Habitat selection in lapwings vanellus vanellus (L.) breeding on marginal hill farmland

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HABITAT SELECTION IN LAPWINGS
Vanellus vanellus (L.)
BREEDING ON MARGINAL
HILL FARMLAND.

by

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Photo by] [*A. Gilpin, F.R.P.S.*

A MALE ABOUT TO COVER THE EGGS

INTRODUCTION

The purpose of this study is to determine the factors which influence the distribution and selection of breeding habitats by the Lapwing, *Vanellus vanellus* (L.), in hill farmland consisting of pasture, hay meadow and moorland borders.

In any area, the distribution of a given species population may be governed by one or more of the following criteria: environmental limitations, powers of dispersal, interactions with other organisms and behaviour responses. Few species, especially birds, seem to be restricted in distribution on a local scale by poor powers of dispersal (Krebs 1972, Ch.2). Extremes of physical or chemical conditions such as temperature, moisture, oxygen, soil structure, nutrients and pH could prevent an area from being occupied. Within the geographical or climatic range of a species, however, such factors are unlikely to be limiting. Birds as a group are well adapted to a terrestrial environment and can withstand great variation in the climatic conditions (Lack, 1933). They will also move before lethal temperatures become operative. Other organisms may have a positive effect on the survival value of an area, such as with food organisms, or a negative effect as in the case of competitors, predators, parasites or pathogens. THe distribution of a species may be effectively limited by the behaviour of individuals in selecting their habitat according to specific preferences, given that they could survive in the area on other grounds.

In addition to affecting distribution in the presence-or-absence sense, the actual density of a population in any occupied habitat may be governed by a separate set of factors, including the last two above and together with the direct reproductive and mortality rates of the population. The latter may vary between locations in an area.

In the opinion of Lack (1933), habitat selection in birds consists of, "The instinctive selection by a bird of the type of habitat frequented by its ancestors". This is extended, according to the present view, to:

"Birds are guideo to their breeding stations by a primarily innate reaction released by certain environmental stimuli, on the principle of summation of heterogeneous stimuli, as in instinctive activities in general. The threshold for the release of the reaction is dependent on the internal motivation of the bird". (Hilden, 1965)

In any consideration of habitat selection and its functioning, a distinction must be made between proximate and ultimate factors in biological causation. This was first proposed theoretically by Baker in 1938 with regard to the onset of breeding seasons in animals, and extended by Klomp (1953): proximate factors are features of the environment to which a bird responds directly; and factors which favour the selection of such preferences in evolution are termed ultimate factors. The latter are essential to the survival of the species, and form the underlying reasons for the breeding of each species in its specific environment. Proximate factors serve only to release the settling reaction and need have no biological significance to the species as such. Lack has stated (1937): "It seems probable that each species selects its own habitat, guided by recognition features not necessarily in themselves essential to its existence.".

In the view of Hilden (1965), the following could be regarded as ultimate factors in the habitat selection of birds: requirements imposed by structural and functional characteristics of the species; food; protection from enemies and adverse weather; or avoidance of competition with other species. Proximate factors could be combined into categories of: landscape features; terrain; sites for nesting, song, watching, feeding and drinking; food in certain species; presence of other animals; and internal motivation. This last contributes to the release of the selection response, determining the bird's sensivity to external stimuli. There are also stimuli having an opposite, repelling effect on habitat selection, decreasing the combined effect of the above influences. These might be termed negative characteristics of the habitat.

There has been a considerable amount of speculation previously over the theoretical aspects of ultimate factors and evolution (for example Brock, 1914; Lack, 1944; Thorpe, 1945), but relatively little progress has been made towards revealing information about the nature and function of proximate factors in the field.

The first worker to make a distinction between ultimate and proximate factors for habitat preference in practice was Klomp (1953), in an extensive study of the habitat selection mechanism in the Lapwing in N.W. Holland. The only other significant habitat study undertaken on this species before the present work has been the Lapwing Habitat Inquiry of 1937, the findings of which are reported by Nicholson (1938). His report contains a large selection of heterogeneous records of varying quality, submitted by different observers; nevertheless the generalised picture emerging from these as to the Lapwing's distribution and habitat preferences would appear to be quite sound and valuable, despite its chiefly qualitative nature.

Various ornithological reference books include sections on the Lapwing covering its typical habitat characteristics, such as in Witherby et al (1940); also in Ennion's Field Study book (1949) and Spencer's book (1953) which are written specifically on the Lapwing and its behaviour.

The work of Klomp (1953), however, is the sole attempt to date at treating the Lapwing's habitat selection response in detail, inasfar as to reveal the proximate factors actually involved in the acquisition of a breeding ground by the bird. He took censuses in early spring in twenty sampling areas of from 5.5 to 35 hectares in lowland grass meadow, by counting displaying males during the first hour after sunrise. This indicated the total number of pairs occupying any district; nests were also counted. Klomp then attempted to correlate pair density with various properties of the habitat. He found no connection between the distribution of Lapwings and:

climate, food abundance, water level, acidity, botanical composition of the vegetation, or other bird species including predators. Slope and altitude were not examined. With soil type, however, a preference for sand was suggested. The birds never visited tall vegetation, favouring short grass or bare ground. A clear negative relationship was also obtained between breeding density and the ultimate height reached by the vegetation in late May. In open vegetation, a greater height was tolerated than in dense growth. The presence of trees in or around fields proved unattractive. It was observed by Klomp also that densely-populated grassland fields were greyish brown in colour whereas unoccupied grasslands were green. This colour was conspicuous in early spring before the ultimate height differences became visible. It was found that an uneven surface, when combined with a brownish coloration, strongly increased the attractiveness of fields.

It is concluded by Klomp that a brown or grey colour of field is correlated with a low ultimate height of vegetation- possibly tied to a lack of nutrients or of artificial fertilization. The Lapwing, in responding directly to colour, thus selects habitats which remain suitable throughout the breeding season. This species is adapted to live on land covered by low or no vegetation, in several respects. During locomotion the free leg is not raised high, and the toes remain open, such that in tall grass the toes become caught, causing the bird to fall forward. The Lapwing collects its food from the surface of the ground, guided by visual stimuli; a greater range of vision is afforded for this in a low vegetation. When alighting, the bird's wings are held horizontally; it has a low flight display; and the vent display of the male to a distant female would be ineffectual in tall grass. Klomp has also postulated a possible survival value in the brown-coloured fields due to a better camouflage of the eggs and young.

Although fairly comprehensive and of considerable value as a pioneer study, the work of Klomp is concentrated on Lapwings of lowland meadow habitats in N.W. Holland only. It relies on conclusions drawn simply through comparison, by inspection only, of tables of figures for environmental data with those for Lapwing pair density. There is no indication of statistical significance, which constitutes a serious limitation to the reliability of the deductions made. Only twenty sampling areas were covered, and a number of possibly important factors have been omitted, notably altitude, gradient, exposure, grazing, fertilization and proximity of human habitation. It is not discernible how far the conclusions reached apply to habitats other than lowland grass meadows in the north and west of Holland. Agricultural practices, for example, may differ considerably between sites, such as in the application of herbicides and artificial fertilizers. In the hill farmland fields of the present work there were no obvious colour differences between fields, being almost uniformly green. Hence other factors must be operative in habitat selection here.

The present study extends the line of investigation followed by Klomp, to include a larger sample size and a more quantitative method of approach, with the aim of providing as clear and objective an analysis as possible of the proximate factors of importance in the selection of breeding habitats by the Lapwing. The work is necessarily limited to essential aspects due to the short length of time available, and the problem would undoubtedly benefit from further investigation in the future.

In Great Britain, the Lapwing is found breeding at all altitudes from Sea Level to well over 2,000 feet, and in a wide range of habitats including arable land, fallow, stubble, plough, pasture, heath, moorland borders, marshes, mudflats, estuaries, shingle and sand dunes (Witherby et al, 1949, and additional information). Because of this ubiquity, it was necessary to confine the present work to one habitat in particular: marginal hill farmland between

800 and 1500 feet above Sea Level. This is partly cultivated as hay meadow, partially permanent pasture, and some alternately as both, though no arable crops are grown. The area selected was the Weardale region of County Durham. This is agricultural land to which very little pesticide has been applied; there is no influence from crop rotation and the area is composed of well-defined units for sampling, as opposed to open moor.

It was planned to survey a large number of fields in various locations in Weardale, both with and without Lapwings, scoring them with respect to a wide variety of geographical, vegetational and biotic features. These data could then be subjected to multivariate analysis by computer, to determine which factors were important as a cause of variation in the presence-or-absence and density of Lapwings. It might thence be possible to assign a measure of predictability to the variables, to estimate the likelihood of any given field being selected as a breeding habitat by Lapwings.

THE STUDY AREA

The area chosen for the Lapwing habitat selection field survey was Weardale in Western County Durham, between Frosterley (NZ 030370) which is twenty miles west of Durham City, and Cowshill (NY 855406). This is an area of approximately 170 Km^2, roughly bounded by points NY 840430, NZ 030430, NY 840340 and NZ 030340. The precise locations of sampling are marked on the map, Fig.

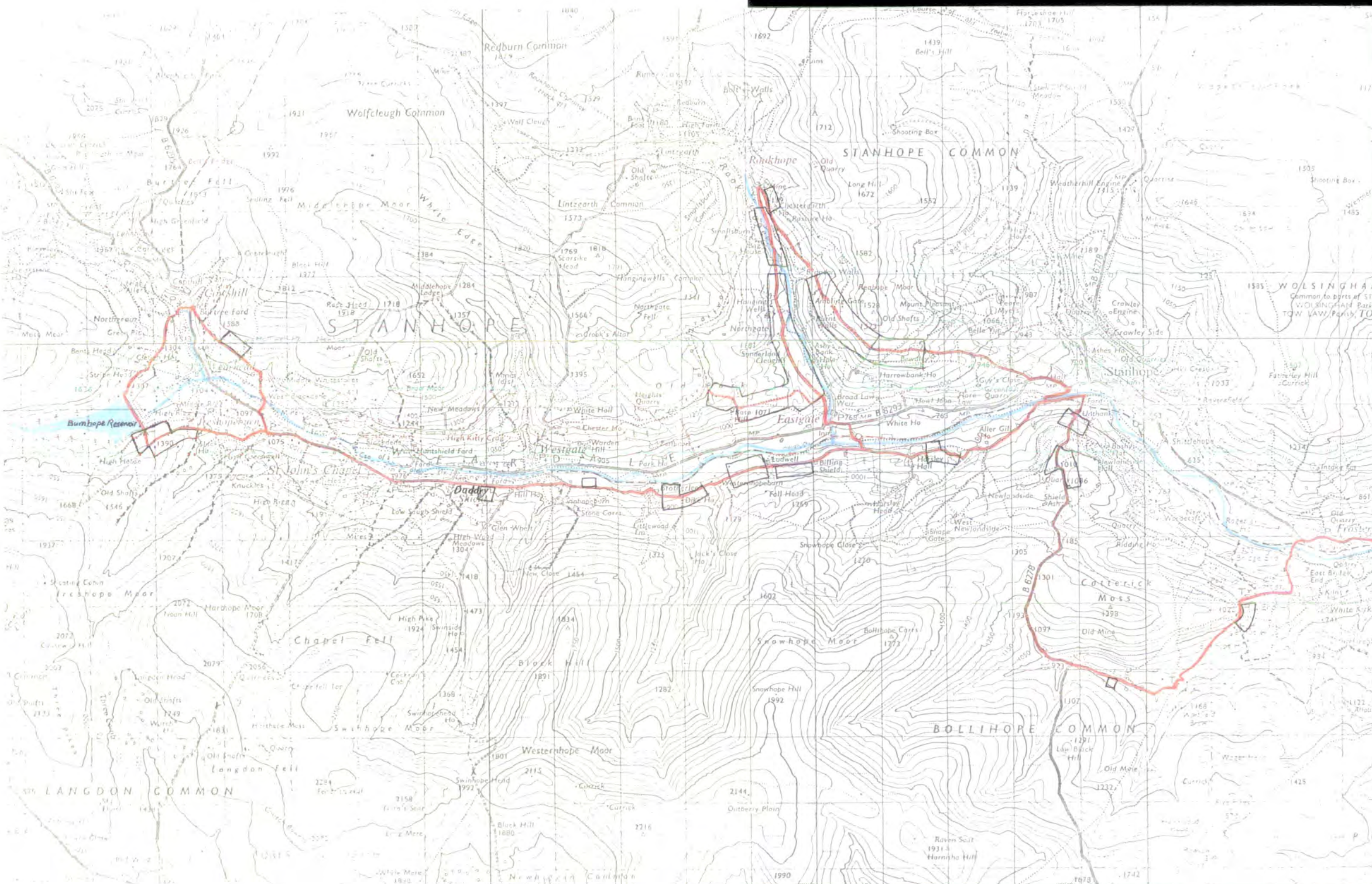
This region comprises marginal hill farmland above the plough line but within the tree line, of varying fertility, ranging from low hay meadows to rough upland permanent pasture and moorland borders. There are patches of woodland scattered at intervals. Climatic extremes and steep gradients preclude the cultivation of arable crops. The area is dissected by the River Wear which flows from west to east, with its tributaries, and includes Burnhope Reservoir.
The natural bedrock is limestone, and the soils are generally podsolized brown earths. Altitudes range from 800 ft (=244m) to around 2000 ft (=610m) above Sea Level (Ordnance Datum).

The farmland is divided into discrete, fairly regular units by solid stone wall boundaries- except in the case of the moorland margins. The study was confined to those fields directly adjacent to minor roads and farm tracks, so that the Lapwings should not be subjected to unaccustomed disturbance by a vehicle. Observations could then conveniently be made from behind a stone wall, without creating undue interference in passing through the fields.

Fig. 2

THE STUDY AREA

Map to Show Locations of Hill Farmland Fields Surveyed
(outlined in black)



From O.S. Sheet 84 : Teesdale.
Scale : 1 inch to 1 mile.

METHODS

"To hunt her nest my rambling step was led...
...but still I searched in vain."
(-John Clare, from : 'The Pewit's Nest'.)

Between 1 May and 15 June, 1974, 109 field units in marginal hill farmland were visited and the number of Lapwings present in each was counted and recorded. This was repeated on at least five separate occasions altogether. A search was made for nests where possible, and a record kept of the number and subsequent fate of eggs. Evidence of nesting looked for included characteristic behaviour of the parent birds- such as an incubating posture, distress calls and activities; the presence of nests, eggs, empty shells, hatched chicks and older chicks in family groups engaged in feeding. Due to the early breeding season, however, only a limited amount of data on nesting were collected. This was insufficient for meaningful statistical evaluation, although the results are included in the appropriate section.

For each field, features of the landscape,terrain, vegetation and other biotic characteristics were recorded as accurately as practicable. Information regarding artificial treatment and past history of the fields was obtained from the respective farmers where necessary. To minimise labour and save time, standard recording sheets were constructed and duplicated. These were filled in at each separate field, the following factors being assessed :

1.Field Type. Categories recognised were: permanent grazed pasture (PGP), grazed pasture (GP), hay grown after grazing until June (GP/M), or hay meadow (HM).

2. Altitude of field- read off from a 1" O.S. map in ft. above Sea Level or Ordnance Datum. (1 foot=0.305m)

3. Aspect of field- compass direction faced by the main slope, if any; otherwise 0.

4. Gradient of slope- on an arbitrary scale of 0-5, where

0= flat and 5= very steep. Judged by eye in comparison to a road of known gradient. 3 corresponded to about 1 in 10, 4 to 1 in 5.

5. Irregularity of gradient- the presence of any double dip or hillock was noted.

6. Enclosure of land- the number of sides on which the surrounding ground was higher than the field itself; 0-4.

7. The number of solid (stone wall) boundaries to the field; 0-4.

8. Roughness of terrain, or unevenness of the ground: assessed on a relative scale of 1-5 where 1= very smooth ground, and 5= very rough with tussocks or hummocks, probably also outcrops of rock and stones.

9. Presence of Surface Water- whether none, marshy patches or actual open water such as a stream or pool.

10. Cover of Juncus effusus over the field, estimated as a %.

11. Distribution of Juncus effusus : the number of tenth parts of the field containing the rush; 0-10.

12. Distance away of the closest human habitation from the nearest edge of the field, in metres. Usually a farm. Any dwellings farther than 500m were considered to exert a negligible effect.

13. Presence of Trees, their location and number. There could be none, several inside the field, along the edge, a row outside, or a row on more than one side.

14. Plant species present in the field: the main constituents of the vegetation were listed. Commonly grasses, dandelion, daisy, dock, plantain, clover and buttercup.

15. Presence or absence of unpalatable weed species, such as thistle or nettle- above the level of the main vegetation.

16. Presence or absence of broad-leaved weeds such as dock, plantain or dandelion- a possible indication of the use of selective herbicides.

17. Proportion of Bare Ground- the inverse of vegetational

cover- recorded as a % estimate.

18. Average height of vegetation in the field, measured in cm.

19. Maximum height of vegetation in the field in cm.

20. Colour of the field: bright green, pale green, dark green, brownish green or brown. This would be necessarily subjective, but relatively consistent between fields since only one observer was involved.

21. Artificial treatment- whether fields were untreated, limed, fertilized or manured; with what substances, concentrations, and when applied (as far as possible).

22. Grazing regime during the Lapwing breeding season: whether absent, periodic or continuous.

23. Presence of large Herbivores- none, sheep and/or cows, pigs, goats or horses.

24. Presence or absence of Redshank (Tringa totanus britannica Mathews) in the field- detected by observation or call.

25. Presence or absence of moles, manifested as mole hills, which would increase the proportion of bare earth in the field.

The areas of the fields were calculated from six-inch Ordnance Survey maps by means of a Planimeter, the resulting values being multiplied by 200 to give area in acres. (1 acre = 0.405 hectares.)

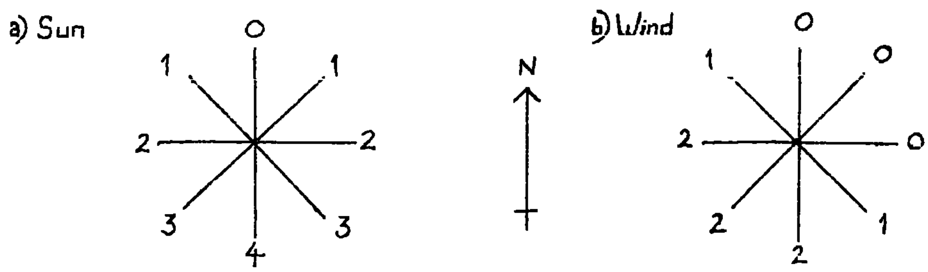
The mean numbers of Lapwings present from at least five observations were calculated, and hence the density of birds in every field could be found by dividing the mean number by the area.

The above data for fields were required to be converted to purely numerical form before the computer analysis could be carried out.

In the Presence or Absence cases- factors 5, 13, 15, 16, 24 and 25- '0' denoted absence and '1', presence. In other cases- factors 2, 10, 12, 17, 18, 19, plus Area, Mean and Density- the value of the factor could be utilized directly. The scale numbers noted in the field could also be used with factors 4, 6, 7, 8 and 11. For the essentially qualitative features 1, 3, 9, 14, 20, 21, 22 and 23, however, a more complex treatment was necessary to convert them to numerical scales.

With Field Type, two alternative scales were devised, such that the computer could 'select' the most meaningful. In one case, all grazed pasture was scored 0 and hay meadow 1. In the second case, the pasture fields were separated and those grazed throughout the study period scored 0; those grazed until June and thereafter left to grow hay scored 1; and those remaining as hay meadows scored 2.

For Aspect, two criteria were considered important: a) the direction faced with respect to insolation (South), and b) that faced with respect to the prevailing wind (South-westerly). Fields were scored according to the following scheme:



A field facing South-East, for example, would score 3 for sunshine and 1 for wind exposure.

With Surface Water, absence was denoted by 0, marshy patch(es) by 1 and any open water by 2.

For the dominant Plant Species, a grouping was made into rough pasture grass (thistle, nettle, daisy,plantain, tussocks); good pasture grass (clover, celandine, buttercup, dock, hedge parsley); and hay grass (meadow grasses, clover, dock, dandelion, cranesbill, meadowsweet). They were represented by 0, 1 and 2 respectively.

The colour of fields was scored both on a 0/1 basis (not all green / green), and on a scale of: brownish (0), green (1) or bright green (2). Treatment possibilities ranged from none (0), limed only (1), lime plus fertilizer -nitrogen, phosphorus & potassium (2), lime + fertilizer + extra nitrogen on hayfields after mowing (3), to lime + NPK + extra N + manure spread (4).

Grazing pressure could be none (0), periodic (1) or continuous (2) throughout the study period. Large herbivores were assigned values of 0-3 representing none, sheep only, cows only and sheep + cows, respectively; the increasing trend of the effect implied may not be genuine however.

The dependent variables for analysis were also scored. These were mean number and density of Lapwings, which could be quoted directly; also breeding choice on a presence - or - absence basis. The latter was determined by four different criteria, to enable the most valid one(s) to be picked out later, during the programming. The criteria were:

A. Actual observation made of nests, eggs or small young in the field.
B. Mean number of adult birds $\geqslant 2$.
C. Mean number of adult birds $\geqslant 1$.
D. Lapwings present in the field on 4 occasions out of 5.

These were presence/absence or 0/1 situations, the cases above being the conditions for 'presence'.
In addition, a Preference scale was designed on the basis of the mean numbers of Lapwings:

Mean= 0.0 or 1 observation:	score 0
$0.2 < \text{mean} < 1.0$:	... 1
$1.0 \leqslant \text{mean} < 3.0$:	... 2
Mean $\geqslant 3.0$:	... 3

Separate Data Cards were punched for the fields and checked for errors. They were then fed into the '360' digital Computer and a program for Multivariate Analysis was applied: University of Michigan Terminal System, model EC123, program reference BMD02R. Several runs were made using different dependent variables, to obtain results which would be biologically meaningful. One limitation of the technique was that each factor was assumed to exert an exactly linear or logarithmic effect on Lapwing density along the chosen scale.

Whilst the computing was in operation, an analysis of soil fauna was undertaken. Four 4" diameter x 3" deep (10.5x 7.5cm) soil cores were extracted from each of 25 fields by means of an Auger. Each core was placed in a separate polythene bag, secured and labelled with the date and field number. In the Laboratory the soil was hand-sorted, and all Lumbricidae and other Invertebrates greater than 2 mm in length were removed. These were preserved in 20% formalin in labelled specimen tubes. A rough classification into groups or Orders was carried out; identification of the animals down to Species level would have occupied more time than available although ideally desirable.

Lumbricids were by far the most abundant animal group represented; all other invertebrates were grouped together for the computer analysis. Totals for the two categories were found for each field. Additional cores were taken on the basis of the computing results for other factors, from fields yielding high'residual' values: those where much variation in Lapwing density was not accounted for by the original factors. Data for Lumbricid and Other Invertebrate totals were then entered in the analysis to assess their significance. The food available to Lapwings in the fields was thus determined, and could be compared to that actually eaten from the work of Collinge (1924-7).

RESULTS

Observed and mean numbers of Lapwings are presented in Table 2; Table 3 covers density and the areas of the fields. All the raw field data are quoted in Table 4, i-vii. Photographs are included (Figs.5-8) to provide an illustration of the appearance of different categories of field and the range of scale values occurring. Some details of artificial fertilization regimes are also given. (Note 2)

The most meaningful results of the computer processing are summarised in Table 5. With each factor, the coefficient of slope in the variance equation, whether positive or negative, the F Value (equivalent to Student's t^2), and the possible magnitude of effect which the factor could exert on the dependent variable are stated. The latter was determined by multiplying the coefficient by the two respective maximum and minimum data values (from Table 4) in each case.

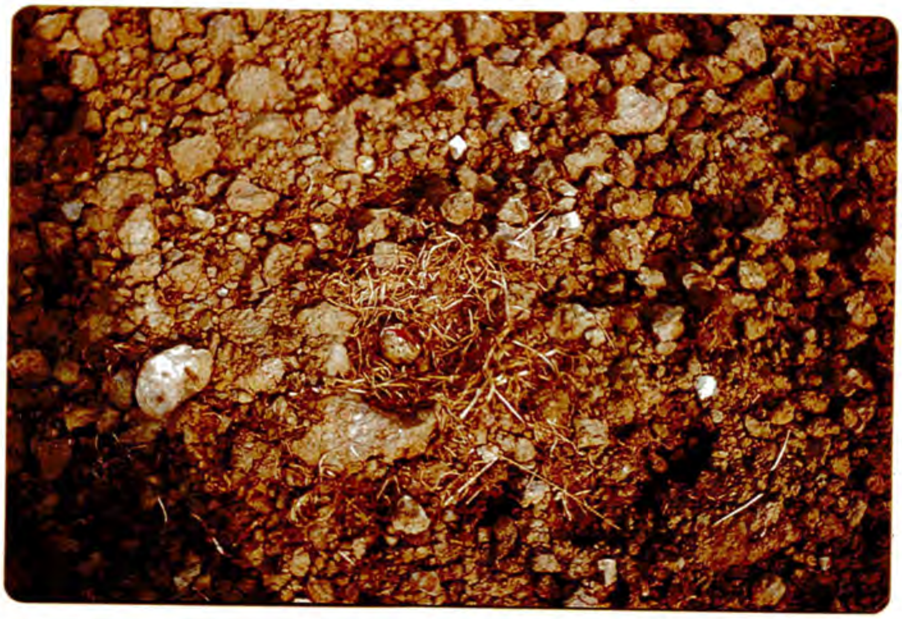
As a result of the computing, it was decided that a more useful basis for assessing the effects of proximity to human habitation on Lapwing density would have been to group the data into fields less than 30, 31-100 and over 100 metres from houses, on a 0-1-2 scale. However, there was insufficient time remaining to permit testing of this on the computer. Instead, a graph was plotted (Fig. 9) of Lapwing density against distance from the nearest house to the edge of the field in m. It appeared that these might be significantly positively correlated. A 3x2 Chi^2 test of significance was accordingly performed, by grouping the fields into the distance categories proposed above, and density classes of below and above 20 birds/ 100ac. The Chi^2 value of 12.014 obtained was significant at the 1% level, showing that houses can, in fact, exert a repelling influence on Lapwings- contrary to the outcome of the computer analysis.

The soil fauna results are given in Tables 6 and 7. When the totals for Lumbricids and for Other Invertebrates were placed in the computer analysis, there was a strong indication of a positive effect on Lapwings from earthworm abundance. A fuller treatment of this aspect would again have been wished, for example in including the total numbers of animals for assessment. Graphical analysis was carried out (Figs. 10-12). It appears from this that, although there is a considerable amount of scatter, the density of Lapwings is related positively to both the abundance of earthworms and, in particular, to that of other invertebrates (chiefly soil and litter beetles). With total animals, the trend is less conclusive though still predominantly positive. From the graph (Fig. 13), an increase in the cover of Juncus effusus suggests a reduction in the abundance of total soil fauna.

Fig. 3

To show Nest Site, Field 1 : Hay meadow.
Colour bright green. Height range 3-6 cm. Bare ground 1%

Fig. 4



Nest on Bare Earth, showing predated egg. Field 23.

Table 1.A

NESTING DATA

Field	No. Nests	Site Description	No. Eggs	No. Hatched	Eggs Pred/ Cold	No. Chicks	Ages
1	(7) 1	Long meadow grass	(10) 4	4	0	-	-
3	(5) 1	Short pasture grass + grazed Juncus	(5) 4 +1	(12) 4	0 1 pred.	(1) 1 (12) 4 (20) 1	med. young old
23	(1) 1	Grass + dead wisps	2	(4) 2	0	-	-
	(4) 1	Patchy grass + earth	4	(7) 3	1 cold	-	-
	(5) 2	Bare soil	1 shell	1 +	-	1	young
		Bare soil	1	-	1 pred.	-	-
	(6) 1	Edge of bare earth	1	(8) 0	1 cold	-	-
	(8) 2	Bare soil	(9) 3	(16) 2	1 cold	-	-
		Bare soil	0	?	-	-	-
	(11) 1	Grass nr. bare earth	4	4	0	-	-
	8						

Key to Observation Dates

Note 1

(1) May 1 1974
(2) May 2 ..
(3) May 5 ..
(4) May 7 ..
(5) May 8 ..
(6) May 10 ..
(7) May 12 ..
(8) May 13 ..
(9) May 14 ..
(10) May 15 ..
(11) May 17 ..
(12) May 20 1974
(13) May 22 ..
(14) May 24 ..
(15) May 27 ..
(16) May 29 ..
(17) May 30 ..
(18) June 4 ..
(19) June 5 ..
(20) June 6 ..
(21) July 11 ..

Table 1.8

OBSERVATIONS OF CHICKS

Field	No. Chicks	Ages
43	(10) 1	old
44	(12) 3	young
54	(15) 1	old
56	(11) 3	old
57	(12) 1	old
68	(16) 1	old
71	(13) 1	young
	(18) 1	med.
74	(16) 1	med.
	(18) 3	old
	(19) 1	med.
78	(16) 1	med.
79	(16) 2	med.
	(18) 4	3m.,1o.
	(19) 1	med.
80	(18) 3	young
	(19) 1	young
81	(16) 3	med.
	(17) 3	med.
90	(17) 2	young
	(18) 1	young
92	(18) 2	1y.,1o.
93	(17) 1	med.
94	(16) 2	old
	(18) 3	1m.,2o.
95	(17) 1	old
	(18) 1	old
101	(18) 1	old
102	(18) 1	med.
106	(17) 1	med.
	(18) 1	med.
109	(21) 1	young

Table 2i

OBSERVED NUMBERS OF LAPWINGS

Field	No. Lapwings	Mean	Field	No. Lapwings	Mean
1	1,3,3,3,4,4	3.00	28	0,0,0,0,0	0.00
2	0,1,0,0,0,2	0.50	29	0,0,0,0,0	0.00
3	9,5,6,6,5,4	5.83	30	0,0,0,0,0	0.00
4	1,1,1,1,2,0	1.00	31	0,0,0,0,0	0.00
5	0,1,0,1,1,2	0.83	32	0,0,0,0,0	0.00
6	0,1,0,0,0,1	0.33	33	0,0,0,0,0	0.00
7	0,1,0,0,1,1	0.50	34	0,0,0,0,0	0.00
8	2,1,1,0,1,1	1.00	35	0,0,0,0,0	0.00
9	1,1,0,1,1,0	0.67	36	0,0,0,0,0	0.00
10	3,2,1,3,2,2	2.17	37	0,0,0,0,0	0.00
11	0,0,0,0,1,0	0.17	38	0,0,0,0,0	0.00
12	0,0,0,0,0,0	0.00	39	5,3,3,4,4	3.80
13	0,0,0,0,0,0	0.00	40	0,0,1,0,1,1	0.50
14	0,0,0,0,1,1	0.33	41	2,5,0,0,1,2	1.67
15	2,0,0,0,1,2	0.83	42	4,5,2,3,2	3.20
16	0,0,0,0,2,0	0.33	43	2,2,2,2,3	2.20
17	0,0,0,0,0,0	0.00	44	2,2,2,0,1	1.40
18	2,0,0,0,0,0	0.33	45	0,4,1,1,0	1.20
19	0,0,0,0,0,0	0.00	46	0,1,0,0,0	0.20
20	0,2,1,0,0,1	0.67	47	0,1,0,2,0	0.60
21	1,0,0,2,0,0	0.50	48	0,0,0,1,0	0.20
22	3,2,2,1,3,2	2.17	49	0,0,0,0,0	0.00
23	8,8,8,10,9,8	8.43	50	0,0,0,0,0	0.00
24	2,1,2,1,2,2	1.67	51	2,0,0,1,0,0	0.50
25	4,6,3,3,5,4	4.17	52	0,1,0,0,0,0	0.17
26	0,0,0,0,0,0	0.00	53	0,0,0,0,0	0.00
27	0,0,0,0,0,0	0.00	54	3,0,3,5,3,4	3.00

All numbers above are repeat counts taken on at least 5 occasions in each field during the breeding season.

Table 2.ii

OBSERVED NUMBERS OF LAPWINGS (contd.)

Field	No. Lapwings	Mean	Field	No. Lapwings	Mean
55	2,0,0,1,1	0.80	83	12,5,3,2,0	4.40
56	4,4,3,2,2	3.00	84	5,2,6,3,3	3.80
57	4,3,3,5,6,4	4.17	85	3,1,2,2,3	2.20
58	1,2,0,0,0,0	0.50	86	2,0,3,0,1	1.20
59	2,3,3,0,4,2	2.33	87	3,4,3,4,4	3.60
60	2,2,1,3,4,2	2.33	88	5,7,6,5,5	7.60
61	0,3,1,3,1	1.60	89	2,1,1,0,3	1.40
62	0,0,0,1,0	0.20	90	1,1,1,1,1	1.00
63	2,0,0,0,0	0.40	91	2,1,3,2,0	1.60
64	0,0,0,0,1	0.20	92	4,9,9,6,5	6.60
65	0,0,0,1,0	0.20	93	4,3,4,1,1	2.60
66	2,0,1,1,1	1.00	94	7,17,10,12,10	11.20
67	1,2,2,0,1	1.20	95	5,3,4,4,2	3.60
68	5,2,2,4,2	3.00	96	0,0,0,0,0	0.00
69	5,5,4,7,7	5.60	97	2,1,0,0,0	0.60
70	0,0,0,0,0	0.00	98	2,3,1,1,5	2.40
71	2,3,1,2,1	1.80	99	3,0,0,0,1	0.80
72	0,0,0,0,1	0.20	100	2,2,2,0,0	1.20
73	0,0,0,0,1	0.20	101	1,2,1,1,0	1.00
74	6,6,7,6,7	6.40	102	4,3,2,4,4	3.40
75	7,9,8,7,6	7.40	103	4,4,3,3,1	3.00
76	3,2,3,1,2	2.20	104	1,1,1,1,0	0.80
77	4,1,4,0,1	2.00	105	2,2,3,2,2	2.20
78	6,3,3,1,2	3.00	106	3,1,3,4,3	2.80
79	4,6,5,6,6	5.40	107	2,2,4,7,6	4.20
80	5,10,10,7,8	8.00	108	2,3,3,4,4	3.20
81	6,7,3,6,7	5.80	109	2,4,3,2,3	2.80
82	4,1,0,6,7	3.60			

Table 3.i

FIELD AREAS AND LAPWING DENSITY

Field	No. of Revolutions * of Planimeter Wheel	x 200 = Area in Acres	Mean No. Lapwings	Density per 100ac.
1	0.025	5.0	3.00	60
2	0.026	5.2	0.50	10
3	0.025	5.0	5.88	117
4	0.045	9.0	1.00	11
5	0.022	4.4	0.83	19
6	0.020	4.0	0.33	8
7	0.022	4.4	0.50	11
8	0.039	7.8	1.00	13
9	0.025	5.0	0.67	13
10	0.014	2.8	2.17	77
11	0.022	4.4	0.17	4
12	0.019	3.8	0.00	0
13	0.006	1.2	0.00	0
14	0.030	6.0	0.33	39
15	0.027	5.6	0.83	15
16	0.035	7.0	0.33	5
17	0.020	4.0	0.00	0
18	0.005	1.0	0.33	33
19	0.005	1.0	0.00	0
20	0.025	5.0	0.67	13
21	0.015	3.0	0.50	17
22	0.020	4.0	2.17	54
23	0.041	8.2	8.43	103
24	0.031	6.2	1.67	27
25	0.035	7.0	4.17	60
26	0.028	5.6	0.00	0
27	0.012	2.4	0.00	0
28	0.005	1.0	0.00	0
29	0.010	2.0	0.00	0
30	0.002	0.4	0.00	0
31	0.055	11.1	0.00	0
32	0.002	0.4	0.00	0
33	0.012	2.4	0.00	0
34	0.002	0.4	0.00	0
35	0.016	3.2	0.00	0
36	0.002	0.4	0.00	0

* from 6" : 1 mile O.S. map

Table 3.ii

Field	No. of Revs. of Planimeter Wheel	x 200 = Area in Acres	Mean No. Lapwings	Density per 100ac.
37	0.010	2.0	0.00	0
38	0.0005	0.1	0.00	0
39	0.042	8.4	3.80	45
40	0.028	5.6	0.50	9
41	0.035	7.0	1.67	24
42	0.050	10.0	3.20	32
43	0.065	13.0	2.20	17
44	0.040	8.0	1.40	18
45	0.038	7.6	1.20	16
46	0.039	7.8	0.20	3
47	0.050	10.0	0.60	6
48	0.030	6.0	0.20	3
49	0.070	14.0	0.60	4
50	0.050	10.0	0.00	0
51	0.018	3.6	0.50	14
52	0.021	4.2	0.17	4
53	0.040	8.0	0.00	0
54	0.120	24.0	3.00	12
55	0.060	12.0	0.80	7
56	0.020	4.0	3.00	75
57	0.021	4.2	4.17	99
58	0.017	3.4	0.50	15
59	0.115	23.0	2.33	10
60	0.020	4.0	2.33	58
61	0.080	16.0	1.60	10
62	0.020	4.0	0.20	5
63	0.012	2.4	0.40	17
64	0.014	2.8	0.20	7
65	0.011	2.2	0.20	9
66	0.022	4.4	1.00	23
67	0.006	1.2	1.20	100
68	0.100	20.0	3.00	15
69	0.031	6.2	5.60	90
70	0.020	4.0	0.00	0
71	0.030	6.0	1.80	30
72	0.016	3.2	0.20	6
73	0.014	2.8	0.20	7

Table 3.iii

Field	No. of Revs. of Planimeter Wheel	x 200 = Area in Acres	Mean No. Lapwings	Density per 100ac.
74	0.055	11.0	6.40	58
75	0.100	20.0	7.40	37
76	0.014	2.8	2.20	79
77	0.025	5.0	2.00	40
78	0.025	5.0	3.00	60
79	0.050	10.0	5.40	54
80	0.120	24.0	8.00	33
81	0.040	8.0	5.80	72
82	0.060	12.0	3.60	30
83	0.095	19.0	4.40	23
84	0.100	20.0	3.80	19
85	0.070	14.0	2.20	16
86	0.035	7.0	1.20	17
87	0.060	12.0	3.60	30
88	0.070	14.0	7.60	54
89	0.030	6.0	1.40	23
90	0.010	2.0	1.00	50
91	0.012	2.4	1.60	67
92	0.045	9.0	6.60	73
93	0.035	7.0	2.60	37
94	0.085	17.0	11.20	66
95	0.045	9.0	3.60	40
96	0.060	12.0	1.20	10
97	0.015	3.0	0.60	20
98	0.041	8.2	2.40	29
99	0.025	5.0	0.80	16
100	0.070	14.0	1.20	9
101	0.070	14.0	1.00	7
102	0.030	6.0	3.40	57
103	0.026	5.2	3.00	58
104	0.025	5.0	0.80	16
105	0.095	19.0	2.20	12
106	0.085	17.0	2.80	16
107	0.085	17.0	4.20	25
108	0.048	9.6	3.20	33
109	0.021	4.2	2.80	67

Table 4.i

FIELD DATA

Factor	Code	1	2	3	4	5	6	7	8	9	10	11
		Field No.										
1 Type (A)	0-2	2	2	0	0	2	1	1	0	1	0	1
2 Type (B)	0/1	1	1	0	0	1	0	0	0	0	0	0
3 Area	(Ac.x10)	50	52	50	90	44	40	24	78	50	28	44
4 Altitude	(ft)	900	850	900	870	900	900	925	900	950	925	950
5 Aspect, Sun	0-4	2	2	2	2	2	2	4	3	2	2	2
6 Aspect, Wind	0-2	0	0	0	2	0	1	2	1	0	0	0
7 Gradient	0-5	2	1	2	1	2	2	2	2	2	3	3
8 Irregularity	0/1	0	0	0	0	1	1	0	0	0	0	0
9 Enclosure	0-4	0	1	0	1	1	0	0	1	1	2	0
10 Solid Walls	0-4	3	3	3	3	4	3	3	3	4	3	3
11 Terrain	1-5	2	1	4	1	1	2	2	2	2	2	2
12 Surf. Water	0-2	0	0	2	2	0	2	0	2	0	0	0
13 Juncus Cover	%	3	0	40	5	0	20	0	0	0	10	0
14 Juncus Distr.	0-10	3	0	8	4	0	3	0	0	0	3	0
15 Habitation	(m)	500	100	500	500	100	50	0	100	0	150	500
16 Trees In	0/1	0	0	0	1	0	0	0	1	1	1	1
17 Trees Adj.	0-2	0	1	0	1	0	1	1	0	0	0	0
18 Dom. Plants	0-2	2	2	0	1	2	1	1	1	1	1	1
19 Weeds (A)	0/1	0	0	1	0	1	1	0	1	0	1	0
20 Weeds (B)	0/1	1	1	1	1	1	1	0	1	1	1	1
21 Bare Ground	%	1	1	10	5	1	5	0	12	1	15	0
22 Ave. Height	(cm)	3	3	2	2	3	3	2	2	2	2	3
23 Max. Height	(cm)	6	5	60	3	6	6	8	3	3	3	4
24 Colour (A)	0/1	1	1	0	1	1	1	1	1	1	1	1
25 Colour (B)	0-2	2	2	0	1	2	1	1	1	1	1	1
26 Treatment	0-4	3	3	2	2	3	3	3	2	4	2	3
27 Grazing	0-2	0	0	1	2	0	1	1	2	1	2	1
28 Herbivores	0-3	0	0	1	3	0	1	1	3	1	3	1
29 Redshank	0/1	0	0	1	1	0	0	0	0	0	0	0
30 Mole Hills	0/1	0	1	0	0	0	1	1	1	1	1	1
31 Mean No. L.	(x10)	30	5	58	10	8	3	5	10	7	22	2
32 Density	(/100 ac)	60	10	117	11	19	8	11	13	13	77	4
33 Preference	0-3	3	1	3	2	1	1	1	2	1	2	0
34 Breeding (D)	0/1	1	0	1	1	0	0	0	1	0	1	0

The code or scale number was that used in the computer analysis.

Table 4.ii

Factor \ Field	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28
1	0	0	1	0	1	0	0	0	0	0	1	0	0	2	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0
3	38	12	60	56	70	40	10	10	50	30	40	82	62	70	56	24	10
4	950	950	975	925	975	975	975	1000	975	1025	1000	1025	1000	1050	1050	975	975
5	2	2	2	2	2	2	2	4	2	2	2	2	2	2	2	2	3
6	0	0	0	0	0	0	1	2	0	0	0	0	0	0	0	0	1
7	5	5	2	3	2	3	2	2	2	2	1	1	2	1	3	4	3
8	1	1	0	1	0	1	0	0	0	0	0	0	0	0	1	0	0
9	3	4	1	2	0	1	2	2	1	2	1	0	2	1	3	3	4
10	4	4	4	4	2	3	3	2	3	4	3	3	1	3	2	2	3
11	5	5	1	4	2	2	3	3	2	2	2	2	3	2	3	3	3
12	2	2	0	2	0	2	2	0	0	0	0	1	2	0	1	0	0
13	25	0	0	20	0	0	5	0	0	0	0	7	5	0	9	5	3
14	2	0	0	4	0	0	2	0	0	0	0	3	2	0	8	4	2
15	20	500	200	250	0	0	100	0	50	0	50	200	500	200	500	500	500
16	1	1	1	1	0	1	0	1	0	1	0	1	0	0	1	1	0
17	0	0	0	1	0	0	1	0	0	0	1	0	2	1	2	2	2
18	0	1	1	1	1	0	0	0	1	1	1	1	0	2	1	0	0
19	0	0	0	1	0	1	1	1	0	0	0	0	1	0	0	1	1
20	1	1	0	1	0	1	1	1	0	0	0	1	1	1	1	1	1
21	20	40	0	20	3	3	20	15	15	0	10	20	10	0	5	10	10
22	4	4	1	3	2	1	2	2	2	3	3	2	4	4	3	3	2
23	14	15	2	4	3	2	4	3	4	5	5	4	6	7	5	6	4
24	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
25	0	1	1	1	1	1	1	1	1	2	1	1	1	2	1	1	1
26	0	0	4	2	4	2	2	2	2	2	3	2	2	3	2	2	2
27	1	0	2	1	2	2	2	1	2	2	2	1	1	1	1	2	2
28	1	0	3	3	1	3	1	2	2	3	3	3	2	1	3	1	1
29	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
30	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0
31	0	0	3	8	3	0	3	0	7	5	22	84	17	42	0	0	0
32	0	0	39	15	5	0	33	0	13	17	54	103	27	60	0	0	0
33	0	0	1	1	1	0	1	0	1	1	2	3	2	3	0	0	0
34	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0

Table 4.iii

Factor \ Field	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45
1	0	0	0	0	0	0	0	0	0	0	2	0	0	2	1	1	2
2	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	1
3	20	4	111	4	24	4	32	4	20	1	84	56	70	100	130	80	76
4	1000	1000	1000	1000	1050	1000	1050	1000	1050	1000	925	950	950	1050	1025	1050	1075
5	0	2	2	2	2	2	2	4	2	2	3	2	2	3	3	2	4
6	0	0	0	0	2	1	2	2	2	2	2	0	0	1	2	1	2
7	5	0	4	1	5	1	5	1	4	1	1	4	3	1	1	3	2
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
9	3	3	3	2	3	2	3	3	2	3	0	1	1	0	0	1	0
10	0	2	0	3	0	0	3	1	2	3	2	3	2	3	2	3	3
11	5	2	4	4	5	4	4	3	2	4	2	3	3	1	2	2	2
12	2	2	0	0	0	2	0	0	0	0	0	1	2	0	1	0	0
13	0	0	0	0	0	5	0	0	1	0	2	10	20	0	10	0	0
14	0	0	0	0	0	1	0	0	1	0	3	2	3	0	1	0	0
15	500	500	500	500	500	500	200	100	30	0	500	500	500	200	200	100	100
16	1	1	1	0	1	1	0	0	0	0	0	0	0	1	0	0	0
17	0	0	0	2	0	1	1	1	0	1	0	0	1	0	0	0	0
18	0	1	0	0	0	1	0	1	1	1	2	1	0	2	1	1	2
19	0	0	0	1	0	1	0	0	0	1	0	1	1	0	0	0	0
20	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1	0	1
21	30	5	5	3	35	5	5	1	0	3	0	5	10	5	20	15	0
22	6	3	4	5	9	4	3	9	3	3	3	2	2	3	2	2	3
23	12	5	7	14	20	10	7	10	4	20	10	3	14	4	4	4	5
24	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1
25	1	1	1	1	0	1	1	2	1	1	2	1	1	2	1	1	2
26	0	1	2	0	0	0	0	2	2	0	4	2	2	4	4	3	3
27	0	0	1	2	0	0	2	0	1	2	0	0	0	0	0	1	1
28	0	0	2	2	0	0	2	0	1	2	0	0	0	0	0	1	1
29	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	0
30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31	0	0	0	0	0	0	0	0	0	0	38	5	17	32	22	14	12
32	0	0	0	0	0	0	0	0	0	0	45	9	24	32	17	18	16
33	0	0	0	0	0	0	0	0	0	0	3	1	2	3	2	2	2
34	0	0	0	0	0	0	0	0	0	0	1	0	1	1	1	1	0

Table 4.iv.

Factor	Field 46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	61
1	1	0	0	0	0	2	2	2	0	0	0	0	0	0	0	0
2	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0
3	78	100	60	140	100	36	42	80	240	120	40	42	34	230	40	160
4	1100	1150	1200	1220	1250	1150	1150	1150	1200	1200	1250	1275	1300	1370	1300	1300
5	4	4	4	2	2	2	2	2	1	2	2	2	2	2	2	2
6	2	1	2	1	1	2	2	2	1	2	2	2	2	2	2	2
7	2	2	3	2	2	4	4	3	3	4	2	2	3	3	3	4
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	1	1	1	0	1	1	1	1	0	1	0	1	1	0	1	1
10	4	4	3	3	4	4	4	4	4	3	3	3	4	0	4	4
11	2	2	4	3	4	2	2	2	4	3	3	3	4	5	3	4
12	0	0	0	1	0	0	0	0	1	0	0	1	2	1	0	0
13	0	0	0	0	0	0	0	0	30	10	7	30	25	10	25	50
14	0	0	0	0	0	0	0	0	9	6	4	8	5	5	6	9
15	40	0	20	70	150	80	500	0	500	0	300	500	500	0	50	0
16	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0
17	1	1	1	2	0	0	0	0	0	0	0	0	0	0	0	1
18	1	1	0	0	1	2	2	2	0	0	0	0	0	0	0	0
19	0	0	0	0	1	0	0	0	0	0	1	1	1	0	0	0
20	0	0	1	1	1	1	1	1	1	1	1	1	1	0	0	0
21	8	10	10	15	20	0	0	1	10	5	10	20	15	10	5	5
22	3	2	1	1	3	3	3	3	2	2	2	2	4	2	3	6
23	4	3	3	3	5	4	4	5	60	3	3	3	20	20	6	30
24	1	1	1	1	1	1	1	1	0	1	1	0	0	0	0	0
25	1	1	1	1	2	2	2	2	0	1	1	0	0	0	0	0
26	3	4	1	1	0	3	3	3	0	2	2	2	2	0	2	1
27	2	2	2	2	2	0	0	0	2	2	2	2	0	2	1	2
28	3	1	2	3	2	0	0	0	3	3	1	1	0	1	2	3
29	0	0	0	1	1	0	0	0	1	0	0	0	0	1	0	0
30	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0
31	2	6	2	0	0	5	2	0	30	8	30	42	5	23	23	16
32	3	6	3	0	0	14	4	0	12	7	75	99	15	10	58	10
33	0	1	0	0	0	1	0	0	3	1	3	3	1	2	2	2
34	0	0	0	0	0	0	0	0	1	0	1	1	0	1	1	1

Table 4.v

Factor	Field 62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	40	24	28	22	44	12	200	62	40	60	32	28	110	200	28	50
4	1300	1375	1300	1300	1300	1300	1370	1300	1300	1275	1250	1225	950	950	950	950
5	2	2	1	3	3	3	4	4	3	3	2	3	2	2	2	3
6	2	2	1	2	2	2	2	2	2	2	1	1	0	0	1	1
7	4	2	4	4	4	3	3	3	3	3	4	3	1	2	1	3
8	0	0	1	0	0	0	0	0	0	1	1	1	0	0	0	0
9	1	1	1	1	1	1	0	1	1	0	1	2	1	1	1	1
10	4	4	4	4	4	4	0	4	4	4	4	4	4	4	4	3
11	4	2	4	3	3	3	5	3	3	4	3	4	2	3	1	3
12	0	0	1	0	1	1	2	0	0	1	1	1	0	1	0	0
13	20	1	20	0	5	7	20	5	0	15	15	18	20	30	0	15
14	6	1	6	0	3	4	4	4	0	4	2	3	4	8	0	5
15	20	0	20	10	10	30	500	0	500	500	100	0	0	70	150	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	1
17	1	0	0	0	1	0	0	0	0	0	1	0	0	0	0	0
18	0	1	0	0	1	1	0	0	0	0	1	1	1	0	1	0
19	0	0	0	0	1	1	0	1	0	1	0	1	0	1	1	1
20	0	1	0	1	1	1	0	0	0	1	1	1	1	1	1	1
21	5	0	3	5	3	3	10	20	0	15	5	10	10	10	5	10
22	5	3	3	2	5	3	3	2	4	5	4	4	3	2	2	2
23	8	6	5	5	10	5	8	4	8	11	10	14	5	30	4	4
24	0	1	0	1	1	1	0	1	1	1	1	1	1	0	1	1
25	0	1	0	1	2	2	0	1	1	1	1	2	1	0	1	1
26	1	2	1	2	2	2	0	1	2	1	2	2	2	2	2	2
27	2	2	2	0	0	0	2	2	0	2	0	0	2	1	1	2
28	1	2	1	0	0	1	1	1	0	1	0	0	3	3	1	3
29	0	0	1	0	0	0	1	0	0	0	0	1	0	1	0	0
30	0	1	0	1	0	0	0	1	0	1	1	1	0	1	0	0
31	2	4	2	2	10	12	30	56	0	18	2	2	64	74	22	20
32	5	17	7	9	23	100	15	90	0	30	6	7	58	37	79	40
33	0	0	0	0	2	2	3	3	0	2	0	0	3	3	2	2
34	0	0	0	0	1	1	1	1	0	1	0	0	1	1	1	1

Table 4.vi

Factor \ Field	78	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93
1	0	0	0	1	0	0	0	2	0	0	0	0	1	2	0	2
2	0	0	0	0	0	0	0	1	0	0	0	0	1	1	0	1
3	50	100	240	80	120	190	200	140	70	120	140	60	20	24	90	70
4	975	1050	1025	975	825	825	850	850	800	900	900	900	835	835	900	835
5	0	2	2	2	0	0	3	1	0	1	0	0	1	1	0	1
6	0	2	2	2	0	0	2	0	0	0	0	0	0	0	0	0
7	3	2	3	1	3	4	1	2	3	4	4	3	2	2	3	2
8	1	0	0	0	0	1	0	0	0	1	0	0	0	0	0	0
9	0	0	0	0	1	1	0	0	1	2	1	1	1	1	0	1
10	3	3	2	0	3	4	4	4	3	3	4	3	4	4	3	4
11	2	3	3	4	2	2	2	2	3	4	3	3	2	2	3	1
12	2	0	0	0	0	0	0	0	0	1	0	0	0	0	1	0
13	10	25	25	0	0	0	10	0	0	15	10	8	0	0	25	0
14	3	9	5	0	0	0	3	0	0	3	2	4	0	0	4	0
15	0	500	500	500	500	500	500	0	500	500	500	70	0	100	500	500
16	1	0	0	0	0	0	0	0	0	0	1	1	1	0	0	0
17	0	0	0	0	1	2	1	1	1	0	1	0	0	0	0	1
18	1	0	0	1	1	1	1	2	0	0	0	1	1	2	1	2
19	0	1	1	0	1	1	1	0	1	0	1	0	0	0	1	0
20	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
21	5	10	10	60	3	5	15	3	20	25	55	7	5	1	5	1
22	2	2	2	7	2	2	3	7	2	3	2	4	2	7	3	5
23	3	15	15	15	3	3	6	15	5	6	10	8	4	10	6	10
24	1	0	0	1	1	1	1	1	1	1	0	1	1	1	1	1
25	2	0	0	1	2	2	1	2	1	1	0	2	1	2	1	2
26	1	1	1	0	2	2	2	3	2	0	0	2	3	3	2	3
27	2	2	2	1	2	2	0	0	1	1	2	1	0	0	0	0
28	1	1	3	1	1	3	0	0	2	2	1	2	0	0	0	0
29	1	0	0	0	0	0	1	0	0	0	0	0	1	0	0	0
30	1	1	0	0	0	0	0	0	0	0	0	1	0	0	0	0
31	30	54	80	58	36	44	38	22	12	36	76	14	10	16	66	26
32	60	54	33	72	30	23	19	16	17	30	54	23	50	67	73	37
33	3	3	3	3	3	3	3	2	2	3	3	2	2	2	3	2
34	1	1	1	1	1	1	1	1	0	1	1	1	1	1	1	1

Table 4.vii

Factor \ Field	94	95	96	97	98	99	100	101	102	103	104	105	106	107	108	109
1	0	0	2	2	0	2	0	0	0	0	0	0	0	0	0	0
2	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0
3	170	90	120	30	82	50	140	140	60	52	50	190	170	170	96	42
4	950	950	900	950	950	875	1000	1375	1400	1400	1425	1375	1375	1400	1375	1350
5	0	0	1	0	0	1	1	4	4	4	4	1	1	0	0	1
6	0	0	0	0	1	0	0	2	2	2	2	1	1	1	0	0
7	3	2	3	2	3	2	4	3	2	2	2	1	1	3	3	4
8	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	1
9	0	0	1	1	0	1	1	1	0	0	0	0	1	0	1	2
10	4	4	3	4	4	4	4	3	4	4	4	3	4	4	4	4
11	3	3	2	2	3	2	4	3	2	2	2	2	2	2	3	2
12	1	2	0	0	2	1	2	1	0	0	1	0	0	0	0	0
13	20	35	0	0	20	5	15	19	0	0	10	7	5	1	3	0
14	7	4	0	0	5	3	4	4	0	0	7	9	8	2	3	0
15	50	0	20	200	100	500	500	5	100	100	50	500	500	500	500	500
16	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
17	0	0	1	0	0	0	1	0	0	0	0	0	0	0	0	0
18	0	0	2	2	0	2	0	0	1	1	1	0	0	0	0	1
19	1	0	0	0	1	0	0	1	1	1	1	1	1	0	1	1
20	1	1	1	1	1	1	0	1	1	1	1	1	1	1	0	1
21	5	10	2	5	5	1	10	10	5	5	5	3	5	5	5	5
22	2	3	6	8	3	5	2	5	3	3	4	1	1	1	2	3
23	13	12	10	15	6	8	10	12	5	5	9	3	13	3	4	5
24	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1
25	1	1	2	1	1	2	1	1	1	1	1	1	0	1	1	2
26	2	2	3	3	2	4	1	1	2	2	2	2	2	2	2	2
27	2	0	0	0	1	0	2	1	2	0	1	2	2	2	2	2
28	3	0	0	0	3	0	1	2	2	0	2	1	2	3	1	1
29	1	1	0	1	1	0	1	0	0	0	0	1	0	0	0	0
30	0	1	0	1	1	0	0	0	1	1	0	0	0	0	0	0
31	112	36	0	6	24	8	12	10	34	30	8	22	28	42	32	28
32	66	40	10	20	29	16	9	7	57	58	16	12	16	25	33	67
33	3	3	0	1	2	1	2	2	3	3	1	2	2	3	3	2
34	1	1	0	0	1	0	0	1	1	1	1	1	1	1	1	1

Fig. 5

Field 23.

Lapwing density : 103/100 ac.
Bare ground : 20%
Colour : Green
Gradient : 1
Roughness of Terrain : 2

Juncus cover : 7%
Average height : 2 cm
Trees present.
3 walls + 1 wire fence
Herbivores : Sheep (subsequently cows)

Fig. 6

Field 57

Density : 99/100 ac.
Colour : brownish green
Juncus cover : 30%

Roughness : 3
Trees absent
Herbivores : sheep only.

Fig. 7

Field 74

Lapwing density : 58/100 ac.
Colour : bright green.
Gradient : 1
Habitation adjacent (0 m.)
Roughness : 2
Average height : 3cm
Herbivores : sheep + cows

Fig. 8

Field 81

Density : 72/100 ac.
Bare ground : 60%
Colour : green + brown earth.
No. stone walls = 0
Roughness : 4
Juncus cover : 0%
Maximum height : 15cm.

Note 2

FERTILIZER DETAILS

Examples :

Fields 1-11 : Compound N,P,K fertilizer applied once a year (early May). 14% N, 8% P, 12% K.
Pasture : grazed.
Hayfields : grazed until April, hay mown July then extra N added. Grazing recommenced.
or: grazed until June/July then hay grown.

Fields 12-14: As above. Fertilized with Hargreaves Supergrade U : 14% N, 14% P_2O_5, 14% K_2O.

Fields 15-18: Fertilized with Hargreaves Topgrade 4 : 16% N, 8% P, 12% K.

Fields 19-25: As above. Pasture limed as necessary.

Fields 26-30: As above. Fertilized with Webbs 20-10-10 : 20% N, 10% P, 10% K.

Supplementary N fertilizers added :

Fisons Nitro-Top 33.5% N
ICI Nitro-Chalk 21% N

Table 5.i

RESULTS OF MULTIVARIATE ANALYSIS

Value of F ($=t^2$) for significance at 5% level = $(1.96)^2$
= 3.842

at 1% level = $(2.5)^2$
(Degrees of Freedom > 30) = 6.250

Thus any F values greater than 3.842 are considered SIGNIFICANT.

All factors not included below gave F values of less than 3.842.

A. LAPWING

I Presence or Absence in Field (dependent variable 34, Breed Choice D)

Constant = 1.23476

Factor	Coefficient	Sign	F value	Effect
Enclosure of land	0.191	-	18.575	0-0.763
Distribn. of *Juncus*	0.063	+	15.103	0-0.566
Roughness of ground	0.213	-	11.683	0.213-1.006
% Bare ground	0.011	+	6.230	0-0.551
Artif. treatment	0.119	-	4.395	0-0.478

II Mean No. Lapwings in Field (dependent variable 31)

Constant = 25.22182

Factor	Coefficient	Sign	F value	Effect
Lapwing Density	0.484	+	74.474	0-56.620
Area of field	0.206	+	40.187	0.021-4.935
Altitude	0.023	-	5.626	19.465-32.632

III Density of Lapwings (dependent variable 32)

Constant = 63.47130

Factor	Coefficient	Sign	F value	Effect
% Bare ground	0.942	+	16.121	0-47.095
% Cover of *Juncus*	0.816	+	11.038	0-40.812
Area of field	0.141	-	10.382	0.014-3.387
Roughness of ground	8.402	-	8.060	8.402-42.008
Presence of trees	9.598	-	7.643	0-9.598
Wind exposure	6.750	-	7.340	0-13.500
Unpalatable weeds	11.131	+	6.929	0-11.131
Enclosure of land	8.083	-	6.692	0-32.330
Slope irregularity	13.692	-	5.592	0-13.692

Table 5.ii

IV Including Soil Fauna (dependent variable 32, Density of Lapwings)
25 Fields Only : 24 degrees of freedom.
F value for significance = 4.260 (5%), 7.823 (1%).

Constant = 43.69608

Factor	Coefficient	Sign	F value	Effect
Slope irregularity	54.137	-	24.985	0-54.137
Area of field	0.243	-	8.361	0.024-5.820
Total Lumbricidae	2.106	+	5.826	0-42.114
Unpalatable weeds	23.566	+	5.704	0-23.566

B. REDSHANK

V Presence or Absence in Field (dependent variable 29)
109 Fields.

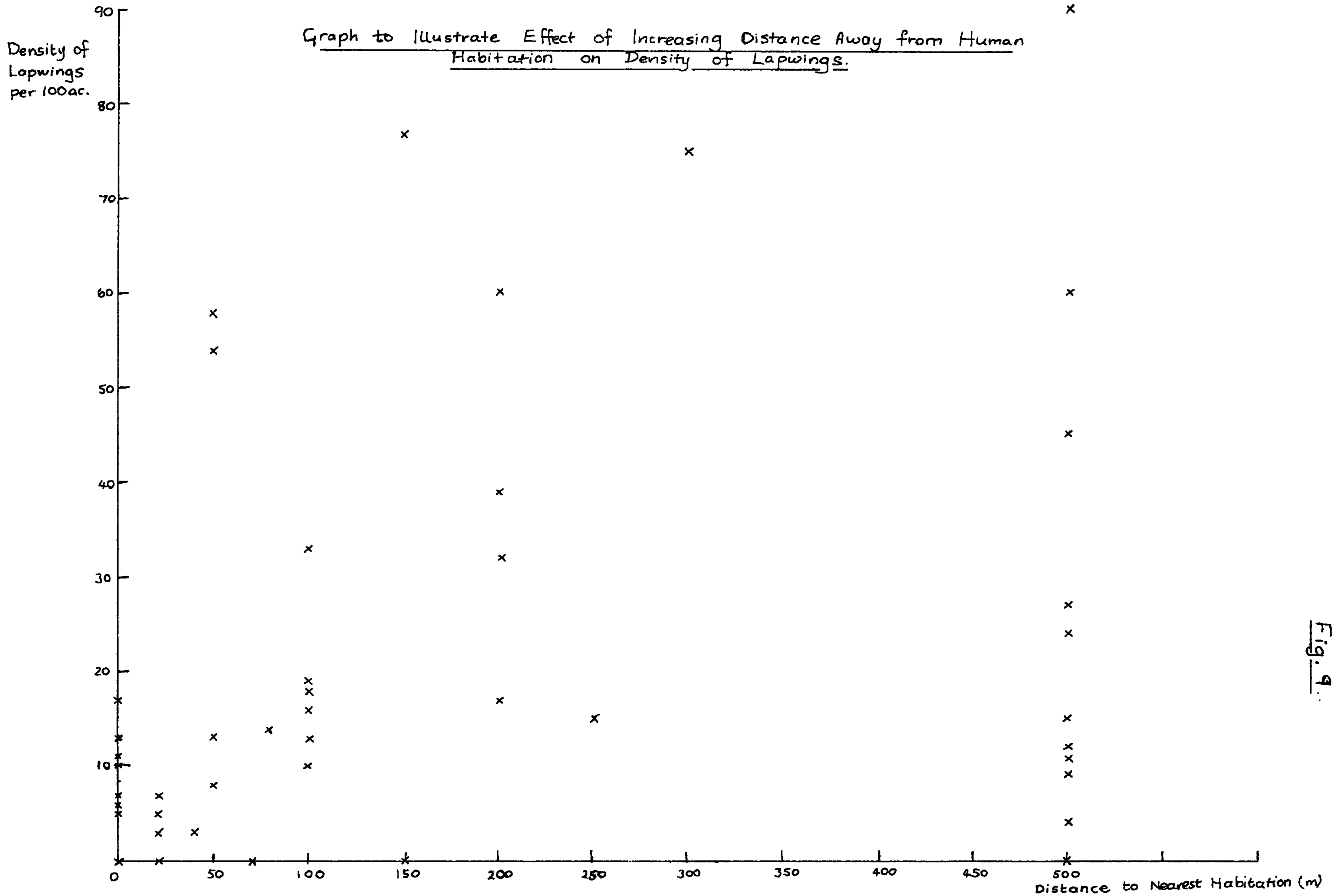
Step 9: Constant = 0.33608

Factor	Coefficient	Sign	F value	Effect
Area of field	0.003	+	16.848	0.0003-0.063
Surface water	0.169	+	15.226	0-0.338
Habitation	0.0005	-	8.683	0-0.225
Gradient of slope	0.088	-	6.773	0-0.442
Sun exposure	0.075	-	6.052	0-0.300
Large herbivores	0.069	-	4.765	0-0.206
Roughness of ground	0.092	+	4.270	0.092-0.457
Ave. height of veg.	0.046	-	4.053	0-0.142

Step 34: Constant = 0.41823

Factor	Coefficient	Sign	F value	Effect
Area of field	0.004	+	9.291	0.0004-0.097
Surface water	0.151	+	6.094	0-0.302
Gradient of slope	0.104	-	5.766	0-0.521
Pref. by Lapwings	0.213	-	4.474	0-0.639
Field type (B)	0.556	-	4.220	0-0.556
Field type (A)	0.306	-	4.096	0-0.611

Fig. 9.


Graph to Illustrate Effect of Increasing Distance Away from Human Habitation on Density of Lapwings.
Density of Lapwings per 100ac.
90
80
70
60
50
40
30
20
10
0
50
100
150
200
250
300
350
400
450
500
Distance to Nearest Habitation (m)

CHI^2 TEST OF SIGNIFICANCE.

Null Hypothesis : There is no increase in the density of Lapwings in fields with increasing distance away from human habitation.

Observed Values (Totals: from Fig. , 50 fields)

Density of Lapwings/100ac	Distance from House m			
	0-30	31-100	>100	Total
Below 20	17	10	10	37
Above 20	0	3	10	13
Total	17	13	20	50

Expected Values

Below 20	12.58	9.62	14.80
Above 20	4.42	3.38	5.20

Chi^2 = $(O-E)^2/E$

Below 20	1.552	0.014	1.556
Above 20	4.420	0.042	4.430

$$Chi^2 = \sum \frac{(O-E)^2}{E}$$

$$= 1.552 + 4.420 + 0.014 + 0.042 + 1.556 + 4.430$$

$$= 12.014$$

Degrees of Freedom = (3-1)(2-1)
= 2

From Tables, χ^2_2 (1%) = 9.210

Thus a value of Chi^2 as high as 12.014 is SIGNIFICANT at the 1% level (not at 0.1%).

Hence the Null Hypothesis is rejected : it is shown that increasing distance from human habitation exerts a significant positive influence on the density of Lapwings.

Table 6

SOIL FAUNA DATA

Field	Lumbricidae White	Lumbricidae Red	Lumbricidae Green	Coleoptera Larvae	Coleoptera Adults	Other Animals
1	5	2	5	2	1	1
2	1	0	0	1	0	1
3	9	1	6	5	0	4
4	1	2	1	1	0	2
5	0	0	0	0	0	1
10	1	1	1	0	0	0
12	1	0	0	0	1	0
15	6	3	2	0	0	4
17	3	2	0	2	1	0
22	9	4	0	2	1	3
23	8	2	0	2	3	3
25	1	1	0	0	0	0
26	7	0	0	3	0	1
54	7	1	1	0	1	0
57	0	6	0	4	0	0
59	3	2	1	0	0	0
64	0	0	1	0	1	0
65	3	0	0	1	1	0
67	8	3	5	1	0	3
68	3	1	2	3	1	1
69	2	7	0	2	2	3
71	1	1	2	0	2	0
74	4	0	2	0	1	2
76	7	3	4	2	0	0
81	11	3	6	5	0	2

Table 7

Field	Lumbricids	Other Inverts.	Total Inverts.
1	12	4	16
2	1	2	3
3	16	9	25
4	4	3	7
5	0	1	1
10	3	0	3
12	1	1	2
15	11	4	15
17	5	3	8
22	13	6	19
23	10	8	18
25	2	0	2
26	7	4	11
54	9	1	10
57	6	4	10
59	6	0	6
64	1	1	2
65	3	2	5
67	16	4	20
68	6	5	11
69	9	7	16
71	4	2	6
74	6	3	9
76	14	2	16
81	20	7	27
Total	185	83	268

Total numbers of animals extracted from four 4" diameter x 3" deep (10.5 x 7.5cm) soil cores in each field.

ANALYSIS OF SOIL FAUNA

Of 268 soil invertebrates extracted from 100 cores :

Lumbricidae . . . 69.0%
Other Animals . . . 31.0%

Of the 185 Lumbricids, types were classified by pigmentation :

White . . . 54.6%
Red . . . 24.3%
Green . . . 21.1%

The green earthworms were mainly Allolobophora chlorotica.

Of the 83 Other Animals, distribution into groups was as follows:

Group	Total	% (of 83)
Coleopteran larvae	36	43.4
Coleopteran adults	16	19.3
Arachnida	8	9.6
Hemipteran nymphs	5	6.0
Dipteran larvae	4	4.8
Dipteran pupae	4	4.8
Mollusca (slugs)	3	3.6
Large Spider mites	3	3.6
Coleopteran pupae	1	1.2
Dipteran adults	1	1.2
Chilopoda	1	1.2
Large Collembola	1	1.2

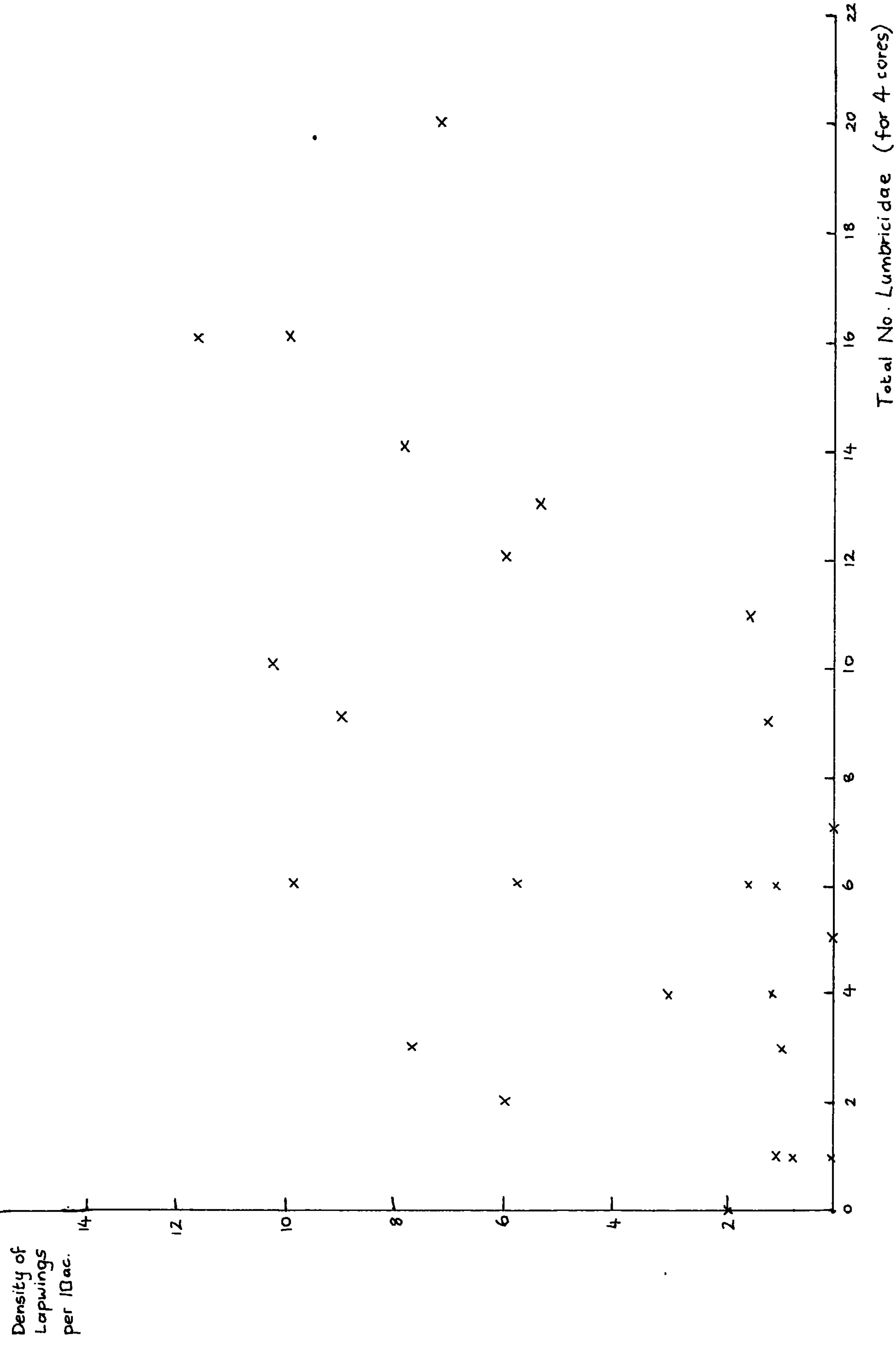
Over two-thirds of the Coleopteran larvae (25) were those of Chafer beetles.

Of the Arachnida, all were Araneid spiders except for one Opilionid.

Half of the Dipteran larvae and one of the Dipteran pupae belonged to the Tipulidae.

Fig. 10

Graph to Show Effect of Number of Lumbricid Worms present in (4 samples from each of) 25 fields on Density of Lapwings.



Graph to Show Relationship Between Number of Other Invertebrates present and Density of Lapwings.

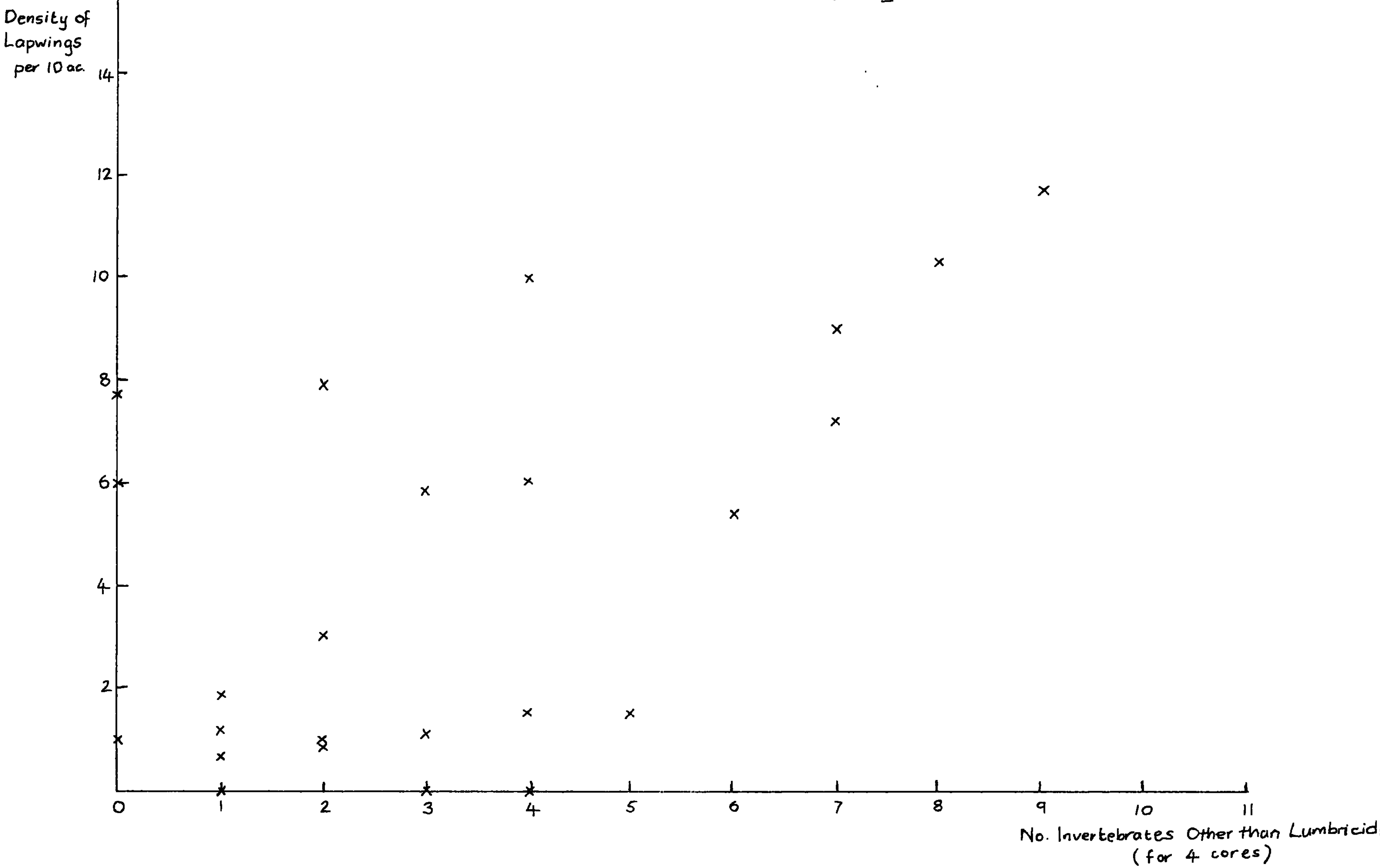


Fig. 11

Fig. 12

Graph to Show Effect of Total Number of Invertebrates present in 4 core samples on Density of Lapwings.

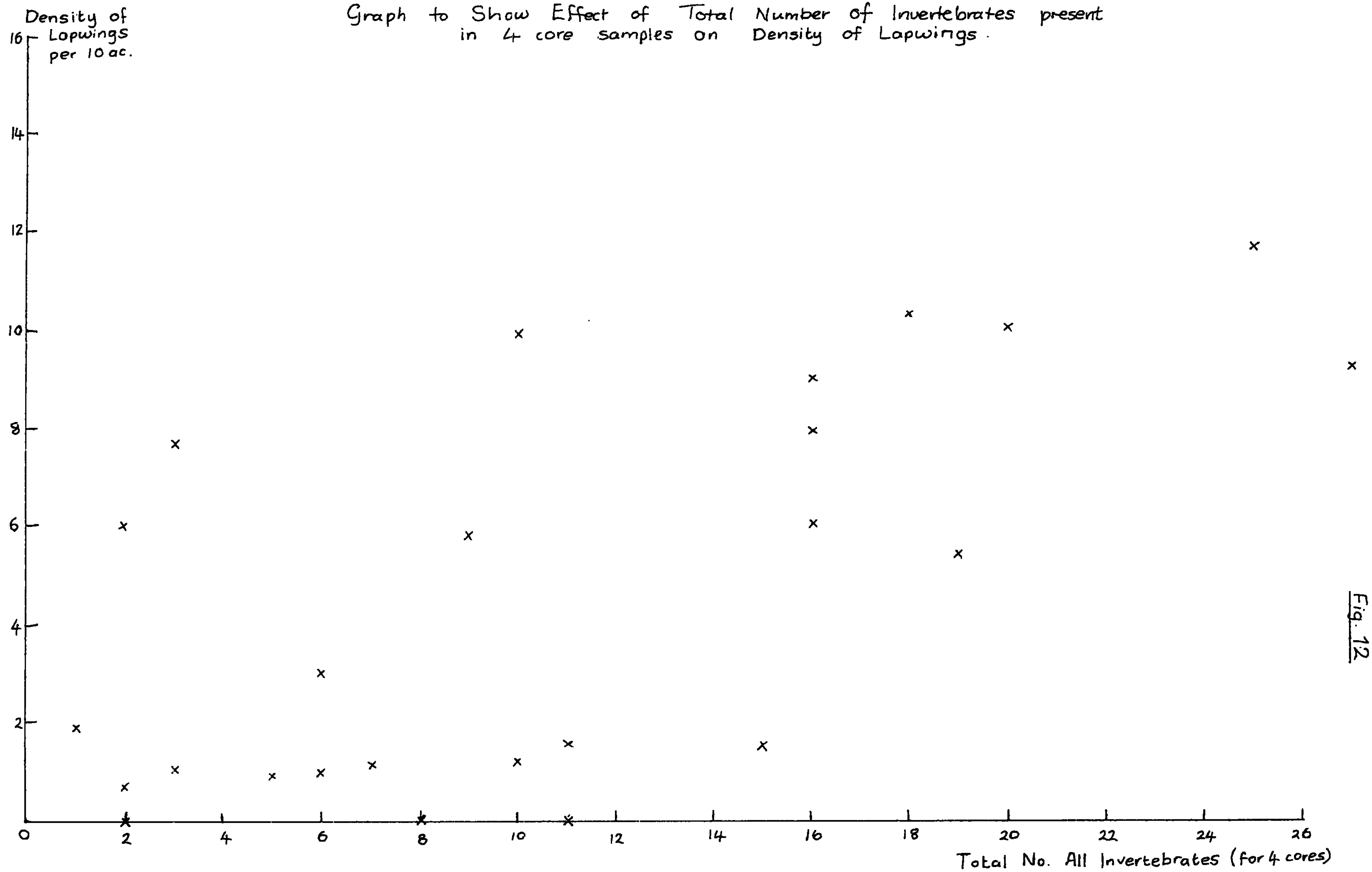
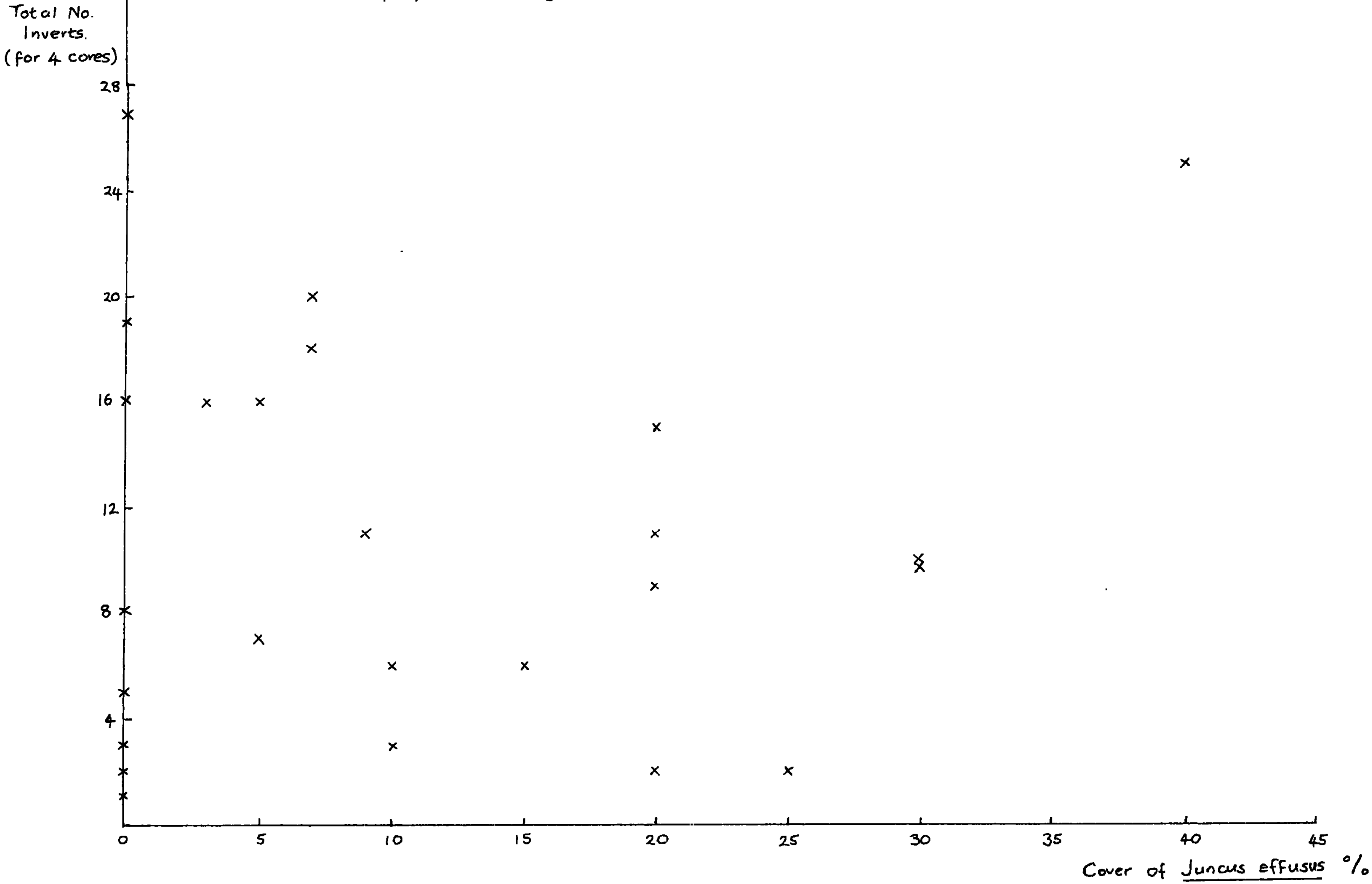


Fig. 13

Graph Relating Abundance of Soil Invertebrates and % Cover of *Juncus effusus*.



CONCLUSIONS AND DISCUSSION

The results of the multivariate analysis showed that the chief factors contributing to variation in the density of Lapwings breedimg on marginal hill farmland, in order of importance, are: i) the amount of bare ground, ii) the percentage cover of *Juncus effusus*, iii) the area of the field, iv) roughness of the ground, v) presence of trees, vi) exposure to wind, vii) presence of unpalatable weeds, viii) enclosure by the surrounding land, and ix) any irregularity of gradient. All were statistically significant, but bare ground, the cover of *Juncus* and presence of weed species have a positive or attracting effect on Lapwings; whilst the other features exert a negative or repelling effect, most strongly accentuated in the case of field area, roughness and the presence of trees.

When choice of fields for breeding by Lapwings on a presence-or-absence basis is examined, a similar group of factors emerges. The distribution of *Juncus* and presence of bare ground are the strongest positive factors, with enclosure of the land, roughness of terrain and degree of artificial fertilization having the most marked negative influence on breeding. When fields where the density of birds was zero were excluded, the results were no different from those considering all fields.

For mean numbers of Lapwings present in the fields, and including Lapwing density as a factor, the latter emerged as the most significant and positive influence- although the two are to some extent correlated to each other. Area of the field was important positively in affecting Lapwing numbers. There would be a relatively greater repelling 'edge effect' by the solid stone walls (reducing visibility) in a smaller field. When the area effect was neutralised, however, density remained a high influence in its own right. Altitude was also shown to significantly reduce the mean numbers of Lapwings in the fields : a coefficient of 0.023 implied that for every

100 ft rise in altitude, the mean number of Lapwings present in a field would decrease on average by 0.23.

Where the numbers of Lumbricids and other soil invertebrates were included for 25 fields, the Lumbricidae appeared to exert a significant positive influence on Lapwing density. The degree of correlation between earthworms and other invertebrates was high (correlation coefficient of $r = 0.689$), and it is difficult to determine whether earthworms only or total suitable soil fauna was influencing the Lapwings' breeding distribution.

Since the presence or absence of Redshank(*Tringa totanus britannica* Mathews) was recorded for each field, it was possible to determine the factors which were affecting the distribution of this species. Area of the field, presence of surface water and roughness of the ground were shown to be the strongest positive influences, while proximity of human habitation, steepness of slope, exposure to sunshine, the presence of large herbivores and average height of the vegetation were all significant negative characteristics of the habitat. Redshank would thus seem to be more susceptible to disturbance from humans and grazing animals than are Lapwings, since neither of these factors emerged as significant in any analyses carried out for the latter species. They are also strongly attracted to water, to which Lapwings are apparently indifferent. In addition, Redshank prefer to settle in large sized fields, and Lapwings in smaller areas, though not consistently so. When various other non-significant factors were introduced into the analysis, the significance levels of all except field area, surface water and gradient decreased markedly, and two additional factors emerged as significant: preference for a field by Lapwings, and hay meadow as a type of field, both negative influences. This would suggest that the presence of Lapwings may be a significant deterring factor to the Redshank but the reverse is not so: the presence of Redshanks neither attracts nor repels Lapwings as far as these results show.

The features of the habitat which at no stage appeared significant in determining the distribution or numbers of either Lapwing or Redshank are: the dominant plant species; presence of broad-leaved weeds; maximum height of the vegetation; colour of the field; intensity of grazing; presence of mole hills and the number of stone wall boundaries.

Thus a high density of Lapwings is attracted to fields possessing a large proportion of bare earth, dense cover of Juncus effusus, the absence of trees in or around the field, shelter from the prevailing wind, open on all sides, with a regular slope and tall weed species such as thistles and nettles. Small sized fields and those already populated by Lapwings are also favoured.

Redshank, in contrast, would be most likely to be found in fields which have a large area, water table near the surface of the ground, a gentle gradient, uneven terrain, shelter from direct sunshine, a low vegetation, the absence of Lapwings or large grazing animals and far from human habitation.

The preceding findings are summarised comparatively in Table 8 .

The attraction of the Lapwing to already-occupied fields demonstrated here is in agreement with the findings of Hildén (1965), who writes : "Vanellus vanellus is a typical example of a species showing clear-cut sociality even during the breeding period, although in character a territorial bird". The indications are that sociality regulates the habitat selection of most species.

The strongly significant preferences for large areas of bare soil, unenclosed situations and treeless land follow the breeding habitat description for the Lapwing given by Witherby et. al. (1940), which states that this species favours "open spaces, wherever the soil is easily accessible, either naked or under some fairly light vegetation cover. It avoids built-up, wooded and enclosed areas, and steep escarpments." From the Lapwing Habitat Inquiry of 1937, Nicholson (1938) again emphasises a preference for bare ground: "The Lapwing is a bird of the soil, its habitats coinciding with areas where the soil is accessible in large tracts, either bare or under fairly light vegetation cover." High hill pastures and rough grazing are described as "ideal breeding ground".

Nicholson notes that steep slopes, high altitudes, exposed areas and trees are generally avoided; rushy fields (Juncus effusus) are frequented throughout the year, with a more marked preference at the breeding season. This finding is in accordance with the present results, which have demonstrated a significant positive effect on both Lapwing density and choice for breeding from the presence of Juncus.

Lister (1939), in a study of the Lapwing population on a Surrey farm, suggested that the greater popularity of some fields over others was related to the irregularity of the gradient : a gentle hollow and ridge in diagonal cross-section as opposed to a straight slope. In the present work irregularity of gradient was found to be a significant negative factor.

Nicholson (1938) found no quantitative evidence of attraction or repulsion by sheep, cattle and horses in pasture, and a neutral relationship was assumed. This is supported by the present findings. Lapwings were often observed to be associated with other birds such as the Skylark (Alauda arvensis), Yellow Wagtail (Motacilla flava), Meadow-Pipit (Anthus pratensis), Curlew (Numenius arquata), Redshank (Tringa totanus), Snipe (Gallinago gallinago), Partridge (Perdix perdix) and Pheasant (Phasianus colchicus) in both the present and Nicholson's studies, though these are probably coincidental occurrences rather than biological associations. Klomp (1953) concluded that other bird species do not affect habitat selection in the Lapwing.

The present results show no marked preference by Lapwings for proximity to open water, whereas Venables (1937) found the species invariably breeding close to a marsh or water on

Surrey greensand heaths. However in the latter region both the climate and soil type would be of a naturally drier nature than in this North-Eastern upland area; probably sufficient moisture was available in all fields covered by the present survey, for example, to support a high density soil fauna.

Little conclusive evidence of a relationship between Lapwing densities and available soil fauna was uncovered by the computing, although graph plots indicated a positive correlation. Theoretically, food is of profound significance to birds, since only an environment with a sufficient supply of suitable food can form a breeding terrain. However, most species are not highly specialised in their diet (Hildén,1965). An examination of food records tends to show that within broad limits, a bird will eat whatever food it can obtain with the least difficulty in its own particular habitat, which has been selected on other grounds. Lack (1933) found no evidence for supposing that food limited the distribution of any particular bird species on Breckland. Food does not seem to have any proximate effect on habitat selection: Klomp (1953) could find no correlation between the distribution of the Lapwing and abundance of food in North-West Holland, and caged Lapwings accepted all invertebrate animals collected in non-breeding areas.

The Lapwing gathers food from the surface of the soil- generally earthworms and insects, occasionally molluscs and spiders. Collinge (1924-7), in a detailed investigation of the food taken by wild birds, examined the crop and stomach contents of 69 Lapwings. He established that 64% of food taken was insects- chiefly wireworms, beetle larvae and adults, leatherjackets, Tipulid larvae and adults, grasshoppers and Lepidopteran larvae. 10% of the diet was earthworms of genera Lumbricus and Allolobophora; 10% was slugs and snails, 5% miscellaneous animal matter including arachnids, myriapods and isopods; 6% was weed seeds of species such as Ranunculus, Spergula and Polygonum; and 5% miscellaneous vegetable matter comprising grass, leaves, moss and fragments of algae. The present work confirms the variety of food probably taken- including spiders, harvestmen, centipedes and Hemipteran nymphs in addition to most of the above.

The clear preference displayed by Lapwings in this study for fields where a relatively large proportion of the ground is exposed as bare soil could be linked to feeding: in such places the soil and litter fauna would be more visible and easily accessible to the birds than in fields supporting a dense vegetational cover. This proposal is probably connected with the Lapwing's established attraction to ploughed fields in arable districts, as explained by Spencer (1953): Lapwings "are drawn to ploughland because food is easily obtainable off it and because the friable surface is very easily 'scrapeable' into nesting-hollows". There might also be better camouflage for the eggs and chicks on brown earth or a patchy surface than on continuous green grass, although the significance of camouflage in the habitat selection process is still in doubt (Klomp,1953).

It is feasible that fields containing a high density of Juncus effusus might furnish cover from enemies and shelter from adverse environmental conditions for young chicks. No significant correlation (r = 0.128) was found between the percentage cover of Juncus and density of soil animals. Hildén (1965) stresses that shelter is especially important for eggs and young and for the incubating bird, which are most exposed to danger from a predator, heavy rainfall or blazing sun. Clumps of Juncus may also help to break the force of high wind, exposure to which is shown in the present work to be a significant negative characteristis of the habitat. In a similar way the presence of tall weeds such as thistle and nettle in close-cropped pasture could again provide cover and shelter, which would account for their positive influence in habitat selection here. Kendeigh (1934) concludes that a high wind may be important in aggravating the effect of low air temperature upon the metabolism of the bird.

The presence of trees appears to exert a strong negative influence on Lapwing density, and this is in accordance with the findings of all previous workers. Klomp (1953) has attempted to define the ultimate cause of this response in terms of the greater offensive power of enemies, such as carrion crows, in wooded areas. In the open field, most attacks can be beaten off in the air, are of much shorter duration than in a wooded habitat; the crows are more conspicuous, require a longer flying time per attack, and less often alight on the ground. They can, however, alight very easily on the ground by a nest if positioned in a nearby tree. The power of the Lapwing to rebuff invading enemies is also greatest in the air.

Enclosure of a field by higher surrounding land and an irregular gradient in the form of a hollow or hummock could both perhaps be understood as negative characteristics in terms of a resulting reduction in the visibility of breeding Lapwimgs, such that approaching enemies could no longer be sighted far in advance- thus increasing potential danger to the incubating bird, eggs and chicks.

The chief enemies of Lapwings appear to be Carrion Crows (Corvus corone), Rooks (Corvus frugilegus), Jackdaws (Corvus monedula), Magpies (Pica pica), Kestrels (Falco tinnunculus), Sparrow Hawks (Accipiter nisus), Weasels (Mustela) and Rats (Rattus) (Ennion, 1949). Peregrine Falcons (Falco peregrinus) and Sparrow Hawks take the greatest toll of adult Lapwings (Spencer, 1953). It was noted by Nicholson (1938) that Gulls- Black-Headed (Larus ridibundus) and Common (Larus canus)- frequently associated with Lapwings, have developed clepto-parasitism : forcing Lapwings to drop their food and taking it from them. Egg-sucking by Carrion Crows and Jackdaws was observed, and it was thought that Rooks might limit distribution by putting otherwise suitable areas out of bounds. No records of predator density have been taken in the present investigation, but Hildén (1965) generalises that: "species do not often nest where their predator species are abundant".

The negative influences provided by field area and roughness of the terrain in this study are difficult to interpret, and do not agree with the findings of other workers. Witherby et. al. (1940) record that the Lapwing prefers "large or medium-sized open spaces". This would support the idea of an increased unattractive 'edge effect' exerted in smaller sized fields. Klomp (1953) concluded that the species was attracted to an uneven ground surface, when in combination with a grey or brown colour of vegetation. In the fields considered here, however, not only is roughness apparently unattractive, but the colour of field remains unimportant- possibly due to its relative uniformity. In Holland a brown colour was correlated with a low ultimate height of vegetation. In Weardale, however, nesting took place in hay meadows where the grass would grow high, with no indication of reduced preference.

Although not confirmed here to any significant degree, Nicholson (1938) proposed that large herbivores would exert important indirect effects on Lapwing distribution through grazing, disturbance of nesting, and dung deposition which would provide insect food. Spencer (1953) additionally suggestet that patches of dung could constitute favourable nesting sites.

The scope of the present study has been necessarily limited by the amount of time available, being five months in all. A large proportion of time was used in attempting to accumulate sufficient data on nesting: searching for nests was time-consuming, and more information on fields and soil fauna could have been collected had this been avoided. Given a longer period of study, a comprehensive survey of nesting including hatching success could have been carried out from the beginning of the breeding season, to obtain actual nest densities and survival rates in the different breeding sites selected by Lapwings.

One possible major source of error in this work may be unreliability of the results for soil invertebrates. These animals invariably have an aggregated distribution, and at least twenty soil cores should have been taken in each field under consideration to minimise sampling variation. Nevertheless, the fact that significant results were obtained suggests this apprehension may be unjustified. Additional methods could have been employed to obtain a more representative result for all types of animal : pitfall traps would enable collection of a wider range of litter-dwelling animals and the application of formaldehyde solution would involve sampling of the earthworm population in greater detail. Klomp (1953) extracted 17-25 drill samples, 1 sq. dm x 5 cm deep, in each sample area. Surveying the soil fauna, however, is of limited value since it gives an indication of the food available to Lapwings only, not of that actually eaten. This could only be attained through an analysis of crop and stomach contents, as performed by Collinge (1924-7).

Thus the present study has re-examined the proximate factors involved in the habitat selection of the Lapwing, first formulated by Klomp (1953), and making use of a computer analysis technique to enable large numbers of fields and environmental factors to be examined quantitatively. The amount of bare ground, percentage cover of Juncus effusus, the presence of weed species and other individuals emerge as the most significant positive features, while roughness of terrain, the presence of trees , exposure to wind and enclosure by the surrounding land constitute the strongest negative influences. These findings are generally in accordance with those of previous investigators whose work has been based mainly on qualitative observations.

The mechanism behind the habitat selection reaction was originally put forward by Tinbergen (1948), and has been described by Svärdson (1949) as follows :

"The selection of habitats is a reaction where purely optical external stimuli are involved. A number of different external stimuli are added to 'internal motivation', which probably is often of hormonal origin- possibly a hormone from the neural part of the hypophysis. When summation of stimuli has reached a certain threshold, the reaction is released."

The topic of habitat selection in birds would benefit considerably from further study, possibly employing techniques similar to those used in the present investigation and increasing the sample size, standardising measurements further and obtaining more accurate information on the soil animals.

It has not been ascertained how far the conclusions reached through the present work might be applicable to areas outside the marginal hill farmland of County Durham, and comparable surveys for other habitat types such as moorland, arable land or sand dunes could be of immense value in the future. The process might be extended to cover other species of birds, and eventually modified for application to various types of wild animal.

Table 8

Summary: Comparison of Factors Affecting the Habitat Selection and Density of Lapwing, Redshank and Neither Species on Marginal Hill Farmland.(in order of significance)

REDSHANK	LAPWING		NEITHER SP.
Presence/Absence	Presence/Absence	Density	+ nor -
Area of field +	Land enclosure-	% Bare ground +	Plant spp present
Surface water +	Juncus distrib+	Juncus cover% +	Weeds-no herbicide
Habitation -	Roughness -	Area of field -	Max ht. of veg.
Gradient -	% Bare ground +	Roughness -	Colour of field
Sun exposure -	Treatment -	Trees present -	Grazing pressure
Herbivores -		Wind exposure -	No. of stone walls
Lapwings -		Unpal. weeds +	Mole hills
Roughness +		Land enclosure-	
Hayfields -		Irreg. slope -	
Average height -			

None of the factors examined for habitat selection were common to the Lapwing and the Redshank; area of the field and roughness of the ground influence both species but in opposite directions. Comparison of the two columns for the Lapwing indicates that the factors affecting whether birds select a field or not are not the same as those determining the density of birds which a chosen field will support.

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