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Biology and metabolism of *Glyptonotus antarcticus* (Eights) (Crustacea: Isopoda) from Admiralty Bay, King George Island, Antarctica

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Abstract: The *Glyptonotus antarcticus* population of Admiralty Bay is characterised by the wider range of body sizes than that from the Signy Island region. The sex ratio is similar in both populations. Females of all development stages were captured in Admiralty Bay between March and November, which confirms the lack of seasonal variation in the developmental cycle of this species. Eggs were found in marsupia of females measuring 75 mm and more. The relationship between the wet weight (Ww) and the total body length (TL) is similar for immature females and males, equalling $Ww = 0.0154\,TL^{3.18}$ and $Ww = 0.0054\,TL^{3.42}$, respectively. In the annual cycle, the basic metabolism ratio ($a = R/Ww^{0.77}$) of *G. antarcticus* is lowest in September and does not change significantly during the daily cycle. Two-, four- and six-week long starvation reduces the metabolism level by 30%, 51% and 71%, respectively. Glutamic acid at the concentration of 10 mmol increases the metabolism by half, both in animals starved for 2 weeks and in freshly captured individuals. Exposure to kynurenic acid at the concentration 0.1 mmol blocks further reactions to the glutamic acid.

key words: Antarctica, *Glyptonotus antarcticus*, metabolism, chemoreception

Introduction

Glyptonotus antarcticus (Eights) is a large marine Chaetiliid isopod, which is one of common species in Antarctic waters. It has been recorded at South Georgia, South Orkneys and South Shetland Islands, the Antarctic Peninsula, and the Ross Sea in the bathymetric range from the littoral level to 585 m (Dearborn, 1967). In Admiralty Bay (South Shetlands) *G. antarcticus* is common between depths of 30 and 90 m (Arnaud *et al*., 1986) but it is most abundant at the depth of 30 m, where it plays an important role as the dominant species in the assemblages of necrophagous invertebrates (Presler, 1986). This isopod is a scavenger and predator, and also shows cannibalistic behaviour. Its diet consists of a wide variety of prey, including an unusually high, for isopods, percentage of echinoderms, as well as ophiuroids, gastropods, isopods, and pelecypods (Dearborn, 1967).

Based on our studies of tropho-chemoreception in antarctic necrophagous and predatory invertebrates, we know that glutamic acid is one of the basic aminoacids acting as a chemical signal that informs animals about a food source. Its 10 mmol

solution increases the level of metabolism in Amphipoda: *Abyssorchonmene plebs* (Janecki and Rakusa-Suszczewski, 2004), *Cheirimedon femoratus* and *Orchomonella rotundifrons* (Rakusa-Suszczewski *et al*., 1999), *Bovalia gigantea* (Kidawa, 1999), as well as in the starfish *Odontaster validus* (Janecki and Rakusa-Suszczewski, 2003).

The aim of this study is to elucidate elements of biology, metabolism and chemoreceptive reactions to glutamic acid in the necrophagous isopod *G. antarcticus*.

Materials and methods

Specimens of *Glyptonotus antarcticus* were collected from Admiralty Bay between the 8th of March and 2nd of November 2001. Two methods were used: SCUBA diving from the sea floor (gravel and sand-mud matrix) and bottom drag nets at the depth of 5–15 m. In total, 176 specimens were captured: 99 males, 54 females and 23 juvenile animals for which their gender was not identified. The total body length was measured from the antreo-dorsal edge of the body to the posterior tip of the pleotelson, and the width was measured as the maximum dimension of the fourth free thoracic somite. The wet weight (Ww) was measured by weighing specimens on analytic scales with the precision level of 0.01 g. Respiration experiments were carried out at the Polish Antarctic "Henryk Arctowski" Station (King George Island, South Shetlands, Antarctica).

Oxygen consumption was measured for 153 *G. antarcticus* individuals which were identified by sex. In order to check seasonal variation, oxygen consumption levels were measured for freshly-captured animals every two months. Daily variation was measured on September 21st, every 4 hours for 24 hours. Between March and May, metabolic reactions of *G. antarcticus* specimens were measured for the following concentrations of glutamic acid: 10 mmol, 1 mmol, 0.1 mmol and 0.01 mmol. Oxygen consumption levels were also measured in the presence of 0.1 mmol kynurenic acid and the influence of a 2-hour long exposure of animals to kynurenic acid on their future reactions to 10 mmol glutamic acid was investigated. Captured animals were kept in refrigerated aquaria in sea water at a temperature of $0 \pm 0.1^{\circ}C$. In our study, some animals were starved for up to 2, 4 and 6 weeks. The control group consisted of freshly caught animals after 24 hours acclimatisation. Selected animals were put into temperature-controlled, closed plastic chambers (volume 1460 m*l*) filled with well-aerated sea water with salinity of 34.2‰ and temperature $0 \pm 0.1^{\circ}C$. To ensure stable thermal conditions all chambers ware submerged in a 700 dm^3 water container. Two control chambers were used in all variants. Oxygen content in the water was measured after two hours exposure using an oxygen sensor (WTW-OXI 197, Germany) equipped with a magnetic rotor. The value of basic metabolism was calculated according to the formula

$$a = R/Ww^{0.77},$$

where R is respiration ($mgO_2\,ind^{-1}\,h^{-1}$), and Ww is wet weight (g).

Statistical differences between variants of experiments with amino acids were detected with Student's *t*-test and differences in seasonal and diurnal changes of metabolism were compared using ANOVA and the Tukey HSD test.

Results

Morphometry

Morphometric features of 176 individuals (99 males, 54 females and 23 juveniles) of *Glyptonotus antarcticus* from Admiralty Bay were analysed. The total body length (TL) of all the captured individuals ranged between 12 and 111 mm, while their wet weight (Ww) varied from 0.48 to 54.2 g (Table 1). The sex ratio (♂ : ♀) was 1 : 0.54.

Table 1. Morphometry of *G. antarcticus* individuals from Admiralty Bay.

	n	TL-total length (mm)		B-breadth (mm)		Ww-wet weight (g)		Ratio TL/W
		range	mean±SD	range	mean±SD	range	mean±SD	
Total	176	12–111	57±11	6–51	27±5	0.5–54.2	14.0± 8.0	2.13±0.06
Juvenile	23	12– 21	15± 1	6–10	7±0	0.5– 1.1	0.7± 0.1	2.17±0.01
Male	99	40–111	81±20	20–51	38±8	2.4–54.2	22.4±13.2	2.14±0.09
Female	54	47– 93	76±13	22–47	36±7	3.5–43.0	18.9±10.7	2.09±0.09

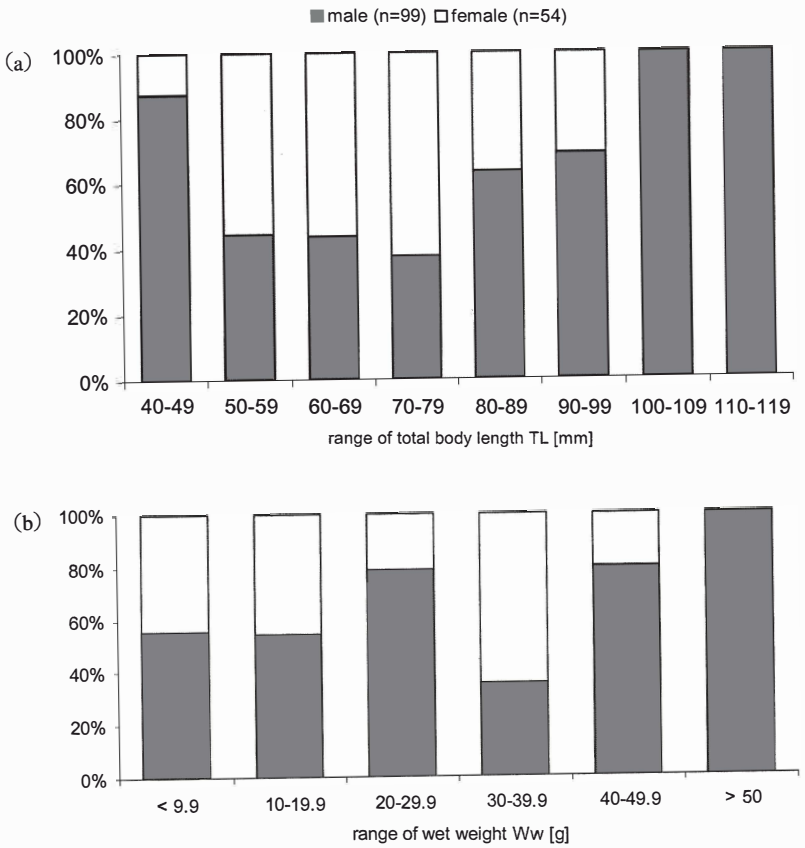


Fig. 1. Distribution of total body length (TL) (a), and wet weight (Ww) (b) of *G. antarcticus*.

The average body length of females was 5 mm (7.5%) shorter than that of males, while the average breadth of the body (B) was similar for both sexes. Males were heavier than females by 3.5 g (15.6%) on average. All *G. antarcticus* individuals with body length larger than 100 mm and wet weight of more than 50 g were males (Fig. 1a and 1b). The range of breadth for *G. antarcticus* was 6–51 mm, 20–51 mm for adult males, and 22–47 mm for adult females (Fig. 2a, 2b and 2c), with the average value 33.8 mm. The largest fraction (11%) consists of animals with body breadth of 42 mm. The proportion of body length to its breadth (TL/B) was, on average, 2.13 : 1, *i.e.* 2.14 : 1 for males and 2.09 : 1 for females.

The relationship between the wet weight (Ww) measured in miligrams and the total body length (TL) in milimetres in the *G. antarcticus* population of Monsimet Cove may be described by the following regression formulae (Fig. 3a, 3b and 3c):

- for juveniles (no gender identified) $Ww = 15.90\,TL^{1.38}$
- for males $Ww = 0.0054\,TL^{3.42}$
- for females without the fully-formed marsupium $Ww = 0.0154\,TL^{3.18}$
- for egg- or larva-bearing females $Ww = 0.0023\,TL^{3.65}$

Throughout the study, *i.e.* from April to October, 2001, *G. antarcticus* females of all developmental stages (from juvenile females without the marsupium, through those bearing eggs or larvae to females with empty marsupia, right after their larvae had been released) were captured in Admiralty Bay (Table 2). Eggs were found in marsupia of females larger than 75 mm TL (see Fig. 3c).

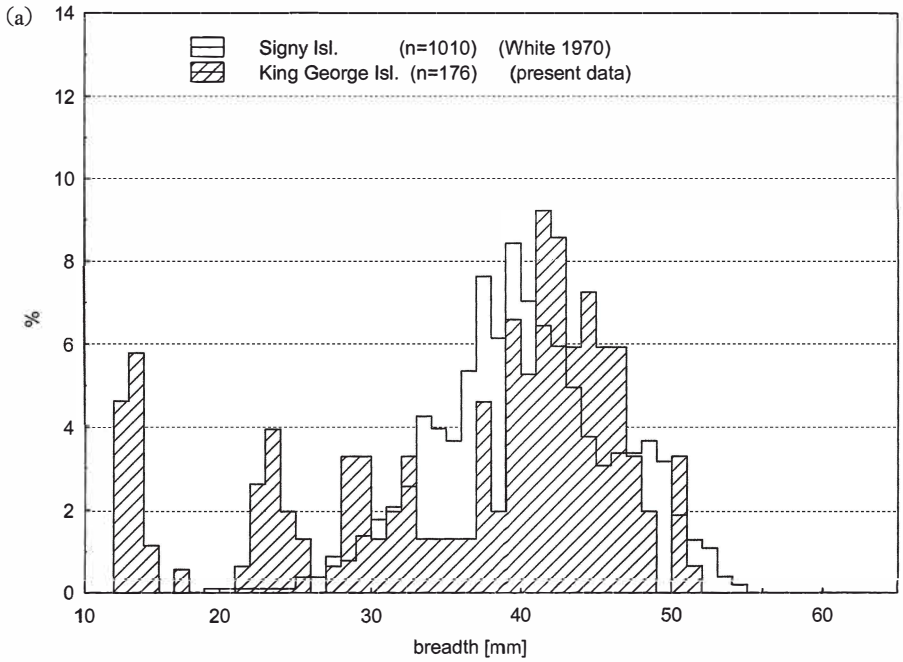
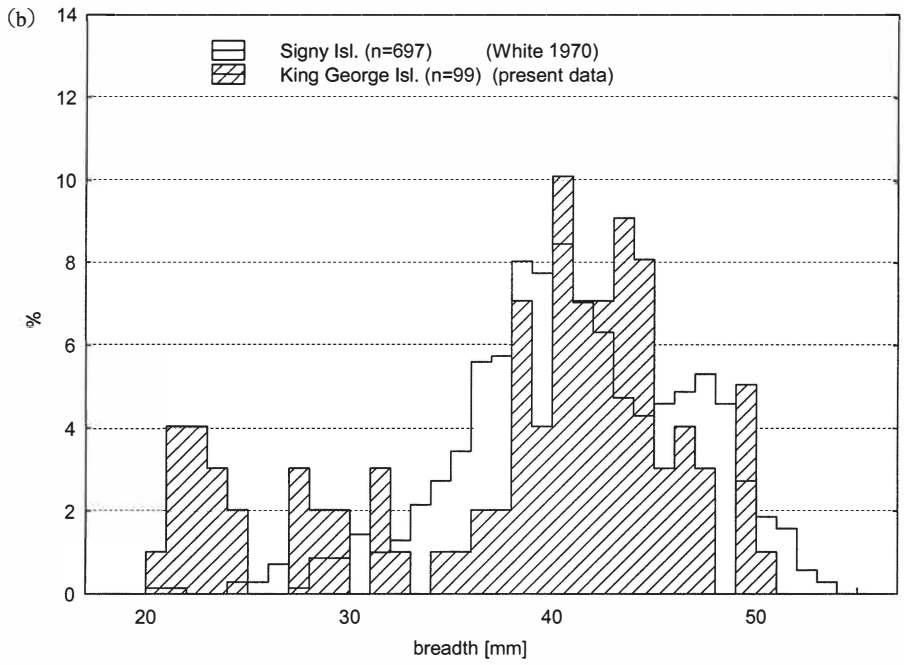


Fig. 2. Range of breadth of *G. antarcticus* (total) (a), males (b) and females (c) from King George Island and Signy Island region.



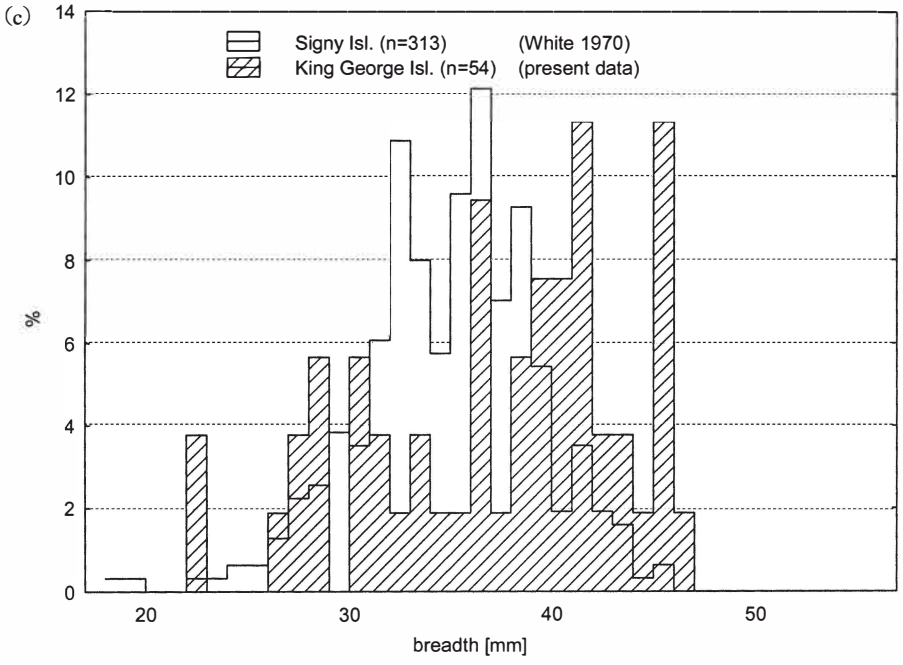


Fig. 2. Continued.

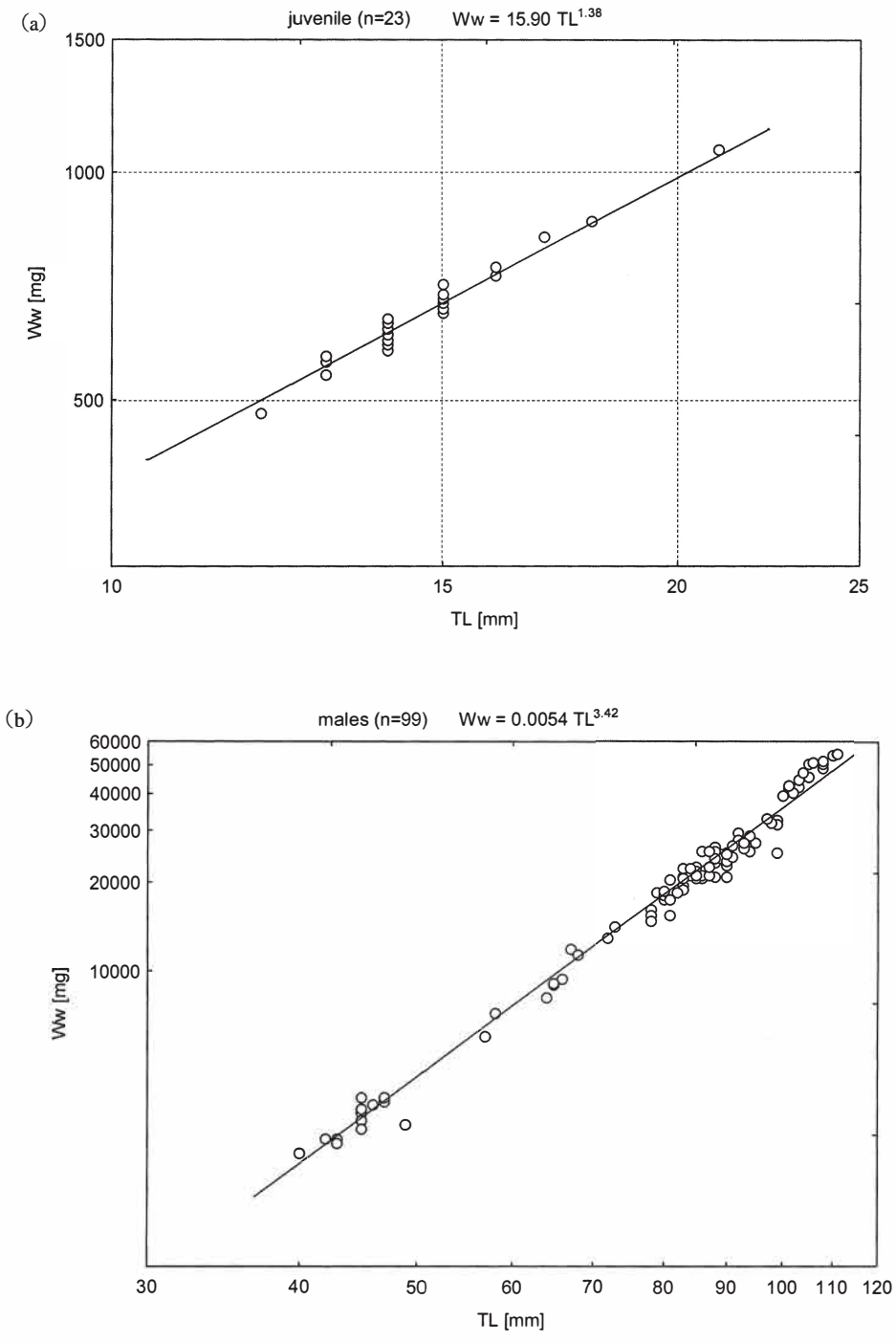


Fig. 3. Relationship between wet weight (Ww) and total body length (TL) for juveniles (a), males (b) and females (c) of *G. antarcticus* from King George Island.

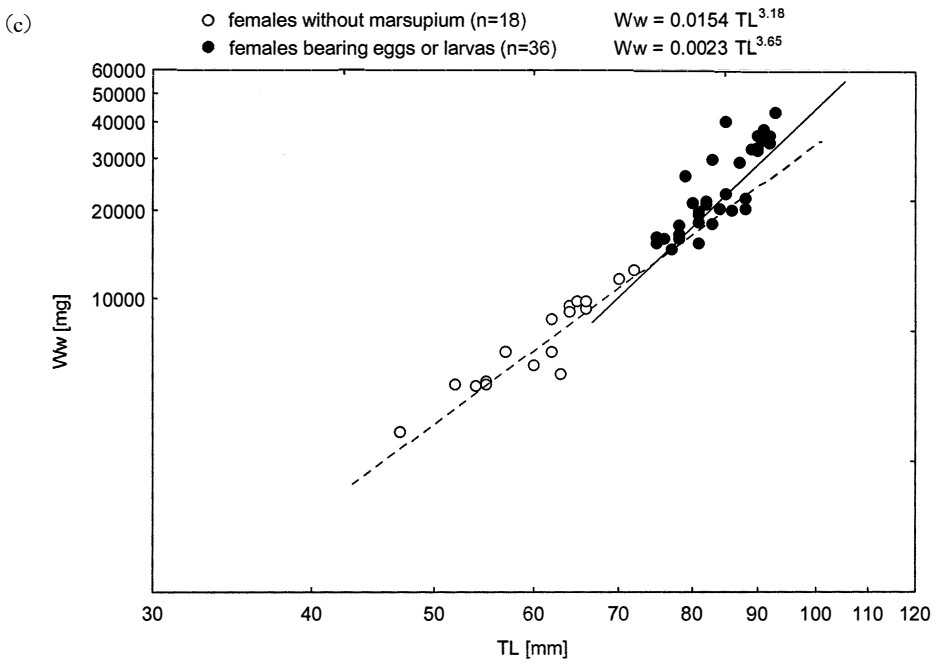


Fig. 3. Continued.

Table 2. Number of females of *G. antarcticus* in different developmental stages in Admiralty Bay in 2001.

Stages	April	May	June	July	Aug.	Sep.	Oct.
Without fully-formed marsupium	—	10	6	—	6	7	—
Bearing eggs in marsupium	—	3	—	1	1	2	1
Bearing larvae in marsupium	2	6	1	1	—	1	1
After release of larvae	1	1	—	—	—	—	—

Seasonal and diurnal variation in metabolism

Between March and May, the relationship between the respiration level and the wet body weight in freshly-caught *G. antarcticus* can be described by the formula: $R = 0.068\ Ww^{0.77}$. The basic metabolism level ($a = R/Ww^{0.77}$) of individuals with the wet weight 32.0 ± 5.1 g was, therefore, 0.070 ± 0.012. A decrease in basic metabolism levels was noted in September (ANOVA $F4.36 = 13.46$, $P < 0.001$). For individuals with the average wet weight of 33.7 ± 3.6 g it equaled 0.040 ± 0.011 (Fig. 4). Metabolism levels in other months (March, May, July and November) did not differ in a statistically significant way (Tukey HSD test, $P < 0.05$).

In September, throughout one day, the level of basic metabolism in animals of $Ww = 33.2 \pm 5.4$ g was measured every 4 hours and did not differ significantly (ANOVA $F5.35 = 2.18$, $P = 0.078$) (Fig. 5).

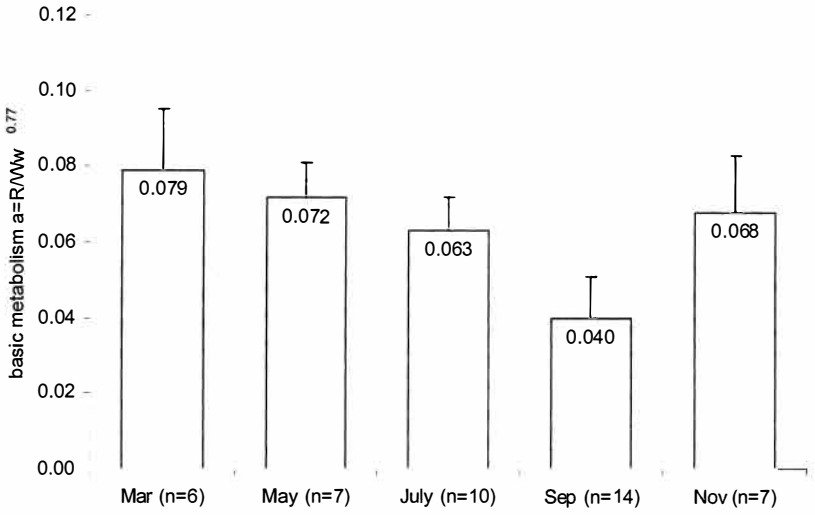


Fig. 4. Seasonal changes of basic metabolism of *G. antarcticus* (range 30.5–33.7 g of Ww).

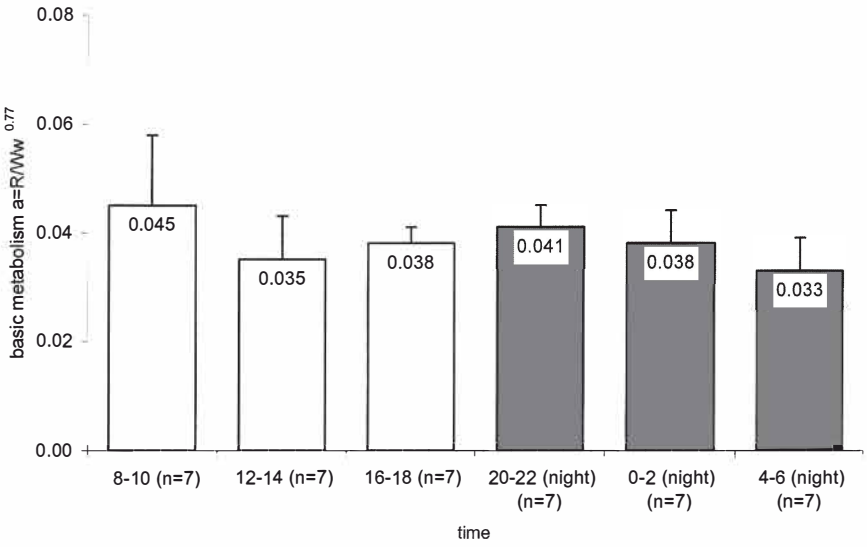


Fig. 5. Diurnal changes of basic metabolism of *G. antarcticus* (20–21 Sep. 2001).

Chemoreception

The level of metabolism in freshly-caught *G. antarcticus* specimens was higher (Fig. 6) than in those starved for 2 weeks. The dependency between the wet weight and respiration was slightly different in both these groups, equaling $R = 0.068\,Ww^{0.77}$ and $R = 0.052\,Ww^{0.73}$, respectively (Fig. 7). Two weeks of starvation decreased the basic metabolism level by, on average, 29%, 4 weeks—by 52% and 6 weeks—by 71% (Fig. 6). Among freshly-caught specimens, 10 mmol and 1 mmol glutamic acid led to an

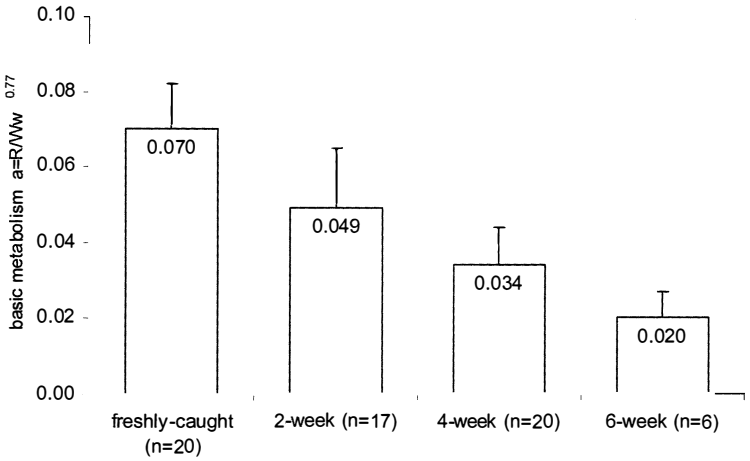


Fig. 6. Changes of basic metabolism during starvation of *G. antarcticus*.

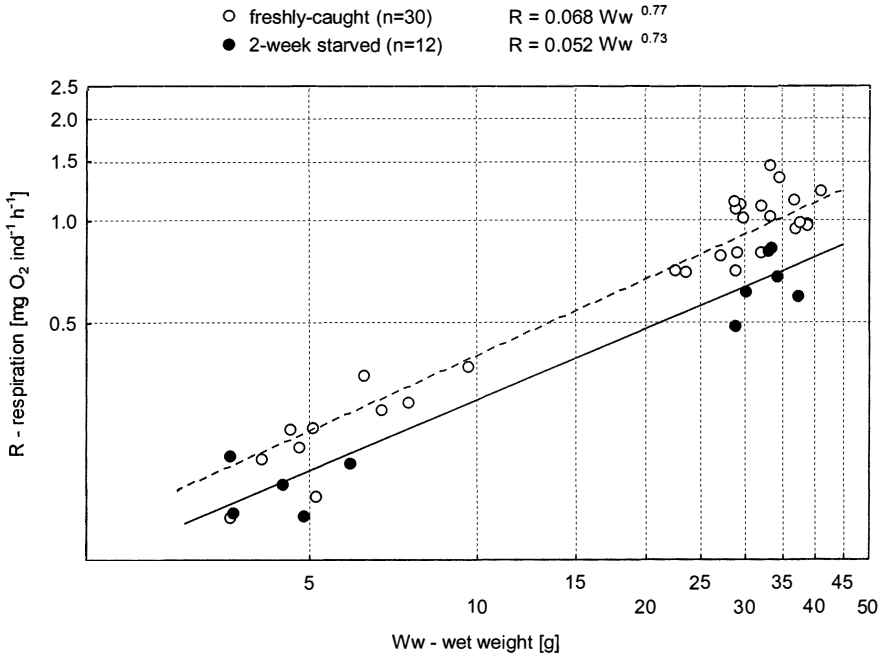


Fig. 7. Relation between wet weight (Ww) and respiration (R) for freshly-caught and 2-week starved *G. antarcticus*.

increase in respiration by 63% and 20%, respectively (Fig. 8), while in those starved for 2 weeks both concentrations led to a 45% increase (Fig. 9). Addition of 0.1 mmol and 0.01 mmol solutions did not cause statistically significant changes in metabolism (Student-*t* test, $P > 0.05$). Two hour-long exposure of animals (both freshly-captured

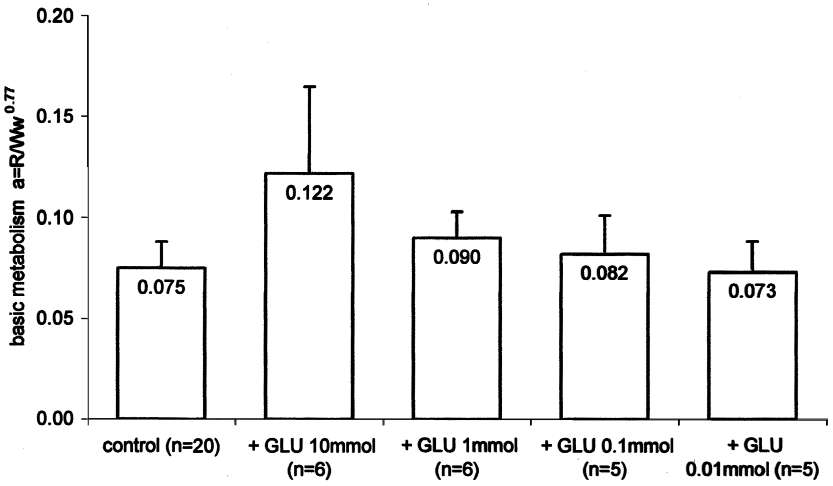


Fig. 8. Influence of glutamic acid solutions on basic metabolism of freshly-caught *G. antarcticus*.

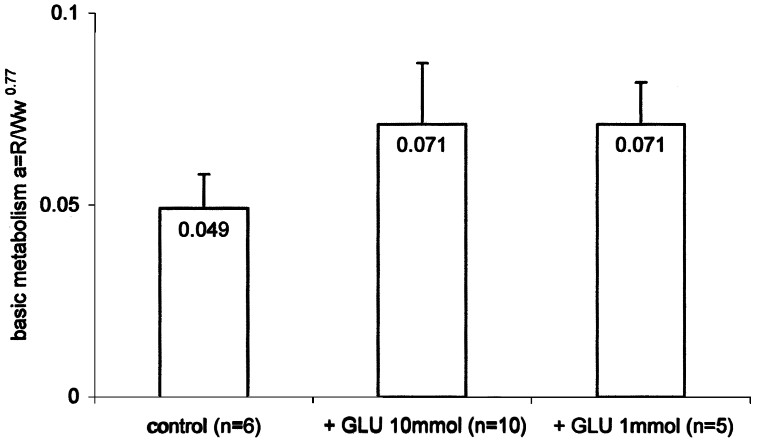


Fig. 9. Influence of glutamic acid solutions on basic metabolism of 2-week starved *G. antarcticus*.

and starved ones) in a 0.1 mmol kynurenic acid solution blocked their further reaction to glutamic acid (Fig. 10) and kept respiration levels at a value not differing statistically from the control (Student-*t* test, $P > 0.05$). Kynurenic acid alone at the concentration of 0.1 mmol did not cause any statistically significant changes in the metabolism of *G. antarcticus* individuals used in this study (Student-*t* test, $p > 0.05$) (Fig. 11).

Discussion

Glyptonotus antarcticus individuals captured in 2001 in Admiralty Bay (King George Island, South Shetlands) had a slightly larger range of body sizes than animals

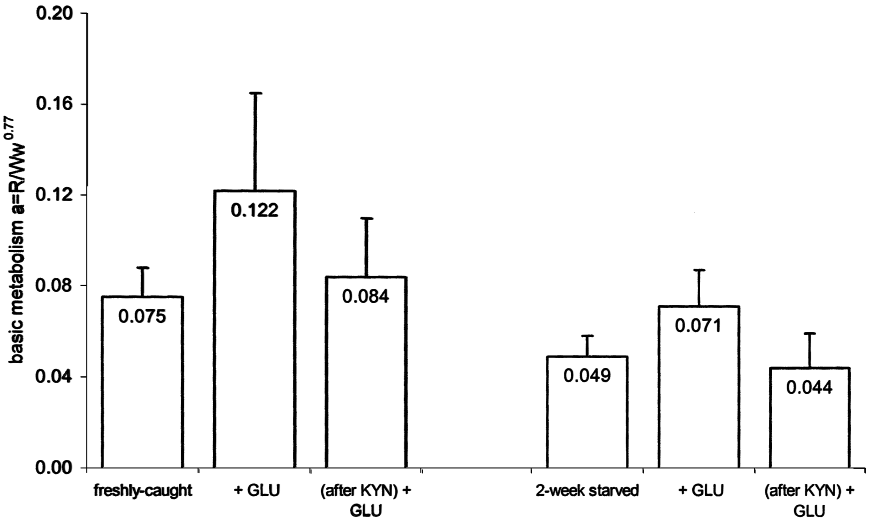


Fig. 10. Blocking effect of kynurenic acid (0.1 mmol) or glutamic acid (10 mmol) in freshly-caught and 2-week starved *G. antarcticus*.

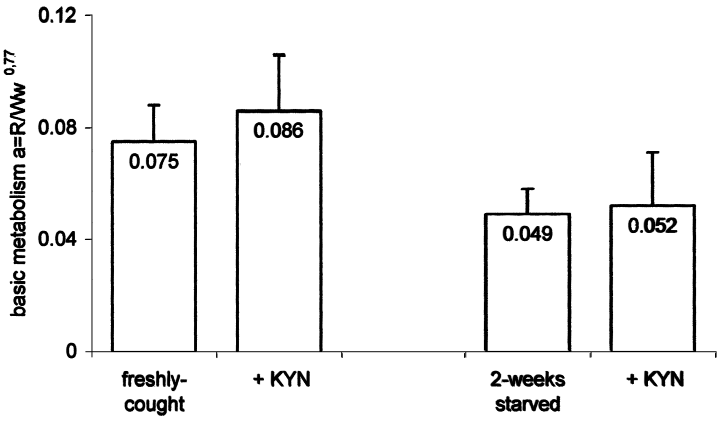


Fig. 11. Influence of kynurenic acid (0.1 mmol) on basic metabolism of freshly-caught and 2-week starved *G. antarcticus*.

from the Signy Island region (White, 1970). In order to compare their sizes, body width was used, as it is a parameter more stable than body length which can change slightly depending on the content of body fluids in body cavities (White, 1970). The average body breadth of Admiralty Bay specimens was 5 mm (15%) shorter than that of Signy Island ones. However, the percentage of small males (20–30 mm) and large females (40–50 mm) was higher in Admiralty Bay. In terms of sex ratio, Admiralty Bay and Signy Island populations are similar in that males dominate. The proportion of males to females was 1.8 : 1 in Admiralty Bay and 2.0 : 1 on Signy Island (2.3 : 1 for animals

caught by hand and 1.7 : 1 for those captured in a baited trap) (White, 1970). These proportions are profundly different from those found at McMurdo, where females were more than six times more numerous than males (1 : 6.6) (Dearborn, 1967).

At Admiralty Bay, body proportions are different for both genders. Females are wider than males; the ratios of body length to breadth are 2.09 : 1 and 2.17 : 1, respectively. Considering the average proportion of body length to breadth (2.17 : 1), *G. antarcticus* specimens from Admiralty Bay are wider than those at McMurdo, where that value varied between 2.26 : 1 and 2.64 : 1 (Dearborn, 1967) and slimmer than animals captured at Signy Island (2.05 : 1) (Key and Barnes, 1999).

The contents of marsupia of females caught in Admiralty Bay were at different developmental stags, which indicates that this species can breed succesfully throughout the year. The lack of seasonal variation in the *G. antarcticus* breeding cycle can be explained by the constant availability of food for this necrophagous species (White, 1970). According to White (1975), *G. antarcticus* females reach maturity at an average body width of 41.4 mm, which may be influenced by hydrological and trophic conditions. According to our observations at Admiralty Bay, *G. antarcticus* females attempt to breed earlier. The smallest female carrying eggs in the marsupium was 32.5 mm wide and 75 mm long.

The metabolism level of *G. antarcticus* depends on the wet weight according to the equation: $R = 0.098\,Ww^{0.77}$. The value of the "b" exponent is similar to the results obtained for other antarctic crustaceans: $b = 0.70$ for *Waldeckia obesa* (Janecki and Rakusa-Suszczewski, 2004) and $b = 0.79$ generally for Amphipoda at 0°C (Rakusa-Suszczewski, 1990). The starvation period also has a significant influence on the basic metabolism of *G. antarcticus.* After two weeks of starvation, it decreases by 30%, which is close to the values that we had previously obtained for other antarctic crustaceans: *Abyssorchomene plebs*—a decrease of 45% (Janecki and Rakusa-Suszczewski, 2003) and *Waldeckia obesa*—a 30% decrease after 10 days of starvation (Janecki and Rakusa-Suszczewski, 2004). Prolongation of the starvation period to 6 weeks (42 days) causes a 70% decrease in metabolism, while for *W. obesa* a 66% decrease was found after 30 days (Janecki and Rakusa-Suszczewski, 2004), which may signify higher resistance of *G. antarcticus* (a much larger species than previously studied) to shortage of food.

On the basis of our earlier results (Rakusa-Suszczewski *et al*., 1999; Janecki and Rakusa-Suszczewski, 2004; Kidawa, 2000), we know that glutamic acid plays an important role in the water environment, acting as a chemical signal that informs animals about the availability of food. It increases the metabolism rate and changes the behaviour of animals. Its 10 mmol solution increases the level of *G. antarcticus* metabolism from 45 to 63%, depending on the length of the starvation period. This may be compared to results for other antarctic marine invertebrates: starved *Bovalia gigantea* show an increase of 82% (Kidawa, 1999) and *Abyssorchomene plebs*—300% (Janecki and Rakusa-Suszczewski, 2004). An increase in the metabolic rate caused by the chemical information provided by a higher concentration of glutamic acid in the environment may connstitute a way in which the animal prepares its energy resources for food searching and consumption.

Kynurenic acid is known as an antagonist for receptors of activated amino-acids (Talman, 1989; Kapoor *et al.* 1994) and for overall excitability in the central nervous

system (Stone *et al*., 1987). In neurophysiology, it is widely used for blocking glutamine receptors (Takemoto, 1999). It blocks reactions to glutamic acid in *A. plebs* (Janecki and Rakusa-Suszczewski, 2004), *Branchinecta gaini* (Kidawa, 2000), *Odontaster validus* (Kidawa, 2001) and in *G. antarcticus* studied here. Blocking of glutamine receptors in *G. antarcticus* by kinurenic acid allows us to conclude that glutamic acid at the 10 mmol concentration serves for these animals as a source of information only and not as a food substrate.

Conclusions

1) *Glyptonotus antarcticus* specimens from Admiralty Bay, King George Island (2001) were smaller on average than individuals from the Signy Island region (1966–1968). But the percentage of small males and large females was higher in Admiralty Bay.
2) Females in all developmental stages were captured in Admiralty Bay from March to November, which confirms the lack of seasonal variation in the developmental cycle of this species.
3) The relationship between the wet weight (Ww) and the total body length (TL) was similar in immature females and males, equalling $Ww = 0.0154\ TL^{3.18}$ and $Ww = 0.0054\ TL^{3.42}$, respectively.
4) In the annual cycle, basic metabolism levels for *G. antarcticus* were lowest in September and they did not change significantly during the day. 2-, 4- and 6-week long starvation decreased these levels by 30%, 51% and 71%, respectively.
5) Glutamic acid at the 10 mmol concentration increase metabolism of both freshly-caught and 2 weeks starved animals by approximately half.
6) Exposure to 0.1 mmol kynurenic acid blocks future reactions to glutamic acid.

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References

Arnaud, P.M., Jażdżewski, K., Presler, P. and Siciński, J. (1986): Preliminary survey of benthic invertebrates collected by Polish Antarctic Expedition in Admiralty Bay (King George Island, South Shetland Islands, Antarctica). Pol. Polar Res., **7** (1–2), 7–24.

Dearborn, J.H. (1967): Food and reproduction of *Glyptonotus antarcticus* (Crustacea: Isopoda) at McMurdo Sound, Antarctica. Trans. R. Soc. N.Z. Zool., **8** (15), 163–168.

Janecki, T. and Rakusa-Suszczewski, S. (2003): Antarctic starfish *Odontaster validus* (Koehler 1911) reactions to glutamic acid (Glu) and kynurenic acid (Kyn). Abstracts of XXVI Symposium on Polar Biology, National Institute of Polar Research. Tokyo, 43.

Janecki, T. and Rakusa-Suszczewski, S. (2004): The effect of glutamic acid and kynurenic acid on the metabolism of the Antarctic Amphipod *Abyssorchomene plebs.* J. Crustacean Biol., **24** (1), 81–83.

Kapoor, V., Kapoor, R. and Chalmers, J. (1994): Kynurenic acid, an endogenous glutamate antagoniost, in SHR and WKY rats: possible role in central blood pressure regulation. Clinic Exp. Pharmacol.

Physiol., **11**, 891–896.
Key, M.M., Jr. and Barnes, D.K.A. (1999): Bryozoan colonization of the marine isopod *Glyptonotus antarcticus* at Signy Island, Antarctica. Polar Biol., **21**, 48–55.
Kidawa, A. (1999): Chemoreception in some Antarctic marine animals—preliminary results on glutamic acid. Polish Polar Studies, The 26th International Polar Symposium, Lublin June 1999, 345–348.
Kidawa, A. (2000): Chemoreception in *Branchinecta gaini* (Anostraca, Crustacea)—the impact of glutamic and kynurenic acids. Polish Polar Studies, XXVII Polar Symposium, 61–64.
Kidawa, A. (2001): Antarctic starfish, *Odontaster validus*, distinguish between fed and starved conspecifics. Polar Biol., **24**, 408–410.
Presler, P. (1986): Necrophagous invertebrates of the Admiralty Bay of King George Island (South Shetland Islands, Antarctica). Pol. Polar Res., **7**, 25–61.
Rakusa-Suszczewski, S. (1990): Respiration of *Orchomene plebs* (Hurley 1965) and *Waldeckia obesa* (Chevreux 1905) from Admiralty Bay (South Shetland Islands, Antarctica). Pol. Arch. Hydrobiol., **37**, 297–303.
Rakusa-Suszczewski, S., Kidawa, A. and Janecki, T. (1999): The effect of amino acids on the respiration and heart beat of necrophagous Antarctic amphipods. Pol. Arch. Hydrobiol., **46**, 3–8.
Stone, T., Connick, J.H., Winn, P., Hastings, M.H. and English, M. (1987): Endogenous excitotoxic agents. Ciba Found. Symp., **126**, 204–220.
Takemoto, Y. (1999): Kynurenic acid inhibits circulatory responses to intracisternally injected L-proline in concious rats. Neurosci. Lett., **261**, 121–123.
Talman, W. (1989): Kynurenic acid microinjected into the nucleus tractus solitarius of rat blocks the arterial baroreflex but not resonses to glutamate. Neurosci. Lett., **102**, 247–252.
White, G.M. (1970): Aspects of the breeding biology of *Glyptonotus antarcticus* (Eights) (Crustacea, Isopoda) at Signy Island, South Orkney Island. Antarctic Ecology, ed. by M.W. Holdgate. London, Academic Press, **1**, 279–285.
White, M.G. (1975): Oxygen consumption and nitrogen excretion by the giant Antarctic Isopod *Glyptonotus antarcticus* Eights in relation to cold-adapted metabolism in marine polar poikilotherms. Proceedings of the Ninth European Marine Biology Symposium, ed. by H. Barnes. Aberdeen, Aberdeen University Press, **1**, 707–724.