THE INFLUENCE OF THE WEATHER ON THE ACTIVITY OF MOTHS DURING THE NIGHT

Introduction

Mohamed Kazanini, writing in the "Book of the Marvels of Nature and the Singularities of Created Things" in the first half of the thirteenth century, states that the Khalif de Samarkande on one night collected round the lamp a measure called Macouc (drinking cup) of moths and, on dividing them, counted seventy-three kinds (in Williams, 1964). But it was not until the 1950's that the mercury vapour light trap was patented (Robinson & Robinson, 1950; Robinson, 1951) and has since been used extensively for collecting and studying moths (see Heath, 1970a for details). It has been noticed that there are "good" and "bad" nights for moth captures, the former being generally warm and humid, especially thundery nights with little wind, rain or moonshine; "bad" nights, on the other hand, tend to be cold, clear and moonlit, often with wind and rain. This investigation involves the use of a light trap to sample a moth population in an attempt to determine the major meteorological factors which affect the activity of moths during the night. It is expected that there will be a positive correlation between the number of moths caught (the catch) and temperature, pressure, humidity and cloud cover; and a negative correlation between the catch and wind speed, rain and moonlight.

A Robinson-type trap with a 125 watt "pearl" U.V. bulb was operated in a small garden in Little Chalfont, Buckinghamshire which stands 440 feet (134 metres) above sea level on the crest of a chalk ridge in the Chiltern Hills. The climate is typically North-West European type and the natural vegetation was mixed woodland, now replaced by gardens, Beech (*Fagus sylvatica*) woodlands with Wild Cherry (*Prunus avium*) and Holly (*Ilex aquifolium*) undergrowth, mixed farmland and Forestry Commission conifer with Birch (*Betula verrucosa*) plantations.

Previous work on the subject has mainly been done at Rothamstead, Hertfordshire by Williams (1939, 1940), Taylor (1963), Taylor & Carter (1961) and Pinchin & Anderson (1936). Williams (1940) has shown that the "catch" is a sample of the total population of moths in the area and is proportional to the population times the activity:—

$$\text{Catch} \propto \text{Population} \times \text{Activity}$$

The catch includes only positively phototrophic moths that are active; activity (total) equals the activity due to temperature times activity due to wind times activity due to humidity etc. thus:—

A_{total} (Activity total) $=$ A_t (Activity due to temperature) X A_w (Activity due to wind) X A_{rh} (Activity due to relative humidity) etc.

$\therefore$ Catch $\propto$ (A_t X A_w X A_{rh} etc.) X Population

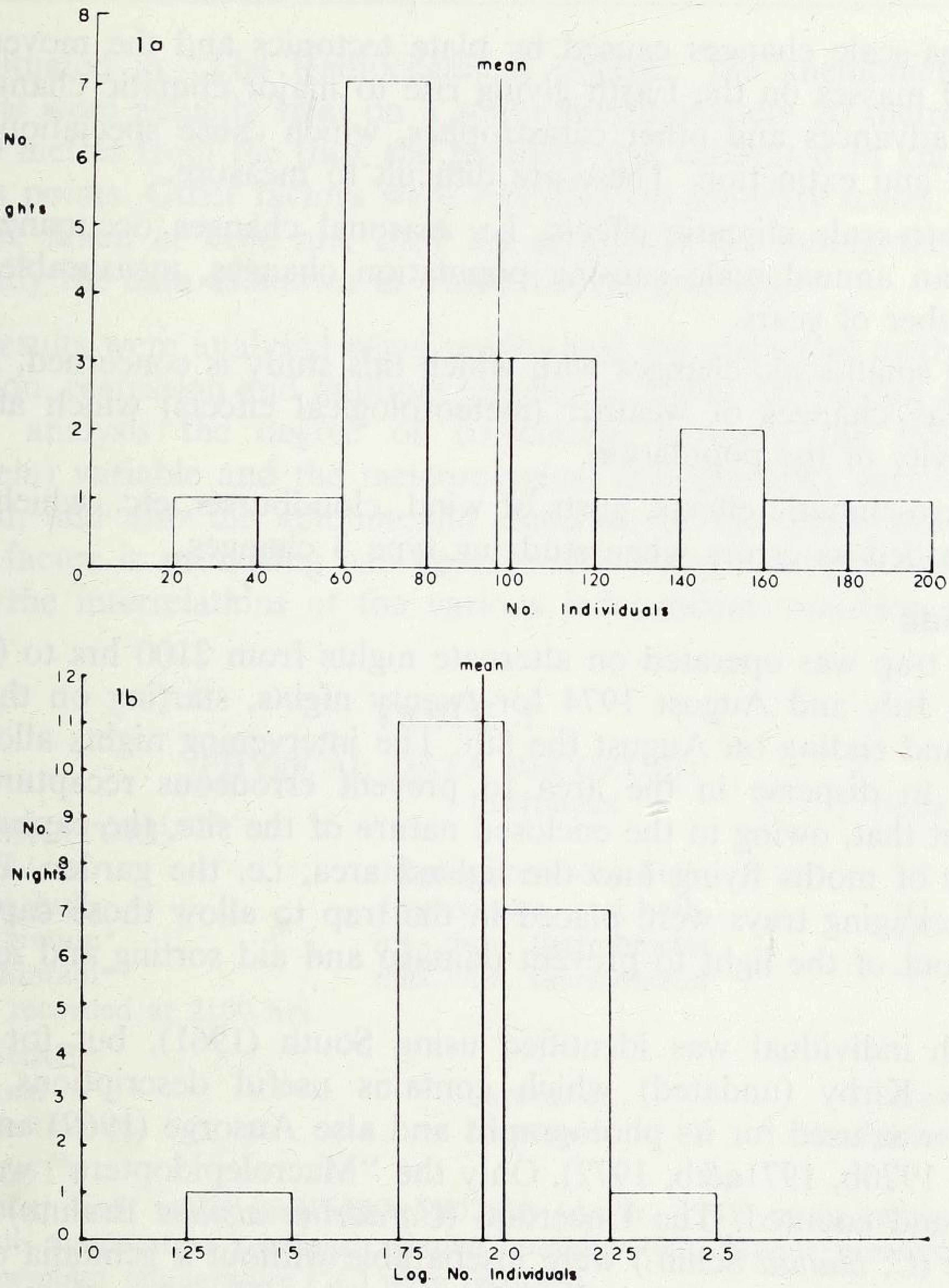
$\therefore$ log. Catch $=$ (log. A_t + log. A_w + log. A_{rh} etc.) + log. Population

The reason for the use of logarithms is discussed later.

Broadly speaking, climate affects moths (as well as other organisms) in four intensities:—

FIG. 1. Frequency distribution of catches expressed as (a) numbers, and (b) logarithms.

FIG. 2. Frequency distribution of number of individuals per species captured (total).


1a
mean
No.
Nights
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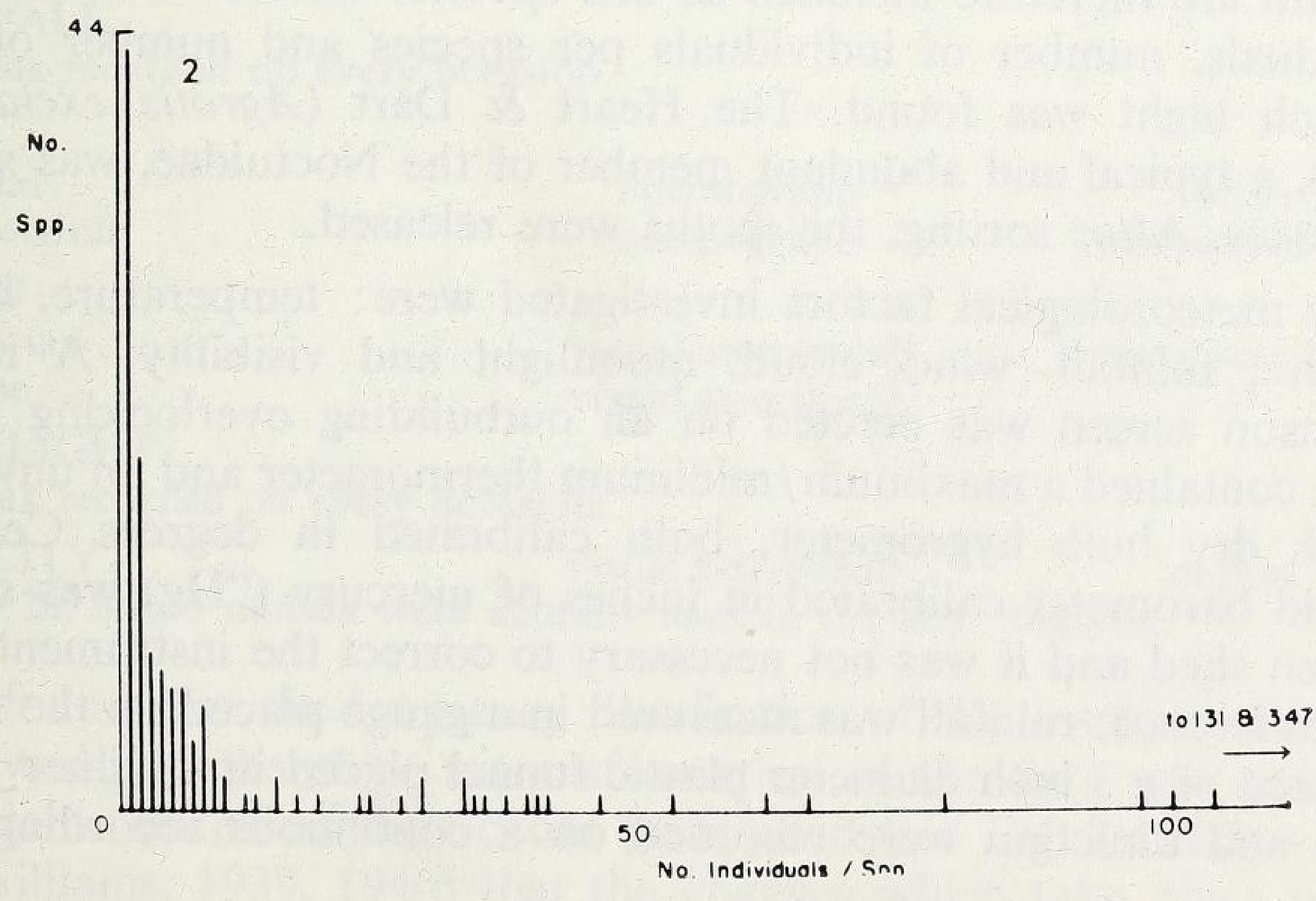
2
No.
Spp.
44
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1. Mega-scale changes caused by plate tectonics and the movement of land masses on the Earth giving rise to major climatic changes, also ice advances and other catastrophes, which cause speciation, evolution and extinction. These are difficult to measure.
2. Macro-scale climatic effects, i.e. seasonal changes occurring mainly on an annual scale causing population changes, measurable over a number of years.
3. The small-scale changes with which this study is concerned, i.e. day-to-day changes of weather (meteorological effects) which affect the activity of the population.
4. Micro-climatic effects, gusts of wind, cloudbursts, etc., which can be regarded as errors when studying type 3 changes.

Methods

The trap was operated on alternate nights from 2100 hrs to 0800 hrs during July and August 1974 for twenty nights, starting on the 1st of July, and ending on August the 8th. The intervening nights allowed the moths to disperse in the area to prevent erroneous recaptures. It is thought that, owing to the enclosed nature of the site, the captures were mainly of moths flying into the lighted area, i.e. the garden. Pieces of egg-packaging trays were placed in the trap to allow those captured to settle out of the light to prevent damage and aid sorting and identification.

Each individual was identified using South (1961), but for difficult species Kirby (undated) which contains useful descriptions, Tykacz (1963) was used for its photographs and also Ansorge (1969) and Heath (1969, 1970b, 1971a&b, 1972). Only the "Macrolepidoptera" were identified and counted. The Uncertain (*Caradrina alsines* Brahm.) and the Rustic (*C. blanda* Schiff.) were inseparable without a genitalia examination and are therefore included as one species. Therefore the number of individuals, number of individuals per species and number of species on each night was found. The Heart & Dart (*Agrotis exclamationis* Linn.), a typical and abundant member of the Noctuidae, was separated into sexes. After sorting, the moths were released.

The meteorological factors investigated were: temperature, humidity, pressure, rainfall, wind, cloud, moonlight and visibility. A makeshift Stevenson screen was erected on an outbuilding overlooking the trap, which contained a maximum/minimum thermometer and an unventilated wet & dry bulb hygrometer, both calibrated in degrees Celsius; an aneroid barometer calibrated in inches of mercury ("Hg) was sited in a wooden shed and it was not necessary to correct the instrument for altitude difference; rainfall was measured in a gauge placed on the lawn and consisted of a 3 inch diameter plastic funnel placed in a Kilner jar; wind speed and direction were recorded on a continuous recording anemograph situated in "The Radiochemical Centre", the anemometer and windvane were actually sited on a tower approximately 20 metres high and 400 metres from the trap, the recorder was calibrated in knots and compass points. Other factors were recorded on arbitrary scales. Readings were taken at 2100 hrs, 2400 hrs and 0800 hrs during the night, specifically the data as shown in Table 1 were recorded.

The results were analysed using graphs and the statistical methods of correlation, regression and multiple regression. Using correlation and regression analysis the degree of correlation between the biological (dependent) variable and the meteorological (independent) variable can be found, and also the amount and direction of the effect which the weather factor is producing can be assessed. Using multiple regression analysis the interrelations of the various independent variables can be analysed.

TABLE 1

PHYSICAL DATA RECORDED

	Instrument	Scale
1. TEMPERATURE		
(a) Ambient	hygrometer—dry bulb	°C
(b) Wet bulb	hygrometer—wet bulb	°C
(c) Maximum*	max./min. thermometer	°C
(d) Minimum*	max./min. thermometer	°C
* Not recorded at 2100 hrs.		
2. PRESSURE		
(a) Actual	barometer	"Hg
(b) Direction	barometer	steady/rise/fall
3. HUMIDITY		
Calculated from tables in HMSO MO265B (Anon., 1961) using ambient and wet bulb temperature readings; relative humidity (%), vapour pressure (mb.) and dew-point temperature (°C) were recorded.		
4. RAINFALL		
Zero was recorded on every occasion.		
5. WIND		
(a) Speed	anemograph	knots
(b) Direction	anemograph	compass points
6. CLOUD		
(a) Amount	visual assessment	sky cover $\frac{1}{8}$ths
(b) Type	visual assessment	—
7. MOONLIGHT		
Zero was recorded on every occasion.		
8. VISIBILITY	visual assessment	m./km.

Only 1, 2a, 3rh, 5 and 6a were actually used in the final analysis.

It was found that the frequency distribution of the catches was positively skewed and therefore a transformation of the data was required before reliable statistical tests could be applied (see Fig. 1). It has been shown (Williams, 1939, 1940) that the changes which take place in the catches are of a geometric nature; i.e. a catch of twice the mean is as likely to occur as one of half the mean, one of four times the mean is as likely to occur as one of a quarter of the mean, and so on; therefore a logarithmic transformation should be used, and has been in this investigation. Similarly the frequency distribution of numbers of individuals per species is also, excessively, positively skewed (Poisson distribution—see Fig. 2). The effect of a transformation is to give a straight line regression rather than a curvi-linear one, for example in the correlation between number of individuals and number of species (Figs. 3 & 4).

When analysing the effect of weather conditions on the number of species captured the actual number cannot be used due to this strong correlation (e.g. if only 30 individuals are captured, as on the 4th of August, then the number of species cannot exceed this figure) so an index of the diversity of the population sample is used, taking into account the logarithmic distribution of numbers of individuals (Williams, 1944, 1945; Fisher, Corbett & Williams, 1943). The index of diversity ($\propto$) can be read directly from a table, such as that in Lewis & Taylor (1967). It should be noted that the index has a logarithmic series involved and also requires transformation if used in statistical analyses.

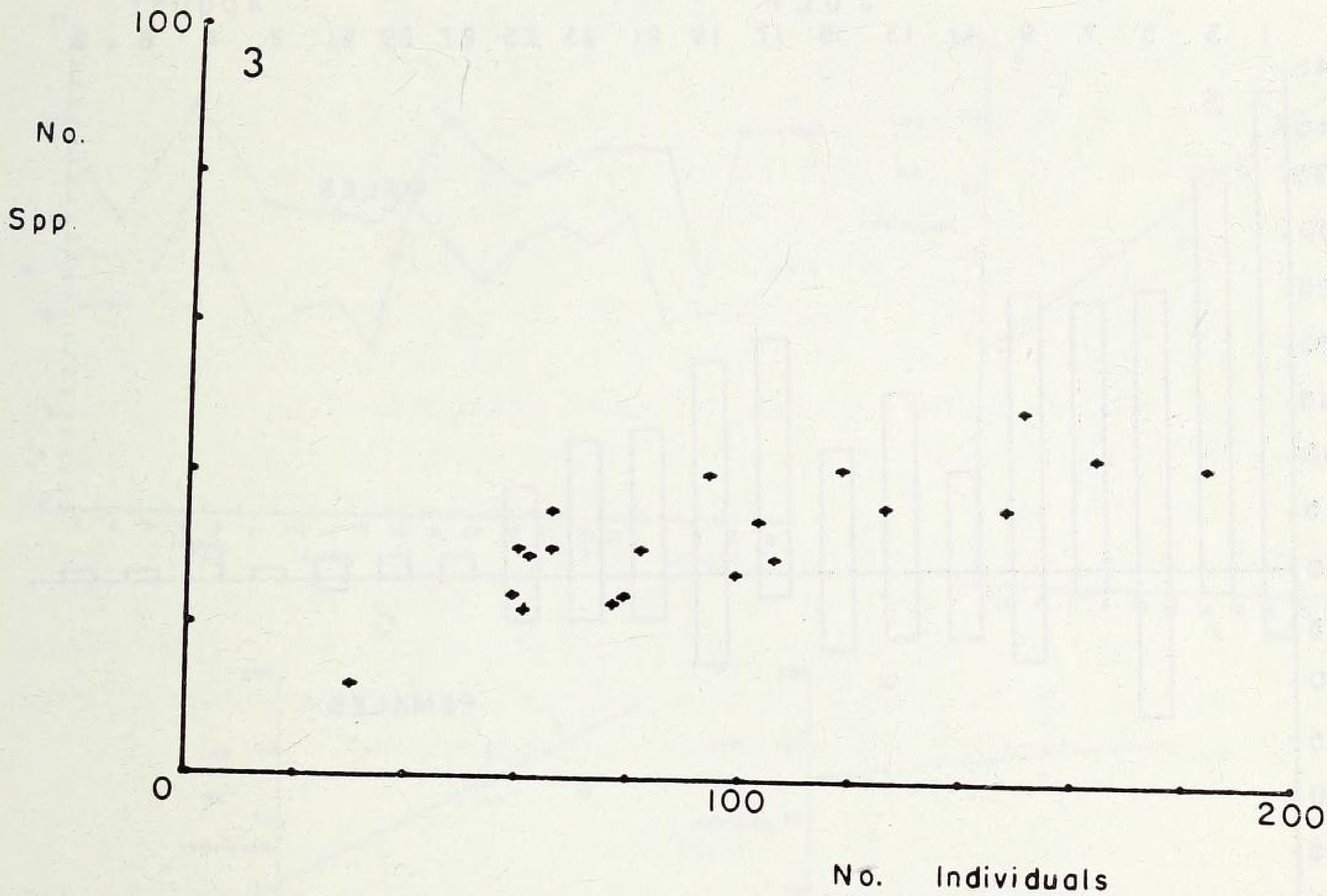
The sources of error are numerous, as in any field investigation, and consist mainly of four types:

(1) Trap errors—the light attracts only positively phototropic insects and some species of moth are not attracted to light very much (e.g. The Mouse, *Amphipyra tragopoginis* Clerck, of which none of this common moth were caught) whereas some are attracted much more than others (up to 5,000 times, see Taylor & Carter 1961), also another attractant may be more inviting, such as flowers, or another light.

(2) Activity errors—escapes from the trap, usually due to the early morning sun causing the trap to warm up, members of the Geometridae tend to escape more easily than the larger species; population fluctuations are compensated for partly by this study having been done during the summer when a fairly constant number of species is on the wing; the activity of predators will also be affected by environmental factors; some species tend to fly at greater heights from ground level than others and are less likely to be attracted; throughout the trapping period there would have been a change in the times of dusk and dawn, thus the night would have been lengthening over the period.

(3) Instrumental error—distance from the trap of the wind recorder may be significant; intrinsic instrument errors; the small number of observations; statistical errors of tables and non-normality of sample, etc.

(4) Human error—intrinsic human error; factors not analysed which may also affect the activity; errors in calculation.



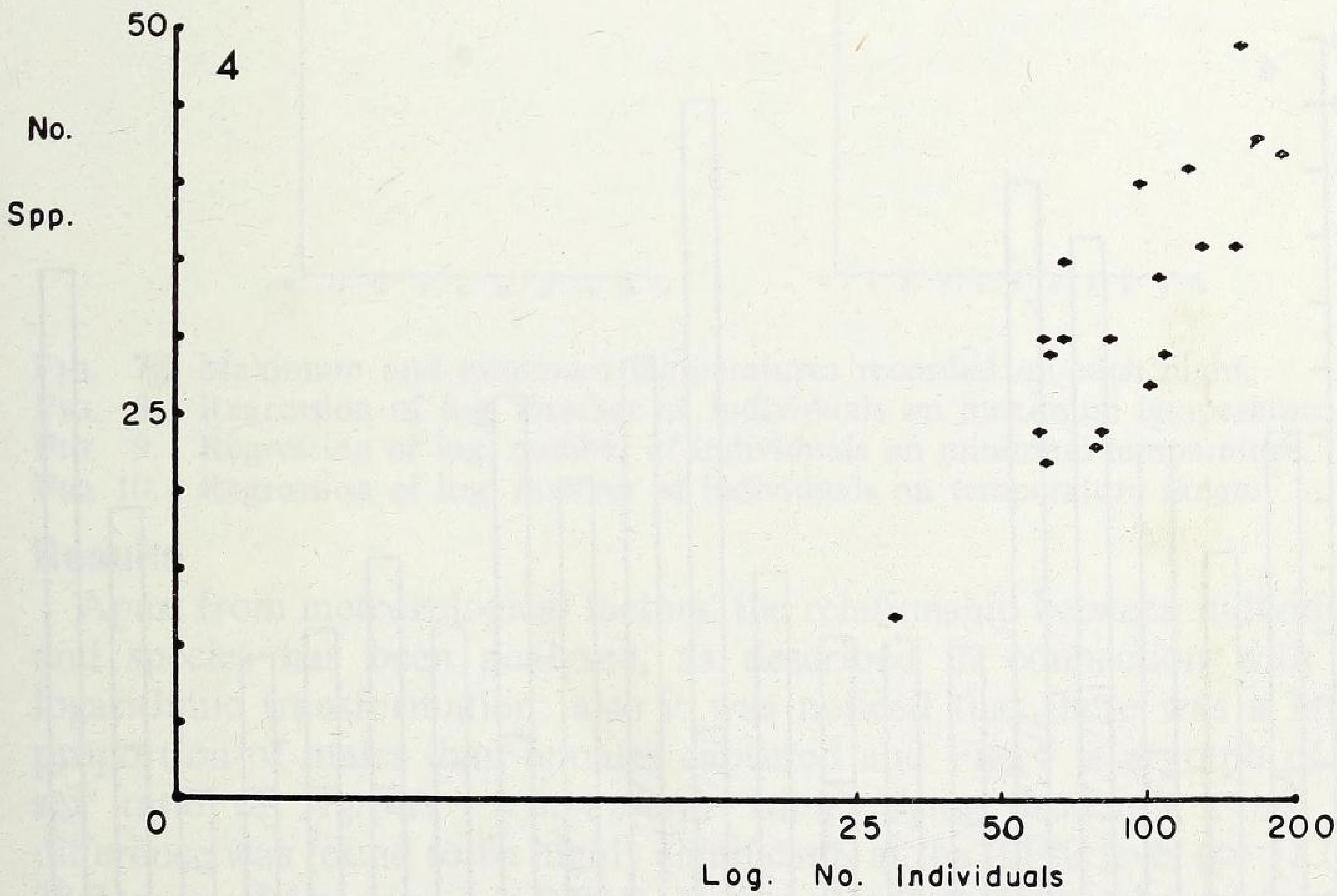
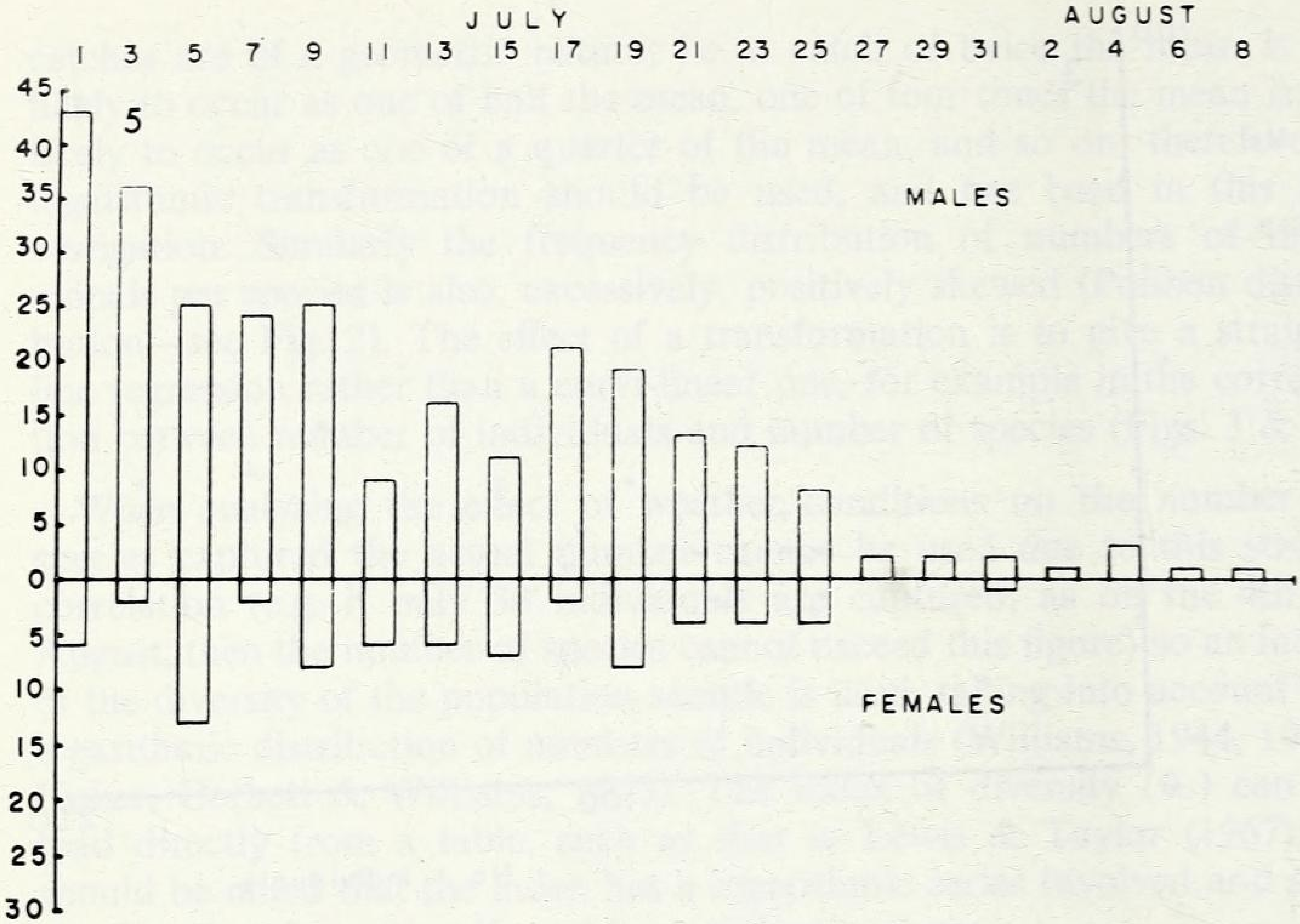


FIG. 3. Showing the curvilinear relationship between the number of species and the number of individuals captured.

FIG. 4. Figure 3 transformed to produce a more linear regression line.



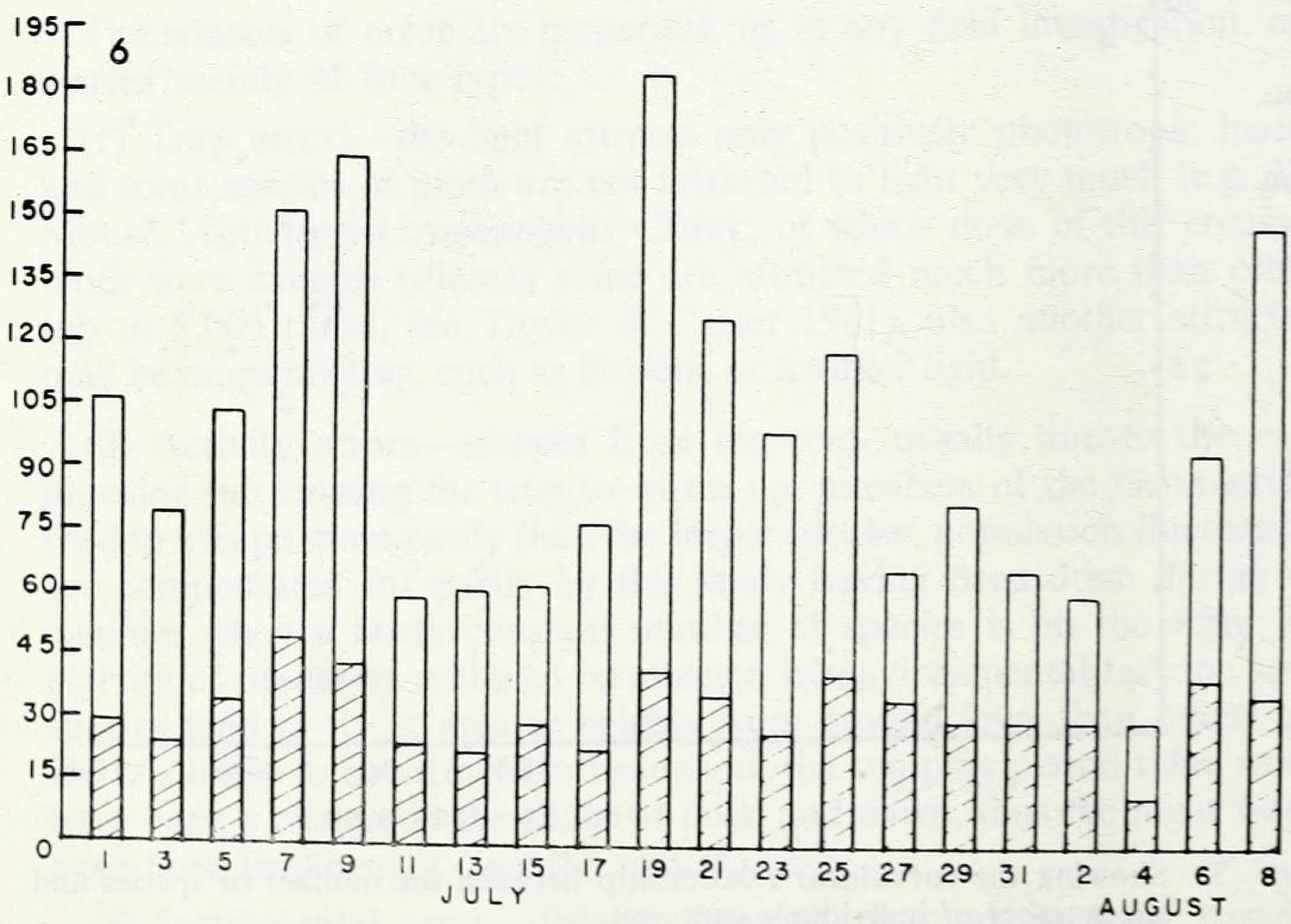
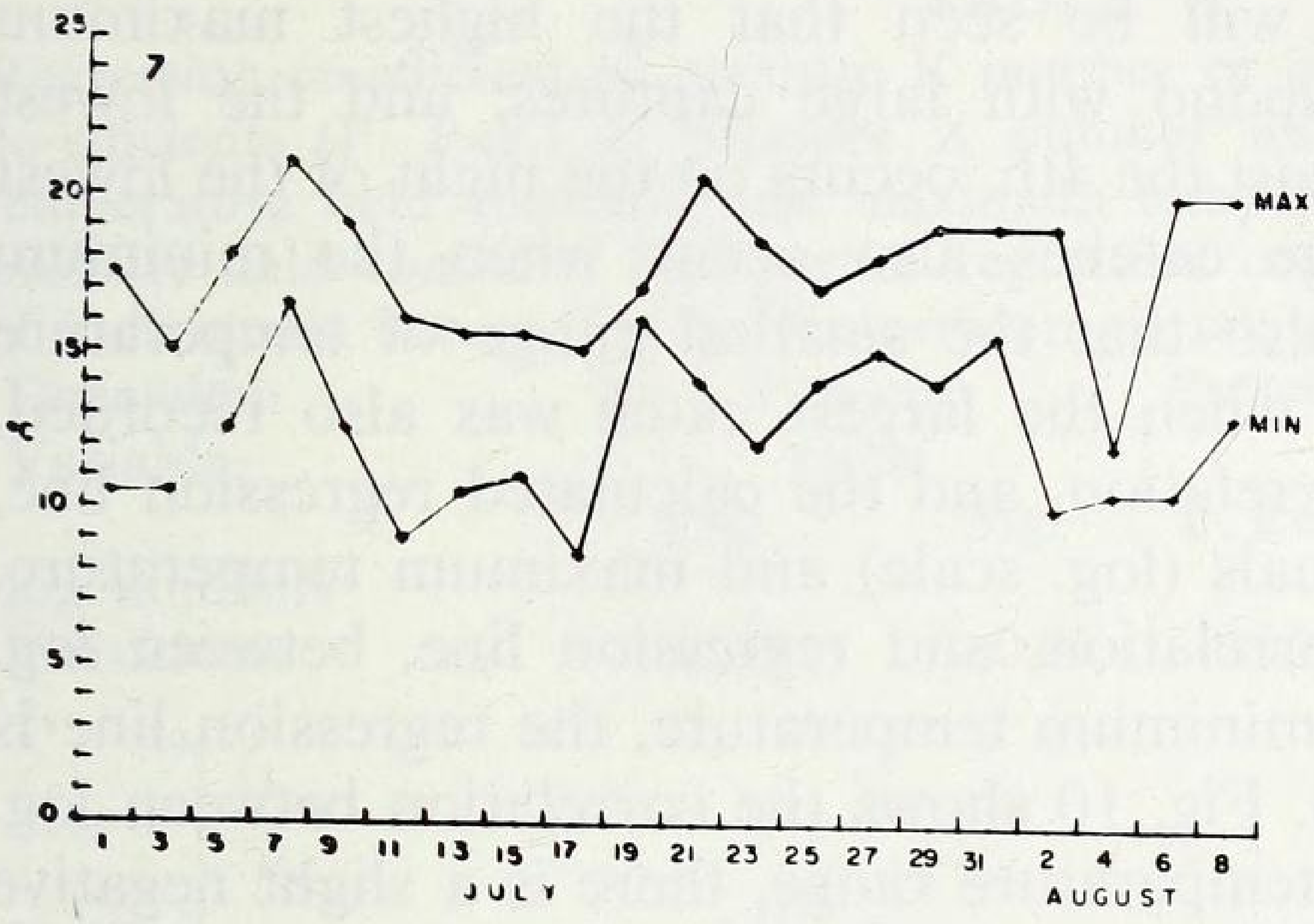
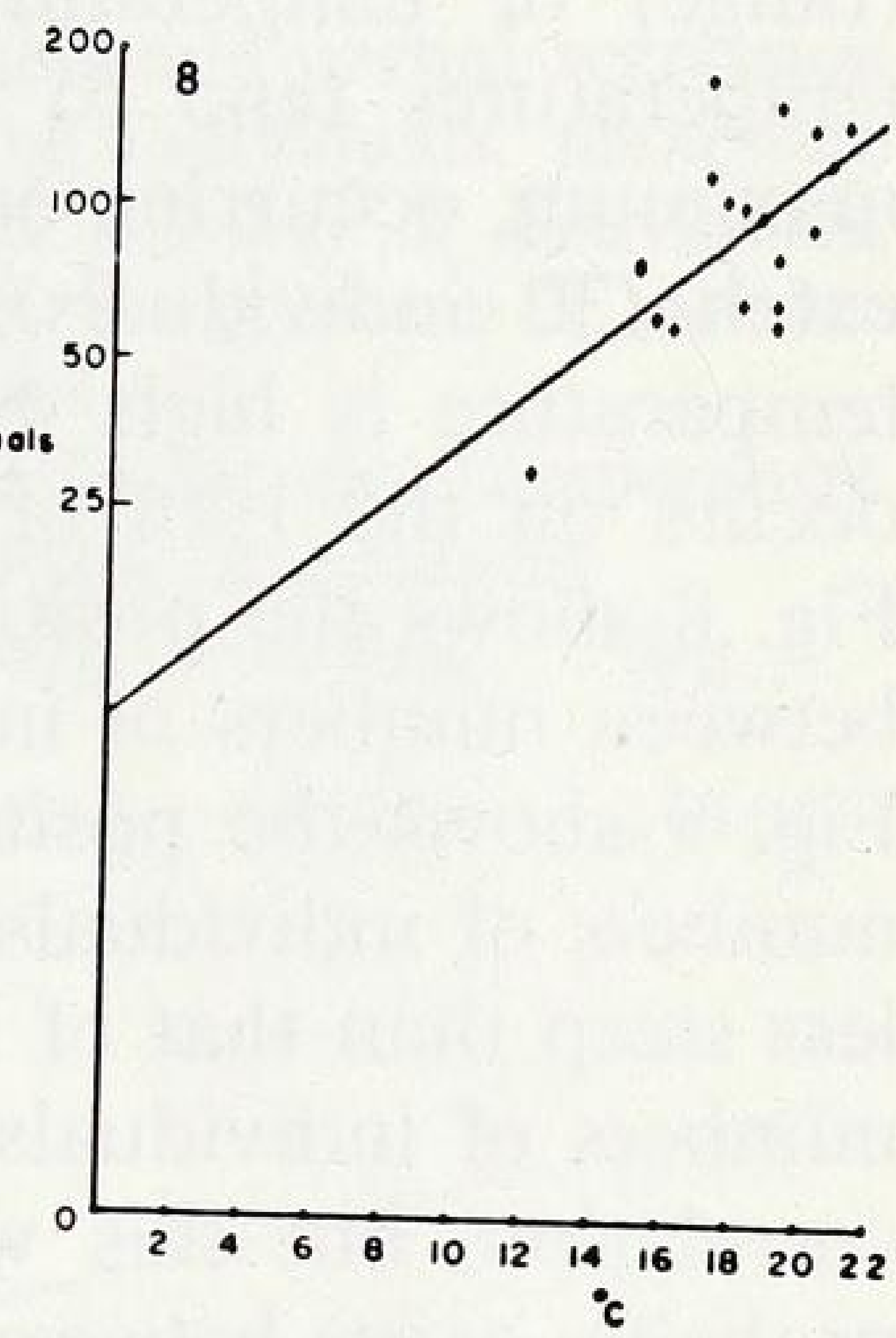
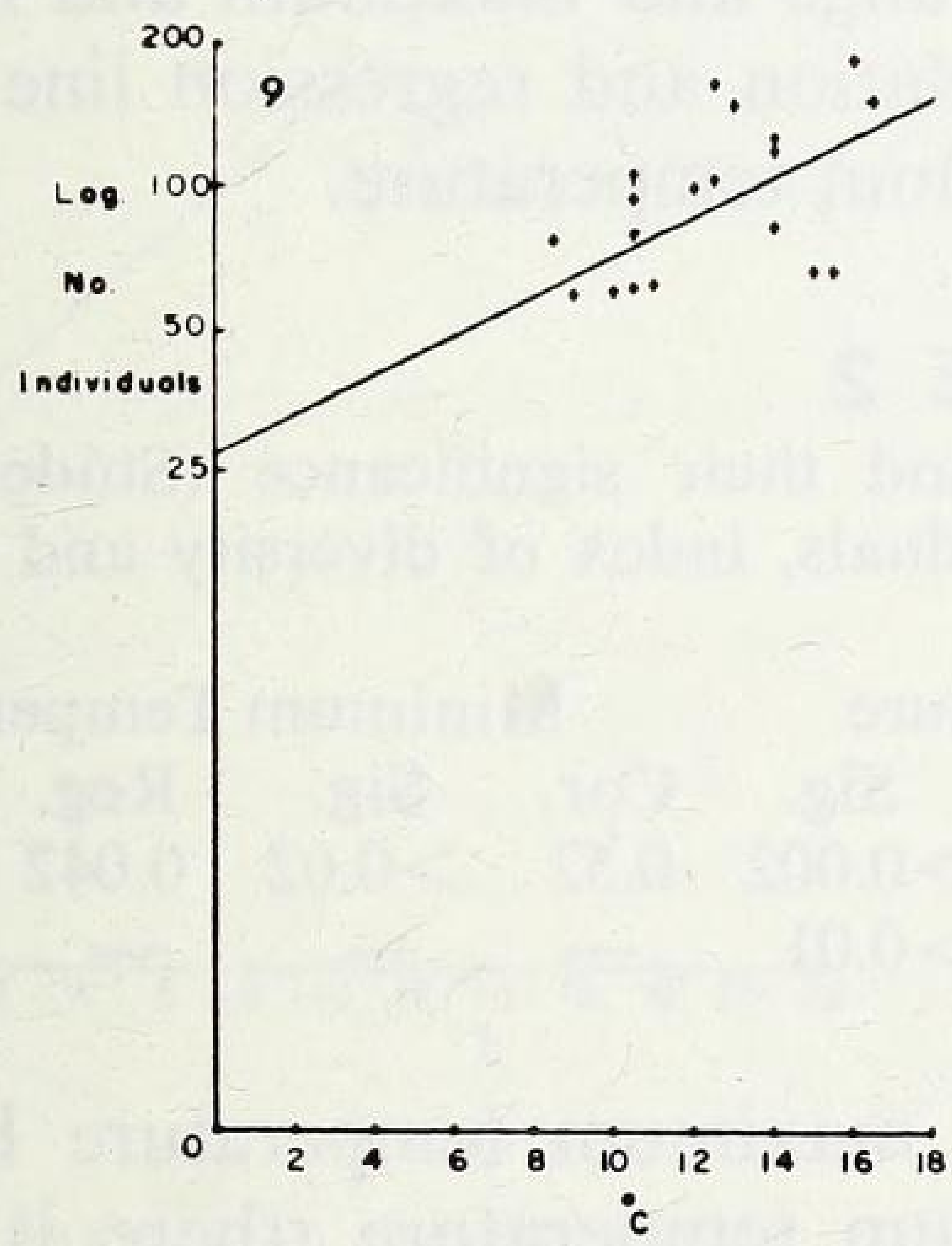


FIG. 5. Graph to show the actual numbers of males and females of *Agrotis exclamationis* (The Heart & Dart) captured on each night. The number of females captured was lower than the number of males on every night. Note also the total numbers declining as the season progressed.

FIG. 6. Histogram showing numbers of individuals (white) and species (shaded) captured on each night.







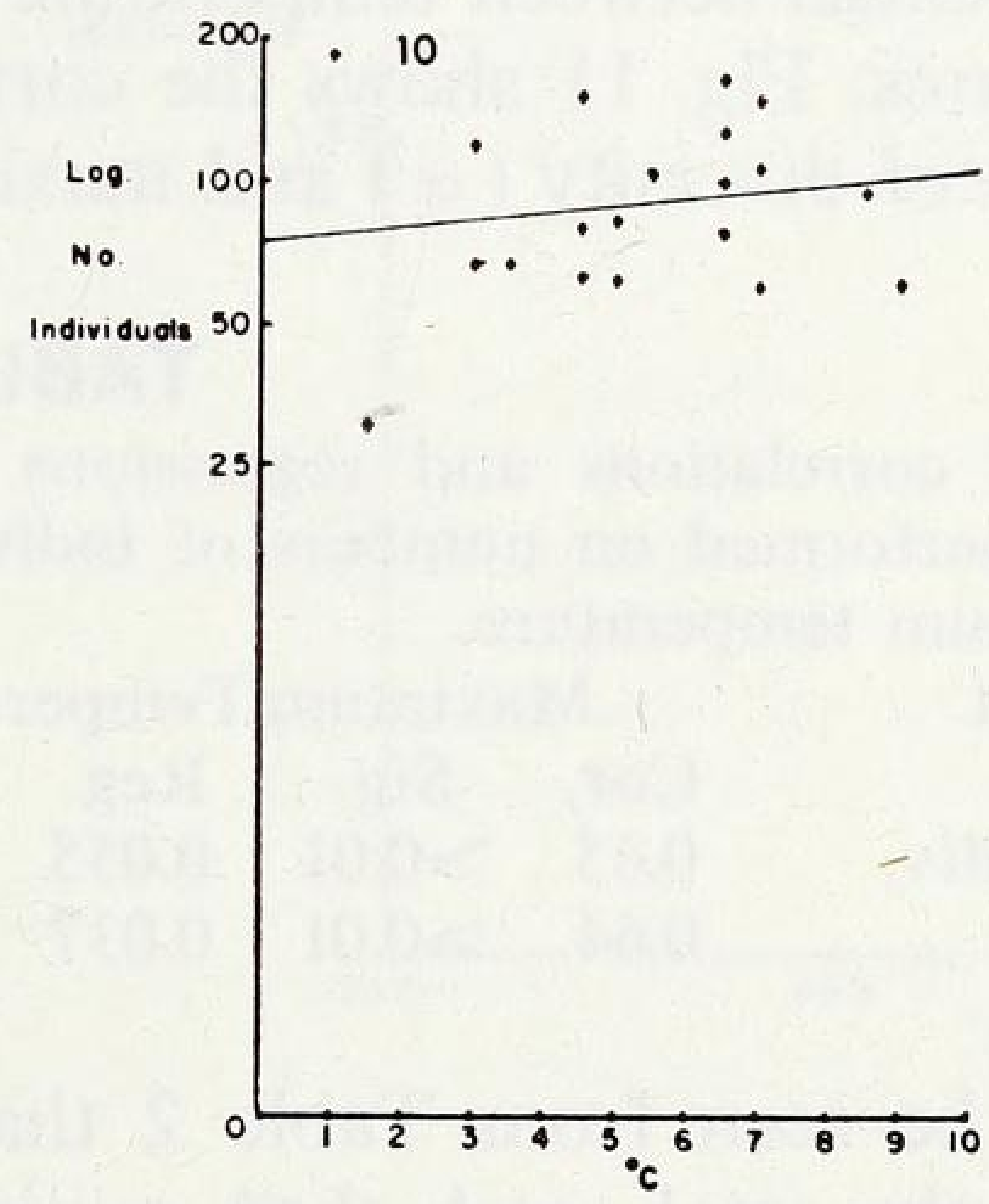


FIG. 7. Maximum and minimum temperatures recorded on each night.
FIG. 8. Regression of log. number of individuals on maximum temperature.
FIG. 9. Regression of log. number of individuals on minimum temperature.
FIG. 10. Regression of log. number of individuals on temperature range.

Results

Apart from meteorological factors, the relationship between individuals and species has been analysed, as described in connection with the logarithmic transformation; also it was noticed that there was a larger proportion of males than females captured and Fig. 5 is a graph of the sex ratio of *Agrotis exclamationis* Linn. Using Student's t-test, the difference was found to be highly significant, at the 0.1% level ($t=11.079$, 38 degrees of freedom, $p > 0.001$). Notice also that the number of females captured each night does not decline so sharply as the number of males does as the flight period tails off.

Temperature was found to be the most important single factor influencing the activity of moths. Fig. 6 shows the actual number of individuals and species captured on each occasion, and Fig. 7 shows the corresponding maximum and minimum temperatures, and therefore the difference (range) of temperature. It will be seen that the highest maximum temperatures tend to correspond with large captures, and the lowest maximum, occurring on August the 4th, occurs on the night of the lowest catch (30 individuals). Large catches also occur when the minimum temperature is high. Note also that the smallest range of temperature occurs on the 19th of July when the largest catch was also recorded. Fig. 8 shows the positive correlation, and the calculated regression line, between numbers of individuals (log. scale) and maximum temperature. Fig. 9 shows the positive correlation, and regression line, between log. numbers of individuals and minimum temperature, the regression line is less steep than that of Fig. 8. Fig. 10 shows the correlation between log. numbers of individuals and temperature range, there is a slight negative correlation, but this was not calculated due to the correlation which probably exists between temperature range and maximum and minimum temperatures. Fig. 11 shows the correlation and regression line between log. index of diversity (α) and maximum temperature.

TABLE 2

Results of correlations and regressions and their significance (Student's t-test, p-values) performed on numbers of individuals, index of diversity and maximum and minimum temperature.

Dependent	Maximum Temperature				Minimum Temperature			
variable	Cor.	Sig.	Reg.	Sig.	Cor.	Sig.	Reg.	Sig.
log. no. indiv.	0.65	>0.01	0.055	>0.002	0.52	>0.02	0.042	>0.02
log. α	0.64	>0.01	0.037	>0.01	—	—	—	—

It can be seen from Table 2 that maximum temperature has more effect on the total catch than minimum temperature (there is a closer correlation and the regression line is steeper) and also affects the catch more than the diversity of the sample captured, but all are significantly affected.

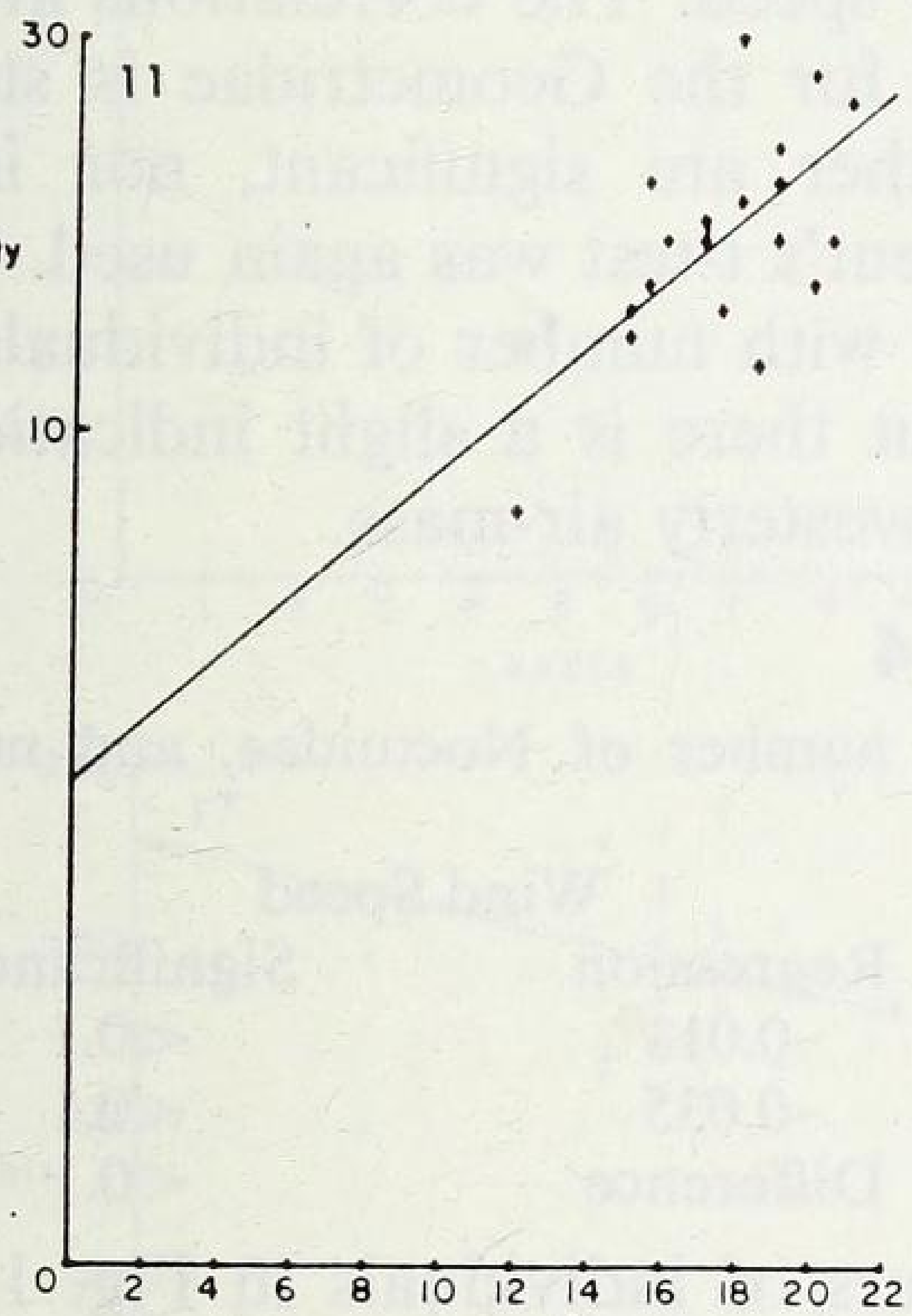
The effect of pressure can be seen in Fig. 12. There is a positive correlation, however, it was suspected that this may have been due to the correlation between pressure and temperature, so partial regressions were calculated for the effect of these two variables on numbers of individuals and it was found that the partial regression of pressure on log. number of individuals was not significant if maximum temperature was held constant (see Table 3). A rise in pressure causes a rise in temperature (they are positively correlated) and it is the temperature rise which causes the rise in the catch.

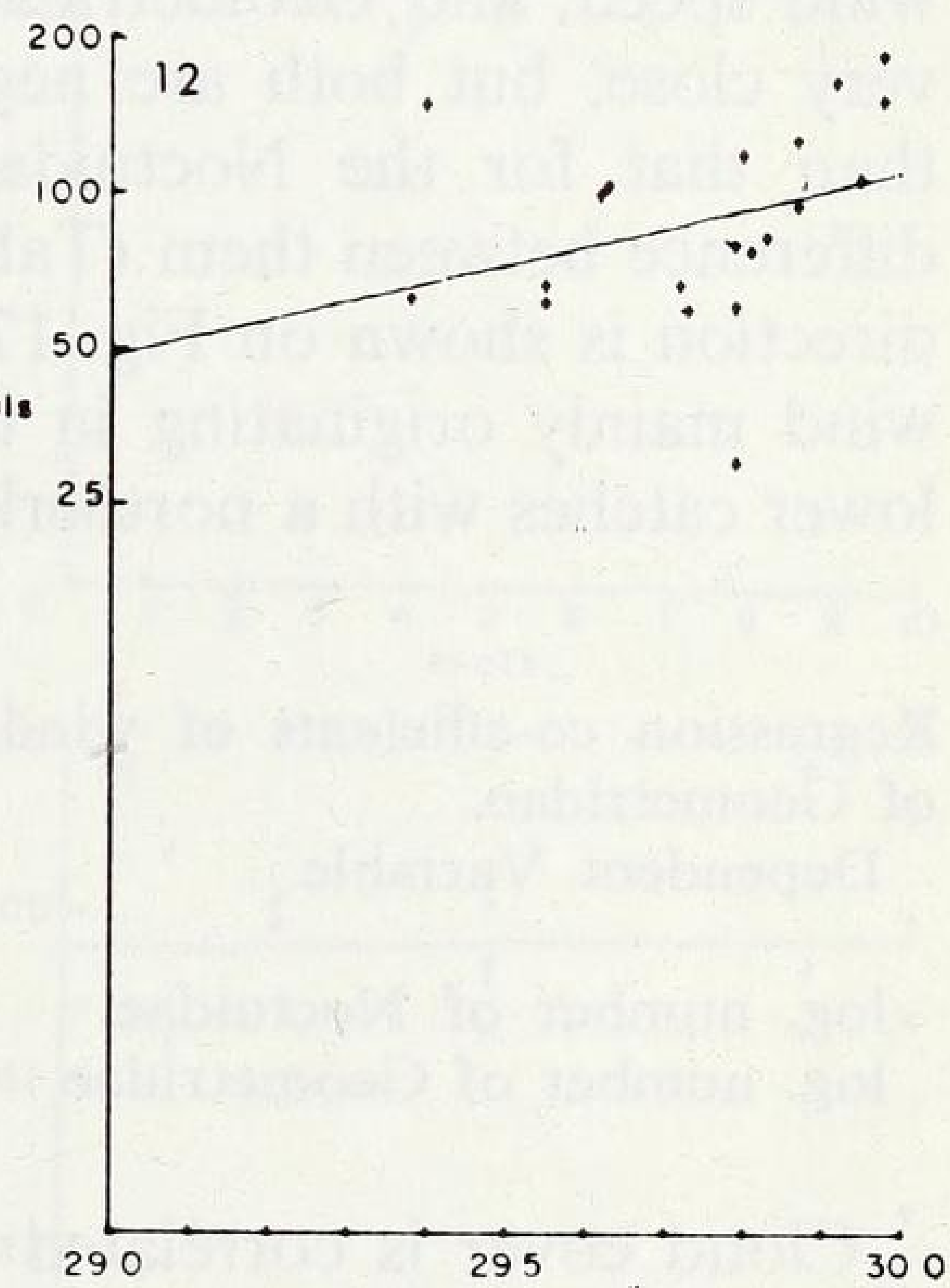
It was expected that there would be a positive correlation between relative humidity and numbers of individuals but Fig. 13 shows the correlation to be negative, but there is not a close correlation. Humidity is likely to be closely affected by temperature, pressure and wind, so its effect would be difficult to determine.

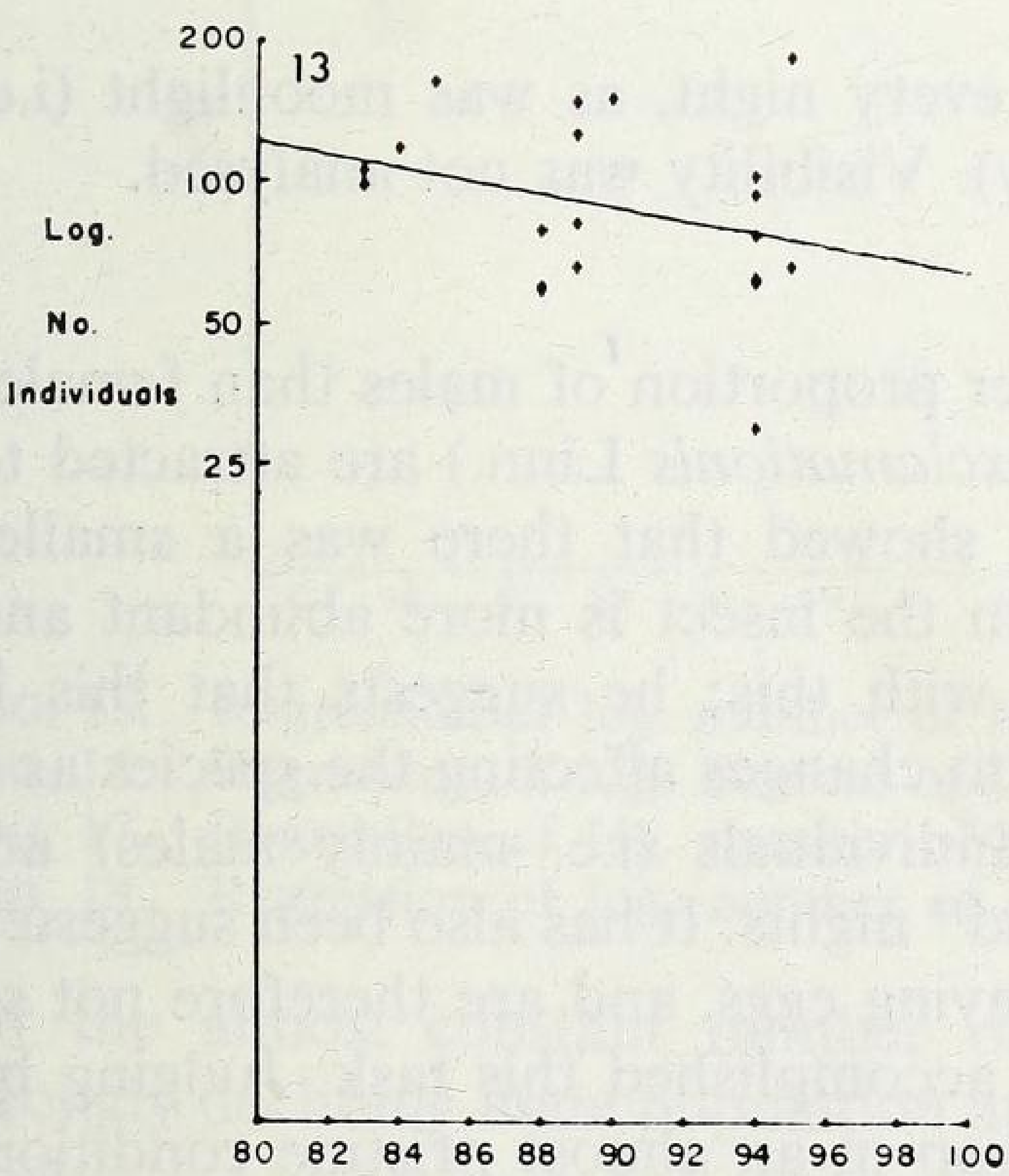
TABLE 3

Regression co-efficient of pressure X number of individuals and partial regression co-efficients (P. Reg.) of pressure X number number of individuals, maximum temperature held constant, and maximum temperature X number of individuals, pressure held constant. The partial regression co-efficient for pressure X number of individuals, accounting for temperature, is not significant.

Dependent Variable	Pressure alone		Pressure and Maximum Temperature Multiple Regression			
	Reg.	Sig.	P. Reg.	Sig.	P. Reg.	Sig.
log. numbers individuals	0.359	>0.01	0.263	<0.1	0.052	>0.01







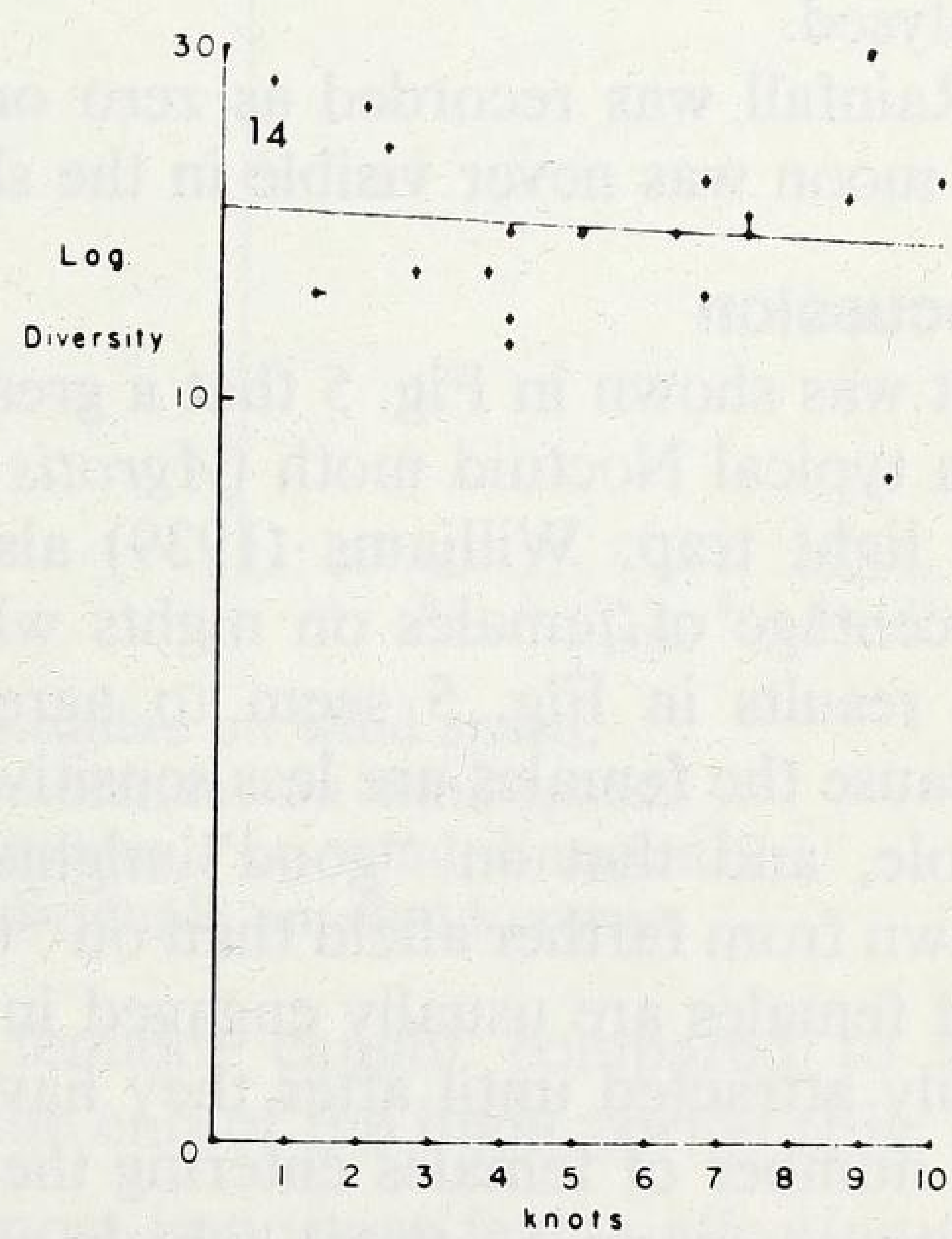


FIG. 11. Regression of log. diversity on maximum temperature.
FIG. 12. Regression of log. number of individuals on pressure.
FIG. 13. Regression of log. number of individuals on relative humidity.
FIG. 14. Regression of log. diversity on wind speed.

Wind speed should be negatively correlated with the size of the catch. It was thought, however, that there would be a difference in the catch itself between the numbers of the family Noctuidae, which tend to be large, strongly-flying species and therefore not much affected by the wind speed, and the Geometridae, which have large wings in relation to their bodies, and would be more likely to be blown by the wind and thus tend not to fly on windy nights. Firstly, the index of diversity was plotted against wind speed (Fig. 14) and there does seem to be a slight negative correlation. Figs. 15 and 16 show the correlation between Noctuidae and wind speed, and Geometridae and wind speed. The correlations are not very close, but both are negative; that for the Geometridae is steeper than that for the Noctuidae, but neither are significant, nor is the difference between them (Table 4). Student's t-test was again used. Wind direction is shown on Fig. 17 correlated with number of individuals, the wind mainly originating in the west, but there is a slight indication of lower catches with a northerly or north-westerly air-mass.

TABLE 4

Regression co-efficients of wind speed with number of Noctuidae, and number of Geometridae.

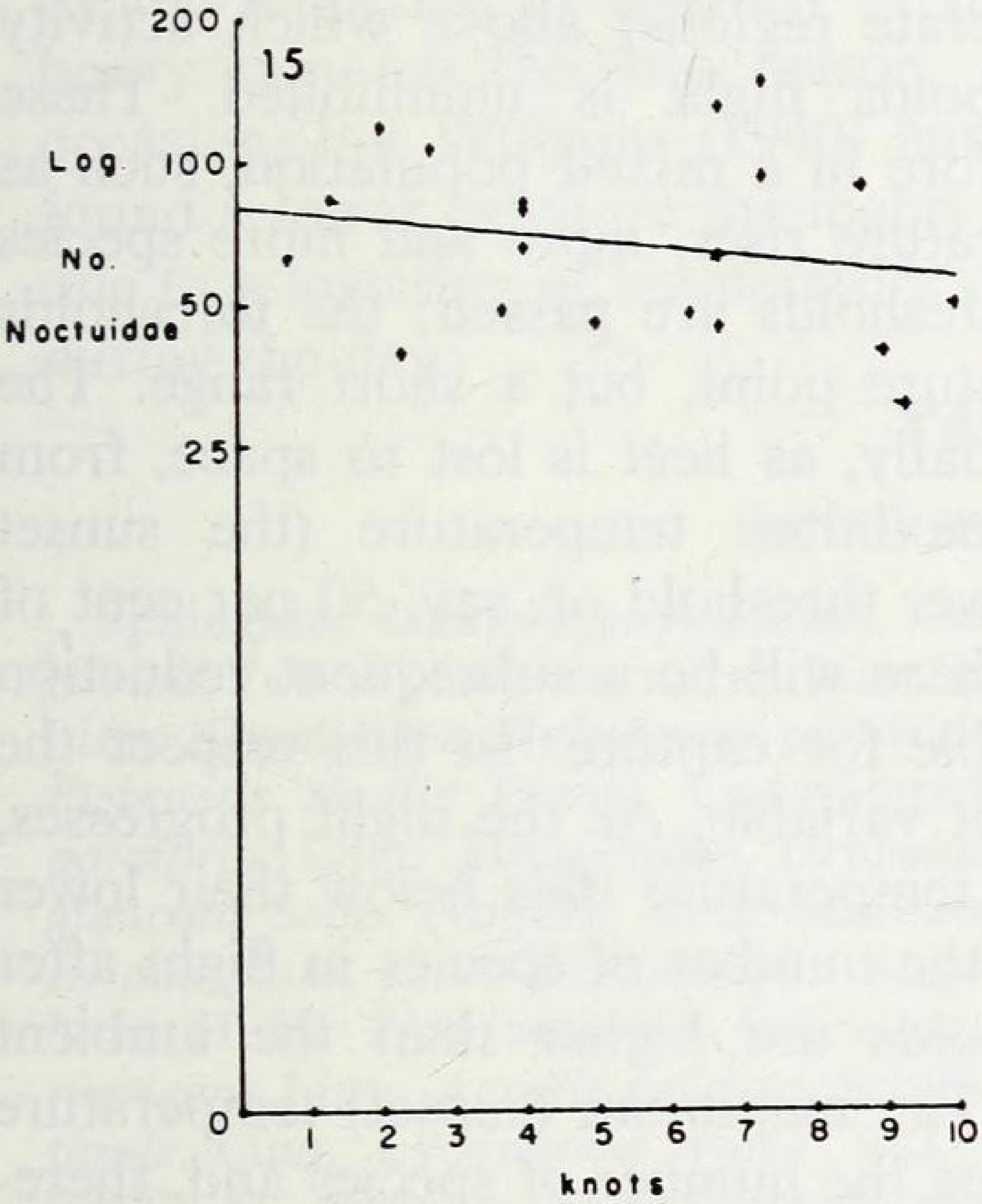
Dependent Variable	Wind Speed	
	Regression	Significance
log. number of Noctuidae	–0.013	<0.1
log. number of Geometridae	–0.035	<0.1
	Difference	<0.1

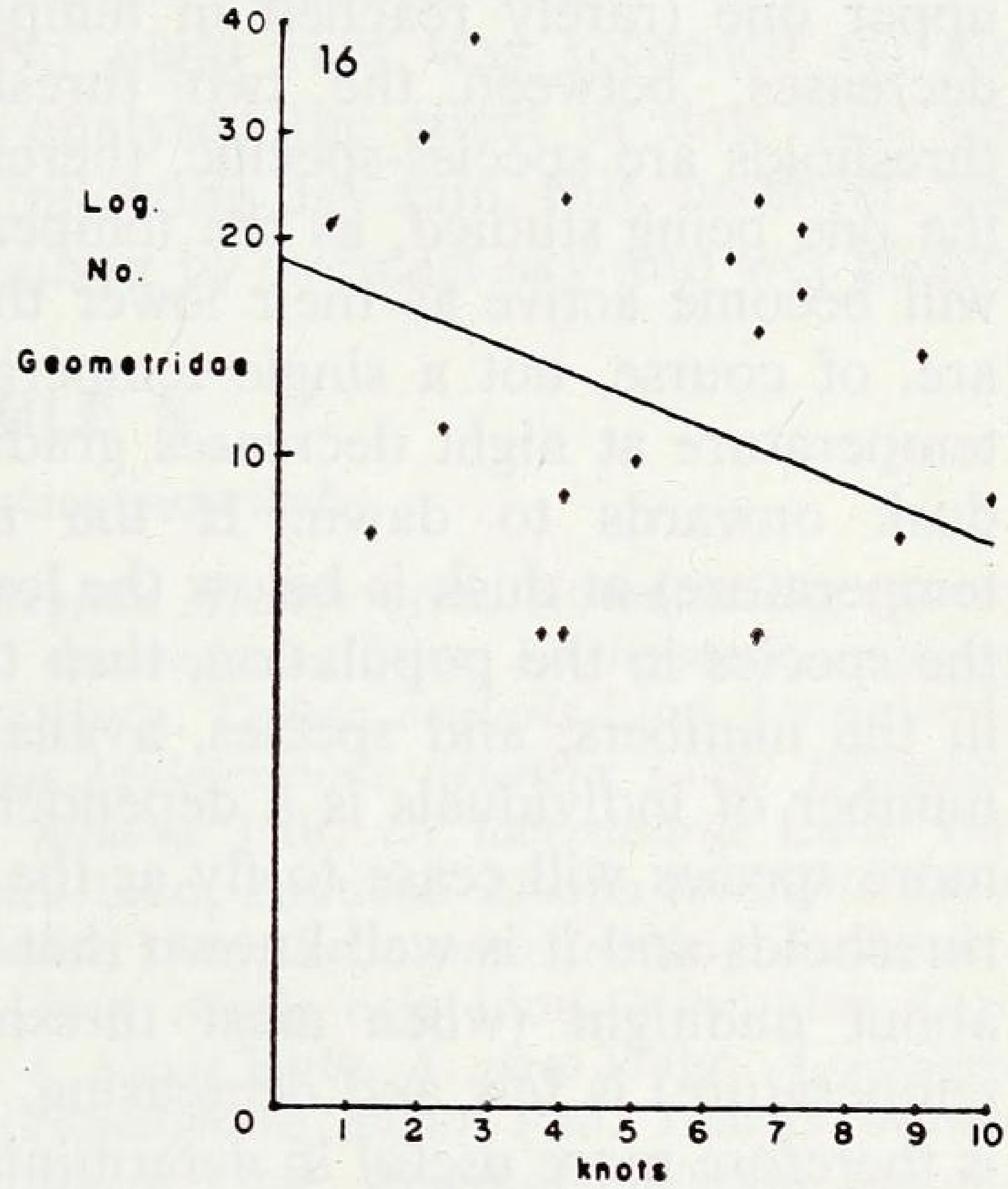
Cloud cover is correlated with numbers of individuals in Fig. 18 but there does not seem to be a very great effect. Cloud type could not be analysed.

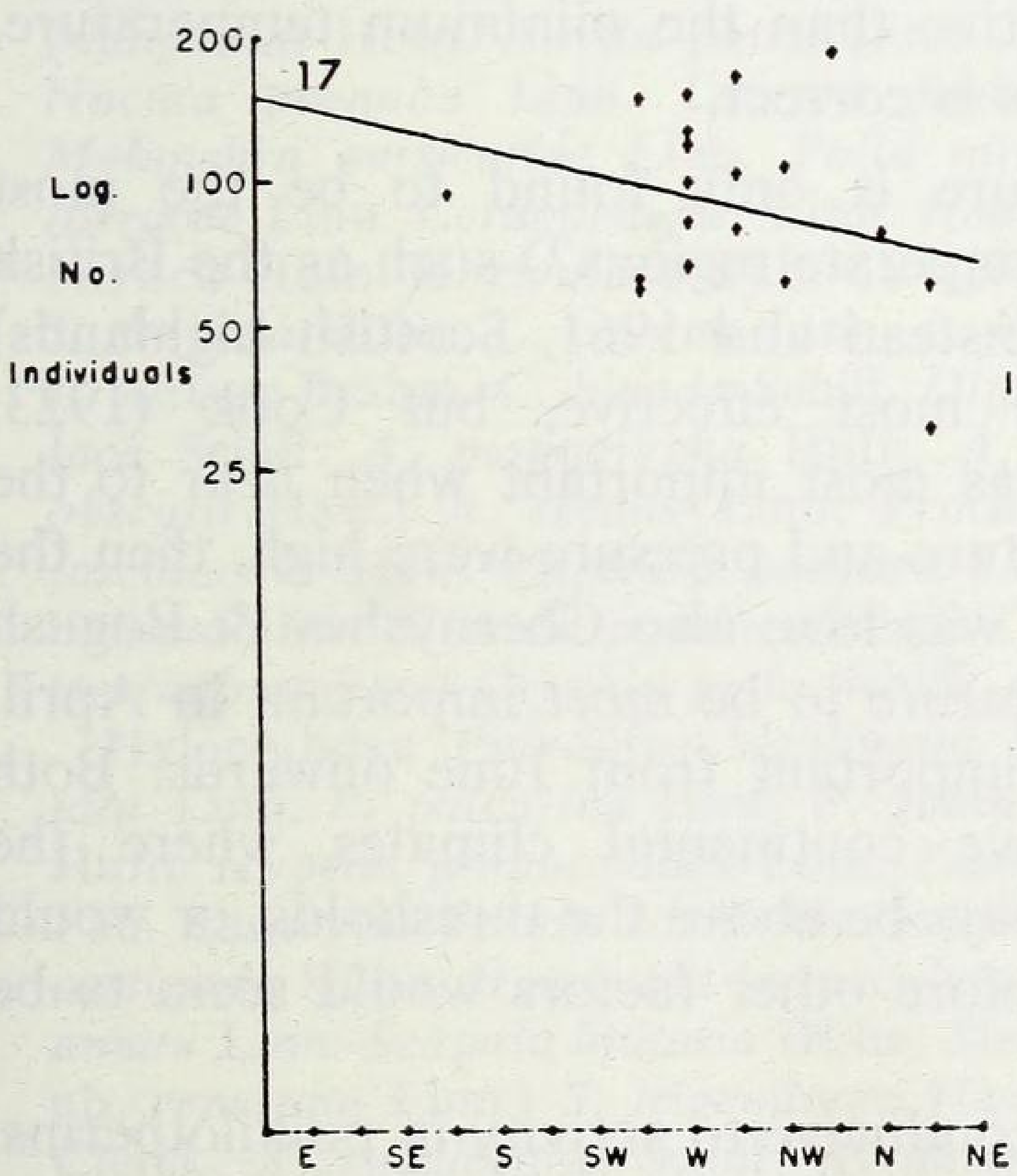
Rainfall was recorded as zero on every night, as was moonlight (i.e. the moon was never visible in the sky). Visibility was not analysed.

Discussion

It was shown in Fig. 5 that a greater proportion of males than females of a typical Noctuid moth (*Agrotis exclamationis* Linn.) are attracted to the light trap. Williams (1939) also showed that there was a smaller percentage of females on nights when the insect is more abundant and the results in Fig. 5 seem to agree with this; he suggests that this is because the females are less sensitive to changes affecting the species as a whole, and that on "good" nights individuals (i.e. mainly males) are drawn from farther afield than on "bad" nights. It has also been suggested that females are usually engaged in laying eggs, and are therefore not so easily attracted until after they have accomplished this task. Judging by the number of females entering the trap in an almost pristine condition, easily as many as those which were imperfect, I would suggest that females fly not only after laying eggs, but also when freshly emerged and are in the process of mating or selecting a laying site; this could account







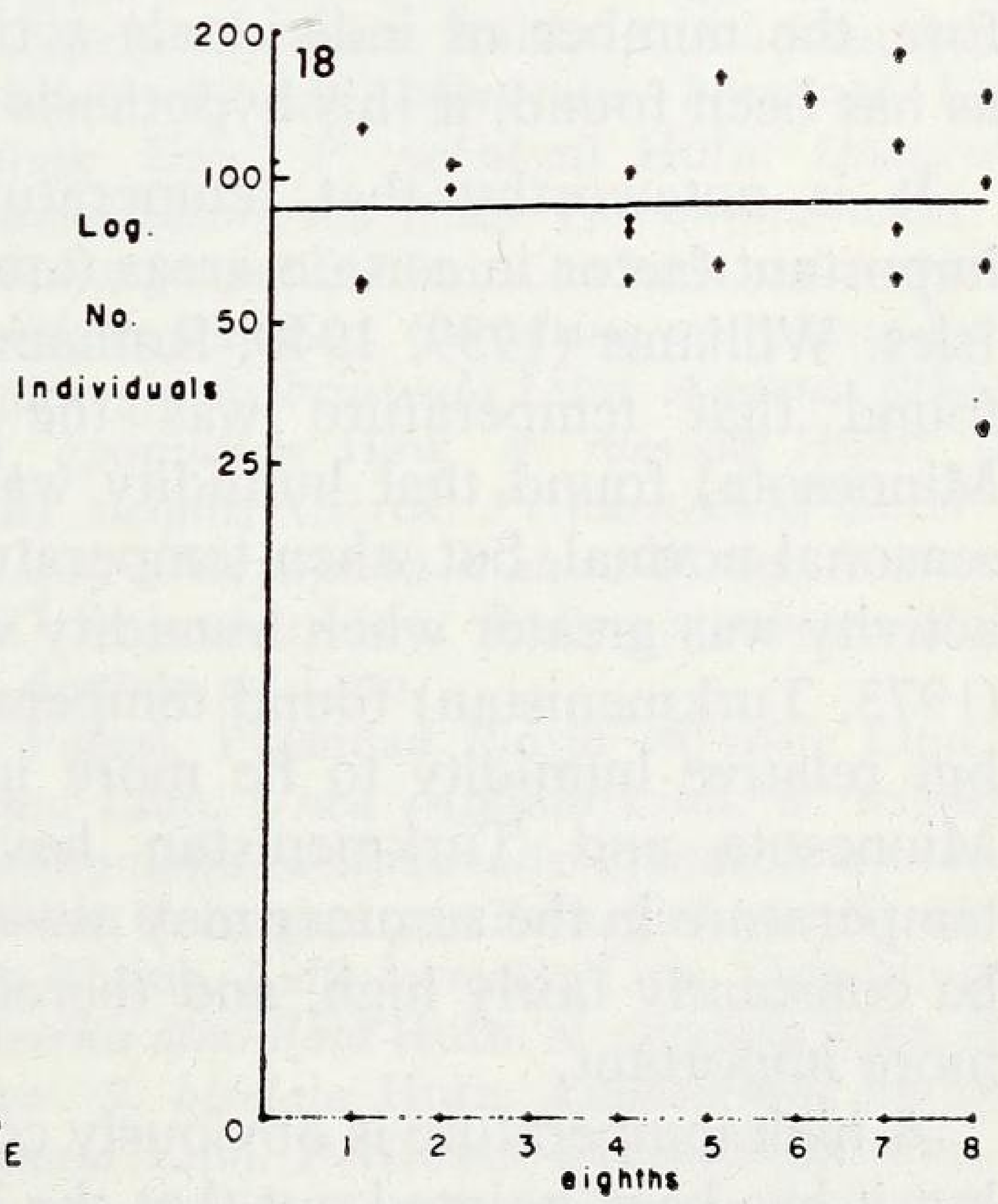


FIG. 15. Regression of log. number of Noctuidae on wind speed.
FIG. 16. Regression of log. number of Geometridae on wind speed.
FIG. 17. Regression of log. number of individuals on wind direction.
FIG. 18. Regression of log. number of individuals on cloud cover.

for the almost constant number of females caught compared to the strongly declining male population at the end of the flight period (Fig. 5).

Temperature was found to be the most important factor affecting the activity of moths, maximum temperature more so than minimum. Taylor (1963) has shown that insect flight is controlled by temperature thresholds, there being a lower threshold below which flight is inhibited, and an upper one (rarely reached in temperate regions) above which activity decreases; between the two thresholds flight is uninhibited. These thresholds are species-specific, therefore in a mixed population, such as the one being studied, as the temperature rises, more and more species will become active as their lower thresholds are passed; the thresholds are, of course, not a single temperature point, but a short range. The temperature at night decreases gradually, as heat is lost to space, from dusk onwards to dawn. If the maximum temperature (the sunset temperature) at dusk is below the lower threshold of, say, 50 per cent of the species in the population, then there will be a subsequent reduction in the numbers, and species, available for capture. In this respect the number of individuals is a dependent variable. As the night progresses, more species will cease to fly as the temperature falls below their lower thresholds and it is well known that the number of species in flight after about midnight (when most thresholds are higher than the ambient temperature) is few and decreasing. The maximum (sunset) temperature is therefore more useful in determining the number of species and, therefore, the number of individuals active than the minimum temperature, as has been found, if this hypothesis is correct.

It is noteworthy that temperature is only found to be the most important factor in certain areas (temperate regions?) such as the British Isles. Williams (1939, 1940, Rothamstead and 1961, Scottish highlands) found that temperature was the most effective, but Cook (1923, Minnesota) found that humidity was most important when near to the seasonal normal, but when temperature and pressure were high, then the activity was greater when humidity was low; also Chernyshev & Bogush (1973, Turkmenistan) found temperature to be most important in April, but relative humidity to be more important from June onwards. Both Minnesota and Turkmenistan have continental climates where the temperature in the summer may always be above the thresholds, or would be constantly fairly high, and therefore other factors would seem to be more important.

A high temperature is obviously conducive to activity in poikilotherms, but it has been pointed out that the body temperature of a moth may be greater than the ambient temperature by perhaps 8° or 9°C. for large hawk moths (Sphingidae) (Taylor, 1963).

Pressure was found to be positively correlated with temperature and therefore its effect on activity is indirect, Cook (1923) also came to this conclusion.

Humidity showed very little correlation and a much larger sample is required, and probably the use of multiple regression analysis, to discover any trends.

Rainfall would influence the catch in various ways; by physically obstructing the moths in flights, by the necessary presence of cloud, and by the reduction in visibility of the light, moths generally do not fly in heavy rain for the first reason. No night rain was recorded on any occasion, but Williams (1940) has analysed the effect of day rain, and found a lower catch on the nights following day rain, this, however, was due to a lowering of temperature caused by overcast sky and wet ground during the day.

TABLE 5

List of species recorded.

Sphingidae *Laothöe populi* Linn. *Deilephila elpenor* Linn. Notodontidae *Pheosia gnoma* Fab. *Notodonta ziczac* Linn. *N. dromedarius* Linn. *Lophopteryx capucina* Linn. Thyatiridae *Habrosyne pyritoides* Hufn. *Tethea ocularis* Linn. Lymantridae *Euproctis similis* Fuessl. Lasiocampidae *Malacosoma neustria* Linn. *Philudaria potatoria* Linn. Drepanidae *Drepana binaria* Fab. *D. lacertinaria* Linn. *Cilix glaucata* Scop. Nolidae *Nola cucullatella* Linn. Arctidae *Eilema lurideola* Zinck. *E. complana* Linn. *Callimorpha jacobaeae* Linn. *Spilosoma lubricipeda* Linn. *S. lutea* Hufn. *Phragmatobia fuliginosa* Linn. *Arctia caja* Linn. Noctuidae *Euxoa nigricans* Linn. *Agrotis segetum* Schiff. *A. clavis* Hufn. *A. puta* Hübn. *A. exclamationis* Linn. *Lycophotia varia* Vill. *Graphiphora augur Fab. Diarsia brunnea* Schiff. *D. mendica* Fab. *Ochropleura plecta* Linn. *Amathes c-nigrum* Linn. *A. triangulum* Hufn. *Axylia putris* Linn. *Euschesis comes* Hübn. *E. janthina* Schiff. *Noctua pronuba* Linn. *Lampra fimbriata* Schreb. *Mamestra brassicae* Linn. *Melanchra persicariae* Linn. *Polia nitens* Haw. *P. nebulosa* Hufn. *Diataraxia oleracae* Linn. *Ceramica pisi* Linn. *Hadena bicolorata* Hufn. *H. compta* Schiff. *H. bicruris* Hufn. *H. rivularis* Fab. *Cerapteryx graminis* Linn. *Leucania pallens* Linn. *L. impura* Hübn. *L. comma* Linn. *L. lithargyria* Esp. *Caradrina morpheus* Hufn. *C. alsines* Brahm. *C. blanda* Schiff. *Dipterygia scabriuscula* Linn. *Apamea lithoxylaea* Schiff. *A. monoglypha* Hufn. *A. epomidion* Haw. *A. remissa* Hübn. (ab. *obscura* Haw.) *A. secalis* Linn. *Procus strigilis* Clerck. *P. latruncula* Schiff. *P. fasciuncula* Haw. *Euplexia lucipara* Linn. *Thalpophila matura* Hufn. *Petilampa minima* Haw. *Cosmia pyralina* Schiff. *C. trapezina* Linn. *Rusina tenebrosa* Hübn. (*ferruginea* Esp.) *Cryphia perla* Schiff. *Apatele psi* Linn.

Hylophilidae *Pseudoips bicolorana* Fuessl. Plusiidae *Plusia chrysitis* Linn. *P. iota* Linn. *P. pulchrina* Haw. *P. gamma* Linn. *Unca triplasia* Linn. *U. tripartita* Hufn. *Hypena proboscidalis* Linn. *Zanclognatha tarsipennalis* Treits. *Z. nemoralis* Fab. *Laspeyria flexula* Schiff. Geometridae *Geometra papilionaria* Linn. *Hemithea aestivaria* Hübn. *Hemistola immaculata* Thunb. *Iodis lactearia* Linn. *Calyothysanis amata* Linn. *Scopula imitaria* Hübn. *Sterrha dimidiata* Hufn. *S. aversata* Linn. (inc. ab. *remutata* Linn.) *S. trigeminata* Haw. *S. biselata* Hufn. *Xanthorhöe ferrugata* Clerck. *X. spadicearia* Schiff. *X. fluctuata* Linn. *Perizoma alchemillata* Linn. *P. flavofasciata* Thunb. *Ecliptoptera silaceata* Schiff. *Lygris mellinata* Fab. *Cidaria fulvata* Forst. *Dysstroma truncata* Hufn. *Hydriomena furcata* Thunb. *Philereme transversata* Hufn. *Epirrhöe alternata* Müll. *Acasis viretata* Hübn. *Ortholitha chenopodiata* Linn. *Asthena albulata* Hufn. *Eupithecia pulchellata* Steph. *E. intricata* Zett. ssp. *parcenthata* Freyer. *Eupithecia absinthiata* Clerck. *E. castigata* Hübn. *E. icterata* Vill. *E. abbreviata* Steph. *E. sobrinata* Hübn. *Gymnocelis pumilata* Hübn. *Abraxas grossulariata* Linn. *Lomaspilis marginata* Linn. *Bapta temerata* Schiff. *Deilinia pusaria* Linn. *D. exanthemata* Scop. *Campaea margaritata* Linn. *Semiothisa liturata* Clerck. *Ennomos quercinaria* Hufn. *Deuteronomos erosaria* Schiff. *Selenia tetralunaria* Hufn. *Crocallis elinguaria* Linn. *Opisthograptis luteolata* Linn. *Ourapteryx sambucaria* Linn. *Biston betularia* Linn. (inc. ab. *carbonaria* Jordan, etc.) *Cleora rhomboidaria* Schiff. *Alcis repandata* Linn. *Ectropis biundularia* Borkh. Cossidae *Zeuzera pyrina* Linn. Hepialidae *Hepialis humuli* Linn.

Although a negative correlation was found to exist between the index of diversity and wind speed (and therefore probably also numbers of individuals) this was very slight and may be more correlated if temperature is held constant as apparently there is a positive correlation between temperature and wind speed (i.e. windy nights are warmer than still nights) which would reduce the gradient of the regression line (see Williams, 1940). A multiple regression analysis would disclose the inter-relations.

A westerly air-mass was predominant over most of the trapping period, as is usual in Great Britain during the summer months; on nights of winds from the north there was a lower catch in general, however there were too few of these occasions for a significant analysis to be carried out. The westerly (Tropical Maritime) air-mass would bring in warm, humid weather which would affect the catch by increasing it, compared to northerly (Polar) air-masses which would reduce the catch by introducing colder air.

There was very little correlation between cloud cover and numbers of individuals and obviously more samples, and possibly multiple regression analysis, is required before a significant effect can be found. The factor most associated with cloud cover, from an entomological point of view, is moonlight, and larger catches are associated with overcast nights (no moon) than on clear, moonlit nights (Pinchin & Anderson, 1936; Williams, 1940). Clear, moonless nights produce an intermediate catch, but this is due to low temperatures caused by rapid heat loss after dusk.

Visibility is related to humidity and varies little during the summer, also the enclosed nature of the trapping site would cause this to have little effect. As far as is known, this factor has been studied very little, but fog was studied by Williams (1940) who found, in general, a low catch on foggy nights, except for Noctuid moths whose captures increased in some cases and the diffuse area of light is suggested by him to be more attractive to these moths than a point source, thus conflicting with the more generally accepted theory that a point source attracts insects more than a lighted area. It could be that the slight negative correlation observed between relative humidity and number of individuals (Fig. 13) in this investigation may have been caused by the reduction in visibility.

Conclusion

The major factor affecting the activity of nocturnal macrolepidoptera is temperature, which is found to be positively correlated with the number of individuals and the diversity of the catch. Therefore as the air temperature increases, so does the catch, and its diversity.

The other factors were found to be related to temperature and their effects were therefore difficult to analyse, for example, pressure causes an increase in the catch but only because a rise in pressure causes a rise in temperature which increases the catch.

Humidity was expected to be positively correlated with the catch but was found to be negatively correlated, and it was suggested that its effect could be discovered by using a larger number of samples, and by isolating its effect using multiple regression analysis. Similarly, more samples and multiple regression analysis could be used to determine the effect of wind speed (if it is correlated with temperature) on number of individuals and diversity, and between the two major families (Noctuidae and Geometridae) or, perhaps, species of differing average weights or wing-spans.

To analyse the remaining factors a much larger number of samples must be taken. No typically "good" or "bad" nights occurred during the study and a number of extreme nights might have favourably affected the analysis. Other work which could be done on this topic would be an analysis of the effects of meteorological factors on single species, or groups of closely related species, as it may be that one group is affected mainly by temperature, say, and another by another factor such as wind speed. From an economic point of view, studies of this kind are useful in agriculture (e.g. Theobald, 1926) in forecasting the fluctuations in populations of certain pests, provided that meteorological forecasts can first be relied upon.

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