

**The effect of density on life-history parameters and morphology
of *Archezogozetes longisetosus* Aoki, 1965 (Acari: Oribatida)
in laboratory conditions**

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Abstract: It is well known that overcrowding results in a decline of population growth, but also a too low density can be harmful to a population. The aim of this experiment was to test how density affects *Archezogozetes longisetosus* Aoki, 1965, the oribatid species most studied in the laboratory. The most favourable initial density of this parthenogenetic species was 1 individual per culture box (5 cm²) and with increasing density the fecundity of mites decreased. However, the longevity of adults did not depend on density. For juvenile stages, only the highest density (20 individuals/box) was harmful (higher mortality and prolonged development). The largest F1 generation adults were in the group with the lowest initial density; but among the other groups adult size did not differ significantly. The reaction of *A. longisetosus* to density was classified as the *Drosophila* type.

Key words: Oribatida, Acari, longevity, fecundity, development, body measurements, behaviour

INTRODUCTION

The density of a population affects population growth mainly through its impacts on fecundity, mortality and distribution of the organisms (ALLEE et al. 1958). If reproduction rate decreases with increasing density, this dependency is called the *Drosophila* type (FUJITA 1954). If there is an optimum density point, at which reproduction rate is the highest, so that both above and below it population growth decreases, this type of dependence is called the Allee type (e.g. FUJITA 1954, ALLEE et al. 1958).

There have been few laboratory studies focused on determining the effects of density on oribatid mites under laboratory conditions (ROCKETT & WOODRING 1966, LEBRUN 1970, STAMOU et al. 1981, STAMOU & ASIKIDIS 1989). In most cases the dependence between the density and fecundity was of the Allee type and the optimum number of mites per culture was 3–7 individuals.

Archezogetes longisetosus Aoki, 1965 is becoming the oribatid mite most studied in the laboratory (for details, see SMRŽ & NORTON 2004). The aim of this research was to determine the optimum density of this parthenogenetic species under laboratory conditions.

MATERIALS AND METHODS

Archezogetes longisetosus is a species with a pan-tropical distribution (AOKI 1965, BECK 1967, PALMER & NORTON 1991). It reproduces parthenogenetically (thelytoky) and there is some evidence that the offspring may be genetic clones of their mother (PALMER & NORTON 1992), which gives an important advantage for using this species in laboratory tests.

Specimens used in this study originated from the laboratory hatchery started in 1994 from a few individuals brought from Prof. R. A. NORTON (University of Syracuse, USA), and those descended from one gravid female from Puerto Rico (for details, see SMRŽ & NORTON 2004).

Stock-cultures were kept in constant climatic conditions (30°C, relative humidity 90%), in plastic boxes with the bottom filled with plaster of Paris and charcoal (4:1) and fed with green algae (*Protococcus* sp.) collected together with tree bark in Bydgoszcz forest.

For the experiment, young females of the same age, just after the last moult, were selected at random from a stock-culture. The experiment included 4 groups, with the initial density of 1, 5, 10 and 20 adult individuals per box (5 cm²), and each group was represented by 10 cultures treated as replicates.

Mites were provided with fresh food (green algae, *Protococcus* sp., served in excessive amounts) every other day, and at the same time the old food was discarded from the boxes and observations of mites were carried out. The experiment was conducted until all mites from the offspring generation became adults. The effect of density was then evaluated on the basis of life-history parameters: longevity of initial adults, fecundity of initial adults, offspring mortality, development time from egg to adult, and number of adults obtained in the F1 generation. For the cultures that had more than 1 female at the beginning of the experiment, the average results per female were calculated. From each experimental group, 30 adults from the offspring generation were selected at random, mounted on slides in lactic acid, and measured. The statistical calculations included ANOVA/MANOVA analyses followed by a post-hoc Tukey test and were carried out with STATISTICA 6.

RESULTS

Density did not affect the longevity of adult mites; in all experimental groups they lived on average for about 40 days (Table 1). However, the fecundity of initial females decreased significantly with increasing density. Also the number of adults in the F1 generation significantly differed among the experimental groups. In the group with the lowest initial density, on average 55.3 adults were obtained per initial female. In the groups started with 5, 10 or 20 females, the mean number of adult F1

Table 1. Life-history parameters and body measurements of adults from the F1 generation of *Archegozetes longisetosus*, depending on the initial density of mites per culture box (5 cm² of bottom area)

Experimental groups		Life-history parameters, N=10				Body measurements, N=30		
	(initial density of mites per 5 cm ²)	Longevity of initial adults (days)	Fecundity (offspring per initial female)	Mortality of juveniles (%)	Number of F1 adults per initial female	Development time of F1 offspring*	Length (µm)	Width (µm)
1	Mean	37.50 ^a	61.10 ^a	9.35 ^a	55.30 ^a	35.70 ^a	970 ^a	680.83 ^a
	Range	20-69	16-92	0-14.5	16-87	29-41	800-1062.5	562.5-762.5
	S.D.	16.40	21.13	7.46	20.55	4.64	72.04	45.69
5	Mean	38.51 ^a	25.20 ^b	4.73 ^a	23.90 ^b	36.60 ^a	812.08 ^b	547.5 ^b
	Range	30-49.5	19.8-32.8	0-14.0	19.8-31.8	32-40	637.5-912.5	425-662.5
	S.D.	6.82	4.92	4.62	4.22	2.87	69.98	49.39
10	Mean	43.39 ^a	12.17 ^{bc}	8.55 ^a	11.27 ^{bc}	35.10 ^a	809.58 ^b	534.17 ^b
	Range	19-62.5	7.3-18.3	0-23.3	5.6-17.5	31-41	662.5-912.5	462.5-625
	S.D.	12.86	4.05	6.59	4.20	2.81	64.13	41.25
20	Mean	38.64 ^a	6.27 ^d	33.36 ^b	4.20 ^d	43.30 ^b	840 ^b	554.58 ^b
	Range	35.3-45.7	5.05-8.2	5.6-51.0	2.9-6.7	36-47	725-900	437.5-625
	S.D.	3.78	1.03	16.03	1.35	3.71	44.33	39.73

* days from egg to adult; different letters indicate significant differences between groups, at $P < 0.05$

offspring per female was respectively 23.9, 11.3 and 4.2, which made the total number ca. 100 adults per box. Thus the latter number can be considered the saturation level.

The parameters of juvenile stages (mortality and development time) were similar in groups started from 1, 5 or 10 females. Only in the group with the highest initial density (20) were these parameters significantly different. Adults produced in cultures started from 1 female were almost 20% larger than those from the other groups.

At the highest initial density, behavioural changes were also observed. The mites were restless and many of them were climbing the walls and lids of the culture boxes.

DISCUSSION

Laboratory studies on oribatid mites have clearly demonstrated that the density influences the fecundity and mortality of these animals. A negative correlation between density and reproduction of mites also has been observed in the field (e.g. HÅGVAR & ABRAHAMSEN 1980, AL-ASSIUTY et al. 1993).

Interestingly, the density dependence of the Allee type has been found both in bisexual and parthenogenetic species. For example, *Achipteria holomonensis* Cancela da Fonseca et Stamou, 1987 raised singly (in culture boxes with 2.5 cm² of bottom area) did not lay eggs, although the mites had been collected from the soil during the reproductive season (STAMOU et al. 1981). The highest reproduction rate was observed at densities 3–5 individuals/box, while at higher densities (10–30 individuals/box) reproduction decreased and behavioural changes, like those noted in *A. longisetosus*, were seen. Density influenced the parameters of adult *A. holomonensis* but not those of juveniles. Also in this study only the highest density affected the juvenile stages of *A. longisetosus*. In 2 other oribatid species, *Scheloribates* cf. *laticipes* (Koch, 1841) and *Achipteria oudemansi* Jacot, 1929, the optimum density was ca. 7 individuals/box with 5 cm² of bottom area (STAMOU & ASIKIDIS 1989).

LEBRUN (1970) demonstrated that *Nothrus palustris* Koch, 1839, another parthenogenetic species, does not lay eggs when raised singly. Its optimum density was 3–5 individuals per culture box (16 cm²) while at higher densities the reproduction rate and survivorship decreased. In contrast, *A. longisetosus*, when cultured singly in this study, laid eggs and its reproduction rate was the highest. Therefore the reaction of *A. longisetosus* to the density should be classified as the *Drosophila* type. A possible explanation could be the difference in mobility. *A. longisetosus* is much quicker than *N. palustris*, and this prevents the development of fungal hyphae in the culture boxes, while the hyphae could be harmful to mites due to immobilization of specimens among them or due to the toxic effects (GRANDJEAN 1948).

REFERENCES

- AOKI J. 1965. Oribatiden (Acarina) Thailand. I. Nat. Life Southeast Asia 4: 129–193.
- AL-ASSIUTY A. I. M., BAYOUMI B. M., KHALIL M. A., VAN STRAALEN N. M. 1993. Egg number and abundance of ten Egyptian oribatid mite species (Acari: Cryptostigmata) in relation to habitat quality. Eur. J. Soil Biol. 29: 59–65.
- ALLEE W. C., EMERSON A. E., PARK O., PARK T., SCHMIDT K. P. 1958. Principles of animal ecology. I. 598 pp., PWN, Warszawa.

- BECK L. 1967. Beiträge zur Kenntnis der neotropischen Oribatidenfauna. 5. *Archegozetes*. Senck. Biol. 48: 407–414.
- FUJITA H. 1954. An interpretation of the changes in type of the population density effect upon the oviposition rate. Ecology 35: 253–257.
- GRANDJEAN F. 1948. Sur l'élevage de certaines Oribates en vue d'obtenir des clones. Bull. Mus. Nat. Hist. Nat. Paris 20: 450–457.
- HÄGVAR S., ABRAHAMSEN G. 1980. Colonisation by Enchytraeidae, Collembola and Acari in sterile soil samples with adjusted pH levels. Oikos 34: 245–258.
- LEBRUN P. 1970. Écologie et biologie de *Nothrus palustris* (C.L. Koch 1839). 3^e Note cycle de vie. Acarologia 12: 193–207.
- PALMER S. C., NORTON R. A. 1991. The distribution, mechanisms and evolutionary significance of parthenogenesis in oribatid mites. In: The Acari: Reproduction, Development and Life – History Strategies (SCHUSTER R., MURPHY P. W., Eds), pp. 107–136, Chapman and Hall, London.
- PALMER S. C., NORTON R. A. 1992. Genetic diversity in thelytokous oribatid mites (Acari: Acari-formes: Desmonomata). Biochem. Ecol. Syst. 20: 219–231.
- ROCKETT C. L., WOODRING J. P. 1966. Biological investigations on a new species of *Ceratozetes* and of *Pergalumna* (Acarina: Cryptostigmata). Acarologia 8: 511–520.
- SMRŽ J., NORTON R. A. 2004. Food selection and internal processing in *Archegozetes longisetosus* (Acari, Oribatida). Pedobiologia 48: 111–120.
- STAMOU G. P., ASIKIDIS M. D. 1989. The effect of density on the demographic parameters of two oribatid mites. Revue d'Écologie et de Biologie du Sol 26: 321–330.
- STAMOU G. P., KATTOULAS M., CANCELA DA FONESCA J. P., MARGARIS N. S. 1981. Observations on the biology and ecology of *Achipteria holomonensis* (Acarina, Oribatida). Pedobiologia 23: 53–58.

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