THE SIGNY ISLAND TERRESTRIAL REFERENCE SITES: VI. OXYGEN UPTAKE OF *Gamasellus racovitzai* (Trouessart) (ACARI: MESOSTIGMATA)

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ABSTRACT. Data are presented of individual oxygen-consumption rates for all post-ovum life stages of the Antarctic terrestrial mite *Gamasellus racovitzai* (Trouessart) (Acari : Mesostigmata). Measurements were made at Signy Island, South Orkney Islands, using a Cartesian diver micro-respirometer at 0°, +5° and +10° C during 1971–74. Oxygen-uptake rates were $3{\cdot}235-26{\cdot}265\times10^{-3}$ μl. ind.$^{-1}$ hr.$^{-1}$ at 0°, $4{\cdot}019-38{\cdot}661\times10^{-3}$ μl. ind.$^{-1}$ hr.$^{-1}$ at +5°, and $7{\cdot}107-72{\cdot}049$ μl. ind.$^{-1}$ hr.$^{-1}$ at +10° C. The slopes of the linear regression lines of $\log_{10}$ respiratory rate against $\log_{10}$ live weight at each temperature were not significantly different. The weight exponent, b, ranged from 0·676 to 0·709. Q_{10} values are given for each life stage, calculated both on an individual (1·36–3·63) and a g. live-weight (1·02–6·31) basis. These data are compared with other mite and collembolan respiration studies.

THE information on mite respiration presented in this paper is part of a study of the population dynamics, oxygen uptake and feeding biology of the mites occurring in two contrasting moss communities at Signy Island, South Orkney Islands. The work was undertaken at Signy Island between November 1971 and April 1974. These two moss communities, known as the Signy Island Reference Sites (SIRS) 1 and 2, were established in 1971 as part of a long-term ecosystem study. A full description of the sites has been given by Tilbrook (1973).

There are few published data on the oxygen uptake of terrestrial Acari, and the majority are for temperate species of the Cryptostigmata, e.g. Engelmann (1961), Berthet (1964), Zinkler (1966) and Webb (1969, 1970*a*). Data on the respiration of temperate species of the Mesostigmata are found in Webb (1970*b*) and Wood and Lawton (1973), the latter including measurements for the juvenile stages. Respiration data are available on two species of Antarctic micro-arthropods. Measurements have been made on the collembolan *Cryptopygus antarcticus* Willem, using cultured animals (Tilbrook and Block, 1972) and field animals (Block and Tilbrook, 1975). The oxygen uptake of the Antarctic cryptostigmatid mite *Alaskozetes antarcticus* (Michael) has also been studied (Block, in press).

The aims of the present study were to measure the oxygen uptake of individuals of each life stage of *Gamasellus racovitzai* (Trouessart), and to examine the effects of live weight, instar, sex, reproductive state and temperature upon the metabolic rate. Further, by extrapolation to field population data, an estimate of population respiration will be made and presented in a later paper.

G. racovitzai is a predatory mesostigmatid mite (Family Rhodacaridae) recorded from many localities in the Antarctic Peninsula–Scotia arc region (Trägårdh, 1907, 1908; Trouessart, 1907; Berlese, 1917; Gressitt and Weber, 1960; Hunter, 1970). It is the only predatory mite recorded from the South Orkney Islands. It often occurs in large aggregations, especially in the deutonymph stage, mainly under stones, on or near moss and algal communities. As the only arthropod predator, *G. racovitzai* may play an important role in the energy flow of terrestrial communities on Signy Island. The orange-brown adult ranges from 900 to 1,100 μm. in length.

METHODS

Experimental animals were collected by aspirator immediately prior to the measurement of their respiration rates. The field temperature in the habitat was measured at the time of collection. Handling of the animals was kept to a minimum, and all preparative work for respirometry was undertaken in a constant-temperature room within $\pm3°$ C of the experimental temperature. The animals were individually separated into numbered glass vials and weighed live on an electromicro-balance (Beckmann L.M. 500). Animals were manipulated out with either a fine (camel-hair) brush or a mounted bristle.

Oxygen-uptake rates of individual mites were measured using a Cartesian diver micro-respirometer (Zeuthen, 1950, 1964). The temperature of the respirometer water bath was controlled to $\pm 0{\cdot}01^{\circ}$ C. Reversed stoppered divers with a gas volume range from 4 to 30 μl., designed for use with terrestrial animals, were used. Calibration of the divers was by means of a gas micro-syringe. After placing the divers in the respirometer, an equilibration period of approximately 1 hr. was allowed before readings commenced. Readings of equilibrium pressure on the manometer were made at hourly intervals and each experiment was run for between 4 and 7 hr. Observations were made on the activity of the mites in the divers during the experiment; these showed that they were relatively quiescent after an initial period of activity during the early part of the equilibration period. After the experiment, the mites were removed from the diver and individually preserved in 70 per cent alcohol with 5 per cent glycerol added. Confirmation of life stage, sex and reproductive state was later made under $\times 25$ magnification.

For each animal, a plot was made of equilibrium pressure with time, a linear regression fitted, and the rate of change of the equilibrium pressure calculated. Oxygen consumption was computed by:

$$V\,O_2 = \frac{E\,P \times Vg \times 273}{P_o \times T},$$

where $V\,O_2$ is volume of oxygen consumed (μl. hr.$^{-1}$), $E\,P$ is change in equilibrium pressure (mm. hr.$^{-1}$), Vg is gas volume of diver (μl.), T is temperature (°K), and P_o is normal pressure (10,000 mm. Brodie's fluid).

Respiration measurements were made at three temperatures: 0°, +5° and +10° C, and except for larvae, at least ten individuals of each life stage were measured separately at each temperature. A total of 209 measurements of oxygen uptake were made. Several respiration measurements were made on unweighed mites after the micro-balance developed a fault. A linear regression of area of the propodosomal shield against live weight was computed for 161 reliably weighed individuals of all stages of *G. racovitzai*. The mites were mounted individually in 100 per cent lactic acid on microscope slides and, after partial clearing, the length and width of the propodosomal shield were measured under $\times 100$ magnification. Fig. 1 shows the plot of length $\times$ width against live weight with the fitted linear regression line. The live weight of the unweighed mites was calculated using the regression equation:

$$y = 63773{\cdot}206 - 1866{\cdot}384x,$$

where y is length $\times$ width (μm.) and x is live weight (μg.).

Results

Oxygen uptake and live weight

Table I gives the mean live weight and weight range for each life stage of *G. racovitzai* from all the weighed material. There is an almost two-fold increase in mean live weight from protonymph to deutonymphal stage, ($P < 0{\cdot}01$) and from deutonymph to adult ($P < 0{\cdot}025$).

TABLE I. THE MEAN LIVE WEIGHT $\pm$S.E. AND THE LIVE-WEIGHT RANGE (μg.) OF EACH LIFE STAGE OF *G. racovitzai*. THE NUMBER OF MEASUREMENTS (n) IS ALSO GIVEN

Life stage	*n*	*Mean live weight* $\pm$*S.E.* (μg.)	*Weight range* (μg.)
Larva	6	$4{\cdot}40 \pm 1{\cdot}16$	2·2—8·9
Protonymph	26	$23{\cdot}65 \pm 1{\cdot}98$	9·0—36·0
Deutonymph	82	$54{\cdot}64 \pm 1{\cdot}99$	21·0—92·0
Adult ♂	62	$102{\cdot}20 \pm 1{\cdot}69$	77·1—129·5
Adult ♀ (non-gravid)	35	$108{\cdot}80 \pm 2{\cdot}40$	70·0—131·5
Adult ♀ (gravid)	21	$115{\cdot}50 \pm 2{\cdot}80$	90·0—138·1

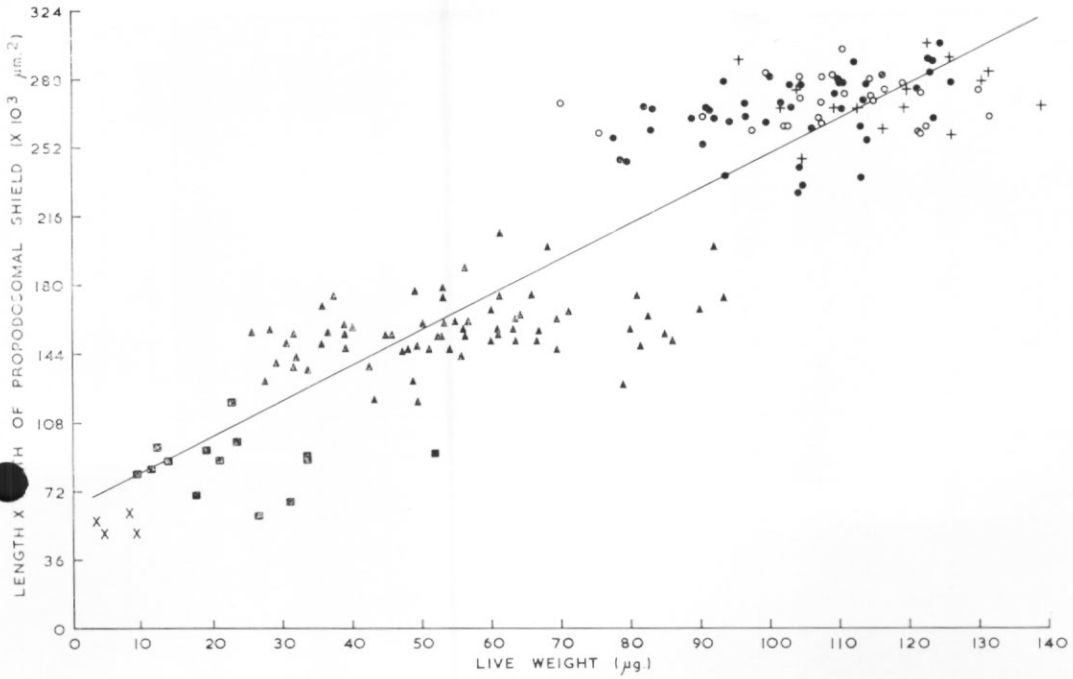


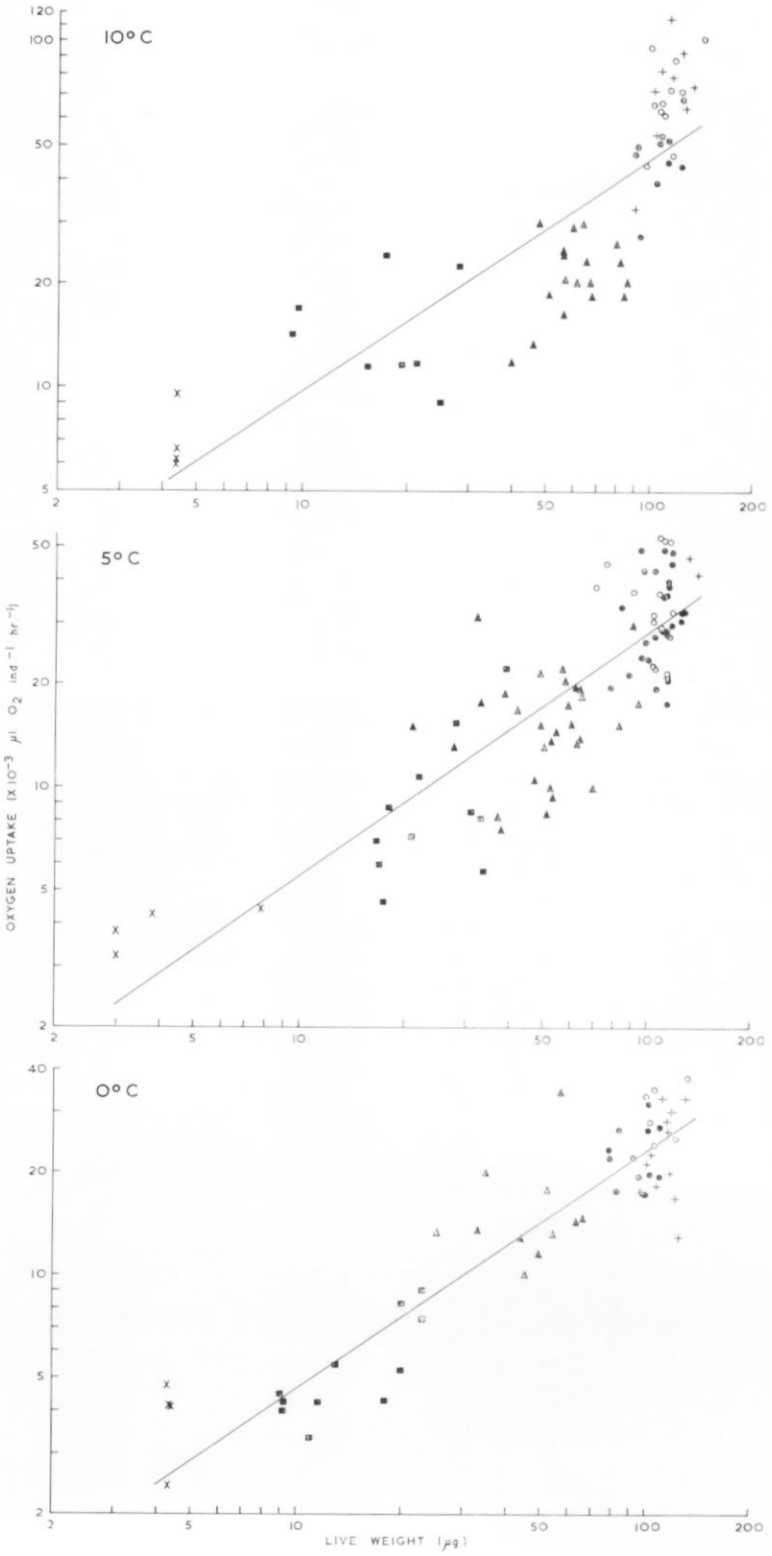
Fig. 1. Relationship between length × width (μm.) of propodosomal shield (y) and live weight (x) (μg.) for all life stages of *G. racovitzai*. The linear regression line $y = 63773{\cdot}208 - 1866{\cdot}384x$ has been fitted ($r = 0{\cdot}9104$).
×, larva; ■, protonymph; ▲, deutonymph;
●, ♂; ○, non-gravid ♀; +, gravid ♀.

The largest weight range is in the deutonymphal stage, which suggests that this is the main growing period. The live-weight ranges of all life stages overlap, so the weights recorded are representative of the whole life span of the species.

The individual measurements of oxygen uptake for all life stages at the three temperatures are plotted against individual live weight on a double log scale (Fig. 2), linear regressions fitted. As expected, individual animal respiratory rates increase linearly with increasing live weight at each temperature. Table II gives the regression and correlation coefficients. All correlations are significant at $P < 0{\cdot}001$. The slopes of the lines in Fig. 2 are not significantly different from each other, indicating that the relationship between respiratory rate and weight in *G. racovitzai* is similar at each of the experimental temperatures. The +10° C regression line is more vertically displaced from the 0° and +5° C lines than they are from each other.

TABLE II. LINEAR REGRESSION EQUATIONS, CORRELATION COEFFICIENTS (r) AND NUMBER OF OBSERVATIONS (n) FOR $\log_{10}$ RESPIRATION RATE (y) ON $\log_{10}$ LIVE WEIGHT (x) FOR *G. racovitzai* AT THREE TEMPERATURES, EXPRESSED AS RATES/INDIVIDUAL/hr.

Temperature (° C)	n	a	b	r
0	56	−0·028	0·694	0·936
+5	90	0·034	0·709	0·846
+10	60	0·308	0·677	0·838


10° C
5° C
0° C
OXYGEN UPTAKE (X 10⁻³ µl O₂ ind⁻¹ hr⁻¹)
LIVE WEIGHT (µg)

This represents a greater increase in oxygen uptake over all life stages between +5° and +10° C than between 0° and +5° C.

The weight exponent (*b*) of the linear regression equations (Table II) is similar at each temperature both for weight specific and whole animal oxygen uptake. This is in contrast to the Antarctic collembolan *Cryptopygus antarcticus*, where a significant difference in *b* was found between +5° and +10° C (Block and Tilbrook, 1975). This suggests that, unlike *C. antarcticus*, the respiration rate of *G. racovitzai* increases uniformly with live weight at each of the three temperatures, and the various life stages have a similar metabolic response to each temperature in respect of live weight.

The mean value of *b* for *G. racovitzai* over the experimental temperature range is 0·69; this is similar to values calculated by Berthet (1964) for 16 species of oribatid mites (0·72), by Zinkler (1966) for eight species of Collembola (0·74), by Block and Tilbrook (1975) for *C. antarcticus* (0·749), and by Chapman and Webb (in press) for all published data on oribatids (0·71). This indicates that respiration is proportional to surface area in these species. In contrast, Block (in press) recorded a mean *b* value of 0·927 for the Antarctic cryptostigmatid mite *Alaskozetes antarcticus* (over the same temperature range as the present study), suggesting that respiration rate is proportional to weight.

The mean oxygen-uptake rates for each life stage at each temperature for both individual and weight specific data are given in Table III. The greatest increases are between the proto-

TABLE III. MEAN OXYGEN-UPTAKE RATES ± S.E. FOR EACH LIFE STAGE OF *G. racovitzai* AT THREE TEMPERATURES. RATES ARE EXPRESSED ind.$^{-1}$ hr.$^{-1}$ AND g.$^{-1}$ hr.$^{-1}$ WITH THE NUMBER OF OBSERVATIONS

Life stage	*Mean oxygen uptake* 0° C	+5° C	+10° C
		10^{-3} µl. O_2 ind.$^{-1}$ hr.$^{-1}$	
Larva	3·235 ± 0·752 (4)	4·019 ± 0·280 (4)	7·107 ± 0·826 (4)
Protonymph	5·520 ± 0·572 (11)	9·552 ± 1·555 (11)	15·746 ± 1·883 (8)
Deutonymph	16·040 ± 2·060 (11)	15·942 ± 0·548 (30)	21·770 ± 1·256 (18)
Adult ♂	22·652 ± 1·246 (12)	32·685 ± 1·570 (31)	47·911 ± 3·347 (10)
Adult ♀	26·265 ± 1·622 (18)	38·661 ± 2·914 (14)	72·049 ± 4·347 (20)
		µl. O_2 g.$^{-1}$ hr.$^{-1}$	
Larva	735·28 ± 171·02 (4)	1,032·05 ± 158·16 (4)	1,615·26 ± 187·71 (4)
Protonymph	376·26 ± 26·25 (11)	380·34 ± 40·24 (11)	955·38 ± 161·70 (8)
Deutonymph	353·15 ± 45·47 (11)	327·46 ± 32·24 (30)	358·61 ± 25·23 (18)
Adult ♂	242·23 ± 14·60 (12)	308·89 ± 15·19 (31)	448·79 ± 28·26 (10)
Adult ♀	231·47 ± 14·01 (18)	375·13 ± 34·60 (14)	637·24 ± 35·01 (20)

nymph and deutonymph at 0° C and the deutonymph and adult at +5° and +10° C. Females show an increase in weight specific oxygen uptake at +5° and +10° C even though they tend to be slightly heavier than males (Table I). This higher metabolic rate may be due to changes in their physiology connected with egg production at temperatures of +5° C and above. Table IV compares individual and weight specific respiratory rates of gravid and non-gravid females at each temperature, but there are no significant differences.

Oxygen uptake and temperature

The experimental temperatures 0°, +5° and +10° C were chosen so that oygen-uptake rates were measured at temperatures experienced by animals in the field at Signy Island. Field temperatures at the times when the experimental animals were collected ranged from −1° to +9° C. The mean summer habitat temperature at Signy Island was approximately +4° C.

Fig. 2. Oxygen consumption ($\log_{10} \times 10^{-3}$ µl. O_2 ind.$^{-1}$ hr.$^{-1}$) as a function of live weight ($\log_{10} W$ µg.) for *G. racovitzai* at 0°, +5° and +10° C. Individual measurements are plotted for each life stage. Linear regression lines have been fitted for each temperature (see Table II).
×, larva; ■, protonymph; ▲, deutonymph;
●, ♂; ○, non-gravid ♀; +, gravid ♀.

TABLE IV. MEAN OXYGEN-UPTAKE RATES ± S.E. FOR THE GRAVID AND NON-GRAVID FEMALE OF *G. racovitzai* AT THREE TEMPERATURES. RATES ARE EXPRESSED ind.$^{-1}$ hr. $^{-1}$ AND g.$^{-1}$ hr.$^{-1}$ WITH THE NUMBER OF OBSERVATIONS

	Mean oxygen uptake		
	0° C	+5° C	+10° C
		$\times 10^{-3}$ µl. O_2 ind.$^{-1}$ hr.$^{-1}$	
Non-gravid ♀	30·884 ± 1·881 (7)	37·621 ± 3·298 (12)	70·883 ± 5·447 (11)
Gravid ♀	23·575 ± 1·975 (12)	44·906 ± 3·043 (2)	73·475 ± 7·312 (9)
		µl. O_2 g.$^{-1}$ hr.$^{-1}$	
Non-gravid ♀	274·12 ± 17·40 (7)	381·75 ± 40·10 (12)	629·72 ± 44·60 (11)
Gravid ♀	206·59 ± 16·18 (12)	335·42 ± 32·30 (2)	646·38 ± 58·30 (9)

Fig. 3 shows the mean oxygen-uptake rates for each life stage of *G. racovitzai* plotted against temperature. The whole animal data (Fig. 3a) show the expected increase in oxygen uptake as temperature increases, with a greater rate of increase between +5° and +10° C than between 0° and +5° C. There is a greater variability in the mean values for all life stages at +5° and +10° than at 0° C. In addition, there is a clear separation of the nymphs and adults into two metabolic groups, the distinction being most marked at +10° C.

Considering the relationship of weight specific oxygen uptake and temperature (Fig. 3b), a similar pattern to the whole animal data is evident in that there is a greater range of oxygen-uptake rates and a greater metabolic separation of life stages between +5° and +10° C than between 0° and +5° C. However, there is no separation of nymphs and adults into distinct metabolic groups, but the larva is clearly separated from the rest at all temperatures, having a higher weight specific respiratory rate. The larval instar in *G. racovitzai* is of a short duration compared with the other stages, and this may explain the higher larval respiratory rates at all three temperatures. The females are again more distinct from the males at +10° C. The deutonymph rates are interesting in that there appears to be no significant increase in oxygen-uptake rate over the whole temperature range. The deutonymph in the Mesostigmata is the final nymphal stage, and in *G. racovitzai* it is the main overwintering stage. The measured animals were collected either in early spring or in late autumn, and so may have had a metabolic rate representative of a pre- or post-hibernation period. There are no data for deutonymphs collected in mid-summer.

Table V shows the temperature coefficients (Q_{10}) for each life stage for both whole animal

TABLE V. TEMPERATURE COEFFICIENTS (Q_{10} VALUES) CALCULATED OVER THE EXPERIMENTAL TEMPERATURE RANGES: 0° TO +5°, +5° TO +10° AND 0° TO +10° C FOR *G. racovitzai*. Q_{10} VALUES ARE GIVEN FOR INDIVIDUAL AND WEIGHT SPECIFIC OXYGEN-UPTAKE RATES

Life stage	*Temperature range*		
	0–5° C	5–10° C	0–10° C
		$\times 10^{-3}$ µl. O_2 ind.$^{-1}$ hr.$^{-1}$	
Larva	1·54	3·13	2·20
Protonymph	2·99	2·72	2·85
Deutonymph	—	1·86	1·36
Male	2·08	2·15	2·11
Total female	2·16	3·47	2·74
Gravid female	3·63	2·68	2·13
Non-gravid female	1·48	3·55	2·30
		µl. O_2 g.$^{-1}$ hr.$^{-1}$	
Larva	1·97	2·45	2·20
Protonymph	1·02	6·31	2·54
Deutonymph	—	1·20	1·02
Male	1·63	2·11	1·85
Total female	2·63	2·89	2·75
Gravid female	2·64	3·71	3·13
Non-gravid female	1·94	2·72	2·30

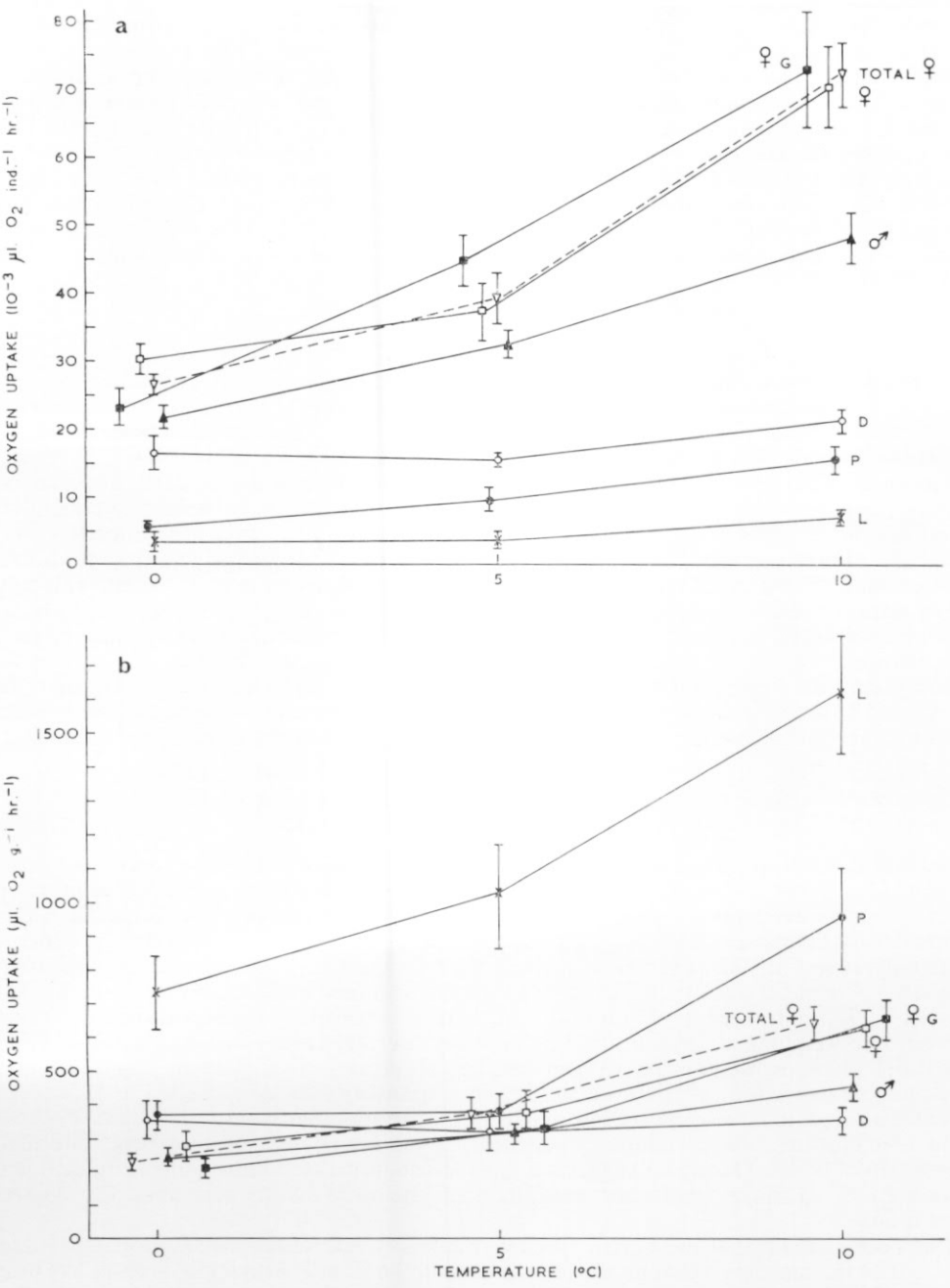


Fig. 3. Effect of temperature on mean ± S.E. oxygen-consumption rates for each life stage of *G. racovitzai*.
a. Individual rates ($\times 10^{-3}$ µl. O_2 ind.$^{-1}$ hr.$^{-1}$).
b. Weight specific rates (µl. O_2 g.$^{-1}$ hr.$^{-1}$).

and weight specific data calculated from the mean rates (Table III). Values sometimes differ for the same life stage and temperature range. There is no previous comparison in the literature of Q_{10} values in this way. The mean Q_{10} values (0° to +10° C) for *G. racovitzai* are 2·25 (whole animal) and 2·07 (weight specific). These mean Q_{10} values and the individual Q_{10} values fall in the normal range recorded for arthropods, and are most similar to those calculated for the oribatid mite *Nothrus silvestris* Nicolet (Q_{10}=2·03) (Webb, 1969). For *G. racovitzai*, the highest Q_{10} calculated was 6·31 for the protonymph between +5° and +10° C on a weight specific basis. However, over the same range from individual respiration rates, the Q_{10} is 2·72, slightly lower than that (2·99) for the 0° to +5° C range. Gravid females have a higher Q_{10} (0° to +10° C) both on an individual and a weight specific basis, than non-gravid females. A similar situation was described for the oribatid *Steganacarus magnus* (Nicolet) by Webb (1975).

Discussion

This paper contains the first published information on the respiratory physiology of Antarctic mesostigmatid mites. Webb (1970*b*) and Wood and Lawton (1973) made measurements on several species of temperate Mesostigmata, mostly adults and only at one temperature (+10° C). These animals had all been previously extracted by Tullgren heat techniques. With the exception of Block (in press), there is no information on the respiration rates of Acari taken directly from the field. Block and Tilbrook (1975), working with an Antarctic collembolan, found significant differences in respiration rates between animals measured directly from the field and acclimated animals from culture. Webb (1969) failed to determine any such difference between Tullgren-extracted and cultured animals in the oribatid mite *N. silvestris*. This subject clearly requires further investigation. As all animals used in the present study were measured directly after collection from the field, comparisons with extracted animals must be treated with caution.

Comparing the regression equation of $\log_{10}$ respiratory rate ($R \times 10^{-3}$ µl. O_2 ind.$^{-1}$ hr.$^{-1}$) against $\log_{10}$ live weight (W µg.) of *G. racovitzai* at +10° C with those of two sub-orders of mesostigmatid mites measured by Wood and Lawton (1973) at the same temperature:

Gamasina $\log_{10} R = 0{\cdot}869 \log_{10} W - 0{\cdot}204$ (Wood and Lawton, 1973),
Uropodina $\log_{10} R = 0{\cdot}671 \log_{10} W - 0{\cdot}324$ (Wood and Lawton, 1973),
Gamasina $\log_{10} R = 0{\cdot}677 \log_{10} W - 0{\cdot}319$ (present work).

Wood and Lawton suggested that as the normal level of activity of the mite species increased so did the slope (b) of the regression line. However, the very active *G. racovitzai* is more comparable, at all three temperatures, to the slow-moving non-predatory Uropodina than it is to the predatory Gamasina. This suggests that the energy cost per individual for the same level of activity is less in the polar *G. racovitzai* than in the temperate Gamasina, and may be indicative of a metabolic adaptation to a colder environment in *G. racovitzai*. Both Wood and Lawton (1973) and Webb (1975) found that there was generally an exponential relationship between live weight and oxygen uptake. Similarly, Berthet (1964) found a highly significant correlation between weight and oxygen uptake except at +5° C, and he suggested that at lower temperatures the influence of weight on respiratory rate decreased. For *G. racovitzai* the correlation of $\log_{10}$ respiratory rate against $\log_{10}$ live weight is highly significant ($P < 0{\cdot}001$) at all temperatures, the correlation coefficient at the lowest temperature being the highest ($r = 0{\cdot}936$ at 0° C). This again suggests a metabolic adaptation to low temperatures. It would be interesting to make respiration measurements below 0° C to determine the degree of adaptation.

It has been shown that the weight specific respiratory rate of female *G. racovitzai* is higher than that of the male even though the female tends to be slightly heavier in terms of live weight. Webb (1975) found that for adult *S. magnus* the effect of weight on respiratory rate was second to the number of eggs carried in order of importance at +18° C. He suggested therefore that egg synthesis had a greater effect on respiratory rate than live weight. The same may be true for *G. racovitzai*, although direct comparison is difficult as female *G. racovitzai* were rarely observed with more than one egg, and never more than two. Deutonymphs of a

similar order of weight to adults generally had lower weight specific respiratory rates. This is similar to *S. magnus* (Webb, 1975), where the last nymphal instar had a slightly lower weight specific rate, associated with a change in metabolic activity prior to moulting to the adult. In *G. racovitzai* this may be an effect of hibernation as well as moulting. On a detailed analysis of several species, Wood and Lawton (1973) found no consistent pattern in variations in the relationship between respiratory rate and live weight. They suggested that activity was as important as live weight in its effect on the respiratory rate of most mites, and that the effect may vary with life stage, the more active instars being dispersive stages. As *G. racovitzai* is a fast-moving predator, activity is probably as important as live weight in its effect on respiratory rate, the levels of activity differing with life stage and temperature. The deutonymph, which deviates most from the general trends in the results, is the only stage which associates in large and relatively inactive aggregations in the field. These aggregations normally occur in spring and autumn, at field temperatures between 0° and approximately +3° C. It is clear that live weight has a major influence on the respiratory rate of mites, though the relationship is complex both between and within species, and varies with temperature, age and season.

There are few data on the oxygen uptake of Acari at different temperatures. Apart from the extensive study of Berthet (1964), the only available data are those of Webb (1969, 1975) and Block (in press). All these studies were made on oribatid mites. Berthet's techniques differed from the other studies in that the same animal was measured at each of the experimental temperatures on the same experimental run, all within 10 hr. This meant that, at temperatures other than that at which the diver was balanced, a relatively large pressure differential had to be applied to the diver apparatus to obtain readings of equilbrium pressure. Berthet found that oribatids adapted rapidly to small temperature changes. In the other studies, the divers were balanced for each experimental temperature, with a fresh animal for each experiment. Berthet (1964) and Webb (1969) used oil-sealed unstoppered standard divers, whilst subsequent work utilized stoppered divers without oil seals. The difference in Berthet's respirometric technique makes direct comparison with his results difficult.

Nielsen (1949) found similar respirometric adaptations to small temperature changes in the soil nematode *Mononchus paipillatus* Bastian. Such adaptability might be expected in the soil fauna as field temperatures can vary considerably over 24 hr., especially in polar regions at air–substrate interfaces in the habitat. No pattern was observed in the respiration rates of *G. racovitzai* collected at varying field temperatures and measured at the same experimental temperature, though the experiments at Signy Island were not designed to test this. The Q_{10} values obtained by Berthet (1964), with a range of 3·5–5·7 (0° to +15° C) and a mean of 4·0 for 16 species, are higher than those obtained in other mite respiration studies, where the Q_{10} values are in the normal range for small invertebrates. There is no comparison in the literature between Q_{10} values derived from weight specific and whole animal respiration data. In *G. racovitzai* there are considerable differences between the two derivations over the same temperature range (Table V). This raises the question of which of the two methods is the most meaningful. Weight specific oxygen-uptake rates are more useful than whole animal rates as the effect of weight on respiration is eliminated, thus enabling an independent assessment of the effect of temperature. Most Q_{10} values for micro-arthropods in the literature have been derived from whole animal data. More information is needed on this subject. Rao and Bullock (1954), in a general review, found seasonal variations in Q_{10} values in a number of poikilotherms. Berthet (1964) was unable to detect Q_{10} variations for oribatid mites in his extensive study; similarly, no variations were observed for *G. racovitzai* in the present study.

The most interesting data for comparison with this study are those of Block and Tilbrook (1975) for the Antarctic collembolan *C. antarcticus*, and Block (in press) for the Antarctic oribatid *A. antarcticus*. Both of these studies were made at Signy Island using the same respirometer, techniques and temperature range, so variation due to differing apparatus and technique will be minimal. The linear regression lines of the relationship between $\log_{10}$ respiratory rate and $\log_{10}$ live weight for *C. antarcticus* have significantly different slopes between temperatures and it was suggested that this may be due to the smaller life stages being able to utilize the relatively long periods of equable summer temperatures for rapid growth. The protonymph and particularly the larvae of *G. racovitzai* are of a relatively short duration compared with the other life stages. There is a considerable increase in live weight between

larva and deutonymph, so it is assumed that the smaller stages of *G. racovitzai* also grow more rapidly than the other life stages. This is not reflected in the respiration data, however, as the regression lines are homogenous (Fig. 2). The temperature response (0° to +5° C) of the smaller *C. antarcticus* is greater ($Q_{10} = 4{\cdot}42$) than that of the larger stages ($Q_{10} = 2{\cdot}49$). This is not the case with *G. racovitzai*, where the smaller stages have a more variable response to increasing temperature in terms of metabolic rate (Table V). This may partially explain the differences in the relationship of respiratory rate to live weight between the two species.

The data for *A. antarcticus* (Block, in press) are similar to those for *C. antarcticus* in that the regression lines of the respiratory rate relationship are not homogenous, and the 0° C line for *A. antarcticus* is less steep than the +5° and +10° C lines. The reason for this was a depression of adult and tritonymph respiration rates at 0° C. The only depression of respiration rate observed in *G. racovitzai* was that of the gravid female at 0° C and the deutonymph at all temperatures, but this had little or no effect on the regression line slope at 0° C. The habits of *A. antarcticus* differ considerably from *G. racovitzai* and these may explain the metabolic differences. *A. antarcticus* is a large, heavily sclerotized, slow-moving herbivore/detritivore and it normally associates in large aggregations of different life stages for most of the year. From field observations on the species, moisture rather than temperature seems to control the dispersion of the aggregations. The two species show a similarity in the response to increased temperature. The range of respiration rate between life stages is small at 0° C. Between +5° and +10° C, both species show a distinct separation into two metabolic groups. For *A. antarcticus* the separation is between the larva+protonymph+deutonymph group and the tritonymph+adult group. For *G. racovitzai* the separation is between the larva+protonymph +deutonymph group and the adult group. Berthet (1964) observed maximum variability of his respiration results at 0° C, but both the Antarctic mite species show minimum variability at 0° C. This may reflect cold adaptation. At 0° C the respiration rate of the gravid female *G. racovitzai* is lower than that of the non-gravid female, both on whole animal and weight specific basis. At +5° and +10° C the situation is reversed. This suggests that egg production and development is either slowed down or arrested at lower temperatures. Block (in press) observed that the respiration rate of gravid female *A. antarcticus* was higher than that of non-gravid females, although in contrast to Webb (1975) the number of eggs carried per female and respiration rate was not correlated. The sex ratios of male to female recorded for *A. antarcticus* was 1·21:1, and for *G. racovitzai* collected under stones it was 9·7:1. This latter ratio is unusual for Acari, but it is possible that after fertilization females tended to disperse below the substrate surface and were not so easily collected in the field.

G. racovitzai is especially important on the Signy Island sites as it is the only arthropod predator in the terrestrial ecosystem. There is a need for further respiration studies on this species, especially with regard to seasonal variations in the metabolic rate of all life stages, and in particular of the overwintering deutonymph. The age of an individual within a life stage and variations in the duration of a life stage may affect the metabolic rate, as Webb (1969, 1975) recorded variations in respiration rates for adult mites of different ages. There is a need for more respiration data for the larval stage of *G. racovitzai*, and no measurements have yet been made for eggs. Finally, the relative importance of the respiration energy pathway in the overall energy balance of such a predatory species needs to be evaluated.

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