COMPARING THE EFFICIENCY OF INSECT TRAPS

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The problem of the best method for comparing the efficiency of different insect traps does not seem to have been well studied, although it is one of considerable interest to entomologists.

In our own work the question has recently arisen of comparing three different light-traps. It is not a simple problem, as not only are there differences between the traps which one wishes to measure, but no two traps can be on the same spot at the same time : thus the simple comparison is complicated by the effects of different locations and different nights.

Our previous work on trapping insects by light, carried out for over eight years, had shown (Williams, 1937 and 1940) that the difference between catches in different nights or in different traps are of a geometric nature, and not arithmetic or additative. Thus one trap catches on an average, say, *twice as many* insects per night as another trap—not 193 *more* insects per night.

Under these circumstances it is not correct to add catches obtained under different conditions and to use either the total or the arithmetic mean for the purpose of comparison. The correct comparison is the geometric mean, and the simplest way to get this is to convert the catch per night into a logarithm. The arithmetic mean of the logs. (obtained by adding the log. values together and dividing by the number of observations) is the log. of the geometric mean catch. For example, if catches of 100, 400, 50, 200, and 2,000 were obtained on successive nights, or in different traps, the logs. would be 2·00, 2·60, 1·70, 2·30, and 3·30 ; the mean log. would be 2·38 ; and therefore the geometric mean catch would be about 240 insects. The arithmetic mean of 550 insects is quite meaningless for comparison as it is completely dominated by the single large catch. Only one night had more than this number and four had less. The geometric mean is, on the other hand, the level above and below which one gets an approximately equal number of catches.

Thus when comparing two or more traps, allowances have to be made for location, for differences between nights or other successive periods, and for geometric changes in catch.

In its simplest form, the problem would be the comparison of two traps, and most of the difficulties would be overcome by having two locations (preferably not too different or too far apart) with the traps interchanged every night ; so that in each pair of nights each trap would be once in each location. The catches are expressed in logs., and the mean log. catch in each trap after a series of repetitions would be the basis for a measure of trap differences.

Our immediate problem however concerned the comparison of three traps :—

(1) The Rothamsted Trap (see Williams, 1948), with a 200-watt ordinary electric light bulb.

(2) The same trap with a Phillip's 125-watt mercury-vapour bulb rich in ultra violet.

(3) A trap designed by H. S. and P. J. M. Robinson (1950) with a similar mercury-vapour lamp.

For completeness there should have been a fourth trap of Robinson's design with a 200-watt ordinary bulb, but unfortunately this was not available.

TABLE I.

Catch of Macrolepidoptera in each of the three light traps on 15 nights in August 1950, together with the position of the traps.

August	Trap 1		Trap 2		Trap 3	
	No.	Position	No.	Position	No.	Position
16	10	C	28	B	95	A
17	17	A	46	C	95	B
18	40	B	(100)*	A	205	C
19	20	C	87	B	137	A
20	24	A	247	C	351	B
21	27	B	195	A	1,396	C
22	18	C	216	B	482	A
23	42	A	356	C	323	B
24	35	B	148	A	421	C
25	43	C	115	B	312	A
26	13	A	157	C	156	B
27	24	B	11	A	253	C
28	31	C	66	B	109	A
30	10	A	188	C	220	B
31	15	B	22	A	671	C

*Estimated.

TABLE II.

Log, catch of Macrolepidoptera each night with three traps in three different positions changed each night: together with mean log. catch per night, mean log. catch for each trap in each position, for each trap in all three positions, and for each position with all three traps.

Position	Trap 1			Trap 2			Trap 3			Mean Log. per night
	A	B	C	A	B	C	A	B	C	
August 16			1·00		1·45		1·98			1·48
17	1·23					1·66		1·98		1·62
18		1·60		(2·00)*					2·31	1·97
19			1·30		1·94		2·14			1·79
20	1·38					2·39		2·55		2·11
21		1·43		2·29					3·15	2·29
22			1·26		2·33		2·68			2·09
23	1·62					2·55		2·51		2·23
24		1·54		2·17					2·62	2·11
25			1·63		2·06		2·49			2·06
26	1·11					2·20		2·19		1·83
27		1·38		1·04					2·40	1·61
28			1·49		1·82		2·04			1·78
30	1·00					2·27		2·34		1·87
31		1·18		1·34					2·83	1·78
Mean Log.										All Traps
Pos. A	1·27			1·77			2·27			A. 1·77
Pos. B		1·43			1·92			2·31		B. 1·89
Pos. C			1·34			2·21			2·66	C. 2·07
All Pos.	Trap 1. 1·35			Trap 2. 1·97			Trap 3. 2·41			

General Mean Log. 1·91.

*Estimated value.

Three locations A, B and C about 100 yards apart were chosen in a small piece of woodland, of about 10 acres in all, on Rothamsted Experimental Station. The direct light of each trap was invisible from the others. The three traps were placed one at each point (3 at A, 2 at B and 1 at C) on the night of the 23rd to 24th August 1950. They were then kept in the woodland for 15 nights and each successive night moved round in the order A, B, C of the locations, so that by the end of the period each trap had been five times in each location. Unfortunately trap B failed on one night in position A. An estimated value has been inserted for this night for purposes of analysis.

Table I shows the actual catch of Macrolepidoptera each night in each trap together with the position in which it was working.

Table II shows the same data converted into a logarithmic scale, together with the mean log. for each night, and for each trap and each position.

TABLE III.

Analysis of variance from the log. catches of Macrolepidoptera.

	Degrees of Freedom	Total variance	Mean variance
Nights	14	2·4009	·1715
Position	2	·6840	·3420
Traps	2	8·5081	4·2540
Error	26	1·8248	·0702
Total ...	44	13·4178	

A statistical analysis of variance is shown in Table III, from which it will be seen that the total variance (*i.e.*, sum of squares of departure from the mean) for all the 45 trap-nights, is 13·4178 ; of this, 63·4 per cent. is accounted for by the differences between the traps, only 5·1 per cent. by the differences between the positions and 17·8 per cent. by the differences between the nights, leaving a small " error " of 13·6 per cent. of the total.

There is of course no doubt of the significance of any of the differences.

TABLE IV.

Geometric mean catches of Macrolepidoptera in 3 traps in 3 positions.

Position	Trap 1	Trap 2	Trap 3	All 3 traps in position
A	19	59	186	A=59
B	27	83	204	B=78
C	22	162	457	C=117
Trap in all 3 positions	22	93	257	

Mean all traps, all positions=81

Table IV shows the mean values at the bottom of Table II converted back to numbers. From the nine central figures in this table it is easy to see that there are considerable differences between the traps and between the localities. The highest mean catch (457 moths) is in Trap 3 when in position C ; while the lowest (19) is with Trap 1 in position A.

The figures at the bottom of Tables II and IV give the mean catch for each trap in all three positions (an equal number of times in each), while the figures at the right are the mean catch in each locality (each trap represented an equal number of times).

It will be seen that the geometric mean catches per night for all Macrolepidoptera in the three different locations were 59, 78 and 117. It is curious to note that the poorest location was in a " riding ", while the best was almost completely covered and enclosed by trees and bushes. Ridings are usually considered by collectors to be more favourable locations.

The comparison of the traps showed that while the average night catch for all Macrolepidoptera in Trap 1 was 22 moths, the same trap with ultra-violet light captured 93 and Robinson's trap 257. This is a ratio of 10 : 42 : 117.

Similar analyses gave the following values for separate sections of the Lepidoptera :—

	Trap 1	Trap 2	Trap 3
Geometridae only	2·5 (10)	6 (24)	10 (40)
Amathes c-nigrum (L.) only	14 (10)	60 (43)	200 (143)
Noctuidae excluding *A. c-nigrum* (L.)	6·2 (10)	26 (42)	58 (94)

Thus the greatest relative difference is in the catches of *A. c-nigrum* (which was the dominant species and accounted for 5,976 out of a total of 7,242 Noctuidae) ; and the least difference was in the Geometridae, which were however not numerous and only 421 were captured in all three traps during the period.

The greatest numerical difference however appeared to be in the Noctuid moths generally designated by the name of " yellow underwings ", of which the catches in the three traps were as follows. Arithmetic totals are used here as there were too many days with zero catches to make the log. transformation reliable.

	Trap 1	Trap 2	Trap 3
Triphaena pronuba (L.)	2	112	211
Triphaena comes (Hb.)	0	22	24
Triphaena ianthina (Schiff.)	0	1	7
Lampra fimbriata (Schreber)	0	5	2
Total ...	2	140	244

Only one species showed a definite location difference, and this was the Noctuid moth *Cerapteryx graminis* (L.). Ninety-two individuals of this were caught, and all except two were in location "C" whatever trap was there. The numbers in the three traps were 8, 33 and 51. A somewhat similar distribution of this species was noted in July 1949 (French, 1951) when six Rothamsted traps were used for one month in the same woodland.

Summary.

An experiment is described in which three light traps were tested for relative efficiency by having three locations in a wood and moving the traps each day so that over a period of three nights each trap had been once in each position. The actual number of moths caught were converted to a logarithmic scale and the mean log.

(*i.e.*, log. of the geometric mean catch) was used for comparison. By analysis of variance it is possible to show what portion of the differences between the catches is due to the difference between the locations, to the difference between the nights, and the difference between the traps.

References.

French, R. A. (1951). Lepidoptera at light in a Hertfordshire wood in July, 1949.—Entomologist, **84,** pp. 49–55.

Robinson, H. S. & Robinson, P. J. M. (1950). Some notes on the observed behaviour of Lepidoptera in flight in the vicinity of light-sources together with a description of a light-trap designed to take entomological samples.—Ent. Gaz., **1,** pp. 3–20.

Williams, C. B. (1937). The use of logarithms in the interpretation of certain entomological problems.—Ann. appl. Biol., **24,** pp. 404–414.

Williams, C. B. (1940). An analysis of four years captures of insects in a light trap. Part II.—Trans. R. ent. Soc. Lond., **90,** pp. 227–306.

Williams, C. B. (1948). The Rothamsted light trap.—Proc. R. ent. Soc. Lond., (A) **23,** pp. 80–85.