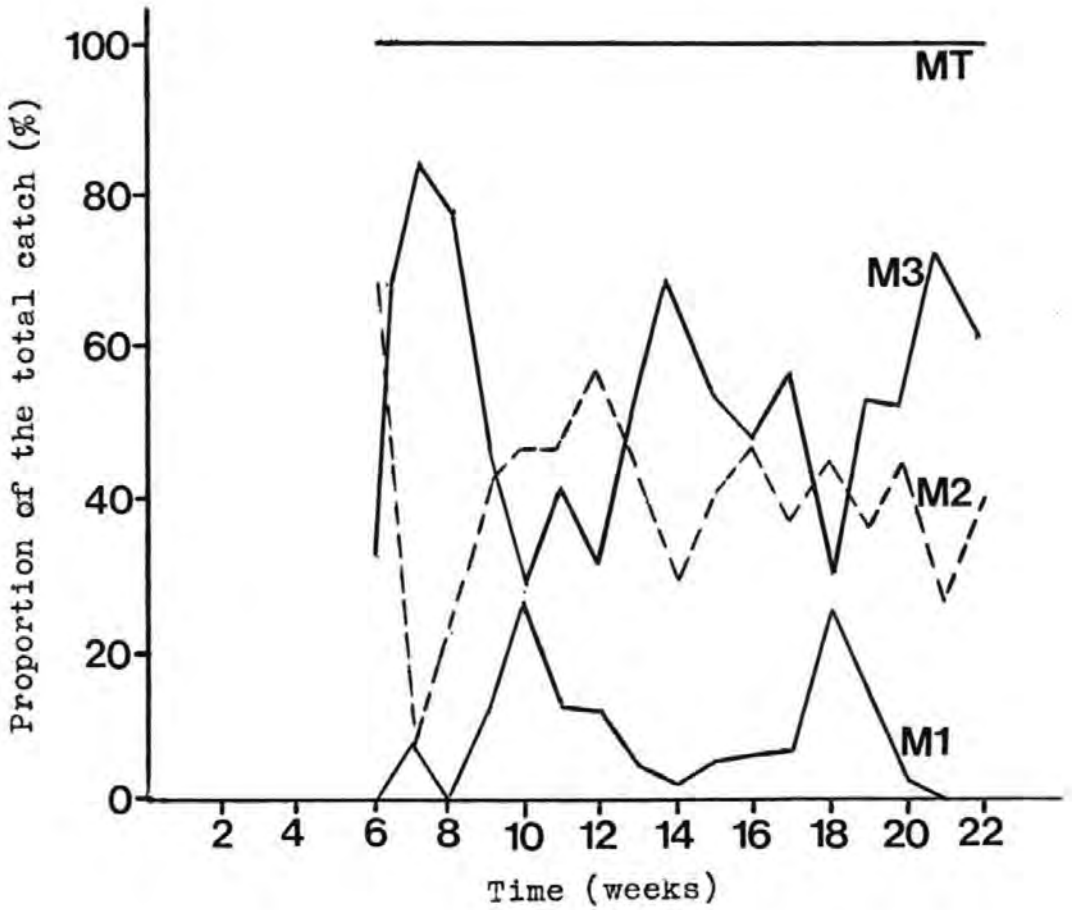
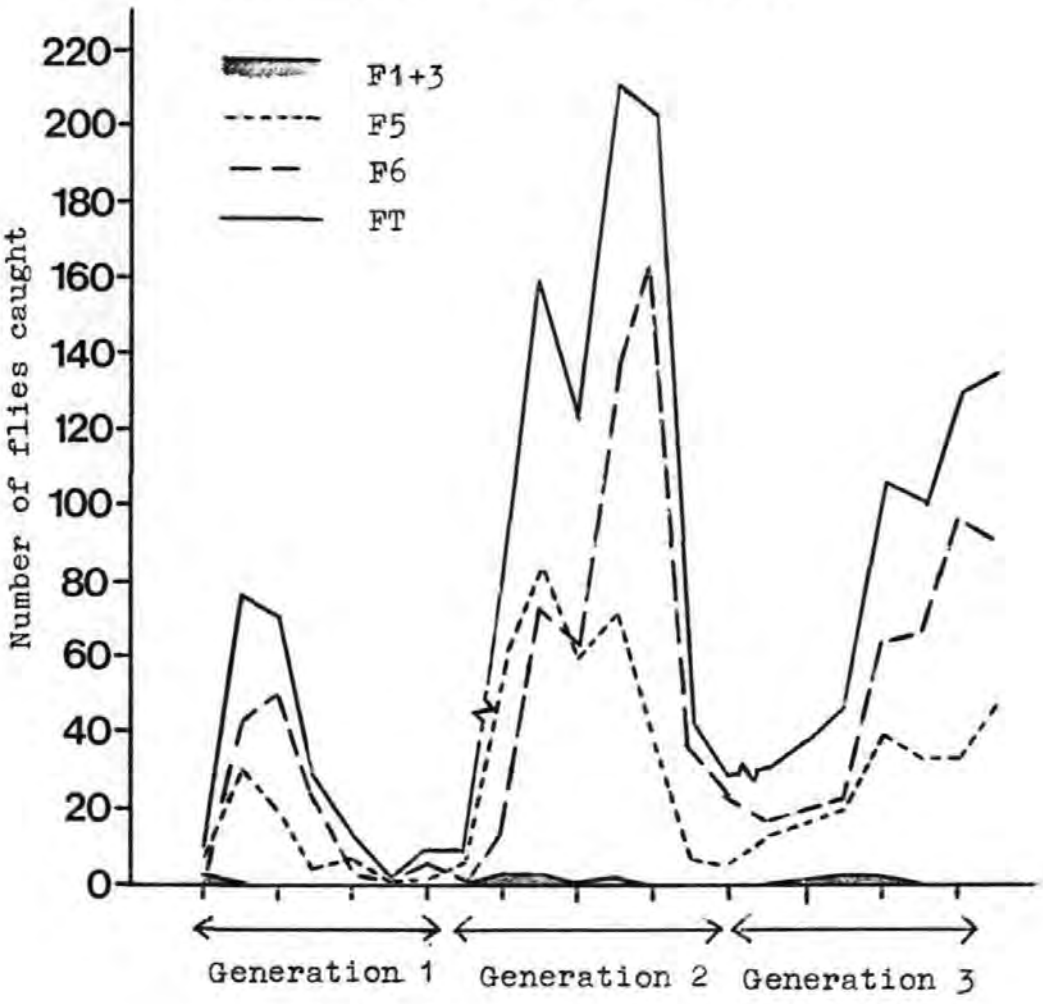


FIG. 24

The change in the age structure of the female population with time at Great Englebourne Farm in 1980.



The continuation of trapping at the emergence site of the first generation .

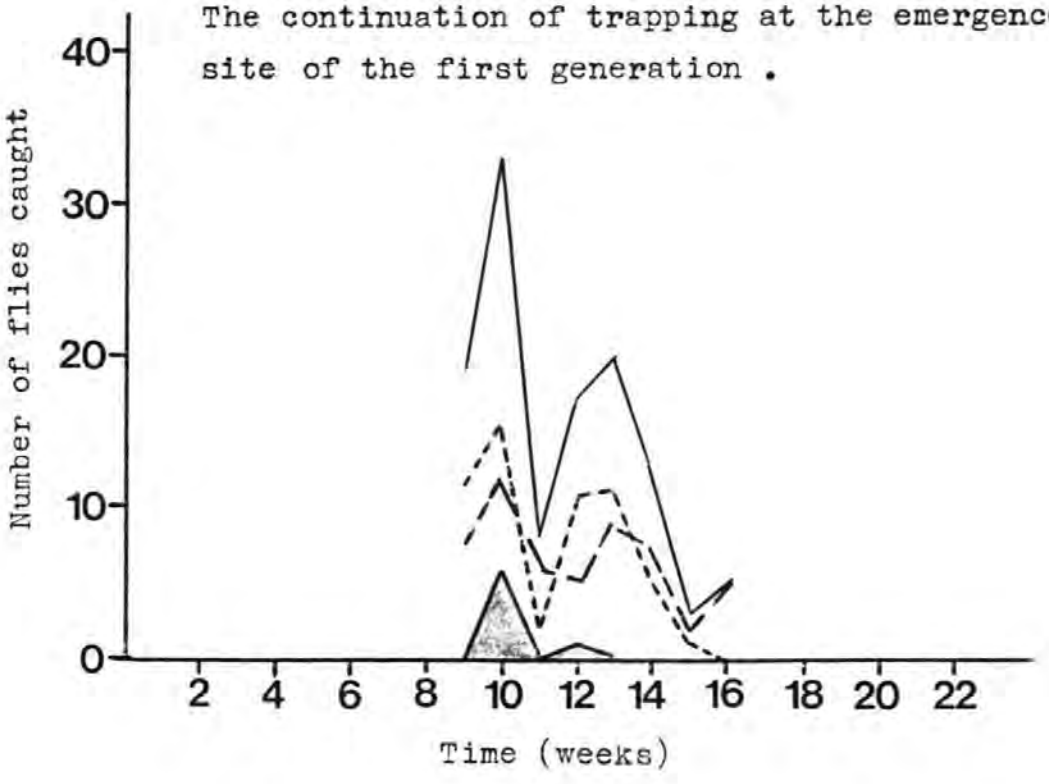
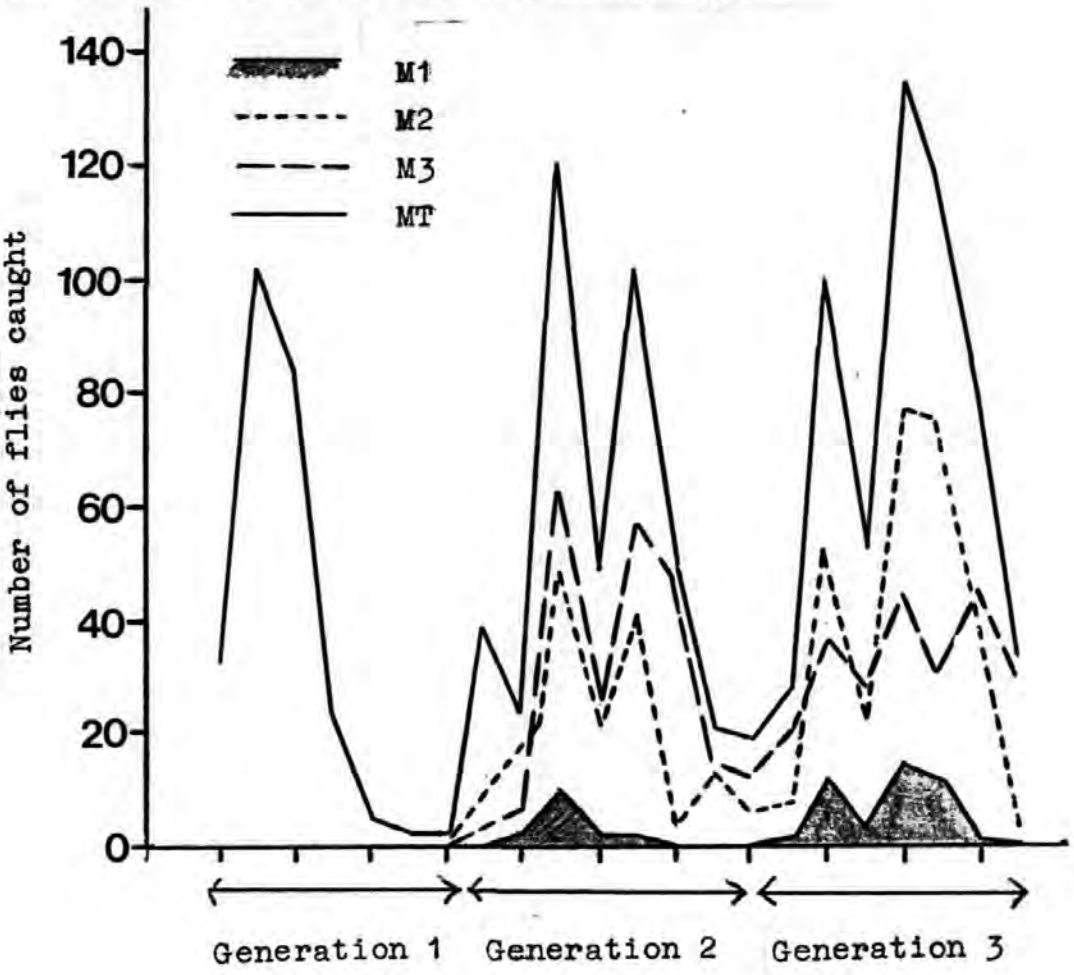


FIG. 25

The change in the age structure of the male population with time at Great Englebourne in 1980.



The continuation of trapping at the emergence site of the first generation.

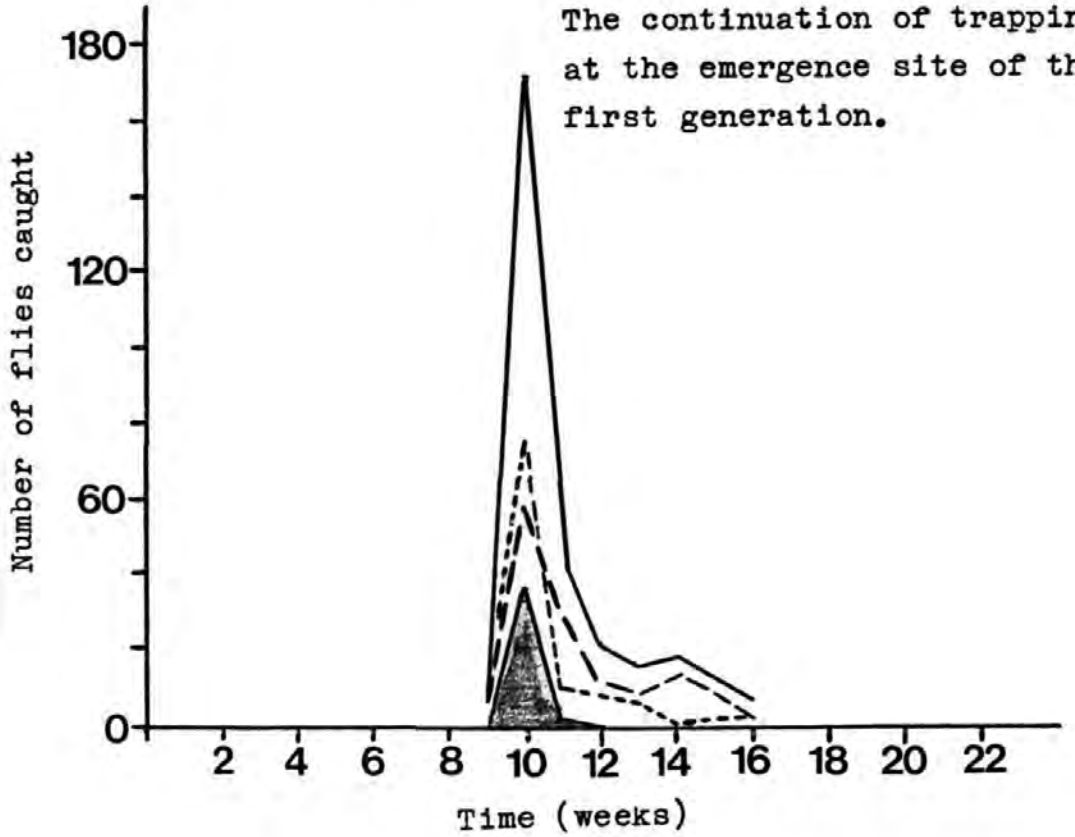


FIG. 26

The change in age structure of the female population with time at Great Englebourne Farm in 1981.

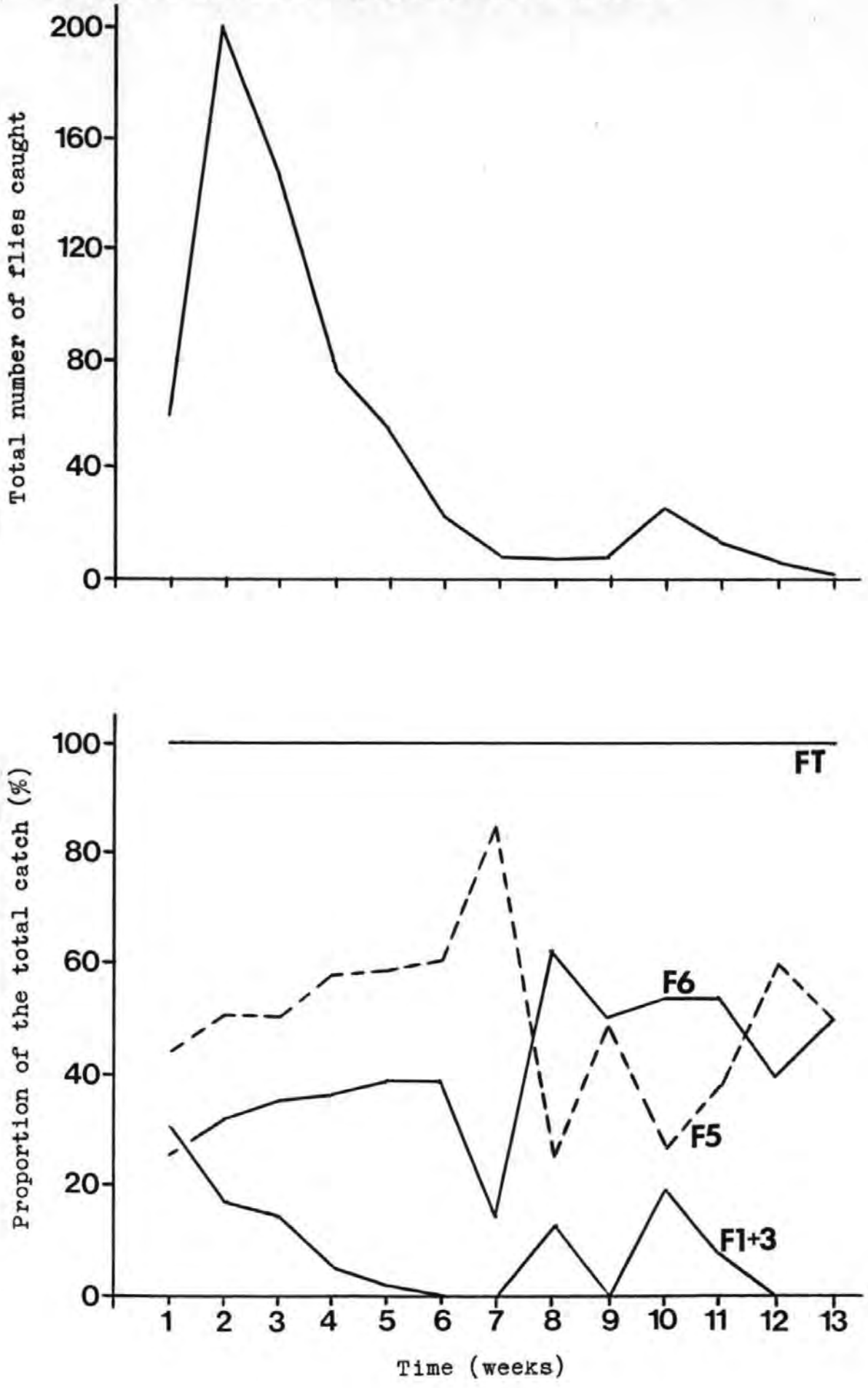


FIG. 27

The change in age structure of the male population with time at Great Englebourne Farm in 1981.

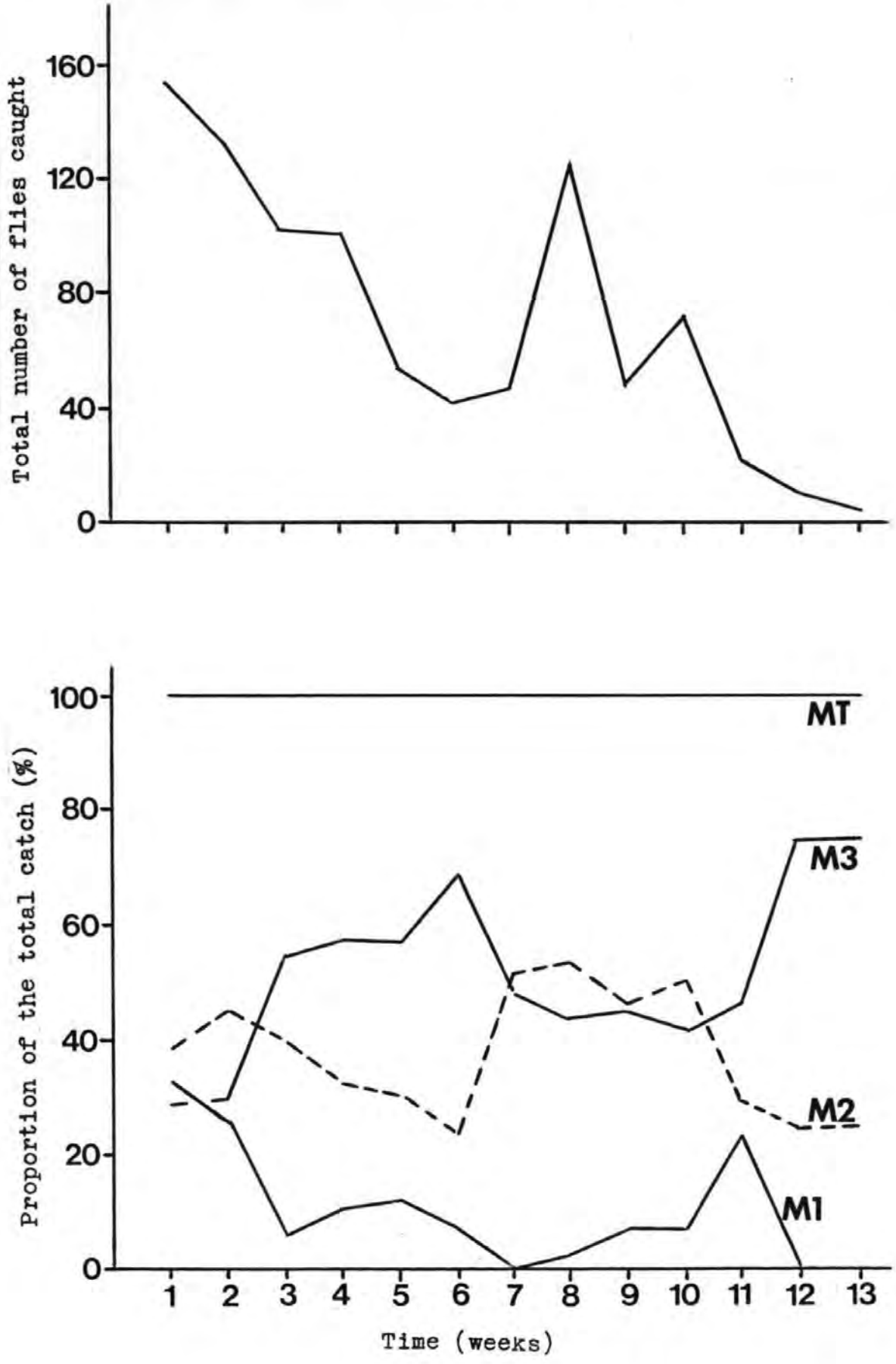
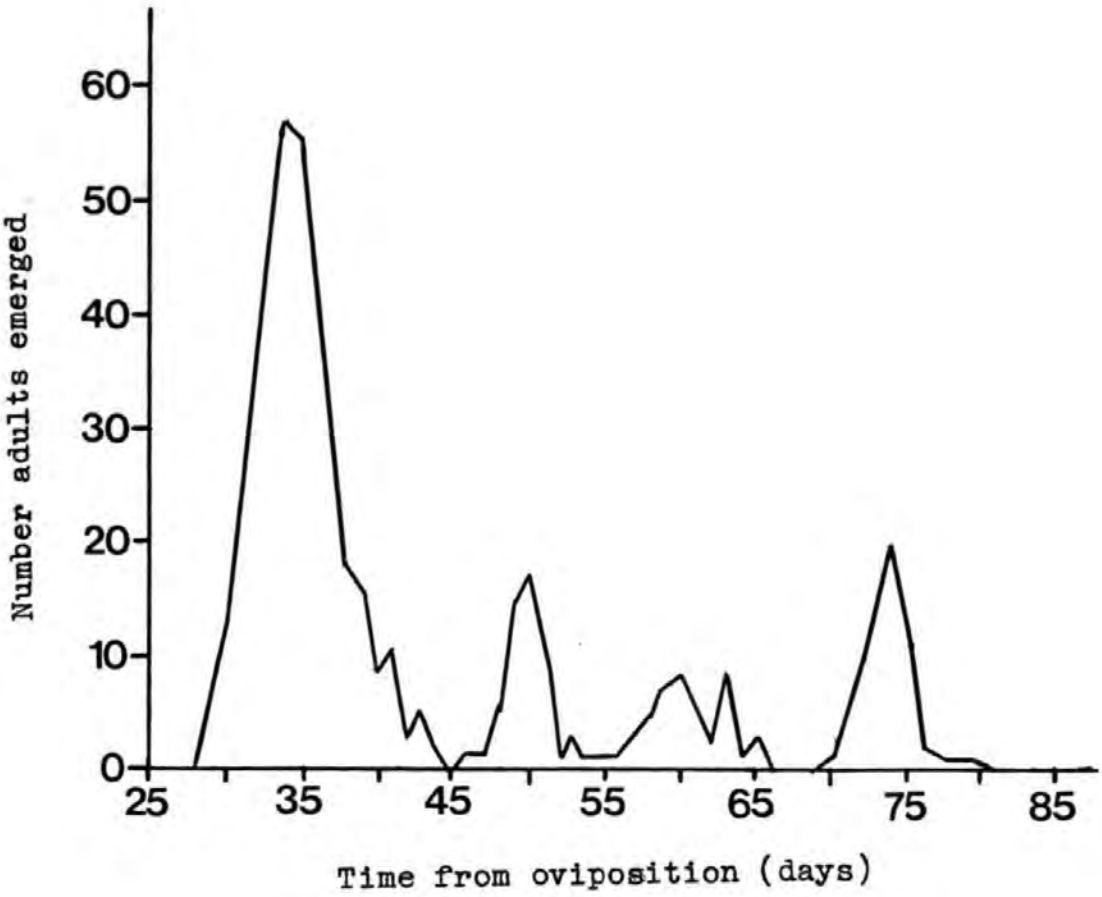


FIG. 28

The emergence pattern of adult cabbage root flies from the pupae.



(Figs 24 & 25). The large number of young flies could not have dispersed from the distant known sources of emerging second generation flies. The peak emergence of second generation flies also occurs a week later at the garden plot. In 1981, there is a small secondary peak (Figs 26 & 27), but it is uncertain whether this is due to dispersal from the garden plot. The garden plot developed only a very small population, so it is unlikely that sufficient numbers could disperse the distance (240 m.) to first generation emergence site.

The delayed emergence of some cabbage root flies has been found from laboratory experiments on field-collected wild pupae (Miles, 1956), or the use of emergence traps on undisturbed populations (Finch & Collier, 1983). The proportion of the population showing delayed emergence varies from site to site, and may reflect differences in agricultural practice. The common practice (e.g. Great Englebourne) of planting the brassicas in midsummer means that there are no host plants available to the first generation. The first generation would be expected to be selected for long distance dispersal or delayed emergence. The laboratory-reared pupae show several peaks in emergence, with some flies emerging up to three months after oviposition (Fig. 28).

Conclusions

The age determination methods can be successfully applied to the field situation, and can provide valuable evidence of the population dynamics and the location of emergence sites. The existence of delayed emergence would mean that the generations of CRF cannot be completly predicted from simple thermal accumulations (Coaker & Wright, 1963; Finch, 1977). It is unknown whether delayed emergence

occurs at other sites, because the emergence sites of the different generations were not sufficiently isolated from each other.

CHAPTER II.9

The influence of environmental variables on the rate of development of the age determination characters

Introduction

The rate of development of the physiological age-groups depends on the prevailing environmental conditions (e.g. temperature, photoperiod, diet, humidity, etc.). The absolute age can be estimated from the age-groups once allowance has been made for the changes in environmental conditions. The temperature is the dominant determinant of the rate of development in the poikilothermic insects (e.g. Tyndale-Biscoe & Hughes, 1969; Vogt, Woodburn & Tyndale-Biscoe, 1974; Kitching, 1977). The other environmental variables are often closely correlated with temperature, and their general effect is to cause delays in the temperature-driven development. In many insect species protein is required for egg development, and any shortage can lead to the actual age being greater than predicted solely from the temperature record (Vogt *et al.*, 1974). A short photoperiod can cause reproductive diapause, where the development of the reproductive organs is suspended (e.g. Begon, 1976b). The majority of insects overwinter as juveniles and the emergence of adults is controlled by photoperiod and temperature (e.g. Coaker & Finch, 1971), so the adults experience only long light photophases. The humidity probably has no direct effect on development, but could affect the availability of the food sources and exert an indirect influence on mortality and development.

The rate of development can be estimated as the reciprocal of the duration of the readily identified life history stages (e.g. Eckenrode & Chapman, 1971; Guppy & Harcourt, 1978). If the stages

can be identified by external criteria, then a single cohort can be followed through all the stages. In order to determine the age-group of an adult, it is necessary to kill the individual for dissection. The developmental period of each age-group has then to be estimated from the progress of development in a series of differently aged samples (Vogt et al., 1974).

The relationship between the rate of development and temperature is often described using a linear function (e.g. Tyndale-Biscoe & Hughes, 1969; Eckenrode & Chapman, 1971). In fluctuating temperatures the proportion of development completed can then be determined as a thermal sum (expressed as day degrees) by the integration of the temperature above the developmental zero (e.g. Eckenrode & Chapman, 1972; Vogt et al., 1974; Guppy & Harcourt, 1978; Woodburn et al., 1978). The relationship between development and temperature is rarely strictly linear, and can be more accurately described using a sigmoid or polynomial curve, especially when extremes of temperature are commonly experienced (Stinner, Gutierrez & Butler, 1974). The day degree concept does not apply to such non-linear models, so the proportion of development completed has to be estimated with a more complex routine when the temperature fluctuates with time (Stinner et al., 1974).

A large number of studies have concluded that the rate of development under fluctuating temperatures differs from the predictions made from the measurements at constant temperatures (Hagstrum & Hagstrum, 1978). In many cases, the relationship between development and temperature was never sufficiently accurately defined (Howe, 1967). It is possible that development could proceed more rapidly in fluctuating temperatures, if development continues at subthreshold

or supralimiting levels, provided the organism spends only a brief period at such temperatures.

Development is normally estimated from the shade temperatures, but solar radiation can have significant effect on the body temperature of insects (Digby, 1955; Cena & Clark, 1972; Vogt et al., 1974). Willmer & Unwin (1981) analysed the effects of various factors on the rates of heating and cooling of insects, and predict a temperature excess of up to 3°C for Delia spp. in full sunlight.

The diet profoundly influences the fecundity and longevity of female cabbage root flies (Finch & Coaker, 1969b; Finch, 1971a). Carbohydrate is required for the production of the first batch of eggs, and protein is also necessary for the second and subsequent batches. The development of male insects is generally little affected by nutrition, although fertility may be reduced in starved individuals (Wigglesworth, 1966). The quality of the larval food has an important influence on the rate of loss of the pupal fat (Tyndale-Biscoe & Hughes, 1969).

Methods

The collection of the emerged flies at 10 a.m. will ensure that the majority of the flies will have completed a minimum of development (Ch. II.2). The flies were transferred using a pooter to 15 cm. diameter perspex rearing cages. The rate of development was determined at eight temperatures (5, 10, 12.5, 15, 17.5, 20, 25, 30°C), which covers the range likely to be encountered in the field with particular emphasis on the region of most rapid change in development rate (Howe, 1967). The experiments were carried out in a series of constant temperature rooms to an accuracy of ± 1°C, under a 16 hour

light daily photophase. Each temperature was replicated three times, except for 30°C where only two replicates were used.

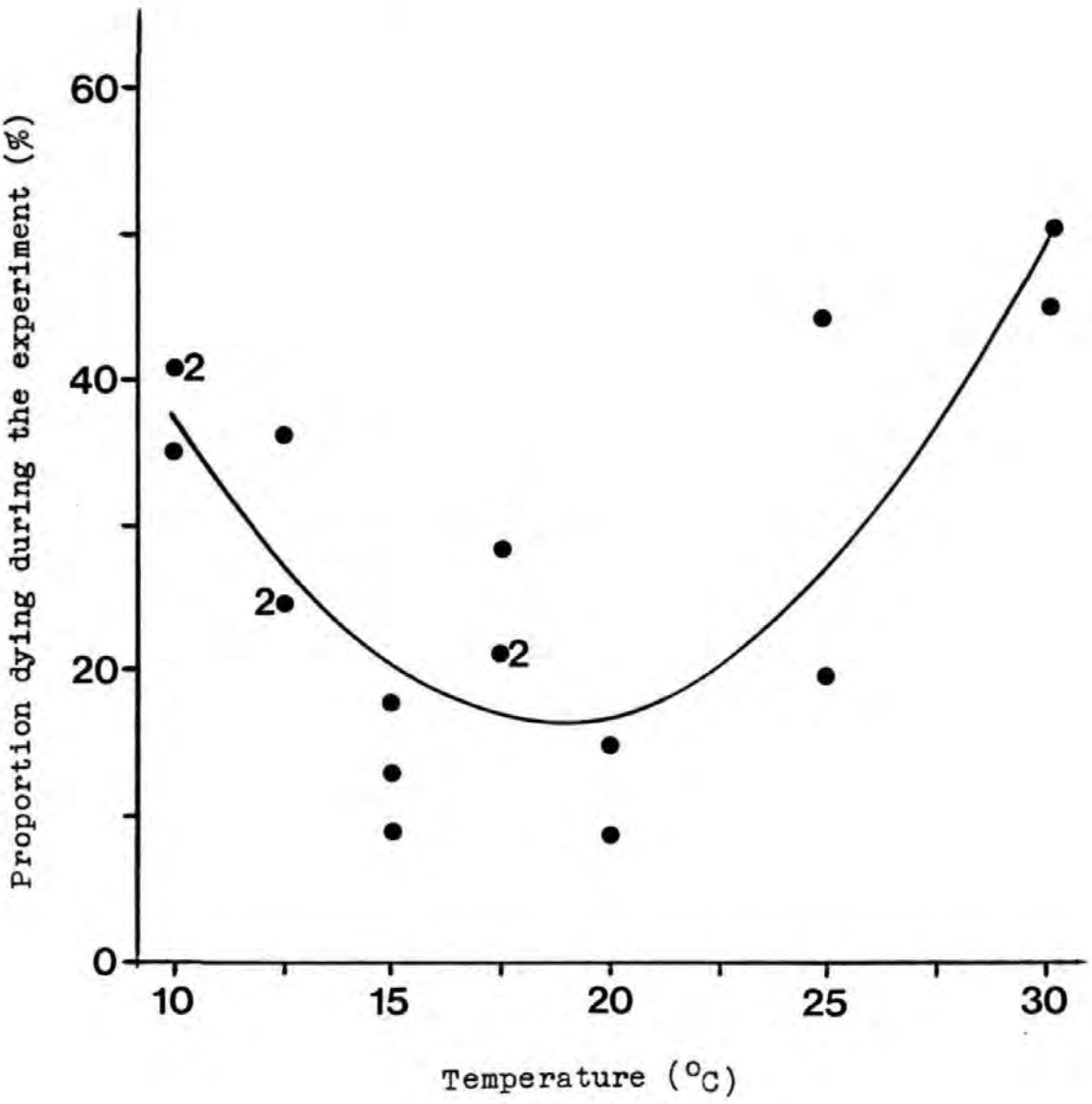
A cage of flies was killed at regular intervals at each temperature, and the flies dissected to ascertain the age-group of the individuals. The sampling interval varied with temperature, being adjusted to provide at least seven samples evenly spaced throughout the complete development of the flies. This required sampling at three-day intervals at 10 and 12.5°C; at two-day intervals at 15°C; and at daily intervals for 17.5 - 30°C. The flies kept at 5°C were sampled weekly, but no development was detectable after six weeks. A minimum of ten males and ten females was felt to be necessary to provide a statistically valid estimate of the age distribution. There is mortality of flies during an experiment, so it is necessary to start the experiment with a larger number of flies. The mortality is strongly dependent on temperature (Fig. 29), and at the low or high temperatures it is essential to use large numbers of flies. The deaths at high temperatures can be minimised by maintaining the sucrose plugs continuously moist; at 25 and 30°C the plugs were replenished in the morning and evening of each day. At the lower temperatures the less active flies tend to become trapped in any free liquid on the plugs, and it was necessary to add only the minimum of fluid to maintain moistness without producing any free liquid.

The oviposition sites were continuously available, so there should be no delay in the commencement of oviposition. The sites were changed daily, the eggs separated by flotation in water and the number of eggs counted.

The individual flies do not develop at the same rate, leading to a spread of age-groups at any sample time. A mean is not particularly meaningful because the age-groups are not of equal duration, as can

FIG 29

The relationship between mortality and temperature.



be seen from the non-linear relationship between age and time (Fig. 30). The distribution between the age-groups is not normal (Howe, 1967; Sharpe, Curry & DeMichelle, 1977), so the median would be a better measure of central tendency because it is more resistant to skewed distributions. Vogt et al. (1974) estimated the mean time to completion for a series of female age-groups. A weighted mean was calculated, using the number of flies that have developed into the older age-groups for the weightings. This method will be seriously biased by slowly developing individuals (Howe, 1967; Sharpe et al., 1977), and cannot provide an estimate for the oldest age-group. In this study, the median time for completion will be estimated for each age-group. The age of each sample will be expressed as a proportion of the flies in the oldest age-group. For example, if half the flies are of age-group five, then the age will be plotted against time as 5.50 (Fig. 30). A sigmoid curve was then fitted to the age-time data, using a non-linear least squares method (NAG, 1978). The median age for each age-group can then be calculated from the fitted equation (Fig. 30). The first fly to enter an age-group will be very influential, and this method may overemphasise the older age-groups. It will not be possible to calculate a median time for the youngest age-group, but it will be possible for the oldest age-group.

The rate of development was estimated as the reciprocal of the developmental period. The relationship between development rate and temperature is best described using a polynomial equation (Fig. 31), since this will allow the rate to decrease above the optimum (Stinner et al., 1974). These polynomial models (Table 10) can be used to estimate the rate of development at any temperature, although it would not be valid to extrapolate beyond the measured range.

Oviposition marks the transition of females from a gravid (age-group 5) to a parous (age-group 6) state, and provides an age indicator that does not require the flies to be killed for dissection. The median oviposition time was estimated from a sigmoid curve fitted to the egg number-time data using the non-linear least squares program.

The final experiment is a test of the predictions of the derived development equations under field conditions. A large muslin cage was erected to house the rearing cages; the muslin prevented direct sunlight from falling on the cages. The oviposition sites in each cage were changed daily and the number of eggs determined, to provide an estimate of the median oviposition time. The daily fluctuation in temperature can be closely approximated by a sine wave fitted to the daily maximum and minimum (Allen, 1976). It was assumed that the maximum temperature occurs at 12 a.m. and the minimum at 12 p.m. The percentage development completed in each hour can then be calculated, and summed until one hundred per cent development is reached (Stinner et al., 1974).

The effect of diet on the rate of development was investigated by raising four simultaneous separate batches of flies, but each supplied with a different diet. One batch was supplied with a complete diet of 10% solution of sucrose and yeast extract to provide protein (Finch & Skinner, 1969a). The second batch received only sucrose solution, the third batch only water, and the final batch were supplied nothing. The four batches were kept at 20 $\pm$ 1°C for six days, when they were killed and dissected to determine the age-group of the individual flies.

Results & Discussion

A summary of the results for the investigation of the change in age distribution with time at different temperatures is given in Appendices 5 and 6.

The relationship between age-group and time was well described by the sigmoid function, as can be seen from the high explanation of variance (Fig. 30). In turn, the relationship between development and temperature is well described by the polynomial equation (Fig. 31; Table 10).

The median time for oviposition is very closely correlated to the median developmental time estimation from the dissection of the adults (Fig. 32). Oviposition can be used as valid indicator of age.

The development of the female flies in fluctuating temperature were not well predicted from the measurements of development made at constant temperatures applied to a sine wave approximation of the hourly temperatures. The predicted development time is consistently higher than the actual time (Fig. 33). The technique is capable of accurate prediction for the development in the field (e.g. Trichoplusia, Butler, Stinner & Greene, 1976).

The air temperature in the perspex cages was no higher than the external air temperature, so the muslin was preventing any significant 'greenhouse' effect. The cage will reduce the wind speed experienced by the flies, which could affect evaporative cooling of the insects. The sine wave approximation may not accurately estimate the intermediate temperatures, which would require testing by taking simultaneous measurements throughout the day.

The diet has a considerable influence on the rate of development of the females, but not on the males (Table 11). A water source is

FIG. 30

The progression in the female age groups at 20°C.

The method of estimating the median development time (50%) of gravid (age group 5) females is illustrated on the graph.

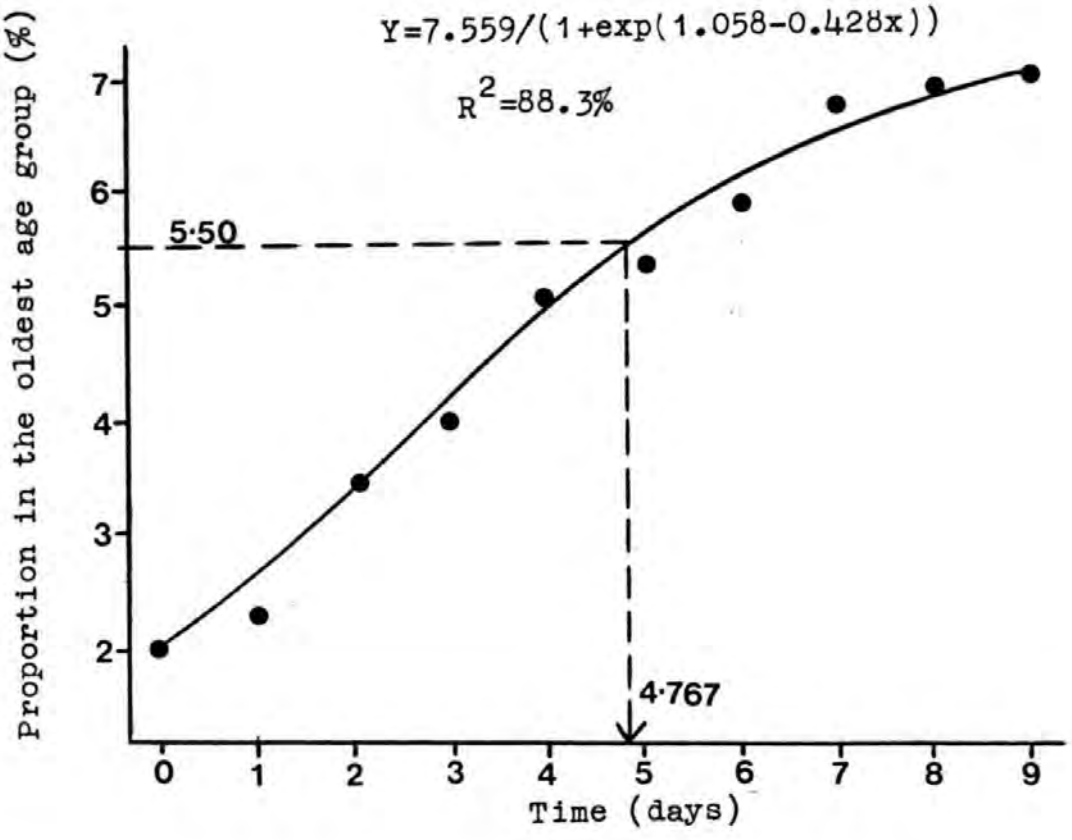


FIG. 31

The relationship between temperature and development of parous (age group 6) females.

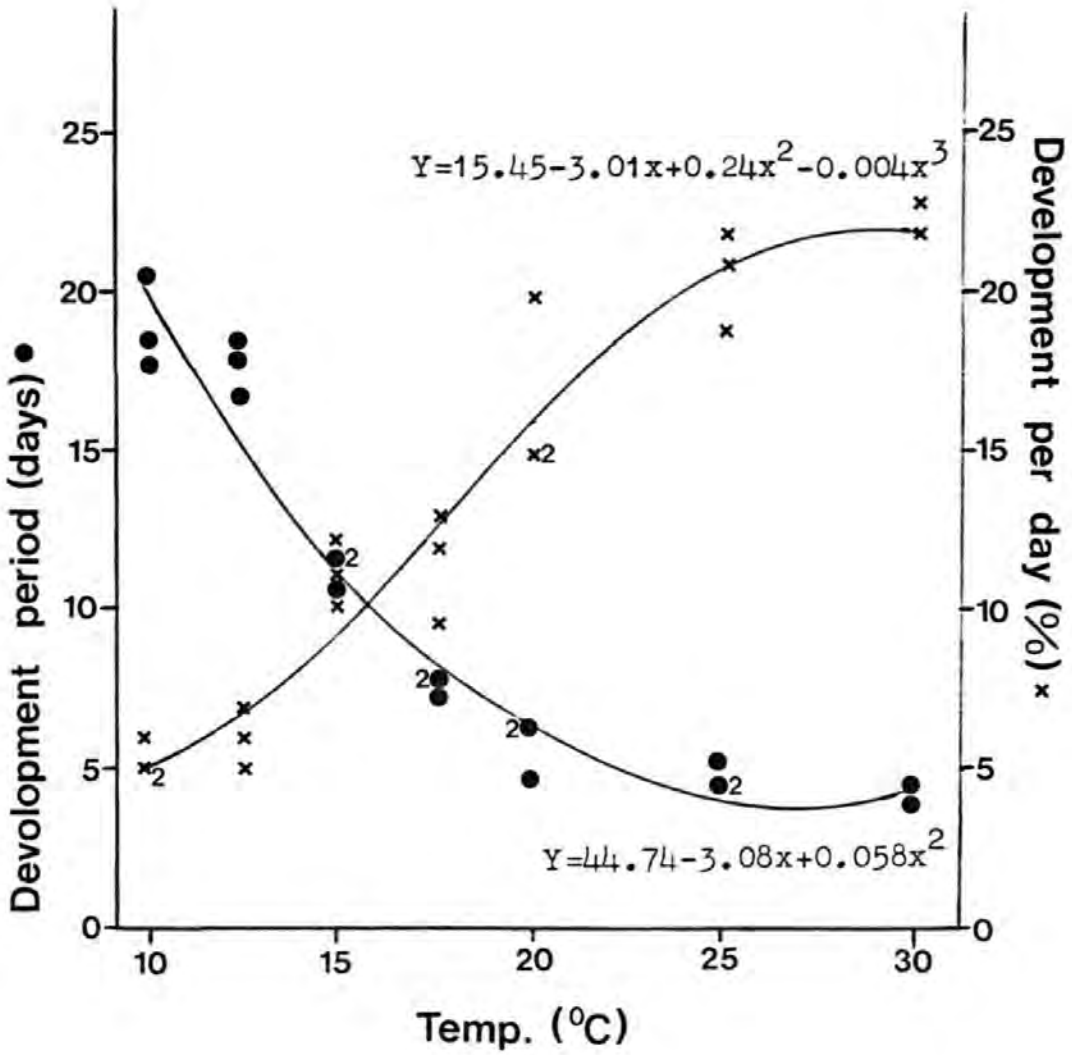


FIG. 32

The comparison of the median development priod of parous females as estimated from the dissection of the females and the oviposition.

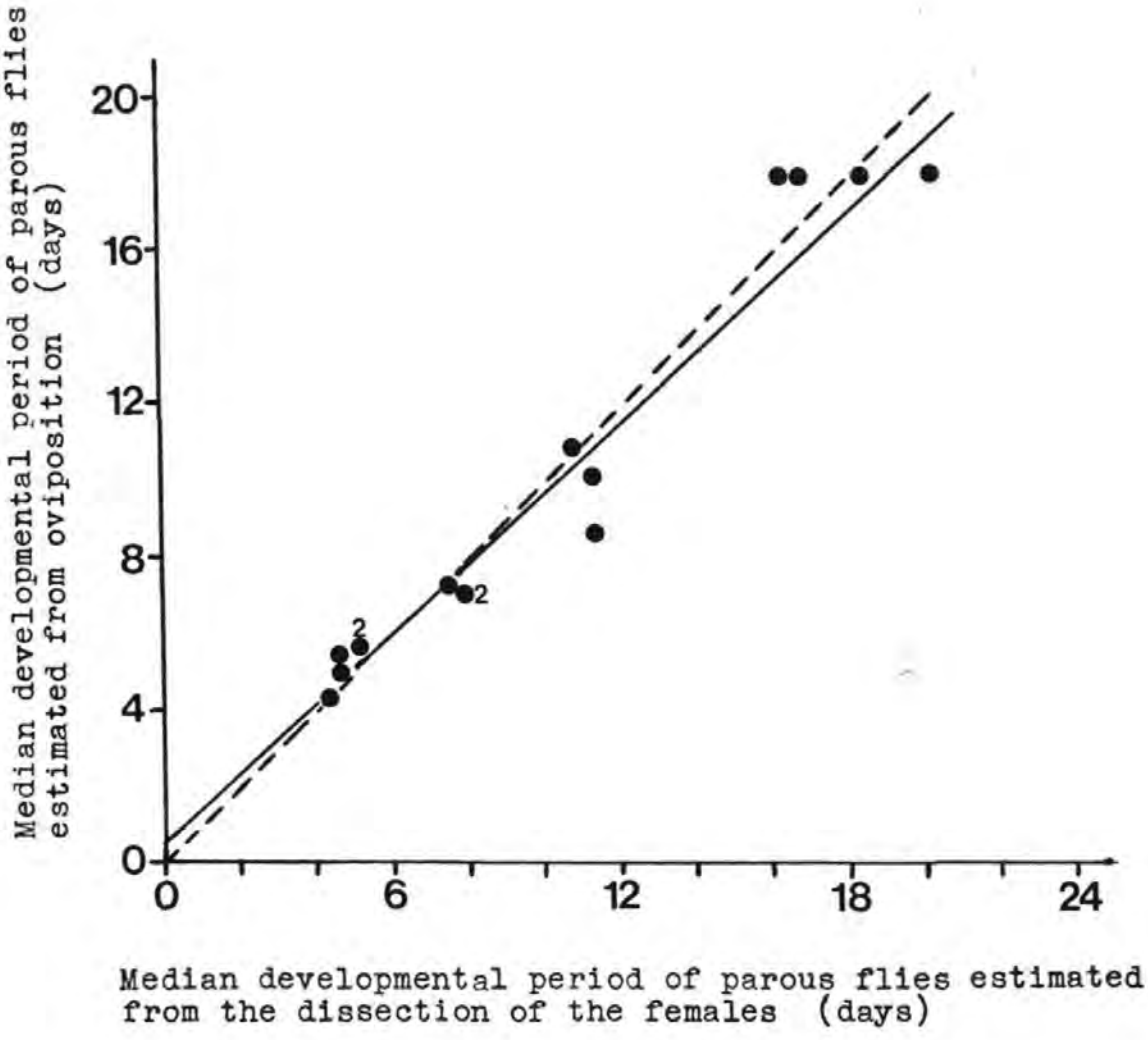


FIG. 33

The comparison of median developmental period of parous females as estimated from the temperatures and the oviposition.

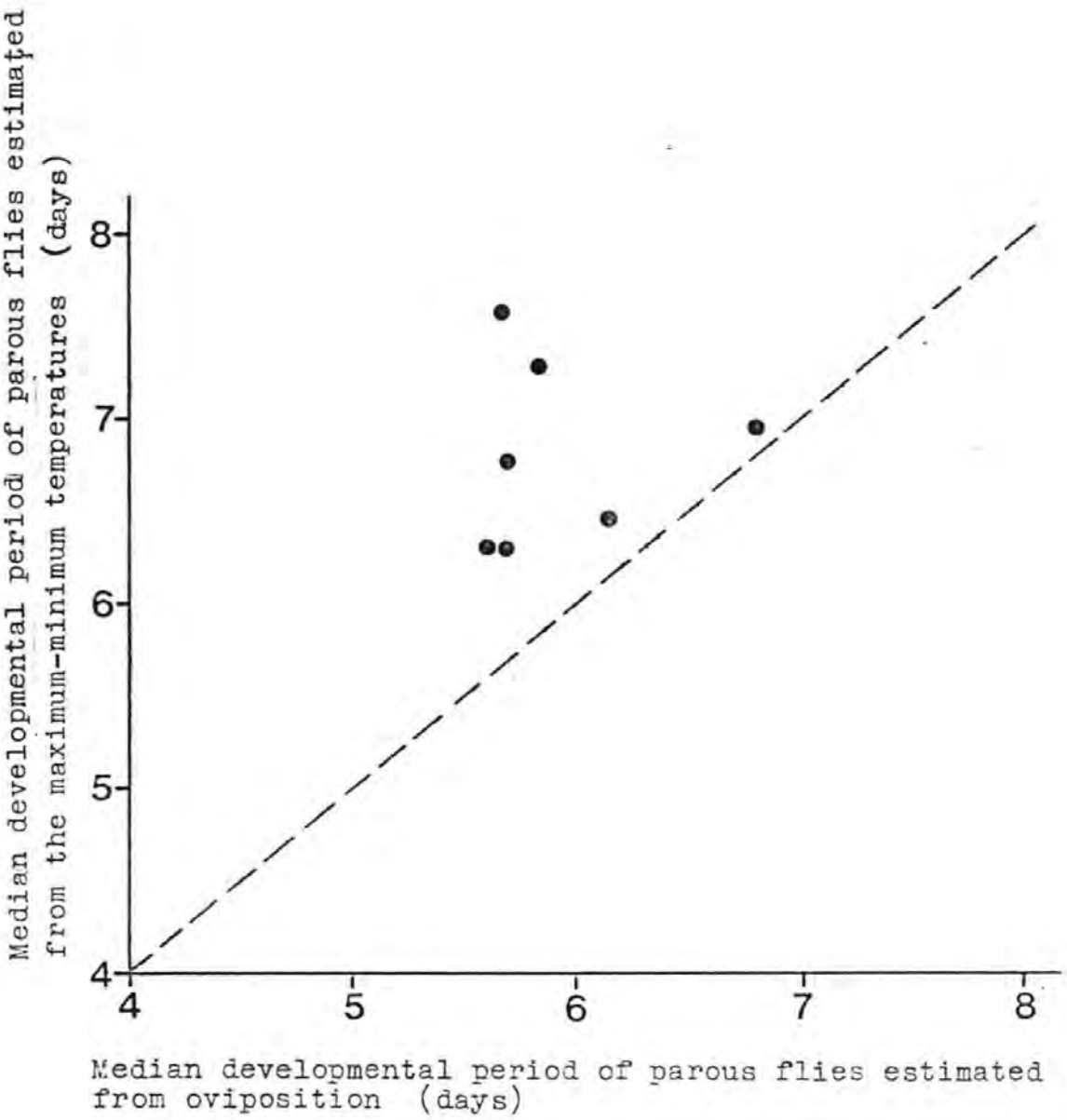


TABLE 10

The relationship between the rate of development(y as % per day) and temperature(^{o}C).

$$y = a + b_1x + b_2x^2 + b_3x^3$$

Age-group	a	b_1	b_2	b_3	R^2
F2	441.6	-82.70	+5.13	-0.090	79.3
F3	150.3	-28.72	+1.84	-0.033	90.4
F4	81.91	-15.75	+1.04	-0.018	92.1
F5	47.49	-9.17	+0.62	-0.011	93.8
F6	15.45	-3.01	+0.24	-0.004	93.6
M2	61.40	-10.770	+0.730	-0.013	57.6
M3	1.72	-0.326	+0.085	-0.002	88.0

TABLE 11

The effect of diet on the development of male and female flies after six days at 20° C.

FEMALES

Treatment	Mean age (± SE)	N	♀ + ♂ Mortality (%)	Oviposition (per ♀)
No water or sucrose	-	20	100	-
Water only	4.50±0.50	6	62.5	53.0
Sucrose	6.39±0.55	18	35.7	45.9
Yeast and sucrose	6.00±0.49	9	30.8	38.7

	SS	DF	MS	F
Sucrose	18.561	1	18.561	12.65 **
Yeast	0.167	1	0.167	0.11
Residual	44.000	30	1.467	
Total	62.727	32		

MALES

Treatment	Mean age (± SE)	N
No water or sucrose	-	20
Water only	3.60±0.25	5
Sucrose	3.60±0.22	6
Yeast and sucrose	3.50±0.22	6

	SS	DF	MS	F
Sucrose	0.027	1	0.027	0.009
Yeast	0.007	1	0.007	0.002
Residual	4.200	14	3.000	
Total	4.235	16		

the minimum requirement for survival of both sexes, and egg production by the females. A sucrose supply increases the survival of the flies, and allows more rapid egg development by the females (Table 11). The additional availability of protein causes no further increase in the female development rate, although it will allow development of subsequent batches of eggs. Carbohydrate is widely available in the field (Finch, 1971a, 1974b), and is unlikely to be a limiting factor.

Conclusions

An approximate age can be estimated for flies in the field on the basis of the daily maximum and minimum temperatures, although this estimate is likely to be an overestimate of the actual age. There is an unknown error attached to this estimated age, because of interpopulation variation. The age-groups are nevertheless valuable in that they indicate relative age, which is comparable for the different populations.

SECTION THREE

THE ESTIMATION OF THE DISPERSAL RATES OF MALE AND FEMALE CABBAGE ROOT FLIES

CHAPTER III.1

The estimation of dispersal from non-point sources

Introduction

The descriptive regression model relating insect density to distance, has previously only been applied to experiments in which there was a discrete release of marked flies from a point source (Hawkes, 1972a, 1974, 1975; Nair & McEwen, 1974; Finch & Skinner, 1975). The descriptive model has been suggested to be inapplicable when the flies originate from non-point sources (Freeman, 1977; Stinner, Barfield & Stimac, 1983). The emergence of wild flies from the site of a former host crop, was envisaged as the source of flies for the experiments of the present study, and clearly cannot be considered a point source.

The flies are to be sampled by a series of regularly spaced traps leading away from the emergence site. The traps situated at the edge of the emergence site will form the nominal zero of the trap line, but flies will also be emerging up to 100 m. (e.g. Venn Farm Figs 40-43) from these traps. Any flies caught in the traps at the nominal zero may have already completed dispersal over a substantial distance. The density of flies decreases non-linearly with distance, so the emergence of flies over a wide area could lead to a disproportionate increase in the number of flies caught close to the emergence site. The slope of density on distance would then be overestimated, and the mean distance dispersed underestimated.

The trap lines are to be laid leading away from the emergence site. The flies dispersing only a short distance will tend to remain within the emergence site, and will not be available for capture by the traps. The mean distance dispersed could then be overestimated,

because it is based on the more actively dispersing members of the population.

The pupae occur in a markedly aggregated distribution, which can be well described by a negative binomial (Mukerji & Harcourt, 1970; Finch, Skinner & Freeman, 1978). Such a distribution can arise from a series of independent randomly distributed clumps (Elliot, 1977). The population of pupae in a field can be considered as a large number of separate clumps, each clustered about a single host plant and effectively a point source. The dispersal of flies emerging from an extensive area can be modelled by the summation of a large number of small populations dispersing from a point source.

The sample sites were partly chosen for their isolation from other sources of emerging flies, but there will still be a small input of flies which disperse over a large distance. The wild crucifers are capable of supporting a small population of flies (Finch & Ackley, 1977), and are common constituents of hedgerows. The long-distance dispersal or emergence of flies from wild crucifers could provide a 'background count' of flies (analogous to the radioactive background count) which could be expected to be present everywhere. The background count could cause an underestimation of the slope of density against distance, with the tail being extended as the catch falls to a constant (within sampling error) instead of gradually decaying to zero.

Methods

A computer simulation was carried out to determine whether the slope of density against distance can be validly estimated when flies are emerging from an extensive source. A series of five separate

density-distance curves were calculated, each with a common slope, but the intercept and the distance between each population, were allocated at random. A value of 0.2 was used for the slope, since this is later found to be the limiting value for many of the age-groups (Figs 72-75). The five curves were then amalgamated, and a regression calculated for the combined population on distance (Fig. 34).

The effect of a second source of flies can be investigated by the superimposition of two identical density-distance curves separated by 400 m. (Fig. 35). This separation distance was chosen to mimic the situation found on one of the sample sites (Venn, 1980B, Fig. 40).

Wild crucifers are common components of hedgerows, and could be expected to occur at random along a hedgerow. The wild crucifers are capable of supporting only a small population of flies, each plant producing a maximum of four pupae (Finch & Ackley, 1977). The emergence of flies from wild crucifers could be simply modelled by the addition of a series of random small numbers in the range 0 - 4 to the expected catch of a trap line (Fig. 36).

Results & Discussion

The combination of a series of independent point sources does not lead to a significant alteration of the slope (Fig. 34). The slope is slightly underestimated because of the formation of a plateau close to the origin, although this could be expected to be less evident if a larger number of subpopulations had been used. This is a particularly important result because it demonstrates that the slope can be correctly estimated from the dispersal of flies from an extensive source. The mean distance dispersed estimated from the

FIG. 34

The simulation of the dispersal of flies emerging from an extensive source.

A $y = \exp(2.0-0.2\sqrt{x})$
B $y = \exp(2.5-0.2\sqrt{x+7})$
C $y = \exp(2.0-0.2\sqrt{x+24})$
D $y = \exp(1.5-0.2\sqrt{x+30})$
E $Y = \exp(2.1-0.2\sqrt{x+41})$

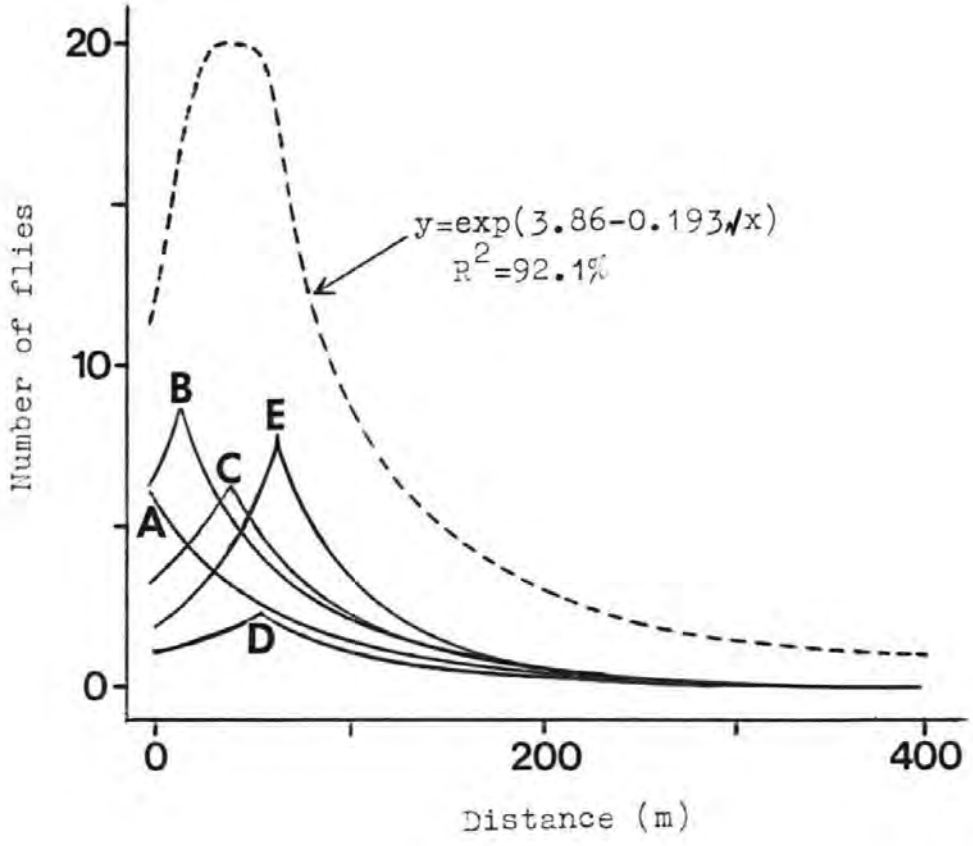


FIG. 35

The effect of a second source of emerging flies on the fitted slope.

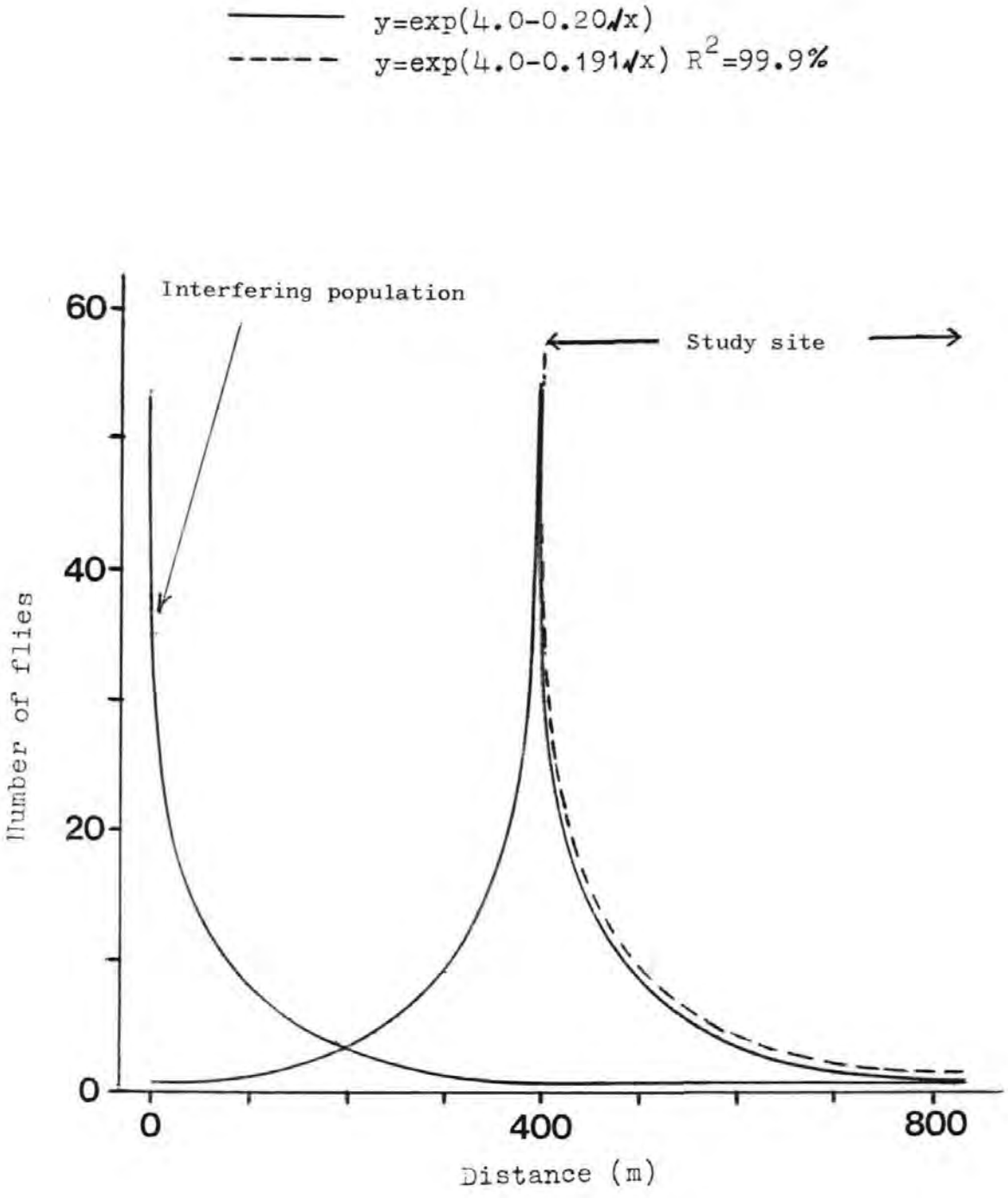
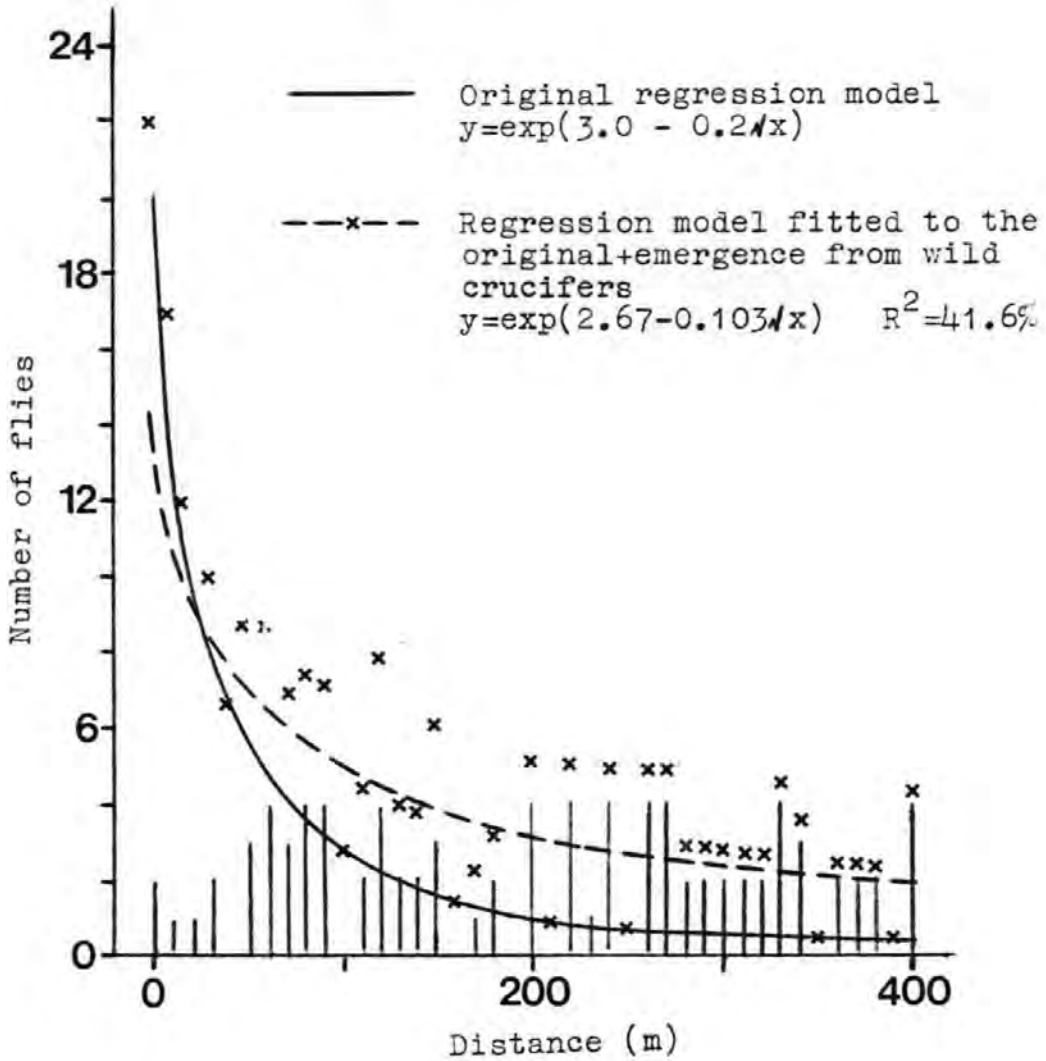
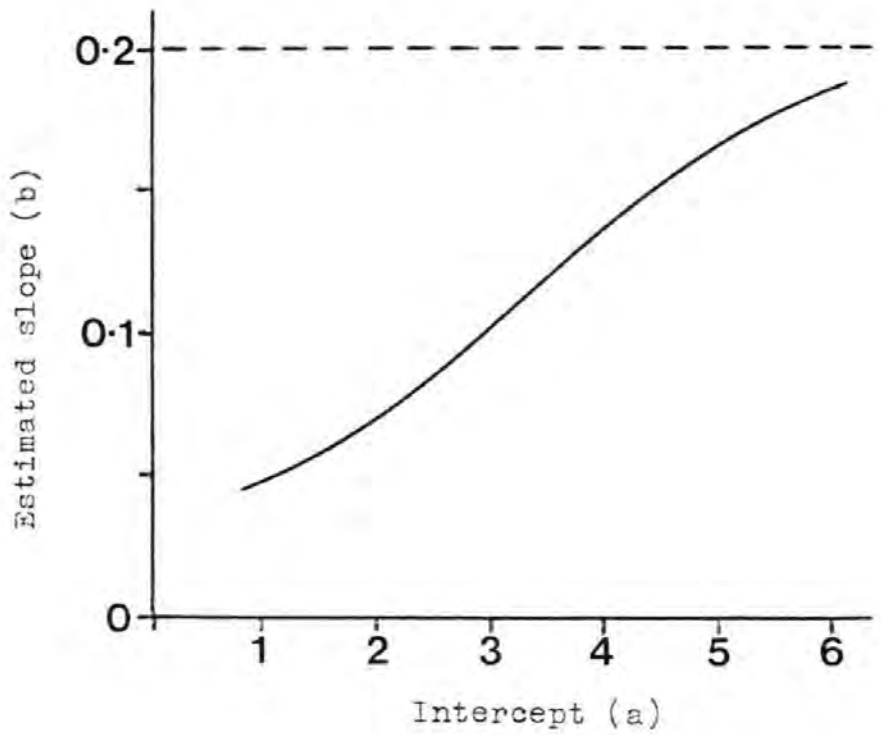


FIG. 36

A simulation of the effect of the emergence of flies from wild crucifers, on the estimated slope.





slope would be expected to be superior to any direct estimate from the actual recapture data, where the emergence location can never be accurately known.

The density of flies declines exponentially with distance, so only a small proportion of flies would disperse over 400 m. The effect of a second source of emerging flies produces only a slight insignificant underestimation of the slope (Fig. 35).

The emergence of flies from wild crucifers can significantly affect the fitted slope (Fig. 36). The addition of small numbers has a greater relative effect on the smaller catches of the more distant traps, causing an underestimation of the slope and overestimation of the mean distance dispersed. The degree of underestimation of the slope depends on the number of flies caught (as measured by the intercept) and will be particularly significant for a small catch of flies (Fig. 36).

Conclusion

The slope of density against distance can be validly estimated from the dispersal of flies away from an extensive emergence source. The source of emerging flies need not be absolutely isolated from other sources, since the secondary sources will exert a negligible influence provided they are not situated too close to the primary source (e.g. greater than 400 m.). It is important to check the hedgerows for wild crucifers, because any significant input of flies from this source could cause serious underestimation of the slope.

CHAPTER III.2

The effect of noise on regression analysis

Introduction

Random sample variation is inevitable in any field sampling programme. The sample plan is designed to minimise the variation in attractiveness of the traps, but the flies are inherently variable in their behavioural responses to the traps. The variability of the catch for each trap (the standard error) can be estimated from the replication of traps at each distance. The standard error can be indirectly estimated, when there are no replicates, from the deviation of the observed catch from an expected regression model. The examination of the residuals is useful in the detection of systematic bias, which can profoundly influence the value of the fitted slope. An assumption of parametric statistics is a random error distribution (Kleinbaum & Kupper, 1978), so it is essential to eliminate bias to achieve a statistically valid description of the data (Ch. III.9). Random noise would not be expected to bias the slope in any particular direction, but could equally increase or decrease the value. The standard error can be used to calculate the statistical confidence limits, within which the true value of the slope would be expected to lie for a certain probability level. The standard error can also be used to test the overall significance of the regression, by testing whether the slope differs significantly from zero. A fully random set of data would be expected to produce a slope of zero. An increasing level of random noise will cause a progressive decrease in the estimated value of the slope, as the data approaches a random state.

The effect of random noise will depend on the number of flies caught, since a small catch will be more vulnerable to noise than a larger catch.

Methods

The effects of random noise were assessed by a computer simulation. The expected values were calculated from the basic model (1), for a series of distances ranging from 0 - 400 m.

$$y = \exp(a - b\sqrt{x}) \qquad (1)$$

A value of -0.2 was assigned to the slope (b), and a series of values were used for the intercept (a), to determine the effect on various levels of catch. A random set of noise was generated with a mean of zero and a standard deviation of unity, using the NRANDOM function of the MINITAB package (Ryan, Joiner & Ryan, 1981). The noise was added to the untransformed data, which was then transformed to logarithms for the calculation of the regression on distance. The noise was gradually increased by repeated addition, until the fit was no longer significant.

The noise was added to the untransformed data to produce a gradual additive increase in variability, rather than the multiplicative increase that would have been obtained by addition to the transformed data. The method does produce a marked heterogeneity of the variance, which is partially corrected by transformation. Negative values are created as the noise increases, but these have to be omitted from the regression because the logarithm of a negative number cannot be computed. This crudely simulates the removal of zero observations before transformation (Ch. III.5).

Results & Discussion

The addition of noise initially causes a small increase in the estimated value of the slope (Fig. 37), although the confidence limits clearly indicate that the slope does not differ significantly from the original value (-0.2). Random noise could equally increase or decrease the slope, and the initial increase is probably caused by the addition of the noise.

The estimated slope is then progressively underestimated and becomes increasingly more significantly different from the original value (Fig. 37). A significant regression fit can be achieved with a standard error for the slope of 50% or less, although the fitted slope may differ significantly from the original value (Table 12). Hawkes (1972) suggested that a standard error of 20% was the maximum acceptable for a useful fit, which would produce a maximum of 33% ((0.20 - 0.134)/0.2) x 100) underestimation of the slope. The influence of the noise depends markedly on the value of the intercept, with the larger catch being far more resistant to the noise (Table 12).

The fitted values of the slope and intercept are strongly correlated (Fig. 38). The points appear to fall into three distinct groups, which is probably caused by the changes in the number of observations (Table 12). The group with the smallest values of slope and intercept, are based on a constant number of observations (N = 29) and produce a clearly linear relationship. The random noise produces a similar effect on the expected values from $y = \exp(4.0 - 0.2\sqrt{x})$ (Fig. 38).

TABLE 12A

The effect of incressing data variability on the fit of the regression model.

$$Y = \exp (5.0 - 0.2\sqrt{x})$$

	Intercept(a)	Slope(b)	SE b %	N	R^2 %	P
0	5.00	-0.200	-	41	100.0	c
1	5.01	-0.201	2.1	41	98.3	c
2	5.05	-0.205	4.2	41	93.3	c
3	5.12	-0.214	6.9	41	84.1	c
4	5.22	-0.229	12.9	40	60.3	c
5	4.98	-0.200	9.8	38	73.6	c
6	4.99	-0.200	11.2	37	68.5	c
7	5.07	-0.214	15.8	37	52.2	c
8	4.89	-0.187	19.2	34	44.1	c
9	4.53	-0.144	13.8	33	62.1	c
10	4.46	-0.139	16.5	33	53.6	c
11	4.38	-0.133	20.5	33	41.8	c
12	4.54	-0.140	16.4	32	54.0	c
13	4.51	-0.137	18.2	32	48.3	c
14	4.47	-0.134	20.5	32	42.4	c
15	4.43	-0.132	16.4	32	36.0	c
16	4.38	-0.130	20.5	32	28.2	c
17	4.48	-0.131	23.3	31	34.2	c
18	4.47	-0.131	27.6	31	27.6	c
19	4.26	-0.105	24.4	30	25.2	c
20	4.42	-0.107	28.4	29	42.6	c
21	4.39	-0.104	30.4	29	39.6	c
22	4.37	-0.101	21.5	29	36.6	c
23	4.34	-0.099	22.8	29	33.8	c
24	4.32	-0.096	24.3	29	31.1	b
25	4.29	-0.093	25.7	29	28.4	b
26	4.26	-0.090	27.2	29	25.9	b
27	4.24	-0.087	28.7	29	23.3	b
28	4.21	-0.085	30.4	29	21.2	b
29	4.18	-0.082	32.3	29	19.0	a
30	4.15	-0.079	34.3	29	16.8	a
31	4.12	-0.076	36.4	29	14.8	a
32	4.09	-0.073	38.7	29	12.9	a
33	4.05	-0.070	41.2	29	11.1	a
34	4.02	-0.067	44.0	29	9.4	
35	3.98	-0.064	47.1	29	7.8	

Increasing noise →

a = $P < 0.05$
b = $P < 0.01$
c = $P < 0.001$

TABLE 12B

$Y = \exp (4.0 - 0.2\sqrt{x})$

	Intercept(a)	Slope(b)	SE b %	N	R^2 %	P
0	4.00	-0.200	-	41	100.0	c
1	4.09	-0.211	6.0	41	87.3	c
2	4.00	-0.204	11.3	38	67.7	c
3	3.57	-0.149	11.9	33	68.3	c
4	3.39	-0.134	19.7	33	43.6	c
5	3.49	-0.135	19.6	32	44.9	
6	3.35	-0.129	29.9	32	24.7	c
7	3.26	-0.105	30.6	30	25.0	c
8	3.37	-0.102	23.8	29	37.4	c
9	3.31	-0.094	28.0	29	29.8	c
10	3.23	-0.087	32.5	29	23.1	b
11	3.15	-0.079	38.5	29	17.0	a
12	3.07	-0.071	46.1	29	11.8	a
13	2.96	-0.063	55.7	29	7.3	

$Y = \exp (3.0 - 0.2\sqrt{x})$

	Intercept(a)	Slope(b)	SE b	N	R^2	P
0	3.00	-0.200	-	41	100.0	c
1	3.17	-0.218	14.9	36	55.8	c
2	2.44	-0.132	22.7	32	37.5	c
3	3.36	-0.001	24.4	29	36.1	c
4	2.16	-0.080	37.8	29	17.8	b
5	1.90	-0.058	63.3	29	5.0	

a = $P < 0.05$
b = $P < 0.01$
c = $P < 0.001$

FIG. 37

The effect of increasing noise on the fitted value of the slope.

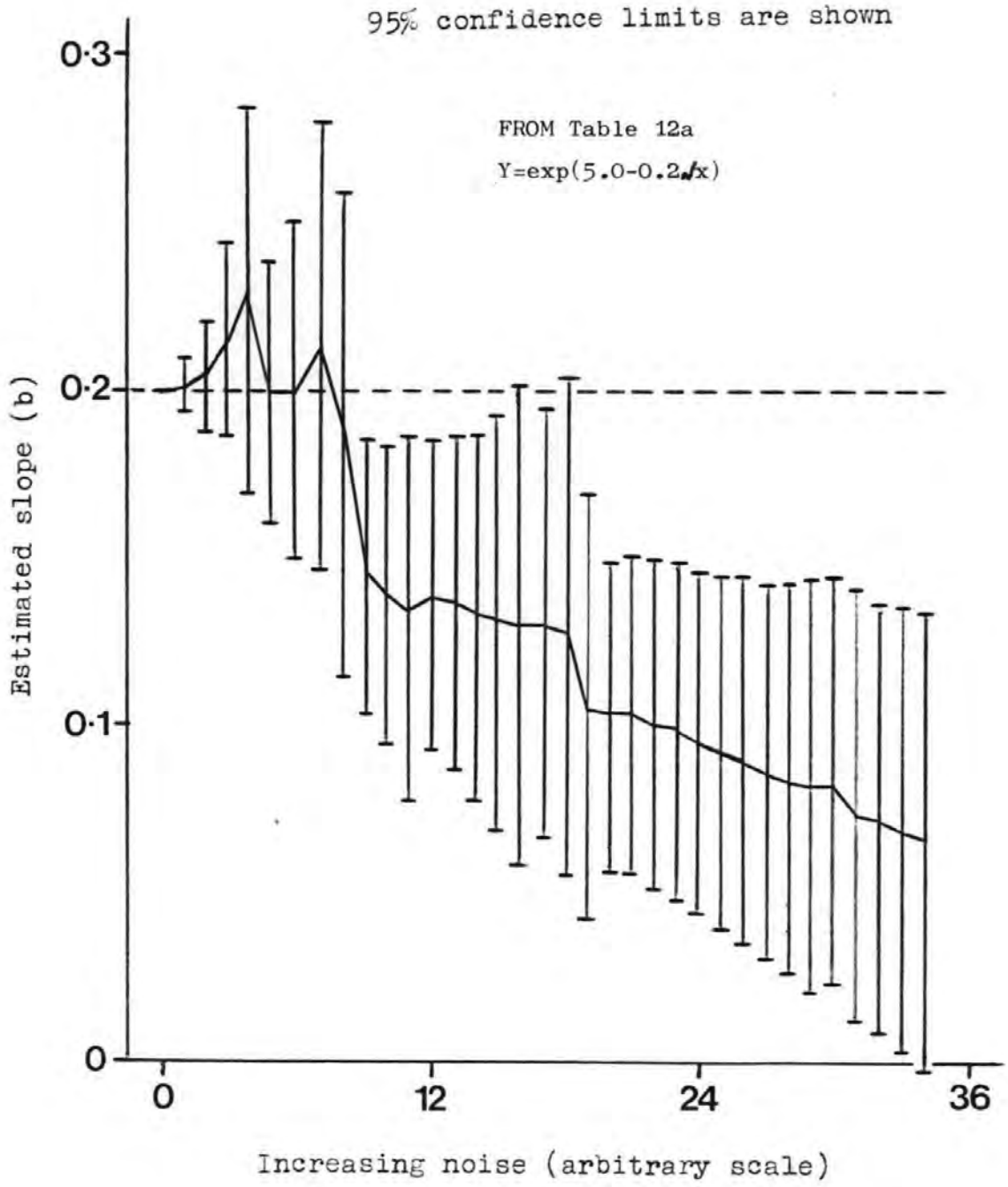
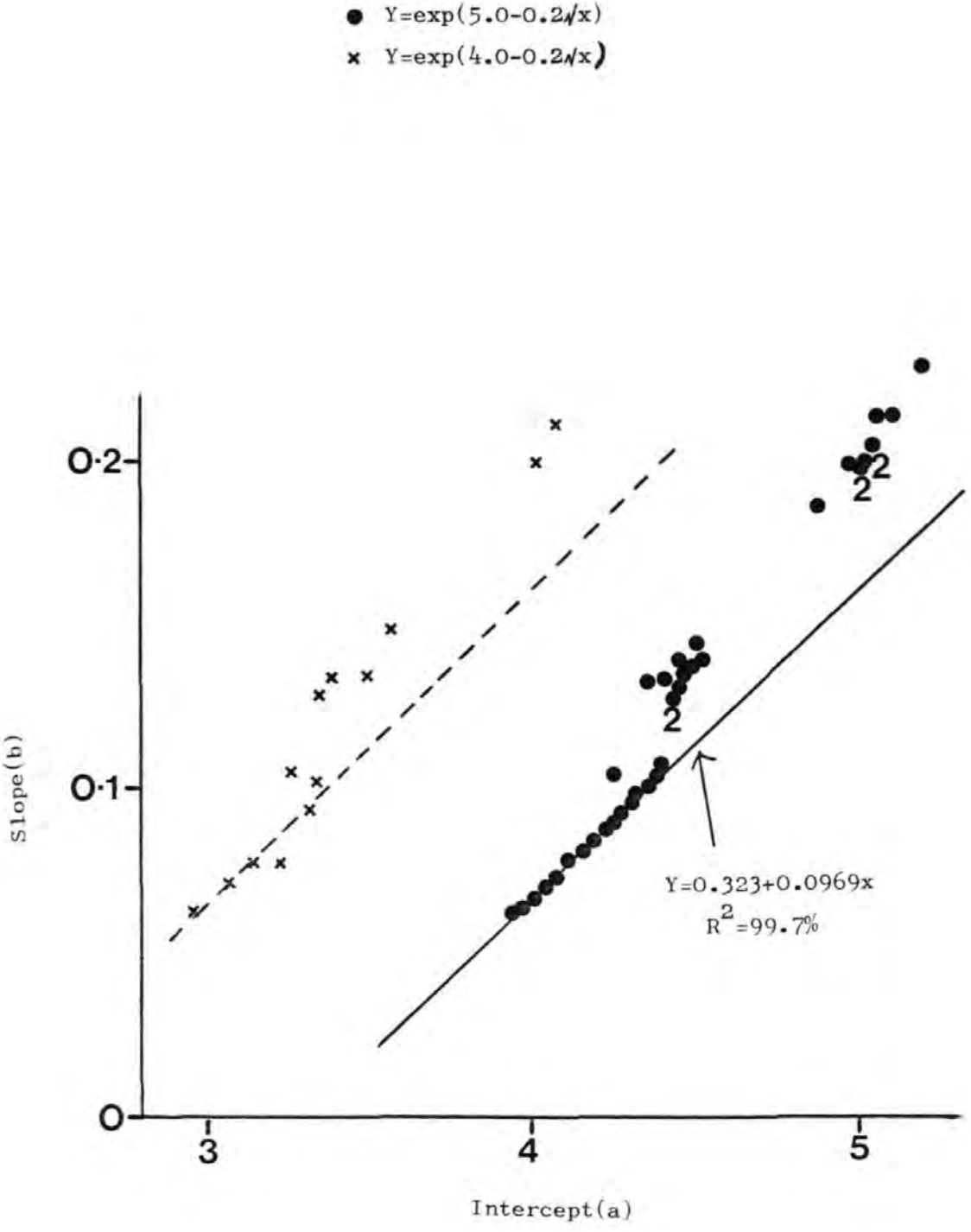


FIG. 38

The relationship between the slope and intercept fitted to data of increasing variablity.

FROM Table 12



Conclusion

Random noise can cause the slope to be significantly underestimated, and the mean distance dispersed would be overestimated. The underestimation of the slope will be greater for the smaller catches of flies. The estimates of the slope derived from the capture of different numbers of flies, will not be strictly comparable.

CHAPTER III.3

The dispersal experiments

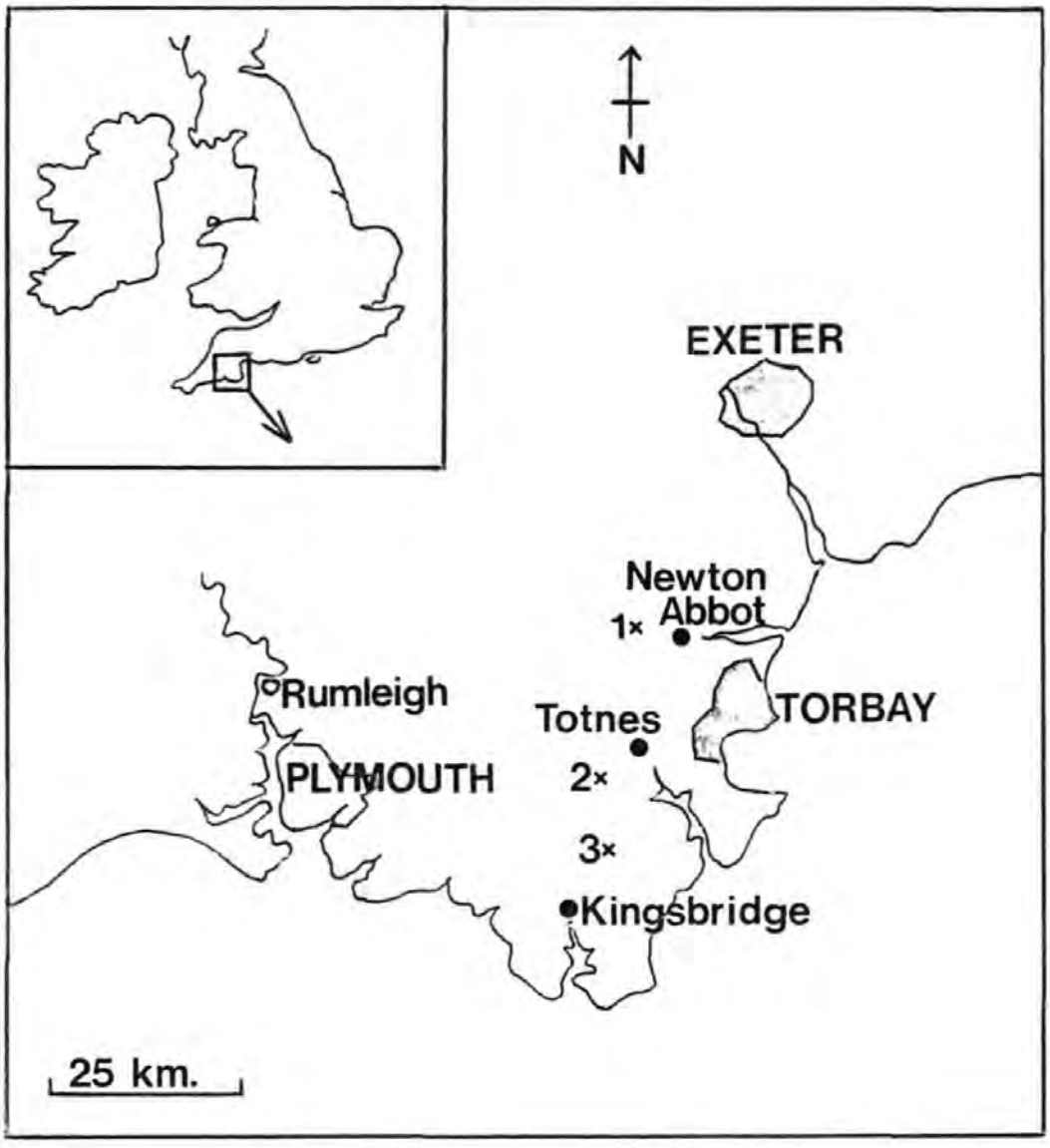
Introduction to the sample sites

Three sample sites were selected to represent the range of agricultural practice in brassica production in South West England (Fig. 39). The first site, Venn Farm, is devoted mainly to barley growing and sheep rearing. Spring or summer cabbage is grown most years for market, with swedes also being grown for fodder. A brassica crop will usually be available to all three generations, although the sites of the crops will vary because of crop rotation. The first generation adults emerging in the spring, will need to disperse to locate a host crop. The swedes are normally planted during the second generation. The third generation can reattack the crop upon which it developed, or disperse in search of an alternative host crop. The best overall strategy would appear to be to disperse at least during the first two generations. This farm was particularly useful because a large fly population could be expected from a heavily infested previous crop.

The second site, Great Englebourne Farm, is devoted almost exclusively to cattle and sheep rearing, with barley and swedes being grown for animal consumption. The swedes are usually planted at the end of June, avoiding the first generation of cabbage root fly, so chemical control is not required. The farm is large and few brassica crops are grown in the district, so the flies are isolated from other host crops. The flies of the first generation would need to adopt a strategy of wide dispersal to locate any available crop or cruciferous weeds in the hedgerows, or delay emergence until the swede crop is planted (Finch & Collier, 1983).

FIG. 39

The location of the sample sites.



SAMPLE SITES
1 Seale-Hayne Agricultural College
2 Great Englebourne Farm
3 Venn Farm

The third site, Seale-Hayne Agricultural College, grows a wide range of crops, including NIAB cabbage field trials. The demonstration garden plot of mixed brassicas is of particular interest, because host plants have been planted in the same general area for at least the past 15 years. The constancy of the location and the availability of host plants to all three generations, might be expected to select against dispersal. The layout of the farm means that there will only be a small input of flies from the other brassica crops. The site is similar to an intensive market garden where brassica production continues throughout the year, with different crops overlapping in time.

Methods

The preliminary experiments in May and June, 1980, indicated that traps could only be located in arable fields. The cows and sheep were found to drink the water in the traps, and were responsible for a high breakage rate.

It was generally necessary to lay trap lines alongside the hedgerows to avoid damage to the crop during the collection of the samples. The hedgerows are known to influence the distribution of the flies (Hawkes, 1972a, 1973; Finch & Skinner, 1973b). The traps cannot be replicated along the one dimension of a hedge, although it would be possible to indirectly replicate along different hedges. It is necessary to rely on the fitting of a regression model to detect and control error. The comparison is along a trend, rather than between replicates.

Finch & Skinner (1975) arranged the traps along the eight cardinal compass points, to a maximum distance of 400 m. from the

release point. The trap arrangement has been suggested as being partially responsible for the production of the migration phase (see Introduction). The wind direction has little effect on fly distribution (Hawkes, 1972a, 1973; Finch & Skinner, 1973b, 1975), so it is unnecessary to trap equally in all directions. A trap line extending 400 m. would seem necessary to attempt to reproduce the results of Finch & Skinner (1975), who were able to estimate dispersal rates ranging from 100 m/day to 1-2 km/day with such a trap arrangement.

The fluorescent yellow water traps interfere at a spacing of 5-10 m. (Finch & Skinner, 1974a, 1982b), so a minimum spacing of 10 m. will be used to ensure the statistical independence of the samples. The traps were filled with tap water containing 0.1% (w.v.) Teepol, to prevent any flies from escaping once they have landed in the water. The vegetation around the traps was cleared, and kept clear, for a radius of 1 m. to prevent the obscuring of the traps.

The insects caught were collected at weekly intervals by straining through a wire sieve, and were brought back to the laboratory in labelled plastic tubes. The tubes were stored in a deep freeze until they could be processed. The yellow water traps were rinsed to clear adhering debris and algal growth, and refilled with fresh solution.

The individual tubes were sorted in a white tray with a small volume of water, to facilitate the extraction of the cabbage root flies. The identification of these selected insects was checked under a dissecting microscope (Brooks, 1951). The confirmed flies were then dissected in 0.75% saline solution to determine the age-group of each individual.

The sample plans

The time of emergence of the overwintering cabbage root flies can be predicted from the day-degree accumulation (Coaker & Wright, 1963; Finch, 1977), and coincides with the flowering of a common hedgerow plant, Anthriscus sylvestris (Coaker & Finch, 1971). A proportion of the first generation may delay emergence (Finch & Collier, 1983), but cannot be predicted from the thermal summation. The emergence of the second and third generations were estimated from the changes in the number of flies caught each week, although the day-degree requirements for each generation have been estimated (Eckenrode & Chapman, 1972; Wyman, Libby & Chapman, 1976; Finch, 1977).

The samples in 1980 were collected from single trap lines, and the standard error of the catch of the individual traps can only be indirectly estimated from the standard error of the overall regression. The heterogeneity of the vegetation produced significant effects on the fly distribution, so it was desirable to reduce this source of variation by trapping across more uniform areas (e.g. barley). It is necessary to set the traps away from the hedges to allow replication, although a small catch of males would be expected. The use of evenly spaced traps was not the most efficient method of allocating the available effort. A variable trap spacing was used in 1981, with more of the traps concentrated close to the emergence site where the most rapid changes in number with distance occur.

(a) Venn Farm

The 1979 cabbage crop was only partially treated with insecticide (Fig. 40). The crop was severely attacked by the second and third generations of cabbage root fly, and should produce a large

FIG. 40

VENN FARM East Allington, Devon SX 780465

1979

The current crops are shown

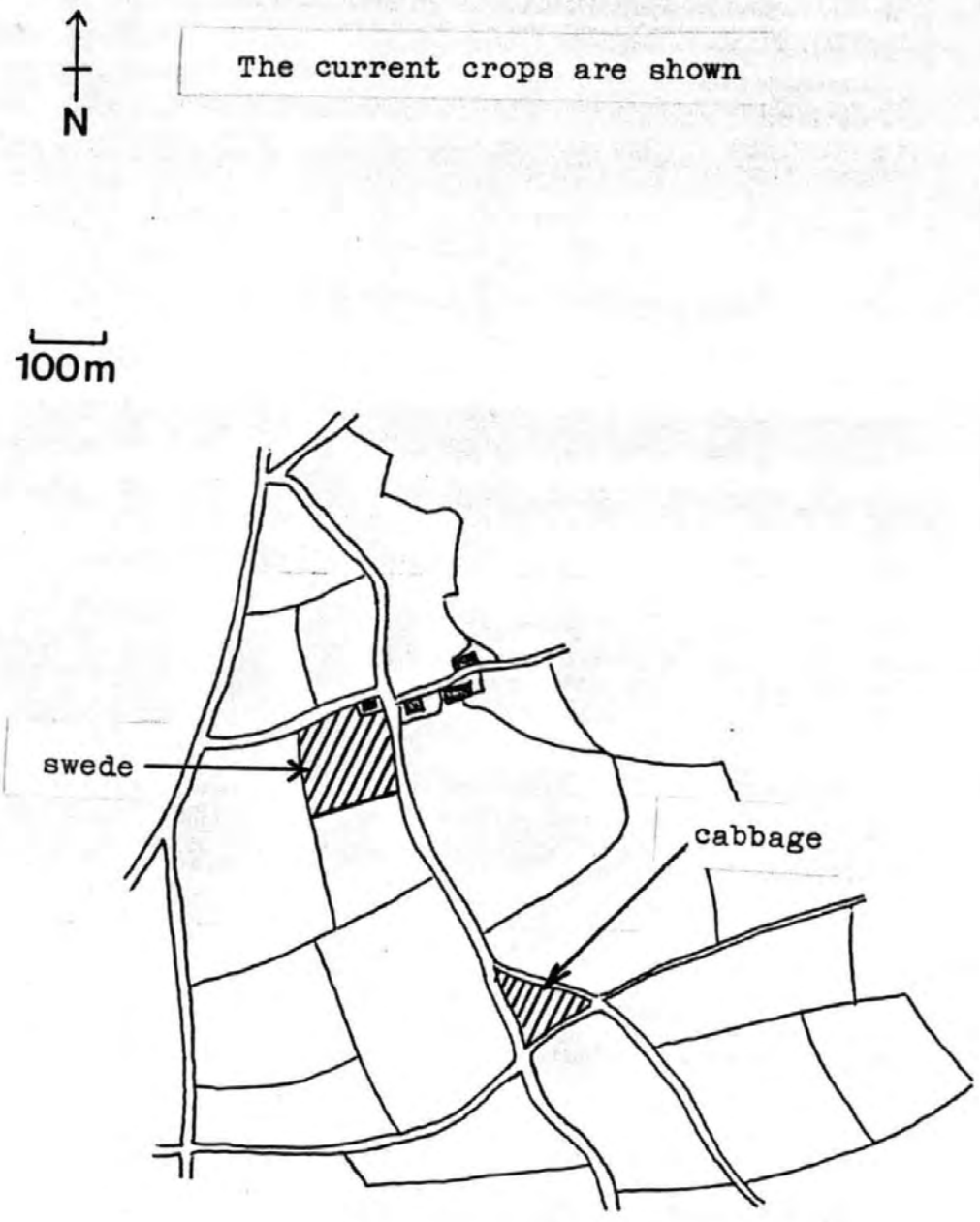
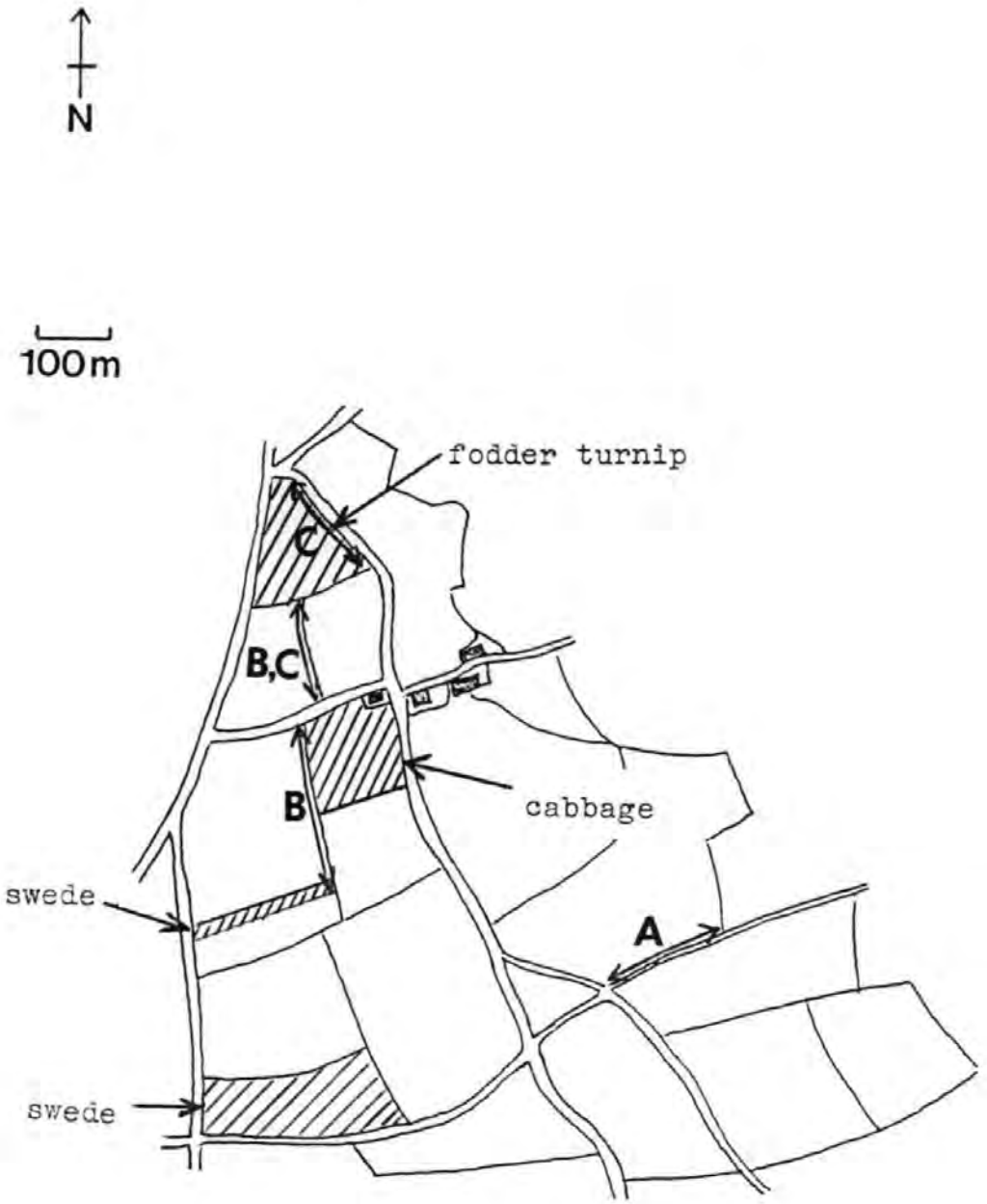


FIG. 41

VENN FARM East Allington, Devon SX 780465

1980



A = trap line for 1st. generation (weeks 1-9)
B = trap line for 2nd. generation (weeks 10-16)
C = trap line for 3rd. generation (weeks 17-23)

FIG. 42

The detailed trap arrangement for the second generation of cabbage root fly on Venn Farm 1980.

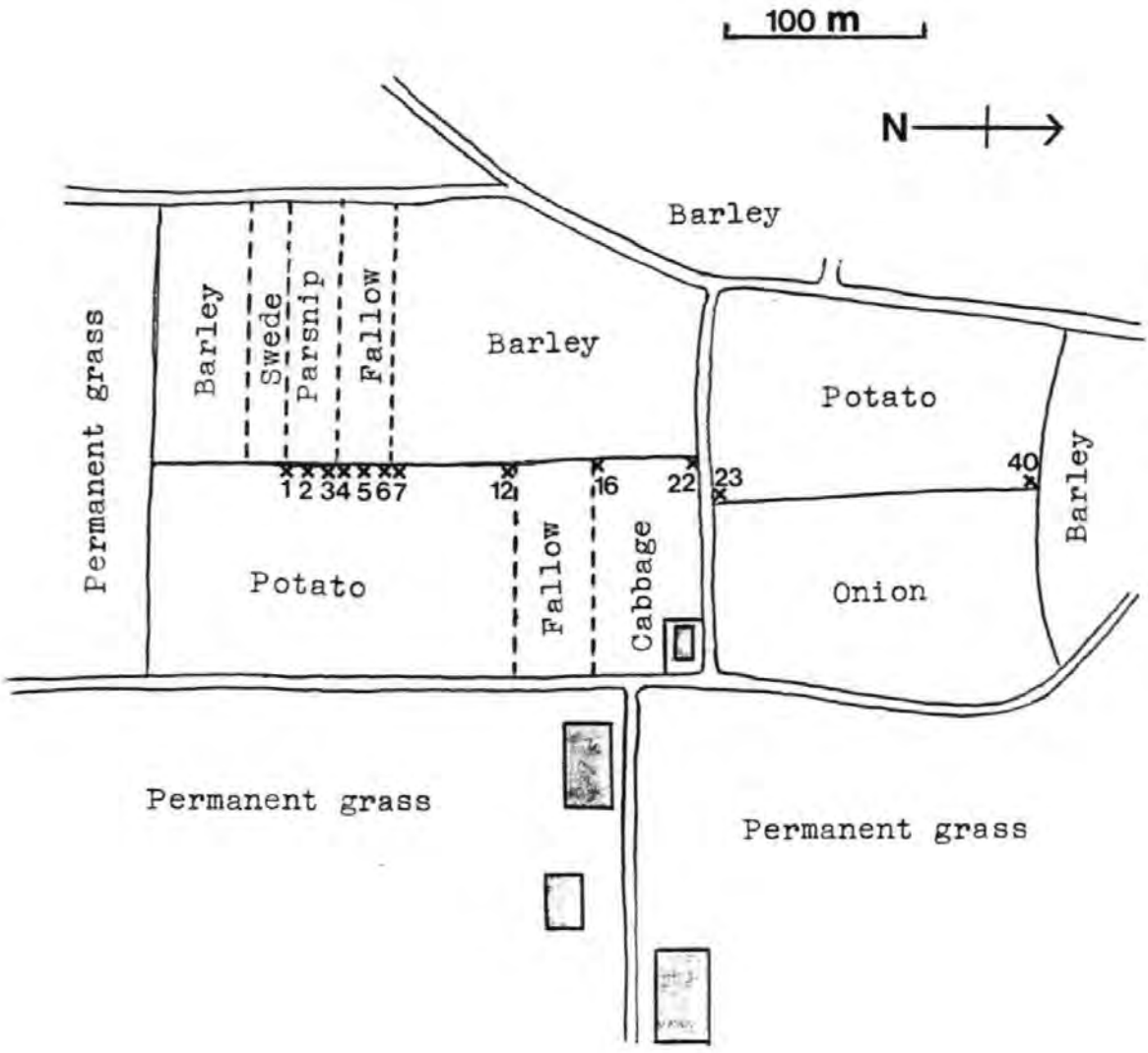
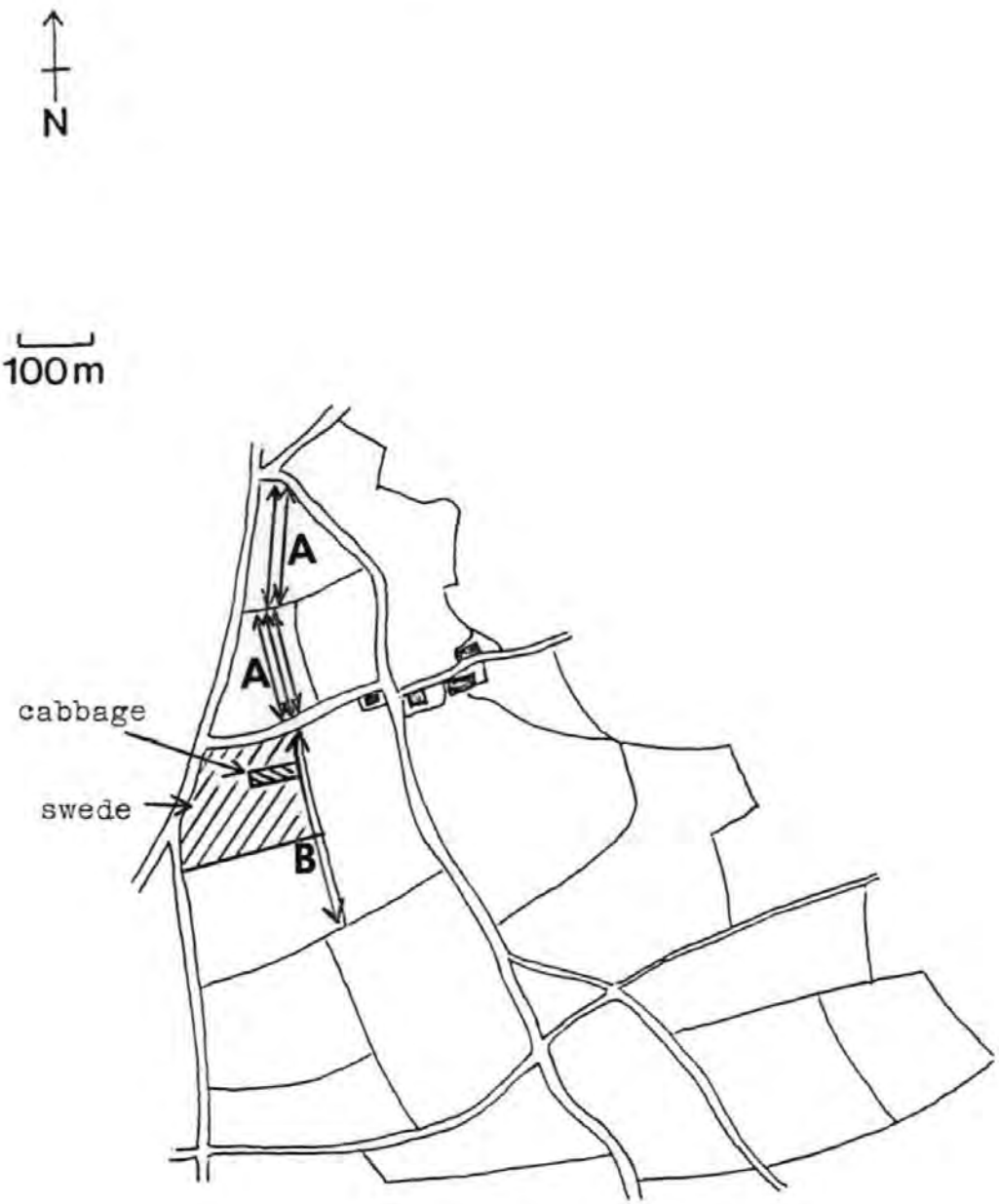


FIG. 43

VENN FARM East Allington, Devon SX 780465

1981



A=trap line for the first generation (weeks 1-8)
B=trap line for the second generation (weeks 9-15)

overwintering population. The 1979 swede crop was not seriously attacked, and should produce a smaller overwintering population. Both crops were removed during the winter, so the female flies will have to disperse in spring to locate a host crop for oviposition. A small area of swedes were planted in May, 1980, and were seriously damaged because they were not treated with insecticide. For the first generation of 1980, a line of traps were laid alongside the hedge in a field of winter barley adjacent to the site of last years' cabbage crop (Fig. 41).

For the second generation, a trap line was arranged along the wire fence leading away from the infested swede crop (Figs 41 & 42). The trap line was continued northwards along a hedge in a field planted with potato.

A field of summer cabbage was planted in peat blocks (Saynor, Davies & Brown, 1982) during the second generation (Fig. 42). The peat blocks contained insecticide which provided effective protection of the crop as shown by the little evidence of attack by cabbage root fly. A small population of flies would have developed on the cabbage crop, with a larger population on the swede crop. The third generation was sampled by a trap line in the potato field, which was extended through a field of recently-planted fodder turnip (Fig. 41). This latter crop was grazed off by sheep after six weeks, and there may have been insufficient development of the root system to support more than a small fly population.

A spring barley crop in the spring of 1981 offered the opportunity for a replicated trap line. There will be emergence of flies from the site of the previous year's cabbage crop, and possibly also from the site of the fodder turnips (Fig. 42). The age structure

of the population will be used to determine the sources of emerging flies (Ch. III.8). Three parallel trap lines were arranged in the barley crop (Fig. 43), each line separated by 20 m. to prevent interference. The trap spacing progressively increased away from the cabbage crop emergence site. It was necessary to gradually raise the traps as the barley grows, to maintain their visibility to the flies. This was achieved using a series of bamboo canes, with two further canes to provide support during strong winds. Two of the trap lines were continued through a neighbouring winter barley field, the site of last year's fodder turnip crop.

A small area of cabbage was planted towards the end of the first generation, which could be expected to be attacked by cabbage root fly. The surrounding area was planted with swedes during the second generation. The second generation was sampled by a single trap line along the wire fence (Fig. 43). The crop layout made it impossible to arrange any length of trap line during the third generation of cabbage root fly, so sampling was continued on a reduced scale to monitor the population changes.

(b) Great Englebourne Farm

A field of fodder swedes and a small area of kale were grown in 1979, both crops being planted in June and harvested during the following winter (Fig. 44). The district is concerned mainly with livestock rearing, and there are no other brassica crops grown within a one mile radius, except for a garden containing a small area of cabbages.

The first generation of cabbage root fly in 1980 was sampled with a trap line extending through two adjacent hayfields (Fig. 45). The

FIG. 44

GREAT ENGLEBOURNE FARM Harbertonford, Devon SX 777568

1979

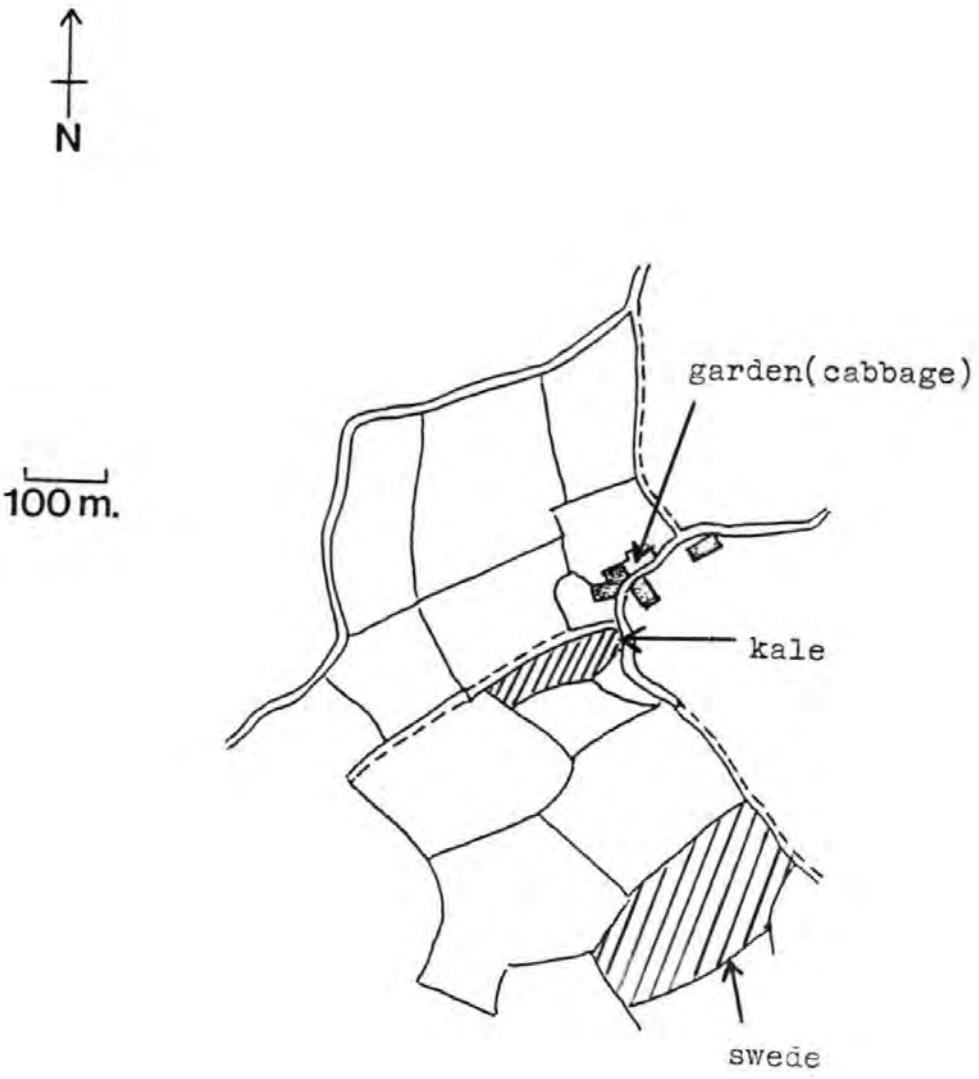
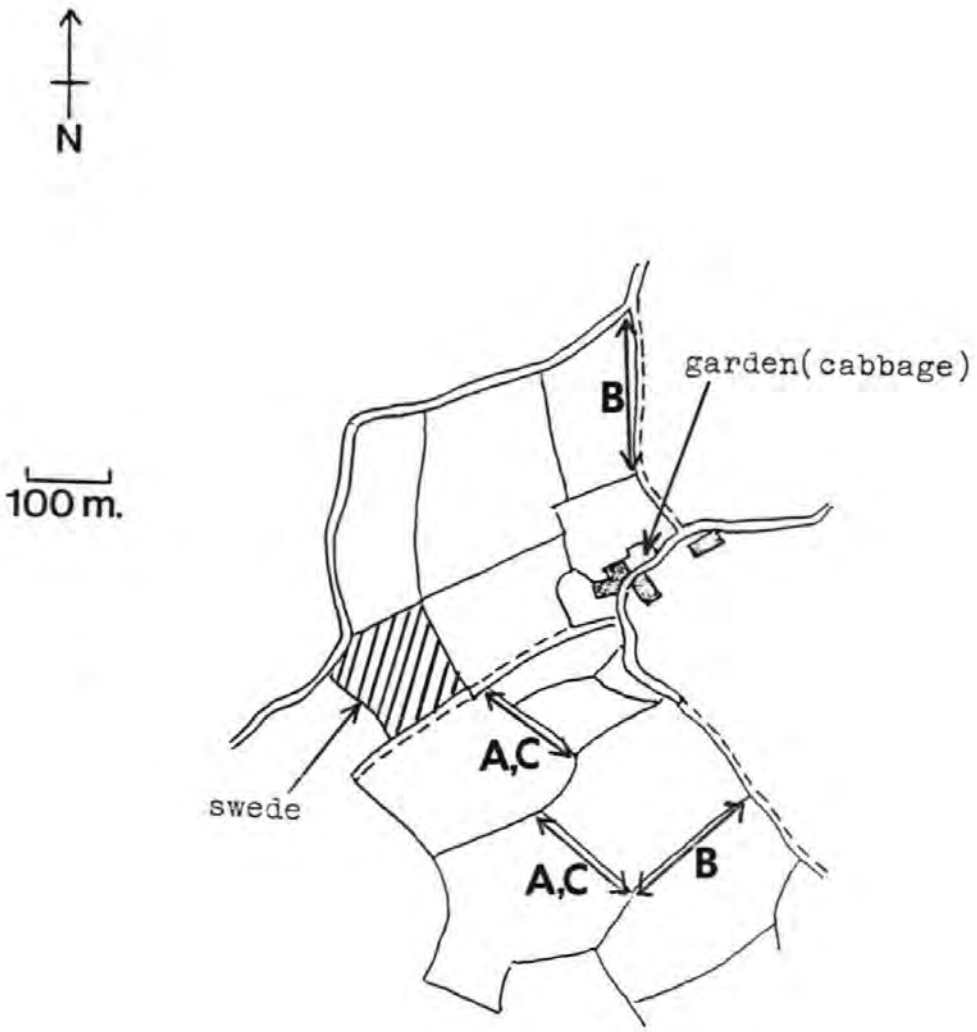


FIG. 45

GREAT ENGLEBOURNE FARM Harbertonford,Devon SX 777568

1980

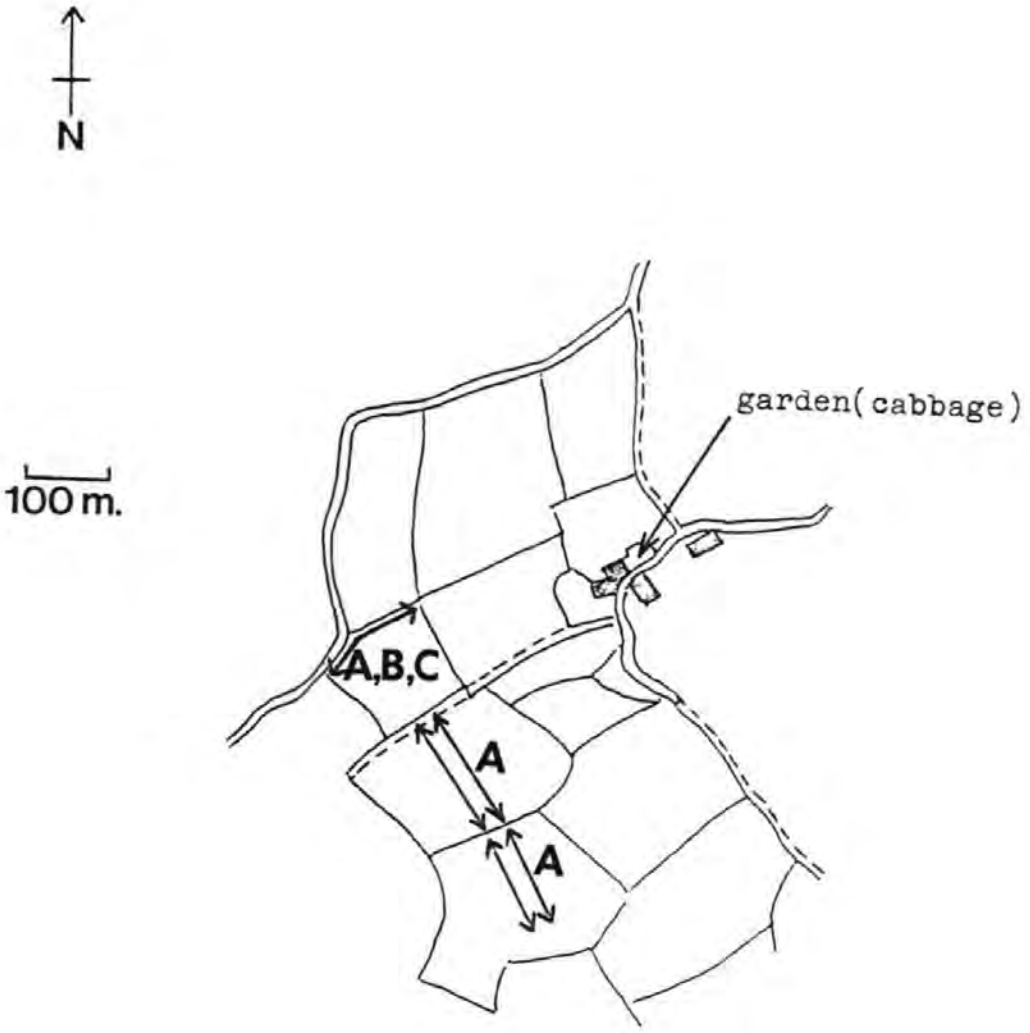


A=trap line for the first generation (weeks 1-9)
B=trap line for the second generation (weeks 10-16)
C=trap line for the third generation (weeks 17-23)

FIG. 46

GREAT ENGLEBOURNE FARM Harbertonford, Devon SX 777568

1981



A=trap line for the first generation (weeks 1-7)
B=trap line for the second generation (weeks 8-15)
C=trap line for the third generation (weeks 16-21)

hedgerows contain few wild crucifers, so the garden plot contains the only brassicas available to the first generation, but located over 600 m. from the emergence site at the previous year's swede crop.

The only source of second generation flies will be the garden plot, so a short line was established through the garden and continued in a nearby potato field (Fig. 45). A number of traps were left in position at the emergence site of the first generation, to test for delayed emergence. The 1980 swede crop was planted during the second generation and was lightly attacked by cabbage root fly.

The third generation was sampled by a trap line laid through two adjacent fields, used for sheep grazing (Fig. 45). The traps were fitted with plastic grids to prevent the sheep drinking the water, but a large proportion of the traps were broken and the data were too incomplete for further analysis.

The first generation of 1981 was sampled by two parallel trap lines arranged through two adjacent hayfields, leading away from the site of the 1980 swede crop (Fig. 46). The traps were raised on bamboo canes to maintain visibility above the growing grass. It was not feasible to lay an adequate length of trap line during the second and third generations, and a few traps were used to monitor the population change.

(c) Seale Hayne

The garden plots are isolated from the other brassica crops on the farm (Fig. 47). In 1980, the nearest crop was more than 600 m. from the other sources of emerging flies, except for a small plot of swedes grown each year, as a clubroot demonstration plot.

FIG. 47

SEALE-HAYNE AGRICULTURAL COLLEGE FARM
Newton Abbot, Devon SX 827727

1979

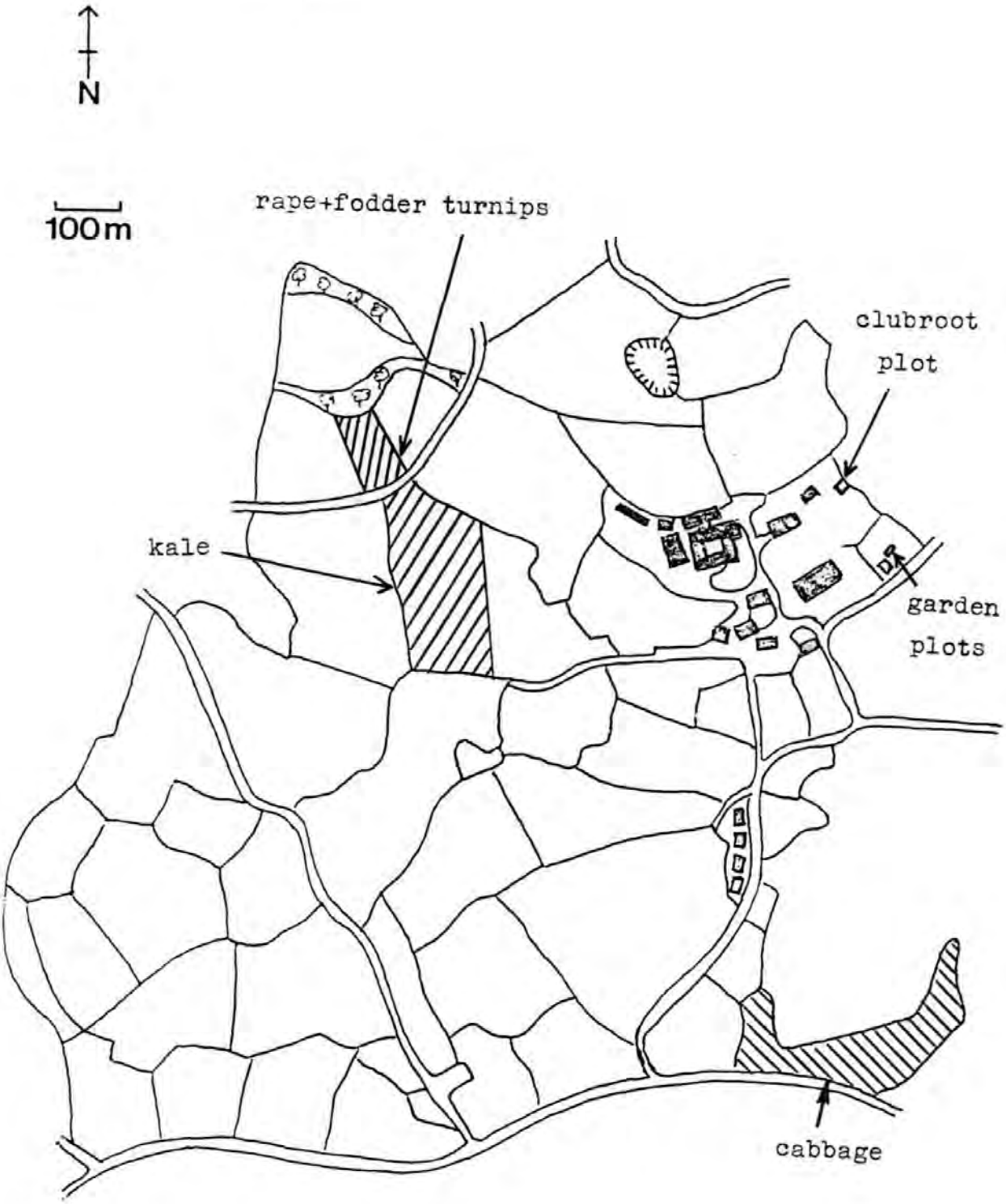
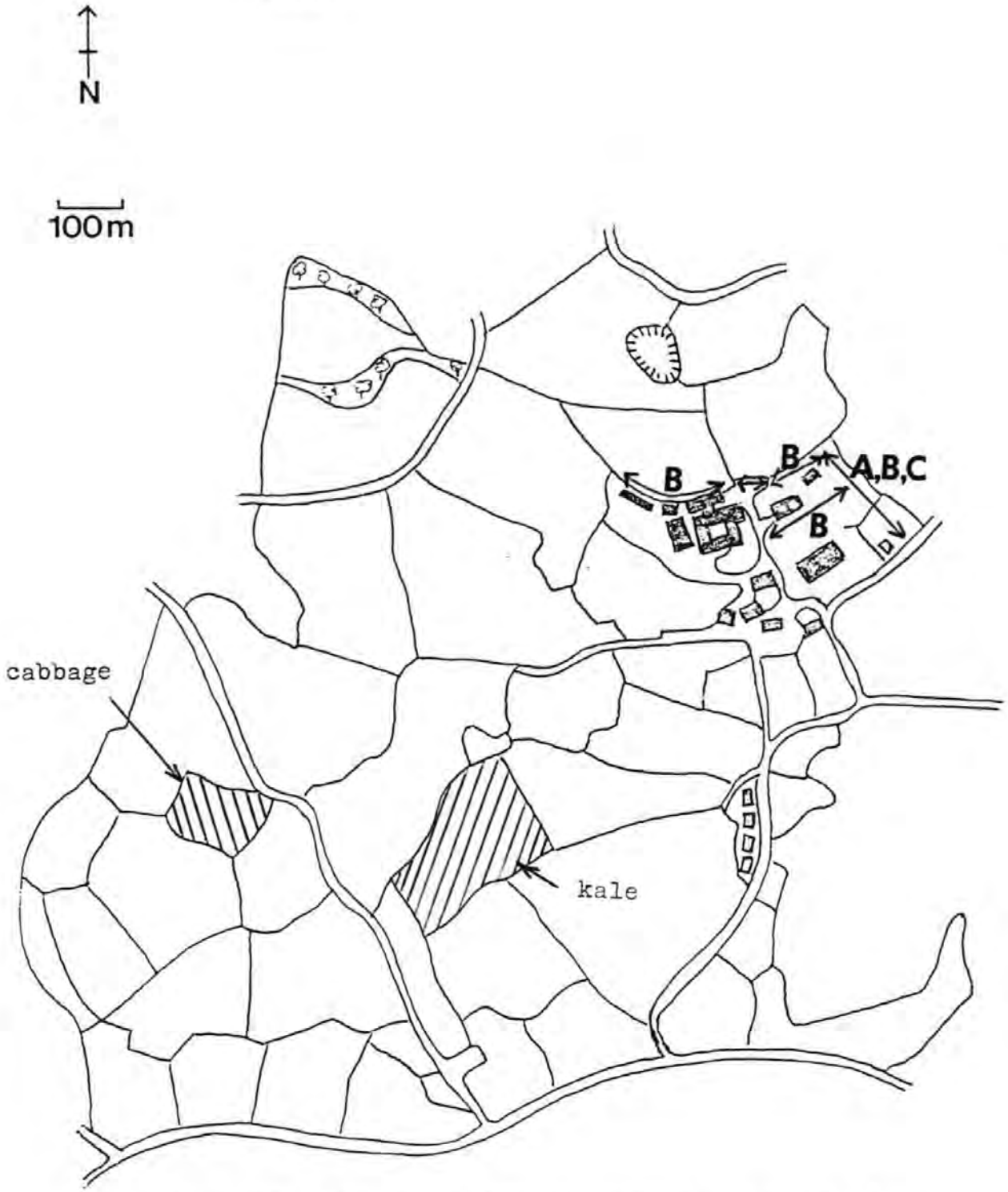


FIG. 48

SEALE-HAYNE AGRICULTURAL COLLEGE FARM
Newton Abbot, Devon SX 827727

1980



A=trap line for the first generation (weeks 1-9)
B=trap line for the second generation (weeks 10-16)
C=trap line for the third generation (weeks 17-23)

FIG. 49

The detailed arrangement of traps in the garden plots at Seale-Hayne Agricultural College.

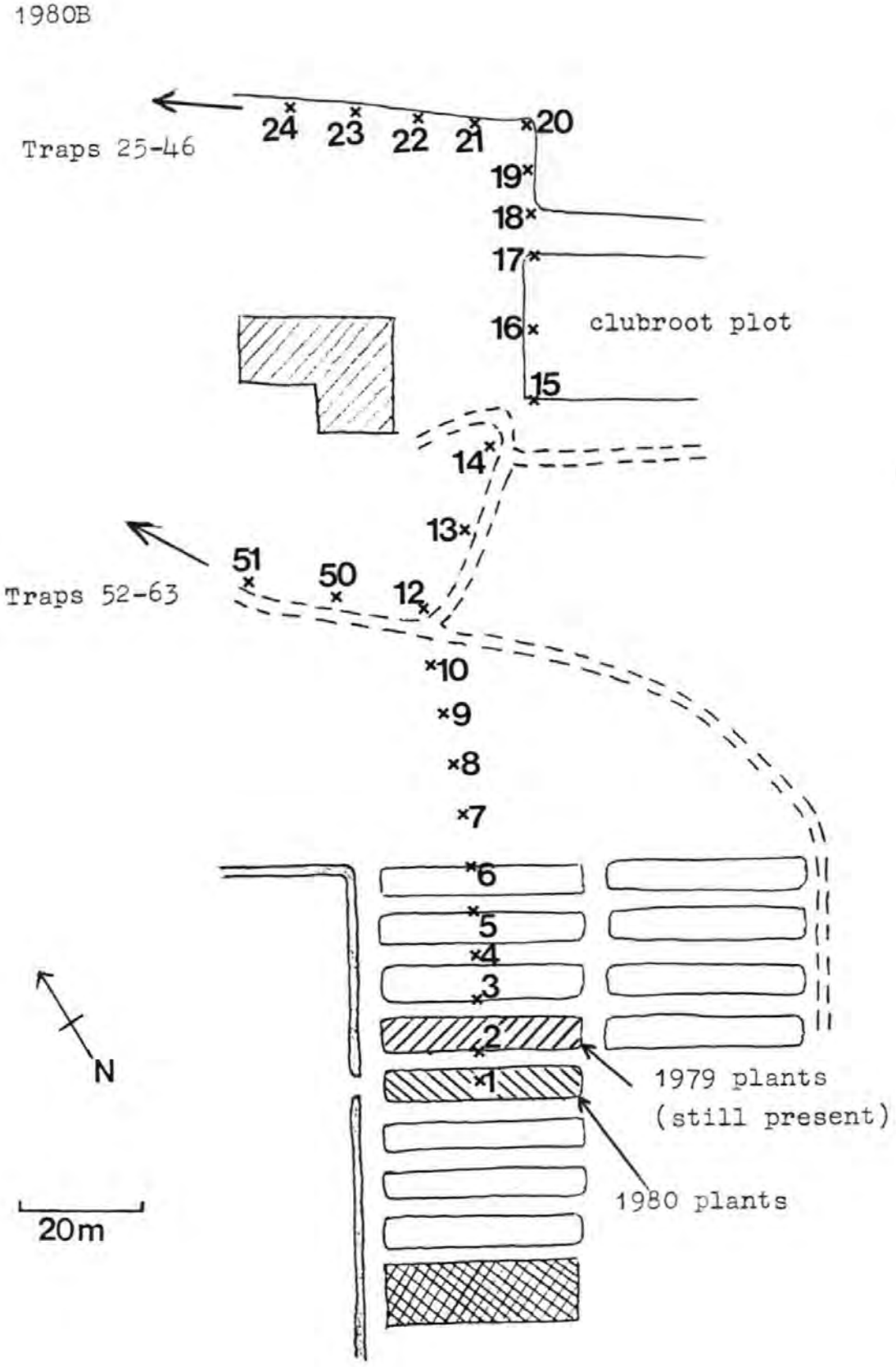
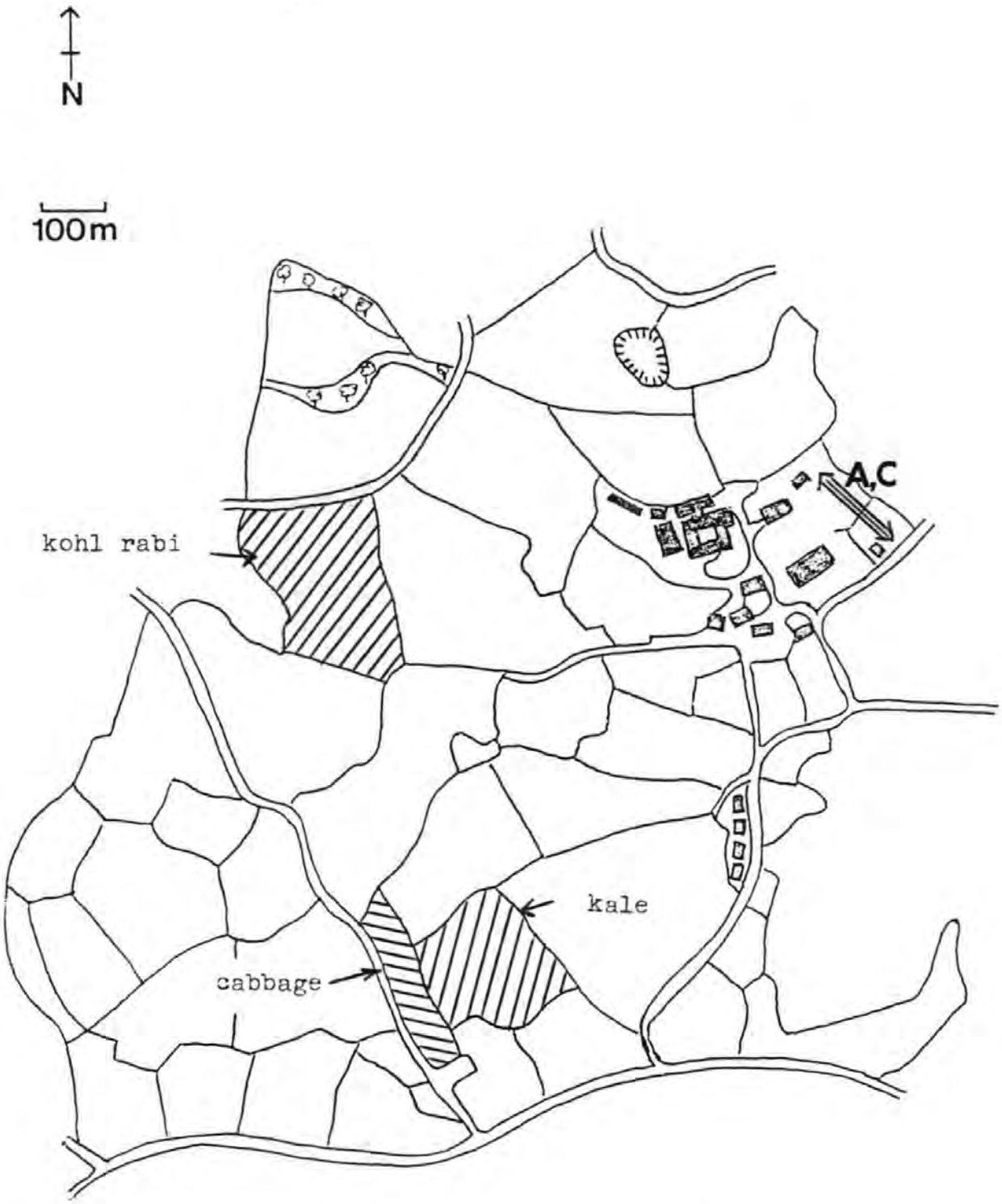


FIG. 50

SEALE-HAYNE AGRICULTURAL COLLEGE FARM
Newton Abbot, Devon SX 827727

1981



A=trap line for the first generation (weeks 1-8)
C=trap line for the third generation (weeks 16-21)

FIG. 51

The detailed arrangement of traps in the garden plots at Seale-Hayne Agricultural College.

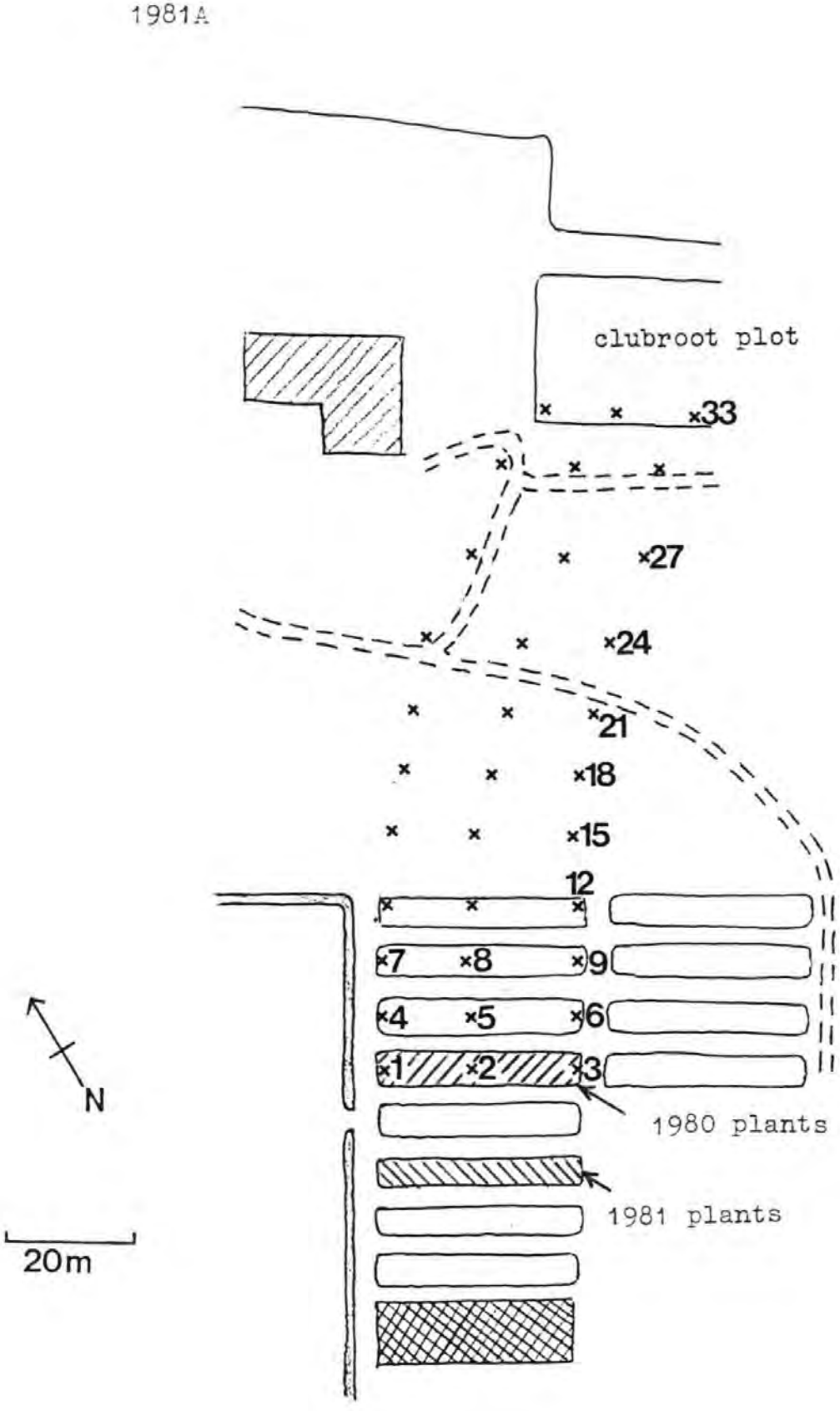
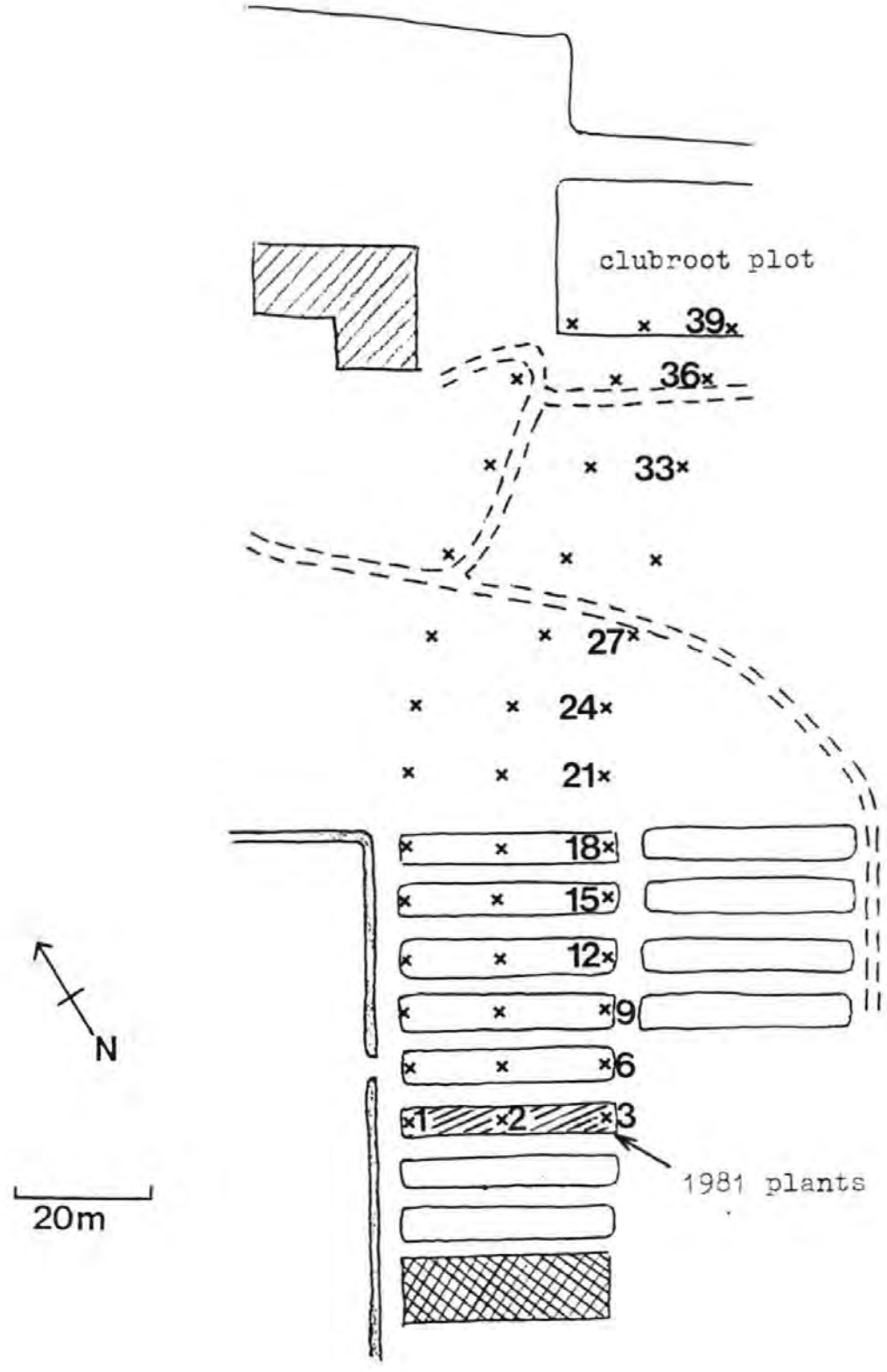


FIG. 52

The detailed arrangement of traps in the garden plots at Seale-Hayne Agricultural College.



The experimental brassica plots are displaced by a short distance in each annual rotation, so it is possible to use a similar arrangement to sample the three generations of cabbage root fly. In 1980, the new brassica plants were grown adjacent to the 1979 site (Fig. 49). A trap line was arranged running northwards, with one branch crossing a mown lawn in front of the buildings, and a second branch passing along a wire fence behind the buildings.

In 1981, the new brassica plants were planted in the plot next but one to the 1980 site (Fig. 51). The long line of 1980 was not an efficient method of sampling cabbage root fly, passing over too diverse a sequence of vegetation types. A shorter, replicated trap line was arranged ending at the clubroot plot. The traps had to be removed during the second generation to allow the area to be ploughed, but the traps were replaced for the third generation.

The generation notation

The following notation will be used to refer to the different generations at each site. The first generation will be denoted by the suffix A, the second by B, and the third generation by C. The first generation of 1980 on Venn Farm would be referred to as Venn 1980A.

CHAPTER III.4

Testing the statistical assumptions

Introduction

Parametric statistics (e.g. regression and analysis of variance) are based on a number of assumptions about the distribution of the data. The error distribution is assumed to be homogeneous, normal and independent of the mean (Sokal & Rohlf, 1969; Kleinbaum & Kupper, 1978). The violation of these assumptions may have serious consequences for the derived coefficients and their associated significance tests. If the data fail to meet the assumptions, then it is usually possible to achieve a closer approximation by a suitable transformation. Parametric statistics are generally robust to moderate departures from the assumptions, although the consequences of violation should be assessed, so analysis can proceed with an awareness of the risk of incorrect conclusions.

Animals usually occur in a markedly aggregated distribution. The dependence of the variance on the mean causes marked variance heterogeneity. The normality and variance heterogeneity can be investigated to determine the required transformation.

The distribution of the data can be described using the moment statistics, the skewness and kurtosis, which can be tested for significant departure from normality (Sokal & Rohlf, 1969). The normality can also be investigated using probability plots, which can reveal multimodality and outlying observations, although it is not possible to test the significance of the observed effects (Southwood, 1978). The cumulative frequency (expressed as a percentage of the total frequency) is plotted against the midpoint of the frequency classes.

A normal distribution will produce a straight line, and any bias will be revealed as changes in the slope of the line (Southwood, 1978).

The relationship between the variance and the mean can be described by fitting a negative binomial function or through the power law (Mukerji & Harcourt, 1970; Finch, Skinner & Freeman, 1975, 1978). In the negative binomial, the variance (S^2) varies with the mean (m) according to the value of the exponent (k) (Elliot, 1977).

$$S^2 = m + m^2/k$$

The inverse hyperbolic sine square root is an exact transformation for the negative binomial (Anscombe, 1948; Elliot, 1977), although, in practice, most data can be transformed to logarithms. The log transform and the more complex transform are nearly linearly related when the value of k is close to two (Green, 1980). A value for k of 2.38 was obtained for the dispersal of cabbage root fly over Brussels spouts, and 1.19 for dispersal over fallow ground (Freeman, 1977). It would be necessary to add a start to the data before transformation to accommodate the zero observations, since log zero equals minus infinity. A start of 3/8 appears to be optimum for practical purposes, except when k is small (Anscombe, 1948). The more complex transform can accommodate zero observations, but would prevent an analytical solution to the integral equations for the estimation of the mean distance dispersed (see Introduction).

The power law states that the variance (S^2) is proportional to a fractional power of the mean (m).

$$S^2 = a\, m^b$$

$$= \log_{10} S^2 = \log_{10} a - b \log_{10} m$$

The value of b is estimated from the regression of log variance on log mean, and the appropriate transform is to replace each count

with $z = x^p$, where $p = (1 - b/2)$ (Elliot, 1977). The value of b is normally of the order of two indicating that a log transform is required (Mukerji & Harcourt, 1970; Finch, Skinner & Freeman, 1975, 1978; Elliot, 1977).

The power law has the advantage of covering a wider range of distributions (including the negative binomial) and being simpler to calculate. The value of k for the negative binomial, is often unstable, increasing with the mean, requiring a specific transform for each sample (Harcourt, 1967; Finch, Skinner & Freeman, 1975, 1978). The transforms derived from both the power law and the negative binomial have been found to be successful in eliminating the dependence of the variance on the mean for cabbage root fly (Harcourt, 1967; Mukerji & Harcourt, 1970).

The equality of the variances can be tested by a number of methods, but in practice all they measure are the departures from normality (Sokal & Rohlf, 1969; Lindeman, 1974).

Results

(a) Normality

The untransformed data produce strongly concave curves on probability paper (Fig. 53), indicating that the distribution is positively skewed. The $z = \log_e(Y + 1)$ transform produces a significant reduction in both skewness and kurtosis, except for the small number of flies caught in the young age-groups, which are relatively unaffected by transformation (Table 13). The transformed data produce a good approximation to a straight line on probability paper, although a definite multimodality exists in some of the data sets (Figs 53-55). The multimodal curves evident for Venn 1980B, Venn 1981A and Great Englebourne 1981A can be shown to arise from the combination of two

TABLE 13

The investigation of the normality of untransformed and transformed data from Venn 1980B.

		UNTRANSFORMED		TRANSFORMED $Z=\log_e(Y+1)$	
Age-group	N	Kurtosis	Skewness	Kurtosis	Skewness
F 1+3	29	+0.063	$+1.105^{a}$	-1.497	+0.309
F 5	29	$+3.420^{c}$	$+1.998^{c}$	-0.332	+0.697
F 6	29	$+5.027^{c}$	$+2.082^{c}$	+0.141	-0.360
F T	29	$+3.713^{c}$	$+1.933^{c}$	-0.576	+0.229
M 1	29	$+3.687^{c}$	$+1.919^{c}$	-0.851	+0.078
M 2	29	$+3.061^{c}$	$+1.722^{c}$	-0.026	-0.041
M 3	29	$+13.254^{c}$	$+3.316^{c}$	+1.216	+0.608
M T	29	$+4.874^{c}$	$+2.057^{c}$	+0.125	+0.185

a = $P < 0.05$
b = $P < 0.01$
c = $P < 0.001$

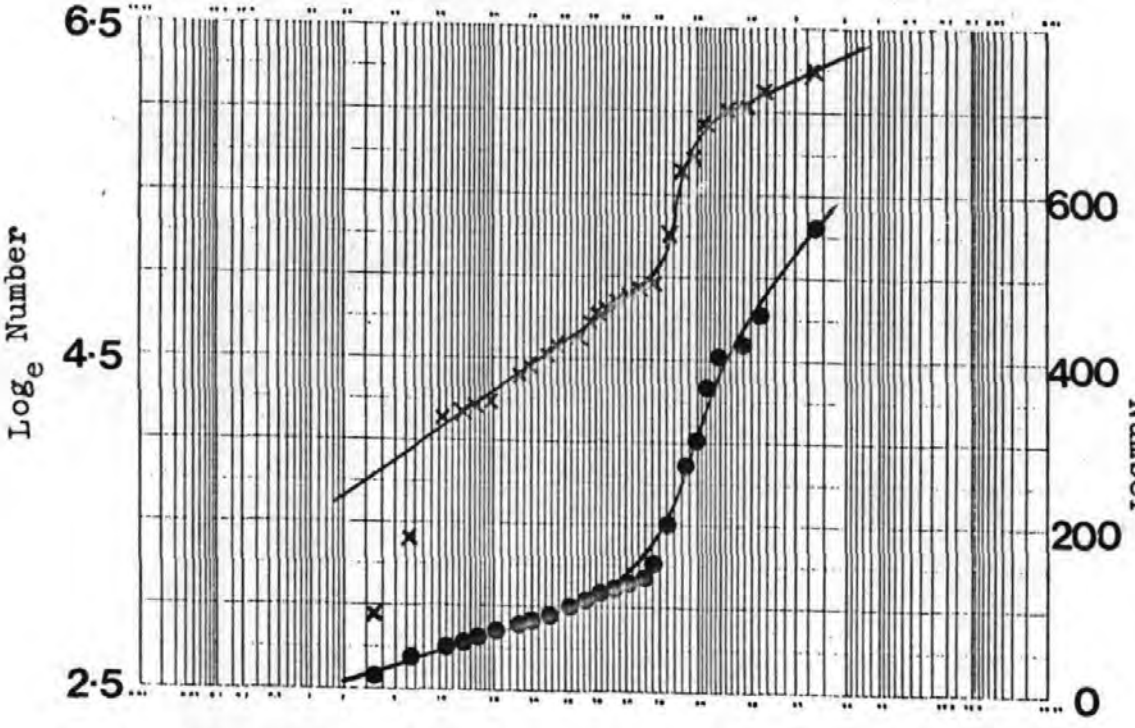
The kurtosis and skewness have been tested for significant departure from normality(zero) (Sokal & Rohlf 1969).

FIG. 53

An investigation of the normality of the data using probability paper.

● Untransformed data ✕ Transformed data

(a) VENN 1980B MALE TOTAL



(b) VENN 1981a MALE TOTAL

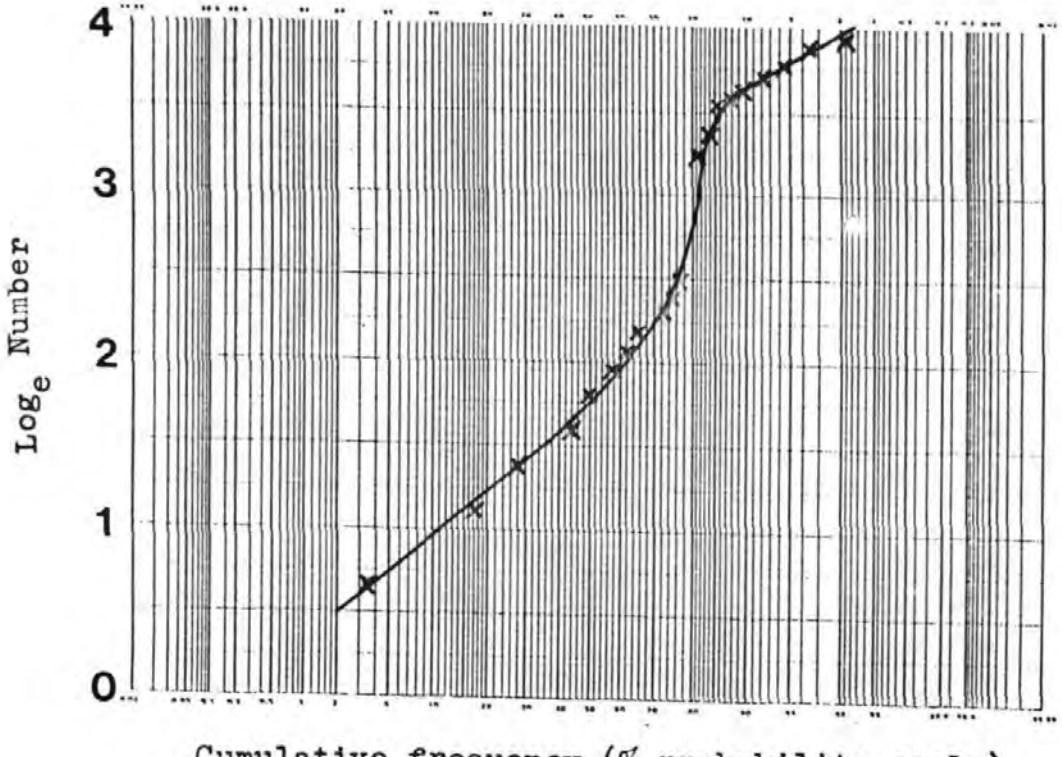
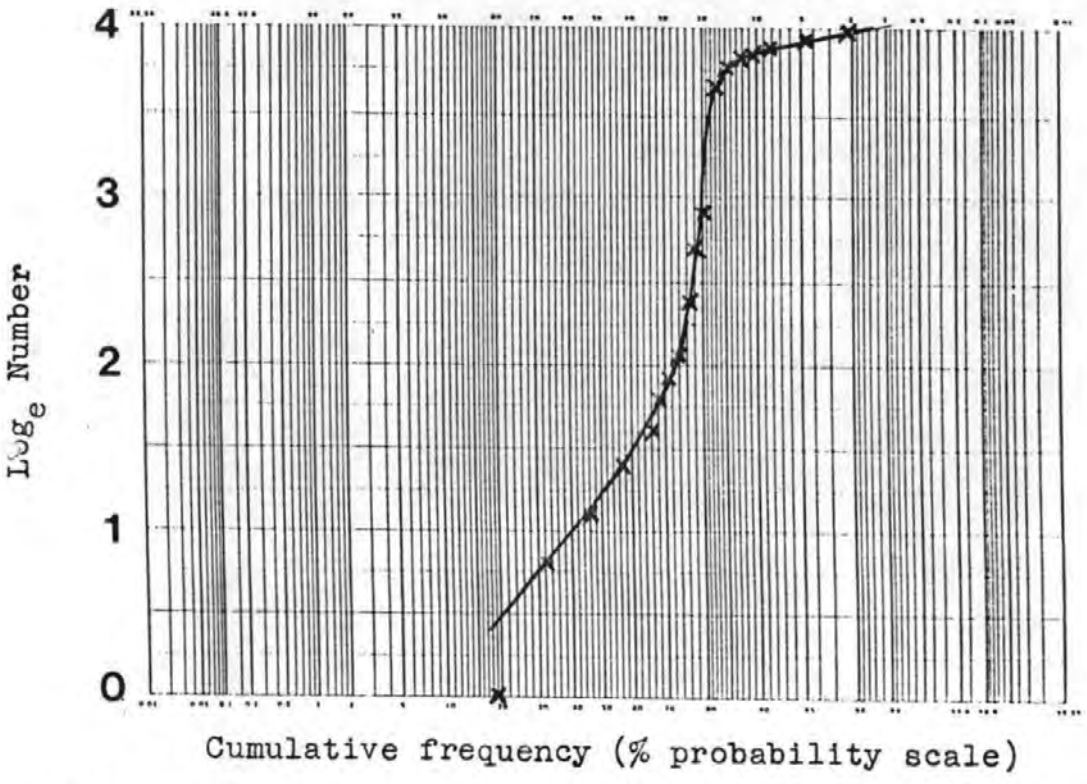


FIG. 54

An investigation of the normality of the data using probability paper.

(c) GREAT ENGLEBOURNE 1981A FEMALE TOTAL



(d) SEALE HAYNE 1980B FEMALE TOTAL

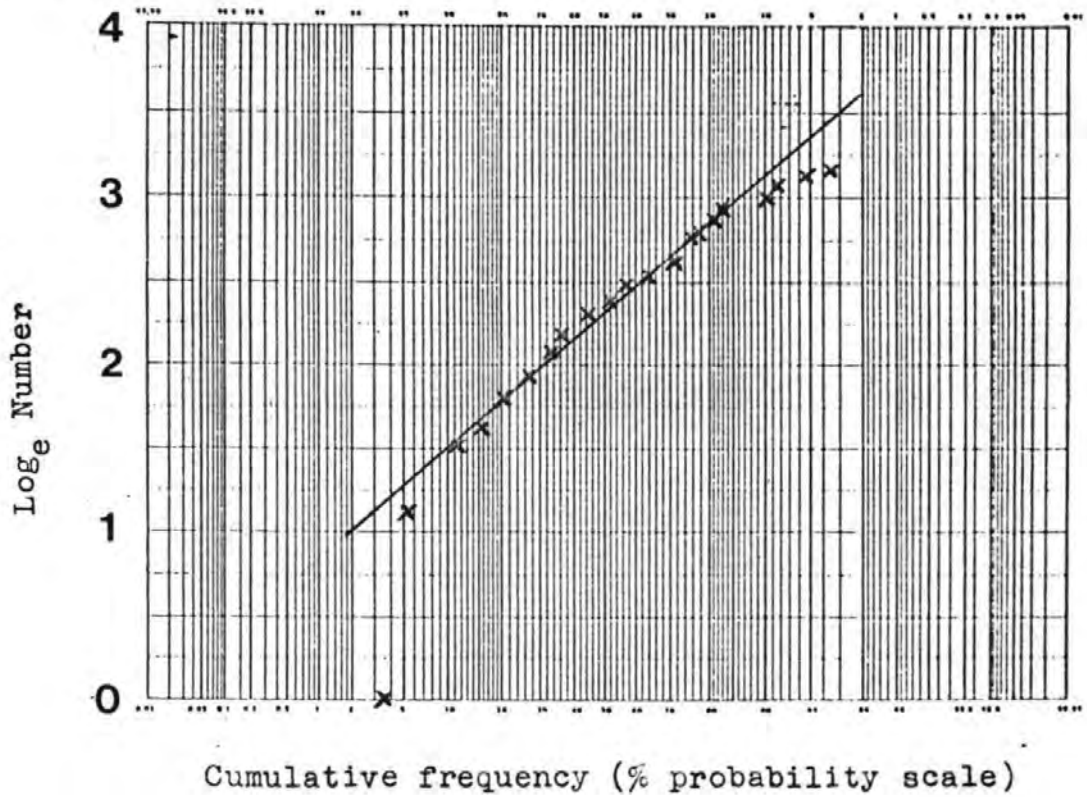
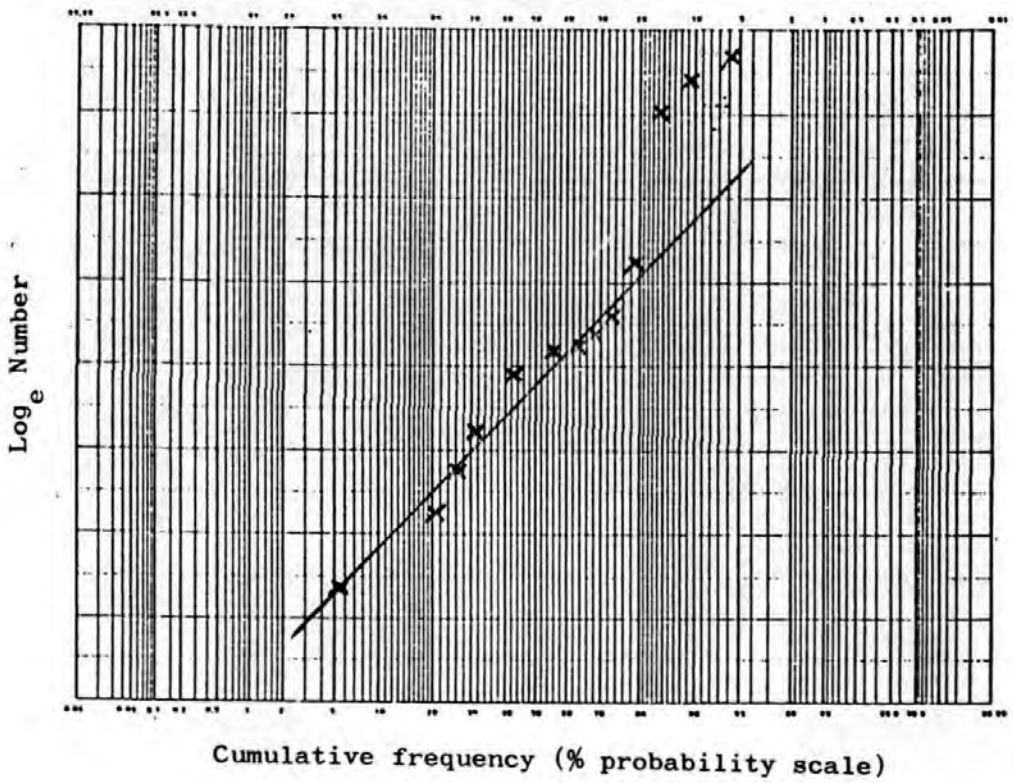


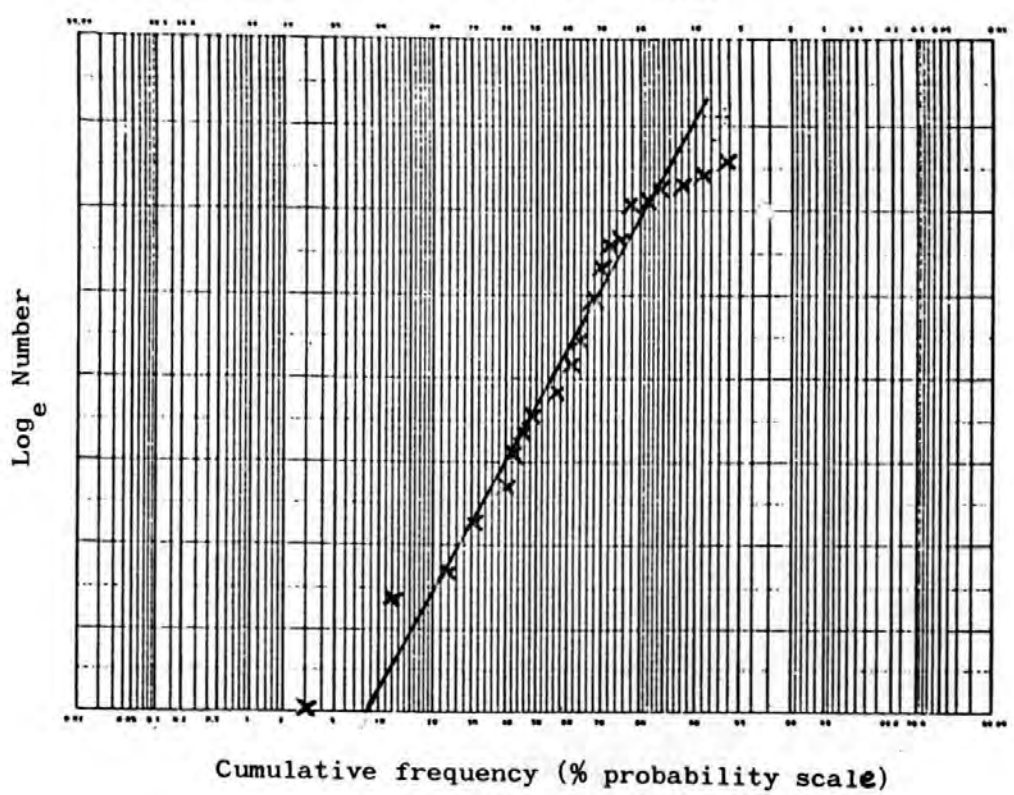
FIG. 55

An investigation of the normality of the data using probability paper.

(e) GREAT ENGLEBOURNE FEMALE TOTAL



(f) SEALE-HAYNE 1981A GRAVID(F5) FEMALES



normal distributions (Cassie, 1962; Stott, 1967). In a study of fish movement, Stott (1967) attributed such a bimodal distribution to the presence of a bimodal group and a second more mobile group. The bimodal distribution of Venn 1980B may indicate that there are two populations of flies present, the first dispersing at normal rates from the primary emergence site and a second population dispersing more slowly from a secondary aggregation (see Ch. III.7). The bimodality of Venn 1981A and Great Englebourne 1981A may be caused by the aggregation of flies at the hedgerows (see Ch. III.7).

There are clearly a number of outlying points in the data of Great Englebourne 1980B, which are caused by the consistently low catch of Traps 5 and 6. This discrepancy may be caused by the shading of nearby trees (Hawkes, 1973). The data of Seale Hayne 1981A contain a small group of upper outliers, but only in the gravid and parous age-groups caused by aggregation at the swedes of the clubroot plot (Hawkes, 1975).

(b) Variance homogeneity

The untransformed data of all age-groups at all samples sites, exhibit a very significant relationship between the variance and the mean. The slope from the power law ranges in value from 1.0-2.3 (Table 14). A slope of 2.0 would indicate that a logarithmic transform was required (Elliot, 1977). Many of the fitted slopes differ significantly from 2.0, but a log transform will be applied for an initial investigation. A start of unity will be added to all the counts before transformation, to accommodate the zero observations (Elliot, 1977).

The variance becomes independent of the mean after transformation in many age-groups, but in all age-groups the dependence of the

TABLE 14

The regression of $\log_{10}$ variance on $\log_{10}$ mean for the seven sample times of Venn 1980B.

A) UNTRANSFORMED VARIABLES

Age-group	Intercept(a)	Slope(b)	R^2	F	DF	P
F 1+3	0.413	1.39	93.7	90.0	1,5	c
F 5	-0.166	2.21	96.6	171.5	1,5	c
F 6	0.137	1.95	71.2	15.9	1,5	c
F T	-0.423	2.30	92.9	80.0	1,5	c
M 1	0.633	1.68	48.3	48.4	1,5	c
M 2	0.288	1.91	89.3	51.3	1,5	c
M 3	0.560	1.40	60.1	10.0	1,5	c
M T	0.213	1 86	91.3	54.8	1,5	c
B TRANSFORMED VARIABLES	$Z=\log_e(Y+1)$					
F 1+3	-0.116	1.04	94.1	116.0	1,5	c
F 5	-0.450	1.19	75.1	19.0	1,5	b
F 6	0.0003	-0.14	-18.7	0.06	1,5	
F T	-0.603	1.27	27.1	3.2	1,5	
M 1	0.126	0.78	77.3	21.2	1,5	b
M 2	0.207	0.36	-7.7	0.6	1,5	
M 3	-0.057	-0.36	-7.5	0.6	1,5	
M T	0.083	0.80	84.3	32.3	1,5	b

a = $P < 0.05$
b = $P < 0.01$
c = $P < 0.001$

the variance on the mean was reduced, as shown by the reduced explanation of variance (R^2)(Table 14). A more specific transform will be applied to those cases where the variance was not adequately equalised. The power law provides the transform $z = y^p$, where $p = (1 - b/2)$ (Elliot, 1977). In all cases, there was no significant improvement in the equalisation of the variance. For example, the male total data of Seale Hayne 1980B yields a slope (b) of 1.36 (R^2 = 97.0%), but after transformation to $z = y^{0.32}$ the variance and mean remain highly correlated (R^2 = 97.9%).

The negative binomial was fitted to the female total data of Venn 1980B, producing a series of estimates of k ranging from 0.65 - 1.40 (Davies, 1971; Elliot, 1977). The fitted distribution all show a significant lack of fit, as measured by X^2 (Elliot, 1977). The exponent was independent of the mean, so a common k (0.39) could be validly calculated (Elliot, 1977). The recommended transform for such low values of k is the log transform (Elliot, 1977).

Discussion

The $z = \log_e(y + 1.0)$ transformation is the best transform available, although it is not completely successful in eliminating non-normality and variance heterogeneity. The more complex transforms do not perform any better, and serve only to make later analysis more difficult.

Parametric statistics are robust to non-normality, particularly when there are a large number of observations (Glass, Peckham & Saunders, 1972; Lindeman, 1974). The multimodality requires further investigation, as it is probably caused by basic changes in the underlying distribution of the flies (see Ch. III.7).

The variance heterogeneity will not bias the regression, but could seriously affect the significance tests (Glass et al., 1972; Lindeman, 1974). The variance ratio (F) test is robust to unequal variances provided there are an equal number of observations for each sample. The actual significance level would be slightly increased over the nominal level. The F test can be seriously affected by small departures from the assumption of equal variances when there are unequal sized samples. The variance heterogeneity should not have serious consequences, because an equal number of traps were used for all the samples within a generation, and there are usually only a small number of missing observations. Care should be exercised in the interpretation of the young age-groups, where the variance remains strongly dependent on the mean. The residual pattern produced by the fitting of the regression models can be examined for significant nonnormality or variance heterogeneity (Kleinbaum & Kupper, 1978)(see Ch. III.9).

CHAPTER III.5

The effect of the starting value on regression analysis

Introduction

The data are to be transformed to logarithms, but some adjustment has to be made to accommodate the zero observations, since log zero is minus infinity. The usual practice is the addition of unity to all the values before transformation (Elliot, 1977). Freeman (1977) found that $z = \log (y + 3/8)$ was satisfactory for the equalisation of variance for adult cabbage root fly, and Mukerji and Harcourt (1970) found that $z = \log (y + \frac{1}{2})$ was as useful in the equalisation of the variance for juvenile cabbage root fly, as more complex transformations.

The log zero values could also be replaced by an arbitrary value, which as log unity is zero, then any negative value would be a move in the right direction (Mosteller & Tukey, 1977). The value chosen will have consequences for the normality of the data, and could profoundly influence the fitted slope. A third alternative would be to omit the zero observations, although this could lead to a serious depletion in the number of observations and does represent a loss of information.

The value of the estimated slope will be used to calculate the mean distance dispersed, so it is essential that it represents an accurate and unbiased fit to the data. The addition of a start will alter the estimated value of the slope, because the addition of constant will affect the smaller values to a greater extent than the larger values. The start will tend to decrease the value of the slope. The effect would be expected to be greater when all the values are relatively low (i.e. when the fitted regression has a small

intercept). The integral equations used to estimate mean distance dispersed (see Introduction) cannot be solved analytically if a starting value had been included.

Methods

The effect of the start will be investigated using a simulation approach. The expected number caught were calculated from the basic model (1) for a range of values for the distance (0 - 400 m.). A slope (b) of -0.1 was used with a series of values for the intercept.

$$y = \exp (a - b\sqrt{x}) \qquad (1)$$

The start was added to these expected volumes, which were then transformed to logarithms and the regression on distance calculated.

Results

The addition of a starting value produces curvature in the previously linear relationship, as can be seen from the slight decrease in the explanation of variance (Fig. 56). The constant start also causes the underestimation of the slope, and the smaller the overall catch (as measured by the intercept) then the greater is the underestimate of the slope (Fig. 57). A start of unity produces less than a 10% error in the slope when the intercept is greater than three (Fig. 57). In practice, the majority of the data sets will have an intercept greater than three, so the error may be acceptable. The pooling of the individual sample times for each generation (see Ch. III.9) would further increase the fitted intercept and reduce the distortion caused by the start.

The influence of the start could be further reduced by decreasing the value of the start. The smaller the value of the start, then the

FIG. 56

The effect of adding a start of unity to a regression line.

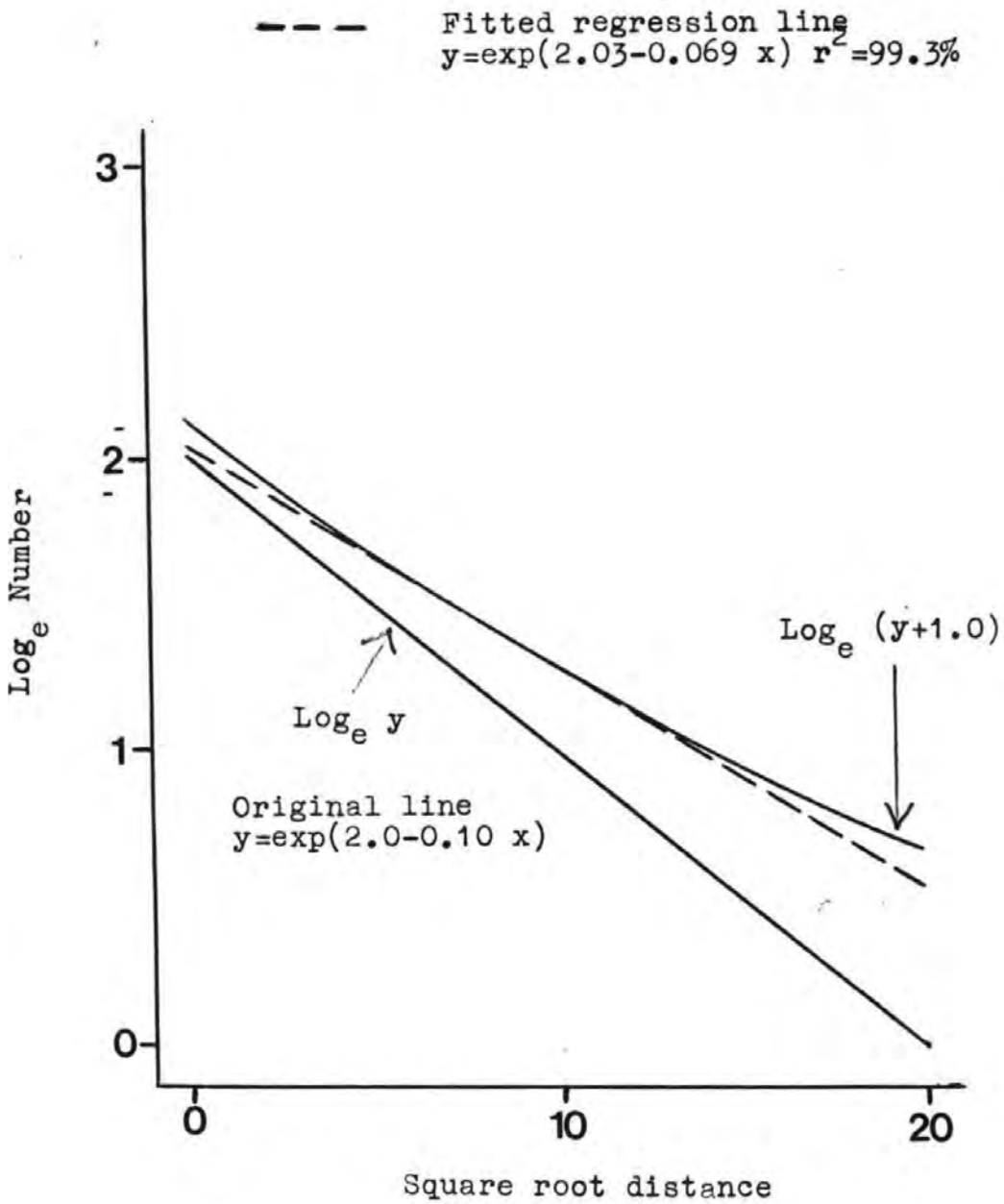


FIG. 57

The effect of different starting values on the relationship between estimated slope and the intercept .

$$\text{Log}_e Y = a - b X^c$$

$b = -0.10$

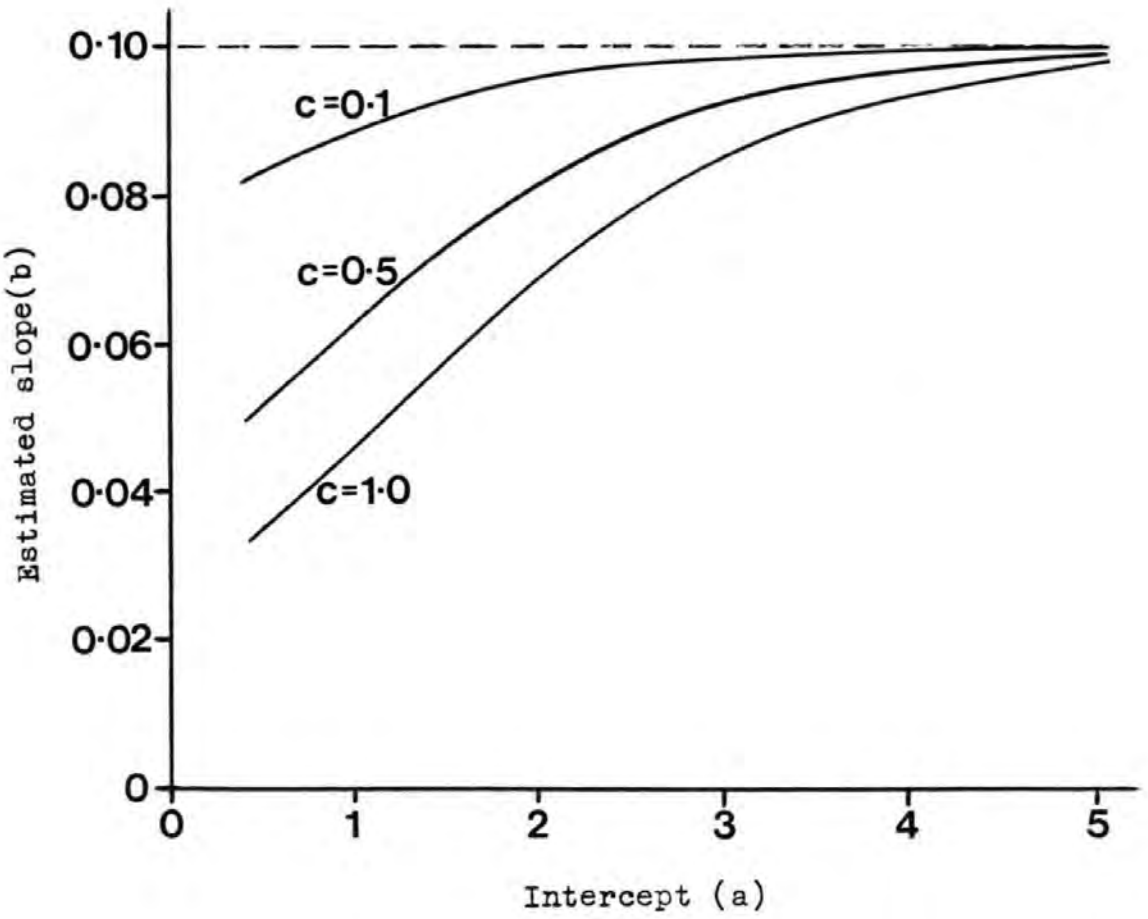


TABLE 15

The different effect of various starting values (c) on the transformed value of zero and unity.

	Log_e (Y+c)		
	c = 1.0	c = 0.5	c = 0.1
Y = 0.0	0.000	-0.693	-2.303
Y = 1.0	+0.693	+0.405	+0.095
DIFFERENCE	-0.693	-1.098	-2.398

smaller the underestimate of the slope (Fig. 57). This is true for all values, except y = 0, when the smaller values increase the distortion (Table 15). The smaller the value of the start, then the larger is the difference between the zero and non-zero values.

Conclusions

The choice of the value of the start must be a compromise between the conflicting requirements of minimising the distortion of the non-zero values, or minimising the distortion of the zero values. If the zero observations are to be retained, then a start of unity will cause the least distortion provided the fitted intercept is reasonably large ($\log_e a = 3.0$). The slope will then be estimated with an error of less than 10%, producing less than 20% error in the mean distance dispersed. If the zero values are omitted, then obviously no start is required, but information is being discarded. The reduction in the number of observations will lead to an increase in the standard error.

CHAPTER III.6

A preliminary investigation by analysis of variance of the factors important in the description of the data

Introduction

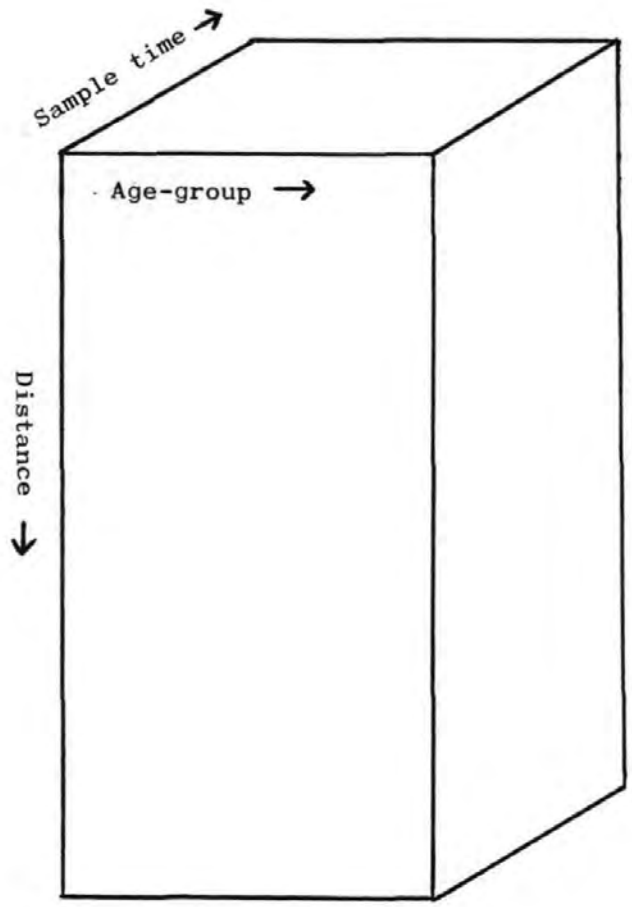
A initial step in analysis is the determination of which variables, or interaction of variables, are important in the description of the data. The explanation of the variables can be examined by analysis of variance, by which the available variance is partitioned between the variables. The data will be analysed as a factorial experiment, albeit with a rather large number of factor levels for distance. A factorial design allows the simultaneous analysis of two or more treatments, from the systematic combination of the treatments (i.e. distance, sample time and age-group). In the case of Venn 1980B there are 29 distance levels, 7 sample times and 3 age-groups, resulting in 609 observations (Fig. 58). The significance of the individual factors can be tested, but also the interaction between the factors. The interaction is the manner in which the effects due to one factor vary because of the changes in other factors. The distance, age-group and sample time would be expected to be important determinants of the numbers of flies caught, but we are more interested in whether there is significant interaction between the factors. Interaction between distance and age would suggest that the distance dispersed by a fly depends on the age.

Methods

The calculation was performed using the GENSTAT package, which was capable of handling the large data arrays. The factor levels can

FIG. 58

A schematic representation of the factorial design.



be conveniently created by the GENERATE command. The number of flies caught were transformed to $z = \log (y + 1.0)$, because omitting the zero observations would have seriously depleted the data set. In the experiments with replication (Table 16), the residual variance can be directly computed for the variance ratio (F) test. In those experiments with no replication, the residual variance was estimated from the higher order interactions.

Results & Discussion

The replicate factor does not explain a significant proportion of the variance (Table 16). The variation in the catch of the individual traps is small in comparison with the effects of distance, sample time or age-group. Replication is not strictly necessary for the control of error, but the larger number of observations will reduce the standard error of the estimated slope.

The distance, sample time and age-group factors all explain a highly significant proportion of the variance for both sexes in all the data sets (Tables 17 & 18). The number of flies caught clearly depends on the distance (Figs 79-107), and there are obvious differences in the catch at different sample times (Figs 22-27). The age-groups are not equally susceptible to capture, with the youngest age-groups being caught the least frequently.

There is a significant interaction between distance and age for most data sets, with the exception of the male data from Venn 1981B and Seale-Hayne 1980C, 1981A & 1981C (Tables 17 & 18). In all these cases there was a low explanation of variance. There were very few males caught at Seale-Hayne, as none of the traps were arranged close to the hedges. An adequate number of males were caught at Venn 1981B,

TABLE 16

The analysis of variance for the male and female data from Venn 1981A.

FEMALE

	DF (MV)	SS	MS	F	P
Replicates	2	0.30	0.15	0.93	
Distance	11	48.84	4.44	27.21	c
Age-group	2	25.06	12.53	76.79	c
Sample time	6	43.29	7.22	44.22	c
Distance -age	22	11.63	0.53	3.24	c
Distance-time	66	22.05	0.333	2.05	c
Age-time	12	10.98	0.91	5.60	c
Dist-age-time	132	22.84	0.17	1.06	
Residual	484(18)	78.98	0.16		
Total	737	263.98			

MALE

Replicates	2	0.003	0.002	0.02	
Distance	11	58.02	5.28	37.61	c
Age-group	2	4.57	2.29	16.30	c
Sample time	6	8.29	1.38	9.85	c
Distance-age	22	9.21	0.42	2.99	c
Distance-time	66	30.95	0.47	3.34	c
Age-time	12	2.91	0.24	1.73	b
Dist-age-time	132	18.84	0.14	1.02	
Residual	490(12)	68.72	0.14		
Total	743	201.52			

a = $P < 0.05$
b = $P < 0.01$
c = $P < 0.001$
MV = missing values

TABLE 17

The partial variance ratios (F) from the analysis of variance of female cabbage root flies.

	Distance	Age	Time	Dist-age	Dist-time	Age-time
Venn 1980B	29.5^{c}	568.7^{c}	42.6^{c}	2.6^{c}	2.4^{c}	22.8^{c}
G 1980B	15.1^{c}	123.9^{c}	14.5^{c}	4.3^{c}	1.8^{a}	9.4^{c}
SH 1980B	7.5^{c}	192.5^{c}	63.3^{c}	2.0^{b}	1.3^{a}	31.0^{c}
SH 1980C	2.7^{c}	45.0^{c}	8.9^{c}	1.6^{a}	1.2	4.1^{c}
Venn 1981A	27.2^{c}	76.8^{c}	44.2^{c}	3.2^{c}	2.0^{c}	1.7^{b}
Venn 1881B	8.3^{c}	404.6^{c}	27.0^{c}	1.5^{a}	1.1	4.3^{c}
G 1981A	28.5^{c}	25.6^{c}	22.4^{c}	2.7^{c}	2.3^{c}	1.4
SH 1981A	51.1^{c}	171.6^{c}	8.5^{c}	12.9^{c}	3.4^{c}	3.6^{c}
SH 1981C	10.0^{c}	15.3^{c}	0.4	3.1^{c}	0.9	2.1^{b}

G = Great Englebourne Farm
SH = Seale Hayne

a = $P < 0.05$
b = $P < 0.01$
c = $P < 0.001$

TABLE 18

The partial variance ratios (F) from the analysis of variance of male cabbage root flies.

	Distance	Age	Time	Dist-age	Dist-time	Age-time
Venn 1980B	22.6^{c}	327.1^{c}	36.9^{c}	1.6^{a}	2.4^{c}	31.9^{c}
G 1980B	6.2^{c}	35.1^{c}	4.2^{c}	1.9^{b}	1.4^{a}	4.6^{c}
SH 1980B	5.5^{c}	53.2^{c}	44.3^{c}	1.5^{a}	1.7^{b}	13.7^{c}
SH 1980C	3.7^{c}	11.3^{c}	22.4^{c}	0.9	1.2	4.6^{c}
Venn 1981A	37.6^{c}	16.3^{c}	9.8^{c}	3.0^{c}	3.4^{c}	1.7^{b}
Venn 1981B	39.0^{c}	13.8^{c}	1.0	30.9^{c}	0.4	2.5
G 1981A	40.1^{c}	14.6^{c}	11.8^{c}	1.9^{a}	2.2^{c}	1.6
SH 1981A	5.8^{c}	20.7^{c}	7.6^{c}	1.2	1.9^{c}	2.0^{a}
SH 1981C	2.8^{b}	2.6^{b}	1.0	1.2	1.6^{a}	1.0

G = great Englebourne Farm
SH = Seale Hayne

a = $P < 0.05$
b = $P < 0.01$
c = $P < 0.001$

but there was a complex relationship between number and distance, which cannot be described by any simple model (Fig. 86).

The significant distance-age interaction suggests that the mean distance dispersed depends on the age of a fly, and the distance-time interaction may indicate that the mean distance dispersed alters with time. The age and time variables are related because the mean age of flies will probably increase with time. The third order interactions are unlikely to reflect any real effects (John & Quenouille, 1979).

CHAPTER III.7

The relationship between the number of flies caught and distance

Introduction

The number of flies should decline exponentially with distance (within sampling error) according to the basic model (1) (Hawkes, 1972a).

$$y = \exp(a - b\sqrt{x}) \qquad (1)$$

The plots of number caught against distance reveals major departures from the expected exponential form (Figs 79 - 107). The local conditions appear to be influencing the number of flies caught, which could be caused by changes in the fly distribution or in the proportion of the population caught. It is necessary to appreciate the mode of action of the yellow water traps and the factors that influence trap catch.

The yellow water traps provide a relative estimate of the population density in the vicinity of the trap. The capture of cabbage root fly depends on the active attraction of the flies, rather than the passive effects of the wind. Wind direction and wind strength have only a small influence on trap catch (Finch & Skinner, 1973b, 1975; Hawkes, 1973). The gravid females are attracted upwind to host crops (Hawkes, 1975) and to ANCS, which is a naturally occurring volatile in brassica plants (Hawkes & Coaker, 1979). Finch & Skinner (1979) suggest that females of all age-groups move upwind even in the absence of host plants, but neglect that they were trapping the flies with traps containing ANCS as an attractant.

The flies respond to visual stimuli, since the colour of the trap has a marked influence on trap catch (Finch & Skinner, 1974a). The

number of flies caught depends on the trap spacing, with the catch reaching a maximum at a 5 m. spacing, suggesting an attractive radius of 2.5 m. (Finch & Skinner, 1974a). A later more sophisticated experiment indicated an effective radius of 5 m. (Finch & Skinner, 1982b).

The number of insects caught depends on the absolute population density and the efficiency of capture, where the efficiency is defined as the proportion of the insects present that are caught (Southwood, 1978). The efficiency is a function of the attractiveness of the traps, the activity and responsiveness of the insects.

The attractiveness of the trap may alter with changes in the surrounding vegetation. The traps could become more conspicuous, or there could be less competition from other attractive points (e.g. flowers). Hawkes (1972a) found that the amount of vegetation affected the trap catch, but may have been caused by the denser plant cover obscuring the traps.

The responsiveness of the insects may alter with age, so the different age-groups may not be equally susceptible to capture. The behavioural pattern of the cabbage root fly has been shown to change with age (Hawkes, 1972b), and the older females are recaptured at a lower rate (Finch & Skinner, 1974a).

The activity of an insect depends on the climate, and particularly on the temperature (Taylor, 1963; Kitching, 1977). The insects are active between a lower and an upper threshold. The activity rapidly rises to the maximum beyond a threshold (Kitching, 1977), so the rate of dispersal will be largely independent of temperature, provided the temperature does not exceed the thresholds. The lower activity threshold lies in the region of 10°C (Hawkes, 1972a; my

observations) and the upper threshold is in excess of 30°C. Strong winds or rainfall can reduce the catch of cabbage root fly by the prevention of active flight (Miles, 1954; Finch & Skinner, 1973b; Hawkes, 1973). The vegetation can also affect the activity level, since gravid females fly more frequently in the presence of host plant odour (Hawkes, Patton & Coaker, 1979).

The models

(a) The effect of hedges on fly distribution

The hedges clearly affect the fly distribution in Venn 1981A and Great Englebourne 1981A (Figs 82 and 83 & 91 and 92). In both cases the trap line passes across fields rather than along hedgerows, and there is a marked increase in the male and female catch where the trap lines intersect with the hedges. The preliminary analysis (Ch. III.4) indicates that there are two populations present. The hedges are known to cause aggregation of the males, and to a lesser extent, of the females (Hawkes, 1972a, 1973; Finch & Skinner, 1973b). The flies are thought to be attracted by visual stimuli to the hedges a source of flowers for feeding sites. In the other data sets the trap lines were either laid along the hedgerows (e.g. Venn 1980B, Great Englebourne 1980B, Venn 1981B), or were arranged well away from the hedges (e.g. Seale Hayne 1980C, 1981A, 1981C).

The effect of the hedgerows will be modelled using a dummy variable (z) to allow the intercept to vary at the hedge.

$$\text{Log}_e\, y = a + b_1\sqrt{x} + b_2 z$$

Traps beyond 1 m. from the hedge (z = 0)

$$\text{Log}_e\, y = a + b_1\sqrt{x}$$

Traps within 1 m. of the hedge (z = 1).

$$\text{Log}_e\, y = (a + b_2) + b_1\sqrt{x}$$

This method assumes that the hedge causes only a local aggregation, and there is no influence over a longer distance. The male flies avoid fallow areas and strongly aggregate at hedges, but when there is plant cover the males are less strongly aggregated at the hedges (Hawkes, 1973). The aggregations at the hedges are sharply defined (e.g. Figs 82 & 83), but there is some evidence for an increase in the catch a short distance from the hedge. The additional explanation of variance would be marginal, if the model were increased in complexity to cover the situation.

(b) The effect of brassica crops on fly distribution

There is a clear increase in the number of female flies caught at the clubroot plot at Seale Hayne 1981A (Figs 105 & 106) and at the cabbage crop of Venn 1980B (Figs 79 & 80). The small proportion of flies in the young age-groups provides evidence that the increased catch is not caused by the emergence of flies (Ch. III.8). The increased catch is probably caused by the aggregation of gravid and parous females. The gravid females are attracted upwind by host plant odour (Hawkes, 1975; Hawkes, Patton & Coaker, 1979), and will be stimulated to oviposit by the host plants. The young females and male flies are unresponsive to host plant odour.

There is also a brassica crop located close to the emergence site at Seale Hayne, but any aggregation caused by the host plants cannot be separated from the emergence of flies. The influence of the host plants can be seen from the higher proportion of gravid

females downwind (Seale Hayne 1980B).

The basic model can be adjusted to allow the intercept to vary at a brassica crop, using a dummy variable.

$$\text{Log}_e Y = a + b_1\sqrt{x} + b_2 z$$

In the absence of a brassica crop (z = 0)

$$\text{Log}_e Y = a + b_1\sqrt{x}$$

In the presence of a brassica crop (z = 1)

$$\text{Log}_e Y = (a + b_2) + b_1\sqrt{x}$$

The brassica crop could also affect the slope downwind, because of the upwind attraction of gravid females. This could be modelled using a second dummy variable, although there is no clear evidence for a depletion in female numbers downwind of the brassica crop.

(c) <u>The emergence of flies from a second source</u>

The emergence of flies from two sources at Venn 1981A is clearly indicates by the high proportion of flies in the youngest age-groups (Figs 82 & 83). The field containing traps 37 - 56 (d = 200 - 320 m.) contained a fodder turnip in the previous autumn. The crop was only grown for six weeks, but this was long enough to develop an appreciable fly population. The emergence from two sources can be modelled by the combination of two independent regression models.

$$\text{Log}_e Y = a_1 - b_1\sqrt{x_1}$$

$$\text{Log}_e Y = a_2 - b_2\sqrt{x_2}$$

where $x_2 = A\ S\ (x_1 - 160)$

$$Y_1 + Y_2 = \exp\ (a_1 + b_1\sqrt{x_1} + a_2 + b_2\sqrt{x_2})$$

$$Y = \exp (a + b_1\sqrt{x_1} + b_2\sqrt{x_2})$$

(d) Secondary peaks in the number of flies caught

The hedgerows and brassica crops have been identified as causing secondary aggregations, but in two data sets (Venn 1980B & Seale Hayne 1980B) the secondary peaks do not correlate with these identified features.

(1) Venn 1980B

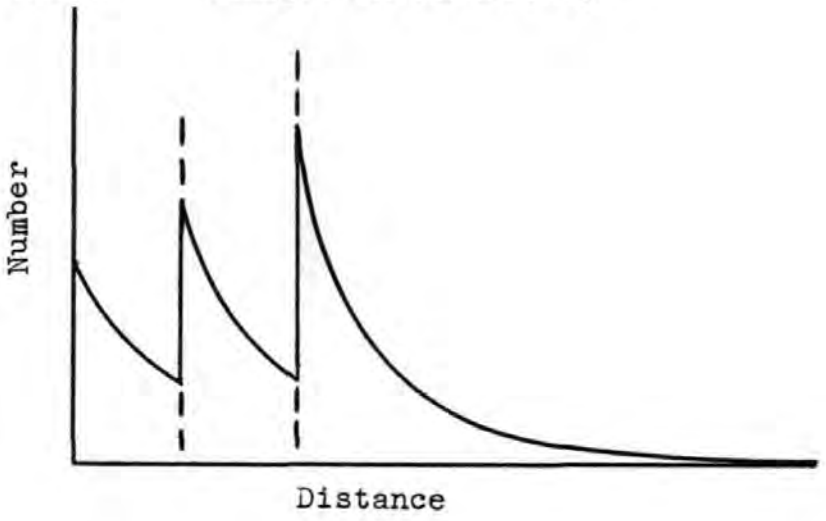
There is a secondary peak present for all the age-groups of both sexes (Figs 79 & 80), so the pattern cannot be a result of changes in the susceptibility to capture with age. The secondary peak of the males and females occur at different positions; the male peak at trap 13 (120 m.) and the females peak at trap 17 (160 m.). The female peak coincides with the boundary of the cabbage crop, which is known to cause aggregation of gravid females (Hawkes, 1975). The male peak occurs at the centre of a barley crop on the western side of the fence, and close to the junction of a potato crop with a fallow area on the eastern side of the fence (Fig. 42). The barley crop could be causing an aggregation of the males by providing feeding sites (Hawkes, 1973).

An increase in catch could be caused by an increase in population density or an increase in the efficiency of capture. A decrease in activity through a decrease in the frequency of flights, or decreased flight length, or an increase in turning moments, would increase the probability of a fly remaining in the area and an increase in population density. A decrease in activity could also lead to a decrease in the efficiency of capture.

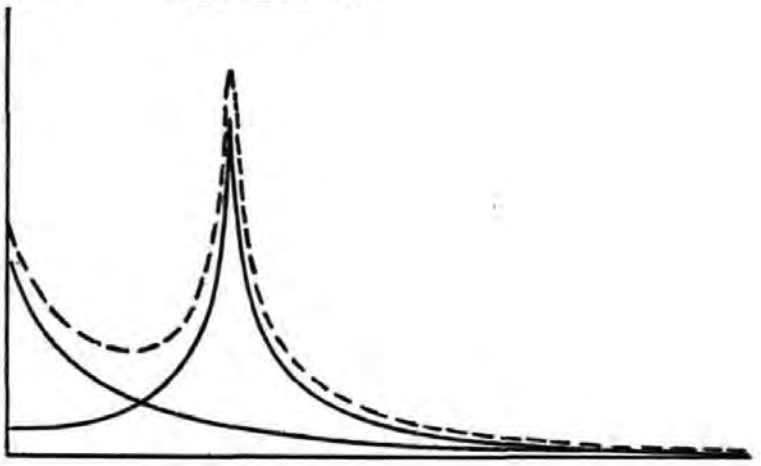
FIG. 59

The three proposed models for the explanation of the secondary peak at Venn 1980B.

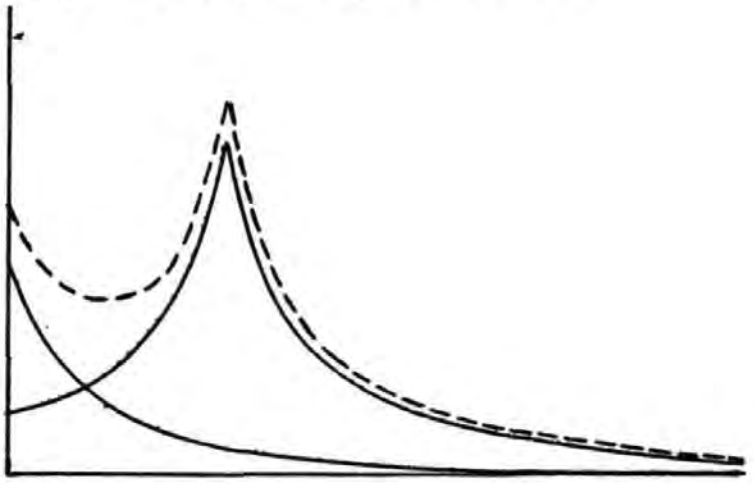
Model changes in efficiency



Model aggregation



Model 3 second emergence source



Three alternative mechanisms can be proposed to explain the observed pattern of fly catch (Fig. 59). The first model suggests that the barley reduces the activity of the males, and the brassica crop affects the females, producing an aggregation. If the population density increases to a greater extent than efficiency is reduced, then the trap catch will increase. The second model suggests that the crop types alter the efficiency of capture. The traps capture only a small proportion of the flies, so will not significantly affect population density (Finch & Skinner, 1974a). The traps are actually situated in the fairly uniform interface between the fence and the crop, but the attractive radius will extend into the crop. The traps could be more attractive in contrast with the barley crop. The third model suggests that the population density is increased by the delayed emergence of flies from a former host crop (the 1979 swede crop).

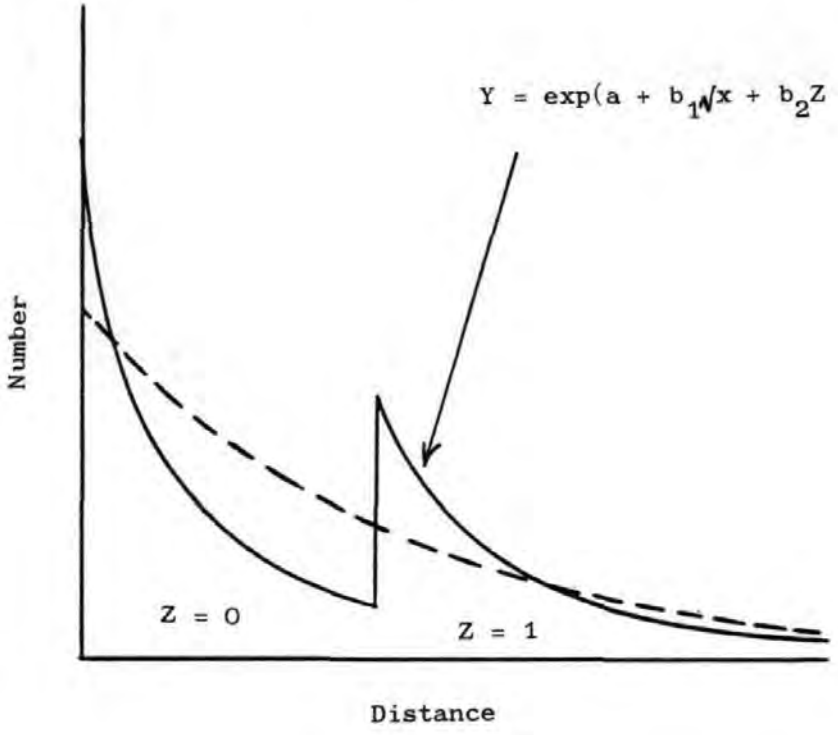
The slope (b) of density against distance can be only directly changed by an alteration in activity, which would probably also affect the efficiency of capture and the value of the intercept (a). A change in efficiency, for example by an increase in the attractiveness of the trap, would cause an increase of movement rates only within the small area of the attractive radius and would have only a small direct influence on the slope. The change in intercept could have a large influence on the fitted value of the slope, if the change in efficiency were not recognised (Fig. 60). Such a major deficiency in the model could be clearly identified from the residual pattern.

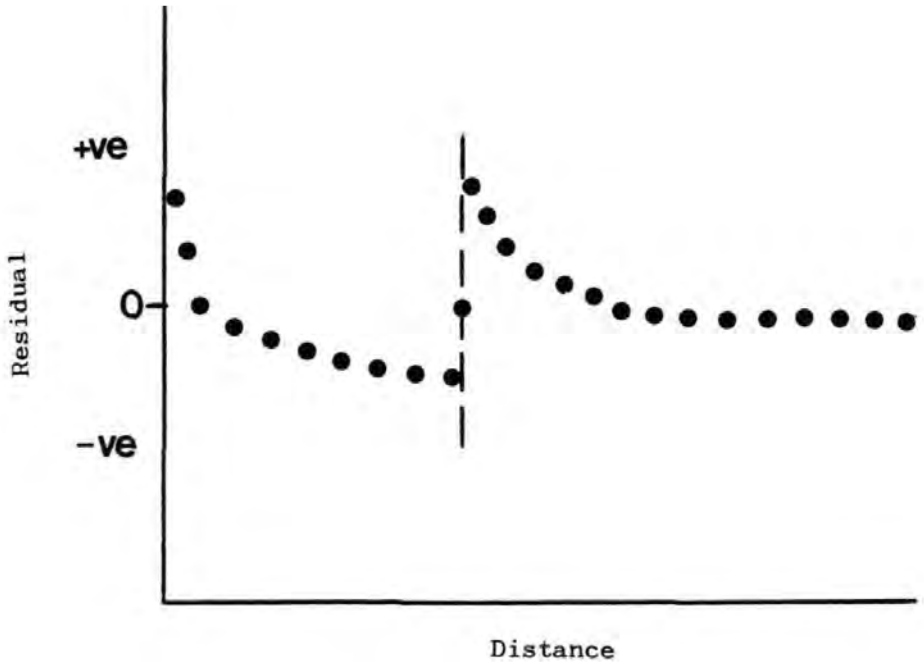
The three models can be expressed as linear regression equations. The efficiency can be allowed to vary by means of dummy variables, coding unity for the presence of a crop and zero for the absence.

FIG. 60

The indirect effect of a change of efficiency on the fitted slope.

– – – The fitter regression if the change in efficiency were not recognized.





$$\text{Log}_e Y = a + b_1\sqrt{x} + b_2 z$$

when $z = 0$ $\text{Log}_e Y = a + b_1\sqrt{x}$

when $z = 1$ $\text{Log}_e Y = (a + b_2) + b_1\sqrt{x}$

The dummy variables could also be used to allow the slope to vary, as the rate of movement decreases to cause the aggregation (model 1). The secondary aggregation could also be treated as a secondary source of dispersing flies.

$$Y_1 = \exp(a_1 + b_1\sqrt{x_1})$$

$$Y_2 = \exp(a_2 + b_2\sqrt{x_2})$$

$$Y_1 + Y_2 = \exp((a_1 + a_2) + b_1\sqrt{x_1} + b_2\sqrt{x_2}) \qquad (1)$$

The emergence from a second primary source (model 3) could be expressed as a similar equation, although b_1 and b_2 would be expected to be identical.

An examination of the plot of density against distance (Figs 79 & 80) reveals no major discontinuities (within sampling error), so the pattern is unlikely to result solely from efficiency changes. The preliminary analysis of the data (Ch. III.4) suggests that there are two superimposed populations, possibly dispersing at different rates. The observed peak is probably a result of either aggregation or emergence from a second source, both of which are capable of producing a similar pattern (Fig. 59). The fitting of the regression model (1) provides a good explanation of the data, leaving no significant trends in the residual pattern (Fig. 81). There is no evidence for changes in the efficiency of capture. The peak is probably the result of aggregation, as shown by the age structure (Ch. III.8).

The sharp definition of the peak requires explanation, since the crops would have been expected to produce a broad plateau. The female peak occurs at the boundary of the brassica crop, which is known to cause upwind attraction of gravid females (Hawkes, 1975). The male peak occurs in the centre of a barley crop on the western side of the fence, and close to the junction of a fallow area and a potato crop on the eastern side of the fence. Male cabbage root flies are known to accumulate at crop interfaces (Finch & Skinner, 1973b), and also to avoid fallow areas (Hawkes, 1973). These cannot explain the male peak, because there is no increase in male numbers at any of the other crop interfaces (e.g. parsnip-fallow, or fallow-barley). The peak may be caused by an 'edge effect', whereby the flies at the edge of the arrestant region, leave the area in the course of random movement and resume dispersal at normal rates. The aggregation would be acting as a secondary source of dispersing flies.

(2) Seale Hayne 1980B

The two trap lines will have to be analysed separately, because of the presence of a secondary peak in the second trap line (traps 1-10 & 12-46)(Figs 97 & 98). The secondary peak appears to be caused by aggregation at an area of long grass (Finch & Skinner, 1975), and will be described using two independent variables.

(3) Venn 1981B

There are secondary peaks towards either end of the trap line for the male flies (Fig. 86), which may be connected with the nearby hedges. The peaks do not correlate with any crop or physical feature, so it is not possible to propose any meaningful model.

Conclusion

The differences in crop pattern and position of hedges requires a specific model for each data set. The models can be expressed as linear regression equations, which will be used for the subsequent calculation of the slopes.

Venn 1980B

$$\text{Log}_e Y = a + b_1\sqrt{x_1} + b_2\sqrt{x_2}$$

where $x_2 = \text{ABS}\ (x_1 - 160)$ (♀)

$x_2 = \text{ABS}\ (x_1 - 120)$ (♂)

Venn 1981A

$$\text{Log}_e Y = a + b_1\sqrt{x_1} + b_2\sqrt{x_2} + b_3 z$$

where $x_2 = \text{ABS}\ (x_1 - 160)$ (♀ + ♂)

z codes for the hedges

Venn 1981B

$$\text{Log}_e Y = a + b_1\sqrt{x}$$

Great Englebourne 1980B

$$\text{Log}_e Y = a + b_1\sqrt{x}$$

omitting traps 5 & 6 as outliers

Great Englebourne 1981A

$$\text{Log}_e Y = a + b_1\sqrt{x} + b_2 z$$

Seale Hayne 1980B

Trap line 1: $\text{Log}_e Y = a + b_1\sqrt{x}$

Trap line 2: $\text{Log}_e Y = a + b_1\sqrt{x_1} + b_2\sqrt{x_2} + b_3 z$

where $x_2 = \text{ABS}\ (x_1 - 200)$

z codes for the brassica crop

Seale Hayne 1980C, 1981A, 1981C

$$\text{Log}_e Y = a + b_1\sqrt{x} + b_2 z_1 + b_3 z_2$$

where z_1 codes for the brassica crop close to the emergence site, and z_2 codes for the clubroot plot.

CHAPTER III.8

The change in age structure with distance

Introduction

The analysis of variance (Ch. III.6) has demonstrated significant interaction between the distance and age, suggesting that the mean distance dispersed by a fly depends on the age. The flies would be expected to move further from the emergence site, as they become older. The age structure of the population would alter with the distance from the emergence site, with the older age-groups gradually forming a greater proportion of the population with increasing distance. The distribution of young flies could be valuable in the location of emerging flies (cf. Venn 1980B), and could indicate which of the alternative models provides the explanation of the secondary peak.

Methods

The number of flies in each age-group caught in traps at different distances, cannot be directly compared because of the variation in the total catch of each trap. The catch of each age-group can be standardised by expressing it as a proportion of the total catch. This conversion of numbers to ratios has the disadvantages of producing wildly fluctuating plots by emphasising any errors in the classification into age-groups and magnifying the small absolute changes when the catch is low. Many of the peaks or troughs are the result of a single extreme point, so the ratios will be smoothed to extract the well-supported trends.

Non-linear filters based on moving medians provide protection against occasional spikey noise, yet respond well to a supported

pattern. One danger of smoothing is the possibility of extracting sinuosoidal pattern from completely random series (Chatfield, 1980). The non-linear filters have been shown to be highly resistant to noise, but capable of accurate recovery of the underlying pattern (Velleman, 1980). The standardised number for each age-group were smoothed using the 4253H subroutine of the MINITAB package (Ryan, Joiner & Ryan, 1981). A similar pattern was extracted by a second non-linear filter (3RSSH) and a simple triple running mean. The residual pattern was found to be random by a runs test (Sokal & Rohlf, 1969).

Results

(a) The effect of hedges

For Venn 1981A and Great Englebourne 1981A there was a consistent increase in the proportion of parous females at the hedgerows (Figs 64 & 65). Hawkes (1972a) noted an increase in non-gravid females at hedgerows, which may be connected with feeding activity.

(b) The effect of brassica crops

The proportion of parous (F6) females increased at the host crops at Seale-Hayne 1980B, both at the emergence site and the clubroot plot (Fig. 63). The gravid (F5) females will be stimulated to oviposit by the available host plants.

(c) The emergence of flies from a second source

For Venn 1981A, the emergence of flies from two sources is clearly marked by the high proportion of young flies (Fig. 65).

(d) The secondary peaks in fly numbers

For Venn 1980B, there is an increase in the proportion of gravid (F5) females at the secondary peak in fly numbers (Fig. 62).

FIG. 61

The changes in age structure with distance for Great Englebourne 1980b.

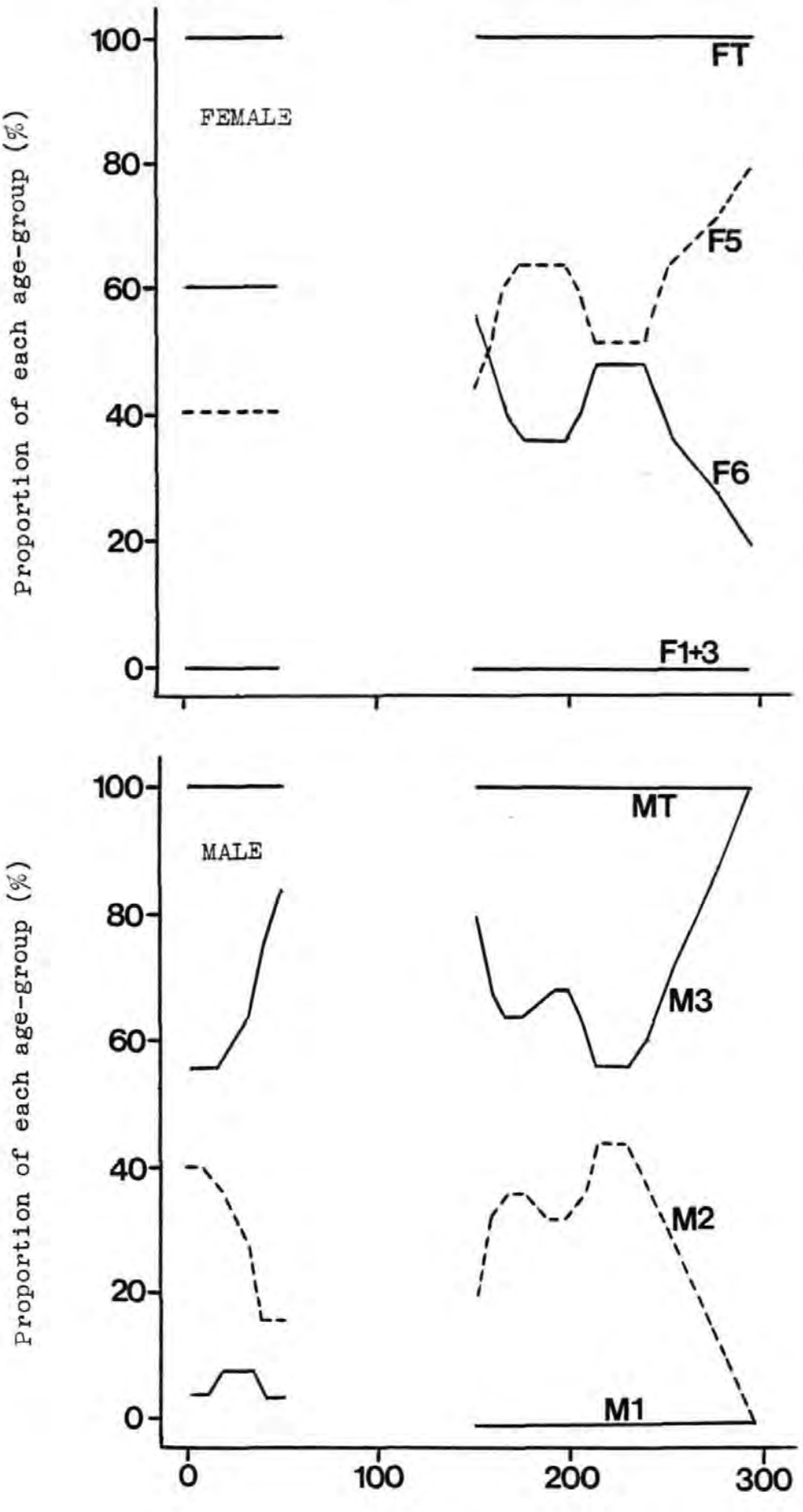


FIG. 62

The changes in age structure with distance for Venn 1980b.

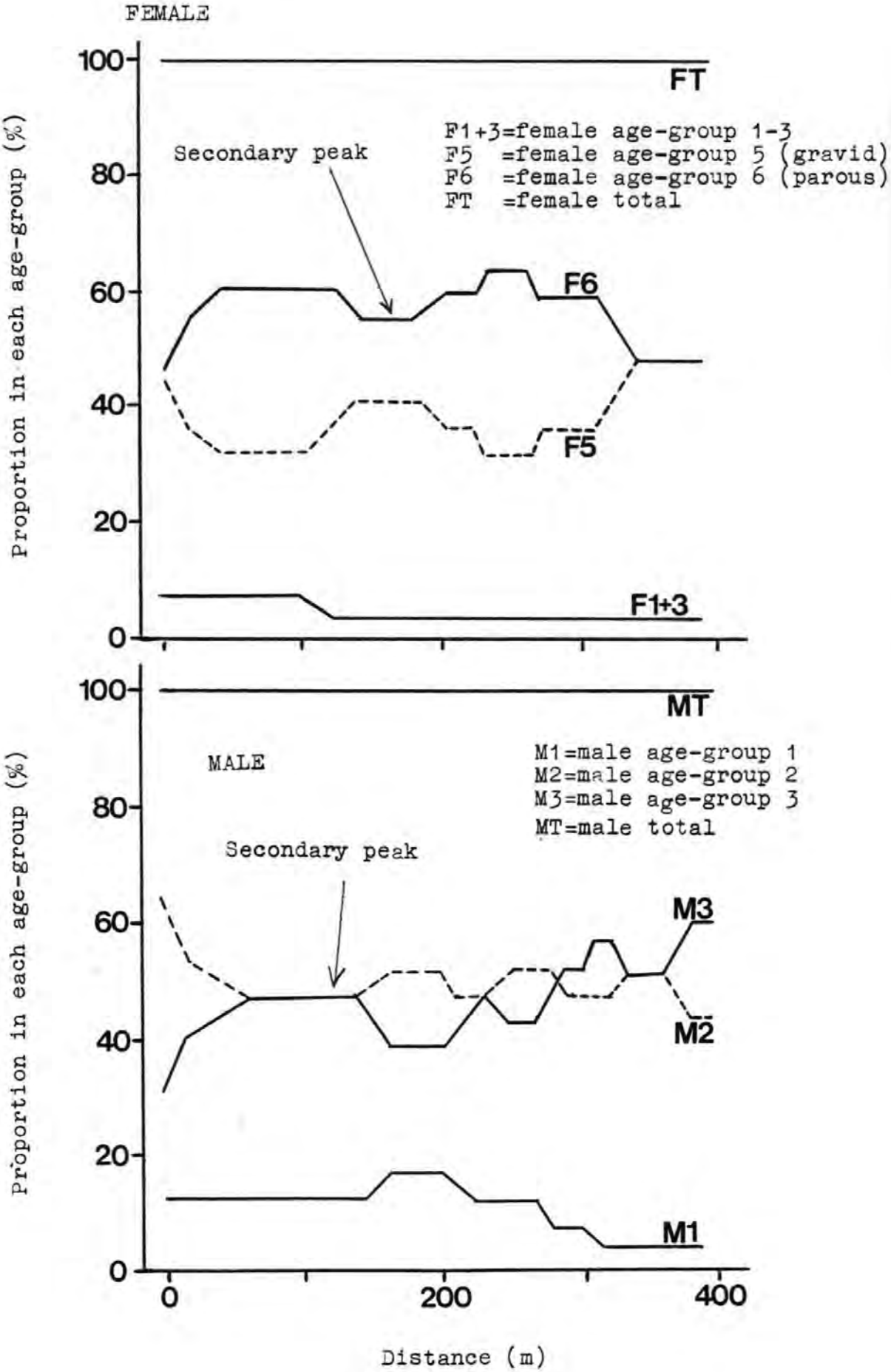


FIG. 63

The changes in age structure with distance for

Seale Hayne 1980b

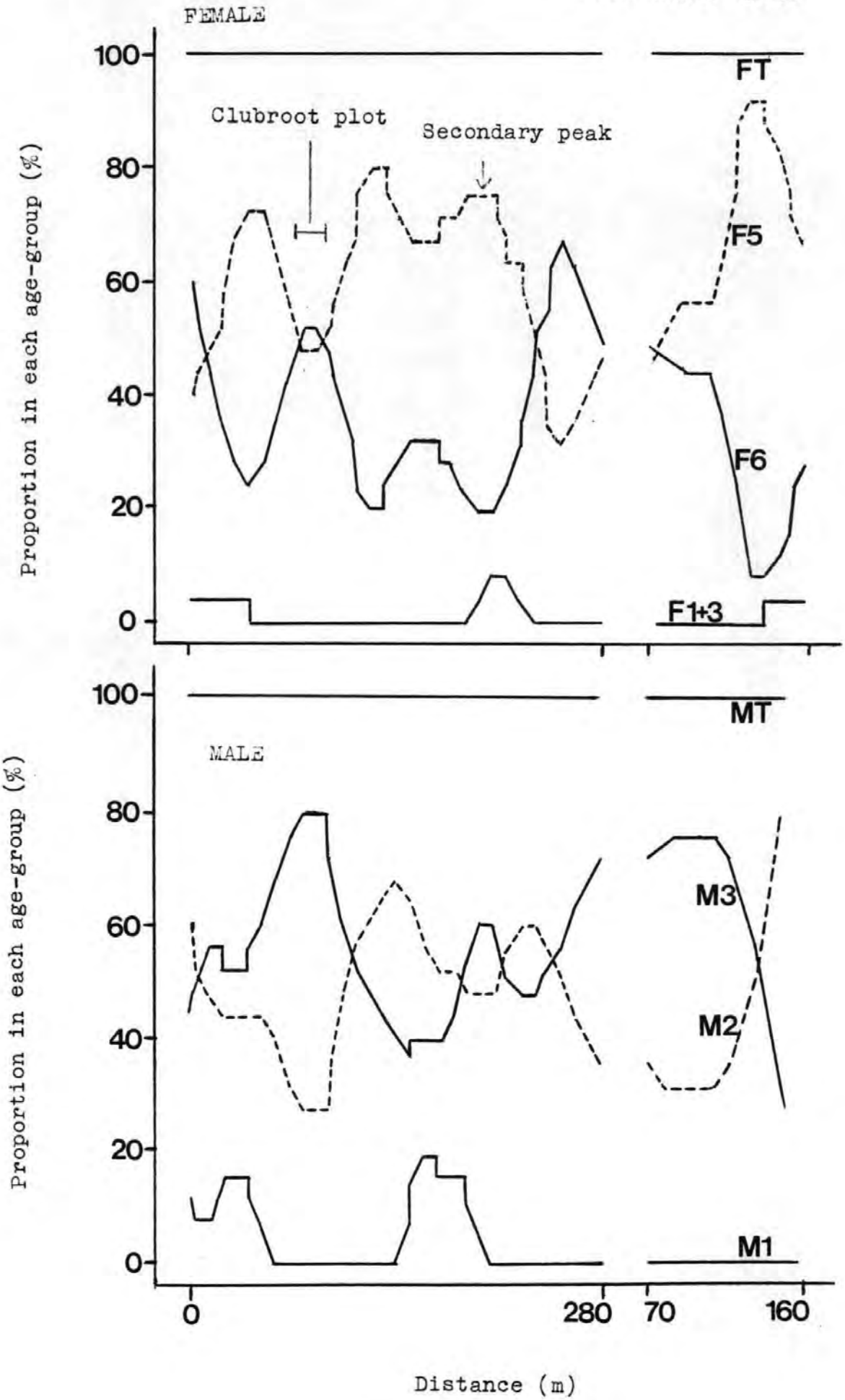


FIG. 64

The changes in age structure with distance for Great Englebourne 1981a.

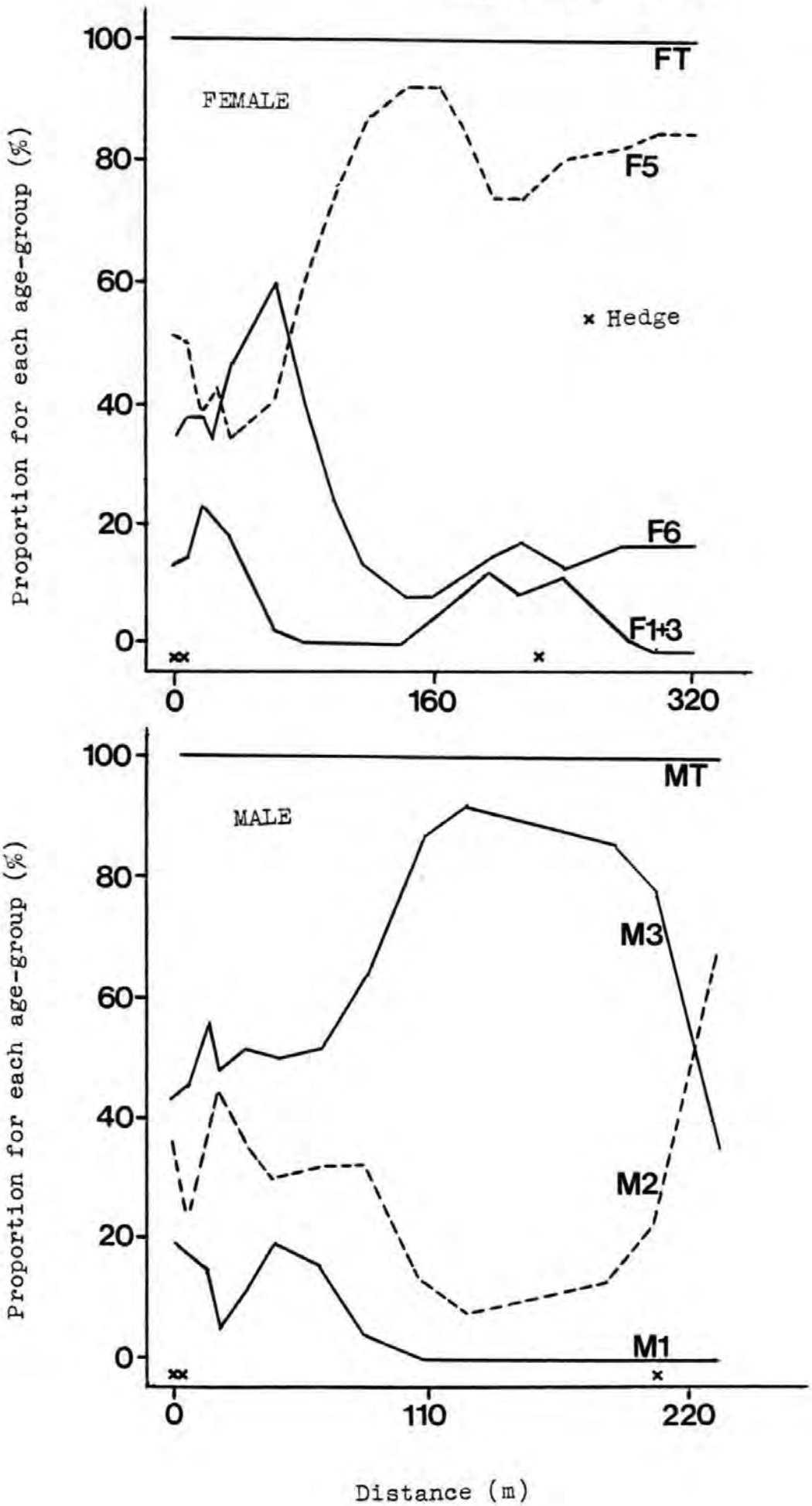
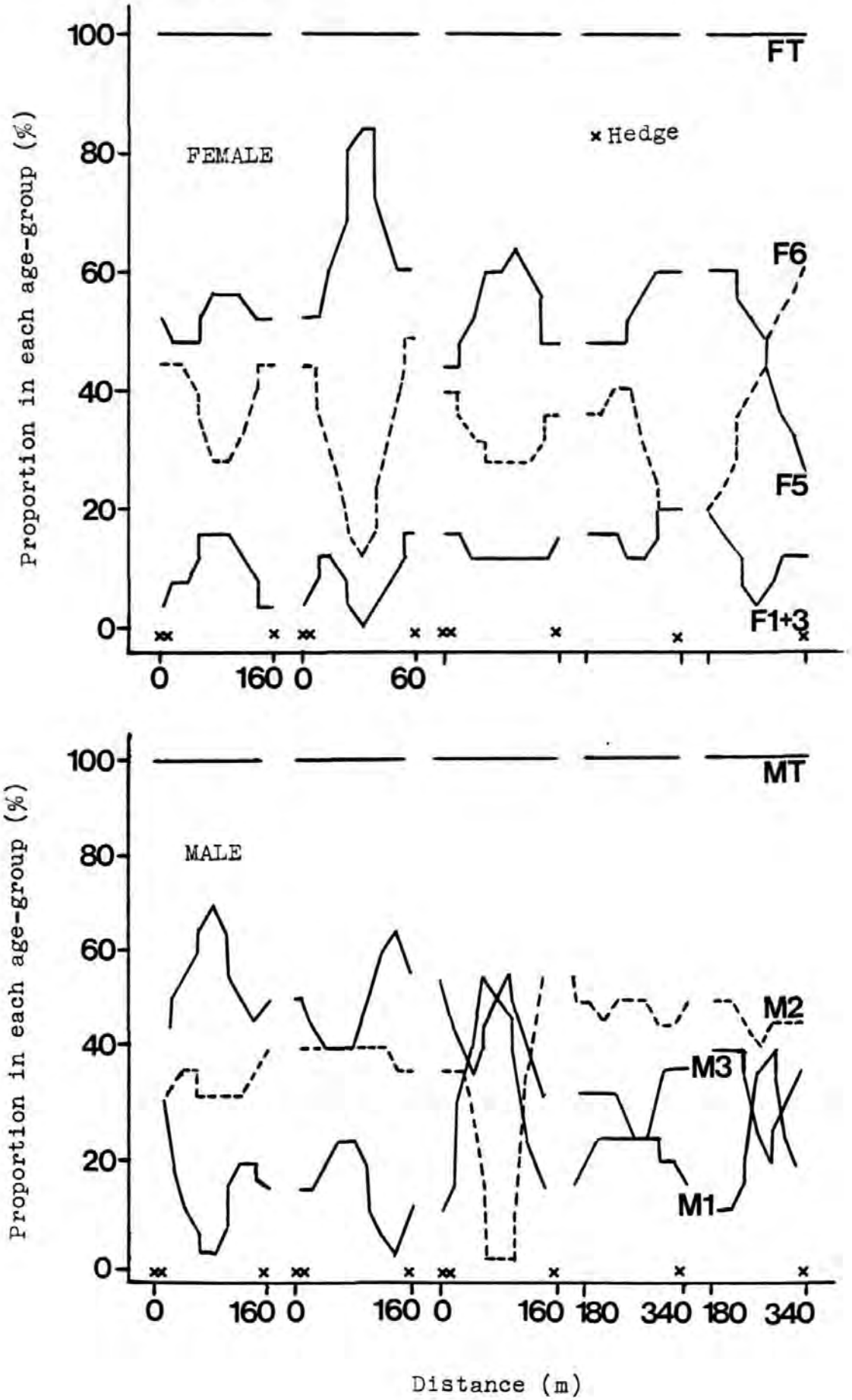


FIG. 65

The changes in age structure with distance for Venn1981a.



The secondary peak is unlikely to be caused by emergence, as there is no evidence for an increase in the proportion of young flies. The brassica crop would appear to be causing the aggregation of female flies (Hawkes, 1975). The males are not responsive to the host crop and are thought to be aggregating because of the barley crop. There is an increase in the younger age-groups (M1 + M2) at the male secondary peak, but we would not expect a clearly defined change in the male age-structure, because the male age-groups are not based on such behaviourally or physiologically defined criteria as the female age-groups.

For Seale Hayne 1980B, there was a secondary peak at about 200 m. along the second trap line, where there is a marked increase in the proportion of the younger (M1 + M2) age groups (Fig. 63). The female secondary peak was less clearly defined, although there is a marked increase in gravid (F5) females. The aggregation is probably caused by the presence of unmown grass and flowers, which could provide a source of food in an otherwise barren site.

Discussion

The age structure of the population can provide useful information in the investigation of insect distribution, and in particular, in the separation of secondary aggregations from the emergence of flies from primary sources.

For Seale Hayne 1981A and Venn 1981B there was little change in age structure with distance. In the other data sets, the oldest male age-group (M3) does generally increase with distance, with the exception of Great Englebourne 1981A where the M2 age-group increases

towards the end.

In some of the data sets (e.g. Venn 1980B, Great Englebourne 1980B & 1981A) the gravid (F5) female age-group appears to increase with distance. In the case of Great Englebourne 1981A, this apparent increase may be caused by the strong aggregation of parous flies at the hedgerows. In all cases, the increase in the proportion of gravid flies occurs where the catch is smallest because of the distance from the emergence site. The absolute increase in the number of flies is small, and the proportions could be greatly affected by the misclassification of a single fly. There is generally no conclusive evidence for an increase in proportion of the older age-group with distance.

CHAPTER III.9

Fitting the regression models

Introduction

The slope of density on distance can now be calculated by fitting the models (Ch. III.7) to the data. The slope will then be used to estimate the mean distance dispersed for wild cabbage root flies emerging from any agricultural crops.

The slope for cabbage root fly has previously been estimated from discrete releases of cultured flies in mark-recapture experiments (Hawkes, 1972, 1974, 1975; Finch & Skinner, 1975; Freeman, 1977). The slope was found to decrease with time, as the flies disperse away from the release point.

The emergence of wild flies from the site of a former host crop will extend over a period of time (Finch, 1977; Fig. 28). The emergence occurs with a definite peak, and the slope of the total catch of males or females would be expected to initially increase until the maximum emergence has occurred, because the addition of flies by emergence will be greater than the departure of flies by dispersal. The slope would then be expected to decline after the peak in emergence, as the emergence of flies fails to replenish the flies dispersing away from the emergence site.

The slope for a particular age-group would not be expected to alter with time, because the mean age of the age-group would be approximately constant, unless there were a radical shift in the climate. The oldest age-group may be an exception, because the flies cannot develop beyond this final stage, so there could be a decline in the slope with time, once emergence has been completed and the

remaining flies continue to disperse until death.

A comparison of the slopes of the different age-groups provides a test of the migration hypothesis of Finch & Skinner (1975). They propose that there is a migration during the fifth and sixth days after release, which corresponds with the development of gravid (age-group 5) females. If there were a migration of gravid females, then the slope for this age-group should be significantly smaller than for the younger age-groups. The slopes of the age-groups can be directly compared by a series of t-tests, but this increases the risk of accepting insignificant differences as significant (Type I error, Sokal & Rohlf, 1969). The intercepts and slopes of the different age-groups can be simultaneously compared within a single test using a multiple regression procedure (Kleinbaum & Kupper, 1978).

The mean distance dispersed for an age-group can be estimated from the slope, and the mean age of the age-group can be estimated from the daily maximum and minimum temperatures (Ch. II.9). The dispersal rate can then be calculated by the division of mean distance dispersed by mean age.

The mean distance dispersed is to be estimated from the slope, so it is essential that the density-distance models are an accurate description of the data. The statistical significance can be assessed by analysis of variance, and the proportion of the variance explained (R^2) will be of practical value in determining the quality of fit. A significant fit may explain only a small proportion of the variance, when there are a large number of observations. A low R^2 could result from an incorrectly specified model, or could reflect high data variability. The critical assumptions of parametric statistics are a normal and independent error distribution, with a common variance

(Kleinbaum & Kupper, 1978). An examination of the residuals is capable of revealing violations of these assumptions (Anscombe & Tukey, 1963, Kleinbaum & Kupper, 1978). The residuals can be standardized to test for influential obsevations and outliers (Prescott, 1975; Cook, 1977; Ryan, Joiner & Ryan, 1981). The normality of the residuals can be investigated by a probability plot, which will reveal any unexplained features in the data capable of imparting a significant bias to the fitted slope (Weisburg, 1980). A successful fit will be achieved if the model explains a maximum amount of the variance, and produced a random, normal residual pattern.

Methods

The preliminary analysis (Ch. III.3) has shown that the data needs to be transformed to logarithms. The zero values have either to be omitted, or a start of unity applied to all the values before transformation (Ch. III.4).

The individual sample times will be pooled for each generation of cabbage root fly, because the variation in the number of flies caught is thought to influence the value of the fitted slope (see later). The pooling has the advantages of increasing the overall catch and hence the statistical precision, and will help to smooth out random sampling errors. The zero observations were omitted from further analysis, because this option avoids any problems of distortion produced by the start (Ch. III.4). The loss of observations for most data sets is only a small proportion of the total, except for the youngest age-groups, where only a few individuals were ever caught. A start would not be suitable with such low catches, because of the inevitable significant distortion (Ch. III.4).

The regression of the transformed data on the square root of distance, will be initially calculated to allow the direct comparison of the fitted slopes (Hawkes, 1972a; Finch & Skinner, 1975; Freeman, 1977). The calculations were performed using the MINITAB package, which is a modern, efficient routine with good facilities for the plotting and testing of the residuals (Ryan, Joiner & Ryan, 1981). A better empirical fit to the density-distance data may be achieved by allowing the exponent of distance to vary (Taylor, 1978, 1980), although the fitted values will no longer be directly comparable. The models were fitted using a non-linear least squares program (E04FCF subroutine, NAG 1978).

The slopes and intercepts of the different age-groups were compared using dummy variables in a multiple regression model (Kleinbaum & Kupper, 1978). The comparison of three groups requires two dummy variables. The first group is coded as zero in both dummy variables; the second group is coded unity in the first and zero in the second variable; the third group is coded zero in the first and unity in the second variable. The multiple regression model (1) is then fitted to the combined data, and the significance of different coefficients can be tested by their explanation of variance (F test).

$$\text{Log}_e Y = a + b_1\sqrt{x} + b_2 z_1 + b_3 z_2 + b_4\sqrt{x}z_1 + b_5\sqrt{x}z_2 \quad (1)$$

where z_1 codes 1 for F1 + 3, 0 for F5 & F6

z_2 codes 1 for F6, 0 for F1 + 3, & F5

For age-group F1 + 3:

$$\text{Log}_e Y = (a + b_2) + (b_1 + b_4)\sqrt{x}$$

For age-group F5:

$$\text{Log}_e Y = a + b_1\sqrt{x}$$

For age-group F6:

$$\text{Log}_e Y = (a + b_3) + (b_1 + b_5)\sqrt{x}$$

The mean age of each age-group was calculated for each generation of cabbage root fly, from the mean daily maximum and minimum temperatures (Ch. II.9) measured at Rumleigh (Fig. 39).

A small number of flies were recorded for many of the younger female age-groups, so the number in age-groups F1, F2 & F3 were combined to form a single age-group (F1 + 3).

Results and Discussion

A summary of the number of flies caught at the various distances for the three sample sites, are presented in Appendix 7.

(a) The variation in the value of the slope for the different sample times within a generation

The estimated slope varies significantly between the different sample times within a generation (Fig. 66). The changes in the slope would imply that the rate of dispersal alters between the sample times. This could arise through climatic changes (e.g. temperature, rainfall, wind) which are known to affect fly movement (Miles, 1954; Hawkes, 1972a; Finch & Skinner, 1975). The changes in slope show no close correlation with any of the climatic variables (Fig. 67), although there is a good correlation with the number of flies caught (Fig. 22). Random noise has been shown to cause significant deviation of the fitted slope, and the degree of influence depends on the number of flies caught (Ch. III.2). The observed variation in the slope is probably caused by the differences in catch at the different sample times. The individual sample times were pooled, which will help in

FIG. 66

The variation in the estimated slope(b) with sample time.

Data: Venn 1980B

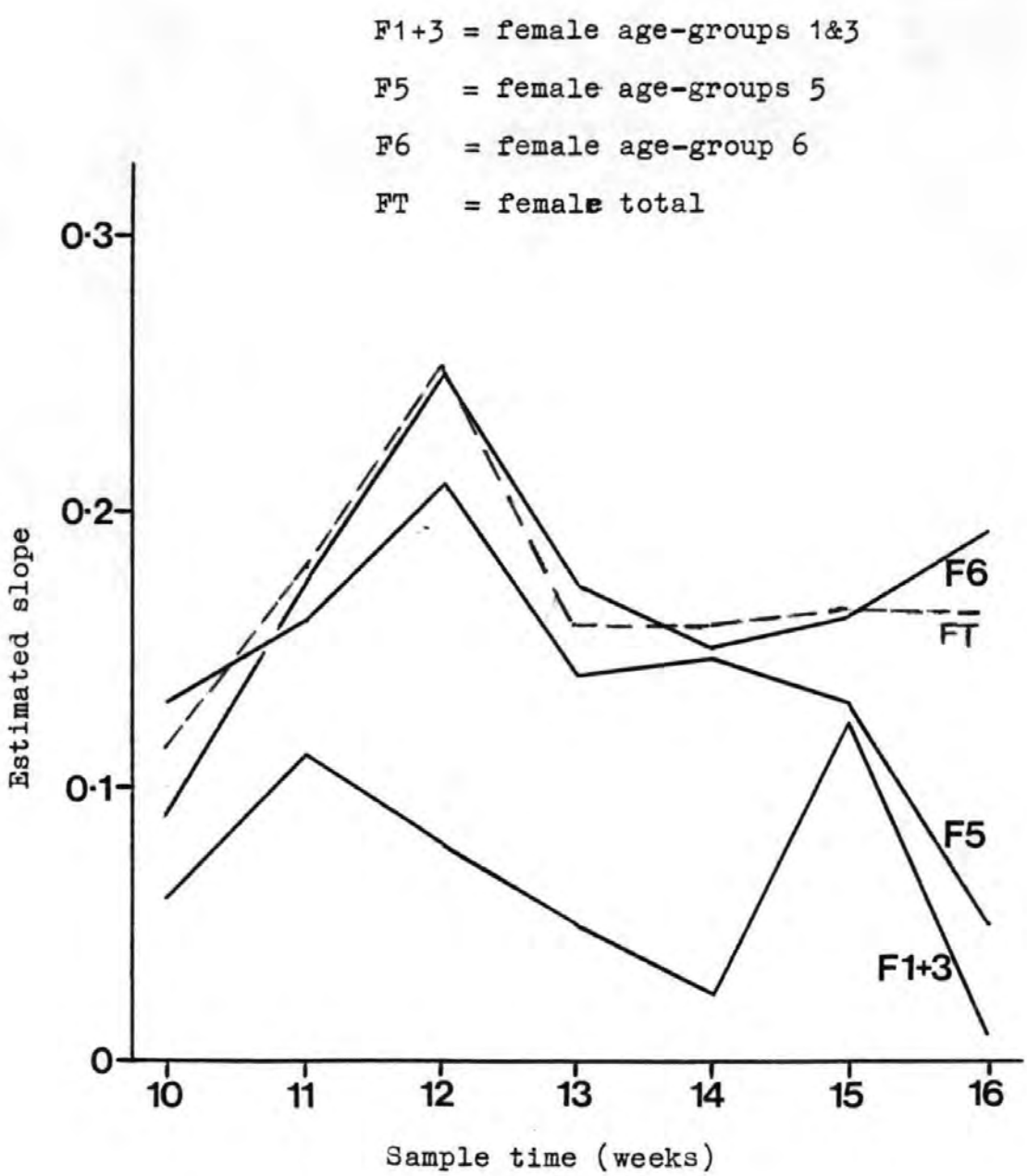
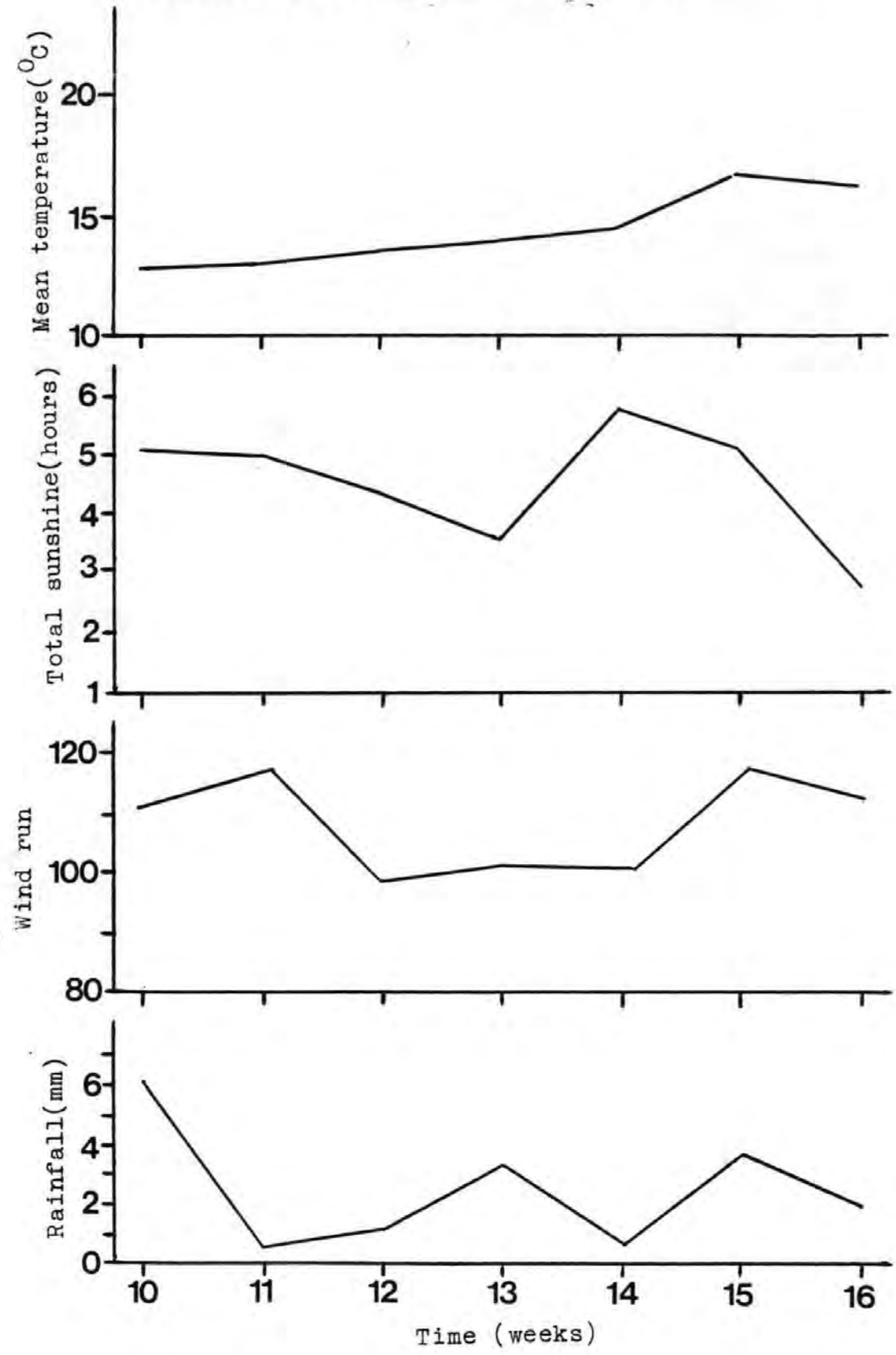


FIG. 67

The weather recorded at Rumleigh for the second generation of cabbage root fly in 1980.



smoothing the random errors and the larger catches will be less vulnerable to distortion by random noise.

(b) Examination of the residuals

The analysis of variance indicates that the models explain a statistically significant proportion of the variance for a majority of the age-groups in the different data sets (Tables 24-34). A non-significant fit was found for most of the young age-groups of both sexes, and also for all the age-groups of Seale Hayne 1980C. In all these cases, the poor fit is a result of the small number of flies caught, so only a small proportion of the observations remain after the removal of the zero values.

The models for Venn 1980B, Venn 1981A, Venn 1981B, Seale-Hayne 1981A and Seale-Hayne 1981C can be considered as satisfactory descriptions of the data, because of the random, normal residual pattern (Appendix 8). The estimates of the slope obtained from Venn 1980B and Venn 1981A are likely to be the most reliable, because they are based on the capture of large numbers of flies and achieve a high overall explanation of variance (Figs 81 & 84).

The residuals from the fitting of the models to the other data sets (Great Englebourne 1980B, 1981A and Seale-Hayne 1980B) contain noticeable trends, suggesting that there may be further unexplained features to the distribution of the flies, which could be causing significant bias to the estimated slope (Figs 90, 93 & 96). If the underlying cause can be established, then it could be incorporated by a suitable elaboration of the model. If no underlying cause can be discerned, the influence on the slope could be empirically investigated by reducing the weight in regression.

The residuals of Great Englebourne 1980B display a marked overdispersion (Fig. 90), which is producing the apparent bimodality. The residuals are random (by a runs test, Sokals & Rohlf, 1969), so the slope is probably an unbiased estimate, although the explanation of variance can never be high because of the wide variation in the data.

The residuals of Great Englebourne 1981A display slight bimodality for the females, and a clear bimodality for the males (Fig. 93). The hedges are probably creating the bimodal distribution, by aggregation of flies at the hedges and a more mobile population away from the hedges. The residuals are clearly not random; the traps at the hedges producing consistently positive residuals and the nearby traps (3 - 6) produce strongly negative residuals. The low catch of these traps may be caused by attraction to the hedges, or the traps (at 5 m. intervals) may be interfering with each other (Finch & Skinner, 1982b).

The residuals of Seale-Hayne 1980B indicate a number of unexplained features in the fly distribution. In the first trap line (Fig. 96) there appears to be a smaller catch than expected at traps 50 - 54 (d = 76 - 90 m.), along the rubble bank. There also appears to be a higher than expected catch for traps 55 - 63 (d = 96 - 159 m.), which may be caused by more conspicuous traps or greater dispersal over a mown lawn. In the second trap line, the two independent variables are not a good description of the data. The females, in particular, do not form a clear secondary peak, but rather a poorly defined plateau (Fig. 97).

The flies of both trap lines are being influenced by a number of factors, which would require a complex model with additional

variables. The data from an unreplicated trap line is too sparse and variable for the reliable calculation of the parameters in a complex model. Instead, the less complex data for traps 1 - 15 will be selected for the fitting of the slope (Figs 100 & 101).

(c) The comparison of the age-groups

The multiple regression model explains a high proportion of the variance for most data sets (Table 19), so reliable conclusions can be drawn about the relationships between the age-groups. The low explanation of variance for Seale-Hayne 1980C is probably a result of the small number of flies caught.

The intercepts of the three female age-groups vary significantly, reflecting the obvious differences in the catch of each age-group. The gravid females are generally caught the most frequently, probably because of their greater activity (Hawkes, 1972b).

There are only a few significant differences between the slopes of the female age-group (Table 19), and these are generally at marginal levels of significance. The significant differences all occur between the youngest age-group (F1 + 3) and the gravid age-group (F5). In all cases, the slope of the youngest age-group is less than the older age-group, which would imply that all the dispersal occurs in the youngest age-group, and that the older flies move back towards the source. This is clearly untrue, as few young flies are caught in the more distant traps (Ch. III.8).

The different age-groups are not directly comparable, because of the different number of flies caught. The smaller catch of the youngest age-group is more susceptible to random noise causing an underestimate of the slope (Ch. III.2).

TABLE 19

The comparison of the intercepts and slopes of the female age-groups using dummy variables in a multiple regression model.

$$Log_e = model + bZ_1 + bZ_2 + b/XZ_1 + b/XZ_2$$

where Z_1 codes for F1+3
Z_2 codes for F6

Site			partial F		
	Z_1	Z_2	XZ_1	XZ_2	R^2
Venn 1980B	543.9[c]	10.4[b]	12.4[b] 1.0	0.1 0.2	91.8
Seale Hayne 1980B	55.1[c]	3.7	1.6	0.4	73.2
Seale Hayne 1980C	-	-	-	-	-
Great Englebourne 1980B	53.0[c]	1.0	3.5	1.4	64.4
Venn 1981A	80.1[c]	15.5[c]	6.4[a] 2.1	0.1 1.3	52.9
Venn 1981B	74.3[c]	62.1[c]	1.3	0.9	84.0
Seale Hayne 1981A	39.9[c]	5.0	5.9[a]	0.2	71.1
Seale Hayne 1981C	-	0.04	-	1.3	28.8
Great Englebourne 1981A	68.7[c]	22.8[c]	8.1[b]	3.0	72.7

a = $P < 0.05$
b = $P < 0.01$
c = $P < 0.001$

(d) The comparison of the slope from different generations and sites

The results of fitting the regression models are summarised in Appendix 8. The various estimates of the slope for each age-group are displayed with their associated confidence limits for easy comparison (Figs 68-71).

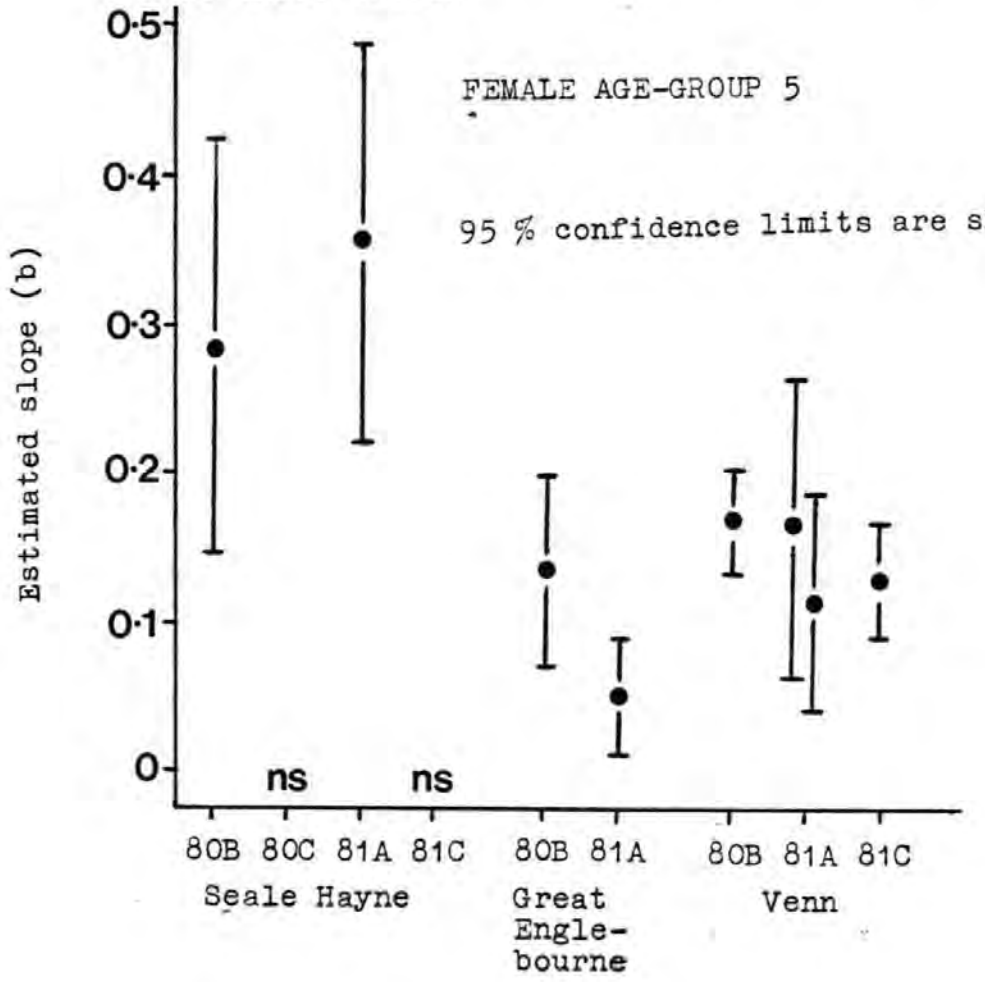
A pair of slopes can be readily compared by means of a t-test, but a comparison of all possible pairs would require $N(N - 1)/2 = 45$ separate tests. The tabulated significance levels would not be correct in such an *a posteriori* search for effects; for 45 tests at a 5% nominal significance level, then we could expect about two ($45 \times 0.05 = 2.25$) incorrect conclusions (Type I errors, Sokal & Rohlf, 1969). The least significant difference could be calculated to ensure an overall 5% significance level for N tests, by using a nominal significance level of 0.05/N (0.05/45 = 0.0011%) for the individual tests. The tests are likely to be too conservative, so there could be a risk of rejecting real differences (Type II error).

A more efficient test was used, whereby only the comparisons of interest were made. The replicate slopes of those sites where two independent variables were used (i.e. Venn 1980B, Venn 1981A), will be compared initially. If the slopes are found to be insignificantly different, then a mean and a pooled variance can be calculated (Steel & Torrie, 1980). The different years for each site could then be compared, and pooled wherever possible. Finally, the different sites could then be compared.

Two estimates of the slope were obtained from the data of Venn 1980B (Table 24), for the dispersal from the primary emergence site (b_1) and from a secondary aggregation (b_2). The slope b_1 is

FIG. 68

The estimated slope for the different generations at three sites.



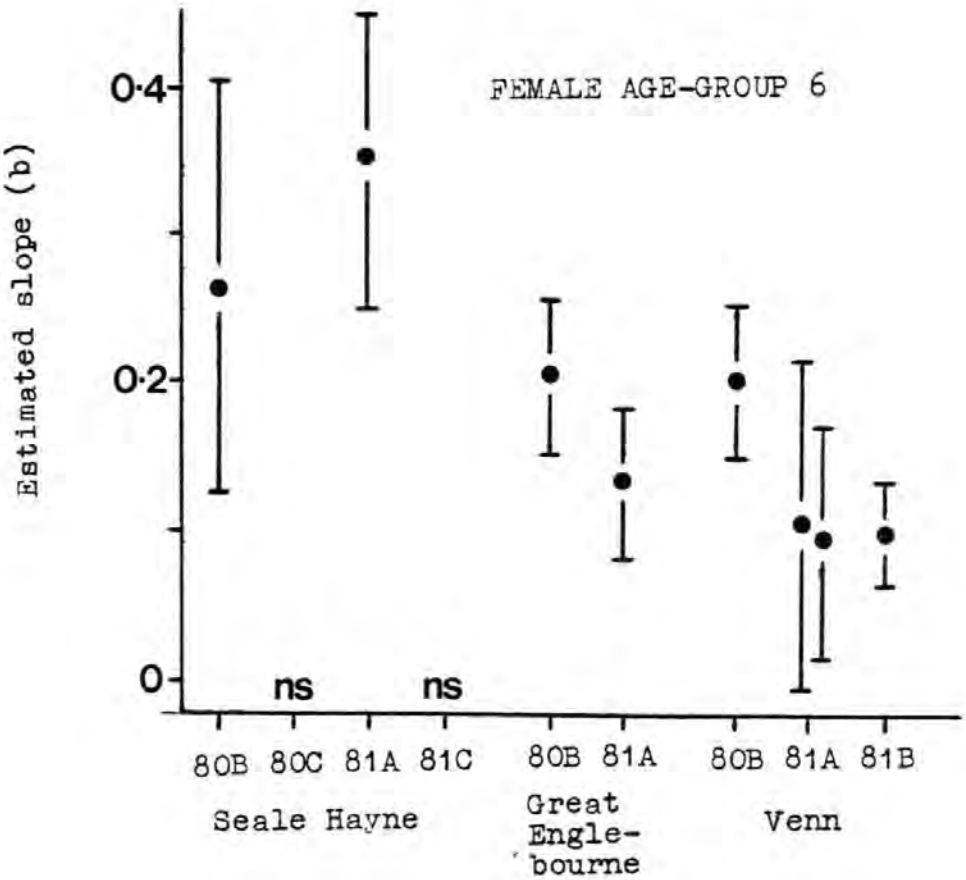


FIG. 69

The estimated slope for the different generations at three sites.

95 % confidence limits are shown

FEMALE TOTAL

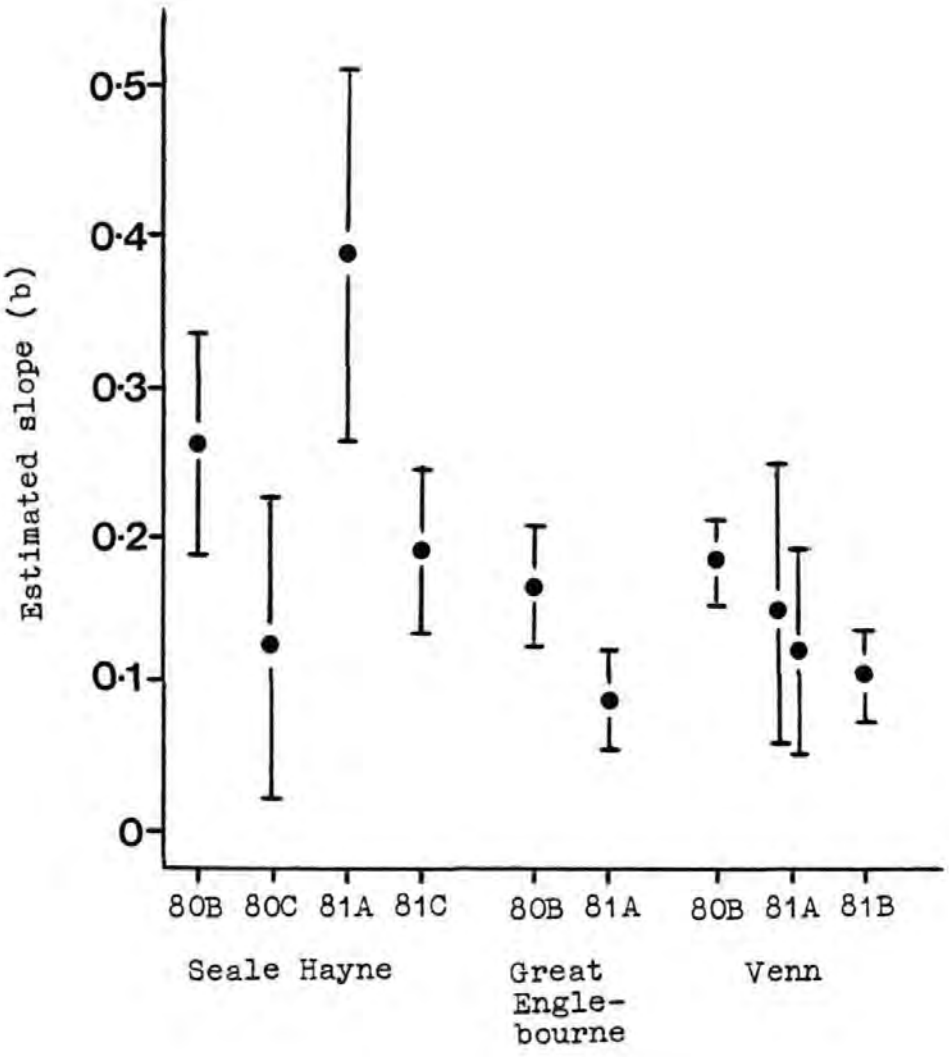


FIG. 70

The estimated slope for the different generations at three sites.

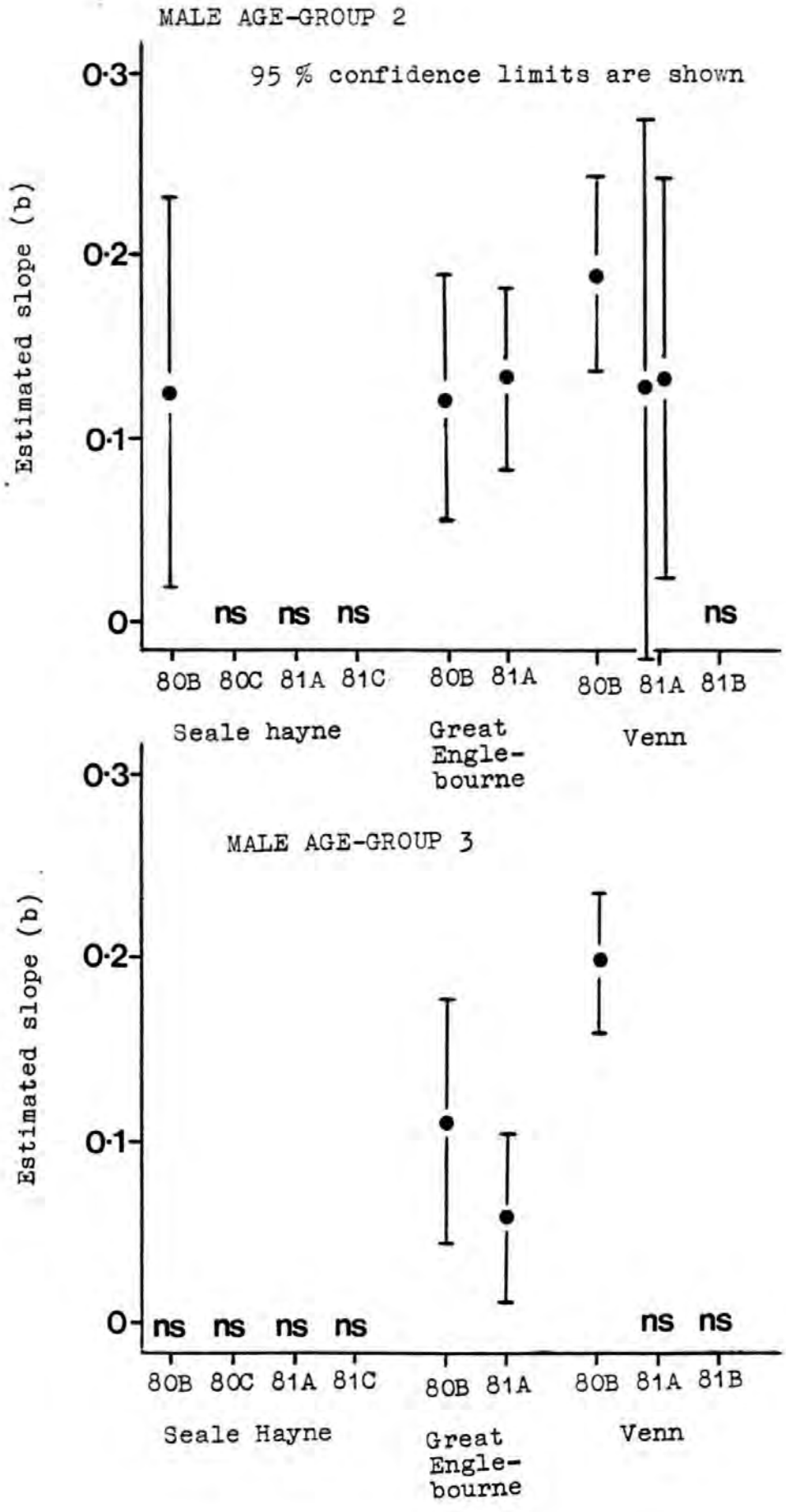
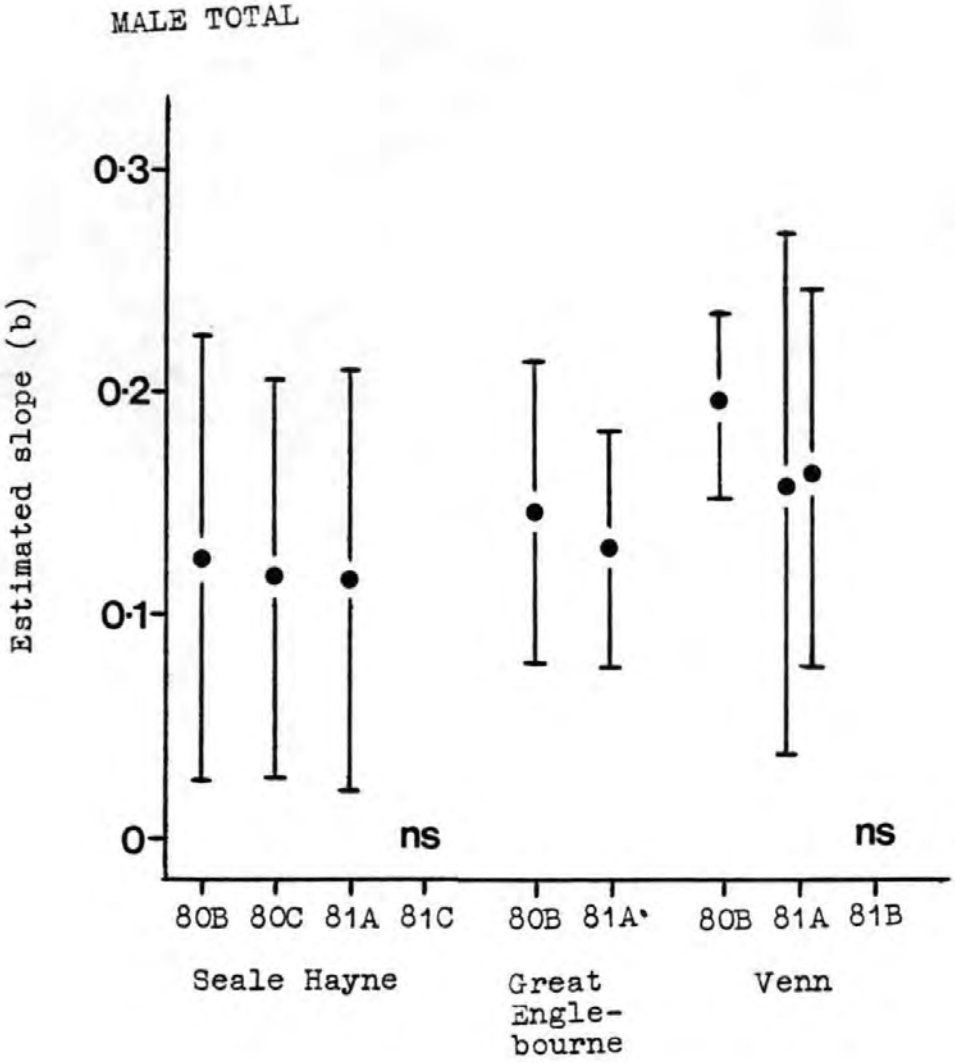


FIG. 71

The estimated slope for the different generations at three sites.

95 % confidence limits are shown



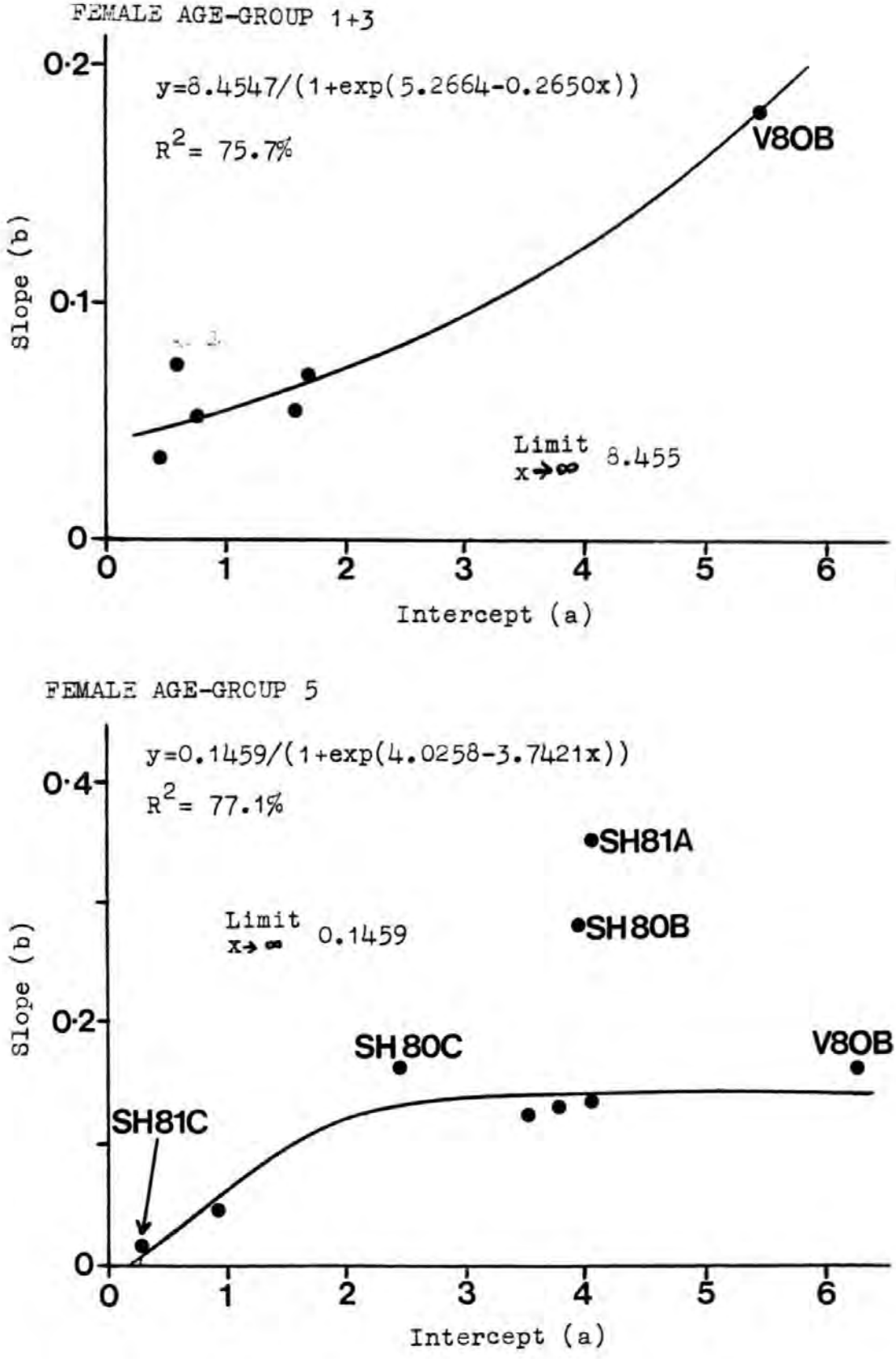
significantly different from b_2 for most age-groups, and for the male age-groups b_1 is not significantly different from zero. The secondary aggregation is thought to derive from the flies emerging from the primary site. The failure of b_1 in the explanation of variance may be caused by sampling primarily the secondary aggregation, after the peak emergence has occurred and during the decline in the number of emerging flies. The data of Venn 1980B would be produced by dispersal from the secondary aggregation. The change in number of flies caught (Figs 22 & 23) shows that sampling was mainly after peak emergence, particularly for the males, which are known to emerge earlier (Finch, 1977). In effect, the slope b_1 will be estimated from a smaller catch of flies, which is known to be more susceptible to underestimation (Ch. III.2), so will be omitted from further analysis.

The estimates of the slope for the different generations and the different sites cover a range of values, and do not appear to form a uniform group (Figs 68 - 71). The estimates of the female age-groups from Seale-Hayne 1980B and Seale-Hayne 1981A appear to be larger than the main body. These apparently outlying values are not significantly different from the main body.

The various estimates of the slope for each age-group are not strictly comparable, because they are each based on the capture of different numbers of flies (as shown by the intercepts). Random noise has been shown to be capable of causing significant underestimation of the slope, and the degree of underestimation depends on the number of flies caught (Ch. III.2). The fitted value of the slope is clearly correlated with the intercept (Figs 72-75). The smaller the value of the intercept, then the greater the underestimation of the slope.

FIG. 72

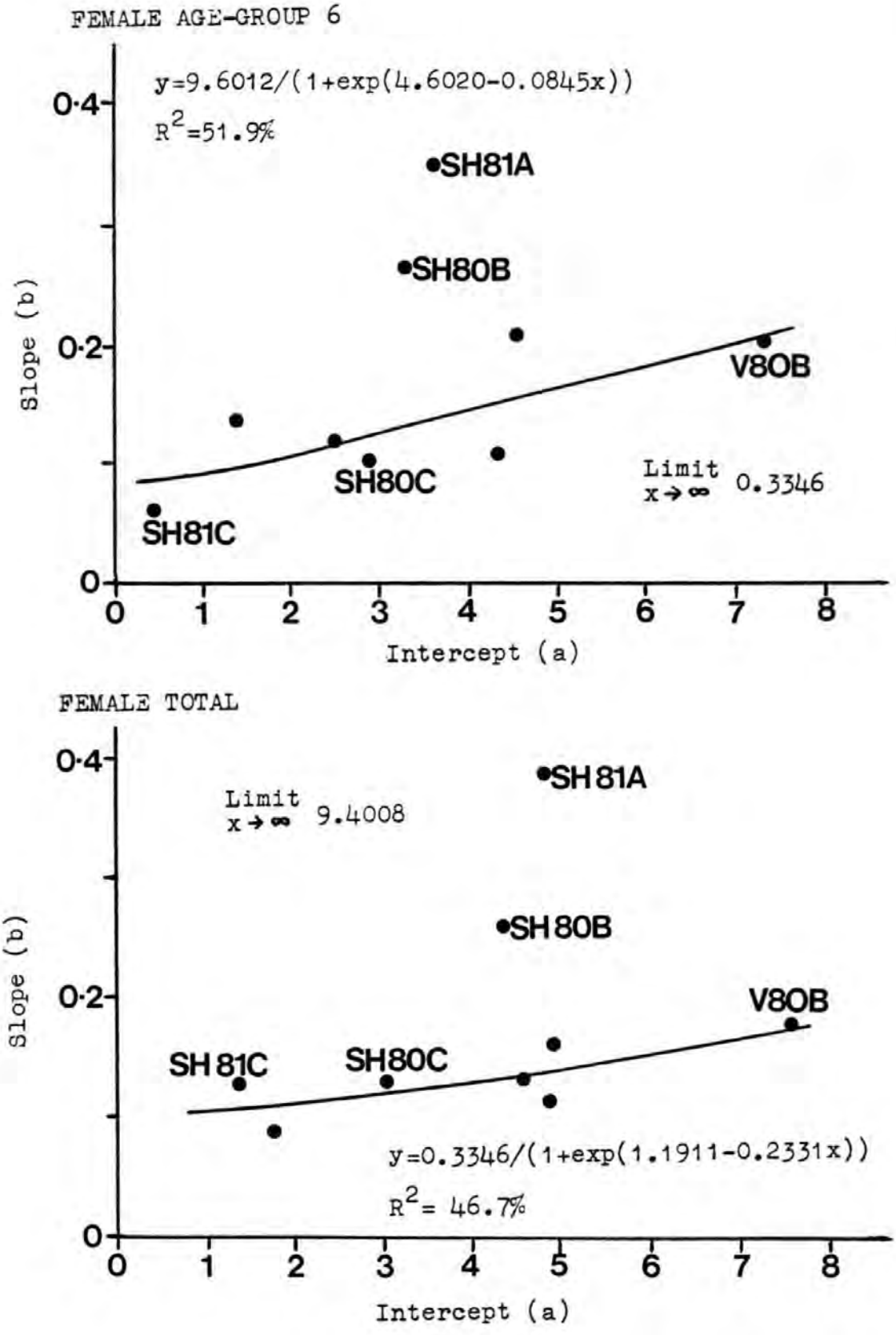
The relationship between the fitted values of the slope and the intercept.



The SH80B+SH81A points have been omitted from the fitting of the curve.

FIG. 73

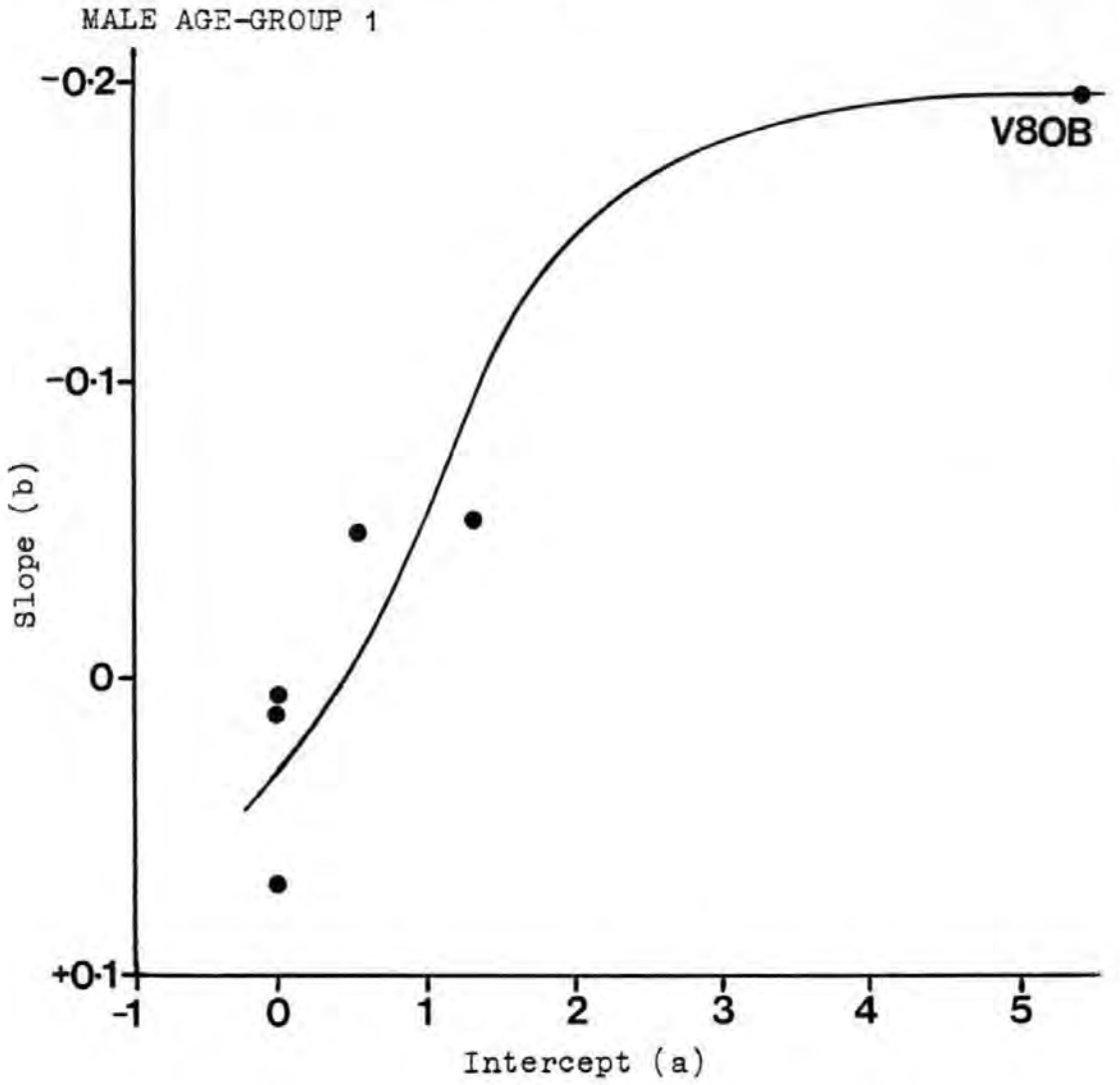
The relationship between the fitted values of the slope and the intercept.



The SH80B+SH81A points have been omitted from the fitting of the curve.

FIG. 74

The relationship between the fitted values of the slope and the intercept.



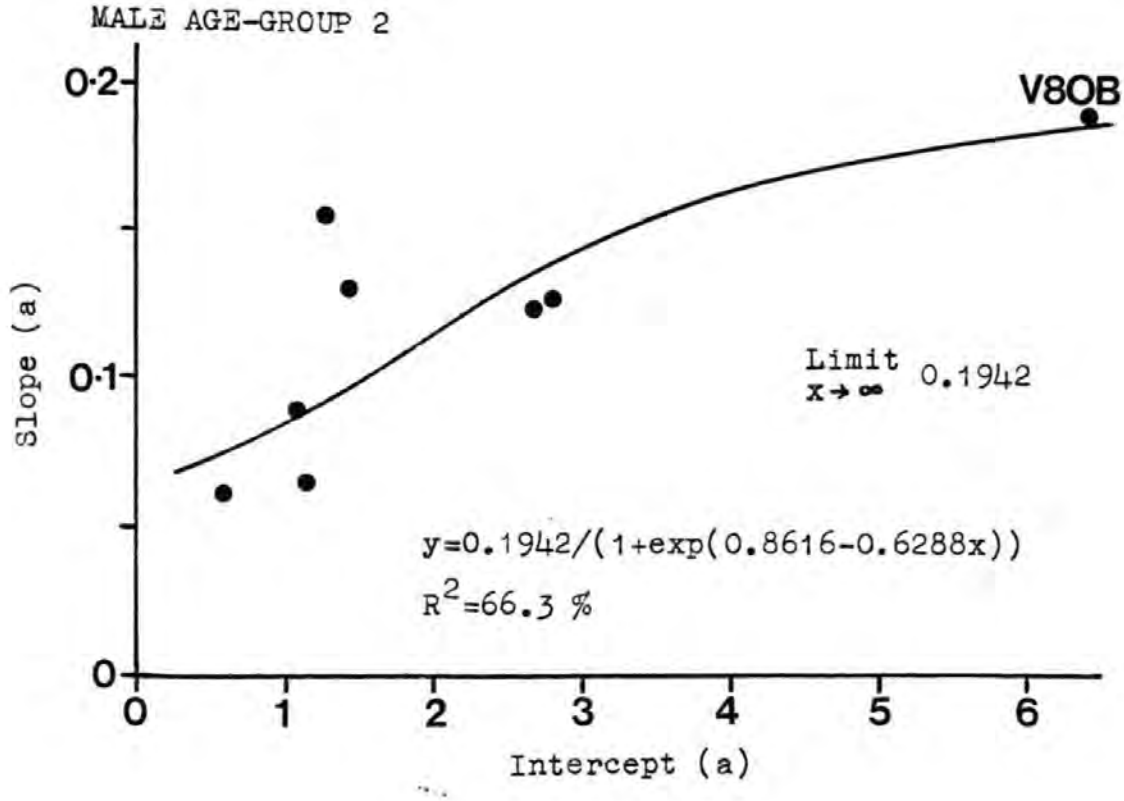
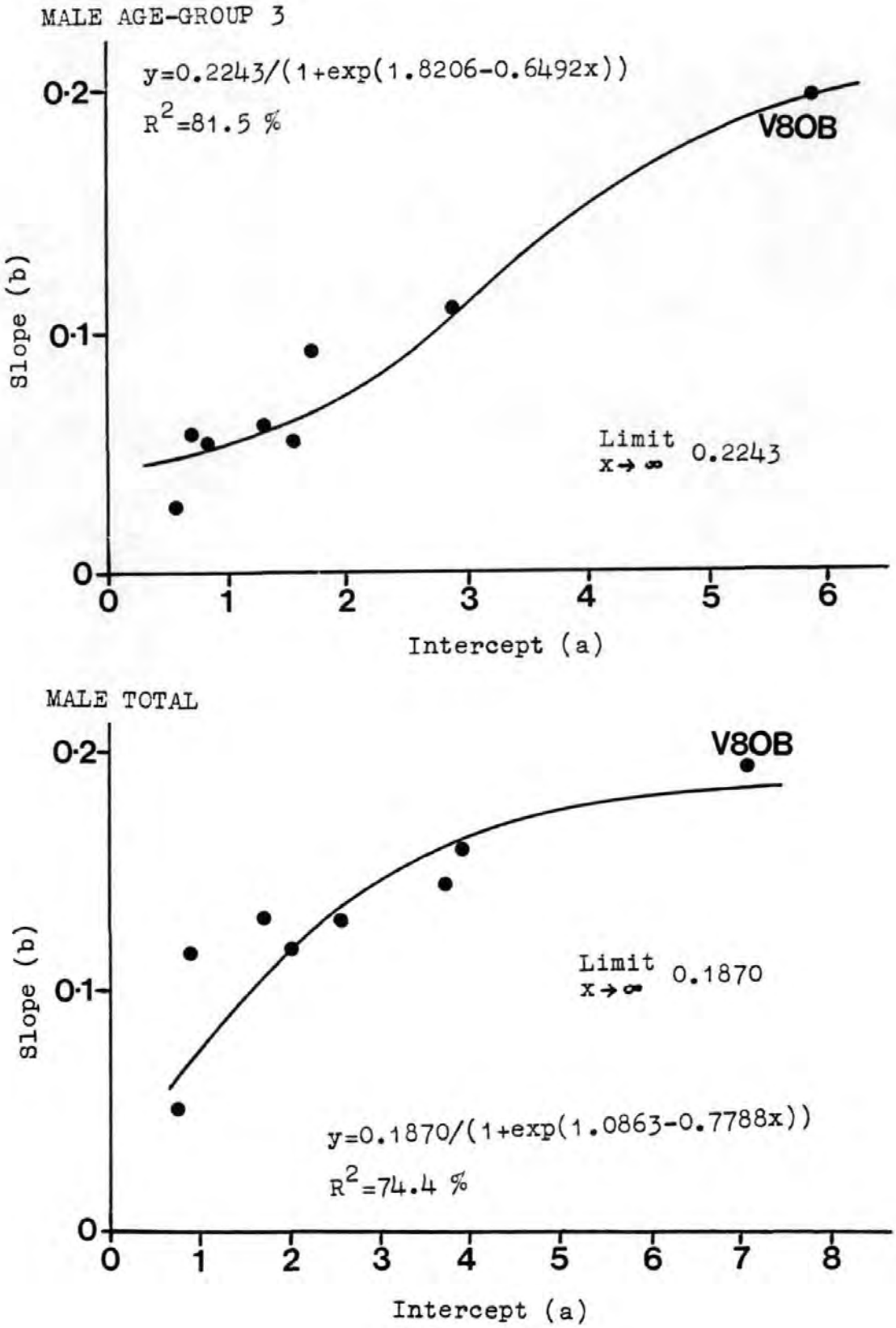


FIG. 75

The relationship between the fitted values of the slope and the intercept.



The slope estimated for the female age-groups of Seale-Hayne 1980N and Seale-Hayne 1981A are clearly outliers to the main trend. For both data sets, a later but similar trap layout produces estimates for the female age-groups which are consistent with the main trend. The female age-groups only are involved, which suggests that the brassica crop could be the underlying cause (Hawkes, 1975). The host crop is specifically attractive to gravid (F5) females, but the distribution of parous females will also be altered by the stimulation of oviposition. The younger females are not affected by the host crop, but insufficient number of these age-groups were caught for any meaningful regression fit. The value of the fitted parameters of the Seale-Hayne data sets are all strongly influenced by the catch of flies close to the emergence site (Cook, 1977), which could cause an overestimation of the slope. The anomalous results could also indicate that dispersal is lower in Seale-Hayne, although the evidence is inconclusive and would need to be resolved by further experiments. The male and female flies could behave differently, which could lead to different dispersal rates (e.g. Pieris, Jones et al., 1980).

All the estimates of the slope are likely to be underestimates of the true slope. The true value of the slope will be approached as the intercept tends towards infinity. The true value of the slope could be estimated as the limit of a function fitted to the observed values of the slope (Figs 72-75). The small number of available observations limits the accuracy of the fitted function, but there clearly appears to be a limit to the slope of approximately 0.2 for all the age-groups. The clustering of the values for the youngest age-groups (Figs 72 & 74) means that the limit cannot be accurately established. The values for the other age-groups exhibit a greater

spread, allowing a reasonable estimate of the limit. There is no evidence for any large differences between the limits of the age-groups, which would indicate that there is no migration phase. The largest number of flies were caught at Venn 1980B, so these estimates of the slope will be the least affected by random noise.

(e) The estimation of dispersal rates

The largest number of flies were caught at Venn 1980B, so the estimates of the slope from this site will be the least susceptible to underestimation. The slopes estimated for the individual age-group (Table 21) are not significantly different. The age-groups are not comparable, because they are based on different catches of flies. The flies in the youngest age-group were the least frequently caught, so their slope could be expected to be underestimated to the greatest extent.

The dispersal rate calculated from the estimated mean distance dispersed and the estimated mean age, can only be an approximation suffering from unknown error (Table 21). The mean distance dispersed is likely to be underestimated, whereas the mean age could be expected to be overestimated (Ch. II.9). The estimated dispersal rates range from 49-165 m/day, which includes the estimates of Finch & Skinner (1975). There is clearly no indication of any large difference between the dispersal of the young and gravid flies, and no evidence of any migratory phase with dispersal rates of 1000 m/day.

The simulation model based on field observations of wild flies, predicts dispersal rates of 29-87 m/day (Fig. 22; Hawkes, pers. comm.) The rate of dispersal shows a progressive decrease with time, which was also noted in the mark-recapture experiments (Hawkes, 1972a, 1974, 1975). At the start of the experiment all the flies will

TABLE 20

The estimated mean age for the male and female age-groups of the different generations of cabbage root fly.

Generation	Mean temperature(^{o}C)		Mean age (days)				
	Max.	Min.	F3	F5	F6	M2	M3
1980B	18.1	10.7	3.79	7.21	8.42	4.46	10.42
1980C	18.7	11.7	3.25	6.58	7.79	4.17	9.83
1981A	15.5	8.4	5.29	10.21	11.88	5.79	13.38
1981B	19.3	12.2	3.04	6.08	7.21	3.96	9.33
1981C	20.4	10.5	2.96	5.96	7.04	3.88	9.33

TABLE 21

The estimated dispersal rates from the data of Venn 1980B.

Age-group	Intercept (a)	Slope (b)	Mean distance dispersed(m)	Mean age (days)	Dispersal rate (m / day)
F1+3	5.40	-0.179	624.2	3.79*	164.7
F5	6.26	-0.167	717.1	7.21	99.5
F6	7.22	-0.206	471.1	8.42	56.0
FT	7.54	-0.183	597.2	-	-
M1	5.47	-0.198	510.2	-	-
M2	6.41	-0.190	554.0	4.46	124.2
M3	5.89	-0.198	510.2	10.42	49.0
MT	7.10	-0.195	526.0	-	-

*Female age-group 3

TABLE 22

The results of the simulation of dispersal of wild females.

HAWKES (pers. comm.)

N = 30

Time(days)	Mean distance dispersed (metres)	Dispersal rate (m / day)
1	87	87.0
2	129	64.5
3	155	51.7
4	202	50.5
5	213	42.6
6	261	43.5
7	261	37.3
8	286	35.8
12	353	29.4

necessarily be at the starting point, and movement will be away from this starting point. As dispersal continues the probability of individuals moving back towards the starting point will increase, and the mean distance will consequently decline.

The mean distance dispersed of the simulation model was estimated from thirty individuals, producing dispersal rates somewhat lower than the indirect estimates from the slope of density on distance. The estimates of dispersal based on the capture of flies may produce higher apparent rates, because of a bias towards capturing the more active flies which are also likely to disperse over greater distances. The flight length used by the simulation model is known to be an underestimate (Hawkes, pers. comm.). The flight length increases with distance away from the emergence site, because the flies with the longer flight lengths will tend to disperse greater distances. The trap lines also sample only a portion of the population, with the flies with greatest flight lengths passing beyond the sample area.

(f) The comparison of the estimated slope with previous studies

The studies of both Hawkes (1972a) and Finch & Skinner (1975) obtained sufficient observations to allow a meaningful estimate of the slope of density on distance. Freeman (1977) reanalysed part of the data of Finch & Skinner (1975) using a more elaborate model allowing the slope to change with time. The slope was estimated by Hawkes (1972a) using a simplex non-linear least squares method (Himmelblau, 1972). The zero observations were accommodated by replacing them with an arbitrary small value and a low weight. Finch & Skinner (1975) do not mention how they dealt with zero observations, but it is probable that they simply ignored the zeroes in the calculation of the slope. Freeman (1977) used a $z = \log_e(Y + 3/8)$

TABLE 23

A summary of the estimates of the slope from previous studies.

The data of Hawkes(1972a) were originally fitted using a simplex non-linear least-squares method,and have been refitted using a linear least-squares.

HAWKES (1972a)

			Simplex	Linear		
Female			b	a	b	R^2
1967 Expt.	(1)		-0.73	0.72	-0.095	23.1
	(2)		-0.75	0.85	-0.119	45.0
1968	(1)	0830-1030	-1.30	3.00	-0.452	60.5
	(2)	1030-0830	-0.51	2.18	-0.274	48.4
Male						
1967	(1)		-0.85	1.55	-0.183	20.5
	(2)	0445-0830	-1.63	2.69	-0.463	52.6
		0830-0830	-0.56	0.71	-0.029	0.1
1968	(1)	0445-0830	-2.15	2.63	-0.416	49.3
		0830-0830	-0.57	1.66	-0.231	70.1
	(2)	0830-1030	-1.59	5.00	-0.705	73.5
		1030-1430	-1.06	4.68	-0.600	25.5
		1430-0830	-0.67	3.66	-0.414	57.3

FINCH & SKINNER (1975)

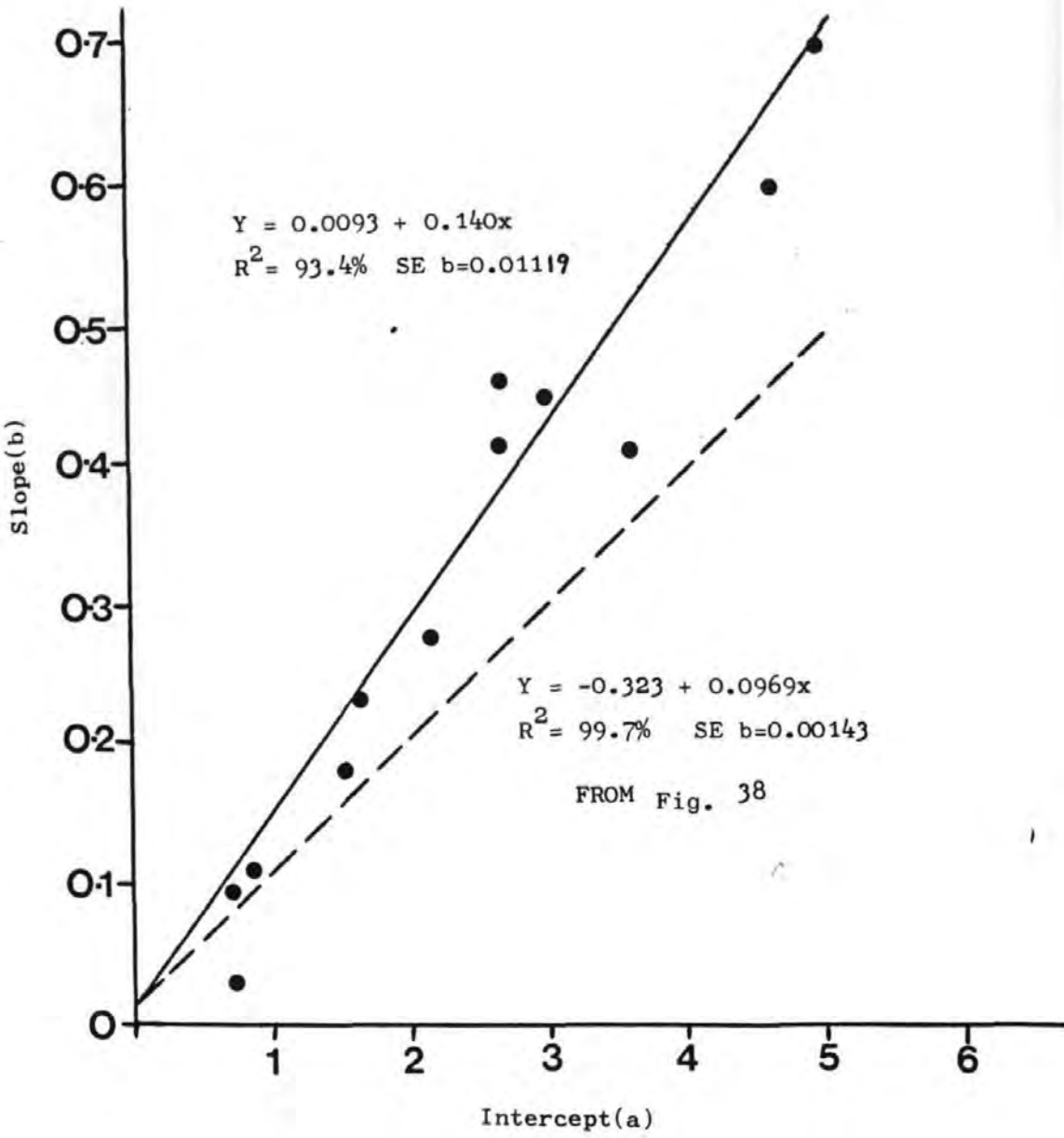
		a	b	R^2
ANCS present	♂	-	c. 0.2	-
ANCS absent	♀	0.075	0.075	26.5
	♂	4.01	0.262	56.9

FREEMAN (1977)

		a	b	R^2
Young culture		2.08	-0.280	39.3
Intermediate culture		0.17	-0.141	31.4
Old culture		1.93	-0.196	51.0
	♀	-0.99		
	♂	-0.32		
Young wild			-0.097	9.3
	♀	-0.61		
	♂	-0.65		
Old wild		1.66	-0.242	22.8

FIG. 76

The relationship between the slope and intercept fitted to the data of Hawkes(1972a) by a linear regression model.



transform, which he found satisfactory for the equalisation of variance, but he did not consider the effect on the estimated slope.

Hawkes (1972) reported values for the slope ranging from 0.51 - 2.15 for culture flies (Table 23). The culture flies have been shown to disperse at about ⅓rd of the rate of wild flies (Finch & Skinner, 1975; Hawkes, Patton & Coaker, 1979). The size of the estimates may also be partly caused by the non-linear least squares method, which will be strongly influenced by the catch of traps close to the release point, but may describe poorly the later decrease with distance. The slope was estimated using a linear least squares method, for direct comparison with the estimates of the present study. It would not be possible to omit the zero observations, because this would leave too few observations. The data were transformed to $z = \log_e (Y + 1)$, but the slopes will be underestimated because of the small number of flies recaptured (Ch. III.4). The estimated slopes range from 0.183 - 0.705, which remain significantly higher than the majority of estimates from this study. The fitted slope and the intercept are strongly correlated (Fig. 76), which would suggest that noise is causing underestimation of the slope. The slope of the regression of fitted slope and fitted intercept is significantly steeper than found in the simulation of random noise on a regression line (Fig. 38). The slope and intercept would be expected to decrease together in a discrete release experiment, as the flies disperse away from the release point. The correlation observed between the slope and intercept (Fig. 76) is probably caused by the combination of a statistical effect produced by random noise and a real effect produced by dispersal of the flies.

Finch & Skinner (1975) present their results as mean distance dispersed, although these estimates were derived from the slope of density on distance. They found low values for the slope for females on the 5th and 6th days after release, which they attribute to a migratory phase. I have proposed that it is an artefact of the use of ANCS attractant in the traps, which is specifically attractive to gravid females. The small number of flies recaptured would also lead to a serious underestimation of the slope (Ch. III.2). The males are unresponsive to ANCS, so the fitted slope should be comparable with the present study. The culture and wild males dispersed to approximately 500 m. after seven days (slope = 0.2), indicating a dispersal rate of 71.4 m/day. The first experiment (in 1971) is particularly useful, because the yellow water traps were used without ANCS, and the slope of males and females can be compared with the present study (Table 23). The catch of females was low, which is why ANCS was used in later experiments. The slope is probably an underestimate caused by the small number of females caught. The estimate for the males is based on the recapture of a larger number of flies, and the slope is only slightly higher than the estimates of the present study.

Freeman (1977) reports estimates of the slope ranging from 0.097 - 0.280, but many of these estimates are based on the capture of very small numbers of flies (Table 23). The smallest values of the slopes were obtained from the old culture and the young wild flies, which were also caught the least frequently (as shown by their intercepts), so would be expected to be underestimated to the greatest extent.

The data of the current study suggest a limit of approximately 0.2 for the slope of density on distance. The estimates of Finch &

Skinner (1975) for the non-ANCS traps, and the estimates of Freeman (1977), broadly agree with this limit. The female migration proposed by Finch & Skinner (1975) was not confirmed by the present study, and is thought to be an artefact of the use of ANCS attractant and the underestimation caused by the small number of flies caught.

(g) The use of X^c instead of the square root of X

A significantly greater explanation of variance is achieved with X^c. The additional explanation of variance is small, because the fitted values of c fall close to 0.5 (Fig. 77). The marginal increase in explanation is outweighed by the disadvantage of the fitted slopes no longer being directly comparable. The comparison could only be made after calculation of the mean distance dispersed (Appendix 1).

FIG. 77

The effect of varying the value of the power (c) in the equation $Y=\exp(a - bX^c)$ on the proportion of the variance explained(R^2).

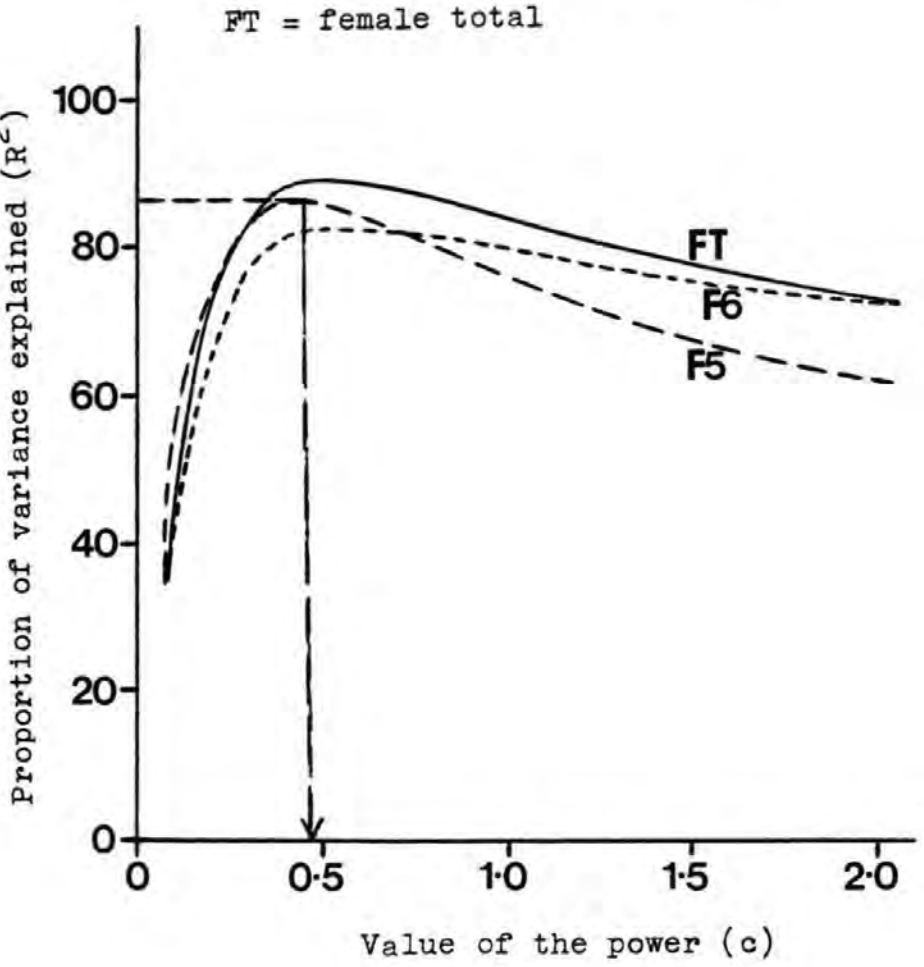
	MAXIMUM R^2	
	Graphical	E04FCF
Age-group	estimate	estimate
F1+3	0.50	0.506
F5	0.42	0.419
F6	0.60	0.604

Data: Venn 1980b

F5 = female age-group5(gravid)

F6 = female age-group6(parous)

FT = female total



CHAPTER III.10

General discussion

The dispersal of the gravid females determines the number of eggs laid in a host crop, controlling the size of the next generation and the level of damage to the crop. The limiting value of the slope of density on distance is clearly close to a value of 0.2 for gravid females (Fig. 72), indicating a mean distance dispersed of 500 m. There is no evidence for a migratory phase during the life of a fly, and little clear evidence for the selection of a different mean distance dispersed under different agricultural practices.

The mean distance dispersed may be rather misleading, because the value is greatly influenced by the small proportion of flies dispersing a large distance. The median (x_{50}) may be more relevant for the design of any future attempts to control by alternative methods (e.g. chemosterilization, removal of hedgerow flowers, etc.). The mean will be larger than the median for positively skewed distributions. The distance within which 95% of the flies remain (x_{95}) can be calculated from equation (1).

$$x_{95} = 60.1/b^2 \quad \text{(Hawkes, 1975)} \qquad (1)$$

The total number of flies could be estimated from the integral of the density-distance relationship (2), if the constant (k) were known.

$$N = \int_0^\infty k.y.2\pi x.dx \qquad (2)$$

where $y = \exp(a - b\sqrt{x})$

The number of flies within a specific radius could be represented as equation (3), although this partial integral cannot be analytically

solved.

$$N_{d_1 d_2} = \int_{d_1}^{d_2} k.y.2\pi x.dx \qquad (3)$$

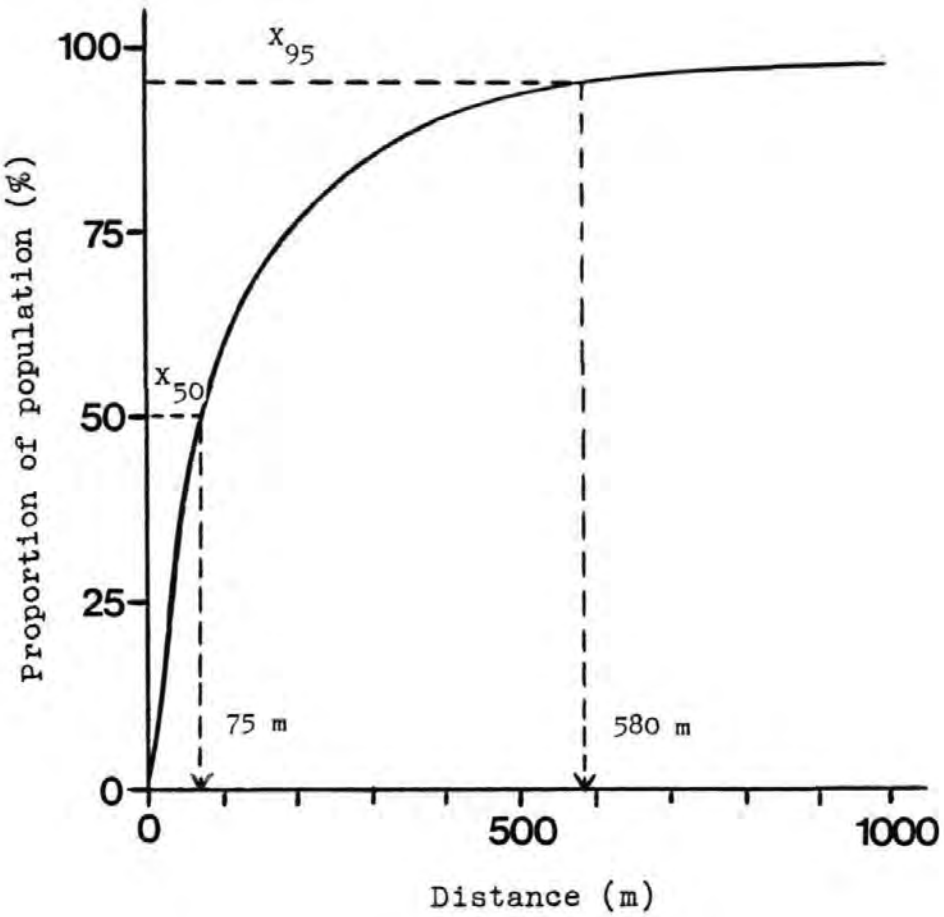
The integral could be evaluated by a numerical integration, if the constant were known. The constant can be eliminated by expressing the number as a proportion of the total population. This method provides a potential means for the quantitative prediction of the proportion of a population that could be expected to disperse far enough to attack a new host crop x metres distant. The input would be dependent on the arc covered by the new host crop, but there is the problem of what happens to flies that disperse past the new host crop.

The majority of flies remain close to the emergence site, but the extended tail means that a small proportion will travel over long distances (Fig. 78). A moderate distance from the emergence site will be effective at reducing the input of flies into a new host crop, but greatly increased distances will be relatively ineffective as a further barrier to the input of flies (Bateman, 1947). The numerical integration suggests that 95% of the flies will remain within 580 m. of the emergence site (Fig. 78), whereas the Hawkes (1975) formula would indicate a distance of 1503 m. The large disparity between these two estimates may arise from the approach to horizontal by the proportion with increasing distance. A large difference in the estimates could be caused by relatively small errors in the numerical integration.

The relatively short dispersal range by a large proportion of the population would suggest that there are good prospects for con-

FIG. 78

The predicted dispersal of a population of cabbage root flies based on a numerical integration of the density-distance relationship with a slope of 0.2.



trol by alternative methods. The individual populations of cabbage root fly on each host crop will be relatively isolated, with only a small exchange of individuals. The study of population variation could provide an independent check on the estimates of dispersal. Cabbage root fly populations have been found to differ significantly in a number of morphological characters (Hill, 1982), and they are likely also to differ in biochemical characters, which might be separated by electrophoresis (e.g. Prakash & Hubby, 1969; Ayala et al., 1972).

The mobility of cabbage root fly is sufficient for the location of host crops, because of the small size of the majority of British farms. A reduction in dispersal could lead to decreased mortality from dispersal, but could increase the mortality from competition. The crops are regularly rotated, so dispersal is essential at least once a year, to avoid the risk of total reproductive failure. An increase in dispersal (e.g. by migration) would spread the flies over a greater area, which could reduce the chance of locating a suitable crop. The observed dispersal may be a compromise, with a small proportion remaining at the emergence site and dispersing over a large distance. The majority of flies disperse over moderate distances, where they are most likely to discover a new host crop or wild crucifers.

The selection pressure would be expected to be different on those livestock farms, where the only host crops are planted at mid-summer. There is no host crop available to the first generation, which would need to disperse over large distances to locate an available host crop, or delay emergence until the host crop is planted. There would be expected to be strong selection pressure for delayed

emergence, since only a very small proportion of the first generation would be expected to successfully locate a host crop. This system of growing swedes has been used for at least the past hundred years, so the flies could be expected to have evolved the optimal strategy. The proportion of flies delaying emergence has been found to vary on different sites, which may be connected with agricultural practice (Finch & Collier, 1983). On Great Englebourne, the largest proportion of the first generation flies emerge normally during the spring, with a smaller proportion delaying emergence (Figs 24-27). The delay in emergence probably carries a high associated cost in mortality from fungi and predators. The pupae can suffer high mortality during the winter (e.g. Finch & Skinner, 1980), and the pupae could be expected to be more vulnerable during the warmer conditions of spring. The observed strategy appears to be a trade off between the high mortality of dispersal and the high mortality of delayed emergence.

The other insect pests of crucifers face similar problems of host plant location as cabbage root fly, but solve them by different strategies of reproduction and dispersal (Hawkes, Patton & Coaker, 1979). The cabbage aphid (Brevicoryne brassicae) is a small insect with a low individual search capacity, but produces a large number of progeny, which undergo a migration (Kennedy, 1976). The cabbage butterflies (Pieris spp.) are large insects with a large individual search capacity, producing a small number of progeny, but do not undergo a migration (Jones et al., 1980). The cabbage root fly has only a moderate search capacity, and the use of host plant odour may have developed to increase the effective area searched.

Summary

1. The objective of this study was the quantitative description of the dispersal of wild cabbage root flies on agricultural sites, as a test of a migration hypothesis and of the predictions of computer simulation model of dispersal.

2. A method of age determination was developed for male cabbage root flies, based on changes in the pupal fat and testes colour. The pupal fat was also used to improve the published method of female age determination, to allow more rapid separation of nulliparous and parous flies.

3. The rate of development of the male age-groups were found to differ in two independent laboratory cultures. The age-groups provide a means of dividing a population into groups of comparable physiological age, although they may differ in chronological age.

4. The age-groups provide useful field information, in the separation of the different generations and in the location of sources of emerging flies. The age-groups provided evidence for the delayed emergence of the first generation on one site, which may be connected with the practice on livestock farms of planting the only brassica crop at midsummer.

5. The rate of development of the age-groups was strongly dependent on temperature, as measured by a series of constant temperatures. A polynomial equation was derived to describe the relationship between development and temperature. The development in the field was predicted by the summation of the hourly development, calculated from the temperature provided by a sine wave approximation fitted to the daily

maximum and minimum temperatures. The development time under field conditions was slightly but consistently overestimated by the development model. The diet had no effect on the rate of male development, although the females develop more rapidly when supplied with sucrose. It is unlikely that carbohydrate will be limiting in the field.

6. A computer simulation demonstrated that the slope of density on distance could be validly estimated from a non-point source of emerging flies (a former host crop). The emergence of flies from a second source would not significantly affect the slope, although the emergence of flies from wild crucifers could cause significant underestimation of the slope, and overestimation of the mean distance dispersed.

7. Random noise was shown by a computer simulation to be capable of causing a significant underestimate of the slope and an overestimate of the mean distance dispersed. The influence of the noise depends on the number of flies caught, so the estimates of slope based on the capture of different numbers of flies are not comparable. The fitted values of the slope and intercept were found to be strongly correlated.

8. The dispersal of wild cabbage root flies was studies using lines of yellow water traps (without ANCS attractant) on three sites in the South Hams, Devon, England. The three sites were chosen to cover the range of agricultural practice, which may select for different strategies in dispersal or emergence pattern.

9. The data were transormed to logarithms to improve normality and variance homogeneity. The zero observations can be retained if a starting value is applied to all the observations before transform-

ation. The start can produce a significant underestimation of the slope. In my analysis, the individual sample times were pooled for each generation, and the remaining zero observations were omitted from the calculation of the regression.

10. An analysis of variance reveals that distance, age and sample time are all highly significant in the explanation of variance. There is significant age-distance interaction for most data sets, suggesting that the mean distance dispersed depends on the age of the fly.

11. The hedges and the brassica crops were found to produce a marked influence on fly distribution.

12. The models were a statistically good description of the majority of the data sets, producing a high explanation of variance and a random, normal residual pattern.

13. The dispersal rate was estimated by a new method. The captured wild flies were separated into age-groups, and a mean age caculated for each group. The mean distance dispersed was calculated from the slope of density on distance, and the dispersal rate was estimated by the division of this distance by mean age.

14. A range of estimates of the slope were obtained for each age-group. The fitted values of the slope and intercept were strongly correlated, caused by random noise producing a progressive under-estimation of the slope for decreasing catches of flies. The slope clearly reaches a limiting value of approximately 0.2 for an infinite catch, indicating a mean distance dispersed of 500 m. for gravid

females. There was no evidence for any migratory phase during the life of a female fly.

15. The migration of female flies proposed by Finch & Skinner (1975) may be an artefact of their use of ANCS attractant, which is known to be attractive to only gravid females.

16. The dispersal rate was estimated at 49-165 m/day, compared to 29-87 m/day predicted by the computer simulation model. The flights lengths used by the model are expected to be underestimates, and the yellow water traps are biased towards the more active flies.

17. A reanalysis of Hawkes (1972a) data reveals a strong relationship between the fitted slope and intercept, but with a steeper slope than a noise simulation. The difference is probably caused by the simultaneous decrease in both slope and intercept in a discrete release, as the flies disperse away from the release point.

18. The distance within which 95% of the population remain, was estimated at 1503 m. using Hawkes (1975) equation, but a numerical integration suggests a value of 580 m. The relatively short dispersal range of cabbage root fly suggests that there are good prospects for the alternative methods of control.

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APPENDIX ONE

A general solution to the integral equations of Hawkes (1972a) used in the estimation of mean distance dispersed from the slope of density on distance.

$$I_1 = \int_0^\infty y \cdot 2\pi x \cdot dx$$

$$I_2 = \int_0^\infty x \cdot y \cdot 2\pi x \cdot dx$$

where $\log_e y = a - bx^c$ or $y = e^a \cdot e^{-bx^c}$

$$I_1 = \int_0^\infty e^a \cdot e^{-bx^c} \cdot 2\pi x \cdot dx$$

$$I_2 = \int_0^\infty e^a \cdot e^{-bx^c} \cdot 2\pi x^2 \cdot dx$$

let $u = bx^c$ gives

$$I_1 = \frac{2\pi e^a}{cb^{2/c}} \Gamma(2/c)$$

$$I_2 = \frac{2\pi e^a}{cb^{3/c}} \Gamma(3/c)$$

then $$\frac{I_2}{I_1} = \frac{cb^{2/c}}{cb^{3/c}} \cdot \frac{\Gamma(3/c)}{\Gamma(2/c)} = b^{-1/c} \cdot \frac{\Gamma(3/c)}{\Gamma(2/c)}$$

for $c = 1/2$

$$\frac{I_2}{I_1} = \frac{1}{b^2} \cdot \frac{\Gamma(6)}{\Gamma(4)} = \frac{1}{b^2} \cdot \frac{5!}{3!} = \frac{20}{b^2}$$

The values of $\Gamma(x)$ for between 1.0 and 2.0 are available in standard tables (e.g. Siegel 1969). The value of any x outside this range can be calculated from the expansion of $(x)=(x-1)\Gamma(x-1)$.

APPENDIX TWO

A summary of the changes in the male organs with age.

AGE = age from emergence (days)
HW = head width (mm. X40)
TW = thorax width (mm. X40)
FATNO = number of pupal fat bodies
MEAND = mean diameter of pupal fat bodies (mm x40)
C = colour of testes (see Table 4b)
TESTL = testes length (mm. X40)
TESTW = testes width (mm. X40)
AGL = accessory gland length (mm. X40)
AGW = accessory gland width (mm. X40)

AGE	HW	TW	FATNO	MEAND	C	TESTL	TESTw	AGL	AGW
0.0	32.0	37.0	1128.0	8.23	1 0	40.00	19.50	31.00	11.00
0 0	37 0	40.0	1602.0	11 13	1.0	46.50	22.50	30 00	10.50
0 0	36 0	41.0	1204 0	10.47	1 0	44 50	19 00	36.50	12.00
0 0	35.0	42.0	1242.0	9 80	1.0	37 50	19.00	28.50	10.00
0 0	30.0	35.0	1104.0	7.83	1.0	36 00	17.00	28.50	8.00
0 0	36 0	40 0	1086.0	10.17	1.0	39.00	20.50	32.00	32.00
0 0	35.0	40 0	1093.0	9 40	1 0	43.50	21.50	27.00	10.00
0.0	35 0	41.0	965.0	9.77	1.0	42 00	23.00	41 00	10.00
0 0	36.0	42 0	1436.0	8.50	1.0	44.50	18.00	33.00	9.50
1 0	35 0	42 0	1058.0	9.50	3.0	45 00	22.50	36.00	12.50
1 0	34 0	40.0	1192.0	8.73	3.0	44.50	21.50	30.00	13.50
1.0	30 0	35.0	994 0	7.87	3.0	40 00	25.00	30.50	11.00
1 0	34.0	39.0	995.0	8.53	1.0	50.00	19.50	35.00	11.00
1 0	34 0	41.0	927.0	8.97	1 0	51 00	19.00	35.00	11.50
1 0	29.0	35.0	1176.0	8.83	1.0	40.00	22.50	29.00	10.50
1.0	28.0	34.0	1173.0	9.80	1.0	36 50	22.50	35.00	12.50
1 0	24.0	28.0	1069.0	6.97	1 0	38.50	12.00	29.50	11.00
1.0	33 0	38 0	1123.0	8.37	1 0	45.00	20.00	36.50	12.50
1.0	32.0	39.0	1012.0	9.47	2.0	47.00	23.00	39.00	10.00
2 0	34 0	41.0	1061 0	8.67	4.0	43.00	21 50	29.50	12.00
2.0	35.0	42.0	995.0	10.60	4 0	41.00	22.00	33.00	13.00
2 0	35.0	42.0	984.0	11 50	4 0	41 50	17.50	33.00	10.00
2 0	30.0	37 0	511.0	6 60	2 0	39.00	19.00	32.00	10.50
2 0	31.0	38 0	665 0	5.17	5 0	46 50	18 00	37.50	11.00
2 0	35 0	41.0	895.0	9.47	4.0	42.50	22.50	40.00	11.50
2.0	33 0	40 0	962.0	9.17	4.0	44 50	22.50	31 00	14.00
2.0	33.0	40.0	829 0	7.17	4.0	38.00	20 00	32 00	12.00
2.0	33.0	40.0	1099.0	6.83	4 0	35.00	18.00	31 50	11.00
2.0	33.0	40 0	789.0	7.47	4 0	46.50	19.00	31.00	10.00
3.0	34.0	40.0	815.0	5.43	1.0	38.00	17.50	28 50	11.00
3.0	33.0	40 0	982.0	6.63	1.0	42.00	16.00	35.00	11.00
3 0	34.0	41.0	1115.0	7.83	1 0	50.00	22 00	3.00	33.00
3.0	34 0	39 0	871.0	6.33	1 0	41 00	20.00	32.00	10.00
3 0	33.0	39.0	1030.0	6.20	1 0	42.00	18.00	35.00	11.00
3 0	31.0	38 0	620.0	7 60	3.0	30.00	21.50	32.00	10.00
3.0	32 0	39 0	768.0	7.43	1.0	43 50	14.50	41.00	10.00
3.0	32.0	38 0	661 0	6.90	1.0	42.50	19.50	33.00	11.00
3.0	31.0	36.0	685.0	5.93	1 0	46.00	19.00	29.00	10.00
4.0	32.0	39.0	823.0	7.23	4.0	31.50	18.00	30.00	12 00
4.0	35 0	42.0	606.0	7.03	4.0	31 00	17.00	38.00	14.00
4 0	35 0	41.0	1030.0	7.93	5.0	42.50	18.50	99.90	99.90
4 0	35.0	42 0	1056.0	7.00	4.0	42.00	19.00	35.50	10.50
4.0	33 0	39.0	514 0	5.43	4.0	45.00	18.00	30.00	11.00
4 0	36.0	42.0	760.0	6.73	5.0	35.50	18.00	33.00	10.50
4.0	33.0	39.0	1014.0	7.63	5.0	41.50	16 00	32.00	12.00
4.0	33.0	40.0	696.0	5.77	5.0	44.50	17.50	36.50	11.50
4.0	32.0	38 0	470.0	4.67	5.0	40.50	15.50	33.00	8.50
4.0	34.0	41 0	913 0	6.73	5.0	42.00	14.00	35.00	11.00
5 0	35.0	40.0	476.0	5.53	3.0	40.00	18.00	37.50	11.50
5 0	35 0	41.0	371 0	5 90	4.0	38.50	17.50	36.50	10.50
5.0	36 0	41.0	124 0	6.00	3.0	35.00	17.00	29.00	12.50
5 0	34 0	39.0	221.0	5.23	3.0	38.50	20.50	34.00	12.50
5.0	35.0	41.0	747.0	6.37	3.0	39.50	17.50	37.50	10.50
5 0	32.0	37.0	814.0	6.33	2.0	43.50	17.00	39.50	11.00
5.0	34 0	41.0	123.0	4.80	5.0	38.00	17.00	33.00	12.50

5.0	32.0	37 0	734.0	6.50	5.0	41 00	13.50	36.00	13.50
5 0	36.0	42.0	370 0	5 70	5.0	33 50	20 50	43.00	14 50
5 0	33.0	37 0	385.0	4.90	5.0	41 00	15 50	37 00	14 50
6.0	33 0	40 0	743.0	5.47	4.0	35.00	18.50	34.50	11.00
6 0	32 0	38 0	5.0	4.00	5.0	29 50	14.00	35 50	12 00
6 0	33 0	40 0	671.0	5.50	5.0	39 00	14 50	32 00	12.50
6 0	32.0	39 0	248.0	5.40	4.0	40.00	14.00	29 50	11.50
6 0	29.0	35 0	161 0	4.00	4.0	45.00	16 00	29 00	10.50
6.0	36 0	43 0	403.0	6.97	5.0	37 00	18.50	31 50	12.50
6.0	35.0	40.0	447 0	5 43	5.0	38.00	20.00	6 00	36.00
6.0	34 0	40 0	50 0	4.00	4.0	30.00	18.50	36 50	13.50
6 0	33 0	38 0	120.0	4.90	4.0	42.00	16.00	31.00	12.00
7 0	34.0	40.0	286 0	5.50	5 0	25.00	18.50	37.50	17.00
7 0	33.0	38 0	222.0	4.10	4.0	40.00	14.50	39.00	12.00
7.0	34 0	40 0	169 0	4.97	5.0	37.00	15.50	37.50	11.50
7 0	33.0	40 0	27.0	3.63	4.0	50.00	15.00	33.50	12.50
7.0	33 0	40 0	489.0	6.60	4.0	40.50	16 50	33.00	12.50
7 0	36.0	42.0	5.0	4.00	4.0	40 00	15.50	37.00	13.50
7.0	34 0	41.0	3.0	4.00	4.0	43 50	15 00	39.00	12.00
7.0	33 0	39 0	728 0	5.27	4 0	35.00	17 50	40 00	15.00
7 0	35 0	42 0	119 0	4.10	4 0	31 50	13.00	34.00	13.50
7.0	34.0	41 0	7.0	4.00	4.0	36 00	13 00	37 50	12.00
8 0	34 0	39 0	136.0	4.96	4 0	43.00	15.00	33.00	11.50
8.0	32.0	38 0	20.0	4.00	4.0	42 50	13.00	33.50	11.00
8.0	32.0	37.0	33 0	5.10	5.0	34 50	12 50	32 50	10 00
8 0	32.0	37.0	0.0	4.00	4.0	35.00	15.00	32.50	10.50
8.0	30 0	36.0	0 0	4.00	4.0	37.50	12.50	31.00	14.00
8 0	36.0	41 0	651.0	6.87	4.0	27.50	18.00	32.00	13.50
8.0	36 0	42 0	231.0	5.13	4.0	34.50	17.00	39.00	13.00
8.0	33.0	40.0	118.0	5.20	4.0	44.00	14 50	32.50	13.00
8.0	33.0	40.0	145.0	4.70	4.0	29.50	15.50	41.00	11.00
8.0	33.0	40 0	66.0	4.15	4.0	34.50	12.00	33.00	12.50
8.0	32.0	39.0	10.0	4.00	4.0	30.50	13.50	33.50	10.50
8.0	33.0	41.0	3.0	4.00	5.0	38.50	16.00	36.50	12.00
9 0	35.0	42.0	15 0	4.00	2.0	30.50	13.50	30.50	12.50
9.0	34.0	39.0	0.0	4.00	4.0	38.00	14.00	41.00	12.00
9.0	34.0	41.0	16.0	4.00	4.0	32.50	15.00	34.50	11.50
9 0	35 0	40 0	394 0	5.70	4 0	42.50	14.00	43.50	12.50
9.0	35 0	41 0	308.0	5.97	5.0	34 50	14.00	31.50	11.50
9.0	37 0	43.0	173.0	4.55	5.0	33.50	14.50	39.00	14.00
9.0	35 0	42.0	83.0	5 10	4 0	40.00	14.00	45.00	12.00
9.0	34 0	40.0	76.0	4.60	4.0	32.50	15.00	32.50	13.00
9 0	34.0	40.0	249.0	5.20	5.0	33.50	11.50	30.00	10.00
9.0	35.0	42 0	267 0	6.05	4.0	41.00	15.00	33.00	11 50
10	33.0	39 0	0.0	4.00	4.0	33.00	13.50	31 50	11.00
10.	33 0	40.0	12.0	4.00	5.0	41.00	13.00	32.50	9.50
10	31.0	36.0	6 0	4.00	4.0	30.50	15.00	27.00	13.00
10	29.0	33 0	3.0	4 00	5.0	36.00	12.50	32.00	10.00
10.	32.0	38 0	14.0	4.00	5.0	42.50	12.50	36.00	10.00
10	29.0	34.0	0.0	4.00	5.0	36.50	12.50	36.00	10.00
10	35 0	41 0	0 0	4 00	4.0	38.50	12.00	38 50	13.00
10.	34 0	40 0	279 0	4.73	4.0	37.50	13.00	44.00	12.00
10	31.0	37 0	0 0	4.00	5.0	34.00	12.50	31.50	13.00
10.	32.0	37 0	0.0	4.00	5.0	36.00	13.00	39.00	12.50
3.0	33.0	39.0	879.0	7.83	4.0	39.50	14.00	30.50	11.00
6.0	36.0	42.0	18.0	4.00	5.0	48.00	15.00	32.00	10.00

APPENDIX THREE

A summary of the changes in the female organs with age.

AGE = age from emergence (days)
HEAD = head width (mm. X40)
THORAX = thorax width (mm. X40)
FATNO = number of pupal fat bodies
MEAND = mean diameter of the pupal fat bodies (mm. X40)
OVARY = ovary stage (see Fig. 1)

AGE	HEAD	THORAX	FATNO	MEAND	OVARY
0.0	39.0	45.0	1165.0	12.40	1.0
0.0	38.0	42.0	1427.0	10.53	1.0
0.0	32.0	37.0	1208.0	10.43	1.0
0.0	32.0	39.0	1113.0	8.87	1.0
0.0	38.0	45.0	1388.0	11.80	2.0
0.0	34.0	40.0	770.0	9.40	1.0
0.0	37.0	42.0	730.0	9.63	1.0
0.0	35.0	41.0	1102.0	9.30	1.0
0.0	40.0	47.0	1345.0	9.93	1.0
0.0	37.0	43.0	1338.0	11.60	1.0
1.0	26.0	32.0	1393.0	10.53	1.0
1.0	37.0	42.0	1495.0	11.20	1.0
1.0	35.0	42.0	1668.0	9.30	1.0
1.0	37.0	43.0	1128.0	10.50	2.0
1.0	34.0	41.0	1312.0	9.47	2.0
1.0	32.0	38.0	1140.0	8.73	1.0
1.0	34.0	42.0	1176.0	10.10	2.0
1.0	36.0	45.0	1425.0	11.03	2.0
1.0	33.0	40.0	1541.0	10.13	2.0
2.0	32.0	40.0	951.0	7.63	2.0
2.0	37.0	44.0	986.0	9.77	3.0
2.0	32.0	38.0	985.0	6.40	3.0
2.0	30.0	38.0	902.0	5.40	2.0
2.0	28.0	33.0	1174.0	5.20	2.0
2.0	29.0	35.0	757.0	9.27	2.0
2.0	35.0	41.0	1371.0	9.00	3.0
2.0	36.0	42.0	1274.0	9.80	3.0
2.0	33.0	40.0	1061.0	8.73	2.0
2.0	33.0	40.0	823.0	6.10	3.0
3.0	38.0	44.0	1115.0	8.43	4.0
3.0	35.0	40.0	857.0	8.13	3.0
3.0	34.0	39.0	1078.0	9.03	3.0
3.0	31.0	37.0	902.0	7.40	2.0
3.0	37.0	44.0	763.0	9.57	5.0
3.0	36.0	42.0	496.0	8.23	5.0
3.0	34.0	40.0	1007.0	7.53	3.0
3.0	36.0	43.0	1126.0	9.17	3.0
3.0	34.0	40.0	926.0	8.43	3.0
3.0	36.0	41.0	974.0	9.03	3.0
4.0	33.0	40.0	305.0	7.20	5.0
4.0	34.0	41.0	1061.0	6.10	5.0
4.0	37.0	44.0	1016.0	6.67	5.0
4.0	35.0	44.0	482.0	5.97	5.0
4.0	35.0	42.0	558.0	5.77	5.0
4.0	30.0	37.0	603.0	5.67	3.0
4.0	29.0	36.0	687.0	6.00	3.0
4.0	35.0	43.0	700.0	8.47	4.0
4.0	33.0	40.0	1094.0	7.07	3.0
4.0	33.0	40.0	1061.0	8.17	5.0
5.0	36.0	44.0	868.0	6.50	3.0
5.0	38.0	47.0	701.0	7.93	7.0
5.0	34.0	41.0	298.0	6.83	4.0
5.0	35.0	42.0	125.0	9.40	5.0
5.0	35.0	43.0	510.0	5.62	6.0

5 0	35.0	42.0	476.0	8 37	5.0
5 0	32.0	39.0	0.0	4.00	3.0
5.0	28 0	35 0	97.0	4 95	7.0
5 0	36 0	42 0	410.0	7.23	6.0
5 0	34.0	41.0	555.0	6 13	6.0
6 0	35.0	42.0	524.0	6.27	8 0
6.0	35 0	42.0	172 0	5.00	7.0
6.0	35.0	42.0	432.0	5 17	5.0
6 0	34 0	40.0	237.0	5.43	7.0
6.0	35 0	42.0	29.0	4.00	8.0
6 0	38 0	44.0	437.0	5.00	6.0
6.0	36.0	45.0	542.0	5.67	6.0
6.0	37.0	44.0	71.0	4.90	6.0
6.0	30.0	37.0	0 0	4.00	6.0
6.0	34.0	40 0	283.0	5.30	6.0
7 0	34 0	40 0	0.0	4.00	6.0
7.0	35.0	42 0	0.0	4.00	7.0
7.0	35.0	42.0	64.0	4.00	5.0
7.0	37 0	44.0	304.0	5.87	6.0
7 0	32.0	37.0	0.0	4.00	6.0
7.0	36.0	44.0	385.0	5 10	6.0
7 0	34.0	40.0	148 0	4.95	6.0
7.0	32 0	40 0	38.0	4.00	8.0
7.0	32.0	39 0	50.0	4 40	5.0
7.0	32.0	39.0	4.0	4.00	7.0
8 0	40.0	35.0	40.0	4.00	7.0
8.0	45.0	37.0	45.0	4.00	7.0
8.0	43.0	36 0	450.0	4.00	6.0
8.0	42.0	37.0	513.0	5.63	6.0
8.0	40 0	33.0	5.0	4.00	7.0
8.0	41.0	35 0	133 0	4.55	5.0
8.0	39 0	33.0	2.0	4.00	7.0
8.0	36.0	31.0	13.0	4.00	6.0
8.0	39.0	32.0	2.0	4.00	6.0
8.0	38.0	32.0	0.0	4.00	6.0
8 0	33 0	27 0	0 0	4.00	6.0
9.0	35 0	43.0	140.0	4.00	6 0
9 0	34.0	41 0	479.0	5.57	6.0
9.0	35 0	43.0	6 0	4 00	8.0
9 0	34.0	40.0	0.0	4.00	8.0
9 0	35.0	41.0	0.0	4.00	8.0
9.0	35 0	41.0	14.0	4.00	5.0
9.0	35.0	41.0	38.0	4.00	7.0
9.0	36 0	43.0	76.0	4.50	7.0
9.0	37 0	44.0	392.0	4 70	6.0
10.0	34.0	40.0	22.0	4 00	6.0
10.0	34.0	40.0	74.0	4.30	7.0
10.0	36 0	43.0	80.0	4 90	8.0
10.0	33.0	40.0	0.0	4.00	7.0
10 0	35 0	42 0	21.0	4.00	8.0
10 0	33 0	38.0	0.0	4.00	6 0
10.0	29.0	34 0	0.0	4 00	6.0
10.0	34.0	40 0	301.0	5.37	7.0
10.0	33.0	40.0	0.0	4.00	6.0
10 0	32 0	39.0	2.0	4.00	7.0
10.0	33.0	39.0	6 0	4 00	8.0
10.0	33.0	39.0	0.0	4.00	8.0
10.0	33.0	39.0	0.0	4.00	6.0
10.0	33.0	40.0	57.0	4.00	8.0

APPENDIX FOUR

A summary of the changes in the male organs of flies from the Wellesbourne culture, used to verify the male aging technique developed from the measurements from Plymouth flies.

AGE = age from emergence (days)
HW = head width (mm X40)
TW = thorax width (mm X40)
FATNO = number of pupal fat bodies
MEAND = mean diameter of pupal dodies (mm X40)
C = testes colour (Table 4b)
TESTL = testes length (mm X40)
TESTW = testes width (mm X40)

AGE	HW	TW	FATNO	MEAND	C	TESTL	TESTW
0	38	45	929	12.53	1	48.0	31.5
0	38	45	1680	10.97	1	50.0	23.5
0	38	45	1320	10.4	1	48.5	22.0
0	42	48	1113	11 23	1	52 5	26.5
0	38	45	1190	11 03	1	47.0	20.5
0	38	46	1185	10.70	1	48.0	25 0
0	36	43	1089	10.77	1	50.0	21 5
0	35	41	712	11 30	1	*	*
0	35	43	922	10.77	1	51 0	26.0
1	37	46	1223	10.57	2	38.5	19.5
1	35	44	1124	8.83	2	40.5	20.0
1	35	42	1425	9.80	4	47 0	22.0
1	35	42	1259	8 87	4	42.5	20.0
1	34	42	685	10.60	4	48.0	18.5
1	37	44	1357	9.10	2	34.5	20 5
1	34	43	1098	8 43	2	35 0	20.5
1	33	39	745	8.20	4	43.5	19.5
1	35	41	1015	8.83	2	40 0	19.0
2	36	43	776	7.57	5	36 0	23.0
2	33	41	678	8.70	5	42.5	22.0
2	36	43	1047	8 73	5	43 0	23.0
2	37	45	497	11.17	5	34 0	20.0
2	35	43	794	10.30	4	48 5	19.0
2	31	*	537	8.80	5	37 0	17.0
2	36	*	836	7.20	5	42 5	23.0
3	35	41	847	6.87	5	41 5	16.0
3	35	42	1143	7.73	5	37.5	19.5
3	39	47	685	9 93	5	50.0	20.0
3	35	41	917	8 17	5	47.5	18 0
3	36	43	695	6.10	5	48.0	17.0
3	37	46	666	7.63	5	33 0	17.5
3	35	42	862	8 27	5	26.5	18 5
3	33	40	617	6 60	5	43 5	18.5
3	34	41	583	6.17	5	46 0	19.0
3	37	*	793	8.00	5	34 0	13.5
4	35	*	795	7.07	5	44 0	16.5
4	39	*	833	7 63	5	39 5	18 5
5	37	*	500	6 27	5	31.0	16.0
5	36	*	315	5.77	5	39.5	16.5
5	35	*	113	5 65	5	44 5	18.5
5	36	*	7	4.00	5	43 0	16.0
5	37	*	241	5.39	5	50.0	17 0
6	38	45	295	4 87	5	46.0	15.0
6	37	45	35	4 00	5	47 5	15.0
6	37	*	17	4 00	5	50.0	15.0
6	38	*	0	4 00	5	52 0	15.0
6	31	*	586	8 13	5	43.0	14.0
6	36	*	366	5 35	5	44 5	15 0
6	36	*	269	5.80	5	40.0	15.0
6	35	*	297	5.35	5	43 0	14 0
6	37	*	5	4 00	5	45 0	15.5
6	34	*	0	4.00	5	36.0	19.0
7	37	44	20	4 00	5	39.0	19 0
7	36	43	4	4 00	5	28 5	14.0

7	35	*	0	4.00	5	48 0	13.0
7	36	*	183	5.73	5	45.0	17.0
7	34	*	0	4 00	5	42.5	17 0
7	35	*	10	4 00	5	43.0	21.0
7	37	*	323	5 55	5	45 5	15 5
7	36	*	3	4 00	5	41 0	15.0
7	34	*	0	4.00	5	44 5	14.5

APPENDIX FIVE

A summary of the changes in age with time for male flies at a series of temperatures.

M1 = male age-group 1
M2 = male age-group 2
M3 = male age-group 3

TIME (DAYS)	MEAN AGE	M1	M2	M3
10.0 DEG C (A)				
0.0	1.000	10.0	0.0	0.0
3.0	1.000	10.0	0.0	0.0
6.0	1.100	9.0	1.0	0.0
9.0	1.625	3.0	5.0	0.0
12.0	1.818	4.0	18.0	0.0
15.0	2.000	2.0	8.0	2.0
18.0	2.643	0.0	5.0	9.0
21.0	2.882	0.0	2.0	15.0
10.0 DEG C (B)				
0.0	1.000	10.0	0.0	0.0
3.0	1.000	27.0	0.0	0.0
6.0	1.167	10.0	2.0	0.0
9.0	1.500	7.0	7.0	0.0
12.0	1.882	5.0	9.0	3.0
15.0	2.100	0.0	9.0	1.0
18.0	2.583	0.0	5.0	7.0
21.0	2.857	0.0	1.0	6.0
10.0 DEG C (C)				
0.0	1.000	10.0	0.0	0.0
2.0	1.000	15.0	0.0	0.0
4.0	1.042	23.0	1.0	0.0
6.0	1.250	9.0	3.0	0.0
8.0	1.500	7.0	7.0	0.0
10.0	1.500	1.0	1.0	0.0
12.0	1.870	4.0	18.0	1.0
14.0	2.231	0.0	10.0	3.0
16.0	2.133	0.0	13.0	2.0
18.0	2.375	0.0	5.0	3.0
20.0	2.000	0.0	3.0	0.0
12.5 DEG C (A)				
0.0	1.000	10.0	0.0	0.0
3.0	1.000	16.0	0.0	0.0
6.0	1.500	6.0	6.0	0.0
9.0	2.000	1.0	2.0	1.0
12.0	2.143	0.0	12.0	2.0
15.0	2.650	0.0	7.0	13.0
18.0	2.600	0.0	4.0	6.0
21.0	3.000	0.0	0.0	9.0
12.5 DEG C (B)				
0.0	1.000	10.0	0.0	0.0
3.0	1.083	11.0	1.0	0.0
6.0	1.300	7.0	3.0	0.0
9.0	1.850	5.0	13.0	2.0
12.0	2.500	1.0	5.0	8.0
15.0	2.545	0.0	5.0	6.0
18.0	2.571	0.0	6.0	8.0
21.0	3.000	0.0	0.0	10.0

12.5 DEG C (C)

0.0	1.000	10.0	0.0	0.0
3.0	1.000	15.0	0.0	0.0
6.0	1.188	13.0	3.0	0.0
9.0	1.625	3.0	5.0	0.0
12.0	1.952	3.0	16.0	2.0
15.0	2.667	0.0	4.0	8.0
18.0	2.750	0.0	4.0	12.0
21.0	2.950	0.0	1.0	19.0

15.0 DEG C (A)

0.0	1.000	10.0	0.0	0.0
2.0	1.000	5.0	0.0	0.0
4.0	1.400	6.0	4.0	0.0
6.0	1.444	5.0	4.0	0.0
8.0	1.600	4.0	6.0	0.0
10.0	2.333	0.0	4.0	2.0
12.0	2.533	0.0	7.0	8.0

15.0 DEG C (B)

0.0	1.000	10.0	0.0	0.0
2.0	1.000	18.0	0.0	0.0
4.0	1.118	15.0	2.0	0.0
6.0	1.600	6.0	9.0	0.0
8.0	2.043	1.0	20.0	2.0
10.0	2.444	0.0	10.0	8.0
12.0	2.533	0.0	7.0	8.0

15.0 DEG C (C)

0.0	1.000	10.0	0.0	0.0
2.0	1.000	18.0	0.0	0.0
4.0	1.200	16.0	4.0	0.0
6.0	1.813	5.0	9.0	2.0
8.0	1.833	2.0	3.0	1.0
10.0	2.167	0.0	15.0	3.0
12.0	2.357	0.0	9.0	5.0

17.5 DEG C (A)

0.0	1.000	10.0	0.0	0.0
1.0	1.000	12.0	0.0	0.0
2.0	1.057	14.0	1.0	0.0
3.0	1.231	10.0	3.0	0.0
4.0	1.250	6.0	2.0	0.0
5.0	1.923	1.0	12.0	0.0
6.0	1.727	5.0	4.0	2.0
7.0	2.462	0.0	7.0	6.0
8.0	2.778	0.0	2.0	7.0

17.5 DEG C (B)

0.0	1.000	10.0	0.0	0.0
1.0	1.000	14.0	0.0	0.0
2.0	1.000	20.0	0.0	0.0
3.0	1.222	14.0	4.0	0.0
4.0	1.533	8.0	6.0	1.0
5.0	2.125	0.0	7.0	1.0
5.0	2.500	0.0	1.0	1.0
7.0	2.636	0.0	4.0	7.0
8.0	2.615	0.0	5.0	8.0

17.5 DEG C (C)

0.0	1.000	10.0	0.0	0.0
1.0	1.000	13.0	0.0	0.0
2.0	1.000	7.0	0.0	0.0
3.0	1.250	9.0	3.0	0.0
4.0	1.688	5.0	11.0	0.0
5.0	1.923	1.0	12.0	0.0
6.0	2.125	0.0	7.0	1.0
7.0	2.357	0.0	9.0	5.0
8.0	2.400	0.0	9.0	6.0

20.0 DEG C (A)

0.0	1.000	10.0	0.0	0.0
1.0	1.000	10.0	0.0	0.0
2.0	1.000	9.0	0.0	0.0
3.0	1.000	14.0	0.0	0.0
4.0	1.217	18.0	5.0	0.0
5.0	1.720	7.0	18.0	0.0
6.0	2.500	0.0	3.0	3.0
7.0	2.444	0.0	5.0	4.0
8.0	2.833	0.0	1.0	5.0
9.0	2.778	0.0	2.0	7.0

20.0 DEG C (B)

0.0	1.000	10.0	0.0	0.0
1.0	1.000	10.0	0.0	0.0
2.0	1.000	7.0	0.0	0.0
3.0	1.000	10.0	0.0	0.0
4.0	1.000	2.0	0.0	0.0
5.0	1.800	1.0	4.0	0.0
6.0	2.600	0.0	4.0	6.0
7.0	2.778	0.0	2.0	7.0
9.0	3.000	0.0	0.0	5.0

20.0 DEG C (C)

0.0	1.000	10.0	0.0	0.0
1.0	1.000	9.0	0.0	0.0
2.0	1.000	2.0	0.0	0.0
3.0	1.217	18.0	5.0	0.0
4.0	1.720	7.0	18.0	0.0
5.0	2.438	0.0	9.0	7.0
6.0	2.375	0.0	5.0	3.0
7.0	2.833	0.0	1.0	5.0
8.0	3.000	0.0	0.0	8.0

25.0 DEG C (A)

0.0	1.000	9.0	0.0	0.0
1.0	1.000	9.0	0.0	0.0
2.0	1.000	10.0	0.0	0.0
3.0	1.000	9.0	0.0	0.0
4.0	1.250	6.0	2.0	0.0
5.0	2.333	0.0	8.0	4.0
6.0	2.471	0.0	9.0	8.0
7.0	2.500	0.0	6.0	6.0

25.0 DEG C (B)

0.0	1.000	10.0	0.0	0.0
1.0	1.077	12.0	1.0	0.0
2.0	1.773	5.0	17.0	0.0
3.0	2.000	1.0	10.0	1.0
4.0	2.158	2.0	12.0	5.0
5.0	2.333	0.0	8.0	4.0
6.0	2.444	0.0	5.0	4.0
7.0	2.545	0.0	5.0	6.0

25.0 DEG C (C)

0.0	1.000	10.0	0.0	0.0
1.0	1.000	9.0	0.0	0.0
2.0	1.250	21.0	7.0	0.0
3.0	1.909	1.0	10.0	0.0
4.0	2.000	1.0	10.0	1.0
5.0	2.111	1.0	6.0	2.0
6.0	2.500	0.0	2.0	2.0
7.0	2.875	0.0	1.0	7.0
8.0	2.818	0.0	2.0	9.0

30.0 DEG C (A)

0.0	1.000	10.0	0.0	0.0
1.0	1.000	15.0	0.0	0.0
2.0	1.000	16.0	0.0	0.0
3.0	1.200	4.0	1.0	0.0
4.0	1.941	5.0	8.0	4.0
5.0	2.231	0.0	10.0	3.0
6.0	2.667	0.0	3.0	6.0
7.0	2.000	0.0	1.0	0.0

30.0 DEG C (B)

0.0	1.000	10.0	0.0	0.0
1.0	1.167	10.0	2.0	0.0
2.0	1.563	7.0	9.0	0.0
3.0	1.800	1.0	4.0	0.0
4.0	2.500	0.0	1.0	1.0
5.0	2.333	0.0	6.0	3.0
6.0	2.500	0.0	3.0	3.0
7.0	2.857	0.0	1.0	6.0

APPENDIX SIX

A summary of the change in female age with time at a series of temperatures.

F1 = female age-group 1

etc.

TIME (DAYS)	MEAN AGE	AGE-GROUP F1	F2	F3	F4	F5	F6
10 0 DEG C (A)							
0 0	2.000	10	0	0	0	0	0
3 0	2 167	10	2	0	0	0	0
6 0	3.200	4	12	4	0	0	0
9 0	3 625	2	7	15	0	0	0
12.0	5 125	0	0	6	1	1	0
15 0	5 167	0	0	2	3	1	0
18 0	5 533	0	0	0	6	8	0
21 0	6 875	0	0	0	0	1	7
10 0 DEG C (B)							
0.0	2.000	10	0	0	0	0	0
3.0	2 100	18	2	0	0	0	0
6.0	3 111	5	11	2	0	0	0
9 0	3 333	4	4	4	0	0	0
12.0	5 111	0	1	6	1	1	0
15 0	6.625	0	0	0	1	2	5
18 0	6 692	0	0	0	0	4	9
21 0	6 800	0	0	0	0	1	4
10 0 DEG C (C)							
0 0	2.000	10	0	0	0	0	0
2.0	2 000	15	0	0	0	0	0
4.0	2 316	13	6	0	0	0	0
6 0	3 200	4	12	4	0	0	0
10 0	4.000	0	0	4	0	0	0
12 0	5.125	0	0	6	1	1	0
14.0	5 333	0	0	5	2	4	0
16 0	5 467	0	0	7	1	7	0
18 0	6 714	0	0	0	0	2	5
20 0	6 833	0	0	0	0	1	5
12 5 DEG C (A)							
0 0	2 000	10	0	0	0	0	0
3.0	3.167	7	9	2	0	0	0
6.0	3.737	0	5	14	0	0	0
9 0	4 125	0	1	13	2	0	0
12 0	5 100	0	0	5	4	1	0
15 0	5.467	0	0	4	4	7	0
18 0	6 706	0	0	0	0	5	12
21 0	6.875	0	0	0	0	1	7
12 5 DEG C (B)							
0 0	2.000	10	0	0	0	0	0
3 0	2 500	9	9	0	0	0	0
6 0	3.600	0	2	3	0	0	0
9.0	4 278	0	1	12	5	0	0
12 0	5 409	0	0	7	6	9	0
15 0	6 333	0	0	1	1	8	4
18.0	6.706	0	0	0	0	5	12
21 0	6 944	0	0	0	0	1	17

12.5 DEG C (C)

0.0	2.000	10	0	0	0	0	0
3.0	2.500	9	9	0	0	0	0
6.0	3.727	1	2	8	0	0	0
9.0	5.333	0	1	3	2	3	0
12.0	5.917	0	0	1	0	11	0
15.0	6.200	0	0	1	1	6	2
18.0	6.250	0	0	0	0	3	1
21.0	6.875	0	0	0	0	1	7

15.0 DEG C (A)

0.0	2.000	10	0	0	0	0	0
2.0	2.409	13	9	0	0	0	0
4.0	3.500	0	5	5	0	0	0
6.0	4.143	0	4	8	2	0	0
8.0	5.200	0	0	4	4	2	0
10.0	6.133	0	0	0	2	9	5
12.0	6.563	0	0	0	0	5	9

15.0 DEG C (B)

0.0	2.000	10	0	0	0	0	0
2.0	2.409	13	9	0	0	0	0
4.0	3.500	0	3	3	0	0	0
6.0	5.071	0	1	9	3	1	0
8.0	5.333	0	0	4	4	4	0
10.0	6.400	0	0	0	0	6	4
12.0	6.800	0	0	0	0	2	8

15.0 DEG C (C)

0.0	2.000	10	0	0	0	0	0
2.0	2.077	12	1	0	0	0	0
4.0	3.533	2	5	8	0	0	0
6.0	5.167	0	3	11	1	3	0
8.0	5.800	0	0	0	2	8	0
10.0	6.083	0	0	0	1	11	1
12.0	6.571	0	0	0	0	6	8

17.5 DEG C (A)

0.0	2.000	10	0	0	0	0	0
1.0	2.059	17	1	0	0	0	0
2.0	2.167	15	3	0	0	0	0
3.0	3.200	6	6	3	0	0	0
4.0	3.500	0	11	11	0	0	0
5.0	5.385	0	1	6	1	5	0
6.0	5.333	0	0	9	1	5	0
7.0	6.083	0	0	2	3	6	1
8.0	6.385	0	0	0	0	16	10

17.5 DEG C (B)

0.0	2.000	10	0	0	0	0	0
1.0	2.000	14	4	0	0	0	0
2.0	2.154	22	13	6	0	0	0
3.0	3.261	4	3	7	0	0	0
4.0	3.700	0	0	6	2	5	0
5.0	5.385	0	0	9	1	5	0
6.0	5.333	0	0	4	1	14	3
7.0	6.136	0	0	0	0	6	5
8.0	6.455	0	0	0	0	0	0

17.5 DEG C (C)

0.0	2.000	10	0	0	0	0	0
1.0	2.000	17	0	0	0	0	0
2.0	2.143	12	2	0	0	0	0
3.0	3.125	4	10	2	0	0	0
4.0	3.375	0	5	3	0	0	0
5.0	5.385	0	0	6	2	5	0
6.0	5.333	0	0	9	1	5	0
7.0	6.333	0	0	1	1	6	4
8.0	6.571	0	0	0	0	3	4

20.0 DEG C (A)

0.0	2.000	17	0	0	0	0	0
1.0	3.077	13	9	1	0	0	0
2.0	3.700	0	6	14	0	0	0
3.0	5.136	0	0	11	8	3	0
4.0	6.188	0	0	0	1	12	3
5.0	6.700	0	0	0	0	3	7
6.0	6.500	0	0	0	0	2	2
7.0	7.000	0	0	0	0	0	5
8.0	7.000	0	0	0	0	0	4

20.0 DEG C (B)

0.0	2.000	10	0	0	0	0	0
1.0	2.294	12	5	0	0	0	0
2.0	3.571	2	4	8	0	0	0
3.0	5.063	0	2	13	0	1	0
4.0	5.526	0	0	5	4	10	0
5.0	6.056	0	0	0	0	17	1
6.0	6.118	0	0	0	0	17	2
7.0	6.391	0	0	0	0	14	9
8.0	6.538	0	0	0	0	6	7
9.0	7.000	0	0	0	0	0	13
10.0	7.000	0	0	0	0	0	11

20.0 DEG C (C)

0.0	2.000	10	0	0	0	0	0
1.0	2.467	8	7	0	0	0	0
2.0	3.571	2	4	8	0	0	0
3.0	4.111	0	1	7	1	0	0
4.0	5.136	0	0	11	8	3	0
5.0	5.444	0	0	2	1	2	4
6.0	6.105	0	0	0	0	17	2
7.0	6.800	0	0	0	0	1	5
8.0	7.000	0	0	0	0	0	13
9.0	7.000	0	0	0	0	0	6

25.0 DEG C (A)

0.0	2.000	10	0	0	0	0	0
1.0	3.360	5	11	9	0	0	0
2.0	4.154	0	3	8	2	0	0
3.0	6.250	0	0	1	0	3	1
4.0	6.313	0	0	1	0	16	5
5.0	6.538	0	0	0	0	6	7
6.0	6.571	0	0	0	0	3	4
7.0	6.538	0	0	0	0	6	7

25.0 DEG C (B)

0.0	2.000	10	0	0	0	0	0
1.0	3.222	2	5	2	0	0	0
2.0	3.667	0	2	4	0	0	0
3.0	6.150	0	3	9	1	6	1
4.0	6.200	0	0	1	1	1	2
5.0	6.538	0	0	0	0	6	7
6.0	6.850	0	0	0	0	3	17
7.0	6.800	0	0	0	0	2	8

25.0 DEG C (C)

0.0	2.000	10	0	0	0	0	0
1.0	3.056	6	11	1	0	0	0
2.0	3.286	3	7	4	0	0	0
3.0	5.143	0	1	4	1	1	0
4.0	5.400	0	0	1	1	1	2
5.0	6.800	0	0	1	0	1	8
6.0	6.882	0	0	0	0	2	15
7.0	7.000	0	0	0	0	0	4
8.0	7.000	0	0	0	0	0	7

30.0 DEG C (A)

0.0	2.000	10	0	0	0	0	0
1.0	3.363	3	4	4	0	0	0
2.0	3.400	0	6	4	0	0	0
3.0	5.333	0	2	5	1	4	0
4.0	6.300	0	0	4	0	3	3
5.0	7.000	0	0	0	0	0	13
6.0	7.000	0	0	0	0	0	5
7.0	7.000	0	0	0	0	0	6

30.0 DEG C (B)

0.0	2.000	10	0	0	0	0	0
1.0	2.429	4	3	0	0	0	0
2.0	4.000	0	0	3	0	0	0
3.0	5.333	0	1	2	1	2	0
4.0	6.667	0	0	0	0	2	4
5.0	6.900	0	0	0	0	1	9
6.0	7.000	0	0	0	0	0	2
7.0	7.000	0	0	0	0	0	4

APPENDIX SEVEN

A summary of the number of flies caught at the different sample sites.

TIME = sample time (weeks)
DIST = distance from the emergence site (m)
F1+3 = female age-groups 1-3
F5 = female age-group 5
F6 = female age-group 6
FT = female total
M1 = male age-group 1
M2 = male age-group 2
M3 = male age-group 3
MT = male total

N.B. Missing values are given as 999.0

VENN 1980B

TIME	DIST	F1+3	F5	F6	FT	M1	M2	M3	MT
10 0	0.0	9.0	34.0	21.0	64.0	10.0	20.0	4.0	34.0
10.0	20 0	7.0	9.0	6.0	22 0	7.0	9 0	1.0	17.0
10 0	40 0	3.0	10.0	6.0	19.0	5.3	12.7	1.1	19.0
10.0	60 0	16.0	18.0	10.0	44 0	29.0	35.0	10.0	74.0
10 0	80 0	9.0	15.0	10.0	34.0	19.0	45.0	4.0	68.0
10 0	100.0	3.0	29.0	5.0	37.0	25.0	35.0	18.0	78.0
10.0	120.0	0.0	17.0	49.0	66.0	91.3	199.7	0.0	291.0
10 0	140.0	12.0	50.0	6.0	68.0	40.0	35.0	4.0	80.0
10 0	160.0	1.0	48.0	19.0	68 0	1.8	11.1	11.1	24.0
10.0	180.0	9.0	28.0	2.0	39.0	999.0	999 0	999.0	98.0
10 0	200 0	3.0	18.0	1.0	22.0	12.0	52.0	1.0	65.0
10 0	220 0	0.0	5.0	1.0	6.0	8.0	5.0	8.0	21.0
10.0	230.0	4 0	4.0	1.0	9 0	4.0	4.0	0.0	8.0
10.0	240 0	1.0	3.0	1.0	5.0	9.0	7.0	3.0	19.0
10 0	250.0	0 0	7.0	0.0	7.0	2.0	4.0	1.0	7.0
10 0	260.0	1.0	2.0	1.0	4.0	3 0	8.0	3.0	14.0
10.0	270.0	1.0	4.0	0.0	5.0	6.0	9.0	1.0	16.0
10.0	280 0	999 0	999 0	999.0	999 0	999.0	999.0	999.0	999.0
10.0	290.0	1.0	5.0	0 0	6.0	6.0	9.0	1.0	16.0
10 0	300 0	0.0	4.0	0.0	4.0	3.0	14.0	3.0	19.0
10 0	310 0	0.0	1.0	0.0	1.0	0.0	8 0	0.0	8.0
10.0	320.0	1.0	11.0	1 0	13.0	3.0	7.0	1.0	11.0
10 0	330.0	1.0	1.0	0.0	2.0	2.0	4.0	0.0	6.0
10.0	340.0	0.0	3 0	0.0	3.0	2.0	6.0	4.0	12.0
10 0	350 0	0.0	2.0	0.0	2.0	1.0	10.0	0.0	11.0
10 0	360.0	0.0	8.0	0.0	8.0	1 0	2.0	3.0	6.0
10.0	370.0	0.0	5.0	1.0	6.0	999.0	999.0	999.0	9.0
10.0	380 0	999 0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
10 0	390 0	0.0	4.0	1.0	5.0	1.0	3.0	2.0	6.0
11.0	0.0	4 0	18 0	25.0	47.0	0.0	15.0	7.0	22.0
11.0	20.0	4.0	9.0	20.0	33.0	15 0	9.0	6.0	30.0
11.0	40 0	5 0	11.0	15.0	31.0	1.0	17.5	16.5	35.0
11.0	60.0	2.2	10 8	27.0	40.0	9.0	22.0	22.0	53.0
11.0	80 0	999.0	999.0	999.0	35 0	999.0	999.0	999.0	58.0
11.0	100.0	4.0	22.0	39.0	65.0	8.0	39.0	26.0	73.0
11 0	120 0	5.0	9.9	16.1	31.0	5.4	112.6	118.0	236.0
11.0	140.0	10.0	53.0	71.0	134 0	20.0	77.0	86.0	183.0
11 0	160.0	7.0	45.0	79.0	131.0	24.0	56.0	40.0	120.0
11.0	180.0	9.0	46.0	53.0	108.0	43.5	69.9	48.6	162.0
11 0	200 0	1.0	11.0	5.0	17.0	1.0	51.0	28.0	80.0
11 0	220 0	0.0	7.0	6.0	13.0	3.1	10.5	9.4	23.0
11.0	230.0	2.0	2.0	6.0	10.0	3.0	9.0	9.0	21.0
11.0	240.0	0.0	5.0	2.0	7.0	2.0	18.0	7.0	27.0
11.0	250 0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
11 0	260 0	2.0	4.0	4.0	10.0	2.0	14.0	5.0	21.0
11 0	270 0	0 0	3.0	7 0	10.0	0·0	9.0	15 0	24.0
11 0	280 0	0 0	5.0	5.0	10 0	5.2	12 4	13.4	31.0
11 0	290 0	0 0	6 0	5.0	11.0	4 0	5.0	7 0	16.0
11 0	300 0	1.0	5 0	1 0	7 0	0.0	10 0	14.0	24.0

11.0	310.0	0.0	1.0	0.0	1.0	2.0	5.0	8.0	15.0
11.0	320.0	0.0	3.0	3.0	6.0	1.0	6.0	6.0	13.0
11.0	330.0	0.0	1.0	3.0	4.0	0.0	5.0	10.0	15.0
11.0	340.0	0.0	4.0	3.0	7.0	0.0	14.0	7.0	21.0
11.0	350.0	0.0	1.0	2.0	3.0	0.0	2.0	10.0	12.0
11.0	360.0	0.0	4.0	2.0	6.0	1.0	3.0	5.0	9.0
11.0	370.0	0.0	6.0	5.0	11.0	0.0	7.0	8.0	15.0
11.0	380.0	1.0	0.0	0.0	1.0	0.0	2.0	2.0	4.0
11.0	390.0	0.0	4.0	1.0	5.0	0.0	1.0	4.0	5.0
12.0	0.0	0.0	1.0	1.0	2.0	0.0	1.0	0.0	1.0
12.0	20.0	3.0	21.0	14.0	38.0	4.0	26.0	7.0	37.0
12.0	40.0	0.0	9.4	16.6	26.0	0.0	12.8	15.2	28.0
12.0	60.0	6.4	10.6	16.0	33.0	4.2	25.2	12.6	42.0
12.0	80.0	4.0	12.0	30.0	46.0	4.8	31.4	21.8	58.0
12.0	100.0	2.0	19.3	37.6	59.0	2.2	31.4	40.4	74.0
12.0	120.0	0.0	16.8	11.2	28.0	0.0	48.4	44.6	93.0
12.0	140.0	0.0	36.5	36.5	73.0	3.7	47.0	43.3	94.0
12.0	160.0	5.0	57.4	75.5	138.0	19.0	84.0	28.0	131.0
12.0	180.0	7.0	41.0	93.0	141.0	25.2	68.6	16.1	110.0
12.0	200.0	3.0	23.0	23.0	49.0	18.0	57.0	20.0	95.0
12.0	220.0	1.0	13.0	13.0	23.0	2.0	9.0	5.0	16.0
12.0	230.0	2.0	5.0	11.0	18.0	2.0	11.0	6.0	19.0
12.0	240.0	0.0	5.0	6.0	11.0	4.0	10.0	4.0	18.0
12.0	250.0	3.0	3.0	18.0	24.0	8.0	11.0	2.0	21.0
12.0	260.0	0.0	4.0	8.0	12.0	5.0	14.0	5.0	24.0
12.0	270.0	0.0	8.0	8.0	16.0	2.0	18.0	14.0	34.0
12.0	280.0	3.0	7.0	3.0	13.0	3.0	16.0	7.0	26.0
12.0	290.0	0.0	5.0	11.0	16.0	4.0	25.0	3.0	32.0
12.0	300.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
12.0	310.0	0.0	1.0	1.0	2.0	0.0	2.0	3.0	5.0
12.0	320.0	2.0	5.0	5.0	12.0	1.0	15.0	6.0	22.0
12.0	330.0	1.0	1.0	3.0	5.0	0.0	2.0	9.0	11.0
12.0	340.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
12.0	350.0	1.0	3.0	6.0	10.0	0.0	9.3	4.7	14.0
12.0	360.0	0.0	2.0	1.0	3.0	0.0	0.0	0.0	0.0
12.0	370.0	0.0	1.0	3.0	4.0	1.0	5.0	4.0	10.0
12.0	380.0	0.0	1.0	6.0	7.0	0.0	2.6	10.4	13.0
12.0	390.0	1.0	9.0	4.0	14.0	0.0	3.0	3.0	6.0
13.0	0.0	0.0	12.3	15.7	28.0	2.7	6.8	5.5	15.0
13.0	20.0	1.0	7.3	19.7	28.0	2.3	9.0	14.7	26.0
13.0	40.0	0.0	5.9	14.1	20.0	0.0	11.5	13.5	25.0
13.0	60.0	1.1	12.0	37.0	50.0	1.3	19.6	26.1	47.0
13.0	80.0	0.0	11.3	23.7	35.0	0.0	20.6	43.4	64.0
13.0	100.0	3.2	17.1	26.7	47.0	2.4	26.3	26.3	55.0
13.0	120.0	2.8	9.8	15.4	28.0	5.1	49.6	34.2	89.0
13.0	140.0	1.1	22.4	38.5	62.0	5.7	30.5	22.8	59.0
13.0	160.0	1.0	24.0	96.0	121.0	1.0	30.8	45.2	77.0
13.0	180.0	0.0	21.3	40.7	62.0	6.0	12.0	17.0	35.0
13.0	200.0	1.0	20.0	26.0	47.0	0.0	9.5	26.5	36.0
13.0	220.0	1.0	3.0	7.0	11.0	0.0	5.0	5.0	10.0

13.0	230.0	1.0	15.0	17.0	33.0	1.0	14.0	15.0	30.0
13.0	240.0	2.1	5.2	25.8	33.0	0.0	13.7	6.3	20.0
13.0	250.0	2.1	6.2	21.7	30.0	0.0	9.0	13.0	22.0
13.0	260.0	1.0	6.0	7.0	14.0	1.0	15.0	8.0	24.0
13.0	270.0	0.0	5.0	19.0	24.0	0.0	12.6	8.4	21.0
13.0	280.0	0.0	2.0	11.0	13.0	0.0	6.4	9.6	16.0
13.0	290.0	1.0	1.0	6.0	8.0	1.1	9.1	5.7	16.0
13.0	300.0	0.0	4.0	8.0	12.0	1.1	7.4	9.5	18.0
13.0	310.0	1.0	3.0	9.0	13.0	1.1	7.4	8.5	17.0
13.0	320.0	0.0	2.0	7.0	9.0	1.0	10.4	15.6	27.0
13.0	330.0	0.0	2.0	1.0	3.0	0.0	5.0	5.0	10.0
13.0	340.0	1.0	3.0	0.0	4.0	1.0	6.0	5.0	12.0
13.0	350.0	0.0	3.0	4.0	7.0	1.5	5.8	8.7	16.0
13.0	360.0	1.0	5.0	9.0	15.0	2.0	16.0	8.0	26.0
13.0	370.0	1.0	2.0	9.0	12.0	0.0	4.3	10.7	15.0
13.0	380.0	0.0	4.0	5.0	9.0	1.5	3.0	7.5	12.0
13.0	390.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
14.0	0.0	0.0	5.0	9.0	14.0	11.0	70.0	31.0	112.0
14.0	20.0	0.0	4.3	21.7	26.0	0.0	1.6	9.4	11.0
14.0	40.0	0.0	2.3	4.7	7.0	0.0	1.3	8.8	10.0
14.0	60.0	0.0	3.0	17.0	20.0	0.0	3.6	28.4	32.0
14.0	80.0	0.0	2.4	14.6	17.0	0.0	7.8	23.3	31.0
14.0	100.0	0.0	1.0	13.0	14.0	0.0	4.4	32.6	37.0
14.0	120.0	0.0	3.4	13.6	17.0	0.0	35.0	42.0	77.0
14.0	140.0	0.0	20.2	25.8	46.0	0.0	14.1	35.9	50.0
14.0	160.0	1.0	24.6	50.3	76.0	0.0	11.1	20.9	32.0
14.0	180.0	0.0	13.4	24.6	38.0	1.2	5.8	22.0	29.0
14.0	200.0	0.0	7.3	17.7	25.0	0.0	7.3	15.7	23.0
14.0	220.0	0.0	5.0	19.0	24.0	0.0	3.1	19.9	23.0
14.0	230.0	0.0	8.0	16.0	24.0	0.0	2.3	14.7	17.0
14.0	240.0	0.0	1.1	12.9	14.0	0.0	2.9	20.1	23.0
14.0	250.0	0.0	8.3	24.8	33.0	0.0	4.2	19.8	24.0
14.0	260.0	0.0	6.3	15.7	22.0	0.0	10.1	17.9	28.0
14.0	270.0	0.0	5.0	5.0	10.0	0.0	2.2	20.8	23.0
14.0	280.0	0.0	2.0	7.0	9.0	0.0	0.0	1.0	1.0
14.0	290.0	0.0	0.0	11.0	11.0	0.0	0.0	10.0	10.0
14.0	300.0	0.0	3.0	13.0	16.0	0.0	3.4	19.5	23.0
14.0	310.0	0.0	5.0	14.0	19.0	0.0	4.3	20.7	25.0
14.0	320.0	0.0	2.0	18.0	20.0	0.0	1.9	33.1	35.0
14.0	330.0	0.0	7.0	5.0	12.0	0.0	3.2	12.8	16.0
14.0	340.0	0.0	0.0	0.0	0.0	0.0	0.0	6.0	6.0
14.0	350.0	0.0	1.3	2.7	4.0	0.0	0.0	3.0	3.0
14.0	360.0	0.0	2.0	2.0	4.0	0.0	0.0	10.0	10.0
14.0	370.0	0.0	2.3	4.7	7.0	0.0	3.8	11.3	15.0
14.0	380.0	0.0	1.0	10.0	11.0	0.0	1.6	6.4	8.0
14.0	390.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
15.0	0.0	0.0	1.1	10.9	12.0	1.3	0.0	10.7	12.0
15.0	20.0	0.0	0.0	2.0	2.0	0.0	1.6	6.4	8.0
15.0	40.0	0.0	3.0	14.0	17.0	1.2	9.7	6.1	17.0
15.0	60.0	0.0	0.0	13.0	13.0	2.5	4.9	8.6	16.0

15	0	80 0	0 0	2.1	16.9	19.0	0.0	12 3	28.7	41.0
15	0	100.0	1.2	8.3	23.6	33 0	3.9	24 9	34 1	63.0
15	0	120.0	5.8	11 5	12.7	30.0	3 0	29 0	29.0	61.0
15	0	140 0	1.0	4 0	14.0	19 0	3 0	24 3	16 7	44.0
15	0	160 0	4.0	10 0	26 0	40.0	1 4	2 9	8 7	13.0
15	0	180.0	2.0	10.0	20.0	32.0	1 3	2.6	5 1	9.0
15	0	200 0	1.0	3.1	20.8	25.0	0.0	1.0	2.0	3.0
15	0	220 0	0.0	0.0	4 0	4.0	0.0	0.0	0.0	0.0
15	0	230.0	0.0	1.3	7 7	9 0	0 0	2 3	6.8	9.0
15	0	240 0	0.0	3.0	4 0	7.0	2 0	4.0	5.0	11 0
15	0	250 0	0 0	2.0	6 0	8.0	0 0	3.8	1.3	5.0
15	0	260 0	0.0	3.0	4.0	7.0	0 0	4.4	7.6	12.0
15	0	270 0	0.0	3.0	6.0	9.0	0.0	3.0	7.0	10.0
15	0	280 0	0.0	3.0	6.0	9 0	1 8	1.8	3.5	7.0
15	0	290.0	0.0	3.8	1.3	5.0	0 0	2.3	4.7	7.0
15	0	300.0	0 0	0.0	5.0	5.0	0.0	1 7	10.3	12.0
15	0	310 0	0 0	6.0	5.0	11.0	0 0	4.7	2.3	7 0
15	0	320.0	0.0	1 0	10 0	11 0	0.0	7.8	2.2	10.0
15	0	330.0	0 0	1.0	1.0	2.0	0.0	1 5	1.5	3.0
15	0	340 0	0.0	1.0	0 0	1 0	0 0	3.0	1.0	4.0
15	0	350 0	0.0	2.0	0 0	2.0	0 0	3.0	3.0	6.0
15	0	360.0	0 0	2.0	2.0	4.0	0 0	4.4	5.6	10.0
15	0	370 0	0.0	0.0	1.0	1 0	0 0	1 5	1.5	3 0
15	0	380.0	0.0	2.0	3.0	5.0	0 0	0.0	0.0	1.0
15	0	390 0	999.0	999 0	999.0	999.0	999 0	999.0	999 0	999.0
16	0	0.0	0.0	1.0	1.0	2.0	0.0	1.0	0.0	1.0
16	0	20.0	1.0	1.0	3.0	5.0	0 0	1.0	0.0	1.0
16	0	40 0	0.0	0.0	4 0	4.0	0.0	0.0	0.0	0.0
16	0	60 0	0.0	2.0	2.0	4.0	0 0	2.4	8 6	11.0
16	0	80 0	0.0	2.0	6.0	8.0	0 0	6.0	2 0	8.0
16	0	100.0	0.0	3.0	8.0	11 0	0.0	13.3	17.7	31.0
16	0	120 0	0.0	5.0	14.0	19.0	4.3	14.0	11.8	29.0
16	0	140 0	1.0	3.0	15.0	19.0	0.0	2.0	5.0	7.0
16	0	160 0	0.0	2 0	21 0	23 0	1.0	2.0	1.0	4.0
16	0	180 0	0.0	1.0	16.0	17.0	0.0	3.0	5.0	8.0
16	0	200.0	0.0	2.0	8.0	10 0	0.0	0.0	2.0	2.0
16	0	220 0	0.0	2.0	6.0	8.0	1.3	2.7	0.0	4 0
16	0	230 0	1 0	1.0	3.0	5.0	1.1	2 3	4.6	8.0
16	0	240 0	0.0	0.0	5.0	5.0	1.0	3.0	5.0	9.0
16	0	250 0	0.0	2.0	4 0	6.0	0 0	5.0	0.0	5.0
16	0	260 0	0.0	1.0	2.0	3.0	0.0	1.0	1.0	2.0
16	0	270 0	0.0	1.0	5.0	6.0	0.0	0.0	0 0	1.0
16	0	280 0	0.0	1.0	3.0	4.0	0.0	2.5	2.5	5.0
16	0	290 0	0.0	2.0	3.0	5.0	0.0	1 0	1.0	2.0
16	0	300 0	0 0	1.0	2.0	3.0	0.0	0.0	2.0	2.0
16	0	310.0	0.0	2 0	4.0	6.0	1 0	6.0	6.0	13.0
16	0	320 0	0.0	0 0	3.0	3 0	0.0	1.0	0.0	1.0
16	0	330 0	0 0	0.0	0 0	0.0	0 0	1.3	2.7	4.0
16	0	340.0	0.0	1.0	1.0	2.0	0 0	4.0	2.0	6.0
16	0	350 0	0.0	1 0	1 0	2.0	0 0	1.0	1 0	2.0
16	0	360 0	0.0	3.0	0.0	3.0	0.0	4.0	0.0	4.0
16	0	370 0	0.0	0.0	2.0	2.0	0.0	0.0	1.0	1.0
16	0	380 0	0.0	2.0	2.0	4.0	0.0	0.0	0.0	0.0
16	0	390.0	999 0	999.0	999.0	999.0	999.0	999.0	999.0	999.0

VENN 1980B TOTAL

1 0	0 0	13 3	72.7	83.0	169 0	24.9	116.2	53 9	195.0
3.0	20 0	17 0	53 1	83.9	154 0	30.3	59 6	40 1	130.0
5 0	40 0	8.3	41.7	74 0	124.0	8.5	66.4	59.2	134.0
7 0	60 0	26.3	56.8	120.9	204.0	50 2	112 4	112.4	275.0
9 0	80 0	16 4	55.4	122.2	194.0	30 9	150 3	132 8	369.0
11 0	100 0	13 5	100 4	152.1	266.0	46.1	178.4	186.5	411.0
13 0	120 0	12 6	71 1	135.3	219 0	16 0	366.6	493.4	876.0
15.0	140 0	25.9	189 3	205 8	421 0	79 0	226 6	210.4	516.0
17 0	160.0	19 1	211.1	366.8	597.0	50.3	201.0	149.7	401.0
19 0	180 0	27.1	160.7	249.1	437.0	99.6	208.5	142.9	451.0
21 0	200 0	9.1	84 9	101.0	195.0	31.3	178 8	93 9	304.0
23 0	220 0	2.0	31.0	56 0	89 0	14.4	35.1	47.5	97.0
24.0	230 0	10.2	36.7	61.1	108.0	11 4	45 6	55.0	112.0
25 0	240.0	3.1	22.5	56.4	82.0	19 2	60 8	47 0	127.0
26 0	250 0	5.1	28.5	74.4	108.0	10.2	36.9	36.9	84 0
27 0	260 0	4 1	26.4	41.6	72.0	11 4	67.1	46.5	125.0
28.0	270.0	1 0	29 0	50.0	80.0	8.3	54 7	66.0	129.0
29.0	280 0	3.0	20.0	35.0	58.0	10 3	40.1	35.5	86.0
30.0	290 0	2.0	22.4	37.6	62.0	15.5	51.6	32.0	99.0
31 0	300.0	1.0	17 0	29.0	47 0	4 4	38.9	55.6	99.0
32 0	310 0	1.0	19 0	33.0	53 0	4 2	37 7	48.1	90.0
33.0	320 0	3 0	24 0	47 0	74.0	7 1	55.9	55.9	119.0
34 0	330 0	2.0	13 0	13 0	28.0	2 1	22.0	40.9	65.0
35 0	340 0	1.0	12.0	4.0	17.0	3 0	33.5	24.4	61.0
36 0	350 0	1.0	13.4	15.5	30 0	2.5	35.7	30.8	64.0
37.0	360 0	1.0	26.0	16 0	43.0	4 4	31 9	33.1	65.0
38 0	370 0	1.0	16.4	25.6	43 0	1.5	26.6	39.9	68.0
39.0	380.0	1 0	10.0	26 0	38.0	1.4	9 6	26 0	37.0
40 0	390 0	1.0	17 0	6.0	24 0	1 0	7.0	9.0	17.0

GREAT ENGLEBOURNE 1980B

TIME	DIST	F1+3	F5	F6	FT	M1	M2	M3	MT
10.0	0.0	1.5	4.5	3.0	9.0	2.0	1.0	0.0	3.0
10.0	10.0	1.0	11.0	2.0	13.0	0.0	4.0	1.0	5.0
10.0	20.0	1.0	4.0	0.0	5.0	0.0	0.0	0.0	0.0
10.0	30.0	0.0	3.0	0.0	3.0	0.0	1.0	1.0	2.0
10.0	40.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
10.0	50.0	0.0	6.0	1.0	7.0	1.0	0.0	0.0	1.0
10.0	150.0	0.0	2.0	1.0	3.0	0.0	1.0	0.0	1.0
10.0	160.0	0.0	4.0	0.0	4.0	0.0	2.0	0.0	2.0
10.0	170.0	0.0	6.0	0.0	6.0	0.0	0.0	0.0	0.0
10.0	180.0	1.0	6.0	3.0	10.0	0.0	2.0	0.0	2.0
10.0	190.0	0.0	9.0	4.0	13.0	0.0	1.0	5.0	6.0
10.0	200.0	0.0	2.0	0.0	2.0	0.0	0.0	1.0	1.0
10.0	210.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0
10.0	220.0	0.0	2.0	1.0	3.0	1.0	0.0	0.0	1.0
10.0	230.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
10.0	240.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
10.0	260.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
10.0	280.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
10.0	300.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
11.0	0.0	0.0	11.0	11.0	22.0	0.0	6.0	18.0	24.0
11.0	10.0	0.0	3.0	3.0	6.0	0.0	0.0	2.0	2.0
11.0	20.0	0.0	7.0	5.0	12.0	0.0	0.0	0.0	0.0
11.0	30.0	2.0	4.0	4.0	10.0	0.0	1.0	0.0	1.0
11.0	40.0	0.0	0.0	1.0	1.0	0.0	0.0	1.0	1.0
11.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11.0	150.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11.0	160.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	2.0
11.0	170.0	0.0	2.0	1.0	3.0	0.0	0.0	0.0	0.0
11.0	180.0	0.0	1.5	1.5	3.0	0.0	1.0	1.0	2.0
11.0	190.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
11.0	200.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
11.0	210.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
11.0	220.0	0.0	3.0	1.0	4.0	0.0	0.0	0.0	0.0
11.0	230.0	1.0	0.0	2.0	3.0	0.0	0.0	0.0	0.0
11.0	240.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
11.0	260.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11.0	280.0	0.0	3.0	0.0	3.0	0.0	0.0	0.0	0.0
11.0	300.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12.0	0.0	0.0	3.0	9.0	12.0	0.0	4.0	8.0	12.0
12.0	10.0	0.0	7.0	7.0	14.0	0.0	1.0	1.0	2.0
12.0	20.0	0.0	10.0	8.0	18.0	0.0	0.0	1.0	1.0
12.0	30.0	0.0	5.0	3.0	8.0	0.0	1.0	0.0	1.0
12.0	40.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
12.0	50.0	0.0	2.0	1.0	3.0	0.0	0.0	1.0	1.0
12.0	150.0	0.0	0.0	2.0	2.0	0.0	0.0	0.0	0.0
12.0	160.0	0.0	1.0	1.0	2.0	0.0	0.0	0.0	0.0
12.0	170.0	0.0	6.0	5.0	11.0	0.0	1.0	0.0	1.0
12.0	180.0	0.0	3.0	1.0	4.0	0.0	0.0	0.0	0.0
12.0	190.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0
12.0	200.0	0.0	2.0	0.0	2.0	0.0	0.0	0.0	0.0
12.0	210.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0

12.0	220.0	0.0	2.0	0.0	2.0	0.0	0.0	0.0	0.0
12.0	230.0	0.0	0.0	2.0	2.0	0.0	2.0	0.0	2.0
12.0	240.0	0.0	2.0	1.0	3.0	0.0	0.0	0.0	0.0
12.0	260.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12.0	280.0	0.0	1.0	1.0	2.0	0.0	0.0	0.0	0.0
12.0	300.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13.0	0.0	0.0	8.0	18.0	26.0	0.0	7.0	3.0	10.0
13.0	10.0	0.0	5.0	14.0	19.0	0.0	2.0	1.0	3.0
13.0	20.0	0.0	4.0	7.0	11.0	1.0	1.0	3.0	5.0
13.0	30.0	1.0	13.0	13.0	27.0	1.0	6.0	6.0	14.0
13.0	40.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
13.0	50.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
13.0	150.0	0.0	1.0	2.0	3.0	0.0	3.0	3.0	6.0
13.0	160.0	1.0	3.0	4.0	8.0	0.0	1.0	3.0	4.0
13.0	170.0	0.0	1.0	0.0	1.0	0.0	1.0	3.0	4.0
13.0	180.0	0.0	0.0	1.0	1.0	0.0	1.0	0.0	1.0
13.0	190.0	0.0	3.0	3.0	6.0	0.0	2.0	0.0	2.0
13.0	200.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0
13.0	210.0	0.0	2.0	0.0	2.0	0.0	0.0	1.0	1.0
13.0	220.0	0.0	1.0	1.0	2.0	0.0	3.0	1.0	4.0
13.0	230.0	0.0	1.0	1.0	2.0	0.0	1.0	0.0	1.0
13.0	240.0	0.0	2.0	3.0	5.0	0.0	0.0	0.0	0.0
13.0	260.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
13.0	280.0	0.0	0.0	1.0	1.0	0.0	0.0	1.0	1.0
13.0	300.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
14.0	0.0	1.0	1.0	12.0	14.0	0.0	0.0	4.0	4.0
14.0	10.0	0.0	2.0	9.0	11.0	0.0	1.0	0.0	1.0
14.0	20.0	0.0	5.4	21.6	27.0	0.0	0.0	0.0	0.0
14.0	30.0	0.0	0.0	4.0	4.0	0.0	0.0	0.0	0.0
14.0	40.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
14.0	50.0	0.0	1.0	2.0	3.0	0.0	0.0	3.0	3.0
14.0	150.0	0.0	0.0	2.0	2.0	0.0	0.0	2.0	2.0
14.0	160.0	0.0	3.0	8.0	11.0	0.0	0.0	5.0	5.0
14.0	170.0	0.0	1.0	0.0	1.0	0.0	0.0	1.0	1.0
14.0	180.0	0.0	2.0	0.0	2.0	0.0	0.0	2.0	2.0
14.0	190.0	0.0	1.0	0.0	1.0	0.0	0.0	1.0	1.0
14.0	200.0	0.0	0.0	2.0	2.0	0.0	0.0	0.0	0.0
14.0	210.0	0.0	3.0	1.0	4.0	0.0	0.0	1.0	1.0
14.0	220.0	0.0	1.0	5.0	6.0	0.0	0.0	4.0	4.0
14.0	230.0	0.0	0.0	2.0	2.0	0.0	0.0	2.0	2.0
14.0	240.0	0.0	1.0	1.0	2.0	0.0	1.0	1.0	2.0
14.0	260.0	0.0	1.0	0.0	1.0	0.0	0.0	1.0	1.0
14.0	280.0	0.0	3.0	0.0	3.0	0.0	0.0	2.0	2.0
14.0	300.0	0.0	3.0	1.0	4.0	0.0	0.0	1.0	1.0
15.0	0.0	0.0	0.0	5.0	5.0	0.0	2.0	0.0	2.0
15.0	10.0	0.0	2.0	3.0	5.0	0.0	2.0	0.0	2.0
15.0	20.0	0.0	1.0	5.0	6.0	0.0	1.0	0.0	1.0
15.0	30.0	0.0	2.0	6.0	8.0	0.0	4.0	0.0	4.0
15.0	40.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
15.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15.0	150.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	3.0
15.0	160.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
15.0	170.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0

15	0	180.0	0.0	0.0	1.0	1.0	0.0	0 0	0.0	0.0
15	0	190 0	0.0	0 0	0.0	0.0	0 0	0.0	1.0	1.0
15	0	200.0	0.0	0 0	0.0	0 0	0 0	0 0	0 0	0.0
15	0	210.0	0.0	0.0	0.0	1.0	0.0	0 0	0.0	0.0
15.0		220.0	0.0	0.0	0.0	0.0	0.0	1 0	3.0	4.0
15	0	230 0	0.0	0.0	0.0	0.0	0 0	0.0	1.0	1.0
15	0	240 0	0.0	0.0	0.0	0.0	0.0	2.0	0 0	2.0
15	0	260.0	0.0	1.0	0.0	1 0	0.0	0 0	0.0	0.0
15	0	280 0	0.0	0.0	0.0	0.0	0.0	0 0	0.0	0.0
15	0	300.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	0	0.0	0.0	1.0	10.0	11.0	0.0	2.0	2.0	4.0
16	0	10.0	0.0	1.0	2.0	3.0	1.3	1.3	1.3	4.0
16	0	20.0	0.0	0 0	1 0	1.0	0.0	0 0	2 0	2.0
16.0		30.0	0.0	0.0	3.0	3.0	0.0	0.0	0.0	0.0
16.0		40 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16.0		50.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
16.0		150 0	0.0	0.0	0 0	0.0	0 0	0.0	1.0	1.0
16.0		160 0	0.0	0.0	0.0	0.0	0 0	0.0	2.0	2.0
16	0	170 0	0.0	0.0	0.0	0.0	0 0	0.0	0.0	0.0
16	0	180 0	0.0	0.0	0.0	0.0	0 0	0.0	0.0	0.0
16.0		190.0	0.0	1.0	0.0	1.0	0 0	0.0	0.0	0.0
16.0		200 0	0.0	0.0	0.0	0.0	0 0	0.0	0.0	0.0
16	0	210 0	0.0	0.0	0.0	0.0	0 0	0.0	1.0	1.0
16	0	220.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
16.0		230.0	0.0	0.0	0.0	0.0	0 0	0.0	0.0	0.0
16	0	240 0	0.0	1 0	2.0	3.0	0.0	1.0	1.0	2.0
16	0	260.0	0.0	1.0	2.0	3.0	0.0	0.0	0.0	0.0
16.0		280.0	0.0	1 0	1.0	2.0	0.0	1.0	2.0	3.0
16	0	300 0	0.0	0.0	0.0	0.0	0.0	0 0	0.0	0.0

GREAT ENGLEBOURNE 1980B TOTAL

1.0	0.0	2.1	27.8	69.1	99.0	2.4	22.9	33.7	59.0
2.0	10.0	0.0	31.0	40.0	71.0	1.2	11.9	5.9	19.0
3.0	20.0	1.0	31.8	47.2	80.0	1.1	2.3	5.6	9.0
4.0	30.0	3.0	27.0	33.0	63.0	1.2	12.2	8.6	22.0
5.0	40.0	0.0	0.0	4.0	4.0	0.0	0.0	1.0	1.0
6.0	50.0	0.0	9.0	6.0	15.0	1.7	0.0	3.3	5.0
7.0	150.0	0.0	3.0	7.0	10.0	0.0	4.0	9.0	13.0
8.0	160.0	1.0	12.0	13.0	26.0	0.0	3.2	11.8	15.0
9.0	170.0	0.0	16.0	6.0	22.0	0.0	3.0	4.0	7.0
10.0	180.0	1.0	12.6	7.3	21.0	0.0	4.0	3.0	7.0
11.0	190.0	0.0	14.0	8.0	22.0	0.0	2.2	8.8	11.0
12.0	200.0	0.0	4.0	2.0	6.0	0.0	1.0	2.0	3.0
13.0	210.0	0.0	6.0	2.0	8.0	0.0	0.0	4.0	4.0
14.0	220.0	0.0	9.0	9.0	18.0	1.0	6.0	8.0	13.0
15.0	230.0	1.0	1.0	7.0	9.0	0.0	3.0	3.0	6.0
16.0	240.0	0.0	7.0	7.0	14.0	0.0	3.6	2.4	6.0
17.0	260.0	0.0	4.0	2.0	6.0	0.0	0.0	1.0	1.0
18.0	280.0	0.0	8.0	3.0	11.0	0.0	1.0	5.0	6.0
19.0	300.0	0.0	4.0	1.0	5.0	0.0	0.0	1.0	1.0

SEALE HAYNE 1980B

TIME	DIST	F1+3	F5	F6	FT	M1	M2	M3	MT
10.0	5.0	0.0	5.0	4.0	9.0	1.0	2.0	0.0	3.0
10 0	0.0	2 0	26 0	4 0	32.0	0 0	1.0	0 0	1.0
10 0	5 0	1.0	11 0	2.0	14.0	0.0	0.0	0.0	0.0
10.0	15 0	999 0	999.0	999 0	999 0	999.0	999.0	999.0	999.0
10 0	25.0	1.0	2 0	0 0	3.0	1 0	3.0	0.0	4.0
10 0	35 0	1.0	8.0	0.0	9.0	1.0	3 0	0.0	4.0
10 0	45 0	0.0	2.0	0.0	2 0	1 0	0 0	1.0	2.0
10 0	55 0	0.0	8.0	0 0	8.0	0.0	5.0	0 0	5.0
10 0	65 0	0.0	3.0	0.0	3.0	0 0	1 0	0.0	1.0
10 0	75 0	0 0	9 0	0.0	9.0	0 0	1.0	0.0	1.0
10 0	85.0	0.0	0.0	1.0	1 0	0.0	1.0	1.0	2.0
10 0	95.0	0.0	0.0	1.0	1 0	0 0	0.0	0.0	0.0
10 0	105.0	999 0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
10.0	115 0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
10 0	125.0	999 0	999.0	999.0	999.0	999 0	999 0	999.0	999.0
10.0	135.0	999 0	999.0	999.0	999.0	999.0	999 0	999.0	999.0
10.0	145.0	0.0	4.0	0.0	4 0	0.0	3.0	0.0	3.0
10.0	155 0	1.0	9.0	1.0	11.0	0.0	0.0	0.0	0.0
10 0	165 0	999 0	999.0	999.0	999 0	999 0	999 0	999 0	999.0
10.0	165.0	0.0	8.0	0.0	8.0	0.0	0.0	0.0	0.0
10 0	166.0	0.0	7.0	1 0	8.0	0.0	2.0	0.0	2.0
10 0	168 0	0.0	9.0	0.0	9.0	0.0	0.0	0.0	0.0
10.0	170 0	0.0	3.0	0.0	3.0	0.0	1.0	0.0	1.0
10.0	172.0	0 0	3.0	0.0	3 0	1.0	1 0	0.0	2.0
10 0	176.0	0.0	2.0	0.0	2 0	0.0	1.0	0.0	1.0
10.0	179.0	1.0	2.0	0.0	3.0	2.0	5.0	3 0	10.0
10 0	183 0	0.0	5.0	0.0	5.0	1.0	2.0	0 0	3.0
10 0	188.0	0.0	6.0	3 0	9.0	4 0	7.0	3.0	14.0
10 0	190 0	0 0	7 0	2.0	9.0	2 0	5.0	2.0	9.0
10.0	196 0	0.0	8.0	0.0	8.0	0 0	4.0	0.0	4.0
10.0	202 0	0 0	8.0	1.0	9.0	0.0	8.0	6 0	14.0
10.0	202 0	0 0	0.0	0.0	0.0	0.0	1.0	2.0	3.0
10 0	209 0	1.0	6.0	0.0	7.0	0.0	2.0	0.0	2.0
10 0	212 0	1.0	3.0	1 0	5.0	0 0	0.0	0.0	0 0
10 0	219.0	0 0	3.0	0.0	3.0	0.0	3.0	3.0	6.0
10.0	223.0	1.0	5.0	1 0	7.0	2.0	6 0	0.0	8.0
10 0	226.0	0.0	2 0	4.0	6.0	0.0	7.0	3.0	10 0
10 0	230.0	0.0	6.0	3.0	9.0	0 0	3.0	8.0	11.0
10 0	237 0	2.0	3.0	0.0	5.0	1 0	3 0	0 0	4.0
10.0	244.0	999 0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
10 0	251.0	999 0	999 0	999.0	999.0	999.0	999.0	999.0	999.0
10.0	258.0	999.0	999.0	999.0	999.0	999 0	999 0	999.0	999.0
10.0	265.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
10 0	272 0	999 0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
10 0	279.0	999 0	999 0	999.0	999 0	999.0	999.0	999.0	999.0
10.0	76.0	0.0	1 0	0.0	1.0	0.0	1.0	0.0	1.0
10.0	78.0	0.0	3.0	1.0	4.0	0.0	0.0	0.0	0.0
10 0	82.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
10 0	85.0	0 0	3.0	0.0	3.0	0.0	0.0	0.0	0.0
10.0	90.0	0.0	0.0	1 0	1.0	0.0	0.0	0.0	0.0
10.0	96.0	0.0	4.0	1.0	5.0	0.0	0.0	0.0	0.0
10 0	103.0	0 0	13 0	0.0	13.0	0 0	2.0	2.0	4.0
10 0	110 0	0 0	12.0	1.0	13 0	0 0	0.0	0.0	0.0

10.0 117.0	0.0	7.0	1.0	8.0	0.0	0.0	0.0	0.0
10.0 125.0	1.0	8.0	0.0	9.0	0.0	0.0	1.0	1.0
10.0 133.0	0.0	8.0	2.0	10.0	0.0	0.0	0.0	0.0
10.0 142.0	1.0	8.0	1.0	10.0	0.0	0.0	0.0	0.0
10.0 150.0	2.0	4.0	0.0	6.0	0.0	0.0	0.0	0.0
10.0 159.0	0.0	6.0	0.0	6.0	0.0	2.0	0.0	2.0
11.0 5.0	0.0	0.0	3.0	3.0	0.0	1.0	0.0	1.0
11.0 0.0	0.0	13.0	28.0	41.0	0.0	0.0	3.0	3.0
11.0 5.0	0.0	8.0	7.0	15.0	0.0	1.0	0.0	1.0
11.0 15.0	0.0	1.0	2.0	3.0	0.0	2.0	2.0	4.0
11.0 25.0	0.0	4.0	1.0	5.0	0.0	0.0	1.0	1.0
11.0 35.0	0.0	4.0	1.0	5.0	0.0	0.0	0.0	0.0
11.0 45.0	0.0	1.0	1.0	2.0	0.0	0.0	0.0	0.0
11.0 55.0	0.0	3.0	0.0	3.0	0.0	0.0	1.0	1.0
11.0 65.0	0.0	3.0	0.0	3.0	0.0	0.0	1.0	1.0
11.0 75.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11.0 85.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11.0 95.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11.0 105.0	0.0	0.0	1.0	1.0	0.0	0.0	1.0	1.0
11.0 115.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11.0 125.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
11.0 135.0	0.0	2.0	1.0	3.0	0.0	0.0	0.0	0.0
11.0 145.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
11.0 155.0	0.0	0.0	1.0	1.0	0.0	0.0	3.0	3.0
11.0 165.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
11.0 165.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11.0 166.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11.0 168.0	0.0	1.0	3.0	4.0	0.0	0.0	0.0	0.0
11.0 170.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0
11.0 172.0	0.0	1.0	0.0	1.0	0.0	1.0	1.0	2.0
11.0 176.0	0.0	2.0	1.0	3.0	0.0	0.0	1.0	1.0
11.0 179.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0
11.0 183.0	0.0	0.0	0.0	0.0	0.0	1.0	2.0	3.0
11.0 188.0	0.0	2.0	2.0	4.0	0.0	3.0	3.0	6.0
11.0 190.0	0.0	1.0	1.0	2.0	0.0	2.0	2.0	4.0
11.0 196.0	0.0	0.0	1.0	1.0	2.0	2.0	2.0	6.0
11.0 202.0	0.0	8.0	2.0	10.0	0.0	2.0	6.0	8.0
11.0 202.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0
11.0 209.0	0.0	1.0	0.0	1.0	0.0	0.0	1.0	1.0
11.0 212.0	0.0	0.0	0.0	0.0	0.0	2.0	2.0	4.0
11.0 219.0	0.0	1.0	1.0	2.0	0.0	0.0	2.0	2.0
11.0 223.0	0.0	1.0	1.0	2.0	0.0	1.0	0.0	1.0
11.0 226.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
11.0 230.0	0.0	0.0	0.0	0.0	0.0	1.0	3.0	4.0
11.0 237.0	0.0	3.0	2.0	5.0	0.0	0.0	6.0	6.0
11.0 244.0	0.0	0.0	2.0	2.0	0.0	1.0	0.0	1.0
11.0 251.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11.0 258.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
11.0 265.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11.0 272.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11.0 279.0	0.0	0.0	2.0	2.0	0.0	0.0	0.0	0.0
11.0 76.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
11.0 78.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0
11.0 82.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

11.0	85.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0
11.0	90.0	0.0	3.0	0.0	3.0	0.0	0.0	0.0	0.0
11.0	96.0	0.0	2.0	0.0	2.0	0.0	0.0	0.0	0.0
11.0	103.0	0.0	2.0	0.0	2.0	0.0	0.0	0.0	0.0
11.0	110.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11.0	117.0	0.0	2.0	0.0	2.0	0.0	0.0	0.0	0.0
11.0	125.0	0.0	2.0	0.0	2.0	0.0	0.0	0.0	0.0
11.0	133.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11.0	142.0	0.0	3.0	0.0	3.0	0.0	0.0	0.0	0.0
11.0	150.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
11.0	159.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12.0	5.0	0.0	3.0	11.0	14.0	0.0	0.0	0.0	0.0
12.0	0.0	1.0	19.0	8.0	28.0	0.0	1.0	1.0	2.0
12.0	5.0	0.0	5.0	8.0	13.0	0.0	0.0	1.0	1.0
12.0	15.0	0.0	3.0	0.0	3.0	0.0	3.0	1.0	4.0
12.0	25.0	0.0	2.0	1.0	3.0	0.0	1.0	1.0	2.0
12.0	35.0	0.0	2.0	2.0	4.0	0.0	0.0	1.0	1.0
12.0	45.0	0.0	3.0	1.0	4.0	0.0	1.0	2.0	3.0
12.0	55.0	1.0	0.0	2.0	3.0	0.0	0.0	2.0	2.0
12.0	65.0	0.0	0.0	0.0	0.0	0.0	1.5	1.5	3.0
12.0	75.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0
12.0	85.0	0.0	3.0	1.0	4.0	0.0	0.0	0.0	0.0
12.0	95.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12.0	105.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0
12.0	115.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12.0	125.0	0.0	0.0	0.0	0.0	0.0	1.0	2.0	3.0
12.0	135.0	0.0	2.0	0.0	2.0	0.0	0.0	0.0	0.0
12.0	145.0	0.0	1.0	1.0	2.0	0.0	1.0	0.0	1.0
12.0	155.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
12.0	165.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
12.0	165.0	0.0	2.0	0.0	2.0	0.0	0.0	0.0	0.0
12.0	166.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
12.0	168.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
12.0	170.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
12.0	172.0	0.0	2.0	0.0	2.0	0.0	0.0	0.0	0.0
12.0	176.0	0.0	1.0	1.0	2.0	0.0	1.0	0.0	1.0
12.0	179.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
12.0	183.0	0.0	1.0	1.0	2.0	0.0	0.0	1.0	1.0
12.0	188.0	0.0	1.0	3.0	4.0	0.0	1.3	2.7	4.0
12.0	190.0	0.0	3.0	1.0	4.0	1.0	8.0	5.0	14.0
12.0	196.0	0.0	2.0	0.0	2.0	0.0	1.0	1.0	2.0
12.0	202.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
12.0	202.0	0.0	1.5	1.5	3.0	2.0	0.0	0.0	2.0
12.0	209.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12.0	214.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
12.0	219.0	0.0	2.0	1.0	3.0	0.0	1.0	0.0	1.0
12.0	223.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
12.0	226.0	0.0	0.0	2.0	2.0	0.0	0.0	0.0	0.0
12.0	230.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	2.0
12.0	237.0	0.0	2.0	2.0	4.0	0.0	4.0	1.0	5.0
12.0	244.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	2.0
12.0	251.0	0.0	1.0	0.0	1.0	0.0	1.0	1.0	2.0
12.0	258.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12.0	265.0	0.0	0.0	2.0	2.0	0.0	1.0	0.0	1.0

12.0	272.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12.0	280.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	2.0
12.0	76.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
12.0	78.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
12.0	82.0	0.0	1.0	2.0	3.0	0.0	1.0	1.0	2.0
12.0	85.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12.0	90.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12.0	96.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12.0	103.0	0.0	2.0	1.0	3.0	0.0	0.0	0.0	0.0
12.0	110.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12.0	117.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
12.0	125.0	0.0	3.0	0.0	3.0	0.0	0.0	0.0	1.0
12.0	133.0	0.0	3.0	0.0	3.0	0.0	0.0	0.0	0.0
12.0	142.0	0.0	1.0	2.0	3.0	0.0	2.0	0.0	2.0
12.0	150.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
12.0	159.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
13.0	5.0	0.0	3.0	2.0	5.0	0.0	0.0	0.0	0.0
13.0	0.0	0.0	6.0	15.0	21.0	0.0	2.0	0.0	2.0
13.0	5.0	0.0	2.0	4.0	6.0	0.0	0.0	4.0	4.0
13.0	15.0	1.0	1.0	2.0	4.0	1.0	1.0	0.0	2.0
13.0	25.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
13.0	35.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
13.0	45.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
13.0	55.0	0.0	1.0	2.0	3.0	0.0	0.0	0.0	0.0
13.0	65.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
13.0	75.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	2.0
13.0	85.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13.0	95.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13.0	105.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
13.0	115.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13.0	125.0	0.0	0.0	2.0	2.0	0.0	0.0	0.0	0.0
13.0	135.0	0.0	3.0	2.0	5.0	0.0	1.0	2.0	3.0
13.0	145.0	0.0	1.0	2.0	3.0	0.0	1.0	1.0	2.0
13.0	155.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13.0	165.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13.0	165.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
13.0	166.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
13.0	168.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13.0	170.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13.0	172.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13.0	176.0	0.0	1.0	1.0	2.0	0.0	1.0	0.0	1.0
13.0	179.0	0.0	2.0	2.0	4.0	0.0	0.0	2.0	2.0
13.0	183.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
13.0	188.0	0.0	0.0	0.0	0.0	1.0	1.0	1.0	3.0
13.0	190.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
13.0	196.0	0.0	1.0	1.0	2.0	0.0	2.0	0.0	2.0
13.0	202.0	0.0	1.0	1.0	2.0	0.0	0.0	2.0	2.0
13.0	202.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
13.0	209.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13.0	214.0	0.0	2.0	0.0	2.0	0.0	0.0	1.0	1.0

13.0	219.0	0.0	1.0	1.0	2.0	0.0	0.0	3.0	3.0
13.0	223.0	0.0	0.0	2.0	2.0	0.0	0.0	0.0	0.0
13.0	226.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13.0	230.0	0.0	1.0	1.0	2.0	0.0	0.0	1.0	1.0
13.0	237.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
13.0	244.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
13.0	251.0	0.0	0.0	3.0	3.0	0.0	0.0	0.0	0.0
13.0	258.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13.0	265.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13.0	272.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13.0	279.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13.0	76.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
13.0	78.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13.0	82.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13.0	85.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	2.0
13.0	90.0	0.0	0.0	1.0	1.0	0.0	0.0	2.0	2.0
13.0	96.0	0.0	2.0	0.0	2.0	0.0	0.0	0.0	0.0
13.0	103.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
13.0	110.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13.0	117.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
13.0	125.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
13.0	133.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
13.0	142.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
13.0	150.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
13.0	159.0	0.0	0.0	2.0	2.0	0.0	0.0	0.0	0.0
14.0	5.0	0.0	1.0	2.0	3.0	0.0	0.0	2.0	2.0
14.0	0.0	0.0	2.0	7.0	9.0	0.0	0.0	0.0	0.0
14.0	5.0	0.0	1.3	2.7	4.0	0.0	0.0	1.0	1.0
14.0	15.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
14.0	25.0	0.0	1.0	2.0	3.0	0.0	0.0	3.0	3.0
14.0	35.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14.0	45.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
14.0	55.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14.0	65.0	0.0	0.0	2.0	2.0	0.0	0.0	0.0	0.0
14.0	75.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
14.0	85.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14.0	95.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
14.0	105.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0
14.0	115.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
14.0	125.0	0.0	3.0	0.0	3.0	0.0	0.0	0.0	0.0
14.0	135.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
14.0	145.0	0.0	0.0	1.0	1.0	0.0	0.0	1.0	1.0
14.0	155.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14.0	165.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14.0	165.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
14.0	166.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
14.0	168.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14.0	170.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
14.0	172.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14.0	176.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14.0	179.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
14.0	183.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14.0	188.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

14	0	190.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	2.0
14.0		196.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	0	202.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	0	202 0	0.0	1.0	1.0	2.0	0.0	0.0	0.0	0.0
14.0		209.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	0	212.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	0	219 0	0.0	0 0	0.0	0.0	0.0	0.0	0.0	0.0
14	0	223.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14.0		226 0	999 0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
14	0	230 0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
14.0		237 0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
14.0		244 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14.0		251.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14.0		258.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14.0		265.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14.0		272.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	0	279.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0
14	0	76.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14.0		78 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14.0		82 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	0	85.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
14.0		90.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14.0		96.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	0	103.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	0	110 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14.0		117.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	0	125.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
14.0		135.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
14.0		142 0	999.0	999.0	999.0	999.0	999 0	999.0	999.0	999.0
14	0	150.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
14.0		159.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
15	0	5.0	0.0	2.0	1.0	3.0	0.0	0.0	0.0	0.0
15	0	0.0	1.0	1.0	3.0	5.0	0.0	2.0	2.0	4.0
15.0		5.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	2.0
15.0		15.0	2.0	1.0	4.0	7.0	0.0	0.0	2.0	2.0
15.0		25.0	0.0	2.0	0.0	2.0	0.0	0.0	1.0	1.0
15.0		35.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15.0		45.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	0	55.0	0.0	1.0	0.0	1.0	0.0	0.0	1.0	1.0
15	0	65.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0
15	0	75.0	0.0	0 0	0.0	0.0	0.0	0.0	0.0	0.0
15.0		85.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0
15	0	95.0	0.0	1.0	2.0	3.0	0.0	0.0	0 0	0.0
15.0		105 0	0.0	0 0	4.0	4.0	0.0	0.0	2.0	2.0
15.0		115 0	0.0	2.0	1.0	3.0	0.0	0 0	1.0	1.0
15	0	125 0	0.0	2.0	6.0	8.0	1.0	0.0	1.0	2.0
15	0	135.0	0.0	1 0	1.0	2.0	0.0	0.0	0.0	0.0
15	0	145.0	0.0	2.0	3.0	5.0	0.0	0.0	1.0	1.0
15	0	155.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	0	165.0	0.0	0.0	1.0	1.0	0.0	0.0	0 0	0.0
15.0		165 0	0 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15.0		166 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	0	168.0	0.0	0.0	4.0	4.0	0.0	0.0	0.0	0.0
15.0		170.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0

15.0	172.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
15.0	176.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
15.0	180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15.0	183.0	0.0	0.0	1.0	1.0	0.0	0.0	1.0	1.0
15.0	188.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0
15.0	190.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15.0	196.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0
15.0	202.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0
15.0	202.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0
15.0	209.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
15.0	212.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
15.0	219.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15.0	223.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
15.0	226.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
15.0	230.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15.0	237.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15.0	244.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15.0	251.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0
15.0	258.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15.0	265.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
15.0	272.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15.0	279.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0
15.0	76.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0
15.0	78.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0
15.0	82.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15.0	85.0	0.0	0.0	2.0	2.0	0.0	0.0	0.0	0.0
15.0	90.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15.0	96.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
15.0	103.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15.0	110.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15.0	117.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15.0	125.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
15.0	133.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15.0	142.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
15.0	150.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15.0	159.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
16.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16.0	0.0	0.0	3.0	2.0	5.0	0.0	0.0	0.0	0.0
16.0	5.0	0.0	0.0	2.0	2.0	0.0	0.0	0.0	0.0
16.0	15.0	0.0	1.0	1.0	2.0	0.0	0.0	0.0	0.0
16.0	25.0	0.0	0.0	2.0	2.0	0.0	0.0	1.0	1.0
16.0	35.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16.0	45.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16.0	55.0	0.0	0.0	1.0	1.0	0.0	0.0	1.0	1.0
16.0	65.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
16.0	75.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
16.0	85.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16.0	95.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16.0	105.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16.0	115.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
16.0	125.0	0.0	0.0	2.0	2.0	0.0	0.0	0.0	0.0
16.0	135.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16.0	145.0	0.0	1.0	2.0	3.0	0.0	0.0	0.0	0.0
16.0	155.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

16.0	165.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
16.0	165.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16.0	166.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16.0	168.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16.0	170.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16.0	172.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
16.0	176.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16.0	180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16.0	183.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16.0	188.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16.0	190.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16.0	196.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0
16.0	202.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
16.0	202.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16.0	209.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16.0	212.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16.0	219.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16.0	223.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16.0	226.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16.0	230.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16.0	237.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16.0	244.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16.0	251.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16.0	258.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16.0	265.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16.0	272.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16.0	279.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16.0	76.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16.0	78.0	0.0	1.0	1.0	2.0	0.0	0.0	0.0	0.0
16.0	82.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16.0	85.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16.0	90.0	0.0	1.0	1.0	2.0	0.0	0.0	0.0	0.0
16.0	96.0	0.0	1.0	1.0	2.0	0.0	0.0	0.0	0.0
16.0	103.0	0.0	2.0	0.0	2.0	0.0	0.0	2.0	2.0
16.0	110.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16.0	117.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16.0	125.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16.0	133.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16.0	142.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
16.0	150.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
16.0	159.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0

SEALE	HAYNE	1980B	TOTAL						
1.0	5.0	0.0	14.0	23.0	37.0	1.0	3.0	2.0	6.0
2.0	0.0	4.0	70.0	67.0	141.0	0.0	6.0	6.0	12.0
3.0	5.0	1.0	28.0	24.9	54.0	0.0	1.0	8.0	9.0
4.0	15.0	3.0	7.0	9.0	19.0	1.0	6.0	5.0	12.0
5.0	25.0	1.1	10.6	7.4	19.0	1.0	4.0	7.0	12.0
6.0	35.0	1.0	15.0	3.0	19.0	1.0	3.0	1.0	5.0
7.0	45.0	0.0	7.0	2.0	9.0	1.0	1.0	3.0	5.0
8.0	55.0	1.0	13.0	5.0	19.0	0.0	5.0	5.0	10.0
9.0	65.0	0.0	6.0	3.0	9.0	0.0	2.4	3.6	6.0
10.0	75.0	0.0	9.0	1.0	10.0	1.3	1.3	1.3	4.0
12.0	85.0	0.0	3.0	2.0	5.0	0.0	1.0	2.0	3.0
13.0	95.0	0.0	2.0	3.0	5.0	0.0	0.0	0.0	0.0
14.0	105.0	0.0	1.0	6.0	7.0	0.0	1.0	4.0	5.0
15.0	115.0	0.0	4.0	1.0	5.0	0.0	0.0	1.0	1.0
16.0	125.0	0.0	5.0	10.0	15.0	1.0	1.0	3.0	5.0
17.0	135.0	0.0	8.0	4.0	12.0	0.0	1.0	2.0	3.0
18.0	145.0	0.0	10.0	9.0	19.0	0.0	5.0	3.0	8.0
19.0	155.0	1.0	9.0	2.0	12.0	0.0	0.0	3.0	3.0
20.0	160.0	0.0	2.0	1.0	3.0	0.0	0.0	0.0	0.0
21.0	165.0	0.0	10.0	2.0	12.0	0.0	0.0	0.0	0.0
22.0	166.0	0.0	10.0	1.0	11.0	0.0	2.0	0.0	2.0
23.0	168.0	0.0	10.0	7.0	17.0	0.0	0.0	0.0	0.0
24.0	170.0	0.0	4.0	2.0	6.0	0.0	1.0	1.0	2.0
25.0	172.0	0.0	7.0	1.0	8.0	1.0	2.0	1.0	4.0
26.0	176.0	0.0	6.0	4.0	10.0	0.0	3.0	1.0	4.0
27.0	179.0	1.0	4.0	2.0	7.0	2.0	6.0	5.0	13.0
28.0	183.0	0.0	7.0	2.0	9.0	1.0	3.0	4.0	8.0
29.0	188.0	0.0	9.0	8.0	17.0	5.2	13.5	9.3	28.0
30.0	190.0	0.0	11.0	5.0	16.0	3.0	15.0	11.0	29.0
31.0	196.0	0.0	11.0	2.0	13.0	2.0	10.0	4.0	16.0
32.0	202.0	0.0	17.0	5.0	22.0	0.0	8.8	16.2	25.0
33.0	204.0	0.0	3.6	2.4	6.0	1.2	1.2	4.7	7.0
34.0	208.0	1.0	8.0	0.0	9.0	0.0	2.0	1.0	3.0
35.0	212.0	1.0	5.0	1.0	7.0	0.0	2.0	3.0	5.0
36.0	219.0	0.0	7.0	3.0	10.0	0.0	4.0	8.0	12.0
37.0	223.0	1.0	7.0	4.0	12.0	2.0	7.0	0.0	9.0
38.0	226.0	0.0	4.0	6.0	10.0	0.0	7.0	3.0	10.0
39.0	230.0	0.0	7.0	4.0	11.0	0.0	4.0	14.0	18.0
40.0	237.0	2.0	8.0	5.0	15.0	1.0	7.0	7.0	15.0
41.0	244.0	0.0	1.0	2.0	3.0	0.0	2.0	1.0	3.0
42.0	251.0	0.0	1.0	3.0	4.0	0.0	1.0	2.0	3.0
43.0	258.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
44.0	265.0	0.0	0.0	3.0	3.0	0.0	1.0	0.0	1.0
45.0	272.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
46.0	279.0	0.0	2.0	2.0	4.0	0.0	0.0	3.0	3.0
50.0	76.0	0.0	2.0	0.0	2.0	0.0	1.0	2.0	3.0
51.0	78.0	0.0	4.0	2.0	6.0	0.0	0.0	2.0	2.0
52.0	81.0	0.0	1.0	2.0	3.0	0.0	1.0	1.0	2.0
53.0	85.0	0.0	3.0	3.0	6.0	0.0	2.0	1.0	3.0
54.0	90.0	0.0	4.0	3.0	7.0	0.0	0.0	2.0	2.0
55.0	96.0	0.0	10.0	2.0	12.0	0.0	0.0	0.0	0.0
56.0	103.0	0.0	20.0	1.0	21.0	0.0	2.0	4.0	6.0
57.0	110.0	0.0	12.0	1.0	13.0	0.0	0.0	0.0	0.0
58.0	117.0	0.0	10.0	1.0	11.0	0.0	0.0	0.0	0.0
59.0	125.0	1.0	13.0	1.0	15.0	0.0	0.0	2.0	2.0
60.0	133.0	0.0	11.0	2.0	13.0	0.0	0.0	0.0	0.0
61.0	142.0	1.0	14.0	3.0	18.0	0.0	2.0	0.0	2.0
62.0	150.0	2.0	5.0	2.0	9.0	0.0	0.0	0.0	0.0
63.0	159.0	0.0	7.0	3.0	10.0	0.0	2.0	0.0	2.0

SEALE-HAYNE 1980C

TIME	DIST	F1+3	F5	F6	FT	M1	M2	M3	MT
17	5	0	0	0	0	0	0	0	0
17	0	0	0	5	5	0	0	0	0
17	5	0	0	0	0	0	0	0	0
17	15	0	1	0	1	0	1	0	1
17	25	0	1	0	1	0	0	0	0
17	35	0	0	2	2	0	0	1	1
17	45	0	0	2	2	0	0	0	0
17	55	0	0	1	1	0	0	0	0
17	65	0	2	0	2	0	0	0	0
17	75	0	0	1	1	0	0	0	0
17	85	0	0	0	0	0	0	0	0
17	95	0	1	1	2	0	0	0	0
17	105	0	1	3	4	0	0	0	0
17	115	0	0	0	0	0	0	0	0
17	125	0	0	0	0	0	0	0	0
17	135	0	0	0	0	0	0	0	0
17	145	0	2	3	5	0	0	0	0
17	155	0	0	0	0	0	0	0	0
17	165	0	0	0	0	0	0	0	0
17	175	0	0	0	0	0	0	0	0
18	5	999	999	999	999	999	999	999	999
18	0	0	2	6	8	0	1	2	3
18	5	0	2	0	2	0	0	1	1
18	15	0	1	1	2	0	0	1	1
18	25	0	5	0	5	1	1	1	3
18	35	0	0	1	1	0	1	0	1
18	45	0	0	1	1	0	1	0	1
18	55	1	0	1	2	0	0	0	0
18	65	0	1	1	2	0	0	0	0
18	75	0	0	0	0	0	0	0	0
18	85	0	0	0	0	0	0	0	0
18	95	0	0	0	0	0	0	0	0
18	105	0	0	0	0	0	0	0	0
18	115	0	1	2	3	0	0	0	0
18	125	0	0	0	0	0	1	0	1
18	135	0	2	0	2	0	0	0	0
18	145	0	1	0	1	0	0	0	0
18	155	0	1	0	1	0	0	0	0
18	165	0	0	0	0	0	0	0	0
18	175	0	0	0	0	0	0	0	0
19	5	0	1	6	7	0	1	1	2
19	0	0	0	0	0	0	1	0	1
19	5	0	3	2	5	0	1	0	1
19	15	0	0	1	1	1	0	0	1
19	25	0	0	0	0	0	0	0	0
19	35	0	0	0	0	0	0	0	0
19	45	0	0	0	0	0	0	0	0
19	55	0	0	0	0	0	0	0	0
19	65	999	999	0	999	999	999	999	999
19	75	1	1	0	1	0	0	0	0

19	85	999	999	0	999	999	999	999	999
19	95	0	2	0	2	1	0	0	1
19	105	0	0	1	1	0	0	0	0
19	115	0	1	1	2	0	0	0	0
19	125	0	1	1	2	0	0	0	0
19	135	0	0	0	0	0	0	0	0
19	145	0	2	0	2	0	0	0	0
19	155	0	0	0	0	0	0	0	0
19	165	0	0	0	0	0	0	0	0
19	175	0	0	2	2	0	0	0	0
20	5	999	999	999	999	999	999	999	999
20	0	0	12	21	33	1	2	0	3
20	5	0	0	8	8	0	2	0	2
20	15	0	3	4	7	1	5	2	8
20	25	0	0	1	1	0	3 7	1 3	5
20	35	0	1 5	1 5	3	0	0	2	2
20	45	0	5	1	6	0	1	0	1
20	55	0	4	2	6	0	2	0	2
20	65	0	4	2	6	1	1	1	3
20	75	0	2	0	2	0	0	2	2
20	85	0	2	2	4	0	4	1	5
20	95	0	0	6	6	0	1	2	3
20	105	0	0	2	2	0	0	0	0
20	115	0	1	1	2	0	1	0	1
20	125	0	1	4	5	0	3 7	1 3	5
20	135	0	1	0	1	0	0	0	0
20	145	0	0	3	3	0	0	1	1
20	155	0	0	4	4	0	1	0	1
20	165	0	0	0	0	0	0	0	0
20	175	0	0	2	2	0	0	0	0
21	5	999	999	999	999	999	999	999	999
21	0	0	2	10	12	0	0	2	2
21	5	999	999	999	999	999	999	999	999
21	15	999	999	999	999	999	999	999	999
21	25	0	0	1	1	0	0	0	0
21	35	0	0	3	3	0	0	0	0
21	45	0	0	1	1	0	0	0	0
21	55	0	0	0	0	0	0	0	0
21	65	0	0	0	0	0	0	0	0
21	75	0	0	0	0	0	0	0	0
21	85	0	0	0	0	0	0	0	0
21	95	0	0	0	0	0	0	0	0
21	105	0	0	1	1	0	0	0	0
21	115	0	0	6	6	0	0	0	0
21	125	0	1	7	8	0	0	0	0
21	135	0	0	0	0	0	0	0	0
21	145	0	0	0	0	0	0	0	0
21	155	0	0	0	0	0	0	0	0
21	165	0	0	1	1	0	0	0	0
21	175	0	1	0	1	0	0	0	0

SHROC-TOTAL

1	5	0	1	6	7	0	1	1	2
2	0	0	16	42	58	1	4	4	9
3	5	0	5	10	15	0	3	1	4
4	15	0	5	6	11	2	6	3	11
5	25	0	6	2	8	1	4 7	2 3	8
6	35	0	1 5	7 5	9	0	1	3	4
7	45	0	5	5	10	0	2	0	2
8	55	1	4	4	9	0	2	0	2
9	65	0	7	3	10	1	1	1	3
10	75	0	3	1	4	0	0	2	2
11	85	0	2	2	4	0	4	1	5
12	95	0	3	7	10	1	1	2	4
13	105	0	1	7	8	0	0	0	0
14	115	0	2	8	10	0	1	0	1
15	125	0	3	15	18	0	4 7	1 3	6
16	135	0	1	0	1	0	0	0	0
17	145	0	6	6	12	0	0	1	1
18	155	0	1	4	5	0	1	0	1
19	165	0	1	1	2	0	0	0	0
20	175	0	1	4	5	0	0	0	0

VENN 1981A

TIME	DIST	F1+3	F5	F6	FT	M1	M2	M3	MT
1.0	0.0	999.0	999.0	999.0	17.0	999.0	999.0	999.0	24.0
1.0	10.0	0.0	2.0	1.0	3.0	0.0	2.0	4.0	6.0
1.0	15.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	30.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0
1.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	60.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	80.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	100.0	0.0	0.0	1.0	1.0	0.0	1.0	0.0	1.0
1.0	120.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0
1.0	140.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	2.0
1.0	160.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
1.0	0.0	0.0	12.0	3.0	15.0	1.0	7.0	8.0	16.0
1.0	10.0	1.0	0.0	2.0	3.0	0.0	1.0	0.0	1.0
1.0	15.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
1.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	60.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	80.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0
1.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	120.0	1.0	0.0	1.0	2.0	0.0	0.0	0.0	0.0
1.0	140.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
1.0	160.0	1.0	4.0	3.0	8.0	3.0	4.0	3.0	10.0
1.0	0.0	1.0	5.0	2.0	8.0	2.0	2.0	5.0	9.0
1.0	10.0	0.0	1.0	1.0	2.0	0.0	1.0	0.0	1.0
1.0	15.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	30.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
1.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	60.0	0.0	0.0	1.0	1.0	1.0	0.0	1.0	2.0
1.0	80.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
1.0	100.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	1.0
1.0	120.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
1.0	140.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
1.0	160.0	1.0	2.0	3.0	6.0	5.0	9.0	6.0	20.0
1.0	200.0	1.0	1.0	0.0	2.0	0.0	0.0	0.0	0.0
1.0	220.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	240.0	1.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0
1.0	260.0	0.0	0.0	1.0	1.0	2.0	0.0	1.0	3.0
1.0	280.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	300.0	0.0	1.0	1.0	1.0	0.0	0.0	0.0	0.0
1.0	320.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	340.0	2.0	1.0	0.0	3.0	0.0	0.0	0.0	0.0
1.0	360.0	3.0	5.0	0.0	8.0	0.0	0.0	0.0	0.0
1.0	380.0	4.0	6.0	5.0	15.0	8.0	14.0	9.0	31.0
1.0	200.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	220.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	240.0	0.0	0.0	0.0	0.0	1.0	0.0	0.0	1.0
1.0	260.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	280.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
1.0	300.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
1.0	320.0	2.0	0.0	0.0	2.0	4.0	0.0	0.0	4.0

1.0	340.0	2.0	4.0	6.0	12.0	1.0	12.0	11.0	24.0
1.0	360.0	1.0	2.0	1.0	4.0	0.0	1.0	1.0	2.0
1.0	380.0	2.0	1.0	2.0	5.0	1.0	6.0	2.0	9.0
2.0	0.0	1.0	18.0	9.0	28.0	0.0	0.0	6.0	6.0
2.0	10.0	1.0	4.0	3.0	8.0	0.0	1.0	0.0	1.0
2.0	15.0	2.0	2.0	1.0	5.0	0.0	0.0	1.0	1.0
2.0	20.0	1.0	3.0	2.0	6.0	0.0	0.0	2.0	2.0
2.0	30.0	0.0	4.0	3.0	7.0	0.0	3.0	2.0	5.0
2.0	40.0	2.0	2.0	1.0	5.0	0.0	0.0	1.0	1.0
2.0	60.0	1.0	2.0	0.0	3.0	0.0	1.0	2.0	3.0
2.0	80.0	1.0	2.0	2.0	5.0	2.0	1.0	0.0	3.0
2.0	100.0	0.0	3.0	1.0	4.0	0.0	3.0	5.0	8.0
2.0	120.0	5.0	7.0	7.0	19.0	1.0	1.0	1.0	3.0
2.0	140.0	0.0	2.0	4.0	6.0	0.0	1.0	1.0	2.0
2.0	160.0	999.0	999.0	999.0	30.0	9.0	6.0	12.0	27.0
2.0	0.0	1.0	11.0	6.0	18.0	0.0	1.0	1.0	4.0
2.0	10.0	0.0	3.0	4.0	7.0	0.0	5.0	4.0	9.0
2.0	15.0	0.0	5.0	0.0	5.0	0.0	1.0	1.0	2.0
2.0	20.0	1.0	1.0	0.0	2.0	1.0	0.0	1.0	2.0
2.0	30.0	0.0	1.0	0.0	1.0	0.0	2.0	0.0	2.0
2.0	40.0	0.0	1.0	0.0	1.0	1.0	0.0	1.0	2.0
2.0	60.0	0.0	3.0	0.0	3.0	0.0	1.0	1.0	2.0
2.0	80.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
2.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.0	120.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	2.0
2.0	140.0	0.0	2.0	0.0	2.0	0.0	1.0	2.0	3.0
2.0	160.0	1.0	2.0	5.0	8.0	1.0	0.0	4.0	5.0
2.0	0.0	4.0	5.0	4.0	13.0	0.0	1.0	1.0	2.0
2.0	10.0	1.0	2.0	0.0	3.0	1.0	0.0	1.0	2.0
2.0	15.0	0.0	1.0	1.0	2.0	0.0	0.0	0.0	0.0
2.0	20.0	0.0	3.0	1.0	4.0	0.0	0.0	0.0	0.0
2.0	30.0	0.0	2.0	0.0	2.0	0.0	0.0	0.0	0.0
2.0	40.0	1.0	2.0	0.0	3.0	0.0	0.0	0.0	0.0
2.0	60.0	1.0	1.0	0.0	2.0	0.0	0.0	0.0	0.0
2.0	80.0	0.0	0.0	1.0	1.0	1.0	0.0	0.0	1.0
2.0	100.0	0.0	5.0	2.0	7.0	0.0	0.0	0.0	0.0
2.0	120.0	2.0	2.0	1.0	5.0	0.0	2.0	0.0	2.0
2.0	140.0	0.0	2.0	2.0	4.0	0.0	1.0	1.0	2.0
2.0	160.0	3.0	5.0	5.0	13.0	2.0	2.0	3.0	7.0
2.0	200.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
2.0	220.0	4.0	7.0	1.0	12.0	0.0	1.0	1.0	2.0
2.0	240.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
2.0	260.0	0.0	2.0	0.0	2.0	0.0	2.0	0.0	2.0
2.0	280.0	3.0	2.0	1.0	6.0	0.0	2.0	1.0	3.0
2.0	300.0	0.0	1.0	1.0	2.0	0.0	1.0	0.0	1.0
2.0	320.0	1.0	1.0	1.0	3.0	2.0	1.0	0.0	3.0
2.0	340.0	1.0	5.0	0.0	6.0	0.0	0.0	0.0	0.0
2.0	360.0	5.0	4.0	4.0	13.0	0.0	1.0	2.0	3.0
2.0	380.0	2.0	5.0	7.0	14.0	0.0	0.0	2.0	2.0
2.0	200.0	0.0	8.0	0.0	8.0	2.0	3.0	2.0	7.0
2.0	220.0	3.0	8.0	0.0	11.0	0.0	1.0	1.0	2.0
2.0	240.0	3.0	4.0	6.0	13.0	0.0	1.0	3.0	4.0
2.0	260.0	0.0	6.0	1.0	7.0	0.0	0.0	0.0	0.0
2.0	280.0	0.0	3.0	2.0	5.0	0.0	1.0	1.0	2.0
2.0	300.0	0.0	4.0	0.0	4.0	0.0	0.0	0.0	0.0

2.0	320.0	0.0	0.0	2.0	2.0	0.0	0.0	0.0	0.0
2.0	340.0	0.0	999.0	999.0	10.0	0.0	0.0	0.0	5.0
2.0	360.0	0.0	5.0	12.0	17.0	6.0	8.0	6.0	21.0
2.0	380.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
3.0	0.0	0.0	5.0	5.0	10.0	1.0	0.0	0.0	1.0
3.0	10.0	2.0	5.0	7.0	14.0	2.0	3.0	4.0	9.0
3.0	15.0	0.0	4.0	3.0	7.0	0.0	2.0	0.0	2.0
3.0	20.0	0.0	4.0	0.0	4.0	0.0	0.0	0.0	0.0
3.0	30.0	0.0	0.0	1.0	1.0	0.0	0.0	1.0	1.0
3.0	40.0	0.0	3.0	1.0	4.0	0.0	0.0	0.0	0.0
3.0	60.0	0.0	3.0	1.0	4.0	0.0	0.0	1.0	1.0
3.0	80.0	1.0	4.0	0.0	5.0	0.0	0.0	0.0	0.0
3.0	100.0	0.0	1.0	1.0	2.0	0.0	0.0	0.0	0.0
3.0	120.0	0.0	4.0	0.0	4.0	1.0	0.0	0.0	0.0
3.0	140.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
3.0	160.0	0.0	5.0	2.0	7.0	1.0	1.0	3.0	5.0
3.0	0.0	999.0	999.0	999.0	9.0	2.0	0.0	0.0	2.0
3.0	10.0	3.0	6.0	7.0	16.0	3.0	8.0	4.0	15.0
3.0	15.0	2.0	1.0	0.0	3.0	0.0	0.0	0.0	0.0
3.0	20.0	0.0	3.0	0.0	3.0	0.0	0.0	0.0	0.0
3.0	30.0	0.0	3.0	0.0	3.0	0.0	0.0	0.0	0.0
3.0	40.0	0.0	1.0	0.0	1.0	0.0	0.0	1.0	1.0
3.0	60.0	0.0	3.0	0.0	3.0	0.0	0.0	0.0	0.0
3.0	80.0	0.0	4.0	2.0	6.0	1.0	0.0	0.0	1.0
3.0	100.0	0.0	2.0	1.0	3.0	0.0	0.0	0.0	0.0
3.0	120.0	0.0	1.0	1.0	2.0	0.0	0.0	2.0	2.0
3.0	140.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.0	160.0	2.0	0.0	7.0	9.0	1.0	0.0	2.0	3.0
3.0	0.0	2.0	6.0	5.0	13.0	0.0	1.0	0.0	1.0
3.0	10.0	1.0	5.0	1.0	7.0	0.0	2.0	3.0	5.0
3.0	15.0	2.0	3.0	0.0	5.0	0.0	0.0	0.0	0.0
3.0	20.0	0.0	2.0	1.0	3.0	1.0	0.0	1.0	2.0
3.0	30.0	0.0	3.0	3.0	6.0	0.0	0.0	0.0	0.0
3.0	40.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
3.0	60.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0	2.0
3.0	80.0	0.0	4.0	1.0	5.0	0.0	0.0	0.0	0.0
3.0	100.0	0.0	2.0	1.0	3.0	0.0	1.0	1.0	2.0
3.0	120.0	0.0	2.0	1.0	3.0	0.0	0.0	0.0	0.0
3.0	140.0	1.0	2.0	2.0	5.0	0.0	2.0	0.0	2.0
3.0	160.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0
3.0	200.0	1.0	6.0	2.0	9.0	0.0	0.0	0.0	0.0
3.0	220.0	0.0	6.0	3.0	9.0	0.0	2.0	1.0	4.0
3.0	240.0	0.0	1.0	1.0	2.0	0.0	0.0	2.0	2.0
3.0	260.0	0.0	1.0	2.0	3.0	0.0	0.0	0.0	0.0
3.0	280.0	0.0	2.0	0.0	2.0	0.0	0.0	0.0	0.0
3.0	300.0	0.0	4.0	0.0	4.0	1.0	1.0	1.0	3.0
3.0	320.0	0.0	2.0	0.0	2.0	0.0	0.0	0.0	0.0
3.0	340.0	0.0	2.0	3.0	5.0	0.0	0.0	1.0	1.0
3.0	360.0	2.0	0.0	0.0	2.0	0.0	2.0	2.0	4.0
3.0	380.0	4.0	4.0	7.0	15.0	3.0	9.0	7.0	19.0
3.0	200.0	4.0	11.0	3.0	18.0	1.0	2.0	2.0	5.0
3.0	220.0	0.0	5.0	2.0	7.0	0.0	0.0	0.0	0.0
3.0	240.0	0.0	3.0	0.0	3.0	0.0	0.0	0.0	0.0
3.0	260.0	0.0	2.0	1.0	3.0	0.0	0.0	0.0	0.0
3.0	280.0	0.0	2.0	1.0	3.0	1.0	0.0	0.0	1.0

4 0	280.0	0.0	0 0	0.0	0.0	0.0	0 0	0.0	0 0
4 0	300.0	1.0	1.0	0.0	2 0	0.0	0.0	0.0	0 0
4 0	320 0	0 0	2.0	0.0	2 0	0.0	0.0	0 0	0.0
4 0	340 0	0 0	0.0	0.0	0.0	0 0	0.0	0.0	0.0
4.0	360 0	0 0	0 0	0 0	0 0	0.0	0 0	0.0	0.0
4 0	380 0	0.0	0.0	3.0	3 0	0.0	1 0	0.0	1.0
5.0	0 0	1.0	1.0	2 0	4 0	1 0	1 0	0 0	2.0
5 0	10.0	0 0	6.0	4.0	10.0	0.0	1.0	0.0	1.0
5 0	15 0	0 0	0 0	4 0	4 0	1 0	3.0	1 0	6 0
5 0	20.0	0.0	0.0	0.0	1 0	0.0	0 0	1 0	1.0
5 0	30 0	0 0	1.0	1.0	2 0	0 0	0 0	0 0	0.0
5 0	40 0	0 0	0 0	0.0	0 0	0.0	0 0	0.0	0.0
5.0	60 0	1.0	0.0	0 0	1.0	0.0	0 0	0 0	0.0
5 0	80 0	0.0	0.0	0 0	0 0	0 0	0.0	0.0	0.0
5 0	100 0	0.0	0.0	0.0	0.0	0.0	0 0	0 0	0.0
5 0	120.0	0.0	1 0	0.0	1 0	0 0	0.0	0.0	0.0
5.0	140 0	0.0	0.0	0.0	0 0	0.0	0.0	0 0	0.0
5 0	160.0	0 0	3.0	0 0	3.0	0 0	1 0	2.0	3.0
5 0	0.0	0.0	0.0	1 0	2.0	0.0	0 0	1 0	1.0
5 0	10 0	2 0	5 0	2 0	9.0	3 0	6.0	3.0	12 0
5 0	15.0	0.0	0.0	0 0	0.0	0 0	0 0	0.0	0.0
5 0	20 0	0.0	0.0	0 0	0.0	0 0	0 0	0.0	0.0
5 0	30 0	0.0	0.0	0 0	0.0	0.0	0 0	0.0	0.0
5 0	40.0	0.0	0.0	0.0	0.0	0.0	0 0	1 0	1.0
5 0	60 0	0 0	0.0	1 0	1 0	0 0	0.0	0 0	0.0
5 0	80 0	0.0	0.0	0 0	0.0	0.0	0 0	0 0	0.0
5.0	100.0	1 0	0 0	0 0	1 0	0.0	0 0	0.0	0.0
5 0	120 0	0.0	0.0	1 0	1 0	0 0	0.0	0.0	0.0
5 0	140 0	0.0	0.0	0 0	0.0	0.0	0.0	0 0	0.0
5 0	160 0	0.0	0 0	0 0	0.0	0.0	1 0	0 0	1 0
5 0	0 0	0 0	0.0	2.0	2.0	1 0	2.0	0 0	4.0
5 0	10 0	2.0	1.0	0.0	2 0	1 0	1.0	1 0	3 0
5.0	15 0	0 0	0.0	0.0	0 0	0.0	0.0	0.0	0.0
5 0	20 0	0.0	0 0	0.0	0 0	1 0	0.0	0.0	1.0
5 0	30 0	1.0	0 0	0.0	1 0	1.0	0.0	1 0	2.0
5.0	40 0	0.0	1.0	0.0	1 0	0 0	0 0	0 0	0.0
5 0	60 0	0.0	1.0	0 0	1 0	0.0	0.0	0.0	0.0
5.0	80 0	1.0	1.0	0.0	2 0	0 0	0 0	1 0	1 0
5 0	100.0	0.0	1 0	0.0	1.0	0 0	0 0	0 0	0.0
5.0	120.0	0.0	0 0	0.0	0 0	0 0	0 0	0 0	0 0
5.0	140 0	0 0	1 0	1.0	2 0	0.0	0 0	0 0	0.0
5.0	160 0	1 0	1.0	1.0	3.0	1.0	2.0	0.0	3.0
5.0	200 0	0.0	0 0	0.0	0 0	0 0	0 0	0.0	0.0
5 0	220 0	1 0	1 0	0.0	2 0	2.0	0 0	0.0	2.0
5 0	240 0	0 0	0.0	0.0	0.0	0 0	0 0	0.0	0.0
5 0	260.0	0.0	0.0	0 0	0.0	0.0	0 0	0.0	0.0
5 0	280 0	0 0	0.0	0.0	0 0	0.0	0.0	0.0	0.0
5 0	300 0	0 0	0.0	1 0	1 0	0 0	0.0	0.0	0.0
5 0	320 0	0.0	0.0	0.0	0.0	0.0	1 0	0.0	1.0
5 0	340 0	0 0	2.0	0 0	2.0	0.0	0 0	0.0	0.0
5 0	360 0	0.0	0.0	0.0	0.0	0.0	0 0	1 0	1 0
5.0	380 0	0 0	0.0	0.0	0 0	0.0	0.0	0 0	0.0
5 0	200 0	0 0	3 0	0.0	3.0	0.0	2 0	0.0	2.0
5 0	220 0	1.0	0.0	0 0	1.0	0 0	1.0	0 0	1.0
5 0	240 0	0 0	1.0	0.0	1.0	0 0	0 0	2.0	2.0

5.0	260.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.0	280.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.0	300.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.0	320.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
5.0	340.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0
5.0	360.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0
5.0	380.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	2.0
6.0	0.0	0.0	1.0	3.0	4.0	0.0	0.0	1.0	1.0
6.0	10.0	0.0	1.0	4.0	5.0	0.0	5.0	6.0	11.0
6.0	15.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	20.0	0.0	1.0	1.0	2.0	0.0	0.0	0.0	0.0
6.0	30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	60.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	80.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	120.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	140.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
6.0	160.0	0.0	1.0	1.0	2.0	0.0	1.0	1.0	2.0
6.0	0.0	0.0	1.0	1.0	2.0	0.0	1.0	2.0	3.0
6.0	10.0	0.0	1.0	1.0	2.0	0.0	3.0	3.0	6.0
6.0	15.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	60.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
6.0	80.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	120.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	140.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	160.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	4.0
6.0	0.0	0.0	1.0	1.0	2.0	2.0	12.0	4.0	12.0
6.0	10.0	0.0	1.0	3.0	4.0	0.0	0.0	0.0	0.0
6.0	15.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
6.0	20.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
6.0	30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	60.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	80.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	120.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
6.0	140.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	160.0	0.0	1.0	3.0	4.0	0.0	0.0	2.0	2.0
6.0	200.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	220.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	240.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0
6.0	260.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	280.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	300.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	320.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	340.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0
6.0	360.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0
6.0	380.0	0.0	1.0	1.0	2.0	2.0	12.0	4.0	18.0
6.0	200.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	220.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

5.0	260.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.0	280.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.0	300.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.0	320.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
5.0	340.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0
5.0	360.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0
5.0	380.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	2.0
6.0	0.0	0.0	1.0	3.0	4.0	0.0	0.0	1.0	1.0
6.0	10.0	0.0	1.0	4.0	5.0	0.0	5.0	6.0	11.0
6.0	15.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	20.0	0.0	1.0	1.0	2.0	0.0	0.0	0.0	0.0
6.0	30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	60.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	80.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	120.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	140.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
6.0	160.0	0.0	1.0	1.0	2.0	0.0	1.0	1.0	2.0
6.0	0.0	0.0	1.0	1.0	2.0	0.0	1.0	2.0	3.0
6.0	10.0	0.0	1.0	1.0	2.0	0.0	3.0	3.0	6.0
6.0	15.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	60.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
6.0	80.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	120.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	140.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	160.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	4.0
6.0	0.0	0.0	1.0	1.0	2.0	2.0	12.0	4.0	12.0
6.0	10.0	0.0	1.0	3.0	4.0	0.0	0.0	0.0	0.0
6.0	15.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
6.0	20.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
6.0	30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	60.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	80.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	120.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
6.0	140.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	160.0	0.0	1.0	3.0	4.0	0.0	0.0	2.0	2.0
6.0	200.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	220.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	240.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0
6.0	260.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	280.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	300.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	320.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	340.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0
6.0	360.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0
6.0	380.0	0.0	1.0	1.0	2.0	2.0	12.0	4.0	18.0
6.0	200.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	220.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

6 0	240.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	260.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0
6.0	280.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	300.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6 0	320.0	0.0	1.0	1.0	2.0	0.0	0.0	0.0	0.0
6 0	340.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	2.0
6 0	360.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6 0	380.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0
7 0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	0.0	2.0
7 0	10.0	0.0	0.0	0.0	0.0	0.0	3.0	2.0	6.0
7 0	15.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0
7 0	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.0	30.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
7.0	40.0	1.0	0.0	0.0	1.0	0.0	0.0	1.0	1.0
7.0	60.0	0.0	2.0	1.0	4.0	0.0	0.0	0.0	0.0
7.0	80.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7 0	100.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
7.0	120.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.0	140.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0
7.0	160.0	0.0	0.0	4.0	4.0	0.0	2.0	6.0	8.0
7 0	0.0	0.0	0.0	2.0	2.0	1.0	3.0	2.0	6.0
7.0	10.0	0.0	1.0	2.0	4.0	0.0	0.0	6.0	6.0
7.0	15.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
7.0	20.0	0.0	1.0	1.0	2.0	0.0	1.0	1.0	2.0
7.0	30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.0	60.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0
7.0	80.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
7 0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7 0	120.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
7.0	140.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.0	160.0	0.0	0.0	2.0	2.0	0.0	1.0	3.0	5.0
7.0	0.0	0.0	1.0	3.0	4.0	1.0	1.0	3.0	5.0
7.0	10.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
7.0	15.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0
7.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.0	30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.0	60.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
7.0	80.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.0	100.0	0.0	1.0	0.0	1.0	0.0	0.0	1.0	1.0
7 0	120.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
7.0	140.0	0.0	0.0	2.0	2.0	0.0	0.0	0.0	0.0
7.0	160.0	0.0	1.0	0.0	1.0	0.0	1.0	1.0	2.0
7.0	200.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0
7.0	220.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
7 0	240.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	2.0
7 0	260.0	0.0	0.0	0.0	0.0	0.0	2.0	1.0	3.0
7.0	280.0	0.0	0.0	1.0	1.0	0.0	1.0	0.0	1.0
7 0	300.0	0.0	0.0	2.0	2.0	1.0	1.0	1.0	3.0
7.0	320.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0
7.0	340.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	2.0
7 0	360.0	1.0	0.0	0.0	1.0	0.0	1.0	0.0	1.0
7 0	380.0	0.0	1.0	1.0	2.0	3.0	14.0	12.0	29.0
7.0	200.0	0.0	0.0	1.0	1.0	4.0	6.0	0.0	10.0

7.0	220.0	0.0	0 0	0.0	0.0	0.0	1.0	1.0	2.0
7.0	240.0	0.0	0.0	1.0	1.0	1.0	1 0	0.0	2.0
7 0	260.0	0.0	0.0	0.0	0.0	0.0	3.0	0.0	3.0
7.0	280.0	0.0	0.0	2.0	2.0	0 0	0.0	1.0	1.0
7.0	300 0	0.0	0 0	1 0	1.0	0.0	1.0	0.0	1.0
7.0	320 0	0.0	0.0	1.0	1 0	0.0	0.0	0.0	0.0
7 0	340.0	0 0	0.0	0.0	0.0	0.0	1.0	0.0	1.0
7.0	360 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
7 0	380 0	0 0	1 0	0 0	1 0	0.0	0 0	0.0	0.0

VENN 1981A TOTAL

1 0	0.0	2.6	41.7	28.7	73.0	17.5	5.0	17.5	40.0
2 0	10.0	4 0	19 0	22.0	45 0	2.0	19.5	20.5	42.0
3 0	20.0	3 0	7 0	9.0	19.0	1.1	5.6	3.3	10.0
4.0	30.0	1.0	8.0	4 0	14.0	0.0	0.0	3.0	3.0
5.0	40.0	0 0	5.0	6 0	11.0	1.0	5.0	3 0	9.0
6 0	60 0	3.0	5.0	3.0	11 0	0.0	0.0	2.0	2.0
7.0	80 0	2.2	7.6	2.2	12.0	0.0	1 0	3.0	4.0
8.0	100.0	2.0	6.0	3.0	11 0	2.0	1.0	0.0	3.0
9 0	120.0	0 0	6.0	4 0	10 0	0.0	4.0	5.0	9.0
10 0	140.0	5.0	13.0	7.0	25.0	2 0	1.0	2.0	3.0
11 0	160 0	0 0	4.0	5.0	9.0	0.0	3.0	2.0	5.0
12.0	180 0	2.4	24 3	21.9	51.0	11.0	11 0	26.0	48.0
13.0	0 0	1 2	34.0	21.8	57.0	3.2	13.8	17.0	34.0
14 0	10 0	6 0	18.0	23.0	48.0	6.0	24.0	21.0	51.0
15.0	20 0	2.0	9 0	3.0	14.0	3.0	2.0	1.0	6.0
16 0	30 0	1.0	4 0	2.0	7.0	1.0	1 0	2.0	4.0
17.0	40 0	0.0	5 0	1 0	6.0	0 0	2.0	0.0	2.0
18 0	60 0	0.0	2.0	0 0	2.0	2.0	0.0	3 0	5.0
19.0	80 0	0 0	8 0	1.0	9.0	0.0	2.0	1 0	3.0
20 0	100 0	0.0	5.0	3 0	8.0	1.0	0.0	1 0	2.0
21 0	120.0	1 0	3.0	1 0	5.0	0.0	1 0	0.0	1.0
22 0	140.0	1 0	2 0	3.0	6.0	0 0	1.0	3.0	4.0
23 0	160 0	0 0	2.0	1.0	3 0	0.0	1 0	2 0	3.0
24 0	180 0	4 6	6.9	10.5	31.0	5 6	6 7	15.7	28.0
25 0	0 0	7 0	23.0	19.0	49.0	6.2	19.5	14 4	40.0
26 0	10 0	4.0	10.0	7.0	21.0	2.0	5.0	6.0	13.0
27.0	20 0	2 0	6.0	3.0	11.0	1 0	1 0	0.0	2.0
28 0	30 0	0.0	7.0	4.0	11.0	2.0	0.0	1.0	3.0
29.0	40.0	1.0	8.0	4 0	13.0	1 0	0 0	1 0	2.0
30 0	60 0	1.0	6.0	2.0	9.0	0.0	0.0	1.0	1.0
31 0	80 0	1.0	5.0	3.0	9.0	2.0	0.0	2.0	4.0
32 0	100 0	1.0	5.0	2.0	8.0	1.0	0.0	1.0	2.0
33 0	120 0	0.0	9.0	4.0	13.0	1 0	1 0	2.0	4.0
34 0	140 0	2.0	7.0	3.0	12.0	0.0	2.0	0.0	2.0
35.0	160 0	2.0	5.0	9.0	16.0	0.0	4.0	1.0	5.0
36.0	180.0	4.0	11.0	14.0	29.0	9.3	14.4	14.4	37.0
37.0	200 0	2.0	9.0	2.0	13 0	1.0	0.0	1.0	2.0
38.0	220.0	5.0	15.0	6.0	26.0	2.0	3.0	2.0	8.0
39 0	240.0	1.0	2.0	3.0	6.0	1 0	3.0	2 0	6.0
40 0	260 0	0 0	4.0	4.0	8.0	2.0	4.0	2.0	8.0
41.0	280 0	3.0	4.0	4.0	11.0	0.0	3.0	1.0	4.0
42.0	300.0	0 0	7.0	4.0	11.0	2.0	3 0	2 0	7.0
43 0	320.0	1.0	5.0	2.0	8.0	3.0	3 0	0.0	6.0
44.0	340.0	3.0	10.0	3 0	16.0	1.2	2.4	2.4	6.0
45 0	360 0	9 8	9.8	4.4	24.0	0.0	5.0	6.0	11.0
46.0	380 0	10.0	20.0	20.0	50.0	18 0	55.0	39.0	112.0
47.0	200 0	4.1	19 7	5.2	29.0	7 0	13.0	4.0	24.0
48.0	220 0	4 0	16.0	2.0	22.0	0.0	4.0	3.0	7.0
49.0	240.0	3.0	10.0	7.0	20.0	2.0	2 0	5.0	9.0
50.0	260.0	0.0	8 0	3.0	11.0	0.0	3.0	1 0	4.0
51.0	280 0	0.0	5.0	6 0	11.0	1 0	1.0	2.0	4.0
52.0	300.0	4.0	3 0	7.0	14.0	2.0	2.0	0.0	4.0
53.0	320 0	1 1	11.8	2.1	15.0	4.8	1.2	0.0	6.0
54.0	340.0	2.1	8.4	9.5	20.0	1.0	16.0	11.0	28.0
55 0	360 0	2.7	5.4	10.9	19.0	0.0	3.0	6.0	9.0
56.0	380.0	4.0	8.0	17.0	29.0	7.0	16.0	12.0	35.0

VENN 1981B

TIME	DIST	F1+3	F5	F6	FT	M1	M2	M3	MT
9.0	60.0	0.0	2.0	4.0	6.0	5.7	6.9	11.4	24.0
9.0	50.0	0.0	1.0	2.0	3.0	2.0	6.0	5.0	13.0
9.0	40.0	1.1	5.7	9.1	16.0	5.0	3.0	0.0	8.0
9.0	30.0	0.0	6.0	7.0	13.0	2.0	3.0	0.0	5.0
9.0	20.0	0.0	3.8	10.2	14.0	2.0	6.0	0.0	3.0
9.0	10.0	0.0	10.0	4.0	14.0	0.0	4.0	1.0	5.0
9.0	0.0	0.0	2.2	10.8	13.0	1.0	1.0	1.0	3.0
9.0	0.0	0.0	11.0	22.0	33.0	7.0	13.0	4.0	24.0
9.0	0.0	0.0	10.0	9.0	19.0	2.0	10.0	1.0	13.0
9.0	0.0	0.0	6.0	11.0	17.0	0.0	8.0	9.0	17.0
9.0	10.0	0.0	8.0	21.0	29.0	6.0	16.0	5.0	27.0
9.0	20.0	0.0	11.0	15.0	26.0	0.0	1.7	3.3	5.0
9.0	30.0	1.1	7.4	8.5	17.0	3.0	5.0	2.0	10.0
9.0	40.0	0.0	8.0	10.0	18.0	1.0	3.0	6.0	10.0
9.0	50.0	2.0	3.0	7.0	12.0	2.0	3.0	1.0	6.0
9.0	60.0	0.0	4.5	4.5	9.0	0.0	5.0	5.0	10.0
9.0	70.0	1.0	2.0	5.0	8.0	1.0	4.0	0.0	5.0
9.0	80.0	0.0	3.0	3.0	6.0	0.0	2.0	4.0	6.0
9.0	90.0	0.0	2.0	2.0	4.0	2.0	5.0	3.0	10.0
9.0	100.0	1.0	3.0	3.0	7.0	0.0	3.0	2.0	5.0
9.0	110.0	0.0	5.0	7.0	12.0	0.0	6.5	6.5	13.0
9.0	120.0	1.0	1.0	0.0	2.0	2.0	1.0	0.0	3.0
9.0	130.0	0.0	0.0	4.0	4.0	0.0	4.7	2.3	7.0
9.0	140.0	0.0	1.0	4.0	5.0	1.0	4.0	2.0	7.0
9.0	150.0	0.0	1.0	1.0	2.0	0.0	1.0	1.0	2.0
9.0	160.0	0.0	2.0	1.0	3.0	1.0	5.0	1.0	6.0
9.0	170.0	0.0	3.0	4.0	7.0	4.0	3.0	1.0	8.0
9.0	180.0	0.0	3.0	3.0	6.0	1.1	10.7	4.3	16.0
9.0	190.0	0.0	4.0	2.0	6.0	7.0	17.0	5.0	29.0
9.0	200.0	0.0	1.3	3.8	5.0	4.0	37.0	20.0	61.0
9.0	210.0	1.0	0.0	1.0	2.0	1.1	1.1	5.7	8.0
10.0	60.0	0.0	2.0	9.0	11.0	0.0	8.1	10.4	15.0
10.0	50.0	0.0	1.0	6.0	7.0	0.0	1.3	2.7	4.0
10.0	40.0	0.0	3.3	6.7	10.0	0.0	3.0	0.0	3.0
10.0	30.0	1.0	2.0	9.0	12.0	0.0	2.0	2.0	4.0
10.0	20.0	2.0	3.0	6.0	11.0	1.3	3.8	0.0	5.0
10.0	10.0	0.0	5.0	7.0	12.0	0.0	0.0	0.0	4.0
10.0	0.0	1.0	1.0	7.0	9.0	1.5	1.5	0.0	3.0
10.0	0.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
10.0	0.0	4.0	6.0	12.0	22.0	2.8	4.2	2.8	7.0
10.0	0.0	1.2	2.4	9.5	13.0	0.0	8.8	2.2	11.0
10.0	10.0	1.0	7.0	15.0	23.0	10.0	8.0	0.0	18.0
10.0	20.0	1.1	4.4	4.4	10.0	0.0	3.0	1.0	4.0
10.0	30.0	1.0	2.0	14.0	18.0	2.0	12.0	2.0	16.0
10.0	40.0	0.0	3.0	13.0	18.0	1.0	9.0	2.0	12.0
10.0	50.0	2.0	8.0	15.0	25.0	6.0	4.0	1.0	11.0
10.0	60.0	2.0	7.0	16.0	25.0	1.0	5.0	2.0	8.0
10.0	70.0	0.0	3.6	15.4	19.0	0.0	3.0	3.0	6.0
10.0	80.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
10.0	90.0	1.0	4.0	14.0	19.0	2.0	13.0	1.0	16.0
10.0	100.0	1.0	2.0	6.0	9.0	4.0	4.0	0.0	8.0
10.0	110.0	0.0	1.0	3.0	4.0	0.0	0.0	0.0	2.0

10.0	120.0	0.0	1.0	4.0	5.0	0.0	6.7	3.3	10.0
10.0	130.0	0.0	4.2	2.8	7.0	0.0	2.5	2.5	5.0
10.0	140.0	1.0	3.0	5.0	9.0	2.0	5.0	2.0	9.0
10.0	150.0	0.0	3.0	7.0	10.0	0.0	1.0	1.0	2.0
10.0	160.0	1.0	0.0	2.0	3.0	1.0	3.0	0.0	4.0
10.0	170.0	0.0	1.0	2.0	3.0	5.0	2.0	1.0	8.0
10.0	180.0	0.0	4.0	3.0	7.0	0.0	3.0	1.0	4.0
10.0	190.0	0.0	0.0	2.0	2.0	0.0	11.2	7.8	19.0
10.0	200.0	0.0	0.0	4.0	4.0	1.3	18.2	6.5	26.0
10.0	210.0	0.0	4.0	5.0	9.0	0.0	4.0	12.0	16.0
11.0	60.0	0.0	1.0	9.0	10.0	3.6	4.9	8.5	17.0
11.0	50.0	1.0	3.0	10.0	14.0	0.0	10.7	1.3	12.0
11.0	40.0	1.1	5.6	2.3	9.0	1.8	5.3	0.0	7.0
11.0	30.0	6.6	5.5	11.0	23.0	7.0	2.8	0.0	7.0
11.0	20.0	0.0	3.0	3.0	6.0	1.0	1.0	0.0	2.0
11.0	10.0	2.0	2.0	18.0	22.0	2.5	6.3	1.3	10.0
11.0	0.0	0.0	4.7	8.3	13.0	0.0	2.8	4.2	7.0
11.0	0.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
11.0	0.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
11.0	0.0	3.1	6.3	13.6	23.0	3.1	6.2	4.7	14.0
11.0	10.0	0.0	2.6	10.4	13.0	0.0	5.3	1.8	7.0
11.0	20.0	0.0	9.4	11.5	21.0	2.0	6.0	2.0	10.0
11.0	30.0	0.0	8.4	10.6	19.0	0.0	5.7	4.3	10.0
11.0	40.0	2.1	10.4	11.5	24.0	1.1	6.6	3.3	11.0
11.0	50.0	0.0	8.0	10.0	18.0	1.3	2.5	1.3	5.0
11.0	60.0	2.4	3.6	16.9	23.0	1.7	3.3	0.0	5.0
11.0	70.0	0.0	1.3	8.8	10.0	1.5	1.5	3.0	6.0
11.0	80.0	1.0	2.0	10.0	13.0	0.0	0.0	1.0	1.0
11.0	90.0	0.0	5.5	5.5	11.0	0.0	5.0	5.0	10.0
11.0	100.0	0.0	3.2	9.7	14.0	4.5	1.5	0.0	6.0
11.0	110.0	1.0	1.0	5.0	7.0	0.0	0.0	0.0	0.0
11.0	120.0	0.0	0.0	5.0	5.0	5.3	1.8	0.0	7.0
11.0	130.0	0.0	1.2	4.8	6.0	1.0	2.0	1.0	4.0
11.0	140.0	0.0	0.0	8.0	8.0	0.0	2.0	1.0	3.0
11.0	150.0	0.0	0.0	6.8	9.0	1.3	3.8	0.0	5.0
11.0	160.0	0.0	0.0	8.0	8.0	0.0	7.8	6.2	14.0
11.0	170.0	0.0	0.0	3.0	3.0	0.0	5.4	3.6	9.0
11.0	180.0	1.0	0.0	5.0	7.0	4.7	14.1	6.3	25.0
11.0	190.0	0.0	0.0	6.0	6.0	0.0	1.9	15.1	17.0
11.0	200.0	0.0	0.0	2.0	2.0	6.4	27.7	14.9	49.0
11.0	210.0	0.0	0.0	2.0	2.0	0.0	2.5	2.5	5.0
12.0	60.0	0.0	2.0	8.0	10.0	0.0	7.7	10.3	18.0
12.0	50.0	0.0	0.0	4.0	4.0	2.0	4.0	0.0	6.0
12.0	40.0	3.0	3.0	7.0	13.0	1.2	4.7	2.3	7.0
12.0	30.0	0.0	2.0	9.0	11.0	0.0	1.5	1.5	3.0
12.0	20.0	2.4	3.6	6.0	12.0	0.0	4.0	0.0	4.0
12.0	10.0	1.1	5.3	13.7	20.0	0.0	6.0	0.0	6.0
12.0	0.0	0.0	1.6	6.4	8.0	0.0	4.0	0.0	4.0
12.0	0.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
12.0	0.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
12.0	0.0	0.0	6.8	2.3	9.0	0.0	3.0	4.0	7.0
12.0	10.0	4.0	7.0	6.0	17.0	1.2	5.9	5.9	13.0
12.0	20.0	1.0	9.3	20.7	31.0	0.0	5.1	3.9	9.0
12.0	30.0	1.3	1.3	11.5	14.0	1.8	3.7	5.5	11.0

12.0	40.0	0.0	2.6	6.4	9.0	3.4	3.4	5.1	12.0
12.0	50 0	1.0	8.0	9.0	18.0	1.0	7.0	6.0	13.0
12.0	60 0	5.5	4 2	12.5	18.0	2.0	2.0	2.0	6.0
12 0	70 0	0.0	1.0	6.0	8.0	0 0	5.0	0.0	5.0
12 0	80.0	0 0	1 3	3.8	5.0	0.0	2.4	3.6	6.0
12 0	90 0	1.4	2.8	2.8	7.0	1 4	7.0	5.6	14.0
12 0	100 0	0.0	2.3	5.7	8.0	0.0	0.0	5.0	5.0
12.0	110.0	0.0	2.0	6.0	8.0	1.0	2.0	1.0	4.0
12.0	120.0	0.0	1.3	1.3	4.0	0.0	4 2	2.8	7.0
12.0	130 0	1.0	0.0	3.0	6.0	2.0	2.0	2.0	6.0
12 0	140.0	0.0	0.0	2.0	2.0	1.0	1.0	1.0	3 0
12 0	150.0	2.0	0.0	4.0	6.0	1.0	1 0	1.0	3.0
12.0	160.0	0.0	1.2	9.8	11.0	2.3	4.7	7.0	14.0
12.0	170.0	0.0	3.8	6.3	10.0	0.0	4.9	3.7	11.0
12 0	180.0	0.0	1.0	5 0	6.0	0.0	4.5	3.0	6.0
12 0	190 0	0.0	1.7	3.3	5.0	0.0	1.7	8.3	10.0
12 0	200.0	1.0	3.0	0.0	4 0	0.0	11.7	14.3	26.0
12 0	210.0	1.0	1.0	0.0	2.0	1.3	5.1	2.6	9.0
13.0	60 0	0.0	1.3	11 7	13.0	0.0	2.6	6.4	9.0
13.0	50 0	0.0	2.0	1.0	3.0	0.0	2.0	5.0	7.0
13 0	40.0	0.0	0.0	0.0	0.0	0.0	2.5	2.5	5.0
13.0	30 0	0.0	3.5	3.5	7.0	0.0	0.0	2.0	2.0
13.0	20 0	0.0	4.0	11.0	16.0	0.0	1.0	3.0	4.0
13.0	10.0	0.0	1 1	7.9	9.0	0 0	0.0	3.0	3.0
13.0	0.0	0.0	2.0	1.0	3 0	0.0	1.0	1.0	2.0
13.0	0.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
13.0	0.0	999.0	999.0	999.0	999.0	999.0	999.0	999 0	999.0
13 0	0.0	0.0	0.0	6.0	6.0	0.0	0.0	0.0	0.0
13.0	10.0	0.0	0.0	8.0	8.0	0.0	0.0	0.0	1.0
13.0	20.0	0.0	0.0	5.0	5.0	0.0	0.0	4.0	4.0
13 0	30 0	0 0	3.4	4.6	8.0	0.0	1 0	2.0	3.0
13 0	40.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
13.0	50 0	0.0	2.0	10.0	12.0	0.0	0.0	5.0	5.0
13.0	60.0	0.0	0.0	9.0	9.0	0.0	0.0	6.0	6.0
13 0	70.0	0.0	1 0	6.0	7.0	0.0	0.0	1.0	1.0
13 0	80.0	0.0	2.5	2.5	5 0	0.0	0.0	0.0	0.0
13.0	90.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
13.0	100.0	0.0	2.3	5.7	8.0	0.0	0.0	5.0	5.0
13.0	110.0	0.0	1.0	3.0	4.0	0.0	0.0	1.0	1.0
13.0	120.0	0.0	1.0	0.0	1.0	0.0	0.0	3.0	3.0
13.0	130.0	0.0	1.0	0.0	1.0	0.0	0.0	1.0	1.0
13 0	140.0	0.0	0.0	3.0	3.0	0.0	0.0	2.0	2.0
13.0	150.0	0.0	1.3	3.8	5.0	0.0	1.0	6.0	7.0
13 0	160 0	0.0	0.0	0.0	4.0	0.0	0.0	5.0	5.0
13.0	170.0	0.0	0.0	7.0	7.0	0.0	0.0	5.0	5.0
13.0	180.0	0.0	0.0	4.0	4.0	0.0	0.0	3.0	3.0
13 0	190.0	0.0	1.0	5.0	6.0	1.3	1.3	7.5	10.0
13.0	200.0	999 0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
13 0	210.0	0.0	1.0	0.0	1 0	0.0	0.0	0.0	0.0
14 0	60 0	0.0	1 1	9.9	11.0	0.0	1.0	2.0	3.0
14 0	50.0	0.0	1.0	5.0	6.0	0.0	1.0	3.0	4.0
14 0	40.0	0 0	0.0	5.0	5.0	0.0	0.0	0.0	0.0
14.0	30.0	0 0	1.0	4 0	5.0	1.3	0.0	2.7	4.0
14 0	20.0	0.0	0 0	2.0	2.0	0.0	3.3	1.7	5.0

14.0	10.0	1.0	1.0	6.0	8.0	0.0	1.0	2.0	3.0
14 0	0.0	0.0	0.0	6.0	6.0	0.0	0.0	1.0	1.0
14 0	0.0	999.0	999 0	999.0	999.0	999.0	999.0	999.0	999.0
14 0	0 0	999 0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
14 0	0 0	0 0	0.0	6 0	6.0	0 0	1.0	0.0	1.0
14.0	10.0	0.0	1.0	5.0	6.0	0.0	0.0	2.0	2.0
14.0	20.0	0.0	1 1	8.9	10.0	0.0	1.2	4.8	6.0
14 0	30 0	0.0	1 0	4.0	5.0	0 0	0.0	6.0	6.0
14 0	40.0	0.0	1.0	7.0	8.0	0.0	0.0	4.0	4.0
14.0	50.0	0.0	4.0	8.0	12.0	0.0	0.0	2.0	2.0
14.0	60 0	0.0	1.1	7.9	9.0	0.0	0.0	3.0	3.0
14 0	70.0	0.0	0.0	5.0	5.0	0.0	0.0	1.0	1.0
14 0	80.0	0.0	1.0	4.0	5.0	0.0	0.0	0.0	0.0
14 0	90.0	0.0	0.0	5.0	5.0	0.0	1.0	2.0	3.0
14 0	100.0	0.0	0.0	4.0	4.0	0.0	1.3	2.7	4.0
14.0	110.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14 0	120.0	0.0	1.0	4.0	5.0	1.0	1.0	2.0	4.0
14 0	130.0	0.0	0.0	4.0	4.0	0.0	0.0	0.0	0.0
14.0	140.0	1.0	0.0	3.0	4.0	0.0	0.0	1.0	1.0
14 0	150.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	2.0
14 0	160.0	0.0	0.0	2.0	2.0	0.0	1.7	3.3	5.0
14.0	170 0	0.0	0.0	3.0	3 0	0.0	2.8	4.2	7.0
14 0	180 0	0.0	0.0	3.0	3.0	0.0	2.0	1.0	3.0
14 0	190 0	0.0	1.0	1.0	2.0	0.0	3.3	6.7	10.0
14.0	200 0	0.0	0.0	1.0	0.0	0 0	10.0	5.0	15.0
14.0	210 0	0 0	0.0	0.0	0.0	0.0	0.0	1 0	1.0

VENN 1981B TOTAL

1.0	60.0	0.0	9.6	51.4	61.0	9.5	30.9	48.7	89.0
2.0	50.0	1.0	8.0	28.0	37.0	3.5	23.6	18.9	46.0
3.0	40.0	5.4	17.3	30.3	53.0	8.3	15.4	2.4	26.0
4.0	30.0	7.3	19.8	43.9	71.0	9.4	9.4	8.2	27.0
5.0	20.0	5.4	17.4	38.1	61.0	4.9	18.3	4.9	28.0
6.0	10.0	4.1	24.6	56.3	85.0	3.0	19.2	8.9	31.0
7.0	0.0	1.1	11.3	39.6	52.0	2.7	8.0	9.3	20.0
8.0	0.0	0.0	11.0	22.0	33.0	7.0	13.0	4.0	24.0
9.0	0.0	4.0	16.0	21.0	41.0	4.0	13.0	3.0	20.0
10.0	0.0	4.4	21.8	47.9	74.0	2.3	27.3	20.5	50.0
11.0	10.0	5.2	26.1	64.7	96.0	18.6	35.1	14.3	68.0
12.0	20.0	2.1	36.1	64.8	103.0	2.5	18.4	17.2	38.0
13.0	30.0	4.3	23.8	52.9	81.0	7.0	28.0	21.0	56.0
14.0	40.0	4.8	28.9	55.3	89.0	5.6	22.5	25.9	54.0
15.0	50.0	5.0	33.0	59.0	97.0	10.2	16.4	16.4	43.0
16.0	60.0	9.1	20.6	66.3	96.0	3.7	15.9	18.4	38.0
17.0	70.0	2.2	8.8	46.0	57.0	2.5	12.6	8.8	24.0
18.0	80.0	1.1	9.6	23.4	34.0	0.0	4.3	8.7	13.0
19.0	90.0	2.4	13.0	30.7	46.0	5.6	31.6	15.8	53.0
20.0	100.0	3.3	13.0	33.7	50.0	8.3	10.6	14.1	33.0
21.0	110.0	1.0	9.0	25.0	35.0	1.2	9.4	9.4	20.0
22.0	120.0	2.2	4.4	15.4	22.0	8.3	13.8	11.0	33.0
23.0	130.0	3.4	5.6	19.0	28.0	3.6	11.9	9.5	25.0
24.0	140.0	2.0	4.0	25.0	31.0	4.0	14.0	7.0	25.0
25.0	150.0	2.1	7.5	22.4	32.0	2.2	7.7	11.1	21.0
26.0	160.0	1.1	3.4	26.4	31.0	5.2	23.2	20.6	49.0
27.0	170.0	0.0	8.0	25.0	33.0	11.2	17.4	17.4	46.0
28.0	180.0	1.1	9.6	22.4	33.0	5.1	34.2	16.5	57.0
29.0	190.0	0.0	9.5	17.5	27.0	9.7	40.2	45.1	95.0
30.0	200.0	1.1	5.3	10.6	17.0	10.2	105.7	61.1	177.0
31.0	210.0	2.1	5.3	8.5	16.0	2.7	12.1	24.2	39.0

GREAT ENGLEBOURNE 1981A

TIME	DIST	F1+3	F5	F6	FT	M1	M2	M3	MT
1 0	5 0	1.0	1.0	4.0	6.0	17.0	7.0	5.0	29.0
1.0	5 0	2 0	0.0	0.0	2 0	4.0	2.0	1.0	7.0
1 0	10 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1 0	20.0	0.0	0.0	0.0	0.0	0.0	0 0	0.0	0.0
1.0	30 0	0 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1 0	30.0	1.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0
1 0	40 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1 0	40 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	60 0	0 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	60 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1 0	80 0	0.0	0 0	0.0	0.0	0 0	0.0	0.0	0.0
1.0	80 0	0 0	0.0	0.0	0.0	0 0	0.0	0.0	0.0
1.0	100 0	0 0	0.0	0 0	0 0	0.0	0.0	0.0	0.0
1.0	100.0	0 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	120.0	0.0	0.0	0.0	0 0	0.0	0.0	0.0	0.0
1 0	120.0	0.0	1.0	0.0	1 0	0.0	0 0	0.0	0.0
1 0	140 0	0.0	0.0	0 0	0.0	0.0	0.0	0.0	0.0
1 0	140.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1 0	160.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1 0	160.0	0.0	0.0	0.0	0.0	0.0	0 0	0.0	0.0
1.0	180 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1 0	200 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	200.0	0.0	0.0	0 0	0.0	0.0	0.0	0.0	0.0
1 0	220 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	220 0	0.0	0.0	0.0	0.0	1 0	0.0	0.0	1.0
1.0	240 0	0.0	1.0	0.0	1.0	1.0	0.0	0.0	1.0
1 0	240.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	260.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	260.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	280.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1 0	280.0	0.0	0 0	0 0	0.0	0.0	0.0	0.0	0.0
1.0	300.0	0 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1 0	300.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1 0	320.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	320 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	0.0	2.0	4.0	1.0	7.0	4.0	6.0	4.0	14.0
1.0	0.0	1.0	5.0	2.0	8.0	3.0	2.0	4.0	9.0
1.0	0 0	2.0	3.0	1.0	6.0	1 0	5.0	1.0	7.0
1 0	0.0	0.0	1.0	0.0	1.0	2 0	0.0	1.0	3.0
1.0	0 0	4.0	2.0	4.0	10.0	2.0	9.0	2.0	12.0
1.0	0.0	0.0	3.0	0.0	3.0	2.0	5.0	8.0	15.0
1 0	0 0	0.0	4.0	0.0	4.0	1 0	4 0	7.0	12.0
1 0	0.0	3.0	2.0	1.0	6.0	5.0	5.0	2.0	12.0
1 0	0.0	2 0	0.0	2.0	4.0	7.0	13.0	10.0	30.0
2.0	5 0	0.0	1.0	1.0	2.0	2.7	1 3	4.0	8.0
2 0	5 0	0 0	1.0	1.0	2.0	2.4	2.4	1.2	6.0
2 0	10.0	1.0	0.0	0.0	1.0	1.0	0.0	0.0	1.0
2.0	10.0	1.0	0.0	1.0	2.0	0.0	0.0	1.0	1.0
2.0	20 0	1.0	0.0	0.0	1 0	0.0	1.0	0.0	1.0
2.0	20.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0

2.0	30 0	2.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0
2.0	30.0	0.0	3.0	0.0	3.0	0.0	0.0	0.0	0.0
2.0	40 0	0 0	1.0	0.0	1.0	1.0	0.0	0.0	1.0
2 0	4.0	0.0	0.0	1.0	1.0	1.0	2.0	0.0	3.0
2.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.0	6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.0	8.0	0 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.0	8.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
2.0	10 0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0
2 0	10.0	0.0	2.0	0.0	2.0	0.0	0.0	0.0	0.0
2.0	12.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
2 0	12.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0
2 0	14 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.0	14.0	0 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.0	16.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.0	16.0	0 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.0	18.0	0 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.0	18.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.0	20 0	1.0	1.0	0.0	2.0	0.0	2.0	1.0	3.0
2 0	20 0	3.0	4.0	1.0	8.0	0.0	1.0	0.0	1 0
2 0	22.0	0 0	1.0	0.0	1 0	0 0	0.0	0.0	0.0
2.0	22.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
2.0	24 0	0 0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
2.0	24.0	0 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.0	26.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2 0	26 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.0	28 0	0.0	0.0	1 0	1.0	0.0	0 0	0.0	0.0
2.0	28 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.0	300 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.0	300 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.0	320 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.0	320.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
2 0	0 0	4.0	7.0	11.0	22.0	8.4	10.5	3.1	22.0
2.0	0.0	2.0	13.0	8.0	23.0	2.0	3.0	4.0	9.0
2.0	0 0	4.0	10.0	4.0	17.0	3.0	6.0	1.0	10.0
2.0	0.0	3.0	6.0	9.0	18.0	0.0	2.3	4.7	7.0
2.0	0.0	9.0	6.0	5.0	20.0	3.0	7.0	4.0	14.0
2.0	0.0	1.0	10.0	4.0	15.0	1.0	2.0	2.0	5.0
2.0	0 0	1.0	11.0	6.0	18.0	1.0	2.0	1.0	4.0
2.0	0.0	0 0	15.0	0.0	15.0	4.0	4.0	2.0	10.0
2 0	0.0	1.0	9.0	8.0	18.0	3.1	11.5	9.4	24.0
3.0	5 0	0 0	0.0	1.0	1.0	0.0	2.0	0.0	2.0
3.0	5.0	0.0	1.0	2.0	3 0	0.0	2.3	4.7	7.0
3.0	10.0	0.0	0 0	1.0	1.0	0.0	0.0	0 0	0.0
3 0	10.0	0.0	1.0	0.0	1 0	0.0	0.0	0.0	0.0
3 0	20.0	1.0	0 0	0.0	0 0	0.0	1.0	0 0	1 0
3 0	20 0	0.0	0.0	1.0	1 0	0.0	1.0	0.0	1.0
3 0	30.0	0 0	0 0	1.0	1.0	0.0	0 0	1 0	1.0
3 0	30 0	0.0	1 0	0.0	1.0	0.0	0.0	1.0	1.0
3 0	40 0	0.0	0.0	0.0	1.0	0.0	0.0	1 0	1.0
3.0	40.0	2.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0
3 0	60.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
3 0	60.0	0.0	1.0	1.0	2.0	0.0	0.0	1.0	1.0
3.0	80.0	0 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3 0	80.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

3.0	100.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	2.0
3.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.0	120.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.0	120.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.0	140.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.0	140.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.0	160.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.0	160.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.0	180.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0
3.0	180.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
3.0	200.0	1.0	1.0	0.0	2.0	0.0	0.0	0.0	0.0
3.0	200.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.0	220.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
3.0	220.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0
3.0	240.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.0	240.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.0	260.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.0	260.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.0	280.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.0	280.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
3.0	300.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.0	300.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.0	320.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.0	320.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.0	0.0	0.0	0.0	0.0	6.0	0.0	3.3	6.7	10.0
3.0	0.0	0.0	0.0	0.0	20.0	0.0	0.0	3.0	3.0
3.0	0.0	0.0	0.0	0.0	14.0	0.0	0.0	4.0	4.0
3.0	0.0	5.0	11.0	4.0	20.0	1.1	5.5	4.4	11.0
3.0	0.0	3.0	8.0	0.0	11.0	0.0	4.0	2.0	6.0
3.0	0.0	1.0	8.0	4.0	13.0	0.0	5.0	3.0	8.0
3.0	0.0	0.0	9.0	4.0	13.0	2.0	6.0	3.0	11.0
3.0	0.0	2.0	8.0	7.0	17.0	2.3	2.3	4.5	9.0
3.0	0.0	1.0	5.0	6.0	13.0	0.0	7.5	13.5	21.0
4.0	5.0	0.0	1.0	0.0	1.0	1.1	6.7	12.2	20.0
4.0	5.0	2.0	3.0	0.0	5.0	0.0	4.0	8.0	12.0
4.0	10.0	0.0	1.0	2.0	3.0	0.0	0.0	0.0	0.0
4.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0
4.0	20.0	0.0	1.0	1.0	2.0	0.0	0.0	0.0	0.0
4.0	30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.0	30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.0	40.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
4.0	40.0	0.0	0.0	0.0	0.0	1.0	1.0	0.0	2.0
4.0	60.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
4.0	60.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.0	80.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.0	80.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
4.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.0	100.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0
4.0	120.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.0	120.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.0	140.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.0	140.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.0	160.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.0	160.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0

4.0	180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.0	180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.0	200.0	0.0	0.0	0.0	0.0	0.0	1.0	4.0	5.0
4.0	200.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.0	220.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.0	220.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.0	240.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.0	240.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.0	260.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.0	260.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.0	280.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
4.0	280.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
4.0	300.0	1.0	1.0	0.0	2.0	0.0	0.0	0.0	0.0
4.0	300.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.0	320.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.0	320.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.0	0.0	0.0	3.0	4.0	7.0	0.0	5.8	1.2	7.0
4.0	0.0	0.0	9.0	6.0	15.0	3.3	4.4	4.4	12.0
4.0	0.0	1.0	9.0	2.0	12.0	0.0	1.1	6.9	8.0
4.0	0.0	0.0	0.0	4.0	4.0	0.0	0.0	5.0	5.0
4.0	0.0	0.0	1.0	1.0	2.0	0.0	0.0	0.0	0.0
4.0	0.0	0.0	1.0	1.0	2.0	0.0	1.0	1.0	2.0
4.0	0.0	0.0	7.0	0.0	7.0	0.0	2.0	0.0	2.0
4.0	0.0	0.0	1.0	3.0	4.0	0.0	1.0	2.0	3.0
4.0	0.0	0.0	2.0	3.0	5.0	5.0	4.0	12.0	21.0
5.0	5.0	0.0	2.0	4.0	6.0	3.0	5.0	5.0	13.0
5.0	5.0	0.0	1.0	0.0	1.0	1.2	1.2	3.6	6.0
5.0	10.0	0.0	0.0	2.0	2.0	0.0	0.0	0.0	0.0
5.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	2.0
5.0	20.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
5.0	20.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0	3.0
5.0	30.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0
5.0	30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0
5.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.0	60.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.0	60.0	0.0	1.0	1.0	2.0	0.0	1.0	0.0	1.0
5.0	80.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.0	80.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
5.0	100.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
5.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.0	120.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.0	120.0	0.0	1.0	1.0	2.0	0.0	0.0	0.0	0.0
5.0	140.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
5.0	140.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.0	160.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.0	160.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
5.0	180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.0	180.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0
5.0	200.0	0.0	1.0	1.0	2.0	0.0	0.0	0.0	0.0
5.0	200.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
5.0	220.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0
5.0	220.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.0	240.0	0.0	2.0	0.0	2.0	0.0	0.0	0.0	0.0
5.0	240.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

5.0	260.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.0	260.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.0	280.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.0	280.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.0	300.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.0	300.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.0	320.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.0	320.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.0	0.0	0.0	2.0	0.0	2.0	1.0	1.0	8.0	10.0
5.0	0.0	0.0	6.0	2.0	8.0	0.0	0.0	3.0	3.0
5.0	0.0	0.0	3.5	3.5	7.0	0.0	4.0	0.0	4.0
5.0	0.0	0.0	0.0	3.0	3.0	0.0	0.0	0.0	0.0
5.0	0.0	0.0	2.0	0.0	2.0	0.0	0.0	1.0	1.0
5.0	0.0	0.0	0.0	2.0	2.0	0.0	0.0	0.0	0.0
5.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
5.0	0.0	0.0	2.0	1.0	3.0	0.0	0.0	0.0	0.0
5.0	0.0	1.0	2.0	0.0	3.0	0.0	3.0	2.0	5.0
6.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.0
6.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	5.0
6.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	60.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	60.0	0.0	1.0	1.0	2.0	0.0	0.0	0.0	0.0
6.0	80.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	80.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	120.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0
6.0	120.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	140.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	140.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	160.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	160.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	200.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	200.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
6.0	220.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	220.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	240.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	240.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	260.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	260.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	280.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	280.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	300.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	300.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	320.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	320.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

6.0	0.0	0.0	1.0	0.0	1.0	0.0	2.0	3.0	5.0
6.0	0.0	0.0	1.0	1.0	2.0	0.0	0.0	0.0	0.0
6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	0.0	0.0	2.0	1.0	3.0	2.0	1.0	0.0	3.0
6.0	0.0	0.0	0.0	1.0	1.0	0.0	0.0	2.0	2.0
6.0	0.0	0.0	1.0	2.0	3.0	0.0	0.0	1.0	1.0
6.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3.0	3.0
6.0	0.0	0.0	2.0	1.0	3.0	0.0	0.0	1.0	1.0
6.0	0.0	0.0	5.0	2.0	7.0	1.0	6.0	10.0	17.0
7.0	5.0	0.0	2.0	0.0	2.0	0.0	0.0	1.0	1.0
7.0	5.0	0.0	1.0	0.0	1.0	0.0	0.0	2.0	2.0
7.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.0	30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.0	30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.0	60.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.0	60.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.0	80.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.0	80.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.0	100.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
7.0	120.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.0	120.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.0	140.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.0	140.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.0	160.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.0	160.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
7.0	180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.0	180.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.0	200.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
7.0	200.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.0	220.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
7.0	220.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
7.0	240.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
7.0	240.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
7.0	260.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
7.0	260.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
7.0	280.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
7.0	280.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
7.0	300.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
7.0	300.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
7.0	320.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
7.0	320.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
7.0	0.0	0.0	0.0	0.0	0.0	0.0	6.0	5.0	11.0
7.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	2.0
7.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0
7.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0
7.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.0	0.0	0.0	0.0	2.0	2.0	0.0	0.0	0.0	0.0
7.0	7.5	7.5	7.5	7.5	0.0	7.5	14.5	14.5	29.0

GREAT ENGLEBOURNE 1981A TOTAL

50.0	0.0	6.0	19.0	20.0	45.0	13.5	34.3	31.2	79 0
51.0	0 0	8.0	45.0	23.0	76 0	8.4	10.6	19.0	38.0
52.0	0 0	7.1	34.6	15.3	57.0	4 4	16.5	13.2	34.0
53.0	0.0	8 2	19.4	22 4	50.0	5.4	8.6	15.0	29 0
54 0	0 0	16 0	15.0	15.0	46.0	5 0	20.0	11.0	36.0
55 0	0 0	2.0	23 0	13.0	38.0	3 0	14.0	15.0	32.0
56 0	0.0	1.0	32.0	10.0	43 0	4.0	14 0	14.0	32.0
57 0	0 0	5 2	31.3	13.5	50.0	11 3	12.4	11.3	35.0
58 0	0 0	5.0	23.0	21.0	49.0	17 8	59.0	70.2	147.0
1 0	5 0	1.0	7 0	10.0	18.0	24.3	22.2	30.6	77.0
2.0	5.0	4.0	7.0	3.0	14.0	8.7	13.7	22.5	45.0
3 0	10 0	1.0	1.0	5 0	7 0	1.0	0.0	0.0	1.0
4 0	10.0	1.0	1.0	1.0	3.0	0.0	0.0	3.0	3.0
5 0	20.0	0.0	1.0	1 0	2.0	0.0	2.0	1.0	3.0
6.0	20.0	1.0	2.0	2.0	5.0	1.0	2 0	1.0	4.0
7.0	30 0	2.0	1.0	1.0	4.0	0.0	1.0	1.0	2.0
8.0	30.0	1.0	2.0	1.0	4.0	0.0	0.0	1.0	1.0
9 0	40 0	0 0	3.0	0.0	3.0	1.0	0.0	2.0	3.0
10 0	40.0	2.0	0.0	1.0	3.0	2.0	3.0	0.0	5.0
11.0	60 0	0.0	0.0	2.0	2.0	0.0	0.0	0.0	0.0
12.0	60.0	0.0	3.0	3.0	6.0	0.0	1.0	1.0	2.0
13.0	80.0	0.0	0.0	0.0	0.0	0.0	0.0	0 0	0.0
14 0	80 0	0.0	1.0	1.0	2.0	0.0	0.0	0.0	1.0
15 0	100.0	0.0	1.0	0.0	1.0	0.0	0.0	1.0	1.0
16 0	100 0	0.0	4.0	0.0	4.0	0.0	1.0	2.0	3.0
17 0	120 0	0.0	0.0	1.0	1.0	0.0	0.0	1.0	1.0
18.0	120.0	0.0	2.0	1.0	3.0	0.0	1 0	0.0	1.0
19.0	140 0	0.0	1.0	0.0	1.0	0 0	0.0	0.0	0.0
20 0	140 0	0.0	0.0	0.0	0 0	0.0	0 0	0.0	0.0
21.0	160.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22.0	160 0	0.0	3.0	0.0	3.0	0.0	0.0	0.0	0.0
23.0	180.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0
24.0	180.0	0.0	1.0	0.0	1.0	0.0	0.0	1.0	1 0
25.0	200 0	2.0	4.0	1.0	7.0	0.0	3.0	5.0	8.0
26.0	200.0	3.0	6.0	1.0	10.0	0.0	1.0	0.0	1.0
27.0	220.0	0 0	1.0	1.0	2.0	0.0	0.0	1.0	1.0
28 0	220.0	0.0	1.0	0.0	1.0	1.0	1 0	1 0	3.0
29 0	240.0	0.0	3.0	1 0	4.0	0.0	1.0	0.0	1.0
30.0	240 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
31.0	260.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
32.0	260.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
33 0	280 0	1.0	1.0	0.0	2.0	0.0	0.0	0.0	0.0
34 0	280.0	0 0	2.0	0.0	2.0	0.0	0.0	0.0	0.0
35.0	300.0	1.0	1.0	0.0	2.0	0.0	0.0	0.0	0.0
36.0	300 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
37 0	320 0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
38 0	320.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0

SEALE HAYNE 1981A

TIME	DIST	F1+3	F5	F6	FT	M1	M2	M3	MT
1.0	0.0	0.0	2.0	0.0	2.0	0.0	1.0	1.0	2.0
1.0	0.0	0.0	2.0	3.0	5.0	0.0	1.0	0.0	1.0
1.0	0.0	0.0	2.0	2.0	4.0	1.0	0.0	2.0	3.0
1.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	10.0	0.0	6.0	2.0	8.0	0.0	0.0	1.0	2.0
1.0	10.0	0.0	1.0	2.0	3.0	1.0	0.0	2.0	2.0
1.0	20.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
1.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	30.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0
1.0	30.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	2.0
1.0	30.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	2.0
1.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	40.0	0.0	1.0	0.0	1.0	0.0	0.0	2.0	2.0
1.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	50.0	0.0	1.0	0.0	1.0	0.0	1.0	0.0	1.0
1.0	50.0	0.0	2.0	1.0	3.0	0.0	1.0	2.0	3.0
1.0	50.0	0.0	0.0	0.0	0.0	1.0	1.0	3.0	6.0
1.0	60.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	2.0
1.0	60.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	60.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	70.0	0.0	0.0	1.0	1.0	0.0	1.0	1.0	2.0
1.0	70.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	70.0	0.0	2.0	0.0	2.0	0.0	0.0	2.0	2.0
1.0	80.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0
1.0	80.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
1.0	80.0	0.0	0.0	0.0	0.0	0.0	1.0	5.0	6.0
1.0	90.0	1.0	0.0	0.0	1.0	0.0	0.0	1.0	1.0
1.0	90.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0
1.0	90.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1.0	100.0	0.0	2.0	0.0	2.0	0.0	0.0	0.0	0.0
1.0	100.0	0.0	0.0	1.0	1.0	0.0	1.0	0.0	1.0
1.0	100.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.0	0.0	0.0	2.0	0.0	2.0	0.0	3.0	3.0	6.0
2.0	0.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
2.0	0.0	0.0	5.0	0.0	5.0	0.0	0.0	0.0	0.0
2.0	10.0	0.0	5.0	0.0	5.0	0.0	2.0	1.0	3.0
2.0	10.0	0.0	6.0	1.0	7.0	0.0	0.0	0.0	0.0
2.0	10.0	0.0	4.0	2.0	6.0	0.0	1.0	0.0	1.0
2.0	20.0	0.0	0.0	1.0	1.0	0.0	1.0	0.0	1.0
2.0	20.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
2.0	20.0	0.0	1.0	0.0	1.0	0.0	0.0	1.0	1.0
2.0	30.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
2.0	30.0	0.0	2.0	1.0	3.0	0.0	0.0	0.0	0.0
2.0	30.0	0.0	1.0	1.0	2.0	0.0	0.0	0.0	0.0
2.0	40.0	0.0	2.0	1.0	3.0	0.0	0.0	0.0	0.0
2.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.0	40.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
2.0	50.0	0.0	2.0	3.0	5.0	0.0	0.0	0.0	0.0
2.0	50.0	1.0	1.0	0.0	2.0	0.0	0.0	0.0	0.0
2.0	50.0	1.0	2.0	1.0	4.0	1.0	0.0	2.0	3.0
2.0	60.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

2.0	60.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
2.0	60.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
2.0	70.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.0	70.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.0	70.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.0	80.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.0	80.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
2.0	80.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.0	90.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.0	90.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
2.0	90.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2.0	100.0	0.0	4.0	1.0	5.0	0.0	1.0	0.0	1.0
2.0	100.0	0.0	5.0	4.0	9.0	1.0	2.0	2.0	5.0
2.0	100.0	1.0	2.0	1.0	4.0	2.0	0.0	0.0	2.0
3.0	0.0	0.0	5.0	4.0	9.0	0.0	0.0	1.0	1.0
3.0	0.0	0.0	2.0	3.0	5.0	0.0	0.0	0.0	0.0
3.0	0.0	0.0	8.0	5.0	13.0	0.0	1.0	0.0	1.0
3.0	10.0	0.0	3.0	4.0	7.0	0.0	0.0	0.0	0.0
3.0	10.0	0.0	3.0	4.0	7.0	0.0	0.0	0.0	0.0
3.0	10.0	0.0	2.0	1.0	3.0	0.0	0.0	0.0	0.0
3.0	20.0	0.0	0.0	1.0	1.0	0.0	1.0	0.0	1.0
3.0	20.0	0.0	2.0	0.0	2.0	0.0	0.0	0.0	0.0
3.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.0	30.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
3.0	30.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
3.0	30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.0	40.0	0.0	2.0	0.0	2.0	0.0	0.0	0.0	0.0
3.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.0	50.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
3.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.0	60.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.0	60.0	0.0	1.0	1.0	2.0	0.0	0.0	0.0	0.0
3.0	60.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
3.0	70.0	0.0	1.0	0.0	1.0	0.0	0.0	1.0	1.0
3.0	70.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.0	70.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.0	80.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.0	80.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.0	80.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
3.0	90.0	0.0	5.0	2.0	7.0	0.0	0.0	0.0	0.0
3.0	90.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
3.0	90.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3.0	100.0	0.0	5.0	0.0	5.0	0.0	0.0	0.0	0.0
3.0	100.0	0.0	2.0	1.0	3.0	0.0	0.0	0.0	0.0
3.0	100.0	0.0	2.0	0.0	2.0	0.0	0.0	0.0	0.0
4.0	0.0	0.0	5.0	3.0	8.0	1.0	2.0	0.0	3.0
4.0	0.0	1.0	3.0	3.0	7.0	0.0	0.0	2.0	2.0
4.0	0.0	0.0	9.0	3.0	12.0	0.0	0.0	0.0	0.0
4.0	10.0	0.0	1.0	3.0	4.0	0.0	0.0	2.0	2.0
4.0	10.0	0.0	3.0	3.0	6.0	0.0	0.0	0.0	0.0
4.0	10.0	0.0	6.0	2.0	8.0	0.0	0.0	0.0	0.0

4.0	20.0	0.0	7.0	3.0	10.0	0.0	0.0	0.0	0.0
4.0	20.0	0.0	6.0	0.0	6.0	0.0	1.0	0.0	1.0
4.0	20.0	0.0	6.0	0.0	6.0	0.0	0.0	0.0	0.0
4.0	30.0	0.0	2.0	1.0	3.0	0.0	0.0	0.0	0.0
4.0	30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.0	30.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.0	40.0	0.0	2.0	0.0	2.0	0.0	0.0	0.0	0.0
4.0	40.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
4.0	40.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.0	50.0	0.0	4.0	0.0	4.0	0.0	0.0	0.0	0.0
4.0	50.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
4.0	50.0	0.0	2.0	4.0	6.0	0.0	0.0	0.0	1.0
4.0	60.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
4.0	60.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
4.0	60.0	0.0	1.0	2.0	3.0	0.0	0.0	0.0	0.0
4.0	70.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.0	70.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
4.0	70.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.0	80.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.0	80.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
4.0	80.0	0.0	1.0	1.0	2.0	0.0	0.0	0.0	0.0
4.0	90.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4.0	90.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
4.0	90.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
4.0	100.0	0.0	11.0	2.0	13.0	0.0	0.0	0.0	0.0
4.0	100.0	0.0	4.0	1.0	5.0	0.0	0.0	0.0	0.0
4.0	100.0	0.0	3.0	0.0	3.0	0.0	0.0	0.0	0.0
5.0	0.0	0.0	3.0	6.0	9.0	0.0	0.0	1.0	1.0
5.0	0.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
5.0	0.0	0.0	20.0	9.0	29.0	0.0	1.0	0.0	1.0
5.0	10.0	0.0	2.0	2.0	4.0	0.0	0.0	0.0	0.0
5.0	10.0	0.0	3.0	3.0	6.0	0.0	0.0	0.0	0.0
5.0	10.0	0.0	3.0	1.0	6.0	0.0	0.0	0.0	0.0
5.0	20.0	0.0	8.0	7.0	15.0	0.0	0.0	0.0	0.0
5.0	20.0	0.0	3.0	3.0	6.0	0.0	0.0	0.0	0.0
5.0	20.0	0.0	3.0	1.0	4.0	0.0	0.0	0.0	0.0
5.0	30.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
5.0	30.0	0.0	2.0	3.0	5.0	0.0	0.0	0.0	0.0
5.0	30.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
5.0	40.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
5.0	40.0	0.0	1.0	1.0	2.0	0.0	0.0	0.0	0.0
5.0	40.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
5.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.0	50.0	0.0	1.0	1.0	2.0	0.0	0.0	0.0	0.0
5.0	50.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
5.0	60.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.0	60.0	0.0	1.0	2.0	3.0	0.0	0.0	0.0	0.0
5.0	60.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.0	70.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.0	70.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.0	70.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
5.0	80.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.0	80.0	0.0	2.0	0.0	2.0	0.0	0.0	0.0	0.0
5.0	80.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0

5.0	90.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0
5.0	90.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
5.0	90.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5.0	100.0	0.0	10.0	6.0	16.0	0.0	0.0	0.0	0.0
5.0	100.0	0.0	3.0	1.0	4.0	0.0	0.0	0.0	0.0
5.0	100.0	0.0	1.0	2.0	3.0	0.0	0.0	0.0	0.0
6.0	0.0	0.0	8.0	8.0	16.0	0.0	0.0	1.0	1.0
6.0	0.0	0.0	10.0	14.0	24.0	0.0	0.0	0.0	1.0
6.0	0.0	0.0	19.1	14.9	34.0	0.0	2.0	0.0	2.0
6.0	10.0	0.0	3.0	1.0	4.0	0.0	0.0	0.0	0.0
6.0	10.0	0.0	1.0	1.0	2.0	0.0	0.0	0.0	0.0
6.0	10.0	0.0	2.0	2.0	4.0	0.0	2.0	0.0	2.0
6.0	20.0	0.0	4.0	5.0	9.0	0.0	1.0	0.0	1.0
6.0	20.0	0.0	2.3	4.7	7.0	0.0	0.0	0.0	0.0
6.0	20.0	0.0	5.0	0.0	5.0	0.0	0.0	1.0	1.0
6.0	30.0	0.0	1.5	1.5	3.0	0.0	2.0	0.0	2.0
6.0	30.0	0.0	2.0	0.0	2.0	0.0	0.0	0.0	0.0
6.0	30.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
6.0	40.0	0.0	3.0	3.0	6.0	0.0	0.0	0.0	0.0
6.0	40.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
6.0	40.0	0.0	1.0	1.0	2.0	0.0	0.0	0.0	0.0
6.0	50.0	0.0	1.0	1.0	2.0	0.0	0.0	0.0	0.0
6.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	50.0	0.0	1.0	1.0	2.0	0.0	0.0	0.0	0.0
6.0	60.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0
6.0	60.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	60.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
6.0	70.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	70.0	0.0	0.0	0.0	0.0	0.0	1.0	2.0	3.0
6.0	70.0	0.0	1.0	0.0	1.0	0.0	0.0	1.0	1.0
6.0	80.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	80.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	80.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	90.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	90.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
6.0	90.0	0.0	2.0	0.0	2.0	0.0	0.0	0.0	0.0
6.0	100.0	0.0	1.0	4.0	5.0	0.0	0.0	0.0	0.0
6.0	100.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
6.0	100.0	0.0	2.0	0.0	2.0	0.0	0.0	0.0	0.0
7.0	0.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
7.0	0.0	0.0	2.8	8.3	11.0	0.0	0.0	1.0	1.0
7.0	0.0	0.0	10.0	15.0	25.0	0.0	0.0	2.0	2.0
7.0	10.0	0.0	0.0	2.0	2.0	0.0	0.0	1.0	1.0
7.0	10.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
7.0	10.0	0.0	0.0	5.0	5.0	0.0	0.0	0.0	0.0
7.0	20.0	0.0	2.0	3.0	5.0	0.0	0.0	0.0	0.0
7.0	20.0	0.0	2.0	0.0	2.0	0.0	0.0	0.0	0.0
7.0	20.0	0.0	3.9	5.1	9.0	0.0	0.0	0.0	0.0
7.0	30.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	2.0
7.0	30.0	0.0	0.0	0.0	0.0	0.0	2.0	1.0	3.0
7.0	30.0	0.0	0.0	1.0	1.0	0.0	0.0	2.0	2.0
7.0	40.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
7.0	40.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
7.0	40.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0

7.0	50.0	0.0	1.0	1.0	2.0	0.0	0.0	0.0	0.0
7.0	50.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
7.0	50.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
7.0	60.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
7.0	60.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
7.0	60.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
7.0	70.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
7.0	70.0	0.0	0.0	0.0	0.0	0.0	2.0	2.0	4.0
7.0	70.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0
7.0	80.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.0	80.0	0.0	1.0	1.0	2.0	0.0	0.0	0.0	0.0
7.0	80.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
7.0	90.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.0	90.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
7.0	90.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7.0	100.0	0.0	1.0	1.0	2.0	0.0	0.0	0.0	0.0
7.0	100.0	0.0	1.0	8.0	9.0	1.0	0.0	1.0	2.0
7.0	100.0	0.0	1.0	2.0	3.0	0.0	0.0	0.0	0.0
8.0	0.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
8.0	0.0	0.0	1.5	1.5	3.0	0.0	0.0	0.0	0.0
8.0	0.0	0.0	2.0	5.0	7.0	0.0	0.0	0.0	0.0
8.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8.0	10.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
8.0	10.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
8.0	20.0	0.0	3.0	1.0	4.0	0.0	0.0	0.0	0.0
8.0	20.0	0.0	0.0	3.0	3.0	0.0	0.0	0.0	0.0
8.0	20.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0
8.0	30.0	0.0	1.0	1.0	2.0	0.0	1.0	2.0	3.0
8.0	30.0	0.0	1.0	0.0	1.0	1.0	1.0	1.0	3.0
8.0	30.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	2.0
8.0	40.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
8.0	40.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
8.0	40.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	2.0
8.0	50.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
8.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8.0	50.0	0.0	2.0	0.0	2.0	0.0	0.0	1.0	1.0
8.0	60.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0
8.0	60.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8.0	60.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8.0	70.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
8.0	70.0	0.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0
8.0	70.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	0.0
8.0	80.0	0.0	1.0	2.0	3.0	0.0	0.0	0.0	0.0
8.0	80.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8.0	80.0	0.0	2.0	0.0	2.0	0.0	0.0	0.0	0.0
8.0	90.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	1.0
8.0	90.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0
8.0	90.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8.0	100.0	0.0	0.0	2.0	2.0	0.0	0.0	0.0	0.0
8.0	100.0	0.0	1.0	3.0	4.0	0.0	0.0	0.0	0.0
8.0	100.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0	999.0

SEALE HAYNE 1981A TOTAL

1.0	0.0	0.0	26.0	21.0	47.0	1.0	6.0	7.0	14.0
2.0	0.0	1.1	21.6	32.4	55.0	0.0	1.3	3.8	5.0
3.0	0.0	0.0	76.1	52.9	129.0	1.1	3.4	4.5	9.0
4.0	10.0	0.0	14.0	12.0	26.0	0.0	2.0	4.0	6.0
5.0	10.0	0.0	22.0	14.0	36.0	1.0	0.0	1.0	2.0
6.0	10.0	0.0	20.1	15.9	36.0	0.0	2.5	2.5	5.0
7.0	20.0	0.0	24.0	21.0	45.0	0.0	3.0	0.0	3.0
8.0	20.0	0.0	15.6	10.4	26.0	0.0	1.0	0.0	1.0
9.0	20.0	0.0	19.6	5.4	25.0	0.0	0.0	3.0	3.0
10.0	30.0	0.0	6.6	4.4	11.0	0.0	5.0	3.0	8.0
11.0	30.0	0.0	8.0	4.0	12.0	1.0	5.0	2.0	8.0
12.0	30.0	0.0	3.0	2.0	5.0	0.0	1.0	5.0	6.0
13.0	40.0	0.0	10.0	4.0	14.0	0.0	0.0	0.0	0.0
14.0	40.0	0.0	8.0	1.0	9.0	0.0	0.0	2.0	2.0
15.0	40.0	0.0	1.0	3.0	4.0	0.0	1.0	1.0	2.0
16.0	50.0	0.0	9.0	6.0	15.0	0.0	1.0	0.0	1.0
17.0	50.0	1.0	4.0	3.0	8.0	0.0	1.0	2.0	3.0
18.0	50.0	1.0	8.0	6.0	15.0	2.0	1.0	7.0	10.0
19.0	60.0	0.0	1.0	0.0	1.0	0.0	0.0	3.0	3.0
20.0	60.0	0.0	2.0	4.0	6.0	0.0	1.0	0.0	1.0
21.0	60.0	0.0	4.0	2.0	6.0	0.0	0.0	0.0	0.0
22.0	70.0	0.0	2.0	3.0	5.0	0.0	1.0	2.0	3.0
23.0	70.0	0.0	2.0	0.0	2.0	0.0	3.0	4.0	7.0
24.0	70.0	0.0	3.0	2.0	5.0	0.0	1.0	3.0	4.0
25.0	80.0	0.0	1.0	2.0	3.0	0.0	0.0	1.0	1.0
26.0	80.0	0.0	4.0	2.0	6.0	0.0	0.0	0.0	0.0
27.0	80.0	0.0	5.0	1.0	6.0	0.0	1.2	5.8	7.0
28.0	90.0	1.0	6.0	2.0	9.0	0.0	0.0	2.0	2.0
29.0	90.0	0.0	0.0	1.0	1.0	0.0	0.0	1.0	1.0
30.0	90.0	0.0	2.0	1.0	3.0	0.0	0.0	0.0	0.0
31.0	100.0	0.0	34.7	15.3	50.0	0.0	1.0	0.0	1.0
32.0	100.0	0.0	16.0	20.0	36.0	2.0	3.0	3.0	8.0
33.0	100.0	1.0	11.0	5.0	17.0	2.0	0.0	0.0	2.0

SEALE-HAYNE 1981C

TIME	DIST	F1+3	F5	F6	FT	M1	M2	M3	MT
16	0	0	1	0	1	0	0	0	0
16	0	0	0	3	3	0	0	1	1
16	0	0	1	0	1	1	0	0	1
16	10	0	0	0	0	0	0	0	0
16	10	0	0	0	0	0	0	0	0
16	10	0	1	0	1	0	0	0	0
16	20	0	1	0	1	0	0	0	0
16	20	0	0	0	0	0	0	0	0
16	20	0	0	0	0	0	1	0	1
16	30	0	0	0	0	0	0	0	0
16	30	0	0	0	0	0	0	0	0
16	30	0	0	0	0	0	0	0	0
16	40	0	0	1	1	0	0	0	0
16	40	0	0	0	0	0	0	0	0
16	40	0	0	0	0	0	0	0	0
16	50	0	0	0	0	0	0	0	0
16	50	0	0	0	0	0	0	0	0
16	50	0	0	0	0	0	0	0	0
16	60	0	1	0	1	0	0	0	0
16	60	0	1	0	1	0	0	0	0
16	60	0	0	1	1	0	0	0	0
16	70	0	0	0	0	0	0	0	0
16	70	0	2	0	2	0	0	0	0
16	70	0	2	0	2	0	1	0	1
16	80	0	0	0	0	0	0	0	0
16	80	0	0	0	0	0	0	0	0
16	80	0	0	0	0	0	0	0	0
16	90	0	0	0	0	0	0	0	0
16	90	0	0	0	0	0	0	0	0
16	90	0	0	0	0	0	0	0	0
16	100	0	0	0	0	0	0	0	0
16	100	0	0	0	0	0	0	0	0
16	100	0	0	0	0	0	0	0	0
16	110	0	0	0	0	0	0	0	0
16	110	0	0	0	0	0	1	0	1
16	110	0	0	0	0	0	0	1	1
16	120	0	0	0	0	0	0	0	0
16	120	???	???	???	???	???	???	???	???
16	120	0	0	0	0	1	0	0	1
17	0	0	1	0	1	0	0	1	1
17	0	0	0	1	1	0	0	1	1
17	0	0	2	1	3	1	0	0	1
17	10	0	1	1	2	0	1	3	4
17	10	0	1	0	1	0	0	2	2
17	10	0	0	0	0	0	0	0	0
17	20	0	0	0	0	0	0	0	0
17	20	0	0	0	0	0	0	0	0
17	20	0	0	0	0	0	0	0	0
17	30	0	0	0	0	0	0	0	0
17	30	0	1	0	1	0	0	0	0
17	30	0	0	0	0	0	0	0	0

17	40	0	0	0	0	0	0	0	0
17	40	0	0	1	1	0	0	0	0
17	40	0	0	0	0	0	0	0	0
17	50	0	0	0	0	0	0	0	0
17	50	0	0	0	0	0	0	0	0
17	50	0	0	0	0	0	0	0	0
17	60	0	0	0	0	0	0	0	0
17	60	0	0	0	0	0	0	0	0
17	60	0	0	0	0	0	0	0	0
17	70	0	0	0	0	0	0	0	0
17	70	0	0	0	0	0	0	0	0
17	70	0	0	0	0	0	0	0	0
17	80	0	0	0	0	0	0	0	0
17	80	0	0	0	0	0	0	0	0
17	80	0	0	0	0	0	1	0	1
17	90	0	0	0	0	0	0	0	0
17	90	0	0	0	0	0	0	0	0
17	90	0	0	0	0	0	0	0	0
17	100	0	1	0	1	0	0	0	0
17	100	0	0	0	0	0	0	0	0
17	100	0	0	0	0	0	0	0	0
17	110	0	0	0	0	0	0	0	0
17	110	0	0	0	0	0	0	0	0
17	110	0	0	0	0	0	0	0	0
17	120	0	0	0	0	0	0	0	0
17	120	0	0	0	0	0	0	0	0
17	120	0	0	0	0	0	0	0	0
18	0	0	0	0	0	0	0	0	0
18	0	0	3	1	4	0	1	0	1
18	0	0	3 7	1 3	5	0	0	0	0
18	10	0	0	1	1	0	0	1	1
18	10	0	1	0	1	0	0	0	0
18	10	0	1	0	1	0	0	0	0
18	20	0	0	1	1	0	0	0	0
18	20	0	0	0	0	0	0	0	0
18	20	0	0	1	1	0	0	0	0
18	30	0	0	0	0	0	0	0	0
18	30	0	0	0	0	0	0	0	0
18	30	0	0	0	0	0	0	0	0
18	40	0	0	1	1	0	0	0	0
18	40	0	0	0	0	0	0	0	0
18	40	0	1	0	1	0	0	0	0
18	50	0	0	0	0	0	0	0	0
18	50	0	0	0	0	0	0	0	0
18	50	0	0	0	0	0	0	0	0
18	60	0	0	0	0	0	0	0	0
18	60	0	0	0	0	0	0	0	0
18	60	0	1	0	1	0	0	0	0
18	70	0	0	0	0	0	0	0	0
18	70	0	0	0	0	0	0	0	0
18	70	0	0	0	0	0	0	0	0
18	80	0	0	0	1	0	0	0	0
18	80	0	0	0	0	0	0	0	0
18	80	0	0	0	1	0	0	0	0
18	90	0	0	0	0	0	0	0	0

18	90	0	0	0	0	0	0	0	0
18	90	0	0	0	0	0	0	0	0
18	100	0	0	0	0	0	0	0	0
18	100	0	0	0	0	0	0	0	0
18	100	0	0	0	0	0	0	3	3
18	110	0	0	0	0	0	0	0	0
18	110	0	0	0	0	0	0	1	1
18	110	0	0	0	0	0	0	0	0
18	120	0	0	0	0	0	0	0	0
18	120	0	0	1	1	0	0	0	0
18	120	0	0	0	0	0	0	0	0
19	0	0	0	1	1	0	0	0	0
19	0	0	6	0	5	0	1	0	1
19	0	0	1	5	6	0	0	0	0
19	10	0	0	1	1	0	0	0	0
19	10	0	0	1	1	0	0	0	0
19	10	0	0	1	1	0	0	0	0
19	20	0	0	1	1	0	0	1	1
19	20	0	0	0	0	0	0	0	0
19	20	0	0	0	0	0	1	0	1
19	30	0	0	0	0	0	0	0	0
19	30	0	0	0	0	0	0	0	0
19	30	0	0	0	0	0	0	0	0
19	40	0	0	0	0	0	0	0	0
19	40	0	0	0	0	0	0	0	0
19	40	0	0	0	0	0	0	0	0
19	50	0	0	1	1	0	0	0	0
19	50	0	0	1	1	0	0	0	0
19	50	0	0	0	0	0	0	0	0
19	60	0	0	0	0	0	0	0	0
19	60	0	0	1	1	0	0	0	0
19	60	0	0	0	0	0	0	0	0
19	70	0	0	0	0	0	0	0	0
19	70	0	0	0	0	0	0	0	0
19	70	0	0	0	0	0	0	0	0
19	80	0	0	0	0	0	0	0	0
19	90	0	0	0	0	0	0	0	0
19	80	0	0	0	0	0	0	0	0
19	90	0	0	0	0	0	0	0	0
19	90	0	0	0	0	0	0	0	0
19	90	0	0	0	0	0	0	0	0
19	100	0	0	0	0	0	0	0	0
19	100	0	0	0	0	0	0	0	0
19	100	0	0	1	1	0	0	0	0
19	110	0	0	0	0	0	0	0	0
19	110	0	0	0	0	0	0	0	0
19	110	0	0	0	0	0	0	0	0
19	120	0	0	0	0	0	0	0	0
19	120	0	0	0	0	0	0	0	0
19	120	0	0	0	0	0	0	0	0

SEALE-HAYNE 1981C-TOTAL .

1	0	0	2	1	3	0	0	1	1
2	0	0	7	3	14	0	2	2	4
3	0	0	7	7	15	2	0	0	2
4	10	0	1	3	4	0	1	4	5
5	10	0	2	1	3	0	0	2	2
6	10	0	2	1	3	0	0	0	0
7	20	0	1	2	3	0	0	1	1
8	20	0	0	0	0	0	0	0	0
9	20	0	0	1	1	0	2	0	2
10	30	0	0	0	0	0	0	0	0
11	30	0	1	0	1	0	0	0	0
12	30	0	0	0	0	0	0	0	0
13	40	0	0	2	2	0	0	0	0
14	40	0	0	1	1	0	0	0	0
15	40	0	1	1	2	0	0	0	0
16	50	0	0	1	1	0	0	0	0
17	50	0	0	1	1	0	0	0	0
18	50	0	0	0	0	0	0	0	0
19	60	0	1	0	1	0	0	0	0
20	60	0	2	1	3	0	0	0	0
21	60	0	0	1	1	0	0	0	0
22	70	0	0	0	0	0	0	0	0
23	70	0	2	0	2	0	0	0	0
24	70	0	3	0	3	0	0	1	1
25	80	0	0	0	0	0	0	0	0
26	80	0	0	1	1	0	0	0	0
27	80	0	0	0	0	0	0	0	0
28	90	0	0	0	0	0	1	0	1
29	90	0	0	0	0	0	0	0	0
30	90	0	0	0	0	0	0	0	0
31	100	0	1	0	1	0	0	0	0
32	100	0	0	0	0	0	0	0	0
33	100	0	0	1	1	0	0	3	3
34	110	0	0	0	0	0	0	0	0
35	110	0	0	1	1	0	1	1	2
36	110	0	0	0	0	0	0	1	1
37	120	0	0	0	0	0	0	0	0
38	120	0	0	1	1	0	0	0	0
39	120	0	0	0	0	0	0	0	0

APPENDIX EIGHT

A summary of the results of fitting the regression models to the data from the different generations at the three smaple sites.

TABLE 24

The result of fitting the regression model to the data from Venn 1980B.

Age-group	Intercept(a)	Slope(b)	SE b	N	F	R^2
F 1+3	5.40	-0.150	13.9	29	67.0[c]	82.5
		-0.179	16.2			
F 5	6.26	-0.070	18.7	29	81.6[c]	85.2
		-0.167	10.9			
F 6	7.22	-0.084	21.7	29	62.6[c]	81.5
		-0.206	12.3			
F T	7.54	-0.079	15.1	29	120.6[c]	89.5
		-0.183	9.1			
M 1	5.47	-0.064	55.0	29	28.8[c]	66.5
		-0.198	22.0			
M 2	6.41	-0.017	77.7	29	49.7[c]	77.7
		-0.190	13.9			
M 3	5.89	+0.025	64.5	29	72.5[c]	83.6
		-0.198	9.8			
M T	7.10	-0.005	29.8	29	77.0[c]	84.5
		-0.195	10.6			

a = $P < 0.05$
b = $P < 0.01$
c = $P < 0.001$

FIG. 79

The regression of female total on distance for Venn 1980B.

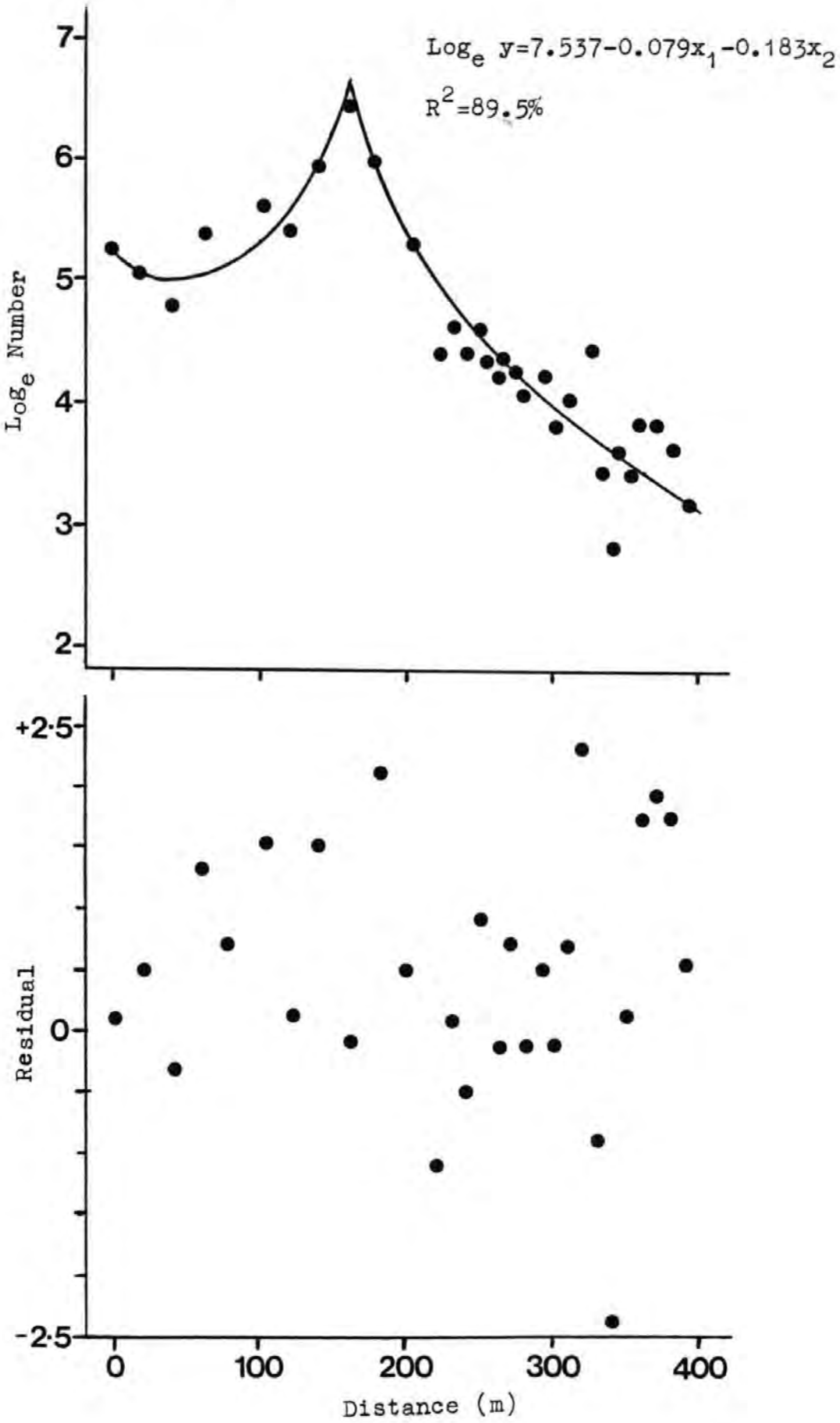


FIG. 80

The regression of male total on distance for Venn 1980B.

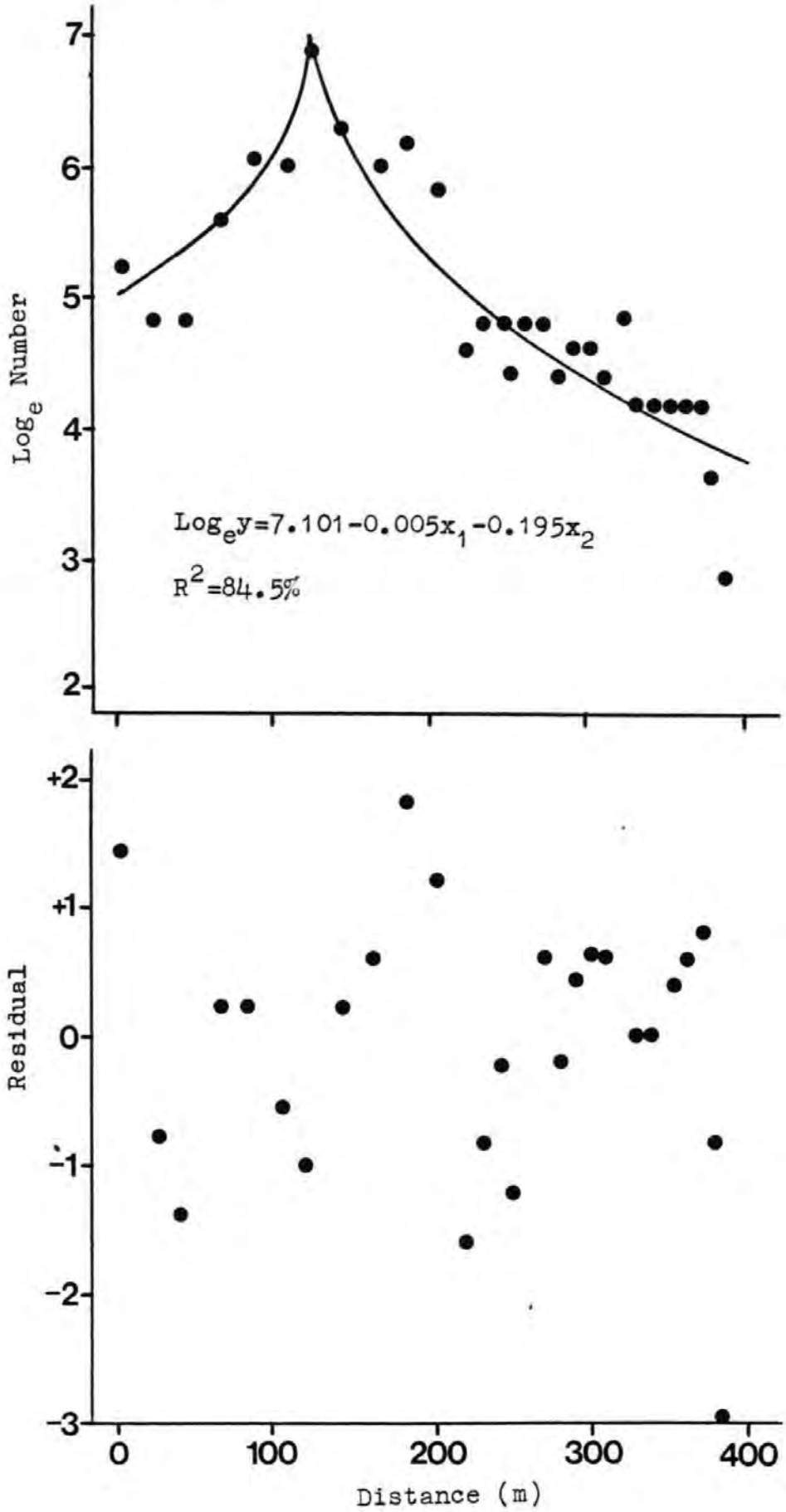
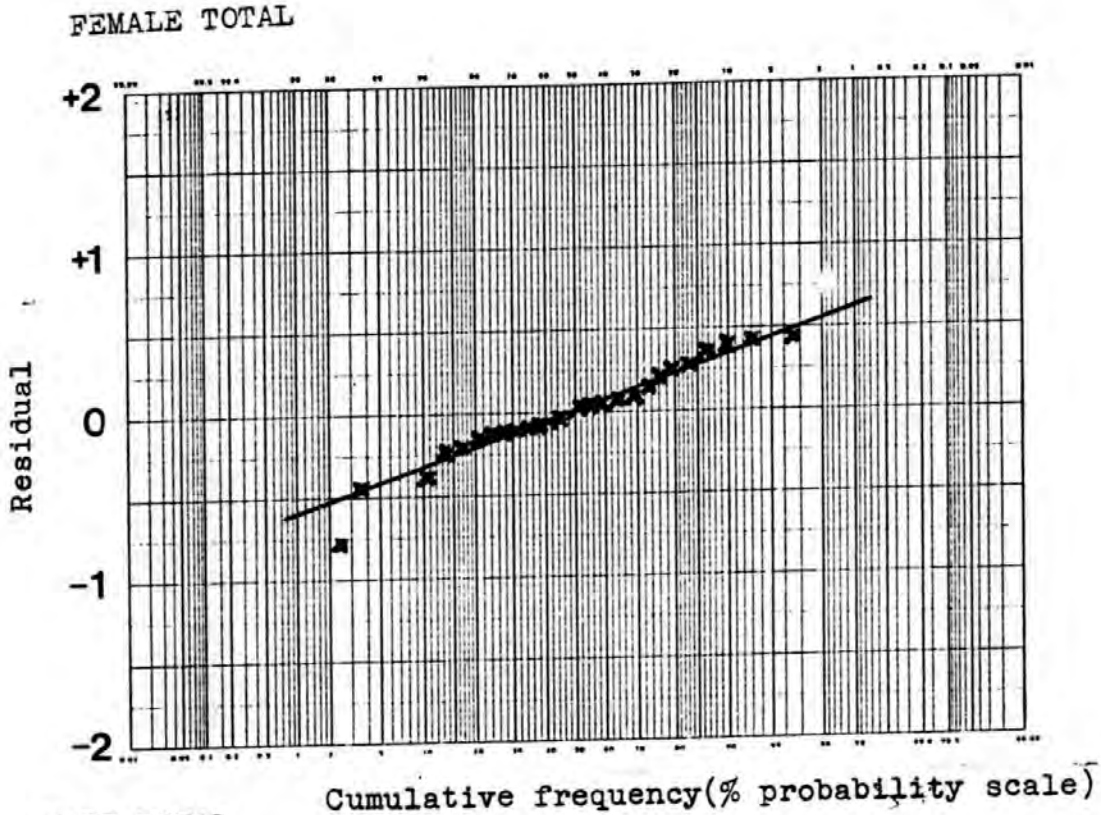


FIG. 81

A test of the normality of the residuals from Venn 1980B using probability paper.



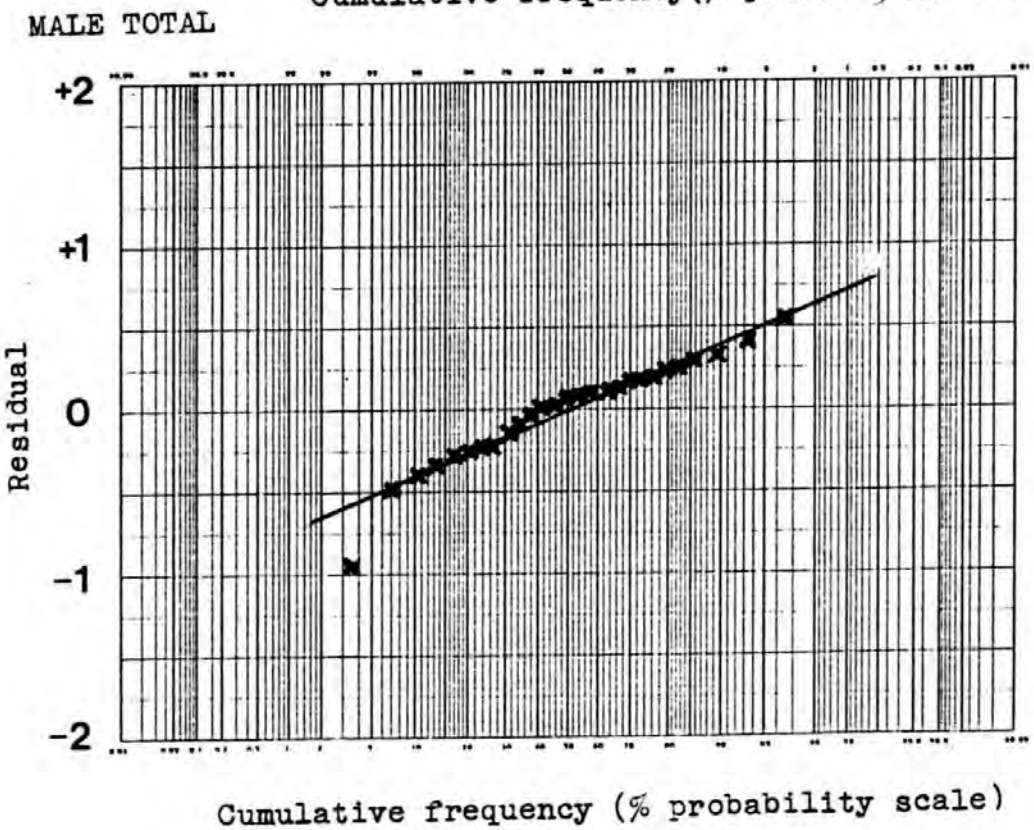


TABLE 25

The results of fitting the regression model to the data of Venn 1981A.

Age-group	Intercept(a)	Slope(b)	SE b	N	F	R^2
F 1+3	1.53	-0.044 -0.070	152.0 75.3	42	5.6[c]	25.2
F 5	4.02	-0.159 -0.110	32.8 34.8	56	14.8[c]	42.9
F 6	2.88	-0.110 -0.098	50.4 41.4	55	30.3[c]	62.0
F T	4.56	-0.146 -0.121	32.1 28.4	56	27.9[c]	59.4
M 1	1.24	-0.040 -0.067	178.5 80.9	38	16.6[c]	55.8
M 2	2.80	-0.126 -0.131	58.7 42.4	46	21.1[c]	57.2
M 3	1.55	-0.046 -0.061	38.4 77.5	48	37.7[c]	70.1
M T	3.98	-0.157 -0.163	37.2 26.3	56	49.4[c]	72.5

FIG. 82

The regression of female total on distance for Venn 1981A.

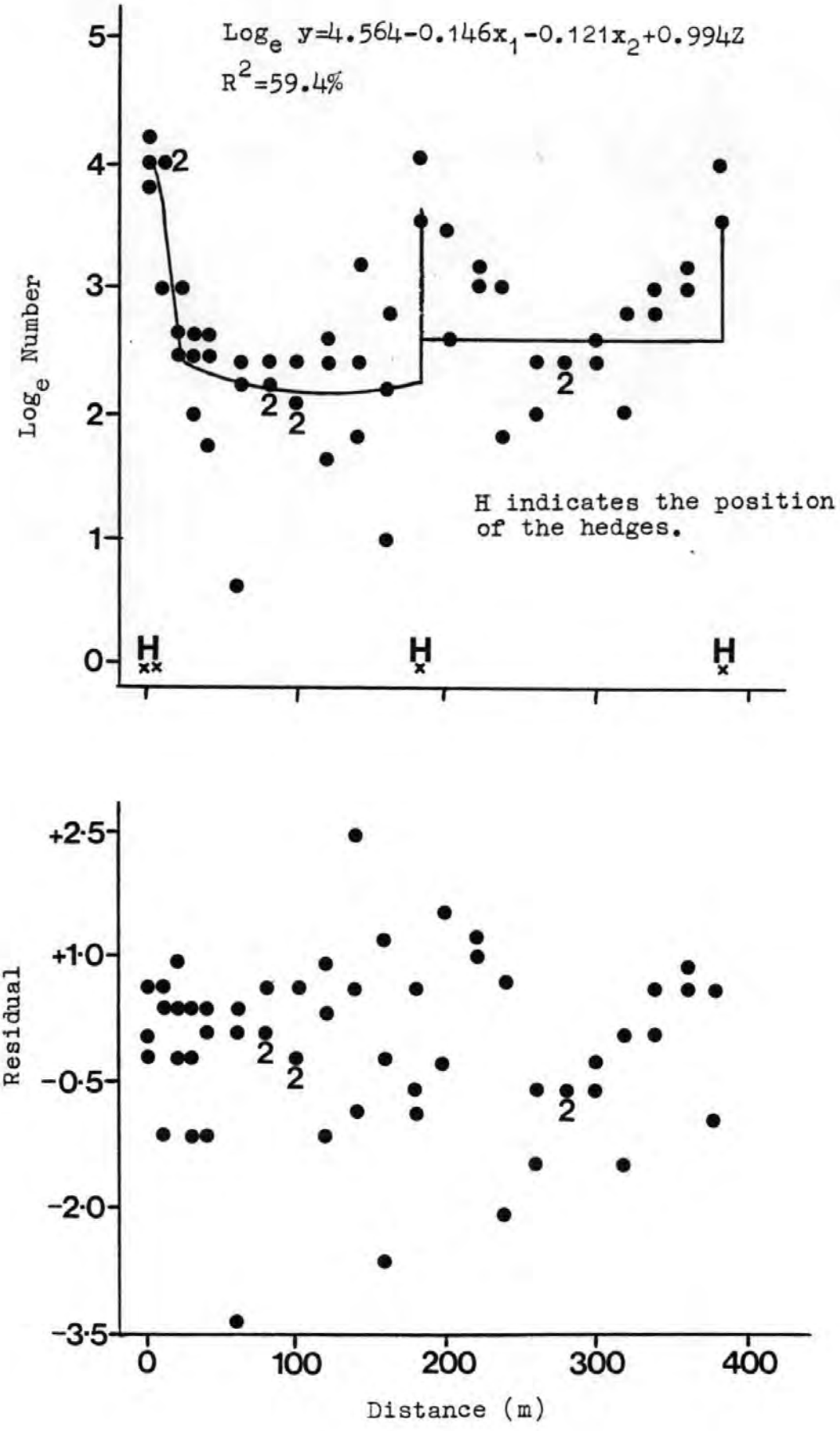


FIG. 83

The regression of male total on distance for Venn 1981A.

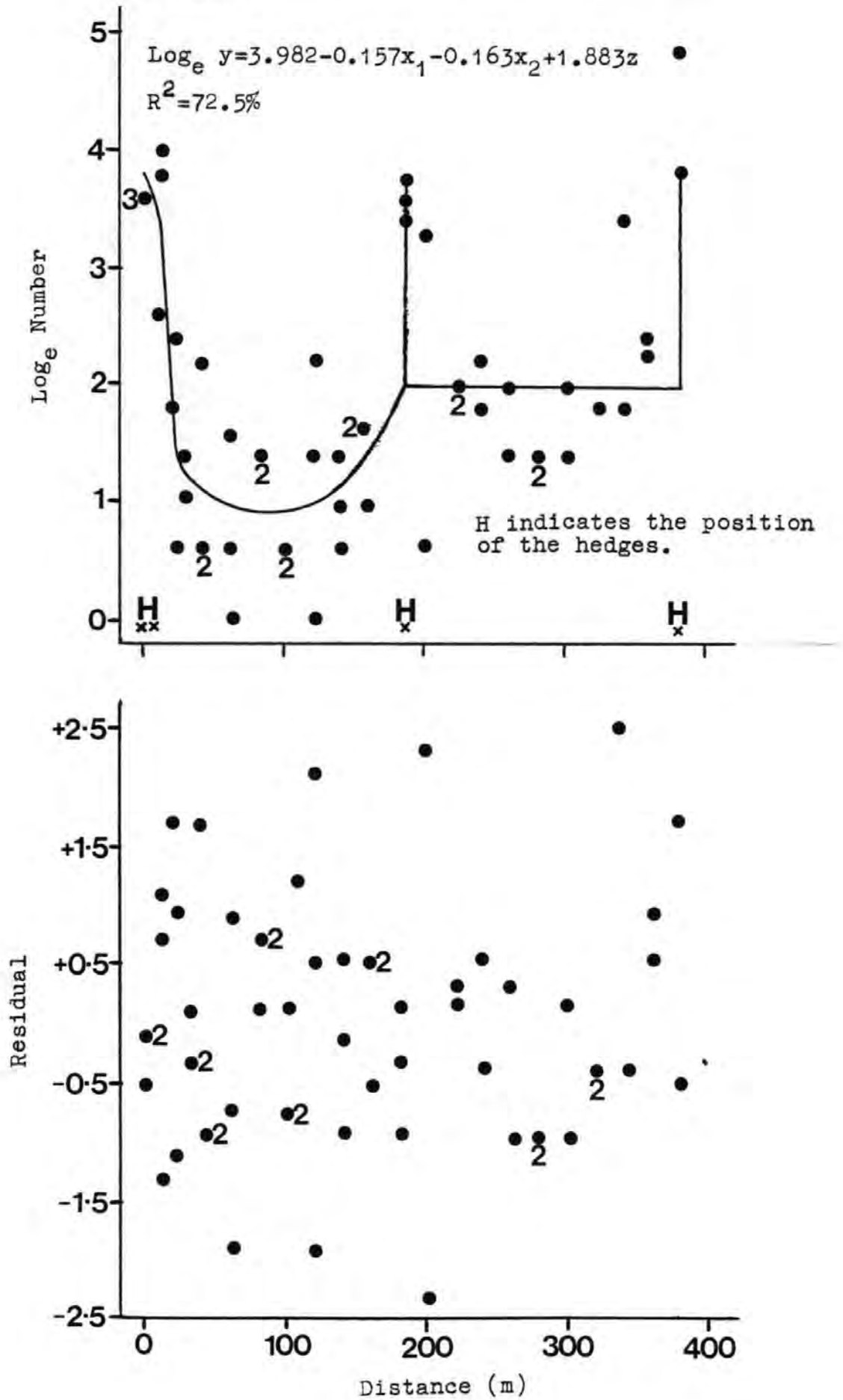
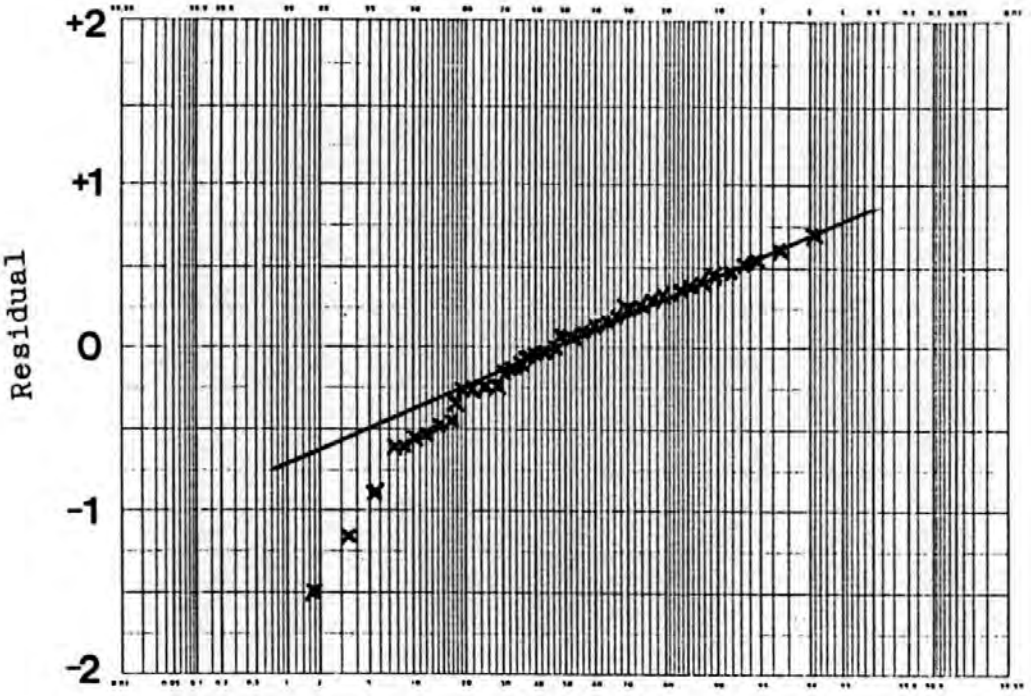


FIG. 84

A test of the normality ot the residuals from Venn 1981A using probability paper.

FEMALE TOTAL



MALE TOTAL

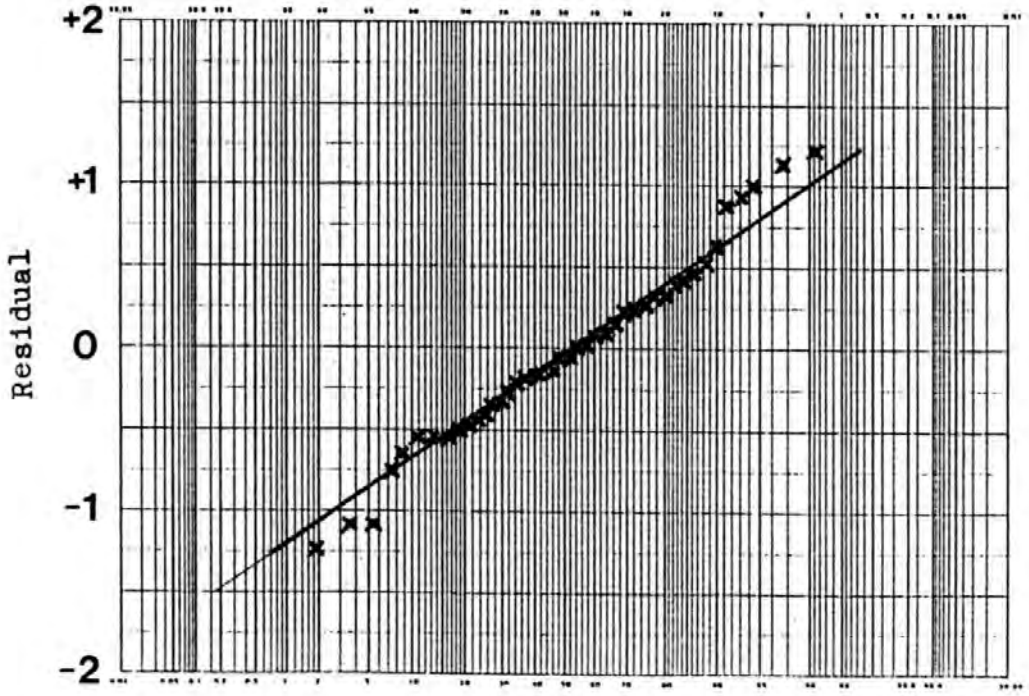


TABLE 26

The results of fitting the regression model to the data of Venn 1981B.

Age-group	Intercept(a)	Slope(b)	SE b	N	F	R^2
F 1+3	1.67	-0.071	37.2	27	8.8^b	17.1
F 5	3.52	-0.128	15.4	31	45.5^c	60.1
F 6	4.29	-0.101	16.1	31	48.7^c	61.8
F T	4.73	-0.107	13.5	31	62.3^c	67.4

FIG. 85

The regression of female total on distance for Venn 1981B.

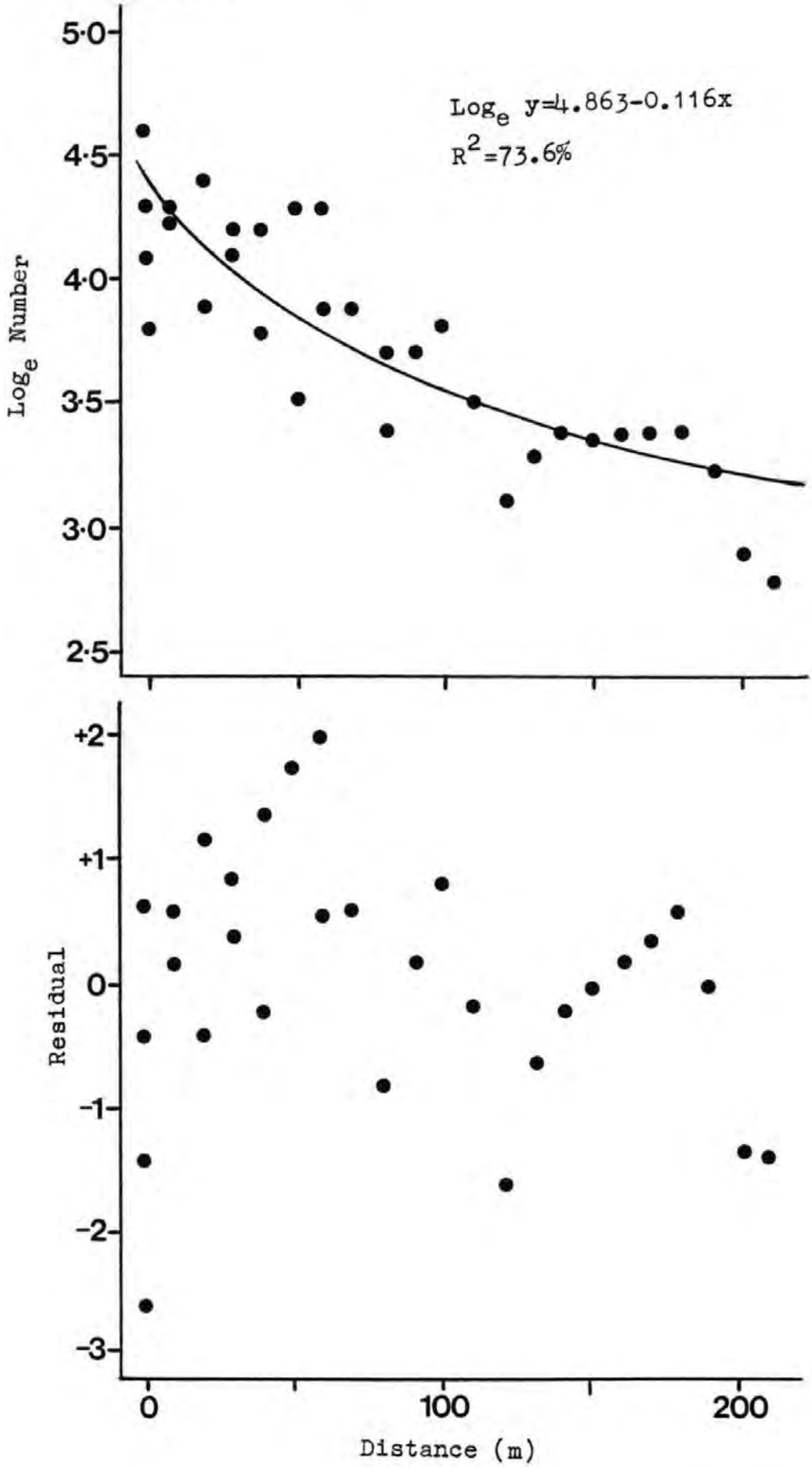


FIG. 86

The change in the male total with distance for Venn 1981B.

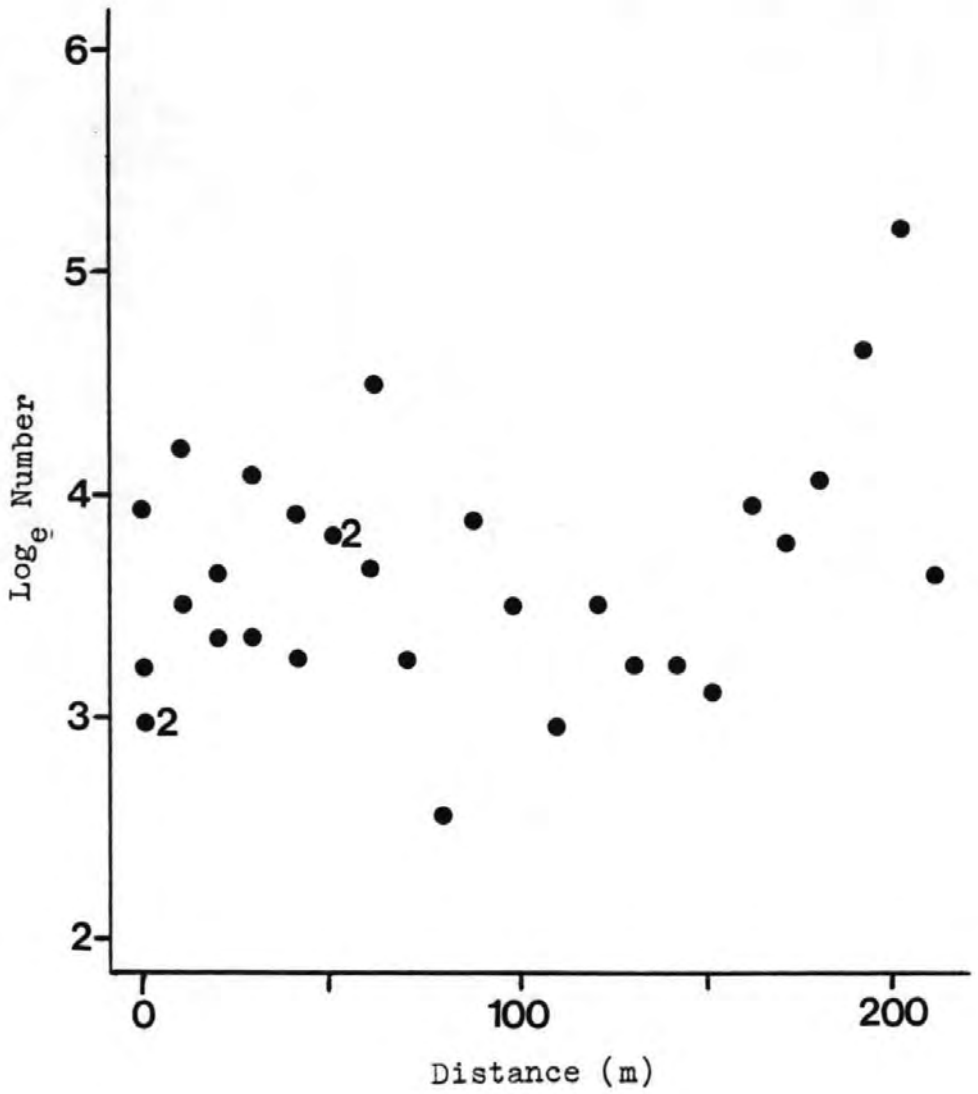


FIG. 87

A test of the normality of the residuals from Venn 1981B using probability paper.

FEMALE TOTAL

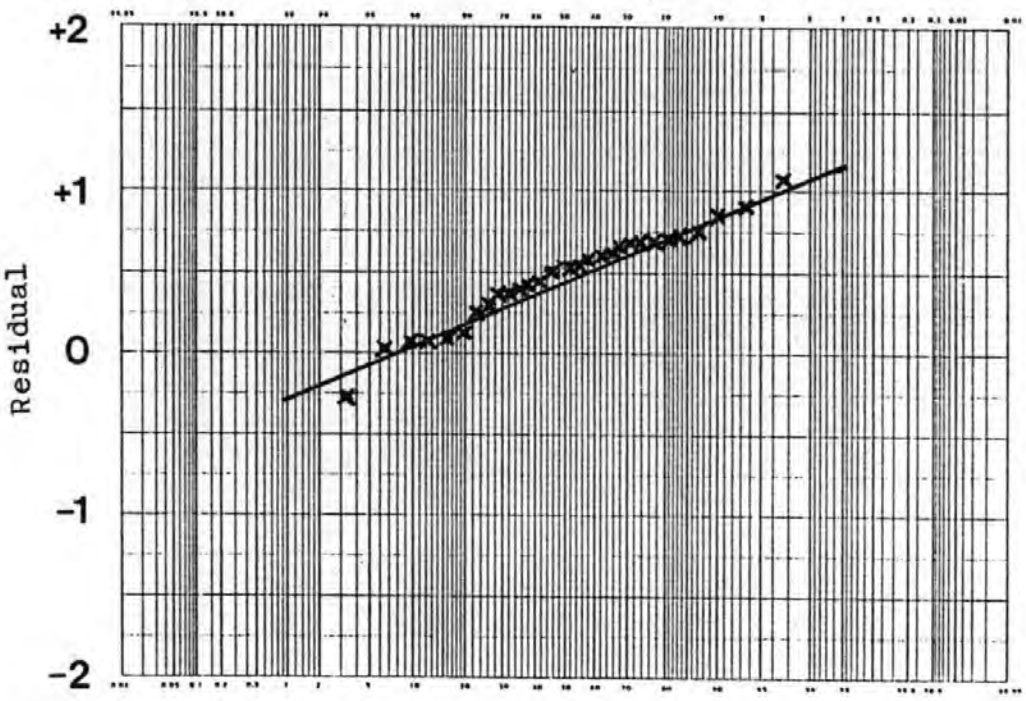


TABLE 27

The results of fitting the regression model to the data of Great Englebourne 1980B.

Age-group	Intercept(a)	Slope(b)	SE b	N	F	R^2
F 1+3	0.76	-0.053	57.5	6	3.0	28.6
F 5	3.78	-0.133	24.3	17	17.0^{c}	50.0
F 6	4.54	-0.209	12.9	17	60.3^{c}	78.7
F T	4.89	-0.165	12.4	17	65.8^{c}	80.2
M 1	0.51	-0.044	58.4	5	3.0	32.9
M 2	2.70	-0.122	27.4	14	13.6^{b}	49.3
M 3	2.87	-0.111	30.0	17	11.2^{b}	38.9
M T	3.76	-0.146	23.6	17	18.1^{c}	51.6

FIG. 88

The regression of female total on distance for Great Englebourne 1980B.

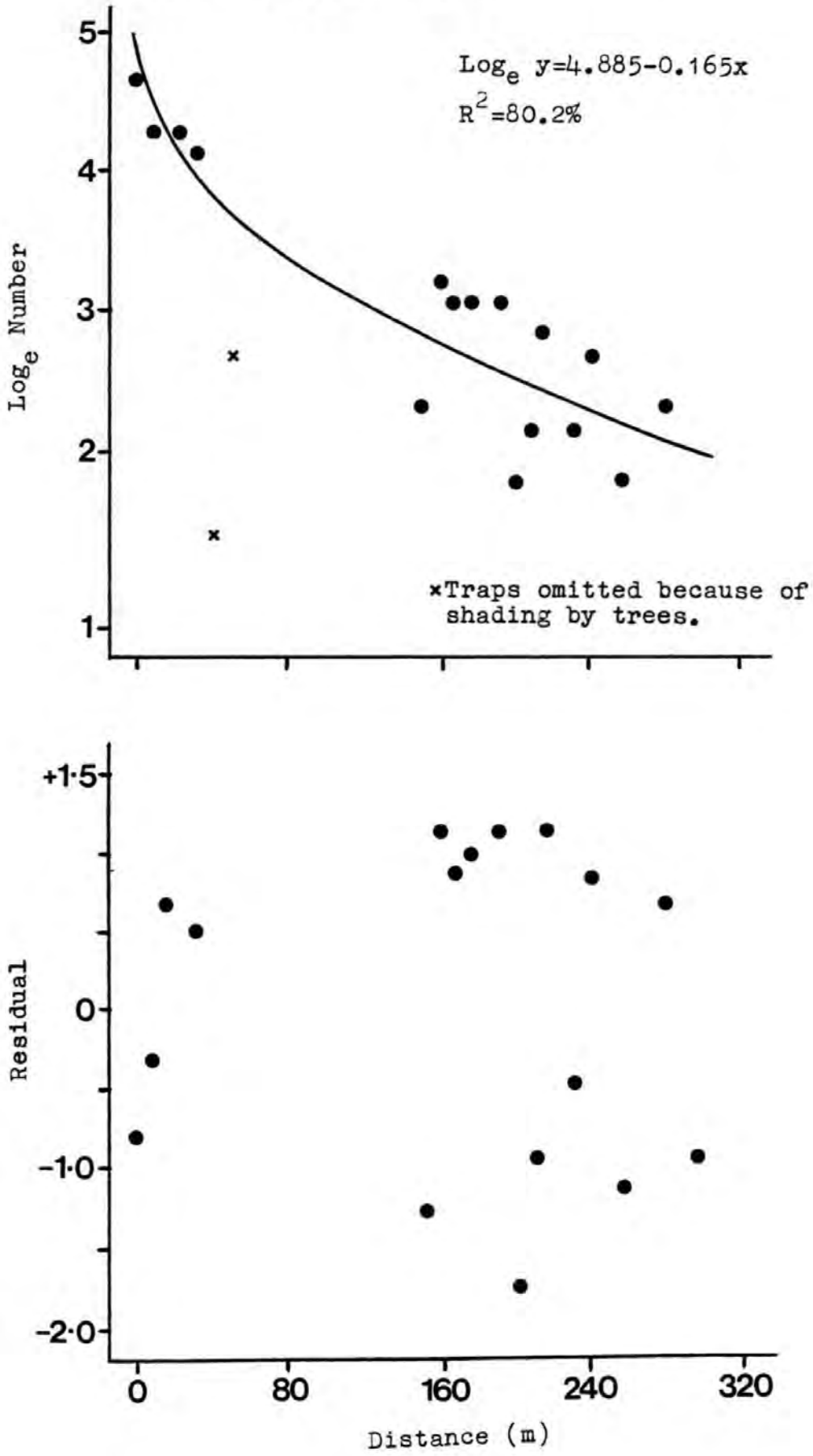


FIG. 89

The regression of male total on distance for Great Englebourne 1980B.

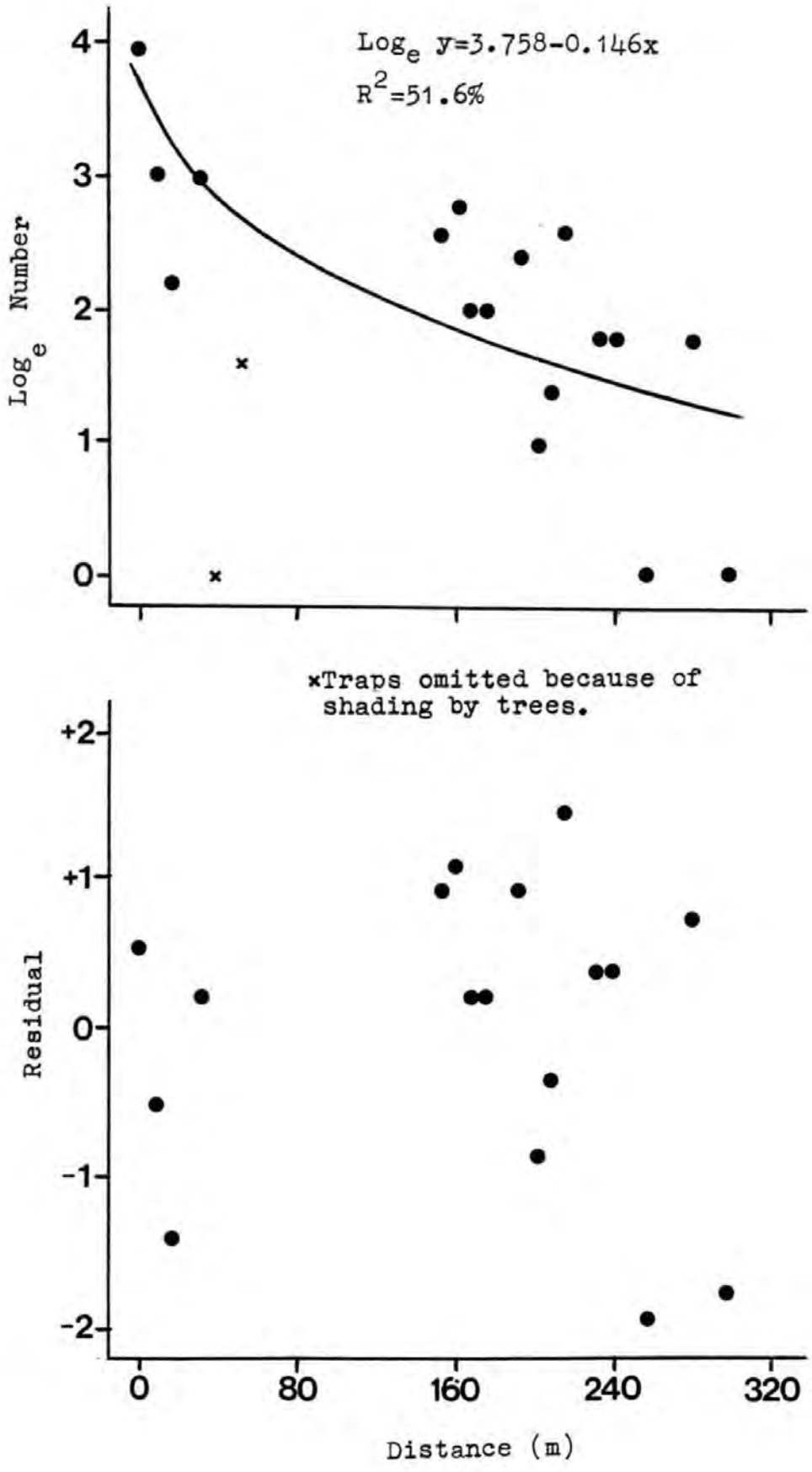
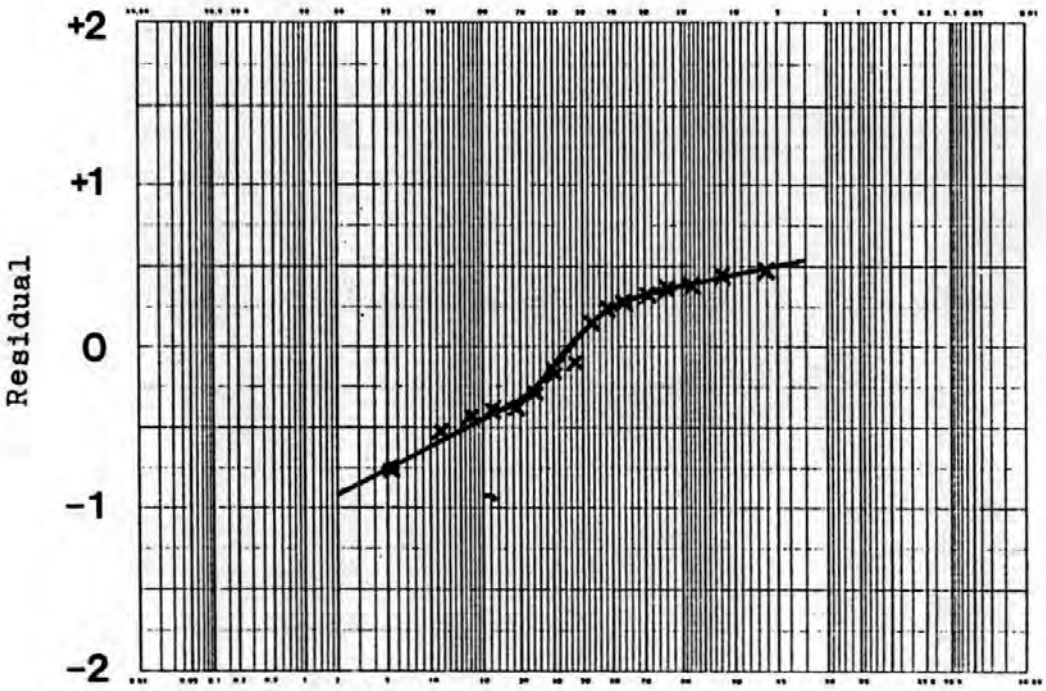


FIG. 90

A test of the normality of the residuals from Great Englebourne 1980B using probability paper.

FEMALE TOTAL



MALE TOTAL

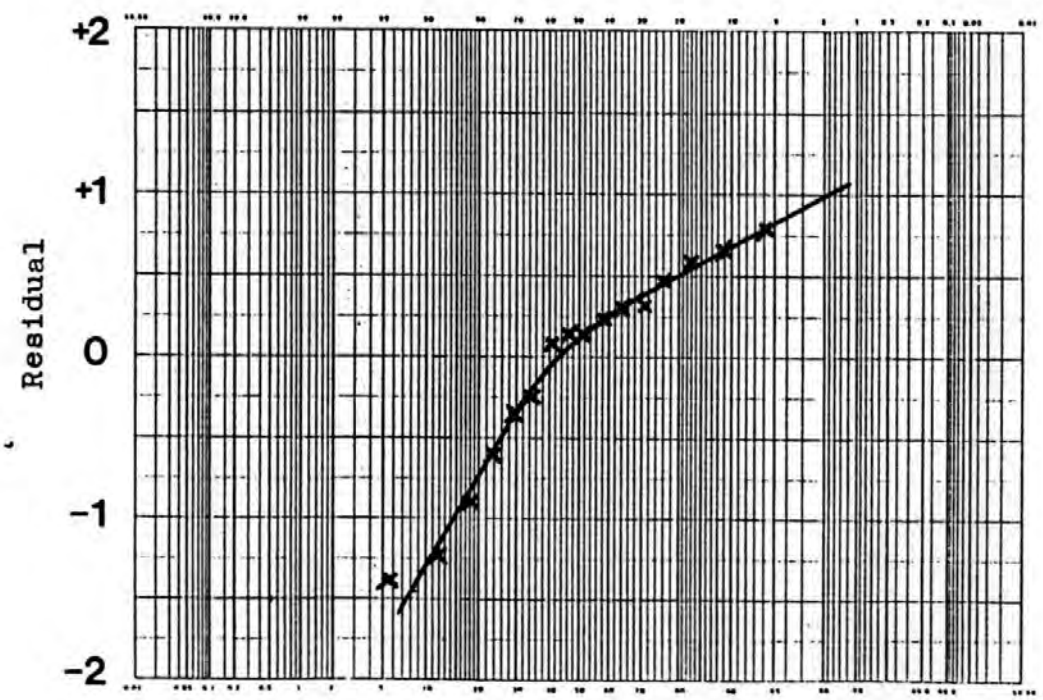


TABLE 28

The results of fitting the regression model to the data of Great Englebourne 1981A.

Age-group	Intercept(a)	Slope(b)	SE b	N	F	R^2
F 1+3	0.44	-0.034	85.0	21	8.2^b	42.0
F 5	0.91	-0.049	40.2	35	74.8^c	81.3
F 6	1.38	-0.139	18.0	27	52.0^c	79.7
F T	1.77	-0.090	18.4	38	136.1^c	88.0
M 1	-0.04	+0.025	253.2	16	17.4^c	68.5
M 2	1.45	-0.133	19.2	22	56.5^c	84.1
M 3	0.69	-0.057	41.6	26	105.3^c	89.3
M T	1.69	-0.131	20.5	32	81.5^c	83.9

FIG. 91

The regression of female total on distance for Great Englebourne 1981A.

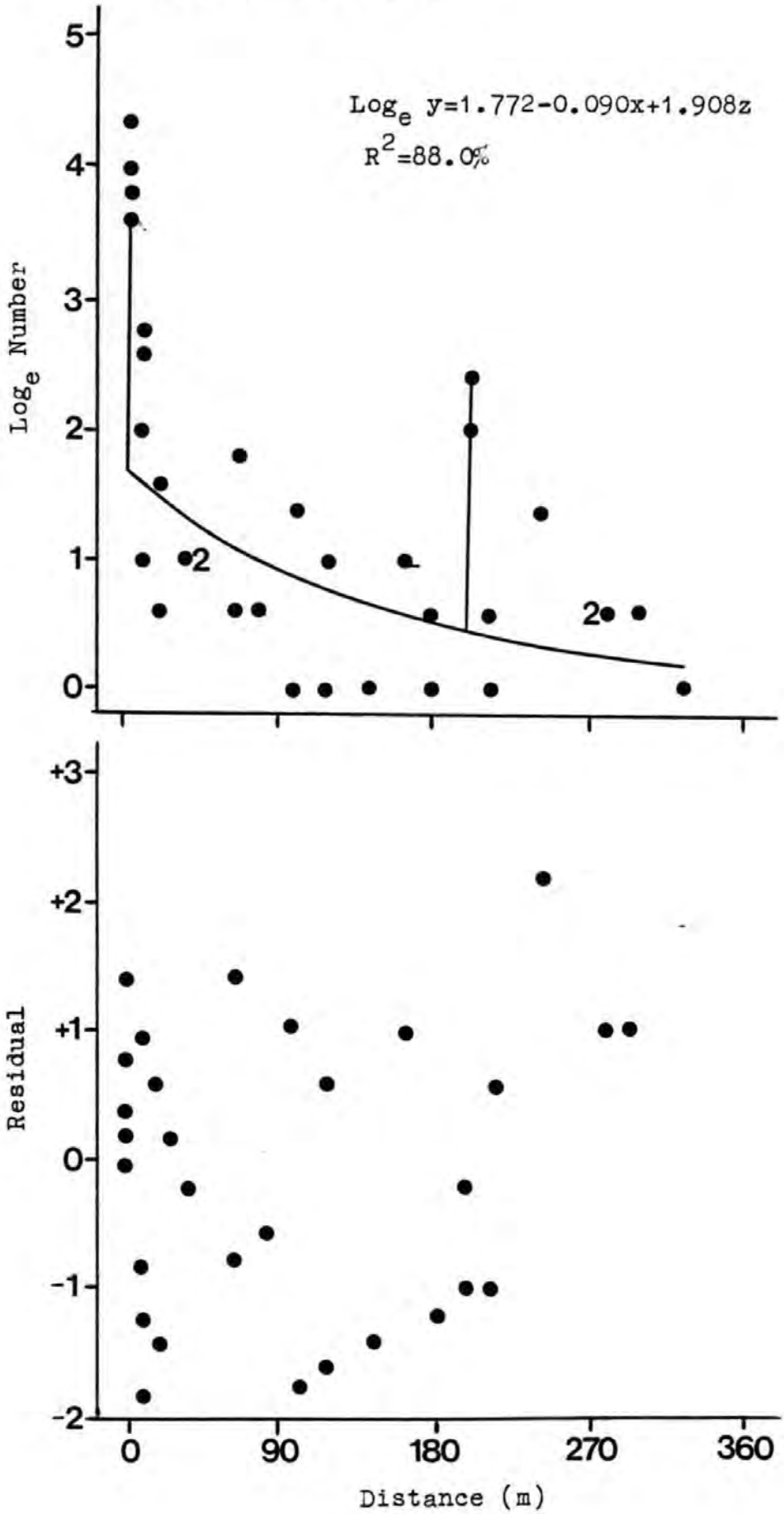


FIG. 92

The regression of male total on distance for Great Englebourne 1981A.

Log_e y=1.693-0.131x+2.038Z

R^2=83.9%

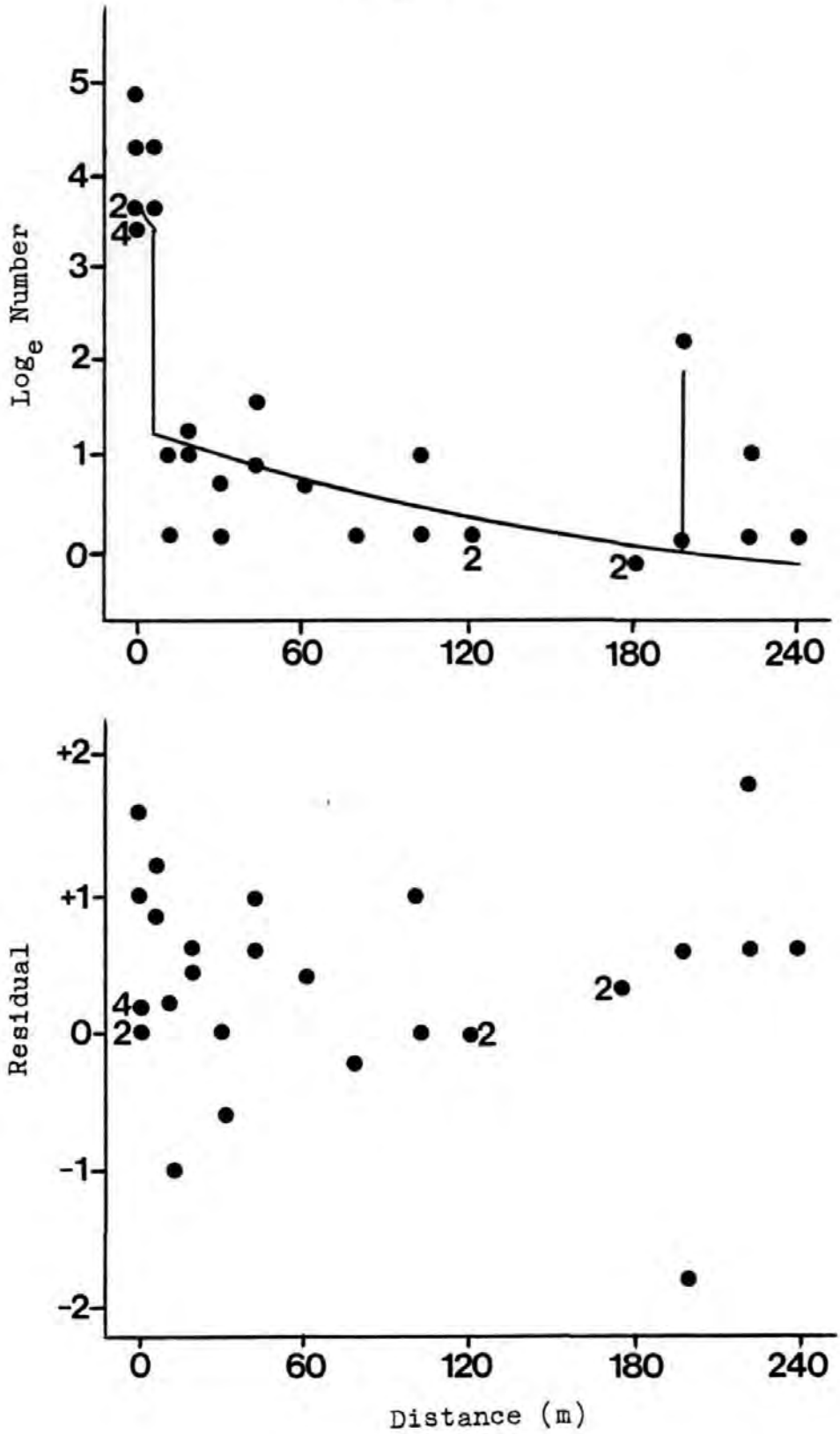
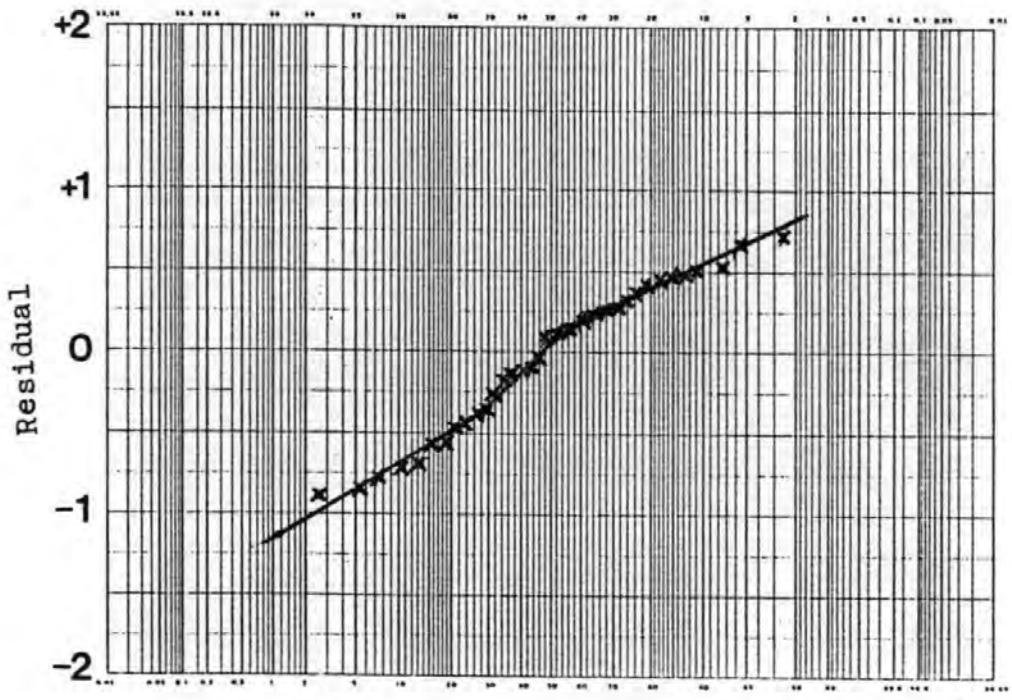


FIG. 93

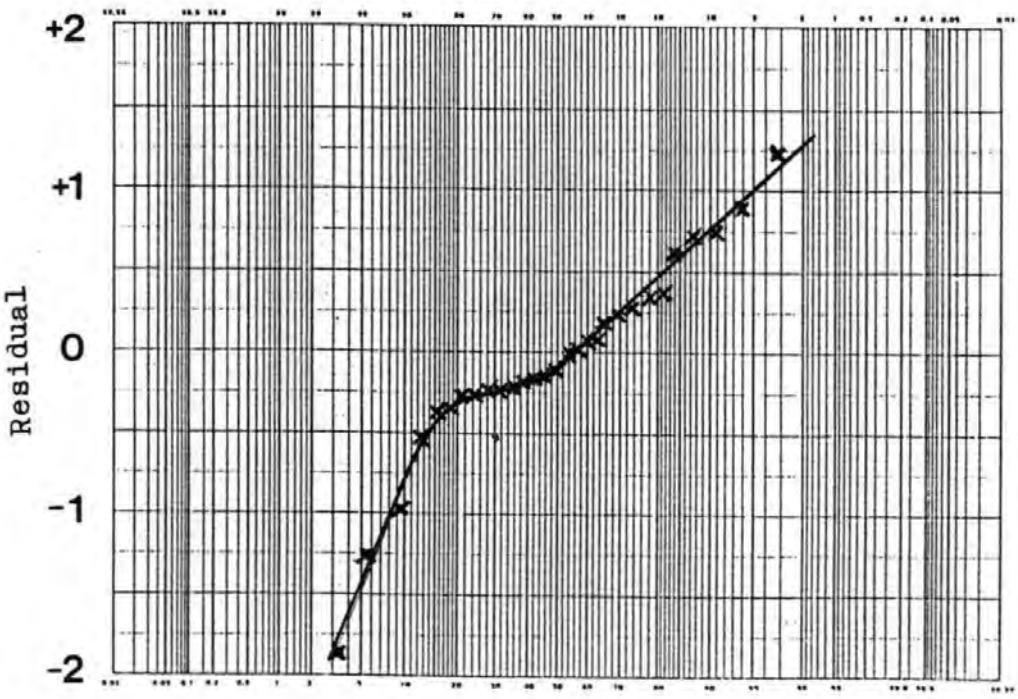
A test of the normality of the residuals from Great Englebourne 1981A usimg probability paper.

FEMALE TOTAL



Cumulative frequency (% probability scale)

MALE TOTAL



Cumulative frequency (% probability scale)

TABLE 29

The results of fitting the regression model to the data of Seale Hayne 1980B (trap line 1 = traps 1-10 + 50-63)

Age-group	Intercept(a)	Slope(b)	SE b	N	F	R^2
F 1+3	0.30	-0.008	530.0	9	2.9	31.7
F 5	2.55	-0.059	106.6	24	3.4	16.9
F 6	2.87	-0.218	20.3	23	33.9^{c}	74.9
F T	3.31	-0.102	52.1	24	9.0^{b}	41.0
M 1	-0.14	+0.034	49.3	6	4.1	38.5
M 2	1.31	-0.074	58.8	16	2.9	11.2
M 3	1.77	-0.116	40.8	17	6.0^{a}	23.8
M	2.66	-0.158	18.7	19	28.5^{c}	60.4

FIG. 94

The regression of female total on distance for the first trap line (trap1-10,12-46) of Seale Hayne 1980B.

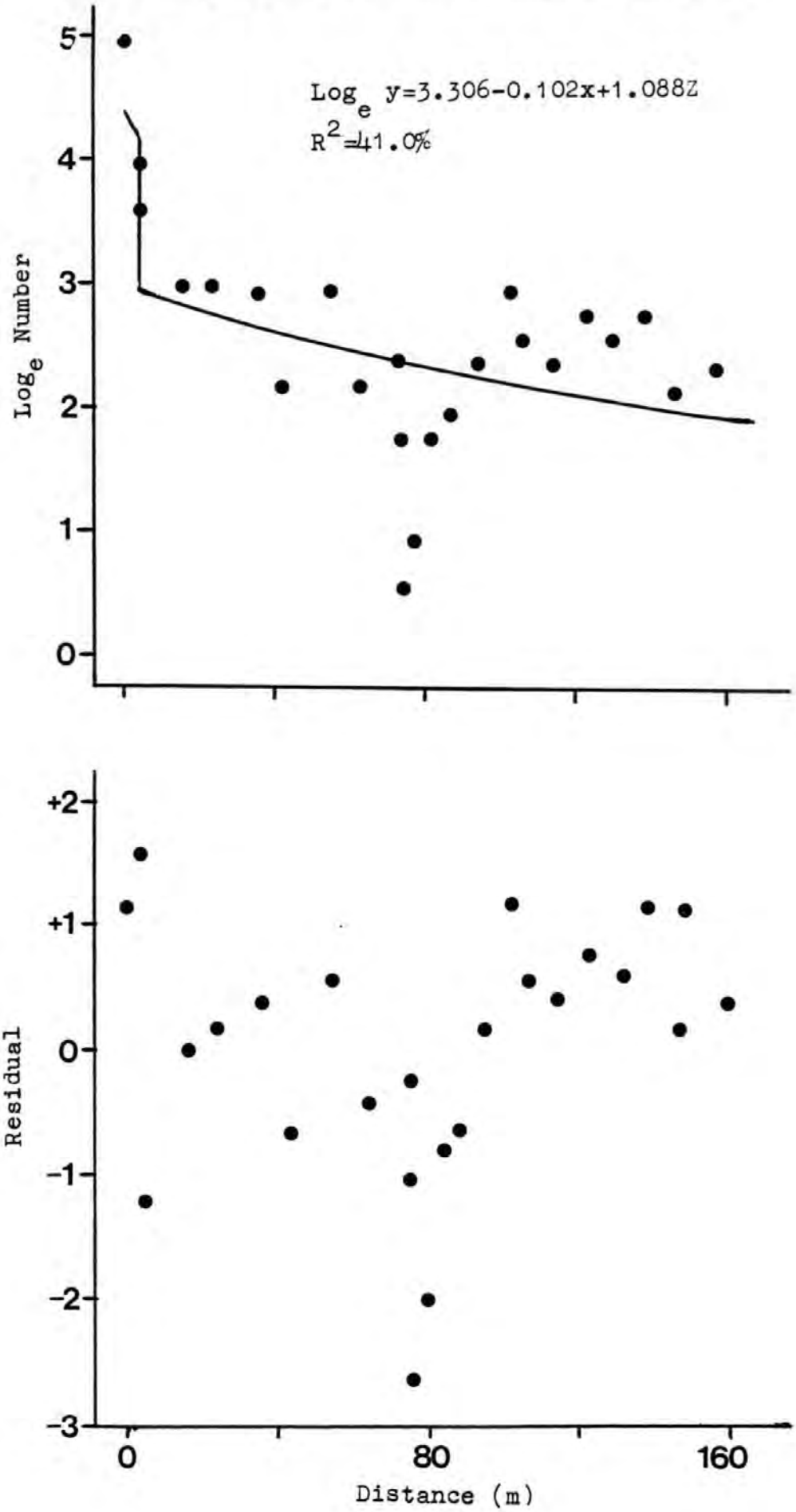


FIG. 95

The regression of male total on distance for the first trap line (traps1-10+12-46) of Seale Hayne 1980B.

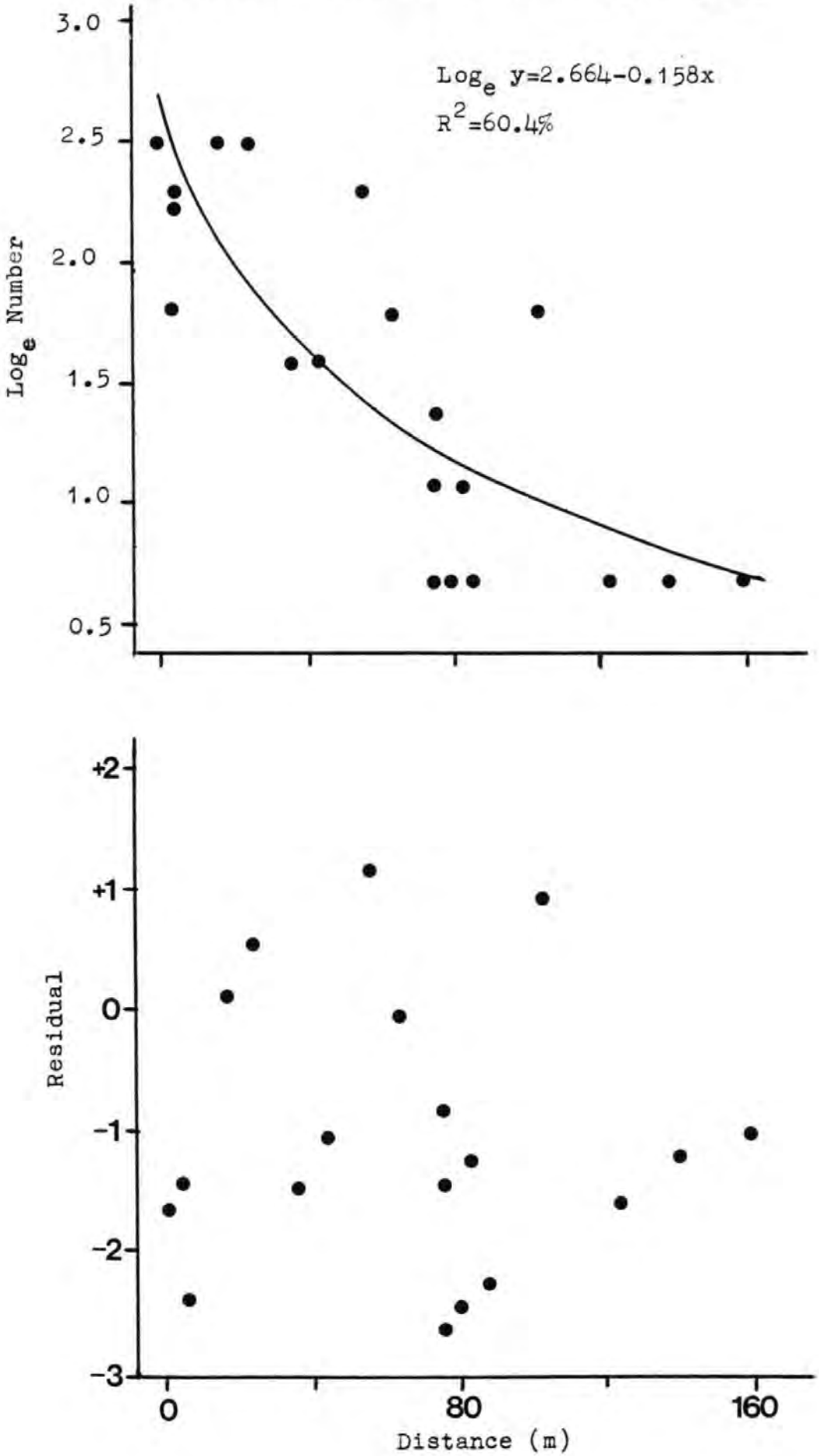
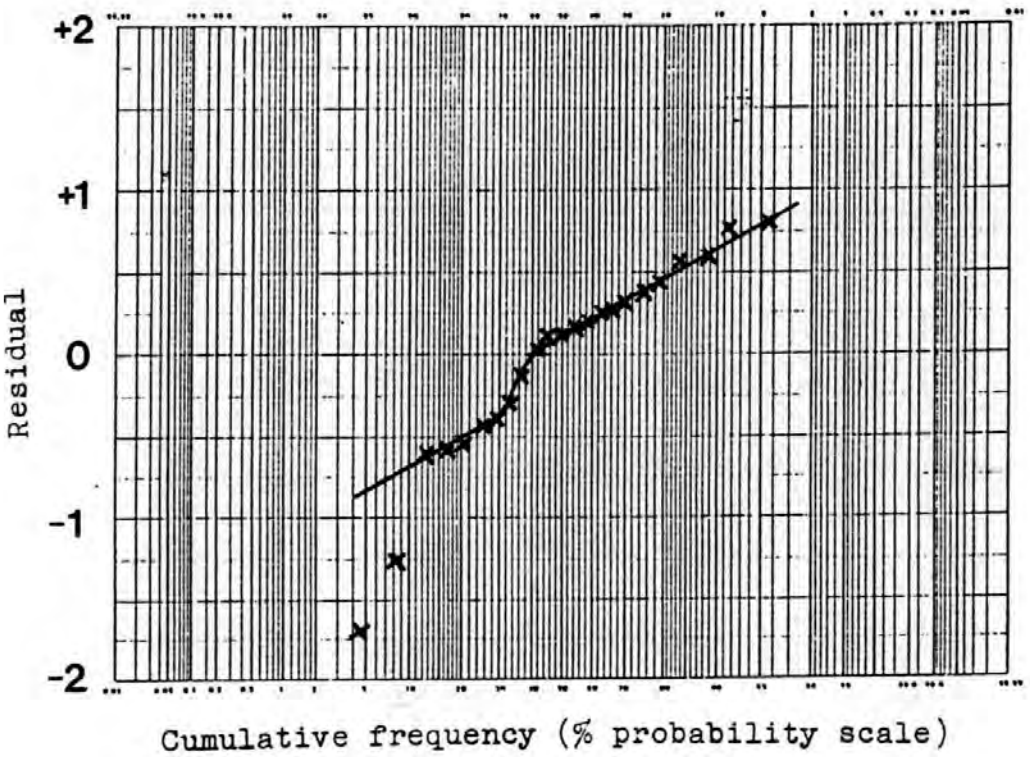


FIG. 96

A test of the normality of the residuals from the first trap line of Seale Hayne 1980B.

FEMALE TOTAL



MALE TOTAL

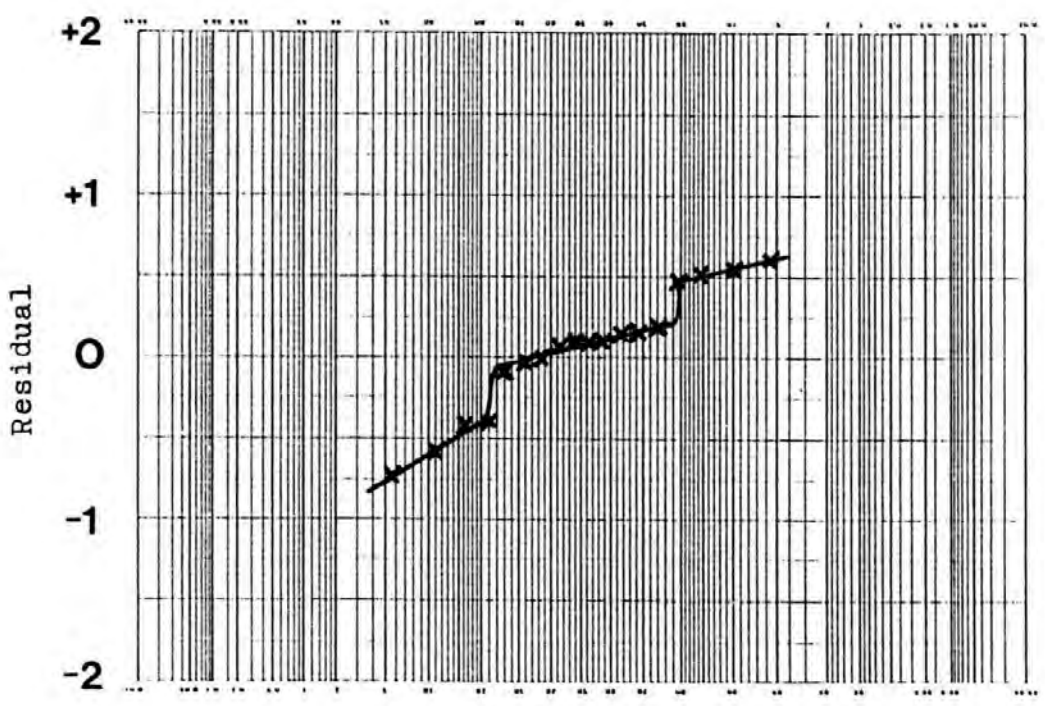


TABLE 30

The results of fitting the regression model to the data from Seale Hay Seale Hayne 1980B (trap line 2 = traps 1-10 + 12-46)

Age-group	Intercept(a)	Slope(b)	SE b	N	F	R^2
F 1+3	-1.22	+0.063 +0.089	140.8 112.1	12	3.3	39.1
F 5	6.63	-0.272 -0.227	19.8 23.8	42	9.9^{c}	46.4
F 6	2.45	-0.093 -0.028	63.1 219.1	42	6.8^{b}	36.2
F T	5.79	-0.206	19.0	43	15.3^{c}	57.7
M 1	1.89	-0.061 -0.120	120.0 59.8	16	3.9^{c}	27.1
M 2	4.24	-0.147 -0.205	42.2 33.5	36	4.6^{a}	17.0
M 3	3.19	-0.098 -0.119	62.3 57.0	36	1.6	3.1
M T	5.39	-0.176 -0.208	29.4 28.2	39	6.6^{b}	22.7

FIG. 97

The regression of female total on distance for the second trap line (traps 1-10+50-63) of Seale Hayne 1980B.

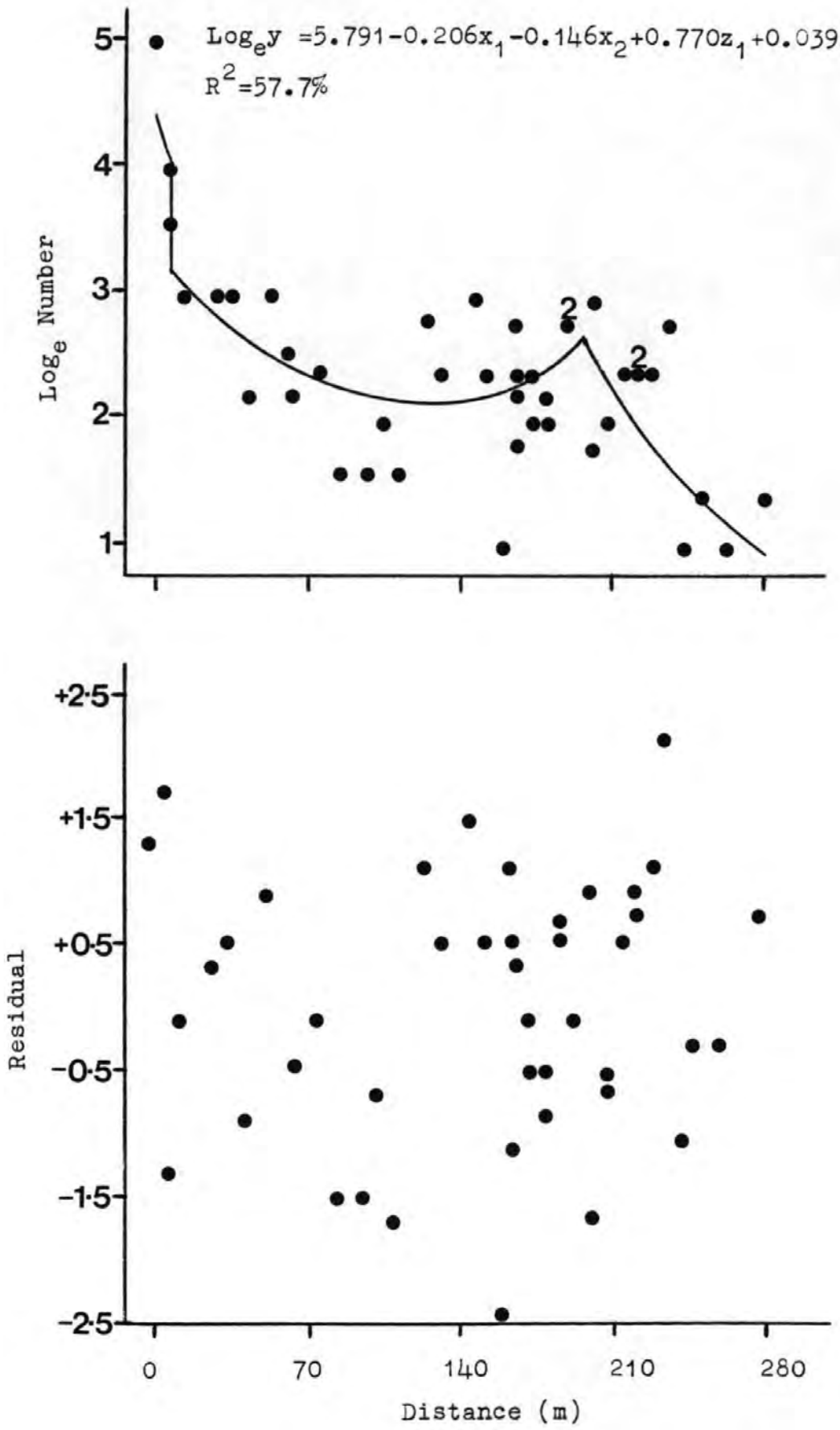


FIG. 98

The regression of male total on distance for the second trap line (traps 1-10,50-63) of Seale Hayne 1980B.

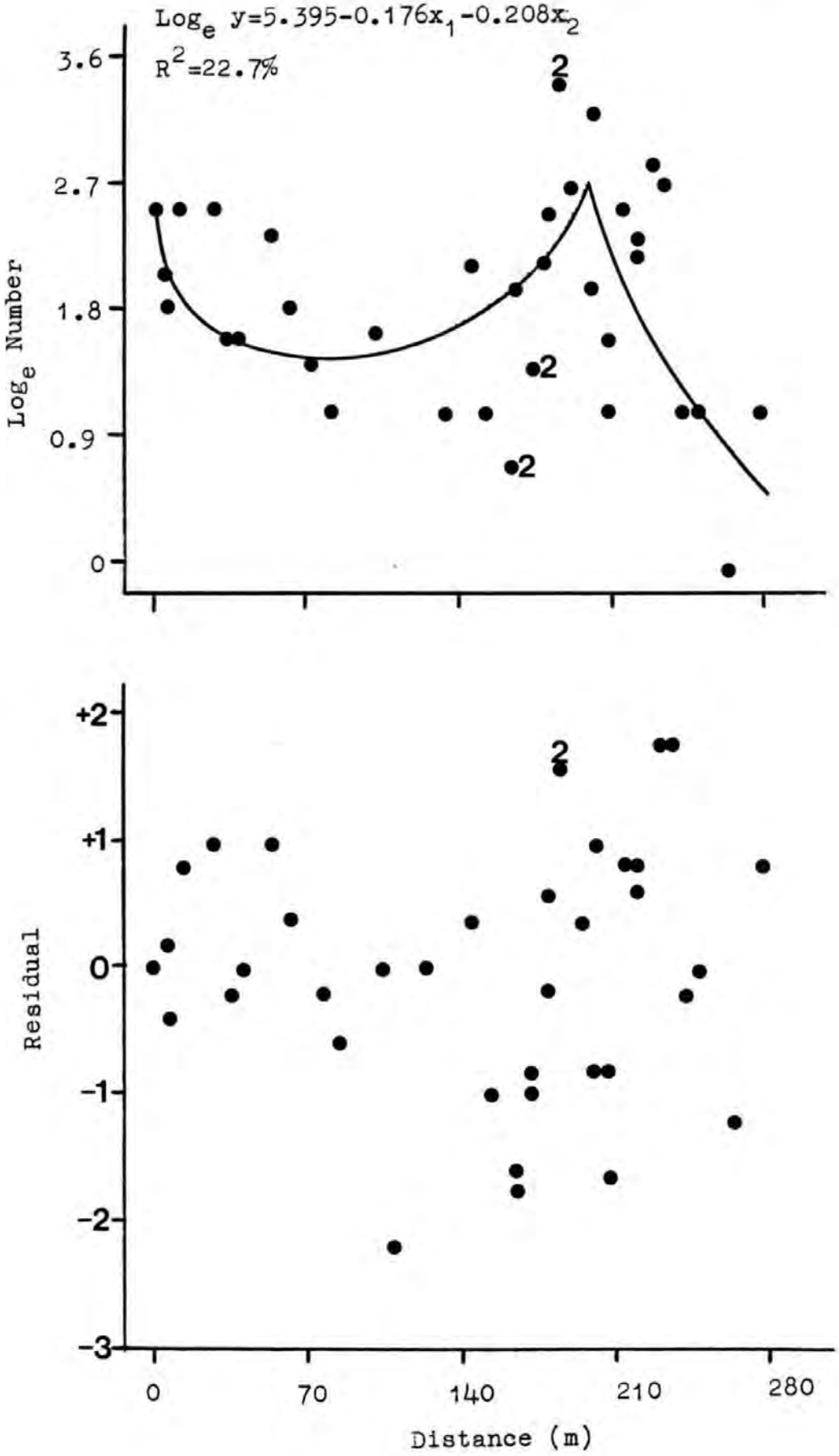
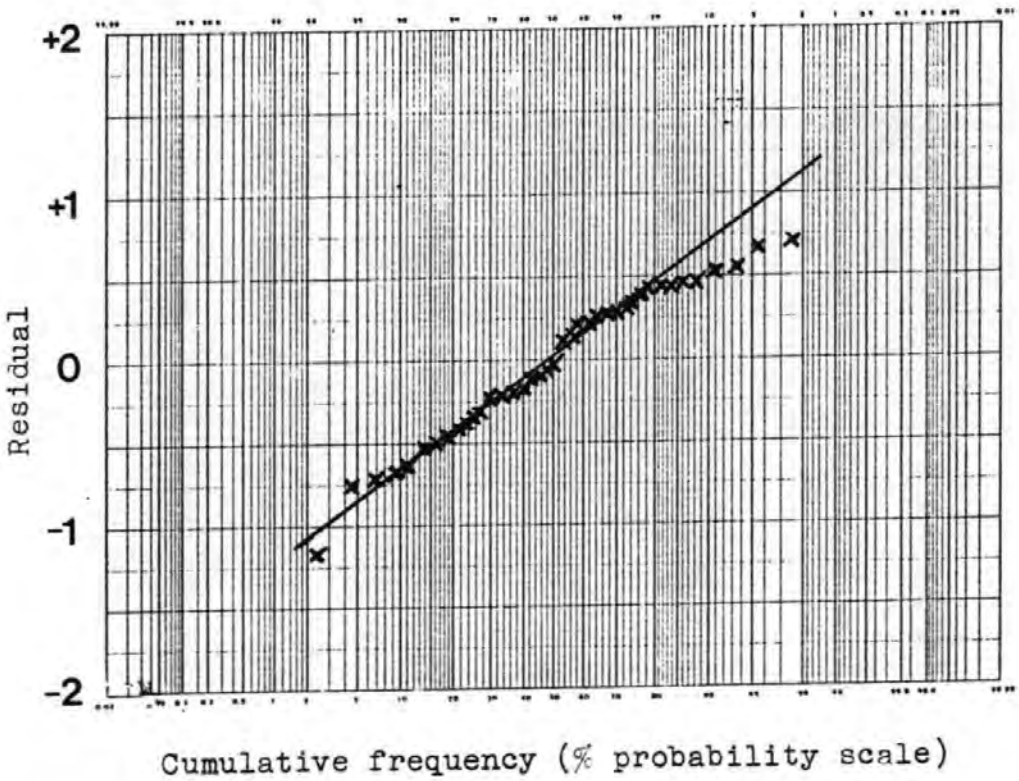


FIG. 99

A test of the normality of the residuals from the second trap line of Seale Hayne 1980B using probability paper.

FEMALE TOTAL



MALE TOTAL

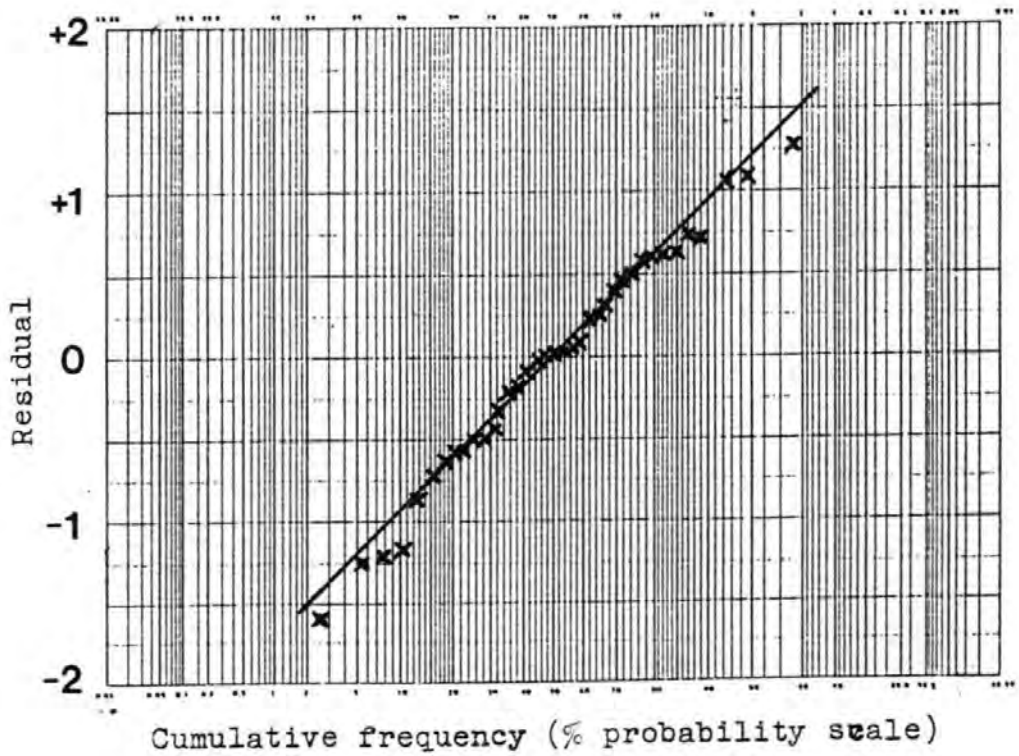


TABLE 31

The results of the fitting of the regression model to the data of Seale Hayne 1980B (traps 1 - 15 only).

Age-group	Intercept(a)	Slope(b)	SE b	N	F	R^2
F 1+3	0.59	-0.071	190.0	6	2.1	30.0
F 5	3.93	-0.286	24.0	15	9.9^{b}	65.5
F 6	3.26	-0.269	26.1	15	13.4^{b}	72.7
F T	4.36	-0.263	14.3	15	33.8^{c}	87.5
M 1	-0.04	+0.012	116.0	7	0.7	-4.6
M 2	1.55	-0.126	42.7	13	5.5^{a}	27.4
M 3	1.72	-0.093	90.4	14	3.4	15.4
M T	2.59	-0.130	31.6	14	10.0^{b}	40.9

FIG. 100

The regression of female total on distance for traps 1-15 of Seale Hayne 1980B.

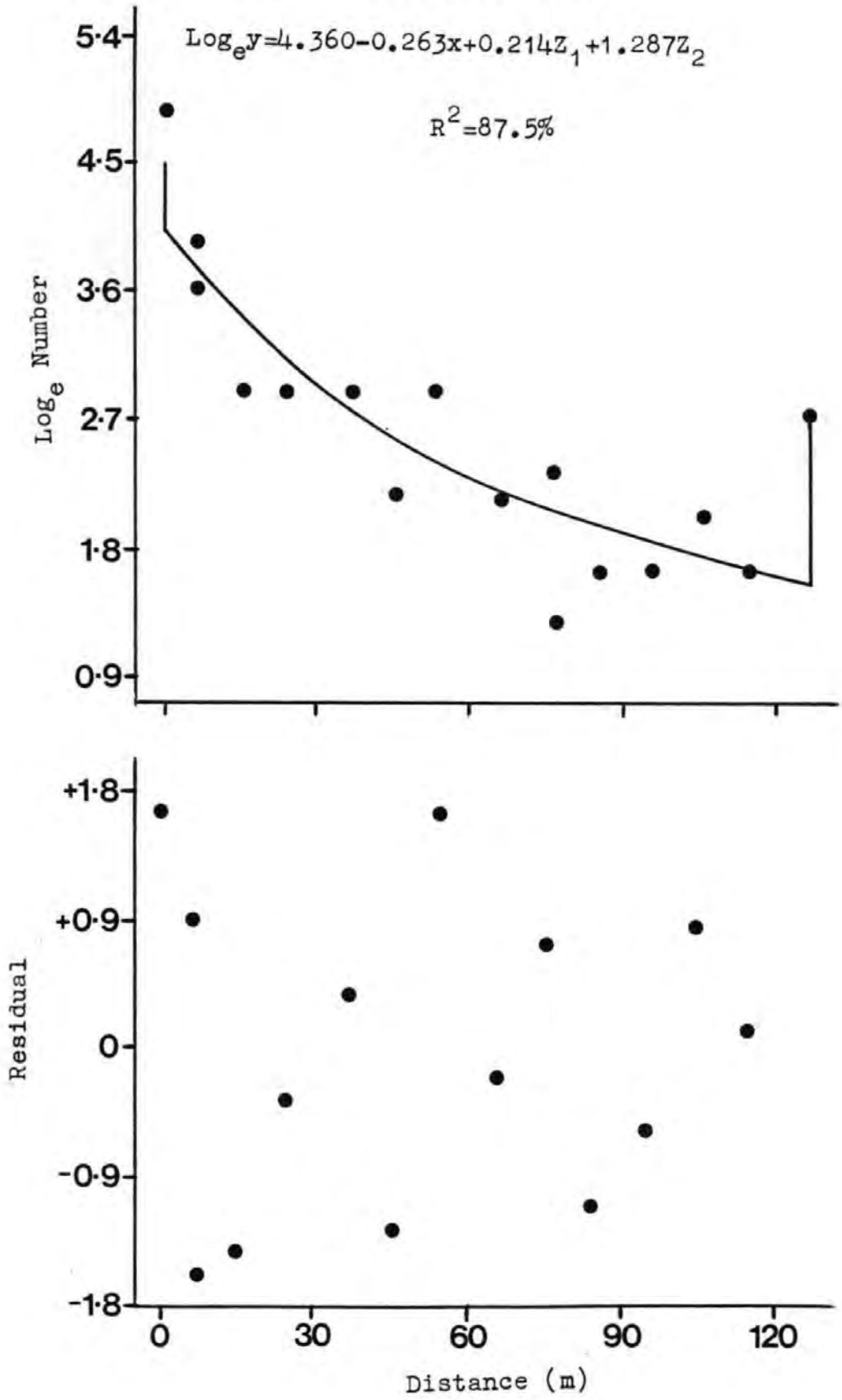


FIG. 101

The regression of male total on distance for traps 1-15 of Seale Hayne 1980.

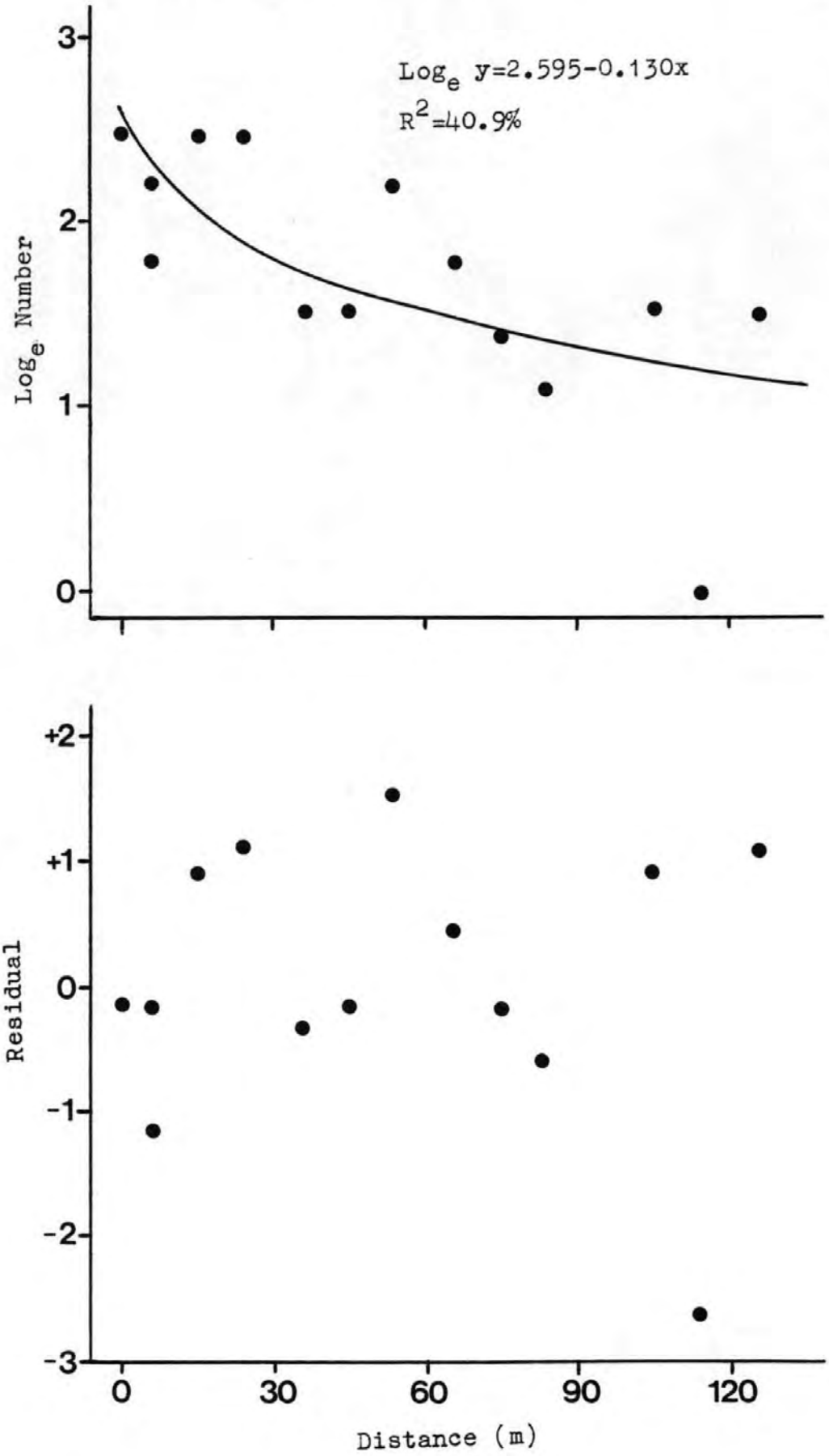
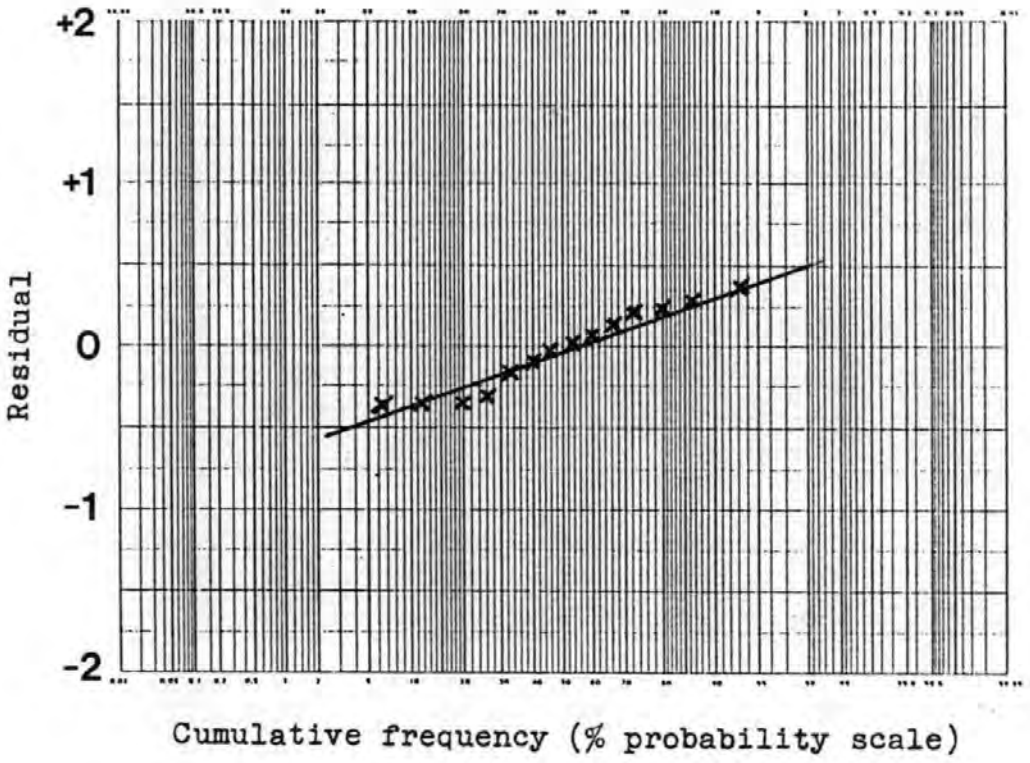


FIG. 102

A test of the normality of the residuals from SEALE HAYNE 1980B (traps 1-15) using probability paper.

FEMALE TOTAL



MALE TOTAL

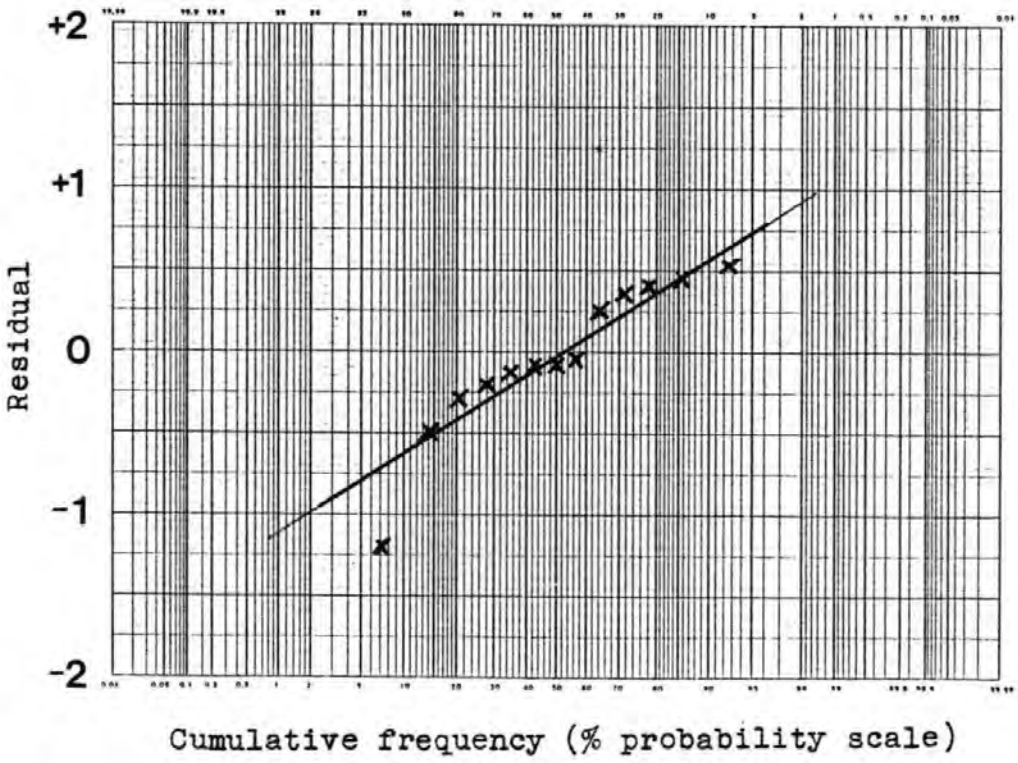


TABLE 32

The results of fitting the regression model to the data from Seale Hayne 1980C.

Age-group	Intercept(a)	Slope(b)	SE b	N	F	R^2
F 1+3	*					
F 5	2.45	-0.166	22.3	20	7.7^a	51.4
F 6	2.51	-0.121	42.8	19	2.6	20.6
F T	3.03	-0.130	39.1	20	4.4^a	34.9
M 1	*					
M 2	1.15	-0.064	81.6	14	1.5	3.7
M 3	0.86	-0.054	72.6	12	1.9	7.6
M T	1.99	-0.119	38.2	16	6.8^a	27.9

* No flies caught

FIG. 103

The regression of female total on distance for Seale Hayne 1980c.

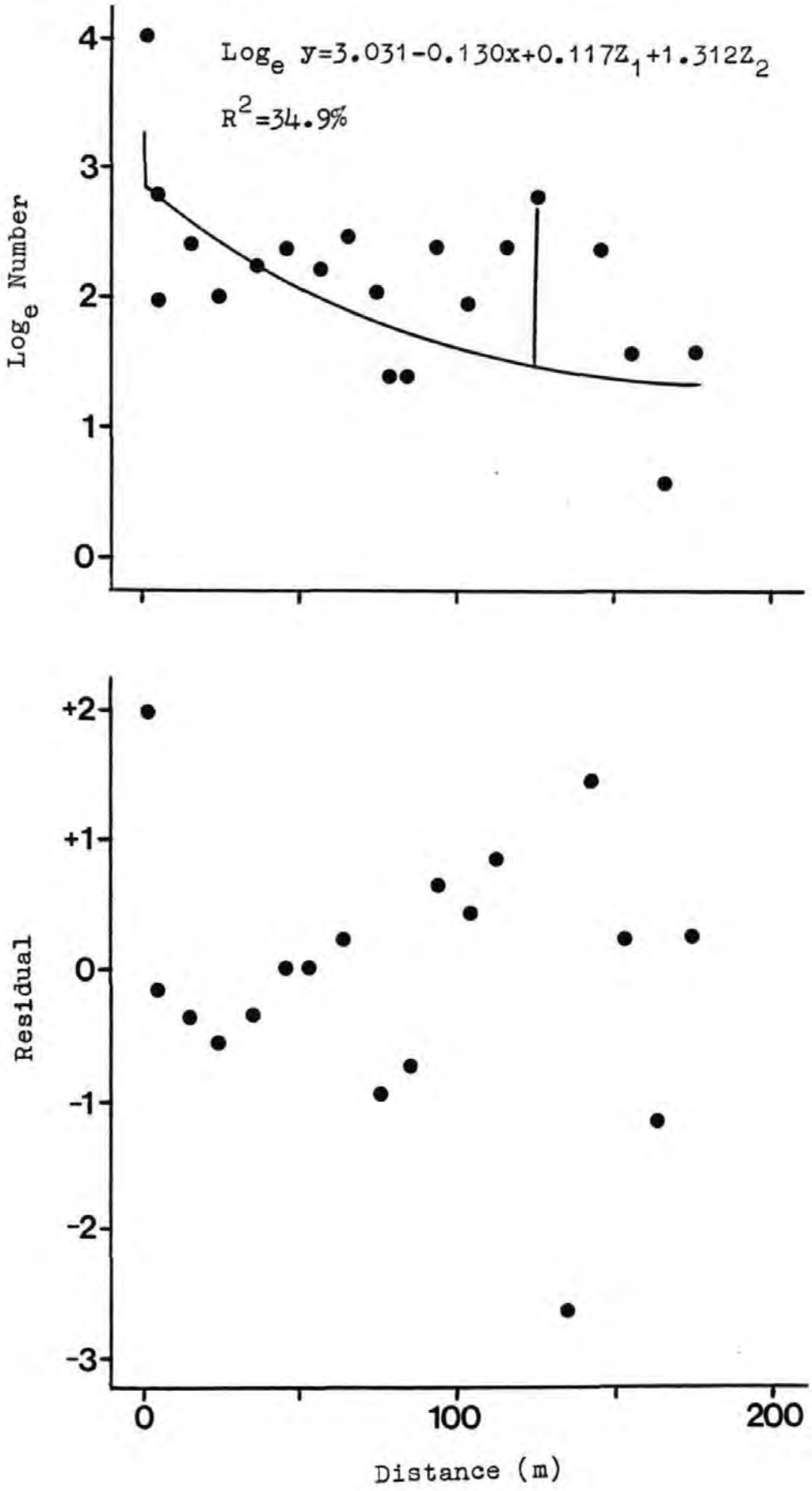
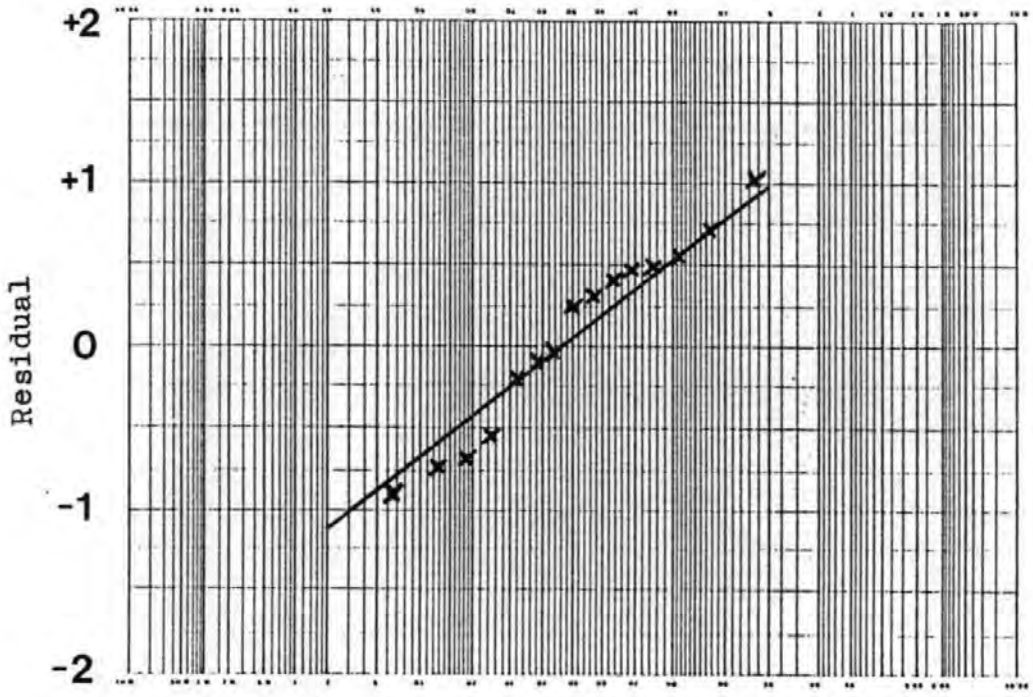


FIG. 104

A test of the normality of the residuals from Seale Hayne 1980C and Seale Hayne 1981c using Probability paper.

SEALE HAYNE 1980C FEMALE TOTAL



SEALE HAYNE 1981c FEMALE TOTAL

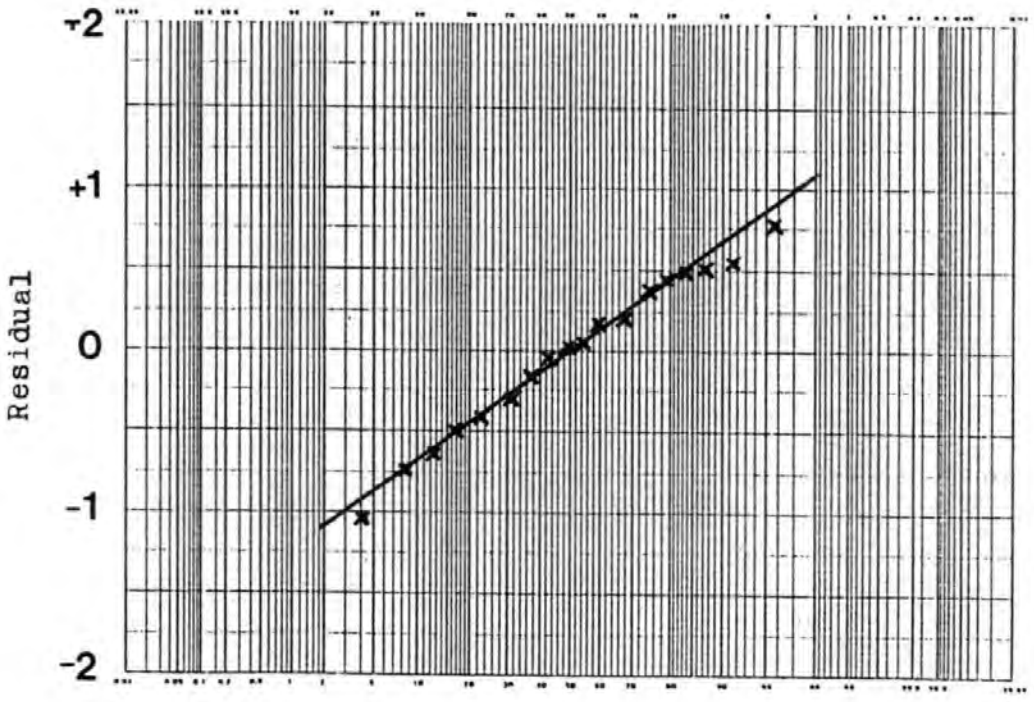


TABLE 33

The results of fitting the regression model to the data from Seale Hayne 1981A.

Age-group	Intercept(a)	Slope(b)	SE b	N	F	R^2
F 1+3	*					
F 5	4.02	-0.356	19.2	32	18.2^{c}	62.5
F 6	3.61	-0.351	15.2	31	32.2^{c}	75.7
F T	4.74	-0.391	31.4	33	26.7^{c}	70.7
M 1	-0.05	+0.071	29.0	7	11.9^{a}	64.5
M 2	1.07	-0.090	48.6	21	4.2	13.9
M 3	1.35	-0.061	65.1	23	2.4	5.8
M T	1.89	-0.114	41.6	29	5.7^{a}	14.5

* No flies caught

FIG. 105

The regression of female total on distance for Seale Hayne 1981a.

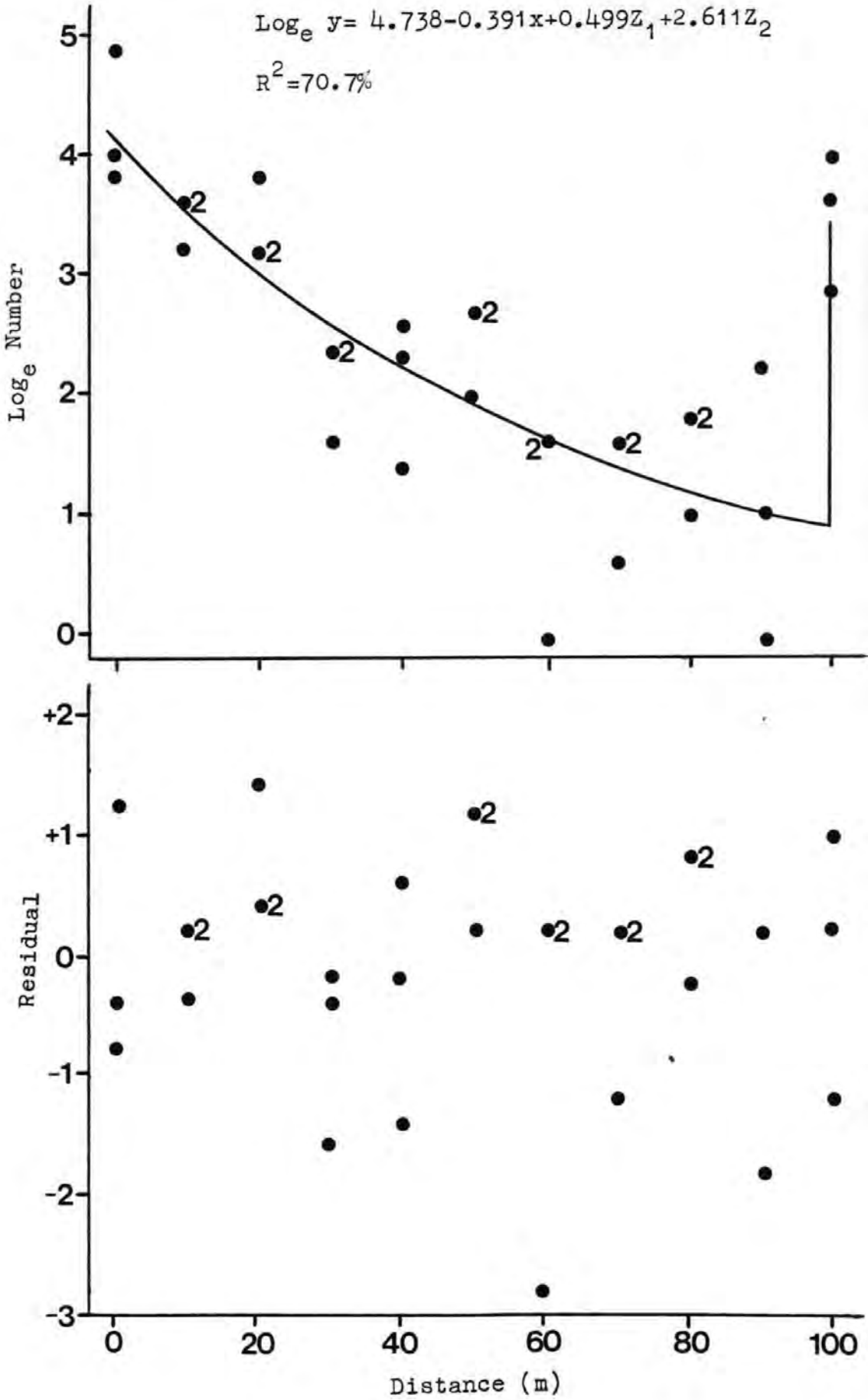


FIG. 106

The regression of male total on distance for Seale Hayne 1981A.

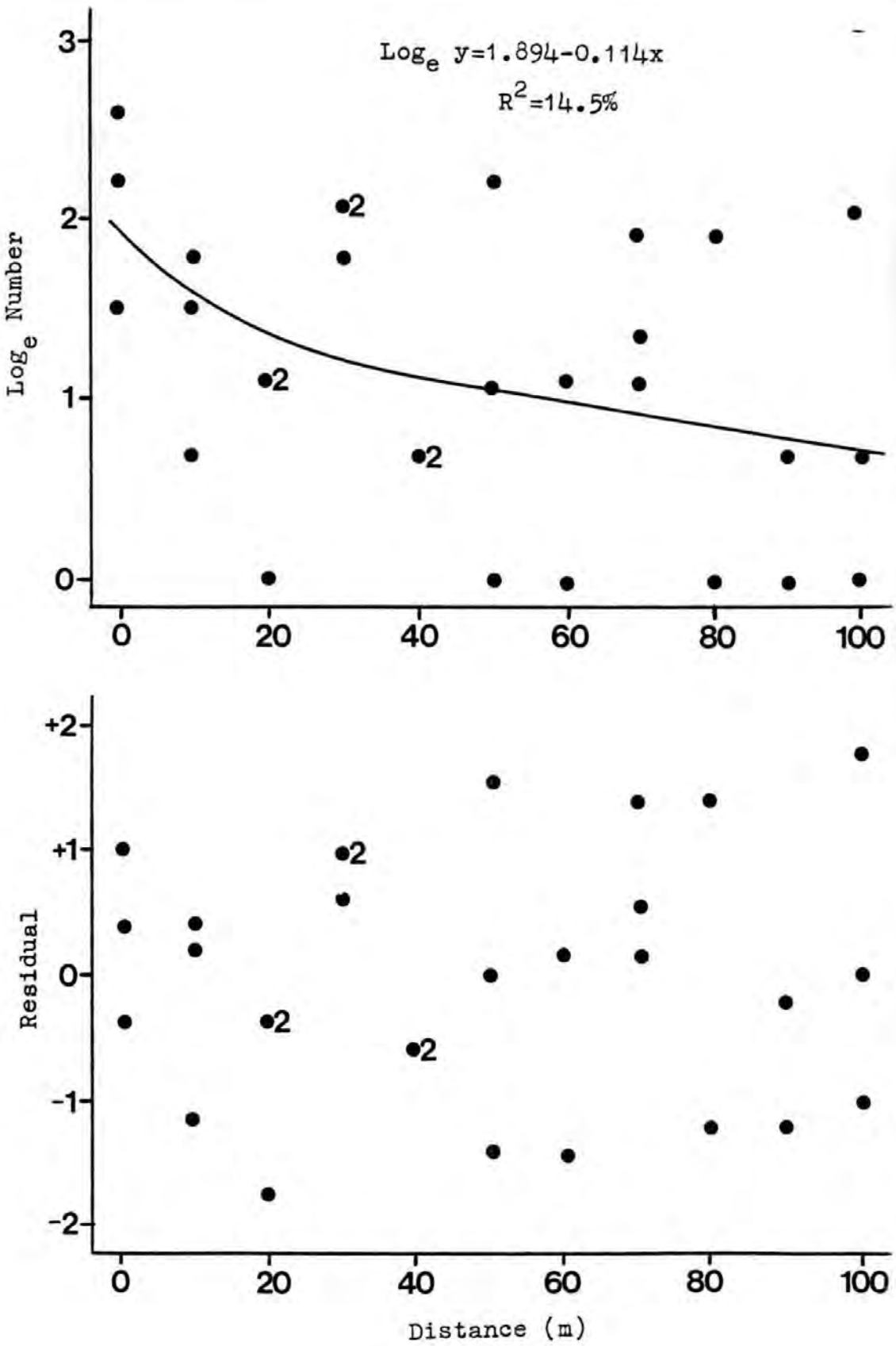
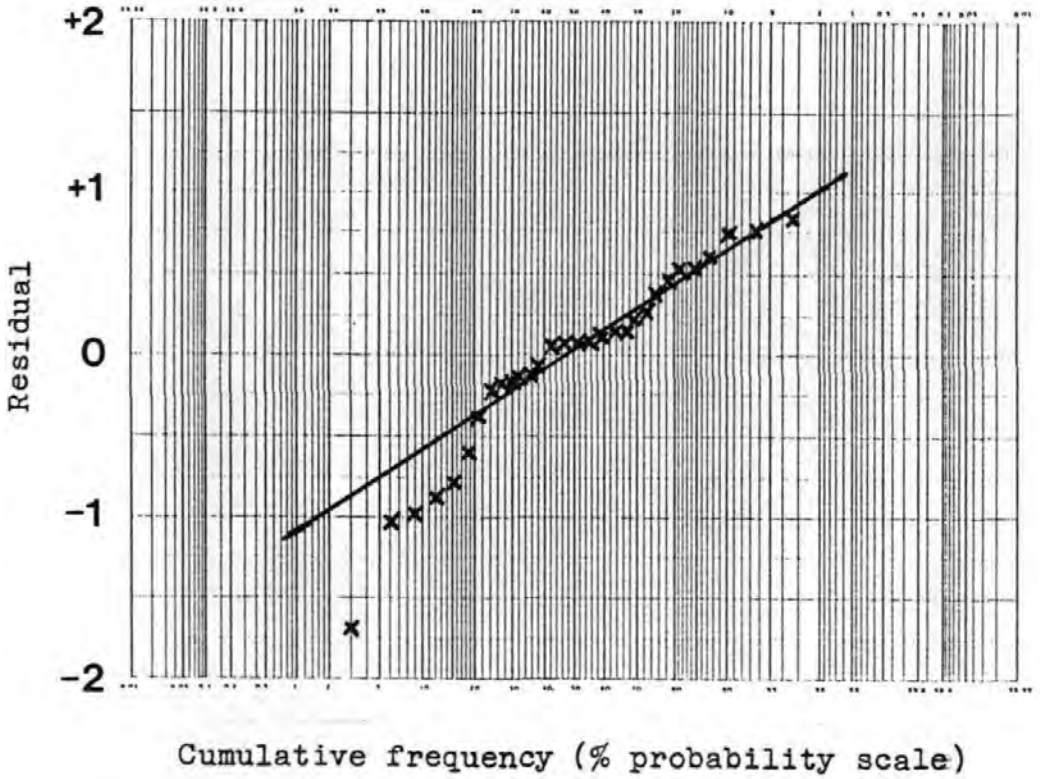


FIG. 107

A test of the normality of the residuals from Seale Hayne 1981A using probability paper.

FEMALE TOTAL



MALE TOTAL

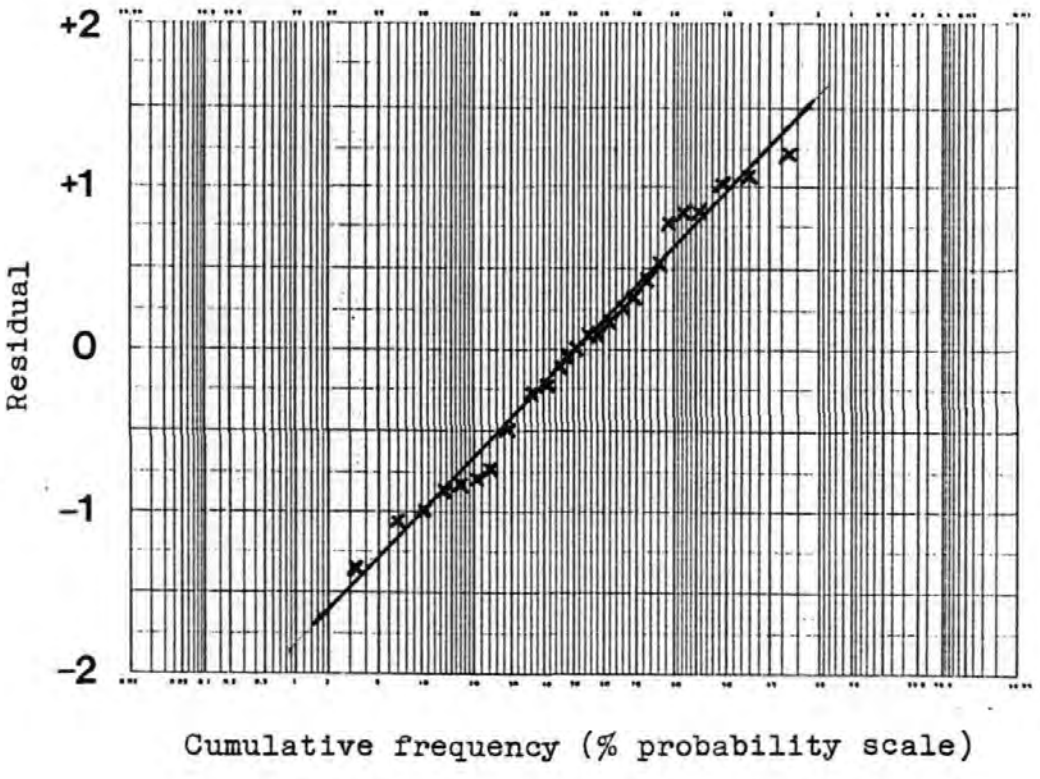
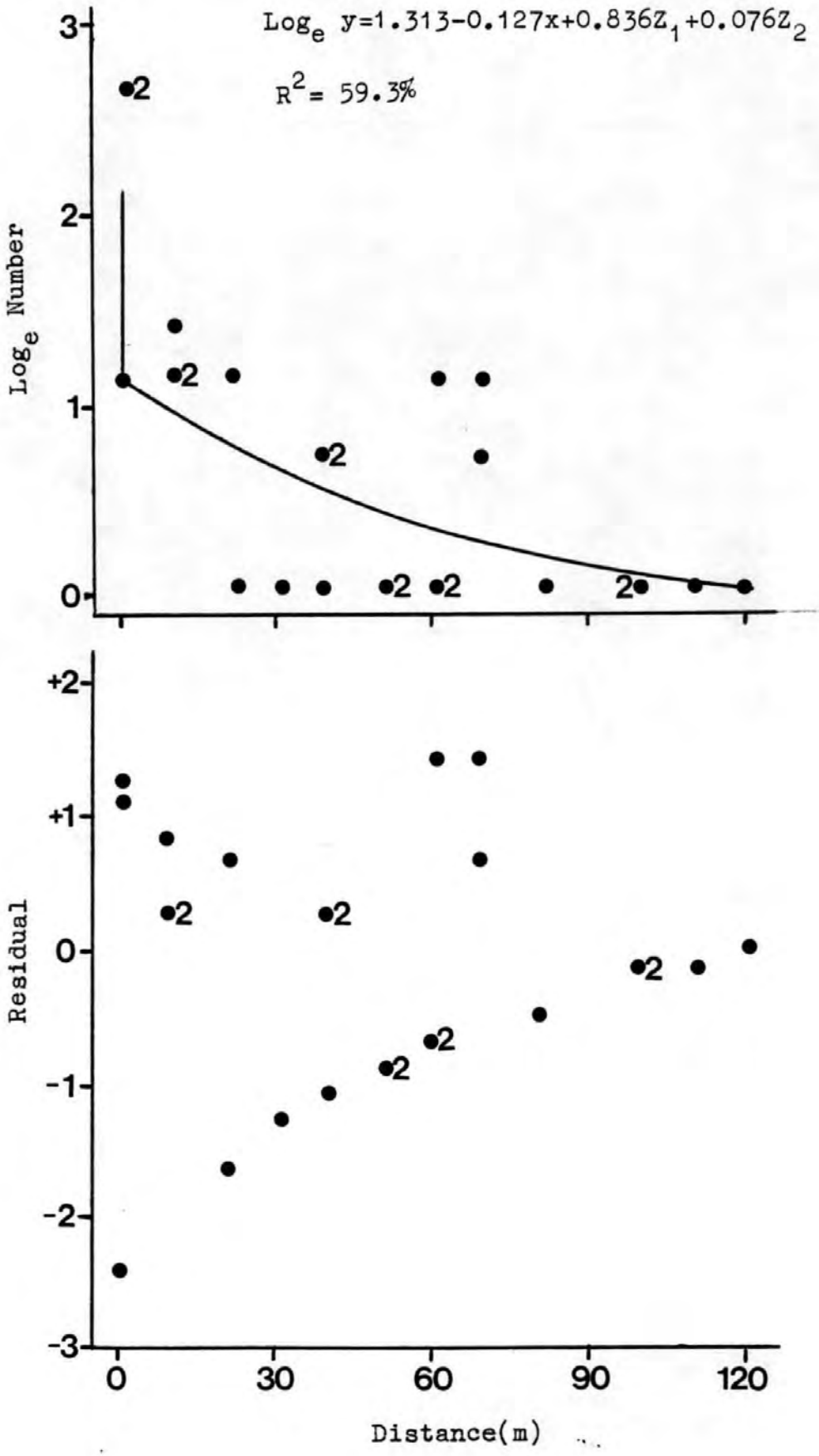


TABLE 34

The results of fitting the regression model to the data from Seale Hayne 1981C.

Age-group	Intercept(a)	Slope(b)	SE b	N	F	R^2
F 1+3	*					
F 5	0.27	+0.014	504.4	14	6.8^a	47.3
F 6	0.57	-0.063	87.6	19	4.3	35.4
F T	1.31	-0.127	41.2	24	11.7^b	58.3
M 1	*					
M 2	0.60	-0.059	62.0	5	2.6	28.5
M 3	0.58	-0.027	176.3	9	0.3	-9.3
M T	0.79	-0.041	101.7	12	1.0	-0.3

* No flies caught

FIG. 108

The regression of female total on distance for Seale Hayne 1981C.