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The Prawn *Palaemon adspersus* in the Hypersaline Lake Moynaki (Crimea): Ecology, Long-Term Changes, and Prospects for Aquaculture

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Abstract: For several years, the prawn *Palaemon adspersus* population was studied in a hypersaline lake (Crimea) for the first time. *P. adspersus* is a more halotolerant species than previously thought and can survive and breed up to a salinity of 55 g/L and probably higher. A significant positive correlation was found between the number and biomass of the prawns and the seagrass *Ruppia* shoot density. The spring temperature increase from 5.5 to 24 °C was accompanied by a significant increase in the prawn number (p = 0.001). In the males and females, the spatial heterogeneity of the distribution of prawns significantly (p = 0.005) negatively correlated with the abundance of prawns. In the period from 2018 to 2021, the area of *Ruppia* cover and the prawn abundance in the lake decreased, and a significant correlation was found between those changes. High salinity, judging by our data, can reduce the production potential of the species, but the absence of predators in Lake Moynaki allowed the prawns to reach a higher abundance than was observed in other habitats. *P. adspersus* can be successfully cultivated in hypersaline waters with a salinity up to 55 g/L as a perspective object for Integrated Multi-Trophic Aquaculture. The development of aquaculture in hypersaline waters may help to save freshwater resources, and the development of aquaculture in brines formed during the desalination of seawater will make it more economically viable to obtain freshwater from seawater.

Keywords: integrated multi-trophic aquaculture; hypersaline waters; prawns; distribution; dynamics; fecundity

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1. Introduction

Hypersaline waters (salinity > 35 g/L), being polyextreme habitats, widespread on the planet, are characterized by reduced biological diversity and unique ecosystem properties [1,2]. In recent years, in the context of a growing shortage of freshwater [3,4], the issue of using the bioresources of hypersaline water bodies and the aquaculture development thereat has become relevant [5]. Currently, only one of their animal bioresources, brine shrimp, is intensively used, and the development of hypersaline aquaculture is also now mainly limited to *Artemia* [6]. However, brine shrimp cultivation can only be carried out at sufficiently high salinity because the predation of various invertebrates (amphipods, ostracods, mysids, corixids, etc.) does not allow this to be successfully carried out at salinities below 80–90 g/L [7–9]. At the same time, several invertebrate species in Crimea can be economically cultivated in hypersaline waters [5,10,11]. Currently, Integrated Multi-Trophic Aquaculture (IMTA), the simultaneous cultivation of species of two or more trophic levels in the same water body, is considered the most promising method for the development of aquaculture [5,12,13]. In such a case, one species or its waste may be consumed as food by other species. The diversity of co-cultivated species should promote a total variety of valuable outputs, with their higher production increasing economic profitability and reducing the negative impact on the environment. One of the urgent tasks of IMTA development in hypersaline water bodies is to establish sets of species that can be successfully co-cultivated in different salinity ranges, and the other is a deeper understanding of the relationships in unique ecosystems [5].

Palaemon adspersus Rathke, 1837 (Crustacea: Decapoda), commonly called the Black Seagrass prawn or Baltic prawn is a species widely found in the NW Atlantic (from Norway to Morocco), the Azov, the Baltic, the Mediterranean, and the Black Sea [14–18]. It was also introduced into the Caspian Sea [19]. The species is strictly confined to thickets of marine grass (*Zostera*, *Ruppia*, *Potamogeton*, *Posidonia*, and *Cymodocea*) throughout its range of distribution [17,20–23]. Seagrasses and macrophytes, with their epibionts, support high primary production, reduce the negative effects of wave and wind effects, etc., thereby making the environment comfortable for prawns and other animals [20,24,25]. As shown before, *P. adspersus* may live in a wide range of temperatures (from 2 to 30 °C) and salinity (from 5 to 35 g/L) and has a wide range of food items, including detritus, aquatic vegetation, and various animals [17,26–28]. In the Black Sea near the Crimean coast, the prawn is a common inhabitant, preferring shallow bays and gulfs [17,28,29]. Earlier, rare individuals of this species were also found in two Crimean hypersaline lakes [30].

After the salinity level dropped to 65–90 g/L in Lake Moynaki (1996–1997), it was invaded by gammarid *Gammarus aequicauda* (Martynov, 1931) and water flea *Moina salina* Daday, 1888, which are of aquacultural interest [10], and later, the authors also found *P. adspersus* in the lake. The Baltic prawn (or the Black Seagrass prawn) is commercially harvested and cultivated in some countries [17,31]. Therefore, in the opinion of the authors, the appearance and naturalization of *P. adspersus* in a hypersaline lake are of interest from both the ecosystem and the aquaculture points of view. The objectives of this work are: (a) to study the structure and dynamics of the *P. adspersus* population in the hypersaline Lake Moynaki; (b) to test the hypothesis that the number of *Ruppia* in the thickets significantly affects the abundance of the prawn population; and (c) to assess the possibility of cultivating this species at a salinity above the oceanic level of 35 g/L.

2. Materials and Methods

Lake Moynaki (45°11″06″ N 33°19′29″ E), one of the many hypersaline lakes in the Crimean peninsula, is located in the western part of the peninsula on the outskirts of the city of Yevpatoria (Figure 1).

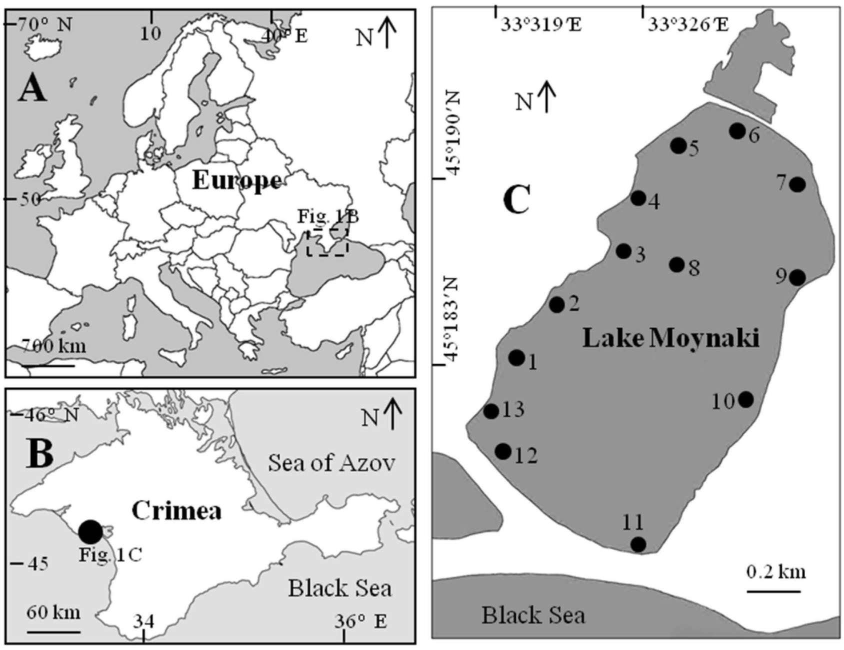

Figure 1. Lake Moynaki and sampling sites.

The lake in the south is separated from the Black Sea by a sandy spit (average width of 300 m); its area is 1.76 km^2, and the depth varies from 0.5 to 1.5 m [7,10,11,32,33]. The lowest water temperature in the lake in 2018–2022 was recorded in January 2022 (0.5 °C), but it rarely falls below 2 °C, and the highest observed temperature did not exceed 31 °C. Until the 1970s, salinity in the lake ranged from 160 to 200 g/L, and later, after the construction of the North Crimean Canal, it began to gradually decrease due to an increase in the flow of freshwater into the lake from agricultural fields and municipal runoff. In 1986, the mineralization was 80 g/L; it reduced from 45 to 55 g/L in 2007–2019. In the 1990s, cardinal changes in the biota in the lake began due to the introduction of new species. In particular, the thickets of the marine grass *Ruppia maritima* Linnaeus, 1753 appeared, the area of which gradually increased, reaching approximately 5% of the total bottom area in 2018–2019. New animals appeared and began to reach a high abundance (the amphipod *G. aequicauda*, three species of Cladocera, etc.). Municipal and agricultural runoff causes the effect of anthropogenic eutrophication, which contributes to outbreaks of mass blooms of microalgae and cyanobacteria, as well as to the growth of the biomass of the green filamentous algae *Cladophora* sp.

Episodic studies were carried out on the prawn in the summer from 2011 to 2016 and from 2018 to 2021; regular monitoring was carried out in 13 stations of Lake Moynaki, where some sites were with *Ruppia* and others without it (Figure 1). Samples with prawns were taken in summer at a depth of 0.4 to 1 m and in winter at a depth of 1.5 m with a lifting net with a mesh diameter of 0.5 mm, in triplicate. The samples were fixed in 4% formalin solution. The prawn number was determined by direct counting of the organisms and biomass weighing on a torsion balance, with subsequent recalculation to m^2. Using a vernier caliper, the total (zoological) length (TL) was measured in the prawns from the tip of the rostrum to the end of the telson. The individual wet mass of an individual (W) was determined using a torsion balance with an accuracy of 0.0001 g. The sex of the prawns was determined by the presence (in males) or absence (in females) of the second appendage (appendix masculina) on the first pair of pleopods. Individual fecundity was determined by directly counting the number of eggs in the clutch of the female. In total, 471 prawns were analyzed this way.

In the areas of *Ruppia* thickets, a quantitative account of the number and the phytomass of the macrophytes was carried out by cutting from an area of 0.25 m^2, limited by a frame, in two repetitions. The number of *Ruppia* shoots was counted, and the raw biomass of the plants was also determined after washing off the fouling and weighing on a torsion balance, followed by recalculation per m^2. The salinity and temperature were monitored using a manual refractometer Kellong WZ212 (Kelilong Electron) and an electronic thermometer PHH 830 (OMEGA Engineering), respectively.

Mean values, standard deviations (SD), correlation (R), variation (CV), and determination (R^2) coefficients were calculated in the standard MS Excel 2007 program. To describe the relations between the studied characteristics, the best-approximated equations were chosen using the highest R^2 values for different types of regression equations, and then, their parameters were also calculated in the standard MS Excel 2007 program. The confidence levels of the obtained correlation coefficients (p) were found [34]. Using a Student's t-test, the significance of the differences in the average values (p) was evaluated after applying normality tests [35]. The significance of the differences in the parameters of the regression equations was considered in STATISTICA 6.

3. Results

3.1. Spatio-Temporal Dynamics

In the lake, for the first time, *P. adspersus* was found in the thickets of *Ruppia* in July 2011. Episodic studies showed its presence in subsequent years at station 3: in July 2012, the number of prawns was 6 ind./m^2; in 2015, it was 5 ind./m^2; and in July 2016, it was 11 ind./m^2. During monitoring studies in 2018 and 2019, *P. adspersus* was found only at stations 1–4, 6, and 8, where *Ruppia* were also present. Significant differences in abundance and biomass were noted between the studied sites. At the other stations, this crustacean was absent even in summer due to the absence or very low abundance of *Ruppia* (less than 40 shoots per m^2). At depths of 0 to 1 m, where *Ruppia* grew, the bottom was sandy or lightly silted sand. The highest density of *Ruppia* thickets occurred at depths from 0.3 to 0.6 m, where the concentration of prawns was also maximum. For the sample totality, all the data for the period from 2018 to 2021, a significant positive correlation was found between the number (R = 0.602, $p = 0.0001$) and biomass (R = 0.446, $p = 0.0005$) of prawns with the number of plant shoots. At some stations, where prawns were usually found, the correlation between the number of *Ruppia* and the number of prawns was even higher. For example, at the third station (for all years), this dependence for the males was (R = 0.767, $p = 0.005$):

$$N_{prm} = 3.445 + 0.0003\ N_{rup}, \tag{1}$$

where N_{prm} is the abundance of males, ind./m^2; N_{rup} is the number of *Ruppia* shoots, ind./m^2.

For the females (R = 0.913, $p = 0.001$):

$$N_{prf} = 0.294 + 0.001\ N_{rup}, \tag{2}$$

where N_{prf} is the abundance of females, ind./m^2, and N_{rup} is the number of *Ruppia* shoots, ind./m^2.

In winter (from December to February), the prawns were only at a depth of 1.5 m, which was associated with the migration of crustaceans to deeper areas when the water temperature near the coast drops below 5–6 °C. In winter, semi-decomposed *Ruppia* was on the bottom throughout the entire water area of the lake due to wind dispersal. In deeper places with a depth of 1.5 m, where the *Ruppia* did not grow in summer, the prawns could find the *Ruppia* remains, which they could eat, or/and they could eat the microalgae growing on it. The spring temperature increase from 5.5 to 24 °C was accompanied by an increase in the prawn number, and a significant positive relationship was observed between these indicators (R = 0.792, $p = 0.001$):

$$N_{pr} = 0.280\ T^{1.423}, \tag{3}$$

where N_{pr} is the number of adult prawns, ind./m^2; T is the temperature, °C.

In summer, when the temperature rose above 25 °C, the number of adult prawns was significantly negatively related to temperature (R = −0.652, $p = 0.01$):

$$N_{pr} = 218.3 - 7.1\ T, \tag{4}$$

In autumn, the prawn number decreased as the temperature dropped. In winter, with temperature fluctuations from 5.5 to 7.8 °C, the abundance remained approximately at the same level, 3.2 ind./m^2 on average (CV = 0.342). If the temperature near the coast in winter can drop below 2 °C, then at a depth of 1.5 m it was higher, and in the cold period, as a rule, it was 5–7 °C. In particular, on December 23, 2020, the water temperature was 3.5 °C near the shore at a depth of 0.4 m, and in the bottom layer at a depth of 1.6, it was 5.5 °C.

The number of prawns did not significantly correlate with salinity in 2018 and 2019, and the prawns were present at all salinities up to the maximum salinity of 55 g/L. In July 2020, the salinity increased to 59–62 g/L in the lake, except for the areas with spring outlets, where it was 52–56 g/L. In these areas (stations 5 and 7), the prawns were abundant, even though there were few or no *Ruppia*. At other stations with dense thickets of *Ruppia*, the salinity was 56–62 g/L, and the prawns were completely absent.

In 2018, during the observation period from July 11 to August 11, at the surveyed stations (1–4 and 6), no directed significant changes in the number and structure of the adult prawns were noted; the number of males averaged 4.2 ind./m^2 (CV = 0.819) and the females 10.6 ind./m^2 (CV = 0.272); the share of females with eggs from the total number was on average 43% (CV = 0.460). A significant positive correlation (R = 0.761, $p = 0.005$) was noted between changes in the total number of adult prawns (not biomass) and the number of *Ruppia* shoots (Figure 2). There was no correlation between the prawn abundance and temperature or salinity.

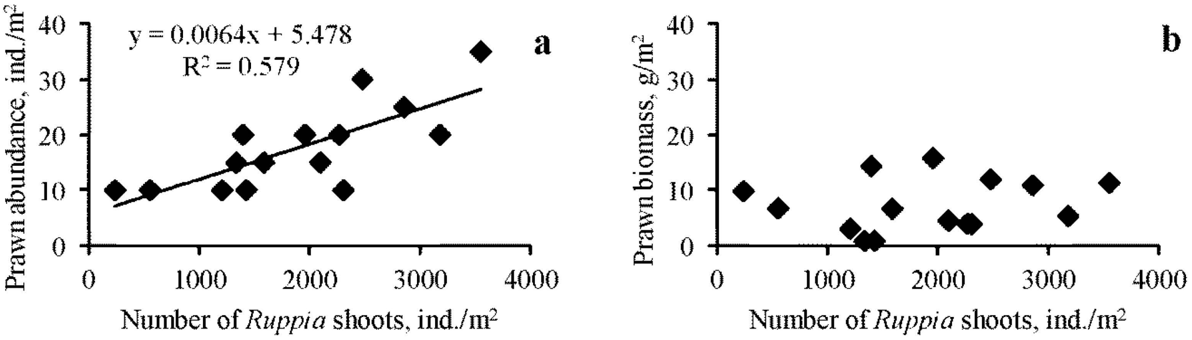

Figure 2. Dependence of the abundance (**a**) and biomass (**b**) of prawn *Palaemon adspersus* on the number of marine grass *Ruppia* shoots in Lake Moynaki during 2018.

During the observation period from 12 February to 10 December 2019, all eight stations fell into two groups: the first (stations 1, 2, and 3), in which the prawns were massively present, and the second, where they were absent or where single crustaceans were encountered once (stations 4–8). At the first group of stations, thickets of *Ruppia* were present, at the second they were not. In the first group of stations, the males were absent in February and March (once, there was a single male), as they were in December. In the period from April to October, the number of males increased until a certain time (June) and then decreased (Figure 3). In the same period, the females, being completely absent in February and December, showed similar seasonal abundance dynamics, but with a later maximum, in August (Figure 3).

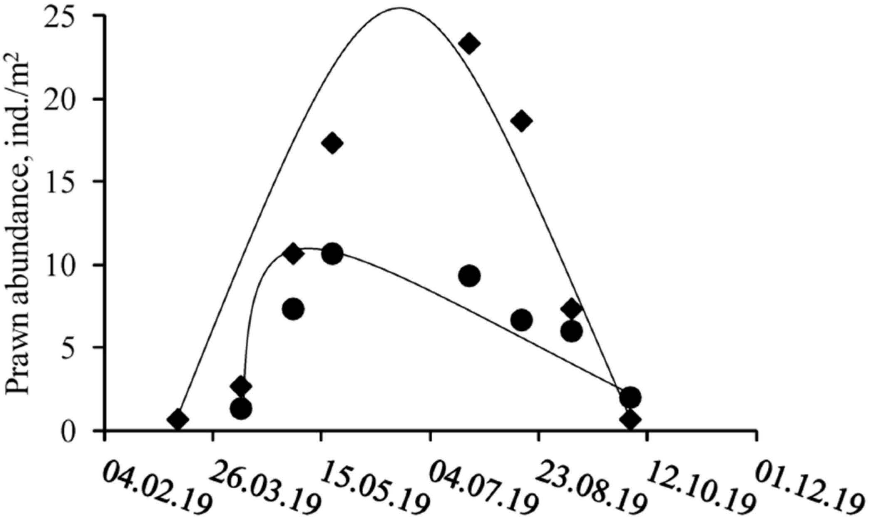

Figure 3. The trends in change of the *Palaemon adspersus* abundance of males (circles) and females (rhombuses) in the hypersaline Lake Moynaki during 2019.

Females with eggs were present from April to September, averaging 41% of their total number (CV = 0.297). Their share was minimal in April and September and maximal in summer (Figure 4).

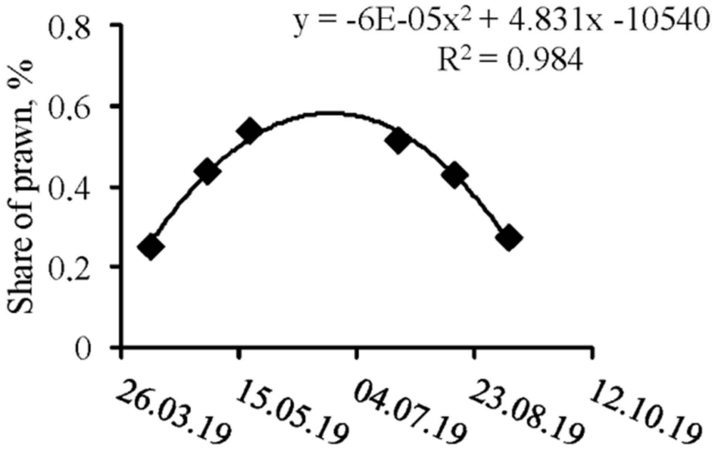

Figure 4. Change the share of *Palaemon adspersus* females with eggs from their total number in the hypersaline Lake Moynaki in 2019.

An assessment of the spatial heterogeneity of the distribution of prawns by the value of the coefficient of variation (CV) showed that the minimum spatial heterogeneity in the distribution of males and females was in summer at the highest abundance (Figure 5).

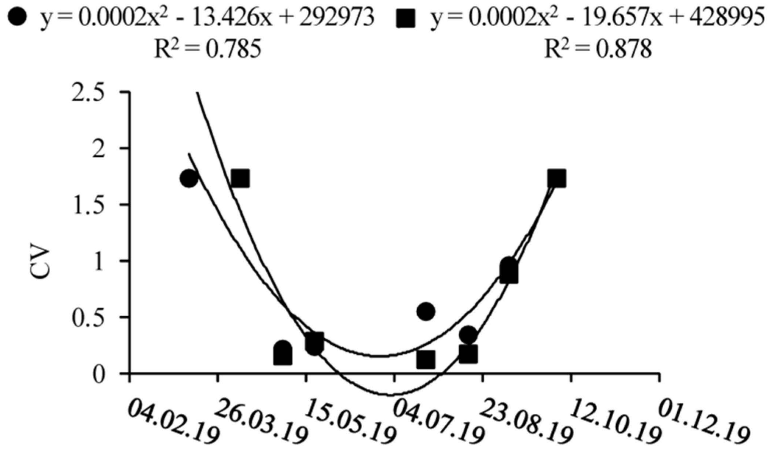

Figure 5. Seasonal changes in the coefficients of spatial variation (CV) in the abundance of *Palaemon adspersus* females (circles) and males (squares) in the hypersaline Lake Moynaki during 2019.

In males and females, the CV significantly ($R = -0.890$, $p = 0.005$) negatively correlated with the abundance of prawns. A significant positive correlation was noted between the changes in the total number of adult prawns (at the stations where they were) and the number of *Ruppia* ($R = 0.940$, $p = 0.001$).

In 2020, as well as in 2019, the study was conducted from February to December, and the average total prawn number was 5.0 ind./m^2 (CV = 0.910) in the sites where it was found. Except for February, prawns were encountered in all the other months. A clear seasonal variation was not revealed at any of the stations. The prawns were only seen in some periods at different sites. The area of *Ruppia* thickets decreased; the density of plants thereat averaged 559.5 ind./m^2 per year (CV = 0.577). At the same time, it should be noted that, unlike in 2018 and 2019, prawns were also observed outside the *Ruppia* thickets occasionally, and there were cases when prawns were absent in the thickets. No significant correlation between the total prawn number and the number of plants was observed in 2020.

In 2021, observations were carried out from January to August; there were few prawns, and they were noted only at two stations. At station 8, they were recorded only in January and were wintering females, 4 ind./m^2, outside the *Ruppia* thickets. At station 3, in early April, there were only females, 6 ind./m^2, without eggs (the number of *Ruppia* was 483 ind./m^2), and in May, there were males, 6 ind./m^2, and females, 18 ind./m^2, of which 56% were with eggs (the number of *Ruppia* was 2070 ind./m^2). Later, prawns were not found in the lake, even at station 1, where there was a spot of *Ruppia* with an average plant abundance of 1076 ind./m^2.

In the period from 2018 to 2021, the area of *Ruppia* cover in the lake decreased, while at stations 1, 2, and 3 the population abundance decreased progressively (Figure 6). A similar thing happened with the prawn abundance. A significant correlation was found between the changes in the abundances of the *Ruppia* and prawns ($R = 0.992$, $p = 0.005$):

$$N_{pr} = 0.012\ N_{rup} - 1.902, \tag{5}$$

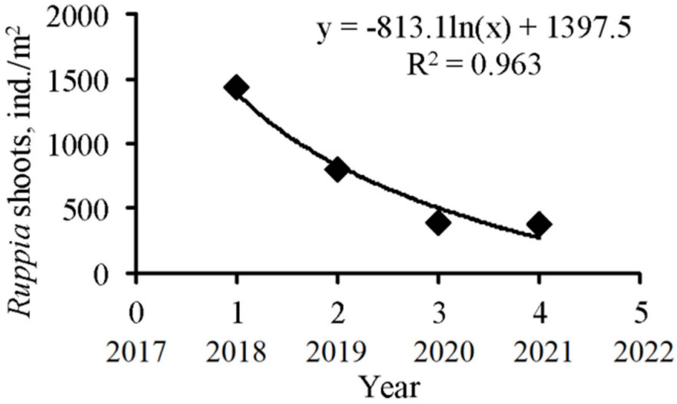

Figure 6. Change in the number of *Ruppia* shoots in its thickets from 2018 to 2021 in the hypersaline Lake Moynaki.

3.2. Length, Mass, Fecundity

Over the entire period of the study, the length of adult prawns varied from 17 to 58 mm: in males from 17 to 46 mm, averaging 28.6 ± 6.8 mm, and in females from 17.5 to 58.0 mm, averaging 38.3 ± 9.5 mm. Females are, on average, significantly ($p = 0.005$) 1.27 times larger than males ($CV = 0.237$) when occurring together. This value varied in the population, and there were periods when the males were significantly larger than the females during joint occurrence ($p = 0.05$). As a rule, this was observed before the start of the period of the appearance of females with eggs. The parameters of the equation for the dependence of body mass on length differed significantly for males and females ($p = 0.001$) (Figure 7). For males, the equation 'length–mass' was ($R = 0.996$, $p = 0.0001$):

$$W_m = 0.6 \times 10^{-5}\ L_m^{3.074}, \tag{6}$$

where W_m is the wet mass of a male, g; L_m is the body length of the male, mm.

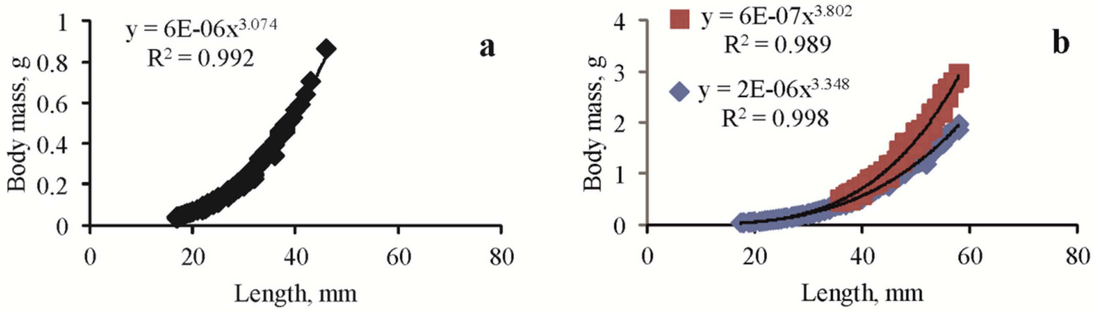

Figure 7. The dependence of body mass on length in *Palaemon adspersus* in Lake Moynaki: (**a**)—males, (**b**)—females (squares—with eggs, rhombuses—without eggs).

For females without eggs, the following relationship was found (R = 0.999, $p = 0.0001$):

$$W_{fwe} = 0.2 \times 10^{-5}\ L_{fwe}{}^{3.348}, \tag{7}$$

where W_{fwe} is the wet mass of a female without eggs, g; L_{fwe} is the body length of a female without eggs, mm.

Single-sized females without eggs (30 mm) had 1.6 times more weight than males. The equation calculated for the two sexes together (males and females without eggs) was (R = 0.998, $p = 0.0001$):

$$W = 0.4 \times 10^{-5}\ L^{3.243}, \tag{8}$$

where W is the wet mass of a male or female without eggs, g; L is the body length of a male or female without eggs, mm.

The averaged relationship between body length and weight for all females (with and without eggs) was (R = 0.990, $p = 0.0001$):

$$W_f = 1.2 \times 10^{-5}\ L_f{}^{3.559}, \tag{9}$$

where W_f is the wet mass of any female (with and without eggs), g; L_f is the body length of a female (with and without eggs), mm.

For females with and without eggs, starting from a size of approximately 36 mm, the curves of this dependence begin to diverge (Figure 7b), and the parameters of the equations differ significantly from each other ($p = 0.0001$). The mass of females with eggs was related to body length by the following equation (R = 0.994, $p = 0.0001$):

$$W_{feg} = 0.06 \times 10^{-5}\ L_{feg}{}^{3.79}, \tag{10}$$

where W_{feg} is the wet mass of a female with eggs, g; L_{feg} is the body length of a female with eggs, mm.

At the same time, among females of the same size, the mass of females with eggs was 1.34 times higher than that of females without eggs (CV = 0.074). In females with eggs, the share of egg mass in the total body mass of females with eggs significantly increases with body mass (R = 0.790, $p = 0.001$):

$$K = 16.4 + 6.6\ W_{feg}, \tag{11}$$

where K is the proportion of the mass of eggs in the total mass, %.

The relationship between the number of eggs and a female length did not differ significantly for spring and summer, and it can be described by the equation (R = 0.999, $p = 0.0001$):

$$E = 3 \times 10^{-5}\ L_f{}^{4.443}, \tag{12}$$

where E is the number of eggs.

The relationship between the number of eggs and the weight of the female with eggs can be approximated (R = 0.997, $p = 0.0001$):

$$E = 629.6\ W_{feg}{}^{1.186}, \tag{13}$$

No significant relationship between egg weight and body length was found, but there are small but significant differences ($p = 0.001$) between the egg masses in spring and summer. In spring, the average egg mass averaged 1.76 mg (CV = 0.164), which is 14% more than in summer, when the average egg was 1.55 mg (CV = 0.108). The average value for all seasons was 1.58 mg (CV = 0.183), and it can be used for practical problems. In summer, there were on average 653 eggs per 1 g of female body weight with eggs (CV = 0.104), and in spring, 581 eggs (CV = 0.145); the differences are statistically significant ($p = 0.001$). The average value for the entire breeding period was 634 (CV = 0.125).

4. Discussion

The new data show that *P. adspersus* is a more halotolerant species than previously thought, and it can survive and breed up to a salinity of 55 g/L, which can be regarded as a strong environmental filter for this species in the lake. The closely related species *Palaemon elegans* Rathke, 1837, which also inhabits the Black Sea, can tolerate salinity up to 62 g/L in the Aral Sea [36]. High salinity, judging by our data, somewhat reduces the production potential of the species, but the absence of predators in Lake Moynaki allowed the prawns to reach a higher abundance than was observed in other habitats [21,22,37].

The results of the study confirmed the existence of a close relationship between the distribution of the prawn and the development of seagrass beds, including *Ruppia*. The new results only confirm what was previously known about the biology of the species [14,38–42] and give a quantitative characterization of the known relation in the lake. The coefficients of determination allow us to estimate the contribution of the changes in one element to the variability of another element, and based on their calculated values, the conclusion may be made that the density of *Ruppia* thickets can determine more than 70% of the variability in the abundance of *P. adspersus* in the absence of predators, as in Lake Moynaki. In 2020, there was no correlation between the prawn and *Ruppia* abundance. This most likely indicates that at that time other causes, acting as environmental filters for the prawns, played a much more important role. In July 2020, an unusual spatial distribution of the species in the lake was observed. The prawn was absent in the thickets of *Ruppia* at a salinity from 56 to 63 g/L, and at the same time, it was found in areas with a salinity from 50 to 52 g/L, where there was no *Ruppia*. It is easy to assume that the main role in the degradation and disappearance of the prawn population in the lake was played by an increase in salinity above 55 g/L. However, the totality of facts makes this conclusion doubtful.

The increase in the prawn abundance in the lake, after its invasion here, went simultaneously with the increase in the area and density of the *Ruppia* thickets; the subsequent decrease in the number was most likely caused by the degradation of the *Ruppia* thickets. Over the past years, eutrophication has been occurring in the lake, which was caused by anthropogenic activities [33]. For freshwater and saline lakes, it was shown that their ecosystems can be in alternative states, and with an increase in turbidity as a result of eutrophication, underwater vegetation disappears in the lakes, and their ecosystems can transit into an alternative state with phytoplankton blooms [43,44]. The frequency, intensity, and duration of the outbreaks of intense blooms, in particular those of cyanobacteria, were increasing in the lake (own unpublished data). In particular, the most intensive among them were: *Pseudoanabaena* sp., 17 million cells/L (3 August 2019); *Microcystis* sp., 46 million cells/L; *Pseudoanabaena* sp., 12 million cells/L (12 July 2020); *Microcystis* sp., 52 million cells/L; *Pseudoanabaena* sp., 7 million cells/L (18 August 2020); and *Microcystis* sp., 33 million cells/L (17 October 2021). The degradation of *Ruppia* thickets may be, therefore, easily explained by all those blooms leading to high turbidity and low penetration of photosynthetically active radiation (PAR) in *Ruppia* thickets. The reducing of PAR below the compensation point, when the oxygen production by *Ruppia* was equal to or less than the oxygen consumption by *Ruppia*, and repeating relatively long-term near-bottom anoxic events with H_2S smelt were observed at that time. The oxygen regime in the lake worsened; currently, hypoxic and anoxic conditions are more easily formed near the bottom. As is known, *P. adspersus* is significantly sensitive to the depletion of oxygen content and does not tolerate temporary periods of severe hypoxia/anoxia [45,46]. It is almost certain that this could be the cause of the mass death of *Ruppia* and prawns. In hypersaline eutrophicated waters, such events may easily occur due to a decrease in oxygen solubility with a salinity increase [47].

During eutrophication, filamentous green algae *Cladophora* begins to develop in macrophyte thickets, which the authors also observed in Lake Moynaki, and this could also lead to the oppression of *P. adspersus* populations [20]. In the summer–autumn months in 2019, illegal shrimp harvesting in the lake was intensive, and to a lesser extent, it was in 2020, which probably also contributed to the degradation of the *P. adspersus* population in the lake to some extent. The available data are insufficient to quantify the contribution of each factor to the near extinction of the prawn population in the lake.

P. adspersus has been studied in various parts of its range, and the maximum sizes of males and females differed (Table 1). No significant correlations of these indicators with salinity were found, and this is understandable as the maximum size of animals in a population depends on a combination of many factors, biotic (food availability, predation, competition, etc.) and abiotic (temperature, oxygen concentration, etc.). At the same time, it should be noted that the minimum size values were noted in areas with the lowest salinity (the Baltic Sea) and the highest (Lake Moynaki). It can be assumed that the dependence of the physiologically possible maximum size of this prawn on salinity has a bell-shaped form, with a maximum salinity of about 35 g/L. However, this is only an assumption that requires further verification.

Table 1. Some quantitative characteristics of *Palaemon adspersus* in different parts of its range.

Area	**Salinity g/L**	**Maximum Length, mm**		**Parameters of Equation W = aL^b**				**Number of Eggs Per 1 g**	**References**
				Females		**Males**			
		Female	**Male**	**a, 10^{-5}**	**b**	**a, 10^{-5}**	**b**		
Mediterranean Sea, Parila Lagoon	<30	72.5	59.0	0.0003	2.13	0.0009	1.81	929	[48]
Black Sea, Sinop Bay	17÷18	82	70.0	0.7	3.25	0.2	2.93	725	[22]
Mediterranean Sea, Mesolongi Lagoon	33÷35	78.7	64.7	0.5	3.11	0.4	3.20	-	[49]
Atlantic Ocean, the Vigo estuary	33÷35	68.2	44.9	-	-	-	-	-	[50]
Baltic Sea, Gdansk Bay	6.4÷6.7	59.0	38.0	0.4 *	3.17 *	-	-	-	[24]
Mediterranean Sea, western part	33÷35	71.0	52.0	0.3	3.32	0.5	3.20	-	[51]
Black Sea, Karkinitsky Bay	17÷18	78.2	57.3	-	-	-	-	792	[17]
Black Sea, Kerch strait	11÷15	95.0	-	-	-	-	-	357	[52]
Black Sea, Karkinitsky Bay	17÷18	58.1	44.1	-	-	-	-	-	[28]
Lake Moynaki	49÷63	58	46	0.4	3.348	0.6	3.074	653	New data

Note: * For both sexes together.

A power-law dependence of body mass on length was noted in all the studies (Table 1), while the calculated exponents, b, in the equation W = aL^b, ranged from 2.130 to 3.348 in females and from 1.81 to 3.20 in males. Probably, these differences are not accidental and exist due to some differences in the habitats, but there are not enough data to discuss this. Using the available equations (Table 1), the authors calculated the mass of 30 mm prawns in different regions. For the females, the average calculated mass was 0.31 g (CV = 0.354), and for the males, it was 0.22 g (CV = 0.761). At the same time, the maximum calculated values were obtained for Lake Moynaki and the minimum for the Baltic Sea and the Black Sea.

In all the studies, a power-law dependence of the egg number on the female size was noted; however, it is not possible to correctly compare all the cases due to the nature of the presentation of the data in the sources. In the opinion of the authors, our data can be correctly compared with those obtained in Sinop Bay, the Black Sea [53], where the dependence had the form:

$$E = 2.4 \times 10^{-5} L_f^{4.427}, \tag{14}$$

where E is the number of eggs; L_f is the body length of females with eggs, mm.

The calculation of the average number of eggs in 40 mm females, using the current data (Equation (11)) and this equation, showed that the value obtained for Lake Moynaki was 6% more than that for Sinop Bay. The integral reproductive potential can be assessed by the number of eggs per 1 g of female body weight (Table 1); in different parts of the area, it varied from 357 (the Black Sea, the Kerch strait) to 929 eggs/g (the Adriatic Sea). It can be assumed that the dependence of this indicator (its highest limit) on salinity is bell-shaped, with a maximum at the most comfortable salinity (from 30 to 35 g/L); in the Black Sea (Kerch strait) at a salinity of about 14 and in Lake Moynaki (salinity > 50 g/L), it is less by 2.60 and 1.42 times, respectively.

This prawn species has been commercially harvested by small-scale fisheries in different countries for a long-time [17,22,39,48,52]. Currently, it is commercially cultivated in some areas, and according to the FAO statistics, in the Black Sea countries the *P. adspersus* aquaculture production exceeded 3.5 tons in Ukraine alone [31]. Based on the data obtained, the species can be cultivated in hypersaline waters with a salinity of up to 55 g/L. In this case, it is necessary to avoid severe hypoxic and anoxic events, which are quite easily solved by aeration. In Lake Moynaki [10,11], as well as other hypersaline lakes and lagoons [9,54,55], there are the highest concentrations of various small invertebrates, which are the important items in the diet of this prawn species [28]. In Crimea and other regions of the Mediterranean and the Black Sea coasts, there are many saline and hypersaline lakes and lagoons [30,54], which can be used for the cultivation of *P. adspersus*. In addition to the natural hypersaline waters, there are currently more than 15,900 seawater desalination plants in the world that produce over 142 million m^3/day of hypersaline brine with a salinity of about 50 g/L [56], which can also be used for the cultivation of *P. adspersus*. Among the studied Palaemonidae species, *P. adspersus* belongs to the species with the highest protein concentration and energy content, which averages about 20 J/mg DW [57,58]. The lipid content of *P. adspersus* is 27.9% PUFA (eicosapentaenoic and docosahexaenoic fatty acids), which amounts to prawn lipids of 27.9% [59]. For comparison, the amount in Antarctic krill is 23.8% [60]. In the modern human diet, there is a deficiency of PUFA [58]. Therefore, prawn meat is a valuable dietary product. There is the expediency of *P. adspersus* biomass utilization as a raw material for the production of biologically active compounds; these compounds are used in the food industry, medicine, and agriculture [61]. This can significantly increase the economic viability of this species' aquaculture.

The development of aquaculture in hypersaline waters may help save freshwater resources [5], and the development of aquaculture in brines formed during the desalination of seawater will make it more economically viable to obtain fresh water from seawater. Consequently, the development of scientific bases and technologies for Integrated Multi-Trophic Aquaculture in hypersaline waters is extremely important. The selection of possible species for this is one of the first steps in this direction, and *Ruppia* spp. and *P. adspersus* are among the prospective candidates.

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