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The influence of thermal acclimation on the amylolytic activity and microanatomy of the alimentary tract of the oribatid mite *Galumna elimata* (Acari: Oribatei)

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Abstract. The oribatid mite *Galumna elimata* was reared under laboratory conditions on algae (*Protococcus* spp.) at different temperatures (5, 15 and 20°C). Higher weight-specific amylolytic activity was found in the whole body homogenates of mites exposed to cold acclimation (5°C, 21 days) in comparison with individuals acclimated to 15 and 20°C. Accompanying parameters (live body weight, content of total soluble proteins in the body, protein-specific amylolytic activity, presence and composition of food boluses, activity of mesenteric and caecal wall cells, gregarinid parasitisation, number of glycogen granulae and guanine deposits in mesenchymal tissue, presence of proventricular glands) were investigated at all three acclimation temperatures to explain mechanisms of this change. The acclimation response of weight-specific amylolytic activity was accompanied by elevation of protein-specific amylolytic activity. Microanatomical features did not confirm any increased secretion activity of mesenteric and caecal cells in cold acclimated animals. Granulation and apocrine secretion of these cells increased with increasing temperature as with food ingestion. The food boluses contained algae or algae mixed with unknown fungal hyphae in individuals acclimated to 15 and 20°C. The concentrated mucoid substances prevailed in animals exposed to cold, indicating lower feeding activity at 5°C. Based on these findigs, we hypothesised that specific amylolytic activity reflected passively the different changes in protein composition of the body at different temperatures and its elevation is without direct adaptive importance.

INTRODUCTION

The feeding biology of oribatid mites has often been studied to assess their contribution to the processes of soil organic matter decomposition (Seastedt, 1984; Siepel & Maaskamp, 1994) and to explain high species diversity of oribatid mites in the soil (Wallwork, 1983). Results showed variability in food preferences of different oribatid species (Schuster, 1956; Hartenstein, 1962; Luxton, 1972; Behan-Pelletier & Hill, 1983; Rihani et al., 1995). The variability is reflected by the differences in distribution of digestive enzymes (Luxton, 1972; Urbášek & Starý, 1994). Siepel & Ruiter-Dijkmann (1993) proposed a classification of feeding guilds of oribatid mites based on the presence and absence of some saccharolytic enzymes (trehalase, chitinase and cellulase).

Little attention has been devoted to season and acclimatisation conditioned changes of digestive enzyme's activity in the same species. However, such changes can influence the results of the tests for the presence of enzymes as well as their ecological interpretations. Some preliminary results showed the existence of changes of amylolytic activity due to thermal acclimation in the oribatid mites *Galumna elimata* and *Platynothrus peltifer*. Weight-specific amylolytic activity appeared to be elevated after 28 days of cold acclimation (Šustr & Starý, 1998). Other studies dealing with acclimation responses in oribatid mites were concentrated on parameters such as respiration rate (Stamou et al., 1995), thermal death point (Madge, 1965) or supercooling point (Sugawara et al., 1995). An increase in weight-specific amylolytic, xylanolytic and lichenolytic activities, measured at 30°C, was observed in the springtail *Tetrodontophora bielanensis* from a mountain population, in contrast to a lowland population of these animals (Urbášek & Rusek, 1994). Elevation of weight-specific amylolytic activity was detected after only one week of exposure of the High Arctic springtail *Onychiurus arcticus* to 5°C (Šustr & Block, 1998). Changes of physiological parameters after acclimation are often assumed to be adaptive in some way or other (a posteriori approach after Block & Vannier, 1994). Elevation of respiration rate of poikilotherms due to cold acclimation is often interpreted as cold compensation in the sense of Krogh (1916). However, an extrapolation from in vitro measured weight-specific enzyme activity to real enzyme activity in digestive tract at ambient temperature (in vivo) is not quite clear. It is not sure that previously observed elevation of in vitro measured weight-specific amylolytic activity in *G. elimata* implies the compensation of digestion efficiency at lower temperatures. To evaluate the adaptive importance of this phenomenon, it is necessary to know whether the observed changes reflected passively changes in the body composition or if they are connected to higher enzyme synthesis. The aim of this study is to collect more information about the mechanisms of this change and to compare changes in several of the accompanying parameters

(live body weight, weight-specific soluble protein content and protein-specific amylolytic activity). It is necessary to determine whether digestive activity in cold acclimated animals is actually compensated (e.g., if it is similar as in animals reared at higher temperature). To evaluate actual feeding intensity and rate of secretion in cells of digestive tract we observed some microanatomical features in acclimated animals.

MATERIAL AND METHODS

Galumna elimata (C.L. Koch, 1841) is a common oribatid species, widespread in the soil of meadows, being panphytofagous in the sense of Luxton (1972). The related species *Galumna lanceata* was classified as a fungivorous grazer (Siepel & Ruiter-Dijkman, 1993). However, all stages of *G. elimata* were successfully reared on *Protococcus* spp. (Sengbush, 1954). Individuals of *G. elimata* were extracted from soil samples taken on a meadow at 406 m a.s.l. near the centre of Říčany, 20 km east of Praha, on March 21 and 25 and April 13 and 15, 1998. Mean air temperature was ca. 5.4°C in March and 11.6°C in April at the collection site. Mean monthly habitat temperatures vary approximately between −1 and 20°C annually. Mites were extracted from soil samples in a Tullgren-Berlese apparatus (35°C, water as collecting fluid was replaced after 24 h, over 3 days). The mites were stored in glass vials (ca 250 ml) on plaster with charcoal in the bottom. Filter paper covered the plaster. Green bark algae *Protococcus* spp. were offered as food. The vials were stored in the bottom of a refrigerator (at 8°C) for one week before all experiments. The same method was used for rearing oribatids during acclimation experiments.

Animals collected in March were used for temperature acclimation. Mites were reared for 2 days in a controlled environmental chamber at acclimation temperature (AT) 5°C in the dark before experiments. Start control sample (SC) was taken for measurements of fresh body mass, soluble protein content and amylolytic activity (weight-specific and protein-specific) before acclimation. At the same time (1 April 1998) the other individuals were divided in three groups: acclimated at AT 5°C (AT5), 15°C (AT15) and 20°C (AT20). All the groups were exposed to the chosen acclimation temperature for 21 days in the dark. All investigated parameters were analysed in each experimental group at the end of the acclimation. Some of these animals were taken for microanatomical observations. The remainder of animals used in microanatomical observations were taken from the second acclimation experiment using samples from the April collection acclimated in the same way as the March collection.

The activity of α-amylase (EC 3.2.1.1) was measured in whole body homogenates of mites. Samples of 20–25 animals were weighed using a Sartorius R160P balance (accurate to 0.01 mg), homogenised in a cooled glass homogeniser in 1.5 ml of phosphate buffer (Britton-Robinson, pH 7 – it was the optimum for amylolytic activity estimated using animals from start control sample). Five samples were homogenised almost at the same time. Homogenisation of one group of samples took about 6 min. Homogenised samples were stored in a refrigerator during this time to minimise thermal inactivation of enzymes as well as protease activity in the homogenate. Homogenates were centrifuged for 7 min at 6,000 g. Enzymatic activities were assayed immediately by incubating 1 ml of supernatant with 50 mg of specific chromolytic substrate (S-test, STU Bratislava,

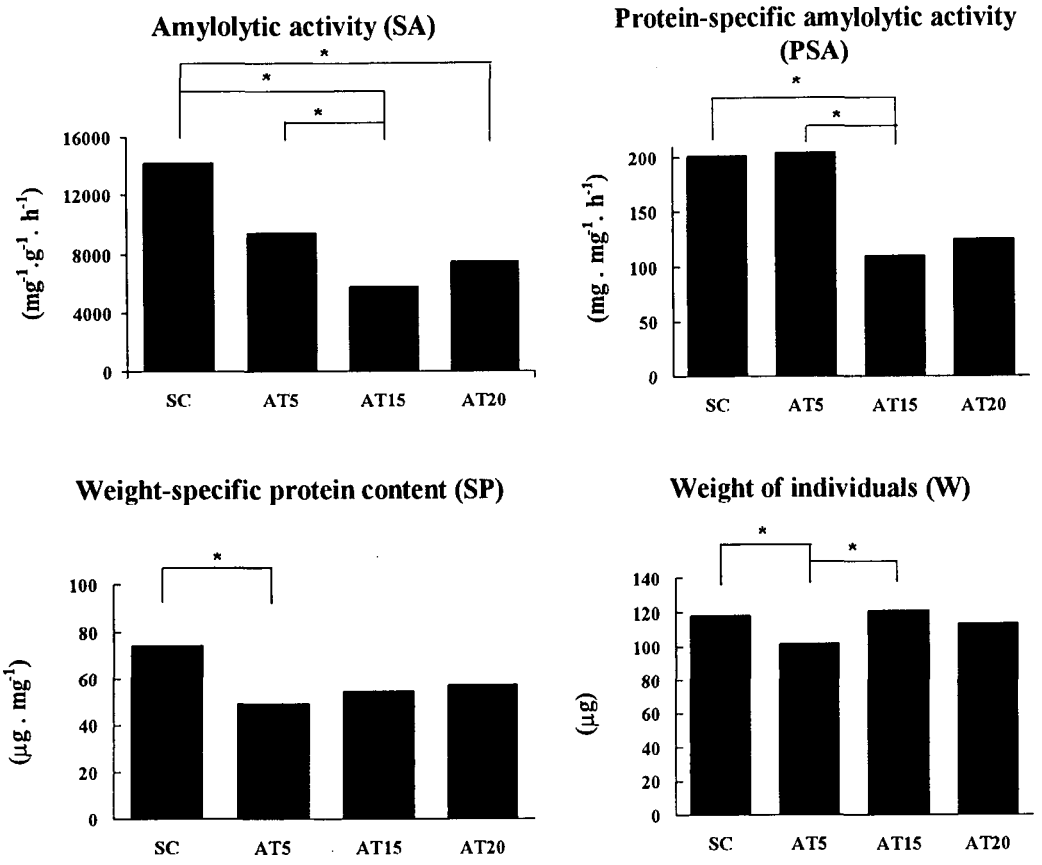


Fig. 1. Temperature acclimation responses of *Galumna elimata*. Experimental groups: SC – start control; AT5, AT15, AT20 – acclimation temperatures were 5, 15 and 20°C respectively. Significantly ($\alpha < 0.05$) different collumns are marked by horizontal bars with asterisks.

Slovakia). A drop of toluene was added as a bactericide to all the samples. The incubation time was 1 h at 30°C. Adding 2 ml of acetone solution with Na_2CO_3 (900 ml H_2O, 100 ml acetone, 10g Na_2CO_3) terminated the incubation. After centrifugation (7 min at 6,000 g) the light absorbance of the final coloured supernatant was measured at 620 nm. The weight-specific amylolytic activity (SA) was expressed in mg of degraded substratum per gram of individual live weight per hour ($mg.g^{-1}.h^{-1}$). The protein-specific amylolytic activity (PSA) was expressed in mg of degraded substratum per milligram of total soluble proteins per hour ($mg.mg^{-1}.h^{-1}$).

A 0.2 ml sample of the supernatant of homogenate was used for the determination of total soluble protein content using phenol reagent micromethod (Sigma). Weight-specific protein content (SP) was expressed in µg of protein per mg of weight. Individual body weight (W) was expressed in µg. Five (PSA and SP) or six (SA and W) replications were made in each acclimation group. Differences of biochemical parameters between experimental groups were evaluated using a non-parametric Kruskal-Wallis test.

Eighteen specimens of *G. elimata* from all treatments were fixed in modified Bouin-Dubosque-Brasil fluid (Smrž, 1989), embedded in paraplast, sectioned (thickness 5–7 µm), and stained in Masson's triple stain. Animals collected in March as well as those collected in April were used. Alimentary tract and mesenchymal tissue of mites were observed in horizontal, vertical and sagittal sections. The presence of food boluses in mesenteron, colon and rectum, type of ingested food, thickness of mesenteric wall, granulation and apocrine secretion of mesenteral and caecal cells, presence of proventricular glands, amount of glycogen particles and guanine deposits in mesenchymal tissue were observed, as in some previous studies (Woodring & Cook, 1962; Smrž & Čatská, 1989). The presence of microanatomical features was expressed as the probability ratio (sum of samples showing presence of a certain event divided by the sum of investigated samples). In some cases the semiquantitative scale for levels of intensity of a certain feature (0, 1, 2, and 3) was used, and probability ratio was calculated for each observed level. The differences in the presence of microanatomical features were tested by χ^2 test (Statgraphics, procedure Contingence tables).

RESULTS

Start control

In the start control (SC) the mean individual live weight (W) was 118.1 µg (SE ± 1.5 µg), soluble protein content (SP) was 74.1 ± 4.2 $\mu g.mg^{-1}$, weight-specific amylolytic activity (SA) was very high at 14,198.8 ± 1,959.8 $mg.g^{-1}.h^{-1}$), protein-specific amylolytic activity (PSA) was 201.2 ± 26.7 $mg.mg^{-1}.h^{-1}$ (Fig. 1).

Food boluses were present in all parts of the digestive tract simultaneously (Table 1). The mucoid substances filled the mesenteron (Fig. 12). Mesenteral cells varied in thickness in different parts of the mesenteral wall. They seldom showed apocrine secretion (Table 1, Figs 7 and 8). Caecal wall cells showed strong apocrine secretion (Table 2, Figs 9–11). Granulation was observed in both mesenteral and caecal cells (Figs 7, 8, 10). Low numbers of individuals had caecal cells producing green coloured inclusions (Fig. 11). The following types of food boluses were observed: (a) ones formed from algae *Protococcus* spp., only (Figs 12, 13), (b) ones formed from algae *Protococcus* spp. and minority of unknown fungal hyphae (Fig. 14), (c) ones containing mucoid substances and unknown particles similar to parts of mesenteral cells (probably the rests of tissue, Figs 17). Exceptionally boluses contained algae and hyphae, and unknown particles (probably the rest of the tissues) or bacteria were observed (Figs 24, 25). Some of the algae cells were not crushed in the mesenteron (Fig. 17) and appeared compact and not digested in the rectum (Fig. 15). The first and second type of food bolus prevailed in animals from the start control (Table 3). Parasitisation by *Eugregarina* (Fig. 2) in the mesenteron and caeca was low. Glycogen particles were observed in the mesenchymal tissue (Figs 4, 5).

A small number of guanine deposits were observed in many mites also (Table 4). Proventricular glands (Fig. 4) were apparent in the proximal part of the mesenteral wall in some individuals. Brown spherical granules (Fig. 6) filled out their cells. The salivary glands (Fig. 2) were present in the three types differing in lumen volume.

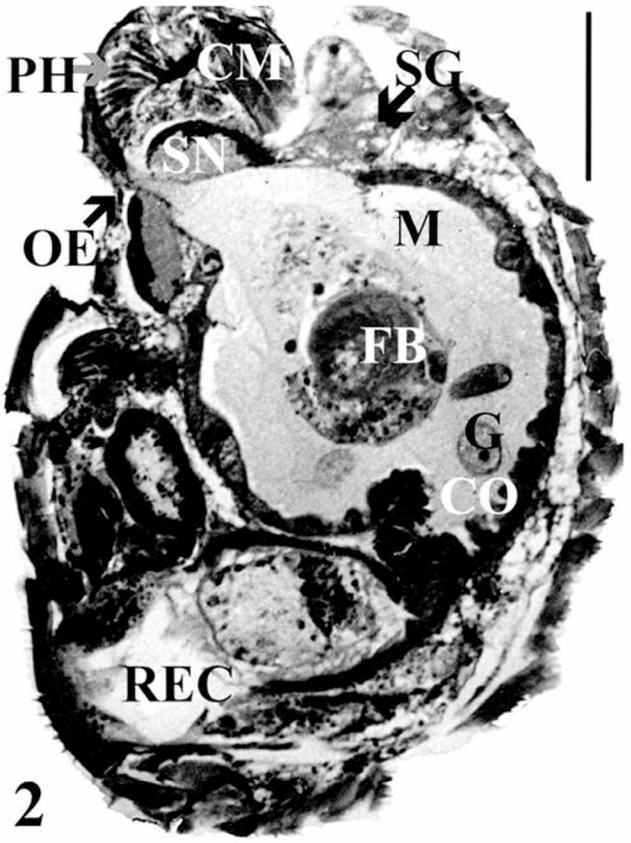
Acclimation responses

SA decreased during acclimation at all three constant temperatures over 21 days (influence of rearing in constant temperature conditions). SA was significantly higher in SC than in the groups AT15 (5,841.0 ± 387.7 $mg.g^{-1}.h^{-1}$) and AT20 (7,489.3 ± 568.4 $mg.g^{-1}.h^{-1}$) (Fig. 1).

TABLE 1. Presence of food in the compartments of the alimentary tract and microanatomical features of the mesenteron of *Galumna elimata* acclimated to three constant temperatures (expressed as percentage of individuals).

Group	Presence of food bolus in alimentary tract										Apocrine secretion of mesenteral cells			Eugregarinids	
	Simultaneously				Mesenteron		Colon		Rectum						
	n	I	II	III	n	pres.	n	pres.	n	pres.	n	1	2	n	pres.
SC	12	0	25	75	18	89	16	81	13	100	17	53	47	18	11
AT5	23	26	48	22	26	77	24	38	23	74	26	100	0	26	15
AT15	25	12	24	64	35	86	31	81	29	93	33	76	24	35	23
AT20	36	0	22	78	41	85	40	95	39	95	42	62	38	42	81
χ^2		12.72***	5.1	20.12***		1.43		28.48***		9.71***		15.79***	15.79***		46.58***

Experimental groups: SC – start control, AT5, AT15 and AT20 – acclimation temperatures 5, 15 and 20°C respectively. Rows headline: I – food bolus present in one part of alimentary tract, II – in two parts, III – in three parts simultaneously; 1 and 2 represent levels of semiquantitative scale, χ^2 – parameters of χ^2 test, *** – significant differences among acclimation groups at $\alpha = 0.05$, n – number of observed individuals, pres. – presence.



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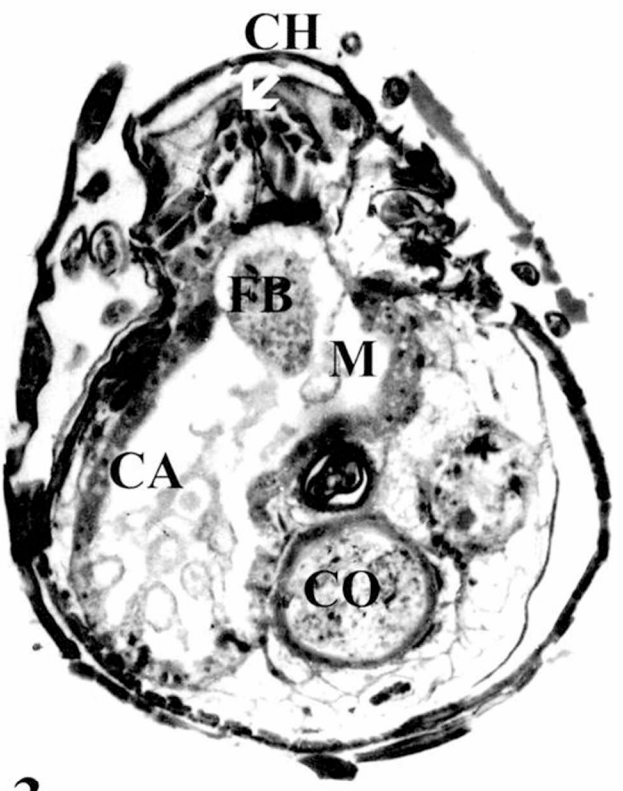

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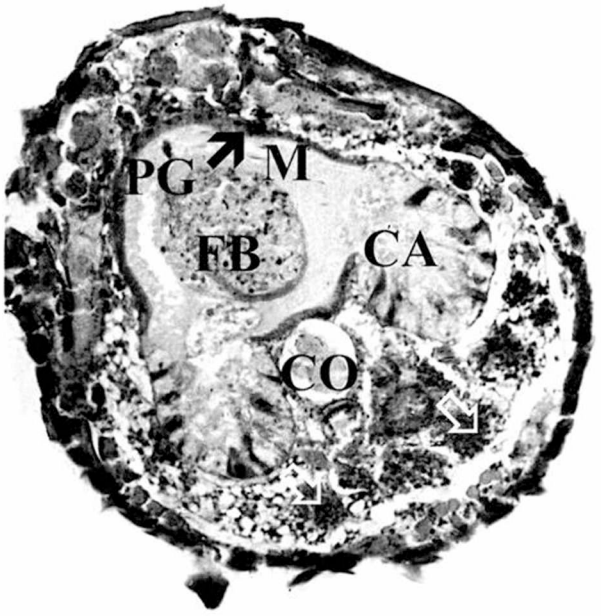

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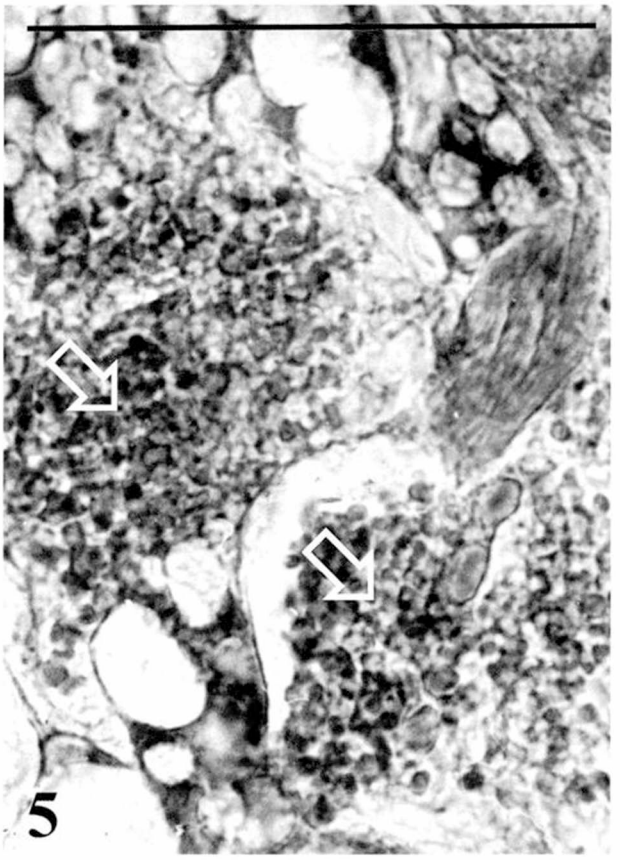

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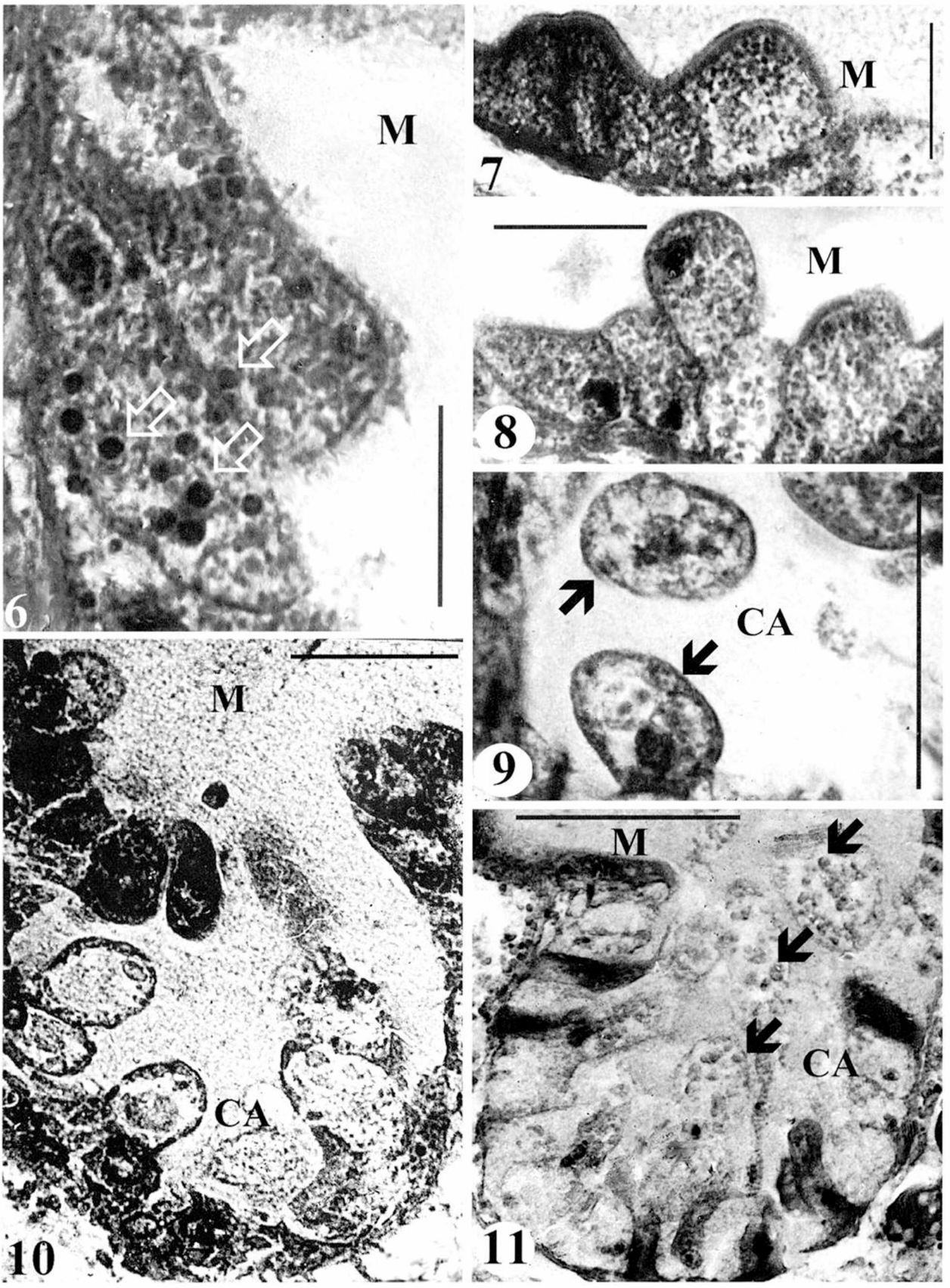
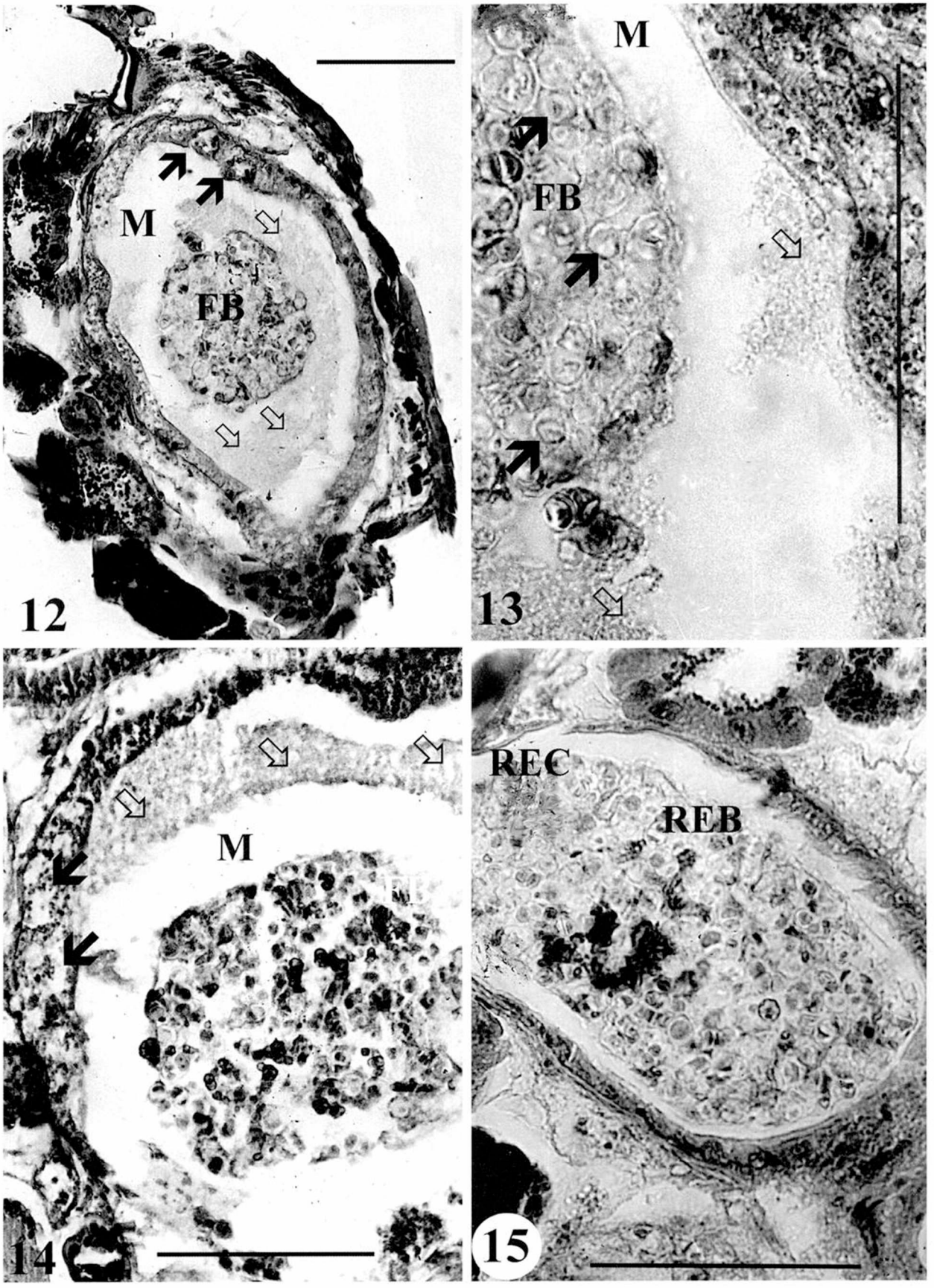
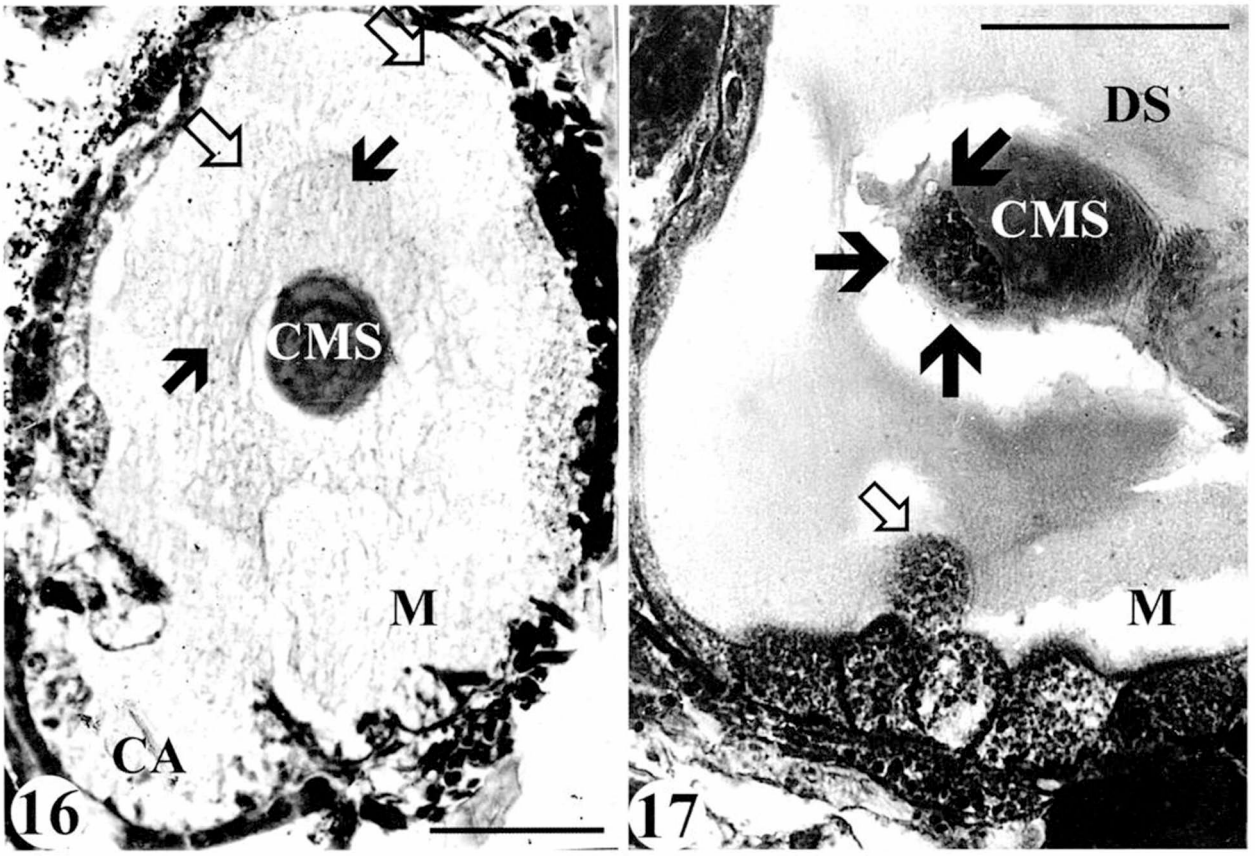
Figs 2–5. The alimentary tract of *Galumna elimata*. 2 – sagittal section; 3 – horizontal section. 4–5: Glycogen particles in mesenchymal tissues. 4 – horizontal section, white empty arrows point to glycogen particles; 5 – detail of the same figure, white empty arrows point to glycogen particles. Abbreviations used: CA – caeca, CH – chelicera, CM – cheliceral muscles, CO – colon, FB – food bolus, G – gregarines, M – mesenteron, OE – oesophagus, PG – proventricular gland, PH – pharynx, REC – rectum, SG – salivary glands, SN – synganglion. Scale: 0.1 mm.



Figs 6–11. Cells of the mesenteron and caeca of *Galumna elimata*. 6 – cells of proventricular glands, arrows point to brown spherical granules; 7 – mesenteral cells; 8 – proliferated mesenteral cells; 9 – proliferated parts of caecal cells (pointed by arrows); 10 – proliferated cells in caecum; 11 – another proliferated cell in caecum, the cells are filled by green granules (arrows). Abbreviations used: CA – caecum, M – mesenteron. Scale: 0.025 mm.



Figs 12–15. Food boluses from *Galumna elimata*. 12 – cross section of mesenteron, black arrows point to proliferated cells; 13 – detail of algae food bolus, black arrows point to algae cells, 14 – mixed food bolus – unknown fungal hyphae and algae cells; 15 – algae cells in rectum. Empty arrows – mucoid droplets. Abbreviations used: FB – food bolus, M – mesenteron, REB – rectal bolus, REC – rectum. Scale: 0.5 mm.



Figs 16–17. 16 – mesenteron of *Galumna elimata* filled with mucoid droplets (empty arrows), more concentrated droplets (black arrows) and others concentrated into a compact bolus; 17 – food bolus formed from mucoid substances and probably by parts of tissues (black arrows), empty arrow points to proliferated cell. Abbreviations used: CA – caecum, CMS – mucoid substances concentrated into bolus, DS – mucoid droplet, M – mesenteron. Scale: 0.05 mm.

W and SP decreased significantly after 21 days of acclimation at 5°C (W 101.5 ± 2.2 μg and SP 49.0 ± 4.0 $\mu g.mg^{-1}$, respectively). SA only showed an insignificant decreasing trend (9,423.1 ± 352.7 $mg.g^{-1}.h^{-1}$) and PSA remained at the same level (204.2 ± 17.1 $mg.mg^{-1}.h^{-1}$) (Fig. 1). In contrast, groups AT15 and AT20 showed significant decreases of SA in the comparison with start control, decrease of PSA was also significant in AT15 (110.3 ± 8.5 $mg.mg^{-1}.h^{-1}$), but insignificant in AT20 (125.8 ± 7.5 $mg.mg^{-1}.h^{-1}$). Both warm acclimated groups did not show significant decrease of W (120.8 ± 5.4 μg and 113.4 ± 7.1 μg, for AT15 and AT20 respectively) and SP (54.6 ± 1.5 $\mu g.mg^{-1}$ and 57.3 ± 4.1 $\mu g.mg^{-1}$, at AT15 and AT20 respectively). There were no significant differences either in the live body weight or in the biochemical parameters between AT15 and AT20 in spite of an increasing trend of SA in the animals acclimated at 20°C (Fig. 1).

The cold acclimated group (AT5) differed from the start control by a smaller number of food boluses (Table 1). These boluses contained mainly remains of tissue and mucoid substances (Table 3). The ingestion of algae and hyphae was small. Some food boluses were formed only from mucoid substances in this group (Fig. 16). Mesenteral and caecal cells showed lower apocrine secretion

Table 2. Microanatomical features of caecal cells of *Galumna elimata* acclimated to three constant temperatures (expressed as percentage of individuals).

Group	Caecal cells								
	Granulation		Apocrine secretion					Green inclusions	
	n	pres.	n	0	1	2	3	n	pres.
SC	18	100	17	0	18	23	59	18	11
AT5	26	100	26	4	19	69	8	26	12
AT15	35	100	34	0	15	12	73	35	43
AT20	41	100	41	2	2	59	37	42	50
χ^2		–		1.73	5.63	27.58***	28.36***		16.08***

Rows headline: 0 (absence), 1, 2 and 3 represent levels of semiquantitative scale.
Experimental groups (SC, AT5, AT15 and AT20), χ^2, ***, n and pres. as in Table 1.

TABLE 3. Food bolus content in individuals of *Galumna elimata* acclimated to three constant temperatures (expressed as percentage of individuals).

Group	Food bolus content				
	n	Algae	Algae and hyphae	Mucoid substances only	Mucoid substances and remainder of tissues?
SC	18	67	72	0	44
AT5	26	12	8	38	42
AT15	35	86	80	3	26
AT20	42	63	79	5	12
χ^2		43.13***	43.39***	10.68***	26.83***

Experimental groups (SC, AT5, AT15 and AT20), χ^2, ***, n and pres. as in Table 1.

(Tables 1, 2). The number of guanine deposits was higher (Table 4). With increasing acclimation temperature (at AT15 and AT20) increased mesenteral and caecal cells apocrine secretion increased, together with the number of green coloured inclusions producing by caecal cells, and the number of parasitic gregarinids (Tables 1, 2, 4). No significant differences were found in appearance of glycogen particles (Table 4), proventricular glands, salivary glands as well as mesenteric and caecal cell granulation.

DISCUSSION

The results confirm the elevation of SA due to cold acclimation in *Galumna elimata* observed in previous experiments with this species (Šustr & Starý, 1998), in potworms (Enchytraeidae) (Šustr, in prep.) and in some springtails (Collembola) (Urbášek & Rusek, 1994; Šustr & Block, 1998). However, this response was not observed in the midgut of the millipede *Glomeris hexasticha* (Diplopoda) (see Urbášek & Tajovský, 1991). In the terrestrial isopod *Porcellio scaber* (Isopoda), a similar level of hepatopancreatic protease was found in animals acclimated to 20 and 8.6°C (Precht et al., 1973). In insects, the thermal compensation of digestive enzyme activity is often modified by factors other than temperature. Salivary gland amylase of females of the cockroach *Periplaneta americana* showed ideal compensation, but inverse acclimation in males (Das & Das, 1982). In the cerambycid beetle *Morimus funereus* compensation, restricted to certain seasons of the year, was observed in both amylase and protease activity (Ivanović et al., 1987).

Temperatures between –1 and 5°C occur in the habitat of *Galumna elimata* for about four months (from December to April). The time of acclimation used in our experiments corresponded to the duration of temperature changes in nature. Animals collected in March and April (SC) are cold adapted similar to our cold acclimated group. The differences of SA between SC and AT5 probably reflected the impact of rearing at constant temperatures. There are no field data on locomotion and feeding activity of this species. Our microanatomical observations showed very low food consumption of mites reared at 5°C. The adaptive importance of elevation of amylolytic activity after long exposition to cold is not understood.

Because the bodies of oribatid mites are small, whole body homogenates were used in the experiments. The changes in weight specific amylolytic activity may be influenced by many indirect factors. It is not possible to explain the increase of SA due to cold adaptation only as the passive consequence of the decrease in non-proteinous compounds (for example body water, lipids and sugars). Body weight decreased during cold adaptation, but SP decreased and the number of glycogen granules increased slightly. Oribatid mites have food available throughout the year and there is no selection pressure on them to build up any reserves (Wallwork, 1975). The oribatid mite *Damaeus onustus* does not demonstrate any ability to convert assimilated food into fatty storage material. This was deduced from the constant calorific equivalents of their bodies (Wallwork, 1975). The increase of PSA indicated an increase in the proportion of amylolytic enzymes in total proteins or qualitative changes of catalytic efficiency of amylases, in cold adapted *Galumna elimata.*

The increase in the proportion of amylase was connected to the synthesis of amylolytic enzymes, or resulted from decrease of protein content excepting amylases (the catalytic efficiency of amylase is assumed to be un-

TABLE 4. Microanatomical features of the mesenchymal tissues of *Galumna elimata.*

Group	Mesenchymal tissue					
	Amount of glycogen particles					Guanin presence
	n	0	1	2	3	
SC	18	44	6	33	17	17
AT5	26	35	35	15	15	38
AT15	35	49	11	26	14	3
AT20	42	55	31	5	9	12
χ^2		1.92	10.17***	9.62***	0.82	15.1***

Experimental groups (SC, AT5, AT15 and AT20), χ^2, ***, and n as in Table 1.
Rows headline: 0 (absence), 1, 2 and 3 represent levels of semiquantitative scale.

changed). The digestion of food proceeds in the mesenteron, whereas colonal and rectal cells resorb mainly water in oribatid mites (Smrž & Čatská, 1989). Apocrine secretion of mesenteric and caecal cells is assumed to be connected with production of digestive enzymes. The mucoid substances, probably containing digestive enzymes, are secreted by passage through the cell surface (Hughes, 1950). The dark granulation within gut wall cells and the apocrine secretion into gut lumen may indicate increasing release of some substances or the intensive absorption of nutrients (Smrž & Čatská, 1989). The cells of the mesenteron and caeca are rich in rough endoplasmic reticulum, but no conventional secretory glands are evident in *Phthiracarus* sp. (Dinsdale, 1974). The lower apocrine secretion of cells of the gut wall in the mesenteron as well as in the caeca observed in our cold-acclimated animals is in contradiction with the assumption of increased amylase secretion. A few other sites of production of digestive amylases may be taken into account. The salivary glands may secrete some form of digestive enzyme, but the saliva itself is probably most important as a means of lubrication (Dinsdale, 1974). The glands were variable in their form. However, no correlation between the form (indicating some possible differences in saliva production) and acclimation type was found. Proventricular glands, described as paired organs composed of dark granules, appear absent even in some individuals of the same species and the same population. Knowledge about the structure and function of these organs is rather limited (Ludwig et al., 1992). No correlation between acclimation temperature and the occurrence of these organs was observed in *Galumna elimata.* The increase in amylase activity is assumed to be passive consequence of changes in protein composition rather then as a result of active production of amylase. In insects, changes in enzyme activity occur in relation to food intake (Janda, 1974; Varis et al., 1983; Chapman, 1985; Teo & Woodring, 1989). Enzymes may be induced directly by certain components of food, changes in their activity may be modified hormonally (Applebaum, 1985). In the mite *G. elimata* a smaller amount of food was ingested during cold acclimation, the ingestion of the offered food (*Protococcus* algae) and gut filling was lower. Therefore the increase of SA was probably not caused by control of enzyme synthesis by certain components of the food. Some type of negative feedback control regulation (the increase of digestive enzyme activity to more efficiently digest a nutritionally poor food to prevent starvation) is more probable. This type of regulation may be useful for animals living in environments with continuous food supply, as is presumed for oribatid mites (Wallwork, 1975). The observed lower food intake in cold was not necessarily accompanied by starvation in the energetic sense of the word, because the metabolic rate, and consequently the need for energy, is lower in cold (this assumes that metabolic rate is not perfectly compensated after acclimation in this species).

The developmental rate of mites decreases with decreasing temperature (Lebrun & Ruymbeke, 1971; Lebrun, 1974). All structural changes connected to growing old in adult mites will be therefore faster at high temperature. The changes may be connected with a change of the body composition, leading to lowering of such parameters as weight-specific respiration rate or protein-specific enzyme activity. However, there is no information about changes in body composition during the lifetime of adult oribatid mites.

The elevation of various physiological activities (mainly respiration rate) due to cold acclimation is often interpreted as compensation for low temperature (Precht et al., 1973). The interpretation is not acceptable in our case because:

(1) there is probably a difference between enzyme activity measured in vitro in optimal reaction conditions and real activity in the gut of the living animal. Enzyme assays may be conducted with homogenates maintained at the optimum temperature, pH and ionic concentration for a particular enzyme, but it is impossible to reproduce situation existing in the gut of the living animal. Certain conditions, notably the removal of the products of the reaction, do not occur in vitro (Dinsdale, 1974);

(2) observed changes in amylolytic activity may be explained more simply as a random consequence of changes in body protein composition connected, for example, with different rates of growth at different temperatures;

(3) no quantitative energy budget of oribatid mites at low temperature is known. It is not clear if any compensation of digestive activity is needed at low temperature because the food consumption is lower under cold conditions and consequently the feeding intensity is not compensated.

To evaluate the ecophysiological importance of the observed changes we need additional information about the internal environment in the gut in vivo and about the energy intake of mites at different temperatures. It is necessary to conduct experiments with reacclimation to test the reversibility of the acclimation response after elevation of temperature. The changes in the digestive activity of oribatid mites due to acclimatisation may influence comparisons of the digestive enzyme's activity in different species. The changes may theoretically influence all calculations of the annual decomposition of soil organic matter by microarthropods. Seasonal changes in abiotic conditions and acclimation history must also be taken into account.

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