

SEXUAL SPECIFICITY OF THE COPPER CONTENT AND WEIGHT VARIATION IN *SADURIA ENTOMON* L.

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Abstract. The present article analyses the variation of copper concentration in the specimens of *Saduria entomon* L. of different sex relative to their size (age). For the specimens of the same size the copper concentration in females is higher than in males. Data on the variation of the dry and wet weight of *Saduria entomon* of different size relative to their sex are presented. The necessity of considering the sex of specimens when using *Saduria entomon* as an indicator organism for evaluating the state of the marine environment is shown.

Key words: *Saduria entomon*, copper, dry weight, sex.

INTRODUCTION

Saduria entomon L. is one of the indicator organisms recommended by HELCOM for evaluating the state of the marine environment. By now a rather extensive data set on the content of heavy metals in the species is available; however, the interpretation of the data is complicated due to their wide variation even for a limited area. Evidently, the impact of different size and age of organisms and their physiological state on the concentration of chemical elements should be considered here. In addition, the sex of specimens is also essential as significant metabolic and physiological changes occur in crustaceans with their sexual maturation.

MATERIAL AND METHODS

The material for this article was collected in different regions of the Gulf of Finland in 1991. The specimens of *Saduria entomon* were caught with dredges and baited nets (Haahtela, 1962, 1975). Separate samples were collected for determining the length—weight relationship and the copper content in *Saduria entomon*. Till the laboratory analysis the animals were cold stored in a freezer (-20°C).

The length of *Saduria entomon* was measured with the precision of 0.5 mm and the weight with the precision of 0.5 mg. The wet weight was determined by weighing the specimens after draining the sample. The animal was placed onto absorbent paper and rolled with forceps from the wet spots to dry parts of the paper until no more moisture was visible on the paper. The dry weight was determined after animals were dried to a constant weight at 80°C . The standard drying time of 12 ± 1 h was

used. To determine the copper content, the animals were dried at 105°C and homogenized in agate mortar. The aliquots of the samples were digested by concentrated nitric acid (superpure). The analyses were carried out by means of atomic absorption (AAS Perkin-Elmer 5000). For the determination of the copper concentration the flameless technique was used (HGA-500). The copper content was expressed in $\text{mg}\cdot\text{kg}^{-1}$ of dry weight.

The specimens of *Saduria entomon* were classified into juveniles and adults and their sex was determined by morphological characteristics (Haahtela, 1978). The length and dry and wet weight were measured for a total of 206 specimens. The copper concentration was determined in 160 specimens.

RESULTS

The length of all the analysed *Saduria entomon* specimens varied from 15 to 75 mm and their dry weight ranged from 28 to 1082 mg. A power function ($r=0.957$) describes the relationship between these two parameters (based on the value of correlation coefficient) somewhat better than a linear function ($r=0.933$). The equation of the corresponding curve (Fig. 1) is: $W=0.058\cdot L^{3.052}$, where W is dry weight in mg and L is length in mm. The relationship between the dry and wet weight is linear and statistically reliable ($r=0.933$; $n=206$). The water content in the specimens of *Saduria entomon* varies from 49.0% to 82.0% (average $68.4\pm\pm 6.3\%$) and does not depend on the size of specimens.

The sex of *Saduria entomon* was determined starting from 35 mm long specimens. The length of 105 analysed females varied in the range of 35 to 55 mm (average 42 ± 5 mm), that of males was from 35 to 75 mm (average 54 ± 9 mm). The variation limits of wet and dry weights were respectively from 406 to 2977 mg (919 ± 522) and 119 to 683 mg ($299\pm\pm 123$) for females. For males the corresponding values were 335 to 5054 mg (1920 ± 1055) and 109 to 1082 mg (562 ± 259). While considering

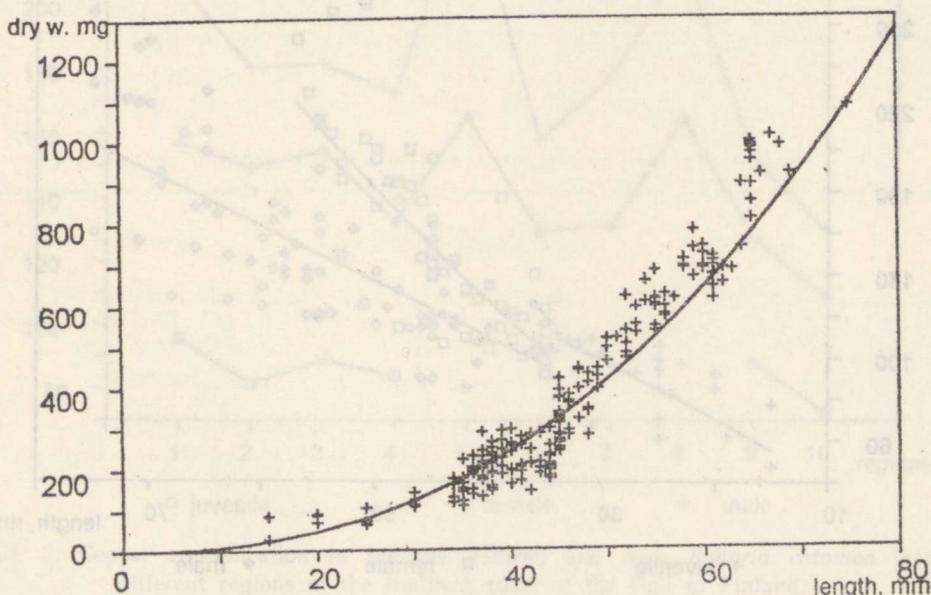


Fig. 1. Relationship between the length and dry weight of *Saduria entomon*.

separately the relationships between the length and dry weight of females and males, the linear function seems to describe these relationships rather well or even somewhat better than the power function. The correlation coefficients of the power and linear functions for females ($n=101$) are $r=0.851$ and $r=0.876$ and correspondingly for males ($n=82$) $r=0.962$ and $r=0.969$. Thus the growth of the dry weight of the specimens of both sexes is linear to the increase of their length. The dry weight of females is somewhat higher for up to 50 mm long specimens while that for bigger (over 50 mm) specimens is higher for the males. For the specimens of *Saduria entomon* with the length of 51.3 mm the dry weight is practically equal both for female and male specimens. The water content varies for females from 52.2% to 79.4% and for males from 49.0% to 82.0% and it practically does not depend on the sex. The average for females is $68.2 \pm 5.8\%$ and for males $69.3 \pm 6.6\%$.

The copper concentration in the analysed specimens of *Saduria entomon* varied within the range of 40.8 to 280.3 $\text{mg} \cdot \text{kg}^{-1}$ (average 141.2 ± 44.1 $\text{mg} \cdot \text{kg}^{-1}$). The copper concentration in young specimens (shorter than 35 mm) was essentially lower: on the average 85.4 ± 22.5 $\text{mg} \cdot \text{kg}^{-1}$ (with the limits from 40.8 to 127.2 $\text{mg} \cdot \text{kg}^{-1}$). The copper concentration in all the analysed female and male specimens was practically the same: in females 155.4 ± 40.8 $\text{mg} \cdot \text{kg}^{-1}$ and in males 148.9 ± 37.6 $\text{mg} \cdot \text{kg}^{-1}$. In general the copper concentration increases with the growth of the length of *Saduria entomon* for juveniles ($r=0.669$; $n=25$), females ($r=0.707$; $n=55$), and males ($r=0.729$; $n=80$). The corresponding linear functions are the following (y — copper concentration, $\text{mg} \cdot \text{kg}^{-1}$; x — length, mm):

$$y = 2.5055 \cdot x + 22.3422 \text{ (juveniles),}$$

$$y = 4.4010 \cdot x - 40.7669 \text{ (females),}$$

$$y = 2.4628 \cdot x + 13.7776 \text{ (males).}$$

On the basis of these curves (Fig. 2) we can conclude that the copper concentration is maximal and at the same time practically equal in the biggest specimens of both sexes: in the 55 mm females and 75 mm males.

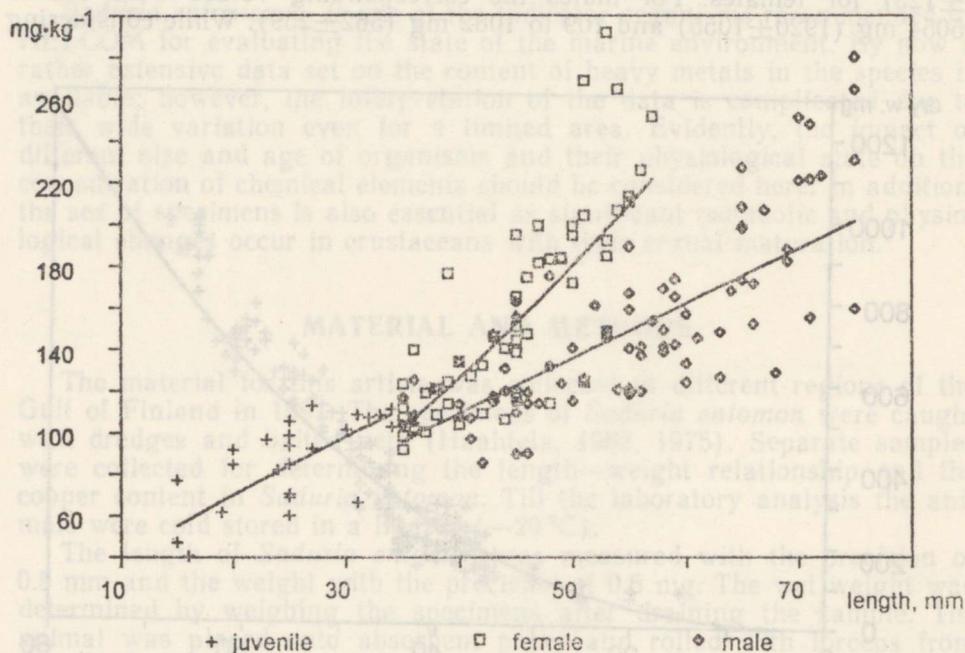


Fig. 2. Copper concentration in the juvenile, female, and male specimens of *Saduria entomon*.

Table 1 shows the copper concentration in the *Saduria entomon* in some regions of the southern coast of the Gulf of Finland. Based on these data it is difficult to evaluate the local differences of copper concentration in *Saduria entomon*. The wide variation range in copper concentration casts doubt on the validity of the conclusions drawn on the basis of the average data. It can be concluded with certain probability that the copper concentration is relatively higher in the region of Saka and Ihasalu bays

Table 1

Copper concentration in *Saduria entomon* at the southern coast of the Gulf of Finland

Area	mg Cu·kg ⁻¹ dry matter			
	Average	Std	Min	Max
Mouth of Neva Bay	163.9	41.6	105.6	264.7
Narva-Jõesuu	126.4	38.6	47.0	183.6
Sillamäe	129.4	57.2	60.2	251.6
Purtse	140.4	50.2	85.6	280.3
Saka	197.0	32.6	155.6	265.0
Käsmu	125.8	15.9	98.4	156.7
Eru	152.7	32.1	104.0	206.7
Ihasalu	199.4	55.9	100.4	292.0
Lahepera	120.9	21.4	93.6	171.6
Lohusalu	110.5	34.3	47.3	159.4

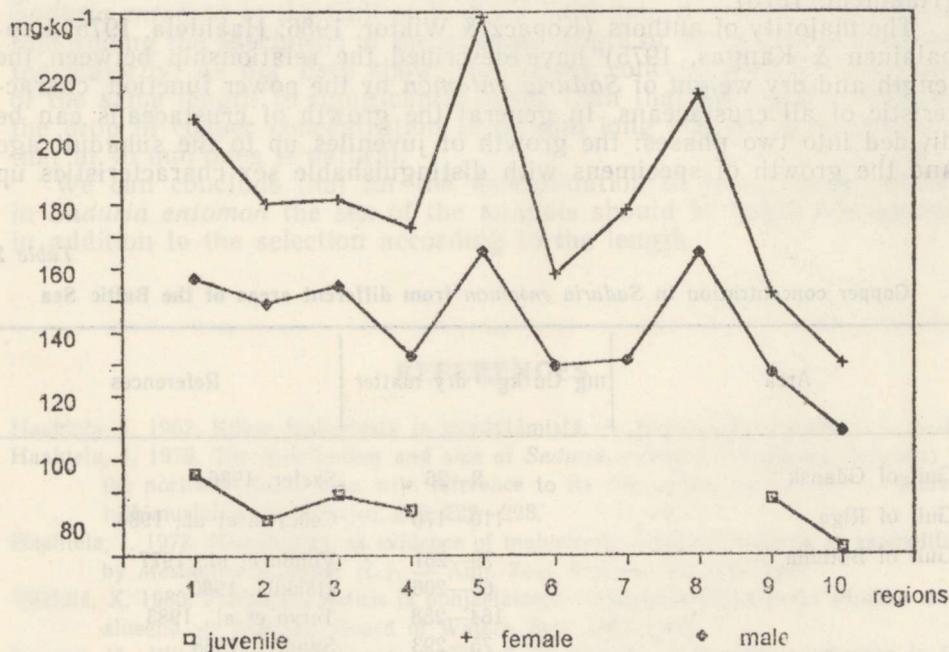


Fig. 3. Copper concentration in juvenile, female, and male *Saduria entomon* from different regions of the southern coast of the Gulf of Finland.

1 — mouth of Neva Bay; 2 — Narva-Jõesuu; 3 — Sillamäe; 4 — Purtse; 5 — Saka; 6 — Käsmu; 7 — Eru; 8 — Ihasalu; 9 — Lahepera; 10 — Lohusalu.

and random elevation of the concentration can be observed at the mouth of Neva Bay and the Purtse River. To get a more descriptive survey, the data were grouped according to the sex of specimens—juveniles, females, males. Further, considering the above relationships between the copper concentration and length of specimens, the copper concentrations in every group were considered for the constant length: juveniles 25 mm, females and males 51.3 mm. The results (Fig. 3) show clearly that both for males and females the copper concentration was the highest in the Saka region and at the mouths of Neva and Ihasalu bays. The lowest concentrations were identified in the western part of the Gulf of Finland, i. e. in the region of Lohusalu and Lahepera bays. The only difference is that for females the copper concentration in the Purtse region was higher than that in Eru Bay; males showed the contrary results. Thus, taking into account the size, age, and sex of the analysed specimens of *Saduria entomon* facilitates the interpretation of the results on copper concentration, including the evaluation of local changes.

DISCUSSION

The maximum length of *Saduria entomon* in different regions of the Baltic Sea varies in a relatively narrow range. For example, the maximum length of males and females in the southern part of the sea is 86 and 63 mm, in the Gulf of Bothnia 84 and 61 mm (Haahtela, 1962), and in the Gulf of Gdansk 79 and 56 mm (Kopacz & Wiktor, 1986), respectively. Our results on the maximum size of specimens, male 75 and female 55 mm, are somewhat lower than the data for the central part of the Gulf of Finland (81 and 61 mm, respectively), but can be compared with the results for the northern coast of the Gulf of Finland—78 and 54 mm, respectively (Haahtela, 1975).

The majority of authors (Kopacz & Wiktor, 1986; Haahtela, 1975; Lapalainen & Kangas, 1975) have described the relationship between the length and dry weight of *Saduria entomon* by the power function, characteristic of all crustaceans. In general the growth of crustaceans can be divided into two phases: the growth of juveniles up to the subadult age and the growth of specimens with distinguishable sex characteristics up

Table 2

Copper concentration in *Saduria entomon* from different areas of the Baltic Sea

Area	mg Cu·kg ⁻¹ dry matter	References
Gulf of Gdansk	9—26	Szefer, 1986
Gulf of Riga	110—170	Сейсума et al., 1984
Gulf of Bothnia	79—261	Voipio et al., 1977
	65—206	Häkkinen, 1980
	164—258	Tervo et al., 1983
	75—293	Sandler, 1983
Gulf of Finland	86—178	Sandler, 1986
	121—126	Voipio et al., 1977
	86—159	Volož et al., 1990
	40—280	Present study

to their final length. In the first phase they grow mainly in length, in the second the weight increases. Thus our linear relationship between the length and dry weight of *Saduria entomon* after the appearance of sex characteristics is regular. The dependence of the given relationship on the sex of the analysed specimens has been shown for *Saduria entomon* in the Gulf of Gdansk (Kopacz & Wiktor, 1986).

The copper content in *Saduria entomon* has been analysed in different regions of the Baltic Sea, mainly in the major gulfs (Table 2). Comparison of the data and explanation of local differences are complicated and the usual conclusion is that the concentration in different areas is practically of the same order. The data for the Gulf of Gdansk show exceptionally low copper content, but it is difficult to believe that it could really be so much lower in that region than in the other parts of the Baltic Sea. Several authors (Tervo et al., 1983; Sandler, 1983, 1984; Сейцма et al., 1984; Szefer, 1986) have presented data on the size (length) of *Saduria entomon*. Higher copper concentrations have usually been found in relatively bigger specimens of *Saduria entomon*. The data on the Gulf of Gdansk (Szefer, 1986), where the highest copper concentration was found in the specimens of the length of 30—40 mm, makes an exception again. Applying our results it can be shown that the variation of copper concentration in the specimens of *Saduria entomon* in the Gulf of Bothnia can be well explained with the variation of their length. The average copper concentrations in different length classes of *Saduria entomon* are the following (Sandler, 1983):

Length, mm	20	30	40	50	60	70	80
Copper concentration, mg·kg ⁻¹	128	148	153	147	157	161	189

A practically linear increase in the copper concentration with the growth of the length of *Saduria entomon* within the limits 25—40 mm and 50—80 mm can be seen. As the maximum length of the females of *Saduria entomon* in the Gulf of Bothnia is 61 mm, it is logical to presume that among the specimens of the average length of 50 mm the males make the majority. As our data show, the copper concentration for the males of the same length is significantly lower than that for females and thus the drop of copper concentration in 50 mm long specimens compared to that in 40 mm ones is natural.

We can conclude that for the determination of heavy metal content in *Saduria entomon* the sex of the animals should be taken into account in addition to the selection according to the length.

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Year	REFERENCES	Concentration
1983	Hanski I. 1983. Kallin eläimistö ja raskasmetallit. — Suomen Kalastuslehti, 1, 9—15.	
1978	Hanski I. 1978. The distribution and size of <i>Saburia entomon</i> (Crustacea, Isopoda) in the northern Baltic area with reference to its role in the diet of <i>Salmo gairdneri</i> (Pisces, Salmonidae). — Acta Zool. Fennica, 18, 186—190.	
1978	Hanski I. 1978. Morphology as evidence of maturity in leopod Crustacea as exemplified by <i>Mesidotea entomon</i> (L.). — Ann. Zool. Fennica, 18, 186—190.	
1988	Hanski I. 1988. <i>Saburia entomon</i> (L.) (Crustacea, Isopoda) as a prey item of the Baltic Sea herring. — National Board of Waters, Rep. 100, 1—38.	
1986	Kopacz M., Wilczyński K. 1986. Some aspects of the biology of <i>Mesidotea entomon</i> in the Gulf of Gdansk. — Opuscula Zoologica, 11, 111—117.	
1975	Lappalainen M., Kangas A., Wirta I. 1975. Littoral stations of the northern Baltic Sea. I. Distribution, abundance, and biomass of macrofauna in the Tvärminne area. — Acta Hydrobiologica, 60, 3, 207—212.	