THE LIFE CYCLE OF AN ALPINE ORIBATID MITE, *OROMURCIA SUDETICA* WILLMANN

BY HEINRICH SCHATZ [1]

LIFE SPAN
HIGH MOUNTAINS
ORIBATIDA
TYROL

ABSTRACT : The life cycle of *Oromurcia sudetica*, a dominant species in meadows at the timberline in the Tyrolean Central Alps (Austria), was investigated in the laboratory. Seasonal and daily fluctuations of soil temperature were simulated in climate chambers using fortnightly means of daily maxima and minima. The development from egg to adult takes a minimum of two years, but can last up to four years. The observed life span of the adults is one to two years. The results found in the laboratory agree with the observed field data. Such long life cycles are often found under extreme conditions as in the high mountains with low temperatures and short vegetation growing periods.

DURÉE DE VIE
HAUTES MONTAGNES
ORIBATES
TYROL

RÉSUMÉ : Le cycle de vie d'*Oromurcia sudetica*, espèce dominante des prairies à la limite de la forêt dans les Alpes Centrales tyrolliennes (Autriche), a été étudié en laboratoire. Les fluctuations saisonnières et journalières de la température du sol ont été simulées en chambres climatiques à partir des moyennes bi-mensuelles de maxima et minima quotidiens. Le développement, de l'œuf à l'adulte, occupe au minimum deux années, mais il peut durer jusqu'à quatre années. On observe chez les adultes une durée de vie de une à deux années. Les résultats obtenus en laboratoire s'accordent avec les données relevées dans la nature. Des cycles de vie aussi prolongés se rencontrent souvent sous les conditions aussi extrêmes que celles des hautes montagnes, avec des périodes de températures basses et de croissance végétale brèves.

LEBENSDAUER
HOCHGEBIRGES
ORIBATIDA
TIROL

ZUSAMMENFASSUNG : Der Lebenszyklus von *Oromurcia sudetica*, einer dominanten Art in Wiesen an der alpinen Waldgrenze in den Tiroler Zentralalpen (Österreich) wurde im Labor untersucht. Die jahreszeitlichen und täglichen Schwankungen der Bodentemperaturen wurden dabei in Klimakammern alle 15 Tage an die mehrjährigen Mittelwerte der Freilandtemperaturen abgepaßt. Die Entwicklung vom Ei zum adulten Tier dauert mindestens zwei Jahre und kann sich bis zu vier Jahren erstrecken. Die beobachtete Lebensdauer der Adulten beträgt ein bis zwei Jahre. Die in der Haltung gefundenen Ergebnisse stimmen mit Freilandbeobachtungen überein. Derart lange Entwicklungszeiten sind unter den extremen Bedingungen des Hochgebirges wie niedrige Temperaturen und kurze Vegetationsperioden häufig.

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INTRODUCTION

The life cycles of numerous oribatid species are already known. LUXTON (1981) gave a survey from literature of the duration of stages of several oribatids. However, most investigations were conducted under constant temperatures ; the development of only a few species was studied under changing field temperatures (e.g. BLOCK 1965, 1980, LEBRUN 1974, 1977, WEIGMANN 1975, 1979).

In the course of ecological studies on alpine oribatids[2] the life cycles of some species were investigated. It seemed interesting to ascertain how the development of oribatids would be adapted to the extreme climatic conditions in the Alps, with short warm vegetation growing periods and long winters with snow cover. Life cycles of more than one year due to temperatures in the alpine region are known from other taxonomic groups (e.g. Coleoptera : DE ZORDO 1979, Diplopoda : MEYER 1979).

MATERIAL AND METHODS

The investigations were carried out on a population of *Oromurcia sudetica* in a meadow (1960 m) at the timberline in the Obergurgl area (Tyrolean Central Alps, Austria). *O. sudetica* Willmann 1939 is with an average of 3,000 individuals per m^2 the most dominant oribatid species (28 %) in this meadow (SCHATZ 1979). The distribution of this species is restricted to mountains (SCHATZ 1983 a).

The animal material was sampled through monthly soil samples, extracted alive in a Tullgren-Berlese apparatus (SCHATZ 1979). The cultures were kept in climatic chambers. The temperature corresponded to the fortnightly means of daily maxima and minima of soil temperature at a depth of 1 cm, ranging from — 4° to + 16°C. The light regime was adjusted according to the photoperiod of the investigation area during the snow free season May to October (Fig. 1). The animals were kept in batches in dishes with a mixture of plaster of Paris and animal charcoal with a relative humidity up to 100 % and they were regularly checked.

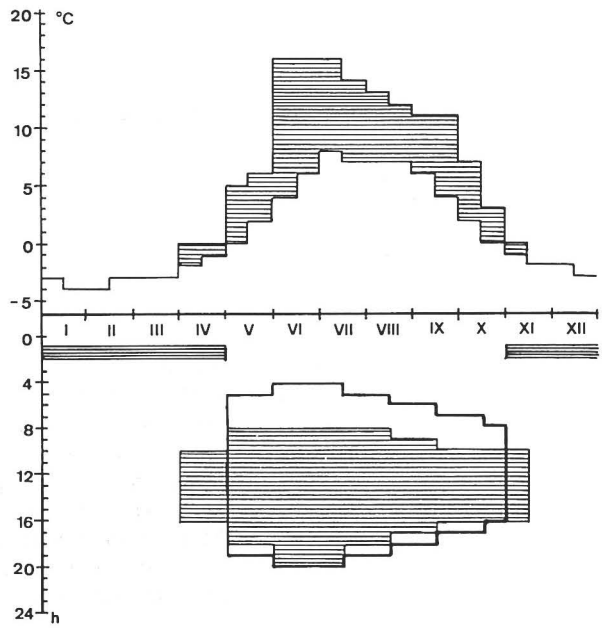

FIG. 1 : Temperature and light regime (means over the years 1974-78 from the investigation area " meadow ", 1960 m a.s.l., Obergurgl, Tyrolean Central Alps) ; simulated in the climatic chamber. Upper diagram : daily minimum and maximum of soil temperature (1 cm depth), fortnightly means. Lower diagram : duration of daily maxima of temperature (shaded area) and photoperiod (bordered). Horizontal bar : mean duration of snow cover in the field.

Soil samples (11 cm^2 surface, 2 cm depth) were taken from July 1975 to June 1979. Thus a comparison of results from cultures with the population in the field is possible.

RESULTS

■ *Culture.*

The results originate from the rearing of continuous field catches of all stages. The animals

2. Project No. 4077 of the " Österreichische Fonds zur Förderung der wissenschaftlichen Forschung " : " Secondary productivity in the Central High Alps ", Project leader : Prof. Dr. H. JANETSCHEK.

passed through several instars until they either reached the adult stage or died. No individual of *O. sudetica* had been reared through all instars up to now. The dates of hatching and the moulting of the instars in this species as well as duration of instars are given in Table 1. Only individuals which reached the succeeding instar were considered. It is apparent that generations overlap in the field since each instar occurs in every month. During each instar there are some individuals which reach the following stage in the same year and some which overwinter. Thus there are some individuals with a short metamorphosis time and others with a much longer development time. These are separated in Table 1.

TABLE 1 : Duration of stages of *Oromurcia sudetica* in culture under field conditions.

Life Stage	Month of ovipos./ hatching	n	Duration of stage (days)		
			$\bar{x}$ ± CL 95 %	max.	min.
Ova	VI — VII	69	36.60 ± 4.70	70	14
	XI	2	194.00	249	139
Larvae	VII — VIII	13	37.69 ± 8.54	70	17
	VII — IX	8	248.38 ± 55.03	332	155
Protonymphae	III — VIII	6	66.67 ± 13.06	82	51
	VIII — X	9	259.44 ± 20.20	297	210
Deutonymphae	V — VI	10	69.50 ± 21.18	135	34
	IX — X	3	272.67	290	246
Tritonymphae	V, VII	2	73.50	101	46
	VII — X	9	309.00 ± 29.85	358	233
Adults	V — VIII	11	423.45 ± 66.36	509	146
	VI — X	6	783.17 ± 60.14	833	685

Oviposition in this species takes place only during the snow free growing period of the vegetation, mostly from June to August. In this season the development of the embryo takes about 40 days. All larvae from these eggs hatch in the same year. Y successful overwintering of eggs was only observed in two cases where the eggs had been deposited at the beginning of November.

The larvae hatch from July to September Two types of further development can clearly be distinguished : one group develops into protonymphs in the same year, the other overwinters as larvae. The latter group also contains individuals which had hatched in July. Development takes about 40 days in the first group ; about 5 to 8 months in the second group, and taking all winter to the beginning of the next vegetation growing period.

The protonymphs can also be subdivided into two groups : the individuals hatched from the larvae of the previous year have a short development of about two months. Hatching can start as early as March, in any case at the beginning of the vegetation growing period. Also some of the protonymphs hatched in August reached the next stage in the same year. Most of the protonymphs hatched in the second half of the vegetation growing period overwinter and continue their development to deutonymphs in the following year — also at the beginning of the vegetation growing period.

Most of the reared deutonymphs hatched at the beginning of the vegetation growing period. They develop to tritonymphs in about two to three months. Some of the individuals that hatch in autumn overwinter as deutonymphs. Almost all reared tritonymphs overwinter still a second time before the adults emerge. The development to tritonymphs can be completed anytime during the vegetation growing period. Only in two cases did tritonymphs become adult during the same year.

The adults emerged during the whole vegetation growing period, mostly in early summer. They are of a light colour and darken during the course of the first year. Eggs are produced after one additional overwintering. After oviposition some of the individuals die, others overwinter a second time and produce eggs again in the next vegetation growing period. These individuals die immediately after depositing eggs, at the latest by the end of the vegetation growing period.

Thus the development of *O. sudetica* reared under fluctuating field temperatures takes two to three years, sometimes up to four years when it takes each instar longer to develop. The adults live for one to two years so that the entire life span of an individual may last from three to six years.

■ *Field.*

The field results are given in Fig. 2. The dynamics of abundance follow a similar pattern each year (SCHATZ 1979 and unpublished data), so that the monthly means of all the study years (1975-79) could be summarized. All instars are found throughout the entire year. Because of the overlapping generations no clear trend in development can be seen ; but the partly significant changes in abundance coincide quite well with the culture results.

The larvae show the clearest abundance dynamics with a significant increase in late summer. The following decrease to a constant winter level is caused by mortality and hatching of the protonymphs. Before the hatching of the next generation of larvae a minimum is reached in June/July. The nymphs show less distinct changes in abundance ; a minimum is reached in early summer. The protonymphs hatched before this date seem to have a short development, as was the case with the cultured animals ; whereas the individuals hatched during the second half of the vegetation growing period overwinter at least partially and become deutonymphs in spring. These seem mostly to overwinter in the field, in contrast to the cultured animals. The tritonymphs occur at an almost constant level during the year. The overwintered deutonymphs hatching to tritonymphs in May cause a maximum during this month. The following decrease of tritonymphs in June may be explained by the emergence of adults.

Each year the adults show a higher abundance in winter. This might be explained, in part, by the lower winter mortality (SCHATZ 1983 b). The addition of new individuals is not noticeable. Fecundity of females was established through dissection (Fig. 2), as no eggs were found in the field. The data of total egg production follow the abundance changes of the adults. However, summer as the main egg laying season can be discerned. As known from the culturing experiments, parts of the population die after depositing eggs, thus reducing adult numbers.

DISCUSSION

The long developmental periods are probably produced by temperature effects. With few exceptions, a progress in development is observed only during the snowfree season, mostly during the vegetation growing period. In this the succeeding instars develop continuously while individuals which hat "too late" in the autumn have to overwinter. Variations in times of development are considerable even under the relatively constant culture conditions. In the field, with weather conditions changing continuously, variation is much larger as can be seen from the occurrence of all instars at all times of the year.

Results from the literature (LUXTON 1981 : 337) suggest a similar pattern : under constant temperature conditions time of development is always shorter than under field conditions with cold periods. Dependance of development on temperature in oribatid mites was investigated by LEBRUN & VAN RUYMBEKE (1971) and LEBRUN (1974, 1977). Hatching is retarded considerably at low temperatures, with each instar showing differing minimum temperatures for developing (WEIGMANN 1975). In winter, this point is not reached for any stage of *O. sudetica*, while mortality during this time is very low (SCHATZ 1983 b). Thus the overwintering forms are inactive "resting stages", with chill coma temperatures little below the freezing point (SCHATZ & SØMME 1981, WEST 1982). BLOCK (1980) found comparable results in an Antarctic oribatid mite, *Alaskozetes antarcticus* (Michael) : supercooling as an important feature of its cold tolerance combined with elevation of standard metabolism at low temperature contribute to a long development and maximum survival.

LEBRUN (1970) and LUXTON (1981) suggest also other factors influencing the duration of life cycles, especially the light regime. This study aimed at nearest possible natural conditions : the long period of snow cover was simulated by darkness in the cultures, while day-length varied according to field conditions (Fig. 1).

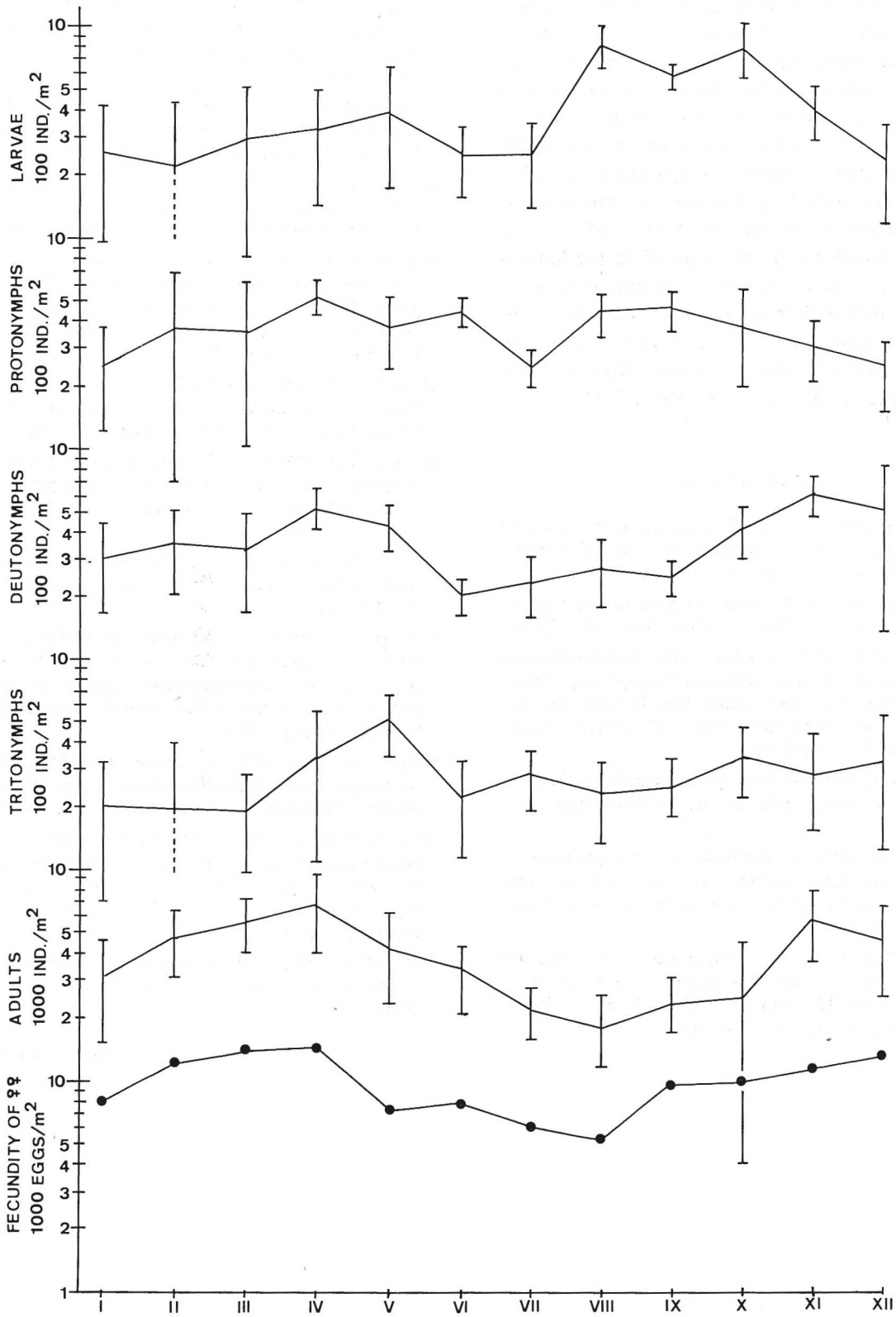

FIG. 2 : Monthly variations in abundance (means over the total investigation time from July 1975 to June 1979 ± 95 % confidence limits) of *Oromurcia sudetica* in the investigation area " meadow " (1960 m a.s.l., Obergurgl, Tyrolean Central Alps).

The females of *O. sudetica* are gravid throughout the whole year. This permanent fecundity is only known from some oribatid species (LUXTON 1981) and coincides with findings in the nearest related species, *Oromurcia bicuspidata* Thor in Norway (SOLHØY 1975). The date of oviposition (June/July with maximum temperature of 16°C) is mainly determined by temperature, but possibly also by humidity in the field (LUXTON 1981). The latter could not be investigated in the laboratory cultures. In *O. sudetica*, the time span adult emerge to oviposition of one year, and the duration of the adult stage of one to two years in the laboratory are considerably longer than in most oribatid species (see LUXTON 1981 : 321).

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