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Yasumatsu, Keizo

Entomological Laboratory, Department of Agriculture, Kyushu University

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REARING OF FLEA LARVAE ON VARIOUS DIETS*

KEIZŌ YASUMATSU

As regards the rearing of fleas, a considerable amount of general information has been accumulated during the past 250 years. But knowledge is scarce particularly about the kind of food used by flea larvae. The following is a review of diets of flea larvae which were used by various authors.

Cestone, J., 1699: the bran-like substance which sticks in the combs when puppies are combed to take out the fleas.

Strickland, C., 1913: refuse from rat cages consisting mainly of dried grain, excreta, gravel, straw, etc. ("rubbish").

Bacot, A. W., 1914: the faeces of the adult flea or anal discharges.

Bacot, A. W. and W. G. Ridewood, 1914: organic matter in the lair of the host, on the dust that collects on the ground in its proximity and the excreta of the adult flea or particles of dried blood.

Bishop, F. C., 1915: partly of blood voided by the adult and partly of particles of animal or vegetable origin.

Lyon, H., 1915: floor sweepings and dried blood.

Illingworth, J. F., 1915: dried blood particles in the dust and the excreta of the adult flea.

Sikes, E. K., 1930: dried blood (human or rabbit) ground up finely.

Sikes, E. K., 1931: dried blood, nest material, flea faeces, albumen.

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Leeson, H. S., 1932: finely ground dried ox-liver.

Hopkins, G. H. E., 1935: unsterilised bran or maize meal with a pinch of dried ox-blood.

Yasumatsu, K., 1946: dust under the Japanese "Tatami".

The foregoing papers present considerable information on diets of flea larvae; but only Sikes' (1931) work studies the effect of various diets upon the growth of flea larvae. The chief object of the present experiments was to make a preliminary study of the growth-rate of flea larvae on various diets in order to determine the more convenient or economic diets which may be used easily in rearing experiments.

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MATERIAL AND METHOD

The fleas, *Ceratophyllus cheopis* Rothschild, were bred in the laboratory on a rat. The rat was combed carefully and given sterilised bedding, before being provided with identified specimens of *C. cheopis*. Samples of adult fleas were taken frequently from the bed of the rat and identified to make sure that the culture remained pure. Pregnant female fleas were taken from the bed and put in a small glass cylinder placed on black paper. The fleas were left in this for 24 hours, and then returned to the rat, a supply of eggs having been laid in the meantime. The eggs were easy to see and count on black paper. From these eggs 0 to 24 hours old flea larvae were easily collected. In all cases 0 to 24 hours old unfed larvae were used in the present experiments. The flea larvae were bred in glass bottles which were previously provided with sawdust and the following diets, and only those which reached adult stage were counted. The experiments were carried out at room temperature and humidity, but both seemed to make little difference to the survival of the larvae, only affecting the rate of development so far as the present experiments were concerned.

1. Flour of miscellaneous cereals and beans (A).
2. Excrements of silk-worms, dried and powdered (B).
3. Silk-worm pupae, dried and powdered (C).
4. Ox-liver, dried and powdered (L).
5. Excrements of rats, dried and powdered (M).
6. Bran of rice (N).
7. Ox-blood, dried and powdered (bl).
8. Haemoglobin (H).
9. Dust under the Japanese "Tatami" or dust on the floor (D).
10. Lactose, vitamins A, B, C, D and liver-oil (powdered) (K).

RESULTS AND CONSIDERATIONS

In order to determine whether dietary reaction would produce a differential effect upon the growth of flea larvae, experiments were conducted in which 721 0 to 24 hours old larvae were reared to maturity on diets of different types. Larvae were supplied with abundance of diets for food. The results of all experiments are summarised in tables 1 to 3.

Table 1. Effect of breeding flea larvae on various diets at room temperature and humidity. Cases fed on single diets.

Diets	Newly hatched larvae used	Larvae which reached adult stage	Larvae which reached adult stage (%)
A	30	11	36.7
B	30	0	0.0
bl	14	4	28.6
C	20	5	25.0
D	25	23	92.0
H	20	0	0.0
K	20	0	0.0
L	20	0	0.0
M	20	19	95.0

Table 2. Effect of breeding flea larvae on various diets at room temperature and humidity. Cases fed on two mixed diets.

Diets	Newly hatched larvae used	Larvae which reached adult stage	Larvae which reached adult stage (%)
A + B	30	11	36.7
A + bl	32	31	96.9
A + C	30	14	46.7

A + K	20	6	30.0
A + L	20	0	0.0
A + M	20	15	75.0
A + N	20	5	25.0
B + bl	30	18	60.0
B + C	30	11	36.7
B + L	30	0	0.0
bl + C	20	7	28.6
bl + K	20	1	5.0
bl + L	20	1	5.0
bl + M	20	0	0.0
bl + N	20	0	0.0
C + K	20	3	15.0
C + M	20	18	90.0
C + N	20	0	0.0
K + M	20	0	0.0
K + N	20	0	0.0
L + M	20	15	75.0
L + N	20	0	0.0
M + N	20	14	70.0

Table 3. Effect of breeding flea larvae on various diets at room temperature and humidity.

Diets	Duration of larval and pupal periods taken together in days			Mean relative humidity	Mean temperature (°C)
	Minimum	Maximum	Average		
A	33	81	43.3	82.7	26.0
A + B	38	126	93.2	82.8	22.6
A + C	33	48	36.0	82.5	26.5
A + bl	20	78	30.9	81.3	26.1
B + bl	23	125	31.2	81.0	26.1
B + C	34	93	44.2	82.7	25.7
D	22	40	27.3	81.2	26.9
A + K	46	91	75.8	81.8	17.1
A + M	39	88	51.2	82.3	18.5
A + N	62	98	74.0	80.9	16.8
bl	63	67	64.0	82.0	19.1
bl + C	49	99	73.5	81.9	17.1
bl + K			82.0	80.8	17.6
bl + L			49.0	83.6	20.4
C	88	94	89.2	79.8	15.5
C + K	50	51	50.3	83.5	15.5
C + M	39	50	41.8	83.8	19.6
L + M	40	65	46.1	83.5	19.3
M	40	66	45.6	83.7	19.3
M + N	24	77	49.1	81.1	17.0

Table 4. Effect of breeding flea larvae on various foods at 80 and 90

(*) percentages of relative humidity (Temperature 21°C)

(Selected from E. K. Sikes, 1931)

Diets	Newly hatched larvae used	Larvae which reached adult stage	Larvae which reached adult stage (%)
* Rabbit blood	27	15	55.6
Rabbit blood and sand 1	25	17	68.0
Rabbit blood on cloth 1	25	15	60.0
* Rat blood and sand	16	9	56.3
* Human blood on cloth	25	13	52.0
Flea faeces and sand	25	15	60.0
Flea faeces on cloth 1	25	18	72.0

The present experiments indicate clearly that there are great differences in the percentage of flea larvae which reached adult stage among nine kinds of a single diet and twenty-three kinds of mixed diets. It is of interest to contrast the present results with those of similar experiments made by Sikes in 1931 (see table 4). The relatively better development of larvae and pupae, as shown by the percentage reaching the adult stage, on diets of dust under the Japanese "Tatami", or dust on the floor, or excrements of rats (dried and powdered) shows that such single diets are clearly sufficient and satisfactory for this flea. On the other hand, the relatively poor development or high mortality of larvae and pupae fed on other single diets, as well as on a number of mixed ones, indicate that even the ox-liver and blood, hitherto known as the best diets, are not as good for the post-embryonic growth of flea larvae as the single diets mentioned above. The duration of larval and pupal periods taken together, from the time of hatching from the egg to the emergence of the adult, seems to vary greatly with the kind of diet. The duration varies greatly both in the minimum and maximum number of days taken to complete the larval and pupal stages; but only the minimum number of days is most significant in the determination of dietary reaction upon the growth of flea larvae and pupae. Therefore there is a certain parallelism between the duration of the larval and pupal periods and the percentage of larvae which reach the adult stage. The experiments show that the best results are obtained in breeding flea larvae with dust under the Japanese "Tatami" or dust on the floor and excrements of ex-

crements of rats, dried and powdered. From the present experiments I would emphasize the dust and excrements of rats are the most convenient and economic diets which may be used everywhere easily in rearing experiments.

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