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A STUDY ON SOME ASPECTS OF AGEING IN *ACARUS SIRO* L. (*ACARINA: ACARIDAE*)

(Ekol. Pol. 21: 173—184). Experimental data revealed that the fecundity of young parents of *Acarus siro* L. (measured by the number of all atages: adults, nymphs and larvae) was higher than the fecundity of older mites. The effect of age of one sex upon the fecundity was independent on the age of the opposite sex. The contents of lipids and proteins in the diet showed no effect on the longevity. Rye germ with minerals and vitamins increased the longevity of both sexes. Females lived significantly longer when fed some of the best foods: yeast, casein, hazel nut, synthetic diet, whereas males lived longer on rye germ and the synthetic diet fortified with rye germ. The respiration rate ($\mu l \times 10^{-3} \times \mu g^{-1} \times hr^{-1}$) of females was higher than that of males regardless of age. With ageing of mites the respiration rate of females was lower than that of males.

1. INTRODUCTION

Results of studies conducted previously on ageing in animals consider mainly insects and mammals. Mites, especially acarids, offer an unusually well suited material for such experiments. Their small size, short life span and availability of large numbers are advantageous attributes.

Effect of parental age upon reproductive potential of mating pairs has been determined for several insect species (Clark and Rockstein 1964). Older females lay smaller numbers of eggs having a lower percentage of viability than those from young mothers. Parental age also affects the life-cycle. As

parental age of *Drosophila melanogaster* (Meig.) increases, longevity of the adult stage of the offspring decreases more so in the females than in the males (Butz and Hayden 1962). Per cent hatchability of eggs of the mealworm, *Tenebrio molitor* L., decreased with an increase in parental age. Larvae from young parents grew at a slower rate than those from the same parents after they had aged (Ludwig and Fiore 1960). Offspring from middle aged or from old parents of *Drosophila melanogaster* had a shorter life span than that of the parental generation (O'Brian 1961). A similar dependence was found with *Tenebrio molitor*, but did not appear in experiments with offspring from isolated pairs (Ludwig and Fiore 1961).

Either males or females may live longer and they may have different nutritional requirements. The virginity of females reduces fecundity but ensures longer survival (Bilewicz 1953).

Besides parental age, temperature and nutrition are important factors in modifying the life span of insects. The amount of protein consumed daily by adult cockroaches seems to be inversely correlated with the longevity of the individual; those consuming more protein had shorter life spans (Haydak 1953). The average longevity of house fly females was increased from about 20 to 32 days by addition of powdered whole milk to the basic diet of sugar and water (Rockstein 1957).

The life span of adult acarid mites has been studied for few species. According to Jakubowska (1971) the longevity of *Acarus farris* (Oud.) adults was highly dependent upon food, temperature and relative humidity. Females feeding on wheat germ lived 13 days while males lived 16 days; on yeast they lived 21 and 32 days, respectively. Increase of temperature from 8 to 30°C decreased the life span of females from 97 to 13 days, and of males from 135 to 19 days.

The life span of males of *Acarus siro* L. was shorter. Increase in temperature from 18 to 28°C caused the life span of females to decrease from 51 to 30 days. Virgin females lived 32 days at 18–20°C and 80% RH (relative humidity) (Boczek 1957).

Tyrophagus putrescentiae (Schr.) was studied thoroughly by Gołębiowska (1963). She found that an increase in temperature from 9 to 31°C shortened the life span of this species from 115 to 43 days. The longest life span was observed in females on powdered milk, and in males on wheat germs. Under the same conditions adults lived on wheat germ 63 days, rye germ 99 days, on powdered milk 75 days and on oat flakes – 25 days. Males usually lived slightly longer.

According to the studies of Rivard (1959) adults of *Tyrophagus castellani* (Hirst) reared on *Aspergillus* sp. lived 43 days (70% RH) to 28 days (100% RH).

Adults of *Carpoglyphus lactis* (L.) reared at 25°C and at 85% RH lived 20 days on yeast and 65 days on dried plums. Increase in temperature from 0–3 to 30°C shortened the life span from 179 to 11 days. An increase in RH from 70 to 96% caused the life span to increase from 19 to 29 days. Males of this species lived a slightly shorter time (Chmielewski 1969).

I. Bielska (unpublished data) found marked differences in the life spans of *Rhizoglyphus echinopus* (F. et R.) and *R. robini* Clap. Adults of *R. echinopus* lived, at 100% RH, longer on yeast (80 days) than on rye germs (71 days), but the results were just the opposite at lower humidities. At 94% RH, they lived 75 days on yeast and on rye germs the longest of all, 94 days. The longest life span for *R. robini* was 106 days on yeast and only 63 days on rye germs.

The following observations on ageing of *Acarus siro* were made in this work: (1) effect of parental age upon the size and age structure of the offspring population, (2) effect of parental age upon the life span of the offspring, (3) effect of food upon the longevity of the males and females, (4) oxygen uptake of males and females of various ages.

2. MATERIALS AND METHODS

2.1. Effect of parental age upon the size and age structure of the offspring population

The mites were kept at 25°C. The experiments consisted of two parts. The first part, conducted at 85% RH, consisted of two combinations: (a) young females and males (Y Y), (b) 25-day old females and males (M M). In each combination mites were reared in two 25-cm^3 Erlenmeyer flasks, each containing 3.5 g of rye germs and 25 pairs. After 23 days the contents of the flasks (after anaesthesia with ethyl ether) were mixed thoroughly, weighed and 8 samples were taken, of 100 mg each. In these samples all eggs, larvae and nymphs, females and males were counted. Numbers of mites were then estimated for the whole.

In the second part (at 81% RH) mites were reared in special rearing cages and 5 combinations were established: (a) young females and males, directly after hatching (Y Y), (b) young females and 25-day old males (Y M), (c) 25-day old females and young males (M Y), (d) 25-day old females and 25-day old males (M M), (e) 35-day old females and young males (O M).

In each combination 5 rearing cages were used, each containing about 100 mg of rye germs (total 500 mg). Into each cage 10 females and 10 males were placed. After 23 days the rye germs with the mites from the five cages were mixed together, anaesthetized and 4 samples, of 50 mg each, were taken.

In these samples all eggs, larvae, nymphs, females and males were counted (total for 200 mg, meaning in about 40% of the medium). The number of mites was then estimated for the entire contents (about 500 mg).

Young adults were obtained by isolating one day resting deutonymphs in separate cages, and by then transferring the hatched adults to rearing cages (or Erlenmeyer flasks) containing rye germs the following day using a needle. Ageing virgin adults were obtained by keeping freshly hatched adults in separate cages on rye germs for 25 or 35 days.

2.2. The effect of parental age on the life span of offspring

Two sets of observations were conducted (at 22°C and 85% RH): (a) longevity of females and males originating from young parents, (b) longevity of females and males originating from 25-day old parents. Five males or five females were kept separately in rearing cages with rye germs.

2.3. Effect of food upon the longevity

Mites were kept in the rearing cages at 25°C and 81% RH. Longevity was checked in each combination for 25 females and 25 males. Adult mites originating from isolated resting deutonymphs were placed in the cages.

In consecutive cages 5 virgin males or 5 virgin females were kept separately. Foods used and their composition are presented in Table I.

Composition of foods (%)

Tab. I

Food	Proteins	Fats	Carbohydrates
Rye germs	42.0	11.2	26.0
Yeast	46.0	1.6	13.0
Casein	98.0	1.5	0.0
Hazel nuts	7.2	33.0	5.5
Marrow	3.2	89.9	0.0
Dried apple	1.4	1.0	73.2
Dried cod	15.9	0.3	0.0
Suet	2.0	93.0	0.0
Mushroom (*Boletus edulis* Bull.), dried	36.7	2.7	41.4
Synthetic diet*	8.0	0.1	8.0
Semisynthetic diet**	11.0	0.8	10.0

*In 100 g: casein 8 g, saccharose 8 g, agar-agar 3 g, vitamins, Wesson's salts, antibiotics and antimicrobial agents, water. **In 100 g: casein 8 g, rye germs 7 g, saccharose 8 g, agar-agar 3 g, vitamins, Wesson's salts, antibiotics and antimicrobial agents, water.

2.4. Oxygen uptake of females of various ages

Respiration was measured using the Cartesian divers' method. Virgin females of 1, 20 and 30 days of age were used. In each case the measurement was taken for 10 females. A microscale (Ventron Instrument Corp., California) was used for weighing the animals.

Results were evaluated statistically using Fisher's analysis of variance, one- and two-way classification. To evaluate the significance of differences *F*-Snedecor and *t*-Duncan tests were used, at the 5 and 1% level of probability. Data dealing with the life span of mites were made with values transformed according to the formula $y = x$, where x is the life span of the specimen in days.

3. RESULTS

3.1. Effect of parental age upon the size and age structure of the offspring population

Data presented in Table II represent the means of four replicates of consecutive developmental stages which are the offspring produced by then parental pairs during 23 days.

Age structure of the offspring as related to the age of parents*

Tab. II

Combinations ♀ ♂	Offspring				
	eggs	larvae and nymphs	adults	females (%)	total
Y Y	3879.8 c_1	8174.5 c	1468.3 d	48.68 a_3	13522.8 c
Y M	3531.5 b_2, c_2	6238.3 b_2	1115.0 c	47.98 a_2	10884.8 b_2
M Y	3936.5 c_2	5753.3 b_1	834.5 b	53.70 a_5	10523.8 b_1
M M	3031.3 b_1	3859.8 a_1	404.8 a_1	50.70 a_4	7296.0 a_2
O Y	1365.0 a	4840.0 a_2, b_1	514.0 a_2	47.93 a_1	6719.5 a_1

*Data followed by different letters (a-c) are significantly different at the 5% level of probability. For the explanation of Y, M and O see the text (Section 2.1).

It can be seen from the Table II that the greatest differences between the combinations occurred in numbers of adults and the smallest, statistically insignificant, in the percentual ratio of females. Apart from the female percentage it is seen that in combinations M M and O M there were the fewest adults,

larvae and nymphs and total number of mites and of eggs. The most numerous, besides the eggs, was the offspring from young females and young males (Y Y).

The differences between Y M and M Y were usually not distinct but in the combination Y M larger numbers of larvae and nymphs, imagines and of total numbers of offspring were found. Only the number of eggs was higher in combination M Y than in Y M.

In Table III the effect of youth of the parental females (x_1) and of the males (x_2) and differences between them in numbers of consecutive stages are presented. This data allowed for an evaluation of the influence of young age of the parental females and males and to check if each of them was dependent on age and upon the other sex.

The effect of parental youth on the age structure of the offspring

Tab. III

Offspring	Parents						
	temales			males			difference (x_1-x_2)
	young	old	x_1	young	old	x_2	
Eggs	3705.6	3483.9	221.7	3908.1	3281.4	626.7**	405.0
Larvae and nymphs	7206.4	4806.5	2399.9**	6963.9	5049.0	1914.9**	485.0
Adults	1291.6	619.6	672.0**	1151.4	759.9	391.5**	280.5**
Females (%)	48.33	52.20	-3.87*	51.19	49.34	1.85	2.02
All mites, total	12203.8	8909.9	3293.9**	12023.3	9090.4	2932.9**	361.0

*Significantly different at the 5% level of probability. **Significantly different at the 1% level of probability. For the explanation of x_1 and x_2 see the text (Section 3.1).

Data in Table III represent the means for the age of each sex. Means for females are estimated as averages for young and for 25-day old males and in opposite, that is, means for males are averages for both groups of females. Differences between x_1 and x_2 can be considered as the effects of young age. Analysis of variance showed its high significance.

The data of Table III show that in all cases (with the exception of sex ratio) young age of the parental females and males favours increase of the population. This effect of young parental age was very distinct and only in the case of females and eggs was the difference insignificant. The concurrence of age of females and of males proved to be insignificant. Hence, it is suggested that the average effect of the age of one sex was independent of the other sex. In other words, effects of x_1 deal both with young and with 25-day old males and the effects of x_2 deal with young and middle-age females. For adults $x_1 = 672.0$. This means that 10 young females produced after 23 days in their

offspring by 672 more adults than middle-age females, independently on the age of males. x_2 for adults is 391.5. This means that 10 young males caused the production after 23 days in their offspring by 391.5 more adults than middle-age males independently on the age of females.

Comparing the effects of young age of males and females (difference $x_1 - x_2$) it is found that a significant difference occurred only for adults. In this case the effect of young parental females (x_1) was significantly higher than the effect of young males (x_2). For other stages the effect of young age of parents was similar; differences between these data were within limits of experimental error.

Using the variance of error of the above experiment the standard error was estimated and using the Student *t*-test the means of the other part of the experiment (at 85% RH) were compared. This evaluation is approximate but reliable one. All differences (Tab. IV) showed to be significant.

Effect of parental age on population size

Tab. IV

Offspring	Combinations		Differences	
	Y Y	M M	No.	percent
Eggs	10,177	5,284	+5,893**	-57.91
Larvae and nymphs	1,542	1,917	-375**	24.32
Adults	1,157	778	+379**	-32.76
Females (%)	59.8	52.3	+7.5*	
All stages, total	12,872	7,680	+5,192**	-40.34

*Significantly different at 5% level of probability. **Significantly different at 1% level of probability. For the explanation of Y and M see the text (Section 2.1).

Also in this case the size of the whole mite population, of adults and of eggs was distinctly higher in Y Y than in M M. The fact of higher percentage of females in Y Y than in M M seems to be accidental.

3.2. The effects of parental age on the life span of offspring

Data are presented in Table V. It can be seen from Table V that a significant difference occurred only between males. Males originating from young parents lived significantly longer than males of old parents. In the case of females the same tendency was observed but it was expressed in very low degree.

Life spans of offspring in days. (Evaluation of differences according to Student *t*-test.)

Tab. V

Parents	Females	Males	Difference
Y Y	39.4	39.6	0.2
M M	37.0	29.5	7.5
Difference	2.4	10.1*	

*Significantly different at 5% level of probability. For the explanation of Y and M see the text (Section 2.1).

The differences between the mean life span of males and females from young parents were insignificant. Females lived, on an average, 39.4 days, males 39.6 days. However, females originating from 25-day old parents lived an average of 37 days and males only 29.5 days.

A mortality of 50% of the offspring from young parents was observed in the 37th day of life; this was the same for both sexes. In this population the maximal life span was also identical for females and males. In the offspring from 25-day old parents maximal life span was identical for both sexes, 55 days, but it was much lower than for the offspring of young parents. A mortality of 50% was observed for females in the 36th day of life and in the 27th day of life for males.

3.3. Effect of food

The effects of food and sex proved to be highly significant. Not all foods had a similar effect upon the life span of the females and males (Tab. VI). From Table VI it can be seen that the effect of food was very distinct in the case of both sexes. Life spans of the females and the males fed on several foods were similar. Exceptionally large and distinct differences occurred with yeast, casein, hazel nut and synthetic diet. In these cases females' life span was much longer. These foods ensured, in general, a long life span. Just the rye germs and semisynthetic diet which contained the rye germs expanded much more the life span of the males than of the females.

Comparing the data of Tables I and VI we may conclude that the longest life span of *Acarus siro* occurred on foods with a high protein content (mushroom, casein, yeast and rye germs) but also on hazel nut containing a high percentage of fats. Synthetic diet was the best food for females and semisynthetic diet (with rye germs) the best one for the males. Dried cod was the poorest food; mites fed on this food lived as short as those kept without

Life span of females and males on different food

Tab. VI

Food	Females		Males		Difference (x_1-x_2)
	x_1	class	x_2	class	
No food, check	6.3	a_3, b_2	6.1	a_2, b_2	0.2
Rye germs	22.9	d_1	25.1	d_2, e_1	−2.1
Yeast	34.1	e_2	25.6	d_3, e_1	8.5*
Casein	33.6	e_1	22.3	c_5, d_6	11.3*
Hazel nuts	30.0	d_6, e_2	18.7	c_4, d_3	11.3*
Marrow	13.5	b_6, c_4	12.3	b_4, c_4	1.2
Dried apple	15.6	c_1	14.5	b_7, c_4	1.1
Dried cod	6.7	a_4, b_3	4.2	a_1	2.5
Suet	11.2	b_3, c_2	9.3	b_1	1.9
Mushroom	28.3	d_5, e_2	26.5	d_4, e_2	1.8
Synthetic diet without mineral salts	10.2	b_2, c_1	12.5	b_5, c_4	−2.3
Synthetic diet without vitamins	17.4	c_2, d_1	17.7	c_3, d_2	−0.3
Synthetic diet	41.1	e_5	29.2	d_6, e_2	11.9*
Semisynthetic diet	32.6	e_1	40.6	e_4	−8.0*

*Significantly different at 1% level of probability. Data followed by different letters are significantly different at 5% level of probability. For the explanation of x_1 and x_2 see the text (Section 3.1). The compositions of synthetic and semisynthetic diets are given in the foot-note to Table I.

any food. Life span of both sexes was significantly longer on full synthetic and semisynthetic diets than on synthetic diets lacking vitamins or mineral salts. Vitamins were of less importance than mineral salts. On suet and marrow containing a very high level of fats (93 and 90%, respectively) and on dried apple containing 1% of fats the life span was similar (Tab. VI – b, c). The life span of the mites fed on the rye germs enriched with vitamins, mineral salts and other components was for both sexes longer than on sole rye germs.

3.4. Oxygen uptake

Data are presented in Table VII. The oxygen uptake evaluated per 1 μg of wet weight of the mite was the highest in the young adults and it was the lowest in 30-day old adults. The respiration rate of 20-day old females was 28.6% lower than the respiration rate of 2-day old females. 20-day old males respired 25.8% less oxygen than the young ones. 30-day old mites respired even with the slower rate. The females respired 51.8% of the oxygen and the males 43.0% comparing with the youngest group.

Oxygen uptake in females (F) and males (M) of different ages

Tab. VII

Age (days)	Oxygen uptake $\mu l \times 10^{-3}$/specimen/hour		Mean wet weight/ specimen (μg)		Oxygen uptake $\mu l \times 10^{-3}$/1 μg of wet weight	
	F	M	F	M	F	M
2	29.58	16.22	11.424	7.242	2.59	2.37
20	29.91	16.77	16.116	9.520	1.85	1.76
30	20.90	15.75	16.728	11.647	1.25	1.35

The respiration was then, in general, higher in all ages for females than for males. Decrease of the respiration during ageing between 20th and 30th day of life was higher in females than in males.

4. CONCLUSIONS

(1) The offspring of young parents was more numerous than that of old parents and was mainly expressed in the combined number of all stages and in numbers of adults, larvae and nymphs.

(2) The effectiveness of one sex was independent on the age of the other sex. The effectiveness of young age of the parental females was usually larger than the effectiveness of the young age of males.

(3) Sex ratio of the offspring was not dependent upon the age of the parents.

(4) Males originating from young parents lived significantly longer than males from old parents.

(5) The content of fats or proteins in food does not alone decide the life span of *Acarus siro*.

(6) The absence of mineral salts showed a stronger inhibitory effect on the life span than the absence of vitamins. Rye germs enriched with those components expanded the life span of both sexes. Females lived significantly longer on some of the best diets (yeast, casein, hazel nut, synthetic diet). On rye germs and on semisynthetic diet with rye germs, on the other hand, under these conditions males lived longer.

(7) Oxygen uptake in the adults of *Acarus siro* was evaluated per 1μg of wet weight. It was found to be higher in the females than in the males independently on their age. The effect of ageing expressed by decrease of the respiration was also higher in the females.

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BADANIA NAD NIEKTÓRYMI ASPEKTAMI STARZENIA SIĘ U ROZKRUSZKA MĄCZNEGO (*ACARUS SIRO* L.) (*ACARINA: ACARIDAE*)

Streszczenie

Badania nad starzeniem się były dotychczas wykonywane głównie nad owadami i ssakami. Roztocze przechowalniane stanowią doskonały obiekt dla tego typu badań.

W doświadczeniach z *Acarus siro* L. stwierdzono, że potomstwo młodych rodziców było liczniejsze (brano pod uwagę łączną liczebność wszystkich stadiów: dorosłych, larw i nimf) niż starych rodziców. Wpływ wieku jednej płci był niezależny od wieku płci drugiej. Wpływ młodego wieku samic rodzicielskich był zwykle większy niż młodego wieku samców. Liczebność samic i samców w potomstwie nie zależała od

wieku rodziców. Samce pochodzące z młodych rodziców żyły istotnie dłużej niż samce od starych rodziców.

Sama zawartość tłuszczów i białek w pożywieniu nie decydowała o długości życia rozkruszka mącznego. Brak w pożywieniu soli mineralnych wywierał większy hamujący wpływ na długość życia niż brak witamin. Zarodki żyta wzbogacone tymi składnikami przedłużały długość życia obu płci. Samice żyły istotnie dłużej na niektórych najlepszych pokarmach (drożdże, kazeina, orzechy laskowe, dieta syntetyczna). Na zarodkach żyta i na diecie półsyntetycznej z zarodkami żyta dłużej żyły samce.

Oddychanie imagines *A. siro* obliczane na 1 μg mokrej wagi było wyższe u samic niż u samców niezależnie od ich wieku. Z wiekiem zmniejszała się intensywność oddychania, silniej u samic niż u samców.

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