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POPULATION STRUCTURE OF THE EASTERN PRAWN, *MACROBRACHIUM NIPPONENSE* (CRUSTACEA, DECAPODA, PALAEMONIDAE), IN THE FIRST YEARS OF ITS INTRODUCTION INTO THE KILIYA DELTA OF THE DANUBE

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Population Structure of the Eastern Prawn, *Macrobrachium nipponense* (Crustacea, Decapoda, Palaemonidae), in the First Years of its Introduction into the Kiliya Delta of the Danube. Zorina-Sakharova, K. Ye., Hoshka, K. I., Liashenko, A. V., Liashenko, V. A. — The population structure, growth, and relative condition factor of the eastern prawn, *Macrobrachium nipponense* (De Haan, 1849), in the first years of its introduction into the Kiliya Delta of the Danube were studied. The quantitative predominance of males over females (♀ : ♂ = 1.0 : 2.5) was established, with egg-bearing females comprising 10.0% of the total prawn population. PCA results indicate that *TL* and *AL* are the primary differences separating females from most males, while egg-bearing and non-egg-bearing females differ in most morphometric parameters, with the key traits being *RChL, LChL,* and *1AbH*. LDA results showed that males, egg-bearing and non-egg-bearing females differed significantly in the population based on the studied characteristics. The growth coefficients indicated a positive allometric growth type for males (b = 3.62) and near-isometric growth for females (b = 3.09). For 65.4 of females and 57.8% of males, the values of the condition factor $K_n > 1$, indicating high fatness in individuals of both sexes.

Key words: invasive crustaceans, sex structure, morphometric analysis, prawn growth, relative condition factor.

Introduction

The eastern prawn, *Macrobrachium nipponense* (De Haan, 1849), was found in the waters of the Ukrainian part of the Kilia Danube Delta for the first time in 2020, near the town of Vylkove (Zhmud et al., 2022). Later, in 2021, individual specimens of these crustaceans were recorded in the Romanian part of the Danube Delta and in the lower reaches of the Prut River (Surugiu, 2022). Since then, the prawns have been found in various lakes of the Romanian part of the Danube Delta (Surugiu, 2022).

Representatives of the genus *Macrobrachium* Bate, 1868 in their natural range are valued as a food resource due to their high-quality protein content and the presence of unsaturated fatty acids (omega-3 and omega-6) (Lavajoo et al., 2018). Their high reproductive capacity and adaptability to environmental conditions make these crustaceans suitable for use as commercial species and aquaculture objects (Kwon & Uno, 1969; New, 2005). Therefore, the appearance of *M. nipponense* in new aquatic ecosystems has both negative (for native fauna, especially decapods) and potentially positive (as a commercial resource for local populations) aspects.

During 2022, a significant increase in the number of eastern prawns was recorded in the water bodies and canals within and around the town of Vylkove, as well as upstream along the Danube, leading to their mass capture by local residents (Bushuiev et al., 2023). The large number and size of *M. nipponense* in the lower Danube in 2022 suggested the possibility of introducing official commercial fishing for these prawns in the Kiliya Delta of the Danube (Bushuiev et al., 2023). However, by 2023, following a significant population surge, the species virtually disappeared from the Kiliya delta, with no specimens registered during our studies in the summer of 2023 within and around Vylkove.

Research on population structure, growth and productivity, as well as comparisons of these indicators with the characteristics of populations in other water bodies, is essential for predicting the state and behavior of the species in the near future. Morphometric analysis (Konan et al., 2008; Konan et al., 2010; Tizkar et al., 2020) is widely used to study variability between crustacean populations from different habitats. Growth type and parameters, as well as the ratio of length to weight, are key indicators of species productivity and population health, which are also used in assessing the potential of species as commercial resources (Abowei, 2010; Deekae & Abowei, 2010; Le Cren, 1951). Moreover, identifying the population structure of alien species is useful and necessary for assessing their condition and managing their development due to their potential negative impact on natural ecosystems.

The goal of our work was to study the population structure of the alien species, the eastern prawn *M. nipponense*, in the Kiliya Delta of the Danube around the town of Vylkove during the first years of its appearance in the region, as well as to compare it with the population structure of this species in its native habitats and other areas of introduction.

Material and Methods

The population structure of *M. nipponense* was studied in the Liski-1 water body, where this species was first recorded in the Kiliya Delta of the Danube in 2019 (Zhmud et al., 2022). This water body is located 32–34 km from the Black Sea along the Danube (45°26'43.3" N 29°25'49.8" E) and is one of the reservoirs of the rice irrigation system (Fig. 1).

Prawn samples were collected in November 2020 and October 2021 using Decapoda traps with a diameter of 30.0 cm, a length of 60.0 cm, and a mesh size of 1.0 cm. The traps were submerged to a depth of up to 2.0 m and left in the water for 24 hours. During each period, samples were collected from four traps. In October 2021, additional qualitative prawn sampling was conducted in coastal macrophyte thickets using an ichthyological juvenile net with a ring diameter of 35.0 cm and a mesh size of 0.1 cm. The captured prawns were frozen and delivered to the laboratory. All measurements and weighing were carried out after thawing and drying the prawns on filter paper. Only undamaged specimens with all body parts intact were used for further analysis.

The list of morphometric, meristic, and weight characteristics measured for each shrimp individual is presented in Table 1 and Figure 2.

Fig. 1. Map-scheme of the study area for the *M. nipponense* population

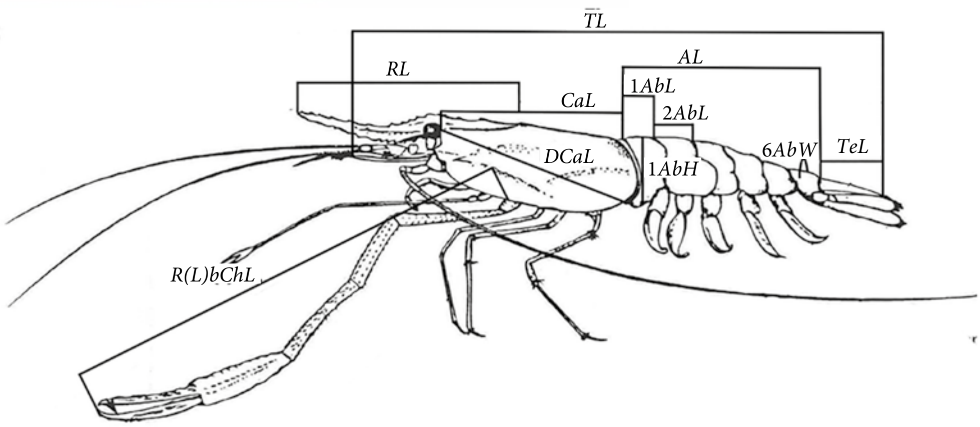

Fig. 2. Visualization of morphometric measurements of *M. nipponense* prawns (see the text for parameter descriptions and explanations) (after Al-Mohsen, 2009)

Table 1. **Morphometric, meristic and weight characteristics used**

No	Abbreviation	Characteristics
		Morphometric
1	*TL*	Total length from the tip of the antennular plate to the end of the telson
2	*AL*	Abdominal length from the posterior end of the carapace to the end of the telson
3	*TeL*	Maximum telson length
4	*CaL*	Carapace length from the base of the eye stalk to the posterior end
5	*DCaL*	Carapace diagonal
6	1*AbL*	Maximum length of the first abdominal segment
7	1*AbH*	Maximum height of the first abdominal segment
8	2*AbL*	Maximum length of the second abdominal segment
9	*RL*	Rostrum length
10	6*AbW*	Width of the sixth abdominal segment
11	*RChL*	Length of the right second pereiopod
12	*LChL*	Length of the left second pereiopod
		Meristic
13	*No.U*	Total number of teeth on the upper side of the rostrum
14	*No.L*	Total number of teeth on the lower side of the rostrum
		Weight
15	*TW*	Total weight of the specimen

Sex determination was carried out by the presence of the Appendix masculina on the second pair of pleopods (in males), male genital pores near the 5th pair of pereiopods, and female genital pores near the 3rd pair of pereiopods, as well as by the curvature of the shell between the 5th pair of pereiopods in females (Shen et al., 2020). Morphological studies were conducted using an MBI-11 binocular microscope and a vernier caliper with an accuracy of up to 0.02 millimeters. After all measurements, the dried prawns were weighed on electronic scales RADVAG XAS-160/c with an accuracy of up to 0.01 g.

Based on the analysis of sexual characteristics, the prawns were divided into males (♂) and females (♀). The latter were differentiated into non-egg-bearing females ($♀_{on}$) and egg-bearing females ($♀_{ov}$) based on the presence or absence of eggs. For each parameter within a specific group of prawns, the mean value and standard deviation (Mean ± SD) were calculated.

Before the comparative analysis, all morphometric measurements of specimens from each group were standardized to CaL to eliminate the effect of growth on morphometric changes. This parameter was chosen as a reference size, as it is less prone to damage during the prawn's life due to various factors, unlike TL (Mariappan & Balasundaram, 2004). Standardization was carried out according to the formula:

$$M_s = M_0\,(\overline{L}/L_0)\,,$$

where M_s is the standardized measurement value, M_0 is the measured value, $\overline{L}$ is the mean carapace length for the group, L_0 is the carapace length of the individual, and b is a coefficient obtained from the allometric equation $Y = aX^b$, where X = CaL and Y = the corresponding morphometric dimension (Chen et al., 2015; Lleonart et al., 2000; Mariappan & Balasundaram, 2004; Paramo et al., 2010).

To obtain statistically significant differences between the mean morphometric, meristic, and weight characteristics, the ANOVA multiple comparison method and Tukey's test were used. A difference was considered significant at $p < 0.05$. To identify morphometric characteristics that significantly differentiate males from egg-bearing and non-egg-bearing females, a principal component analysis (PCA) was conducted using the covariance matrix. Significant differences between groups of prawns based on the chosen morphometric characteristics were assessed using discriminant analysis (LDA). For both PCA and LDA, standardized values for each parameter were used, obtained by subtracting the mean value and dividing by the standard deviation.

Growth parameters of prawns were assessed using the weight-length relationship equation: $W = aL^b$, where $W = TW$ (total weight in g), $L = TL$ (total length in cm), a = regression constant, and b = regression coefficient. Non-standardized TL values were used for the analysis. The values of a and b were obtained from the regression equation $log_{10}W = log_{10}a + log_{10}L$ (Pauly, 1983). Regression analysis was conducted separately for the weight-length relationship of ♂ and ♀ without distinguishing between egg-bearing and non-egg-bearing, as well as for the population as a whole.

To assess the population condition of *M. nipponense* in water bodies of the Kiliya Delta, the relative condition factor (K_n) was calculated as $K_n = TW/\overline{W}$, where TW is the measured weight of the prawn and $\overline{W}$ is the measured weight of the prawn and $\overline{W}$ is the calculated weit of ecach individual obtained from the weight-length relationship equation (Le Cren, 1951). This index, unlike the widely used ponderal index (K) (Abowei et al., 2008; Abowei, 2010; Andem et al., 2013; Aye, 2020; Deekae & Abowei, 2010; Namin et al., 2014), eliminates the effect of individual length on the calculation results (Le Cren 1951). If $K_n > 1$, the individual is considered in good condition, and if $K_n < 1$, it is considered undernourished. The significance of the difference in mean K_n values for individuals of both sexes was determined using the Student's t-test, after normalizing the K_n values by logarithmic transformation.

All statistical calculations were performed using PAST 4.11 and StatPlus AnalystSoft Inc. Version 7.

Results

Sexual Structure and Morphometric Analysis. In the autumn period of 2020–2021, 90 individuals of *M. nipponense* were caught in the Liski-1 water body, including 26 females (28.9%) and 64 males (71.1%). Among all females, only 9 specimens (34.6%) were identified as egg-bearing individuals, which constituted 10.0% of the total number of crustaceans.

The average values of all measured characteristics of shrimp individuals are presented in Table 2. The *CaL* range, which is the primary morphometric characteristic of males (9.00–25.50 mm) and females (10.50–21.50 mm), overlapped partially. For non-egg-bearing females, this parameter corresponded to the general limits for all individuals of this sex, while for egg-bearing females it was significantly narrower, ranging from 15.50 to 18.00 mm.

The results of the mean values comparison of body morphometric characteristics of the crustaceans' selected groups showed that they did not differ significantly in *CaL* and 1*AbL* (Table 2). Other parameters for males (except 2*AbL*) were significantly larger than those for females overall. This was due to the significant difference in body and body part sizes between males and non-egg-bearing females, whereas egg-bearing females did not differ significantly from males in the sizes of most studied morphometric parameters (except for *RL* and 1*AbH*). Egg-bearing and non-egg-bearing females differed in *TL*, *AbL*, *RL* and 2*AbL*, as well as 1*AbH*, while other parameters did not differ significantly.

The mean values of meristic and weight indicators for individuals of both sexes did not differ significantly. *No.U* varied more widely in males (11–18) than in females of both groups (12–16 for ♀$_{on}$ and 12–15 for ♀$_{ov}$), while the *No.L* was narrower for non-egg-bearing females (3–4), while for other groups, it varied within 2–4 teeth. The range of *TW* for males was wider (0.25–6.13 g) than for females of both groups,

Table 2. **Comparison of the Mean Values of Parameters for Males (N = 64), Females Overall (N = 26), Non-Egg-Bearing Females (N = 17), and Egg-Bearing Females (N = 9) of the *M. nipponense* population in the Kiliya Delta of the Danube during the First Years of Invasion: Mean ± SD, ANOVA, Tukey's Test**

Parameters	♂	♂	♀$_{on}$	♀$_{ov}$
CaL, mm	16.44 ± 3.94^{a}	15.44 ± 2.41^{a}	14.79 ± 2.74^{a}	16.67 ± 0.75^{a}
*TL**, mm	71.95 ± 4.40^{b}	66.93 ± 5.36^{a}	63.79 ± 2.79^{a}	72.88 ± 3.67^{b}
*AbL**, mm	43.20 ± 3.91^{b}	40.51 ± 4.20^{a}	38.44 ± 3.11^{a}	44.41 ± 3.09^{b}
*TeL**, mm	9.18 ± 0.76^{b}	8.56 ± 0.74^{a}	8.29 ± 0.73^{a}	9.06 ± 0.46^{ab}
*DCaL**, mm	17.14 ± 1.35^{b}	15.67 ± 1.60^{a}	15.05 ± 1.56^{a}	16.85 ± 0.88^{ab}
1*AbL**, mm	4.21 ± 0.59^{a}	4.36 ± 0.73^{a}	4.29 ± 0.79^{a}	4.50 ± 0.62^{a}
1*AbH**, mm	8.78 ± 0.82^{a}	9.08 ± 1.52^{a}	8.29 ± 1.20^{a}	10.57 ± 0.68^{b}
*RL**, mm	20.85 ± 1.45^{c}	18.45 ± 1.25^{ab}	17.95 ± 1.10^{a}	19.39 ± 0.98^{b}
2*AbL**, mm	6.13 ± 0.80^{b}	5.92 ± 0.99^{ab}	5.50 ± 0.90^{a}	6.73 ± 0.59^{b}
6*AbW**, mm	5.06 ± 0.42^{b}	4.71 ± 0.44^{a}	4.62 ± 0.49^{a}	4.89 ± 0.27^{ab}
*RChL**, mm	46.77 ± 8.55^{b}	36.65 ± 3.95^{a}	35.79 ± 2.83^{a}	38.26 ± 5.32^{a}
*LChL**, mm	47.23 ± 7.91^{b}	35.48 ± 4.29^{a}	35.14 ± 4.15^{a}	36.12 ± 4.72^{a}
No.U, pcs	13.22 ± 1.20^{a}	13.46 ± 1.27^{a}	13.71 ± 1.31^{a}	13.00 ± 1.12^{a}
No.L, pcs.	3.14 ± 0.39^{a}	3.12 ± 0.43^{a}	3.00 ± 0.35^{a}	3.33 ± 0.50^{a}
TW, g	1.73 ± 1.40^{a}	1.58 ± 0.97^{a}	1.46 ± 1.18^{a}	1.80 ± 0.20^{a}

* Indicates morphometric parameters standardized to CaL; highlighted parameters show significant differences between groups ($p < 0.05$), different letters indicate samples within each parameter with significant differences according to Tukey's test ($p < 0.05$).

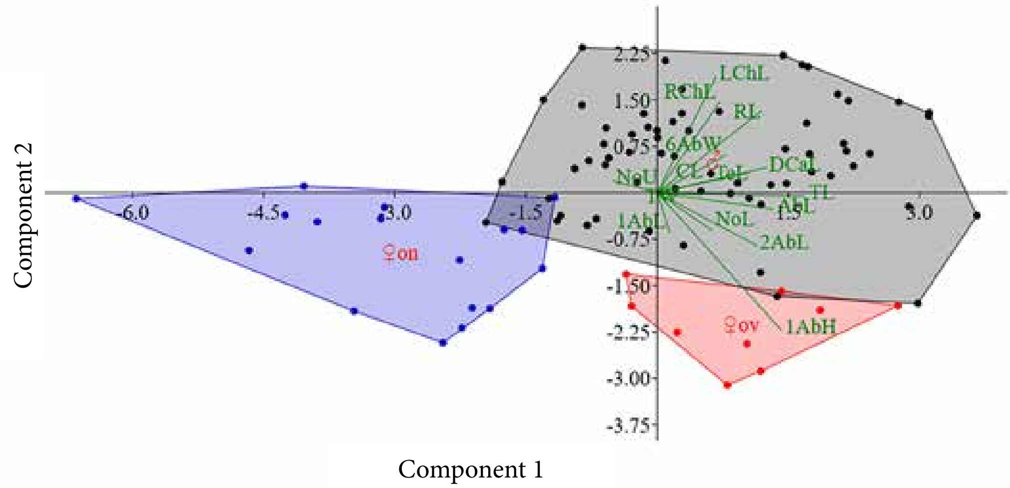

Fig. 3. Results of group PCA (variance–covariance) for 15 parameters, 64 ♂ individuals (black), 17 $♀_{on}$ individuals (blue), and 9 $♀_{ov}$ individuals (red): The PC1 and PC2 axes explain 100.0% of the variance; the areas bounded by lines correspond to the range of points in the coordinate system defined by the first two components; the center of each group of individuals is marked with the corresponding symbol

Table 3. **Factor loadings of the first two PCA axes (variance–covariance matrix, between-group differences) of morphometric, meristic, and weight measurements of *M. nipponense* prawns**

Characteristics of prawns	Factor loadings of the PC 1	Factor loadings of the PC 2
CL	0.13	–0.01
TL	**0.44**	–0.01
AbL	**0.35**	–0.07
TeL	0.27	0.08
DCaL	0.33	0.11
1*AbL*	0.04	–0.17
1AbH	0.37	**–0.58**
RL	0.31	0.35
2*AbL*	0.30	–0.22
6*AbW*	0.20	0.16
RChL	0.19	**0.38**
LChL	0.18	**0.49**
NoU	-0.13	0.05
NoL	0.16	–0.16
TW	0.06	–0.01
Eigenvalue	4.69	1.81
% variance	72.22	27.78

Note. Characteristics with the highest values are highlighted in bold.

although the mean values of these indicators did not differ significantly, with higher values for egg-bearing females than for other prawns.

The principal component analysis (PCA) of all types of prawn measurements showed that the first two PCA axes explain 100.0% of the distribution of characteristics of individuals of both sexes (Table 3, Fig. 3). The first axis (PC 1) is mostly associated with *TL* and *AbL*. Based on these characteristics, most males are separated from females. The second PCA axis is mostly associated with *1AbH* and the length of the second pereiopods (*RChL, LChL*), distinguishing non-egg-bearing from egg-bearing females. The distribution fields of non-egg-bearing and egg-bearing females do not overlap, and for males, only a separate pool of individuals with characteristics similar to those of females was identified.

According to the results of the discriminant analysis ($\Lambda = 0.11$ F (d.f.1 = 30 d.f.2 = 146) = 9.80 $p < 0.05$), most prawns (88 individuals, 97.8%) identified by sexual characteristics as male, egg-bearing, or non-egg-bearing female, differ in general morphometric, meristic, and weight characteristics (Table 4). The general morphometry of only one non-egg-bearing prawn corresponds to the parameters of males and one male — to the parameters of egg-bearing females (Table 4).

Growth Parameters and Relative Condition Factor. The regression coefficient *b* indicated positive allometric growth for males and near-isometric growth for females (Table 5, Fig. 4). Overall, the equations describing the relationship between weight change and shrimp growth showed a high coefficient of determination (r^2), which, along with the results of the analysis of variance, indicates that the obtained regression models are significant.

The calculated mean $\overline{W}$ for both females and males were lower than the actual weights obtained during prawn weighing (*TW*) (Table 5). This, in turn, influenced the calculation of the relative condition factor for individuals of both sexes separately and for the population as a whole. The range of K_n values for females was 0.44–3.16, and for males — 0.35–3.59, with the mean values for females (1.30 ± 0.59) being slightly lower than those for males (1.35 ± 0.80), but this difference was not significant ($t = 0.33$, d.f. = 89, $p > 0.05$). For 65.4% of females and 57.8% of males, the obtained K_n values were greater than 1.

Table 4. **Resulting classification matrix of *M. nipponense* prawns Based on discriminant analysis results**

The actual group	Intended group				The percentage of correctness, %
	♂	$♀_{on}$	$♀_{ov}$	♂ ♀	
♂	63	0	1	64	98.4
$♀_{on}$	1	16	0	17	94.1
$♀_{ov}$	0	0	9	9	100.0
♀ ♂	64	16	10	90	97.8

Table 5. **Growth parameters and relative condition factor of *M. nipponense* prawns in the first years of introduction into the Liski-1 water reservoir**

Parameters		♀	♂	♂ ♀
Estimation of the relationship between shrimp body length and weigh				
Regression coefficients	*b*	3.09	3.62	3.41
	a	0.09	0.05	0.06
Regression statistics	r^2	0.66	0.7	0.67
Analysis of Variance	*d.f.*	25	63	89
	F	49.5	145.15	175.02
	p	< 0.05	< 0.05	< 0.05
Estimation of the relative condition factor				
Measure weight, g	*TW*	1.58 ± 0.97	1.73 ± 1.40	1.68 ± 1.29
Calculated weight, g	$\overline{W}$	1.16 ± 0.23	1.15 ± 0.36	1.15 ± 0.32
Relative condition factor	K_n	1.30 ± 0.59	1.35 ± 0.80	1.34 ± 0.74

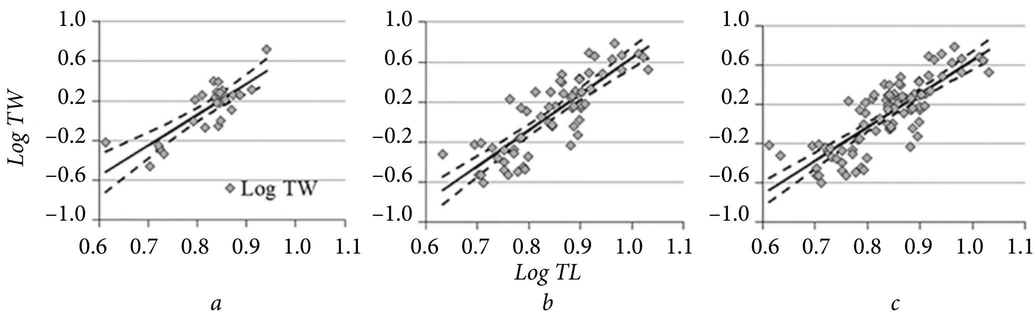

Fig. 4. Scatter plots of individual weight (*TW*) relative to total length (*TL*) (*a* — ♀, *b* — ♂, *c* — ♂, ♀): the dashed line represents the upper and lower bounds of the 95.0% confidence interval

Discussion

The population of *M. nipponense* in the Kiliya Delta of the Danube in 2020–2021 was characterized by the predominance of males (71.1%), while females made up about one-third (28.9%) of all captured individuals. Egg-bearing females were represented in small numbers, accounting for 34.6% of the total number of female individuals and 10.0% of the total prawn population. The minimum carapace length at which females were found to carry eggs was 15.50 mm. In the following year, during the autumn period (October), there was a change in the sex structure in the Kiliya Delta, with a significant dominance of females (78.3%), and egg-bearing females made up 6.2% of the total number of individuals (Bushuiev et al., 2023).

In general, for stable natural populations, the sex ratio is 1 : 1 (Fisher, 1930). Similar indicators are recorded for *M. nipponense* in most water bodies and waterways within its native range (Chen et al., 2015) (Fig. 5), with a slight dominance of one sex in certain water bodies. However, in the areas where this species has been introduced, there is a pronounced dominance of one sex (Al-Maliky, 2022; De Grave et al., 2006; Namin et al., 2014; Salman et al., 2006; Surugiu, 2022).

The materials presented in Fig. 5 from the Soon Lun reservoir (Aye, 2020), Alagol Lagoon, Almagol Lagoon, Ajigol Lagoon (Bandani et al., 2013), and Al-Hammar Marsh (Al-Maliky, 2022) were obtained from studies conducted over a full year (12 months), while in other water bodies, this period varies from 1 to 4 months. At the same time, monthly studies of the sex structure of the *M. nipponense* population in the native Soon Lun reservoir (Aye & Sein, 2012) showed that it is not stable throughout the year: significant dominance of females is characteristic from January to May and in July–August, while males dominate from September to December and in June. The reasons for this dynamic are not clear, but our results from the first two years of prawn introduction into the Kiliya Delta of the Danube, with a significant predominance of males in the population during the autumn months, confirm this trend. However, the radical change in the sex ratio during the following year (Bushuiev et al., 2023) indicates population instability and the species' search for a strategy to survive in new conditions.

M. nipponense individuals of different sexes in the Liski-1 water body did not differ in meristic characteristics and weight, but they had significant differences in most morphometric parameters, as confirmed by discriminant analysis based on the

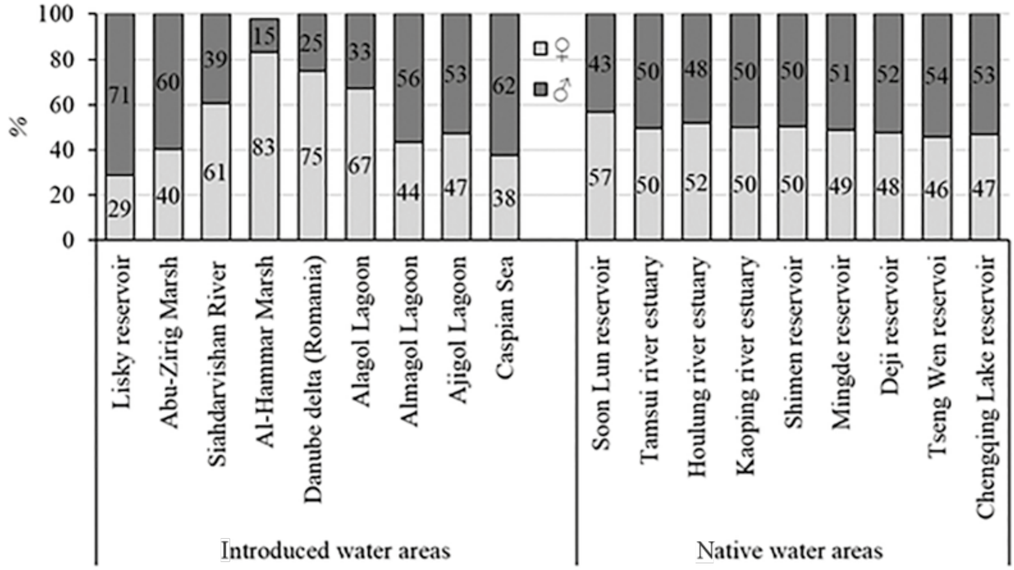

Fig. 5. Ratio of female to male *M. nipponense* in water bodies and watercourses of the native range and introduced range: Lisky reservoir — own data, Abu-Ziring Marsh — after Salman et al. (2006), Siahdarvishan River — after De Grave et al. (2006), Al-Hammar Marsh — after AL-Maliky (2022), Danube Delta (Romania) — after Surugui (2022), Alagol Lagoon, Almagol Lagoon, Ajigol Lagoon — after Bandani et al. (2013), Caspian Sea — after Namin et al. (2014), Soon Lun Reservoir — after Aye (2020), other native areas — after Chen et al. (2015)

overall morphometry of the body. This distinguishes the population of *M. nipponense* from the Kiliya Delta of the Danube from natural populations, which are characterized by pronounced sexual dimorphism in both size and weight (Chen et al., 2015; Wang et al., 2023).

Overall, in the *M. nipponense* population at the initial stages of introduction, a clear size-age differentiation among different groups of females is observed. Their pools do not overlap, as shown by the PCA results (Fig. 3), which are also confirmed by the ANOVA results (Table 2). For males, most morphometric parameters significantly differ from those of non-egg-bearing females, while egg-bearing individuals differ from males only in *RL* and *1AbH* measurements. It is known that *M. nipponense* exhibits genetically determined heterogeneous individual growth (HIG) (Jiang et al., 2023): adult males are divided into larger and smaller individuals (often smaller than females). It is likely that the pool of *M. nipponense* males morphometrically resembling females results from this genetic characteristic of the species.

The average *CaL* of females from the Liski-1 water body is smaller than the corresponding measurements in males, and although this difference is not statistically significant, similar ratios are characteristic of populations of these prawns in their native ranges (Fig. 6). Meanwhile, in areas where *M. nipponense* has been introduced, ♀ dominate in this indicator. The mean *CaL* values of prawns from the Liski-1 water body are 1.1 and 1.2 times lower than the mean values of these indicators in native populations and 1.4 and 1.3 times lower for females and males, respectively, in introduced populations.

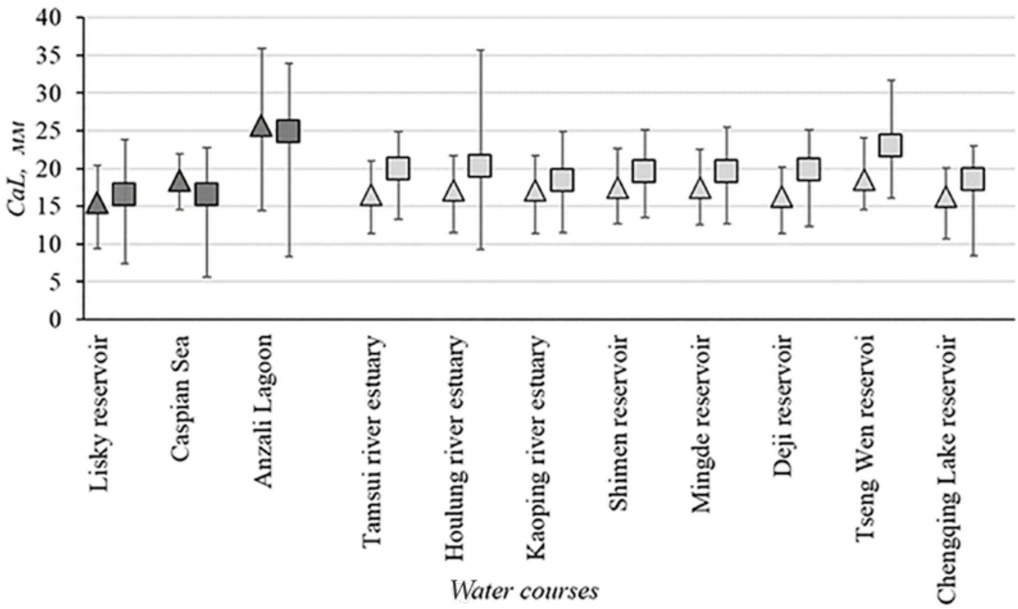

Fig. 6. Mean values and ranges of carapace length (*CaL*) in *M. nipponense* individuals of different sexes from water bodies and watercourses worldwide: dark triangle — females in introduced habitats, dark square — males in introduced habitats, light triangle — females in native range, light square — males in native range; Lisky reservoir — own data, Caspian Sea and Anzali Lagoon — after Tizkar et al. (2020), other water bodies — after Chen et al. (2015)

Correlation coefficients indicate a strong relationship between the weight and length of prawns in both sexes (Table 5), although they are lower than those established for these prawns populations from other water bodies and waterways (Aye, 2020; Khanipour et al., 2020; Tizkar et al., 2020). A strong linear relationship between these two parameters for individuals of both sexes and the population as a whole is also evident in the scatter plots (Fig. 4), where the majority of intersections of length and weight measurements form straight lines with narrow ranges of variation. According to the obtained results (Fig 4, *a*–*b*), in the Liski-1 water body, females have a greater weight than males with the same growth, while males are characterized by greater total length than females with the same weight. For both sexes, length increases faster than weight.

The obtained regression coefficients for females (b = 3.09) are consistent with the data for *M. nipponense* populations from the Caspian Sea lagoons in Iran (b = 2.91–3.00) (Tizkar et al., 2020; Khanipour et al., 2020), where this species was introduced, as well as in water bodies of its natural range (Soon Lun reservoir in Myanmar) (Aye, 2020) (b = 3.07) and characterize their growth as close to isometric. For males in the Liski-1 water body, the regression coefficient (b = 3.62) indicates positive allometric growth, but its value is higher than in other aquatic environments, where b ranges from 2.53 to 3.23 (Aye, 2020; Khanipour et al., 2020; Tizkar et al., 2020). Such fluctuations in growth coefficient are typical for aquatic invertebrates, as they depend on a combination of external environmental factors, sufficient food resources, and the presence or absence of stress (Mazlan et al., 2012; Prasad & Ali, 2007).

The obtained values of the condition factor K_n demonstrate high fatness in individuals of both sexes; the weight of most individuals exceeds the calculated values, which generally indicates sufficient food resources and the absence of stress factors for the development of the prawn population in the water body. Studies of native populations of *Macrobrachium* species have shown that average annual K_n values are close to 1, and fluctuations throughout the year depend on the reproductive cycle and growth period: during and after reproduction, as well as after molting, K_n decreases to values < 1, while during the pre-reproductive and pre-molt periods, when nutrients are being accumulated, K_n increases and exceeds 1 (Bahuguna et al., 2021; Hossain et al., 2012; Rocha et al., 2015; Soomro et al., 2012). Most individuals of *M. nipponense* during the study period were likely in the stage between molts and reproductive periods, i. e., at a time when all the organism's resources are directed towards nutrient and energy accumulation, as confirmed by the high condition factor values.

Conclusions

The population of *M. nipponense* in the Liski-1 water body of the Kiliya Delta of the Danube during the first years of its introduction (2020–2021) was characterized by a predominance of males in terms of the number of individuals (♀ : ♂ = 1.0 : 2.5). However, by 2022, during the same period, a significant predominance of females (♀ : ♂ = 25.6 : 1.0) was recorded (Bushuiev et al., 2023). Both ratios are typical for aquatic environments where this prawn is an introduced species, but their significant variability over adjacent vegetation seasons indicates the instability of the crustacean population.

Sexual dimorphism in prawns was most evident between males and non-egg-bearing females. Egg-bearing females only differed significantly from males in terms of rostrum length and first abdominal segment height. However, given that non-egg-bearing females predominate among females, it is they that determine the difference in body size between the sexes.

The predominance of males in size unites the population structure of *M. nipponense* in the Liski-1 water body with native populations of this species, while in water bodies where this prawn is an introduced species, females dominate in size. Overall, based on the set of selected morphometric, meristic, and weight characteristics, males are significantly differentiated from both egg-bearing and non-egg-bearing females.

The obtained values of the relative condition factor, along with high growth coefficients, as well as information on the significant increase in prawn numbers and their rapid spread to adjacent aquatic environments, suggest that the physicochemical parameters of the water, hydrological and temperature regime of the water bodies in the Kiliya Delta of the Danube, the availability of sufficient food resources, and the absence of natural predators stimulated the development of the *M. nipponense* population, which could reach commercial scales, as was confirmed in the subsequent vegetation period (Bushuiev et al., 2023). Further population decline could be caused by the development of infectious diseases diagnosed in previous years (Bushuiev et al., 2023) and intensive crustacean fishing during the 2022 vegetation season.

The main characteristics of the population of the alien prawn species during the first years of its introduction into a new ecosystem were the quantitative predominance and domination in some morphometric characteristics of males, who, unlike females, are characterized by positive allometric growth, as well as the high fatness of individuals of both sexes.

Overall, the observation results correspond to the classic picture of the introduction of an alien species into new habitats, where after a burst of development, a period of decline is followed by stabilization, as was observed in the Kiliya Delta during the introduction of another bivalve mollusk species, *Corbicula fluminea* (O. F. Müller 1774), in 2004–2008 (Lyashenko & Makovskiy, 2011).

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