Body weight, condition, and carapace width and length in the Chinese mitten crab (*Eriocheir sinensis* H. Milne-Edwards, 1853) collected from the Szczecin Lagoon (NW Poland) in spring and autumn 2001

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Abstract

A newcomer to the Baltic Sea, the Chinese mitten crab is especially abundant in the Szczecin Lagoon (NW Poland), where it was first reported in 1927. Body weight, and carapace width and length, were studied in 647 individuals collected with fyke nets in the Szczecin Lagoon from 30 March – 18 April 2001 and from 5–21 November 2001. 51.01% of the 543 autumn specimens were males, but only 30.97% of the 113 spring specimens were males. Body weight varied from 45.1 to 306.5 g, carapace length from 41.07 to 81.02 mm and carapace width from 46.68 to 88.85 mm. The autumn crabs were significantly heavier than the spring specimens.

1. Introduction

The Chinese mitten crab (*Eriocheir sinensis* Milne-Edwards 1853) is included with a few similar species in the genus *Eriocheir*, whilst its specific name *sinensis* denotes the natural area of its occurrence, which stretches from Fukien province in China (26°N) to the Korean Peninsula (40°N) (Hymanson et al. 1999, Veldhuizen et al. 1999). It is not known for certain when and where it originally colonised the saline waters of Europe.

It was first reported in 1912 in the River Aller, a tributary of the Weser in Germany, where single specimens were captured (Panning 1939). The species most probably reached the North Sea in the ballast water of ships (Cohen & Carlton 1997). Evidence supporting this claim is the fact that in Hamburg in 1932, two adult specimens (length 40 and 50 mm) were found in the ballast water tanks of the 'Artemisia', a scrapped vessel that had very often called at Far Eastern ports (Grabda 1973). Favourable conditions in the rivers flowing into the North Sea and the dense network of rivers and canals in Europe facilitated the spread, colonisation and rapid population growth of this crustacean. It has been found from Portugal and Great Britain in the west (Ingle 1987, Cabral & Costa 1999), through France (Hoestlandt 1945), The Netherlands (Kamps 1937), Denmark (Rasmussen 1987) and Poland (Grabda 1973), to Finland and Estonia in the east (Haathela 1963). On present-day Polish territory, this crustacean was first reported from the Szczecin Lagoon (Oderhaff) in 1927, and just a year later its presence was confirmed in almost all of the tributaries of the River Odra (Oder) below Wrocław – the Nysa Łużycka, Bóbr, Noteć, Kwisa, Ślęża and Oława. In the 1930s it was found in the river basins of the Noteć, Warta, Wisła (Vistula), in Puck Bay and off the Hel Peninsula (Grabda 1973), and in the Mazurian lakes (Stańczykowska 1986). Nowadays, the occurrence of this allochthonic species in Polish waters is restricted to the Odra estuary (e.g. the Szczecin Lagoon), the Baltic coastal lakes and the Gulf of Gdańsk. In the Szczecin Lagoon the Chinese mitten crab population is growing – their large numbers in fish catches is ample demonstration of this (Czerniejewski et al. 2001). Current knowledge of this invasive species is limited, so definitive conclusions cannot yet be drawn about its role in and its influence on the native aquatic fauna.

The Szczecin Lagoon is a freshwater coastal lagoon (haff) in the Szczecin Basin (Mikołajski 1966), through which the River Odra (Oder) flows (Fig. 1). Geographically it belongs to the Baltic Sea, from which it is blocked by the islands of Wolin and Uznam (Usedom). The whole hydrographic system of the lagoon lies between latitude 52°24′N (the southern tip of Lake Dąbie) and 54°08′N (Peenemünde), a meridional distance of about 85.5 km, and between longitude 13°45′E (Peenemünde) and 14°48′E (the eastern end of Wrzosowo Bay), a latitudinal distance of 70.5 km. The lagoon is connected with the sea through three straits – the Dziwna and Świna (in Poland), and the Peenestrom (in Germany). Through these straits waters are exchanged in both directions: excess water in the lagoon flows into the sea, and periodically there is a back-flow of saline water from the Pomeranian Bay (Mikołajski 1966).

The aim of this work was to determine the biological (size and condition) and populational parameters of Chinese mitten crabs caught in the Szczecin Lagoon (NW Poland).

1.1. Material and methods

656 specimens of the Chinese mitten crab were caught with fyke nets in spring (113 from 30 March to 18 April 2001) and autumn (543 from 5 to 21 November 2001) during routine fishing activities in the southern part of the Szczecin Lagoon (Fig. 1). On arrival at the laboratory, the specimens were weighed (with an accuracy to 0.1 g), then deep-frozen (−20°C) in dihedral plastic bags to prevent sublimation of water from the crabs' tissues. Later, after each batch of crabs had thawed out, they were sexed on the basis of the structure of their abdominal parts (Schäferna 1935). The carapace length and width of each individual were then measured with a computer-linked electric Vernier calliper gauge (accuracy ± 0.01 mm). These measurements were analysed statistically and the arithmetic mean and standard deviation

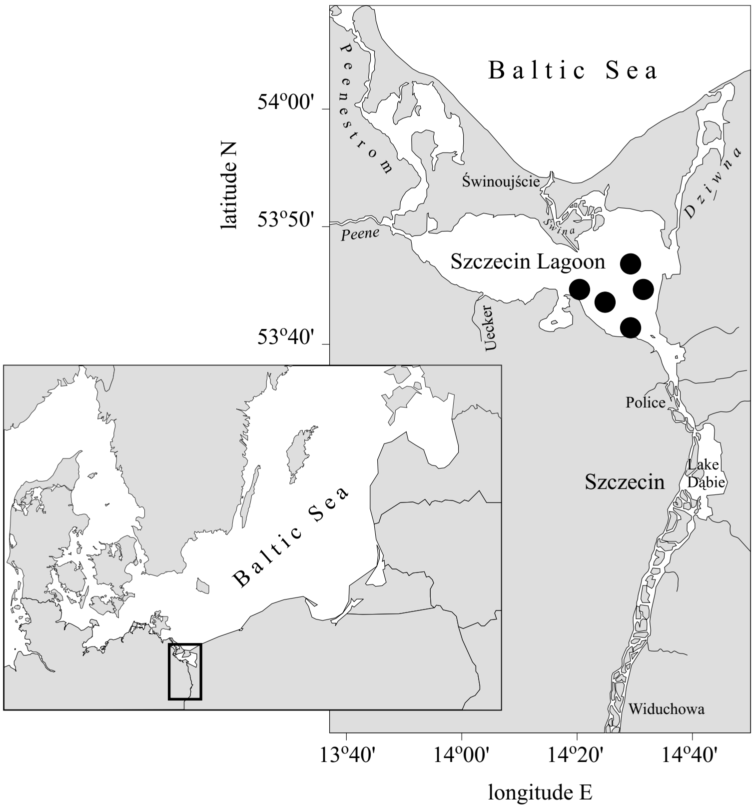

Fig. 1. Location of Chinese mitten crab collection sites in the Szczecin Lagoon

calculated; the significance of the differences between the samples from the two periods were assessed by the t-test.

The condition of the crabs was calculated using the exponential function:

$$W = a \times L^b,$$

where
W – individual weight [g],
L – carapace width [mm],
a, b – coefficients of the regression equation calculated from the empirical data.

In order to assess and compare the size structure of male and female specimens, the crabs were divided into classes according to carapace width – one class every 5 mm.

2. Results

The sex distribution in the Chinese mitten crabs caught in the two periods was strongly disproportionate. 69.03% of the 113 crabs obtained in spring were males, whereas only 51.01% of the autumn specimens were males. In a similar study of Chinese mitten crabs caught in the Szczecin Lagoon in autumn 1999 by Czerniejewski et al. (2001), there were only small differences in sex distribution, 52.1% of the animals being males.

The individual weight range of the crabs was quite significant (Tables 1 and 2), especially in the autumn males; one specimen weighed in at a record 306.5 g. Among the females, only two were heavier than 250 g (251.6 g and 253.1 g); most of them weighed between 100 and 180 g. Statistical analysis of the individual weights revealed significant differences between the spring and autumn periods ($p < 0.05$): the autumn specimens were conspicuously heavier.

Table 1. Mean individual weight, and carapace length and width, of Chinese mitten crabs collected in the Szczecin Lagoon in spring (from 30 March to 18 April 2001)

	Weight [g]		Carapace length [mm]		Carapace width [mm]	
	Range	Mean	Range	Mean	Range	Mean
Total	57.10–269.80	125.18*	44.82–76.57	58.62	50.37–88.85	64.54
	71.80–269.80	145.82*	48.37–71.57	59.84	52.67–82.32	66.74
	57.10–231.31	115.92*	44.82–76.57	58.07*	50.37–88.85	63.56*

*difference between crabs collected in spring and autumn statistically significant ($p < 0.05$).

Table 2. Mean individual weight and carapace length and width, of Chinese mitten crabs collected in the Szczecin Lagoon in in autumn (from 30 March to 18 April 2001)

	Weight [g]		Carapace length [mm]		Carapace width [mm]	
	Range	Mean	Range	Mean	Range	Mean
Total	45.10–306.50	147.71*	41.07–81.02	61.02	46.68–87.00	67.45
	45.10–306.5	160.06*	42.52–81.20	61.15	47.04–87.00	68.11
	46.30–253.10	134.85*	41.07–72.54	60.87*	46.68–80.44	66.77*

*difference between crabs collected in spring and autumn statistically significant ($p < 0.05$).

The respective spring and autumn ranges of carapace length and width were similar (see Tables 1 and 2): 44.82–76.57 mm and 41.07–81.02 mm (carapace length), and 50.37–88.85 mm and 46.68–87.00 mm (carapace width). There were slight differences between the two groups of crabs, but they did not exceed 5% of the differences between the mean carapace lengths and widths. Interseasonal differences were statistically significant only in the case of the males.

The spring and autumn crabs were divided into size classes with respect to carapace width (Figs 2 and 3). 66 (58.41%) of the 113 spring crabs were assigned to the 60.1–65.00 mm and 65.01–70.00 mm size classes. The highest numbers of males and females in autumn – almost 75% of the entire batch – fell within three size classes: 60.01–65.00 mm, 65.01–70.00 mm and 70.01–75.00 mm.

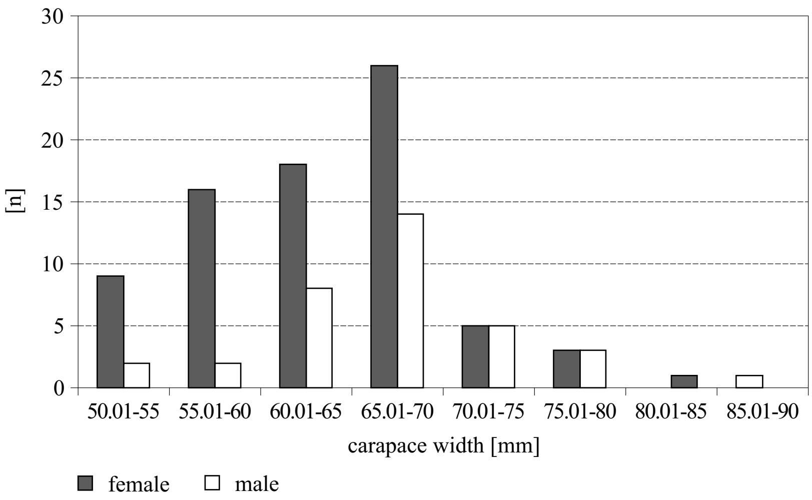

Fig. 2. Carapace width-based size structure of Chinese mitten crabs collected in the Szczecin Lagoon in spring (from 30 March to 18 April 2001)

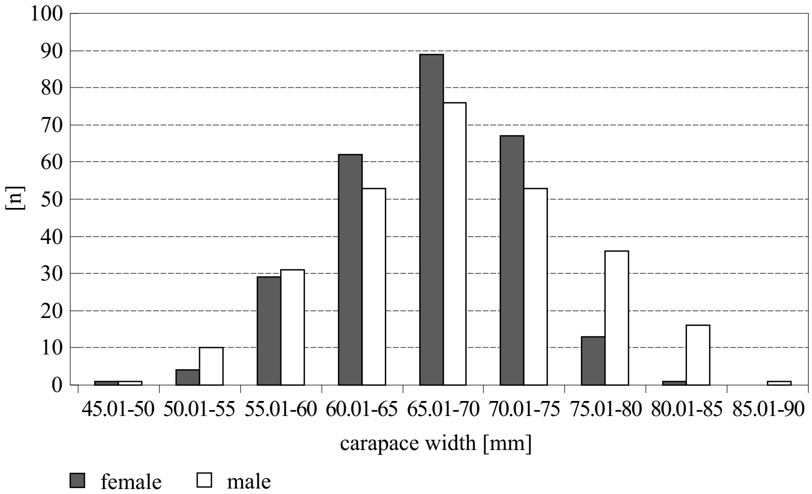

Fig. 3. Carapace width-based size structure of Chinese mitten crabs collected in the Szczecin Lagoon in autumn (from 5 to 21 November 2001)

Measurement of carapace width and individual weight of males and females enabled the parameters of the dependence between these biological features to be determined. On the one hand, carapace width and individual weight were strongly correlated (Fig. 4), with a statistically significant determination coefficient ($R^2 = 0.9326 - 0.9568$); on the other, the differences between the exponential values of these functions indicated

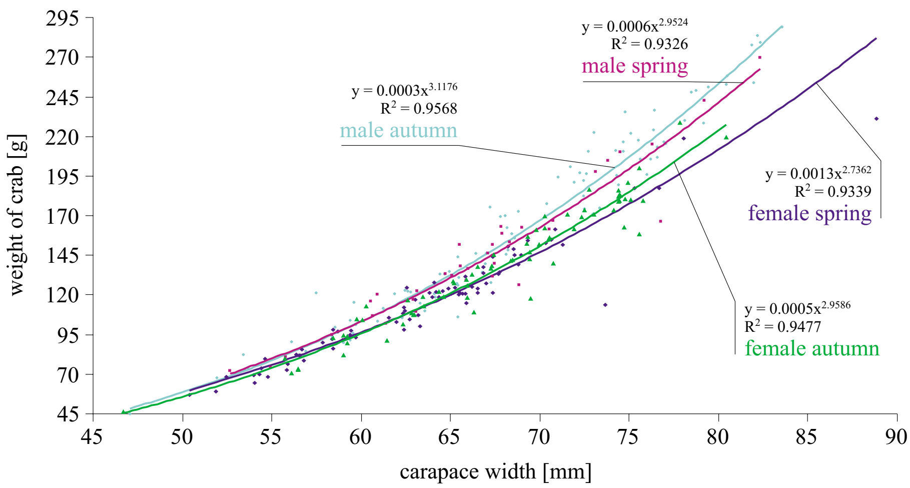

Fig. 4. Relationship between the carapace width and the weight of Chinese mitten crabs collected in the Szczecin Lagoon in spring (from 30 March to 18 April 2001) and autumn (from 5 to 21 November 2001)

that individual weights increased more quickly in males than in females. Simultaneously, the higher position of the curve for the autumn crabs than for the spring crabs showed that the former had a higher individual weight for the same carapace width, which suggests they were in better condition.

3. Discussion

Invasions of non-indigenous species are now recognised as one of the major threats to native species and ecosystems (Shine et al. 2000). The human-mediated addition of alien species to a community has been termed xenodiversity (Leppakoski et al. 2000), and the coastal lagoons of the Baltic Sea have been identified as centres of such xenodiversity (Leppakoski et al. 2001). In the Szczecin Lagoon, for example, more than 20 allochthonic species have been reported (Gruszka 1999), among which the Chinese mitten crab seems to be the most numerous. Studies by Czerniejewski et al. (2003) and Normant et al. (2000), and also the present authors' own data, show that the majority of Chinese mitten crabs captured in the Odra estuary weigh from 80 to 180 g, whereas the mean value in Lake Dąbie is 169 g (Normant et al. 2000), which is statistically significantly higher in comparison with the mean individual weight of these crabs from the Szczecin Lagoon. Interestingly, individual Chinese mitten crabs obtained in 2001 were heavier than those caught in the same waters in 1999 (Czerniejewski et al. 2001). In his study of the Chinese mitten crab population in the River Elbe in northern Germany, Fladung (2000) found the prevalent weight range to be 70–200 g, the largest crab weighing 331 g. He also quoted Berlin fishermen, who reported one crab as weighing more than 400 g.

The range of carapace width in the Chinese mitten crabs examined in the present study was slightly wider than that reported by Normant et al. (2000) in the population of these crabs caught in nearby Lake Dąbie (53–88 mm), but similar to the values given by Czerniejewski et al. (2003) for such crabs caught in the Szczecin Lagoon in 1999. Of especial interest is the lack in both water bodies of specimens smaller than 40 mm or larger than 90–100 mm, which are sometimes caught along the shores of Great Britain (Wall et al. 1983). It seems that Chinese mitten crabs from the Szczecin Lagoon are mature specimens: according to Rudnick et al. (2000), when these crustaceans achieve a carapace width of 35 mm, they are capable of reproduction. The presence in both of these water bodies of large numbers of juveniles, which enter Polish inland waters in spring (Demel 1974), should not be ignored; very likely, though to a minimal extent only, they leave their hiding places – nooks and crannies, usually in the coastal zone – i.e. an area not covered by the fishermen from whom the samples were obtained. Adult and juvenile crabs are found in the Elbe estuary in northern Germany, and the range of carapace width in spring varies from 15 to 38 mm (juveniles) and from 50 to 60 mm (adults), and in autumn from 5 to 15 mm (juveniles) and from 45 to 60 mm (adults) (Herborg et al. 2003), so they are significantly smaller in comparison with the specimens from the Szczecin Lagoon. Hereborg et al. (2003) suggested that this is the result of distance from reproduction sites, i.e. from waters of salinity > 20 PSU (Anger 1991). According to Haahtela (1963), crabs inhabiting the Baltic Sea may have arrived from the North Sea as larvae or juveniles. Żmudziński (1961), however, does not rule out the reproduction of Chinese mitten crab in some more saline parts of the Baltic, especially in the deeps, where the salinity is significantly higher than in other parts of this sea (Cyberska 1994).

Analysis of the sex structure of the crabs obtained from the Szczecin Lagoon in 2001 revealed the significant predominance of males (69.03%) in the spring sample, and an almost equal distribution of both sexes in the autumn batch. According to Kobayashi et al. (1994) the dominance of males in the population of a related species (*Eriocheir japonicus*) is due to their much greater mobility. This suggests that the males' ability to move faster gives them better opportunities to catch food, and in consequence, to achieve a higher rate of growth and a better condition. Supporting this hypothesis is the significantly better condition of males (determined by the parameters of the dependence between carapace width and individual weight) in comparison to that of the females, not only among the crabs in the spring sample, but also among those in the autumn sample. It should be noted that the allometric coefficient b in the relationship between carapace width and crab weight lies between 2.80 and 3.2, that is, within the range most commonly reported for other Baltic crustaceans (Kopacz et al. 1986, Rychter 1999 – quoted by Normant et al. 2000). Besides the statistically significantly greater individual weight for the same carapace width in males, sexual dimorphism is obvious, especially in the size of the pincers (Flores et al. 1999, Jesse 2001, Czerniejewski et al. 2003). In females, the pincers constitute about 15% of body weight, whereas in males they are much larger (in both length and weight), making up more than 30% of the crab's total weight (Czerniejewski et al. 2002). Sexual dimorphism is common in decapod brachyuran crabs (Barnes 1997). When explaining the adaptive significance of larger male pincers, Jesse (2001) invoked intraspecific competition for mates among cancerids on Chilean coasts, a contention strengthened by the male-favouring sex ratios (males were more numerous than females in the populations of *Cancer polyodon*, *C. coronatus* and *C. porteri* that she studied). As no data on chelal morphology are available from other populations of *E. sinensis*, it is not possible at present to assess pincer dimorphism in a broader ecological and ethological context.

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