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Egg Output of Different Populations of *Leposcelis bostrychophila* (Liposcelidae: Psocoptera)*

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Abstract.- *Liposcelis bostrychophila*, a psocopteran species, is parthenogenetic in reproduction. At two different temperatures, the egg output of *L. bostrychophila* was studied. Significant variation in fecundity was found between populations at these two temperatures. Some of the populations were observed to have higher egg production at lower temperature (20°C) than higher temperature (30°C), showing the possibility of survival of best fit genotypes of this tropical species in the temperate regions.

Key words: *Lepioscelis bostrychophila*, population variation, egg output, 20°C and 30°C temperature.

INTRODUCTION

In a few decades time, *Liposcelis bostrychophila* commonly known as book louse has established itself in domestic environment in a vast variety of stored food products in the UK and other European countries (Turner, 1986, 1987, 1988; Turner and Ali, 1996). One of the many reasons for this small insect to be so widely distributed is of its being a parthenogenetic species. The reproductive potential of *L. bostrychophila* is far greater than that of bisexual species of the same genus. Once the adult emerges, egg production starts within a few days. The whole of the adult life is devoted solely to feeding and reproduction. In optimum conditions, it produces about 100 eggs in the life span of about six months.

Relatively little work has been done on the effect of temperature on the fecundity of this species. Broadhead and Hobby (1944) studied the effect of different foods upon growth, longevity and reproductive rate under controlled conditions of temperature (25°C) and relative humidity (76%). They reported the average total number of eggs laid by an adult *L. bostrychophila* to be 212 on a yeast diet and 178 when fed on whole meal flour. While studying the effect of different environmental conditions on *L. divinatorius* (which may be *L. bostrychophila*), Ghani and Sweetman (1951) recorded a maximum of 240 eggs laid by a female in her lifetime at 30°C.

Turner and Ali (1993) reported some initial findings of their study of population variation in *L. bostrychophila*. They observed significant differences in the egg output of several populations of this species at different temperatures. This paper describes the results of the study of egg output and adult mortality at two temperatures, 20°C and 30°C in different populations of *L. bostrychophila*. Eggs are laid only in the temperature range of 18°C to 35°C (Turner, 1994) therefore, 20°C and 30°C were selected. The duration of study was limited to the first six weeks of adult life, the period that covers the maximum egg production.

MATERIALS AND METHODS

Egg laying was studied in 17 populations at 20°C and 18 populations at 30°C. These populations included British populations (including a laboratory population) and four populations belonging to tropical regions, two from Thailand and one each from Indonesia and Ethiopia established in the laboratory on standard food and other environmental conditions (Ali and Turner, 1999).

Acquisition of Liposcelis *eggs*

Adult psocids (100-150) from the stock cultures were placed in separate vials containing no food and 3-4 small pieces of black filter paper. They were kept in an incubator at 30°C and 75% relative humidity. After 24 hours, adults were returned to their respective cultures while the filter paper strips were examined for the presence of eggs.

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The eggs from each population were divided into two sets and kept at different temperatures, 20°C and 30°C, while the relative humidity remained the same at 75%. The sets were regularly examined until adulthood (change in colour of individuals from light to dark brown is considered as attainment of adult hood).

Egg output and adult mortality

Synchronous series of individuals from different populations at two temperatures were kept separately in small vials. Small pieces of "Benchcote" paper, with food glued on the smooth plastic side, were added each to the vials. Eggs were laid mostly on the rough surface of paper. This character can be used to advantage if the paper used has one side rough and the other smooth; almost all the eggs are laid on the rough side of the paper. The papers and vials were examined thoroughly under a microscopet (Magnification 40x) each week for the presence of eggs and dead individuals. New food strips were provided weekly.

RESULTS

Oviposition in individuals drawn from a number of British and tropical *Liposcelis* populations (as two temperatures, 20°C and 30°C) was studied during the first 6 weeks of adult life. For each population a cohort of 12-16 individuals were followed.

Egg output at 20°C

Table I presents data on the egg laying of individuals from different British and tropical populations at 20°C. The variation in individual egg output within and between populations was considerable.

Table I also shows the percent mortality and average egg production of populations at 20°C. Populations numbers 90 and 126, which had high percent mortality (62% and 50% respectively) had low average egg outputs (4.63, 11.8 eggs per individual per 6 weeks). On the other hand, populations numbers 3 and 10, with low percent mortality 6.66% had high average egg output (35, 34.8 eggs per individual per 6 weeks). Some populations (numbers 21, 35) were found not to follow the general rule having, low percent mortality (13.33%, 0.00%) and low average egg production as well (5.8, 10.9 eggs per individual per 6 weeks).

Egg output at 30°C

Table II presents data on the egg laying of individuals, drawn from different populations, at 30°C. Considerable variation was observed within and between populations, as can be seen from the range and standard deviation figures. Interestingly, some populations (*e.g*., population numbers 21, 126, 32) had a very low egg production at 30°C, particularly population number 32, the average egg production of which was only 3.20 eggs in 6 weeks at this temperature.

As for as the percent mortality is concerned, in general, individuals in populations (*e.g.* numbers, 3, 16, 18) with low mortality (20%, 13.3%) had high average egg production (78.6%, 74.2%, 66.13%) and populations (*e.g.* numbers 126, 21) with high mortality (46.7%) had low average egg production (14.07 and 14.33, respectively). There were some exceptions. Populations number 8 had high mortality (33.3%) as well as a high average egg production (61.13) per individual, whilst population number 32 had a low mortality (13.3%) and a low average egg production (3.20). The tropical populations showed considerable variation in their mortality levels for the 6 weeks period ranging from 13.3% and 46.7% and average egg output per individual in the range 23.71 to 50.93 for the first 6 weeks of adult life.

Populations of tropical origin might be expected to perform better at 30°C than native British populations, but this was not evident on the population basis, however, on an individual basis the population from Indonesia had the highest oviposition rate; with one individual producing 34 eggs in a week, almost five eggs per day. That individual only produced 6 eggs in the following week. Peak production in all tropical populations was attained in the second week and all of them showed an increase in egg output again after the decline.

Variation between populations

Figure 1 shows the average egg output of

Liposcelis bostrychophila populations at 20°C and 30°C. The obvious variation between populations, (the founder individuals coming from both Britain and the tropics) are clear from the difference in the average egg output at both the temperatures. The individual average egg output ranged from 4.63 to 35.27 for the 6 weeks period at 20°C. The tropical populations showed a smaller range from 6.87 to 16.75.

Fig. 1.Average egg production per individual during the first 6 weeks of adult life in different populations of *L. bostrychophila* at two temperature. The error bars are ± SD.

There was also a significant variation in egg output between these population at 30°C, some (*e.g.* populations numbers 3, 16, 18) and a higher egg production (66.13, 78.67 and 74.20 mean individual egg production respectively in 6 weeks) than others (*e.g.* numbers 21, 32, 126) with (14.33, 3.20 and 14.07 mean individual egg production respectively in 6 weeks) (Fig. 1).

In order to test the significance of the differences between temperatures and populations, an analysis of variance was performed on the data. Table III shows the ANOVA output. Collectively F values were significant for both variables, temperature and population, and the population temperature interaction. Overall egg production differed significantly between 20°C and 30°C. At any one temperature there were significant differences between populations. These differences were also influenced by temperature. Whether the populations were from the UK or the tropics was not a significant variable. However, the interaction between tropical populations and temperature was different from that of British populations.

Comparison of results at two temperatures

Figure 2 shows the average total individual egg production of populations at 30°C plotted against that for 20°C. According to the Q10 rule of vant' Hoff and Arrhenius one would expect egg production at 30°C to be about double than that at 20°C, therefore, all the values should be on or near the 45° line: (Q10=2) (Wigglesworth, 1967).

Fig. 2. Average egg production by different population of *L. bostrychophila* at 30°C plotted against 20°C. See text for the explanation of the highlighted points.

Table I.- Egg production and mortality data of cohorts of *L. hostrychophila* populations at 20°C.

Population number	Number of individuals	Average egg production in 6 weeks	1 standard deviation of mean	Range of egg production in 6 weeks	Percent motality in 6 weeks
1	13	31.69	4.97	23-39	13.33
2	15	10.47	7.55	2-32	13.33
3	15	35.27	8.23	22-49	6.66
8	14	20.93	8.07	9-37	13.33
10	15	34.80	10.62	11-55	6.66
21	15	5.80	5.21	0-17	13.33
32	15	10.20	7.45	1-25	33.33
35	16	10.94	5.70	4-22	0.00
38	16	15.81	7.99	2-31	12.5
83	15	10.73	4.35	2-16	26.67
90	16	4.63	4.47	0-15	62.5
126	14	11.88	4.98	2-19	50
Lab. culture	15	9.63	6.74	0-26	18.75
Chiang Mai	16	7.38	4.43	0-16	43.75
Ethiopia	16	6.87	6.20	0-24	26.67
Indonesia	16	16.75	4.60	10-30	6.66
Thailand	16	11.56	4.79	4-19	0.00

Table II.- Egg production and mortality data of cohorts of *L. hostrychophila* populations at 30°C.

Population number	Number of individuals	Average egg production in 6 weeks	1 standard deviation of mean	Range of egg production in 6 weeks	Percent motality in 6 weeks
1	14	60.20	19.67	23-101	26.7
2	14	51.27	19.73	18-92	26.7
3	14	66.13	21.28	13-93	20.0
8	14	61.13	18.30	32-96	33.3
10	14	61.20	27.49	18-103	20.0
16	14	78.67	24.07	15-100	13.3
18	14	74.20	17.08	40-99	13.3
21	14	14.33	9.01	3-33	46.7
32	14	3.20	2.88	0-9	13.3
38	12	24.00	18.17	5-61	20.0
83	14	30.53	9.63	16-45	20.0
90	12	52.33	19.30	28-83	60.0
126	14	14.07	9.13	0-37	46.7
Lab. culture	14	45.00	24.85	9-96	33.3
Chiang Mai	14	45.27	23.38	2-92	26.7
Ethiopia	14	50.93	26.37	0-81	13.3
Indonesia	14	69.27	20.19	37-106	0.0
Thailand	14	23.71	14.93	2-48	46.7

Some of the populations (*e.g.* numbers 3, 10, 1) were “high output conformers” lying on the upper end on the Q10=2 line, *i.e.* with high production at both temperatures. Others were “low output conformers” (*e.g.,* populations numbers 21, 38, 83). In the upper left of the graph (circled) there were a group of “high temperature, non-conformers” (*e.g.* population numbers 2, 8, 90) having high egg output at 30°C but lower than expected production at 20°C. Population number 32 (arrowed) is a “low

Table III.- ANOVA table of the egg output of 16 populations at two temperatures. The analysis identifies the variation attributable to temperature, population and interaction between these two. In the lower part of the table the effects of temperature and origin (whether the populations are from the UK or elsewhere (variable labeled tropical) are shown.

	DF	Seq. SS	Adj. SS	Adj. SM	F	P
Temperature	1	79481.6	40778.1	40778.1	210.32	0.000
Population	16	92587.2	93287.1	5830.4	30.07	0.000
Temperature population	16	38099.8	38099.8	2381.2	12.28	0.000
Origin	1	154	212	212	0.47	0.492
Temperature origin	1	5295	5295	5295	11.83	0.001

Fig. 3. Egg output and % mortality in cohorts of *L. bostrychophila* population at two temperatures. Egg output is measured as mean number of eggs per individual per six weeks. Mortality relates to deaths in the cohorts.

temperature non-conformer" with an egg output that was low at both temperatures but it was even lower at 30°C than 20°C.

Only one tropical population from Thailand was found to be a "conformer" with mean egg output at 30°C (23.71) double than at 20°C (11.56). The other three, Indonesia, Ethiopia, and Chiang Mai populations were "high temperature, non-conformers" with high average individual egg output at 30°C (69.27, 50.93, 45.27, respectively) but lower than expected values at 20°C (16.75, 6.87, 7.38 respectively). The laboratory population was also among the "high temperature, non conformers" with an average individual egg production of 45 at 30°C and 9.63 at 20°C.

Figure 3 shows the relationship between percentage mortality and average egg production at 30°C (Spearman Rank correlation r = -0.438, P<0.05) at 20°C (r = -0.594, P<0.05). In general the average egg output decreased with the increase of percentage mortality. Percent mortality of adults gradually increased at both temperatures. Three tropical populations had higher percentage mortality at 20°C while one (Thailand) had lower percentage mortality at 20°C than 30°C. All the British populations except four populations (numbers 32, 83, 90, 126) had higher mortality at 30°C than 20°C. Three of the four populations (numbers 32, 83, 126) had low egg output at both the temperatures, whilst population number 90 suffered the highest mortality at both temperatures and was a high temperature non-conformer.

DISCUSSION

L. bostrychophila populations clearly vary from each other in egg production. Being considered to be of tropical origin the egg laying potential of some *L. bostrychophila* populations was remarkable in this temperate region. Many individuals produced more than 1 egg per day at 20°C and four eggs at 30°C. A maximum of 125 eggs at 30°C in lifetime of a single female was observed that is in agreement with the total egg production reported by Turner (1994).

The study of egg output at two temperatures, showed considerable variation between populations. Some populations were found to be more successful at 20°C than others. One particular population had an oviposition rate higher at 20°C than that of 30°C. The explanation for this trend may be that those populations have been in Britain for a long time. Generally mortality increases with increase of temperature (Ghani and Sweetman, 1951; Spieksma and Smits, 1975; Rees and Walker, 1990 and Turner, 1994). All these studies were made on temperate populations. In the present study most of the tropical populations had higher percentage mortality (with comparatively low egg output) at cooler temperature. Some of the British populations showed the same features suggesting they may be recent immigrants from the tropics.

According to White (1973) natural selection may possibly tend to favour genotypes that are specially plastic phenotypically in the case of pathogenetic population explaining genetic polymorphism by physiological adaptations. As reported earlier (Ali, 1999), egg production correlates with the size of the individual in this species. Variation in the egg production of *L. bostrychophila* may be genetic. Genetic variation in pest species is very important in insects (Bush and Hoy, 1983). The ability of this tropical species to become more widely spread in the cooler environment of the UK may depend very much on this variation. It is also reported by Turner and Maud-Roxby (1988) that this species survives in adverse conditions of food scarcity and low temperature indicating the possibility of best fit genotypes.

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