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DISTRIBUTION OF THE ALIEN SPECIES *PALAEMON MACRODACTYLUS* RATHBUN, 1902 IN THE VENICE LAGOON

DISTRIBUZIONE DELLA SPECIE ALIENA *PALAEMON MACRODACTYLUS* RATHBUN, 1902 NELLA LAGUNA DI VENEZIA

REDOLFI BRISTOL SIMONE[1*], SCAPIN LUCA[1], CAVRARO FRANCESCO[1], FACCA CHIARA[1], ZUCCHETTA MATTEO[2], FRANZOI PIERO[1]

1. *Dipartimento di Scienze Ambientali, Informatica e Statistica (DAIS) – Università Ca' Foscari di Venezia, Via Torino 155, 30170 Mestre-Venezia, *corresponding author s.redolfibristol@unive.it*
2. *Istituto di Scienze Polari, Consiglio Nazionale delle Ricerche (CNR-ISP), Via Torino 155, 30170, Mestre-Venezia*

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Parole chiave: *Palaemon macrodactylus*, specie aliene, distribuzione, struttura in taglia, relazione lunghezza-peso, acque di transizione

Abstract
Palaemon macrodactylus Rathbun (1902) is an estuarine shrimp native to north-western Pacific which, due to its wide environmental tolerance to chemical-physical conditions and its long breeding period, from 1957, probably carried by ship ballast water, massively colonized estuarine ecosystems worldwide. After its first record, in 2012, *P. macrodactylus* appears to have rapidly colonized the entire Venice lagoon, showing higher abundance in the confined saltmarsh stations of the northern sub-basin, probably due to the relatively low salinities values of this area. Records collected from 2014 to 2020 confirm the long reproductive period, comprised between Spring (mid-April) and Autumn (October), and the potential large invasion capacity of this species, which in the future could provoke competition with autochthonous species of the genus *Palaemon* and *Crangon crangon*.

Riassunto
Palaemon macrodactylus Rathbun (1902) è un gamberetto di estuario originario del Pacifico nord-occidentale che, grazie alla sua grande tolleranza alle condizioni chimico-fisiche e al suo lungo periodo riproduttivo, dal 1957, probabilmente trasportato attraverso le acque di zavorra delle navi, ha colonizzato molti ecosistemi di estuario in tutto il mondo. Dopo la sua prima segnalazione in laguna di Venezia nel 2012, *P. macrodactylus* sembra aver colonizzato rapidamente l'intero bacino lagunare, mostrando abbondanze maggiori nelle stazioni di barena confinate del sottobacino settentrionale, probabilmente a causa dei valori di salinità relativamente bassi in quest'area. Osservazioni raccolte tra il 2014 e il 2020 confermano il lungo periodo riproduttivo, compreso tra la primavera (metà aprile) e l'autunno (ottobre), e la grande capacità potenziale di invasione di questa specie, che potrebbe entrare in competizione con le specie native del genere *Palaemon* e con *Crangon crangon*.

Introduction
Palaemon macrodactylus Rathbun (1902) (Figure 1) is a large, edible, estuarine shrimp native to north-western Pacific. *Palaemon macrodactylus* was firstly described in waters around Japan (Rathbun, 1902), China and Korea (Newman, 1963). From 1957 to nowadays an expansion of

this species in, at least, six geographic regions has been observed (Ashelby *et al.*, 2013). *Palaemon macrodactylus* can reach the length of 51 mm (Newman, 1963), 55 mm (Siegfried, 1980) or up to 73 mm (California Resources Agency, 2002). According with Ashelby *et al.* (2004), females are relatively larger than males, ranging from 25 to 70 mm and from 25 to 35 mm, respectively. *Palaemon macrodactylus* is a very resistant species, withstanding wide ranges of temperature, salinity, and dissolved oxygens conditions (Newman, 1963; Siegfried, 1980). *P. macrodactylus* is euryhaline and show a strong osmoregulatory capability, tolerating a salinity ranging from 3 to 35 PSU (Born, 1968; Gonzalez-Otregon *et al.*, 2007) and it can be found also in fresh or nearly fresh waters (Siegfried, 1980). The highest densities of its populations usually occur in the upper part of estuaries, where salinities are lower than or equal to 10 PSU; however, the tolerance to diluted waters differ between larvae and juveniles or adults (Gonzalez-Otregon *et al.*, 2007; Vazquez *et al.*, 2015). Most populations of *P. macrodactylus* were found in transitional water ecosystems, which are its common habitats (Ashelby *et al.*, 2013; Spivak *et al.*, 2006). Nevertheless, there is one exception, Mar del Plata Harbor (Argentina), where this species live in marine water, even if several physiological problems are detected, possibly linked to high salinity stress conditions (Vazquez *et al.*, 2012).

Figure 1. Photograph of a specimen of Palaemon macrodactylus *(total length 38.2 mm, left) and detail of the rostrum (right)*
Figura 1. Foto di un esemplare di Palaemon macrodactylus *(lunghezza totale 38.2 mm, sinistra) e dettaglio del rostro (destra)*

Taking advantage of its strong tolerance to a wide water chemical-physical conditions and its strong reproductive capacity, which starts at a length of about 20 mm (Siegfried, 1982), *P. macrodactylus* easily colonized a broad set of estuarine habitats outside its native range (Ashelby *et al.*, 2013; Beguer *et al.*, 2007). Moreover, even if the vector of dispersion of *P. macrodactylus* is still unclear, the pelagic larval phase of *P. macrodactylus* make it probably easily transportable in ship ballast water (Ashelby *et al.*, 2013; Torres *et al.*, 2012). Furthermore, due to nocturnal habits of this species (Siegfried, 1982), adults are likely to be incorporated into ballast water more frequently (Ashelby *et al.*, 2004). A confirmation of this hypothesis is that all localities outside its native areas where it has been reported, are close, or nearby, to large international harbor or shipping traffic (Chicaro *et al.*, 2009; Gonzalez-Otregon *et al.*, 2007).
In Europe, the first record of *P. macrodactylus* was detected in Guadalquivir Estuary (Spain) where its appearance occurred between 1997 and 1999 (Cuesta *et al.*, 2004). At present, in Guadalquivir Estuary *P. macrodactylus* is the more abundant Palaemonidae, representing almost 46% of all co-generes (Gonzalez-Otregon *et al.*, 2007). In 2001-2002 *P. macrodactylus* was collected in Orwell Estuary (UK) (Ashelby *et al.*, 2004) and in coast of Zeebrugge

(Belgium) between July and October 2004 (d'Udekem d'Acoz *et al.*, 2005). In the same year, 2004, *P. macrodactylus* was recorded also in Geeste River Mouth (Germany) (Gonzalez-Otregon *et al.*, 2007) and then, in 2006, in Gironde Estuary (France) (Beguer *et al.*, 2007). During the same period, oriental shrimp was recorded in Black Sea, firstly, in 2002-2009, in western parts (Romania and Bulgaria) and recently, in 2018, in northeastern part (Evchenko *et al.*, 2020). Relatively to the Mediterranean Sea, *P. macrodactylus* was first recorded as zoeae in the Balearic Island (Spain) (Torres *et al.*, 2012) and then, in 2012-2013, it was collected as adult also in Grado-Marano lagoon, Venice lagoon and in Sacca di Goro, Adriatic Sea (Italy) (Cavraro *et al.*, 2014; Cuesta *et al.*, 2014; Rinaldi, 2012).

The first record of *P. macrodactylus* in the Venice lagoon occurred in 2012: 6 specimens, respectively 5 females and 1 male, were collected in the central sub-basin. Moreover, two females were observed to be ovigerous (Cavraro *et al.*, 2014).

Due to their similar morphologies, *P. macrodactylus* could be easily confused with other Palaemonidae species. *Palaemon macrodactylus* is well described in Newman (1963) and in Gonzalez-Otregon & Cuesta (2006). As in Cavraro *et al.* (2014), for this study it was necessary to distinguish between *P. macrodactylus*, *Palaemon adspersus* Rathke 1837 and *Palaemon elegans* Rathke 1837, the latter two species being the most common resident palaemonids in the Venice lagoon. The main characters to discriminate between the three species were: 1) the number of teeth on the dorsal margin of the rostrum, which ranged between 9 and 15 in *P. macrodactylus*, between 5 and 6 in *P. adspersus*, and between 7 and 9 in *P. elegans*; 2) the presence in *P. macrodactylus* of a double row of plumose setae on the ventral margin of the rostrum, while *P. adspersus* and *P. elegans* bear a single row of setae; 3) the shorter ramus of the outer flagellum of the antennule, which is fused for about 20% of its length in *P. macrodactylus*, for one third in *P. adspersus*, and for about 50% in *P. elegans* (Cavraro *et al.*, 2014). Moreover, the body of *P. macrodactylus* is greenish brown, with brown scattered chromatophores and dull orange joints in living specimens (Ashelby *et al.*, 2004). Chromatophores of *P. macrodactylus* do not form streaks or lines of pigment, as occur in *P. elegans* and the rostrum, in *P. macrodactylus*, lacks the red pigments spots characteristic of *P. adspersus* (Ashelby *et al.*, 2004).

The aim of this work was to detect the distribution and the size structure of *P. macrodactylus* in shallow water areas of the whole Venice lagoon from 2014 to 2020, and to analyze the expansion of this species after its first record in 2012.

Material and methods

Data on presence and densities of *Palaemon macrodactylus* in shallow water areas (≤ 1 m depth) of the Venice lagoon (45°24′47″N 12°17′50″E) (Figure 2) were obtained from several monitoring programs conducted from February to October, between 2014 and 2020. Data were divided in two period: 1) from February to June, "I"; 2) from July to October, "II".

Samplings were performed in 49 stations distributed in the whole Venice lagoon (Figure 2). Sampling stations were not sampled during each month or each year. Nekton samplings were conducted using a fine mesh small beach seine (Franco *et al.*, 2006, 2012); the length of the tow and the opening of the net were measured to estimate and standardize the species densities (number of individuals per 100 m^2). During sampling actions, two replicates in each station were conducted and temperature (± 0.01°C), salinity (± 0.01 PSU) and turbidity of the water (± 0.01 FNU) were also recorded with a multiparametric probe (Hanna Instrument 9829).

Nekton samples were transported refrigerated in the laboratory and frozen at -20 °C. *Palaemon macrodactylus* individuals were identified using the keys of Gonzalez-Otregon and Cuesta (2006), Ashelby *et al.* (2004) and the description provided by Newman (1963), Beguer (2010) and Cavraro *et al.* (2014) and measured (total length TL, represented by the sum of carapace and abdomen length, ±0.1mm) and weighed (total weight, ±0.1 mg or ±0.01 mg, TW). In the case of samples with less than 100 individuals, the measurements were performed on all individuals. In the case of more abundant samples, the measures were limited to a representative subset of at least 100 individuals. Length and weight of *P. macrodactylus* individuals collected from 2014 to 2020 were used to analyze the length and weight frequency distribution for each sampling month, cumulating all the sampling stations and sampling years and to calculate, after a log-transformations, the length-weight relationship. The Pearson correlation coefficient was calculated and tested to evaluate the correlation between the density of individuals and the salinity and turbidity of the water.

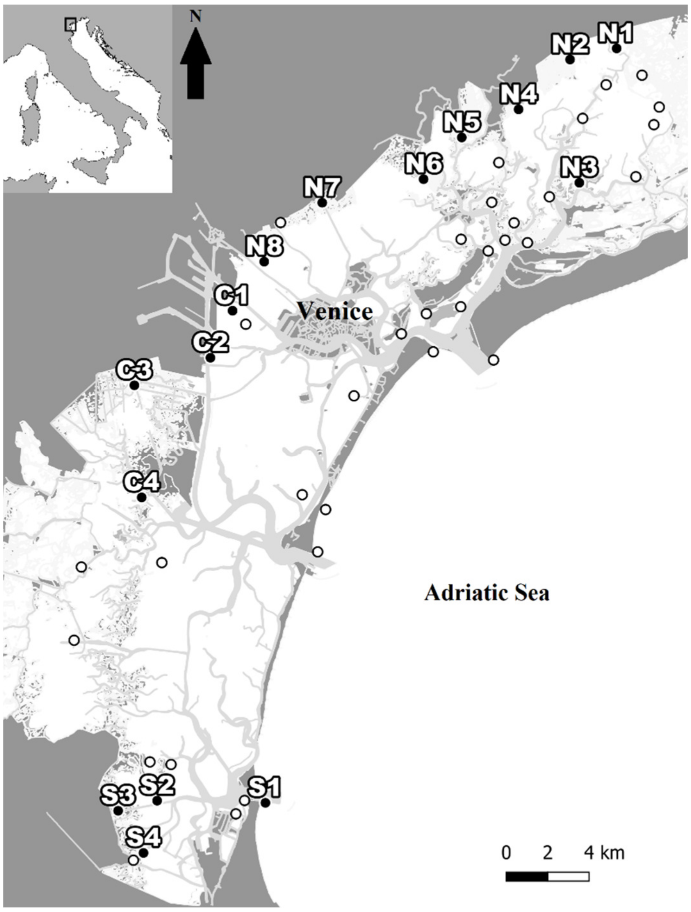

Figure 2. Location of the 49 sampling stations investigated from 2014 to 2020. White dots the sampling site where P. macrodactylus *was not found. Black dots the 16 sampling sites where* P. macrodactylus *individuals were collected. C4 = station where* P. macrodactylus *were firstly found in 2012 (Cavraro* et al.*, 2014)*

Figura 2. Localizzazione delle 49 stazioni di campionamento campionate dal 2014 al 2020. I punti bianchi indicano le stazioni dove P. macrodactylus *non è stato trovato. I punti neri indicano le 16 stazioni in cui* P. macrodactylus *è stato catturato. C4 = stazione in cui* P. macrodactylus *è stato segnalato per la prima volta nel 2012 (Cavraro* et al.*, 2014)*

Results

During the study period, 5040 specimens of *P. macrodactylus* were collected.

The highest densities of *P. macrodactylus* (Table I) were recorded in N7 in 2014; furthermore, the oriental shrimp was always present in N7, during the entire sampling period, from 2014 to

2020. Indeed, the high density of *P. macrodactylus* observed in 2014 in N7 were recorded performing only one sampling campaign per part of the year. *P. macrodactylus* was abundant also in station N8. Moreover, *P. macrodactylus* appears to be found especially from February to June.

During the whole sampling period, from 2014 to 2020, the number of sampling campaigns differ in relation with sampling stations. In general, some stations (e.g., N1, N2 and N4) were sampled only one time per part of the year while other stations (e.g., N5, N6 or stations located in the central or south sub-basin) were surveys two or three times per part of the year. However, the presence of *P. macrodactylus* in some stations was detected even with few sampling surveys per part of the year (e.g., stations N1, N3, N4).

From the results it can be observed that the northern sub-basin is the one in which *P. macrodactylus* were found more frequently during the whole sampling period as well as with generally higher densities. Moreover, in the stations of the northern sub-basin, *P. macrodactylus* was found during two or more sampling year, while in the stations of central and south sub-basins, when present, it was found only for one year, except for C2 station. Indeed, *P. macrodactylus*, albeit occasionally, is present in all three sub-basins. Furthermore, the results show that *P. macrodactylus*, except for N3 and S1 stations, seems to be located in confined stations, near the lagoon edge, and densities of individuals are positively correlated with turbidity of the water (Pearson correlation coefficient = 0.48, p-value < 0.001) and negatively correlated with salinity (Pearson correlation coefficient = -0.18, p-value < 0.001).

The specimens of *P. macrodactylus* collected measure between 15.65 mm and 60.75 mm in TL, with weight between 0.038 g and 2.743 g TW. The highest abundances occur in May (3846 specimens), when most specimens ranged from 30 to 50 mm TL (Figure 3). *P. macrodactylus* was collected also in April, June, and October, with 615, 248 and 242 specimens respectively. Smaller and younger individuals (TL < 20 mm) were collected in March, June, and October while larger individuals (TL > 50 mm) were found in May, June, and October.

Table I. Mean density of P. macrodactylus *(number individuals/100m^2 ± standard error) in the sampling stations where the species was found at least in one sampling occasion, grouped for sampling year and sampling part of the year (I = from February to June; II = from July to October). In brackets number of observations performed in each station. 0 indicates that the station was sampled but no individuals were captured. Standard error was reported only when more than two observations were performed*

Tabella I. Densità media di P. macrodactylus *(numero di individui/100m^2 ± errore standard) nelle stazioni di campionamento in cui la specie è stata trovata almeno in una campagna, divisa per anno e per parte dell'anno di campionamento (I = da febbraio a giugno; II = da luglio ad ottobre). Tra parantesi il numero di osservazioni effettuate in ogni stazione. 0 indica che la stazione è stata campionata ma non sono stati catturati individui. L'errore standard è stato riportato solo quando sono state eseguite più di due osservazioni*

	2014		2015		2016		2017		2018		2019		2020	
Station	**I**	**II**	**I**	**II**	**I**	**II**	**I**	**II**	**I**	**II**	**I**	**II**	**I**	**II**
N1									0.67 (2)	0 (2)	0 (2)		0 (2)	0.36 (2)
N2									2.86 (2)	0 (2)	0 (2)		1.56 ± 1 (4)	0.36 (2)
N3	0 (2)	0.29 (2)	0 (2)	0 (2)	0 (12)	0 (2)	0 (2)	0 (2)	0 (2)		0.07 ± 0.07 (10)	0 (6)	0 (6)	0 (6)
N4	0 (2)	0 (2)	0 (2)	0.36 (2)	0 (2)	0.71 (2)	0 (2)	0 (2)	0 (2)	0.71 (2)	0 (2)		0.89 ± 0.45 (4)	0 (4)
N5					0.12 ± 0.06 (10)						0 (10)	0 (6)	0 (4)	0.95 ± 0.95 (6)
N6			0 (4)		0.06 ± 0.06 (14)		0 (6)		0 (6)		0.07 ± 0.07 (10)	0.48 ± 0.35 (6)	0.18 ± 0.18 (4)	0 (6)

	2014		2015		2016		2017		2018		2019		2020	
Station	**I**	**II**	**I**	**II**	**I**	**II**	**I**	**II**	**I**	**II**	**I**	**II**	**I**	**II**
N7	476.30 (2)	64.94 (2)			59.60 ± 30.92 (20)								8.93 (2)	
N8	13.96 (2)	0.6 (2)												
C1				1.56 ± 0.85 (4)										
C2	0 (2)	0.65 (2)		0.71 ± 0.37 (8)										
C3	0 (2)	0 (2)			0.09 ± 0.05 (6)		0 (6)		0 (6)		0 (4)	0 (6)	0 (2)	0 (4)
S1					0 (3)		0 (2)		0.06 ± 0.06 (3)		0 (4)	0 (6)	0 (2)	0 (4)
S2											0 (4)	0.13 ± 0.13 (6)	0 (2)	0 (4)
S3					0.03 ±0.03 (6)		0 (6)		0 (6)		0 (4)	0 (6)	0 (2)	0 (4)
S4	0 (2)	0 (2)									0 (4)	0 (6)	0 (2)	0.54 ± 0.54 (4)

Young individuals, characterized by very low weight values and a TL < 20 mm, appear repetitively in March, May, June and October with peak of abundance in May, but also in March and October. May, June, and October were the months during which both young and adult individuals were found, although in June the number of young individuals was low. From the results it was possible to observe an increase in size of individuals from February to June, which probably continues up to October.

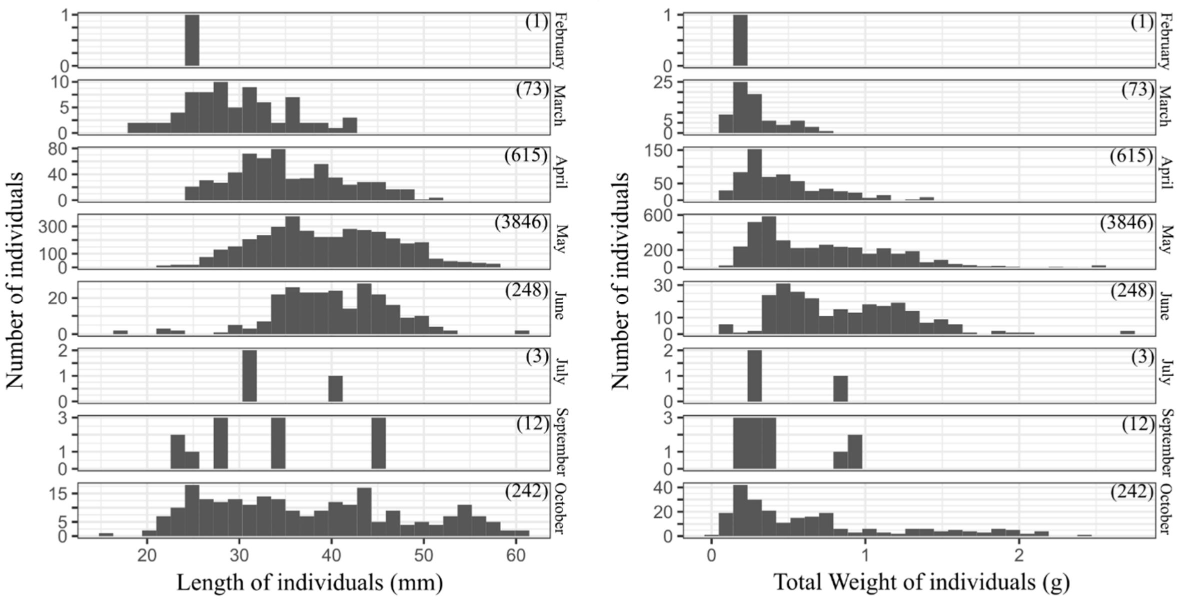

Figure 3. Length (TL, mm) (left) and total weighty (TW, g) (right) frequency distribution of P. macrodactylus *from 2014 to 2020, cumulating all the sampled stations and years. In bracket the total number of individuals per months. Note the different scale of the y axis*
Figura 3. Distribuzione di frequenza della lunghezza (TL, mm) (sinistra) e del peso totale (TW, g) (destra) di P. macrodactylus *dal 2014 al 2020, cumulando tutte le stazioni campionate. Tra parantesi il numero totale di individui ritrovati durante ogni mese. Notare la differente scala degli assi delle y*

Log-transformed length and weight data of measured *P. macrodactylus* were used to calculate the length-weight relationship (LWR) (Figure 4). A linear regression was fitted to estimate the

LWR and coefficient of determination (r^2) was calculated (Figure 4). The r^2 values of LWR was 0.90; in terms of growth, *P. macrodactylus* were positively allometric (b > 3).

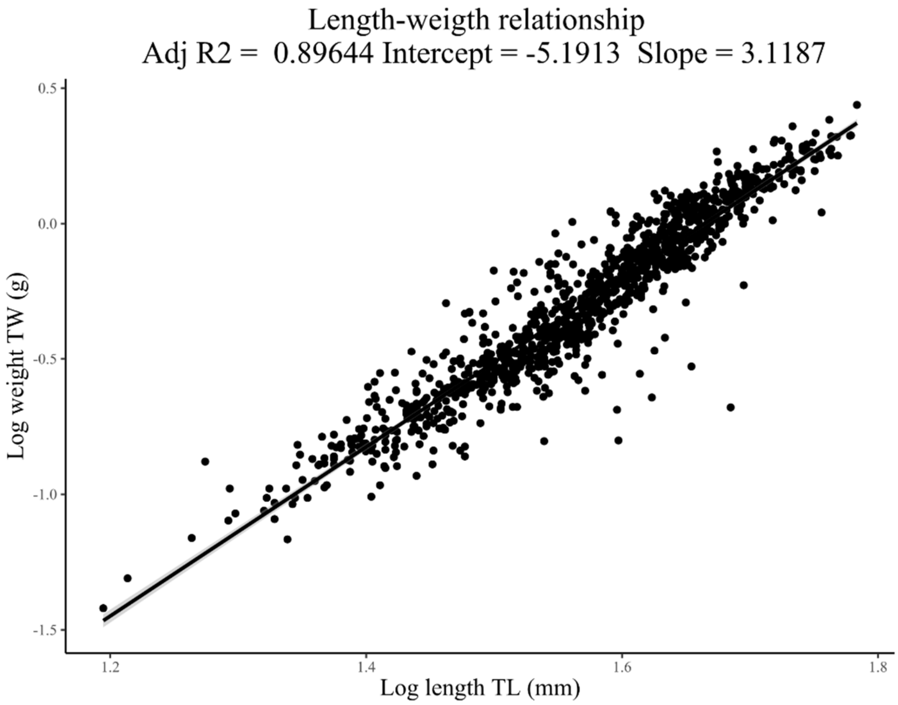

Figure 4. Palaemon macrodactylus *relationship between log-transformed length (TL, mm) and total weight (TW, g). n = number of individuals. Intercept and slope of the linear regression and r^2 are reported*

Figura 4. Relazione lunghezza (TL, mm) peso totale (TW, g) di Palaemon macrodactylus *su valori trasformati in logaritmo. n = numero di individui. Sono riportate l'intercetta, la pendenza dell'equazione della regressione ed il coefficiente r^2*

Discussion and Conclusions

The first appearance of *P. macrodactylus* in the Venice lagoon occurred in 2012 in only one station of the central sub-basin (Cavraro *et al.*, 2014). The presence of this species in Venice lagoon, as in other transitional water ecosystems, could be associated with ship water ballast discharge, which is considered the most likely vector of introduction (Ashelby *et al.*, 2013; Carlton, 1985; Beguer *et al.*, 2007) and this could be true also for the introduction within the Venice lagoon (Cavraro *et al.*, 2014). Indeed, the appearance in the Venice lagoon of non-indigenous species, for example the lobate ctenophore *Mnemiopsis leidyi* Agassiz, 1865; the Atlantic blue crab *Callinectes sapidus* Rathbus, 1896; the small mud crab *Dyspanopeus sayi* (Smith, 1869) and the Cyclopoida *Oithona davisae* Ferrari F.D. & Orsi 1984, has been commonly associated with water ballast discharge (Mizzan, 1993; Mizzan, 2017; Occhipinti-Ambrogi, 2000; Occhipinti-Ambrogi *et al.*, 2011; Vidjak *et al.*, 2019). In general, coastal lagoons and harbors present the highest number of alien species due to their importance in international commercial activities (Occhipinti-Ambrogi *et al.*, 2011). Shipping traffic, in fact, is one of the most important vector of non-indigenous species invasion worldwide (Marchini *et al.*, 2015; Occhipinti-Ambrogi, 2000) and it was found to have a significant role in the Venice lagoon, that was recognized to be the main hotspot of alien species introduction in Italy (Occhipinti-Ambrogi *et al.*, 2011). The first record of *P. macrodactylus* in the central sub-basin, in a sampling station near to the oil port of S. Leonardo (2.3 km), corroborates the hypothesis that *P. macrodactylus* arrived in this lagoon through the ship water ballast discharge (Cavraro *et al.*, 2014).

After its first collection in 2012 (Cavraro *et al.*, 2014), in few years *P. macrodactylus* spread in the entire Venice lagoon basin, confirming its ability to rapidly colonize transitional water ecosystems. From literature, this species is known to have wide environmental tolerance to chemical-physical conditions (Cavraro *et al.*, 2014; Gonzalez-Otregon *et al.*, 2007) but prefers salinity values ranging from 8 to 28 PSU (Ashelby *et al.*, 2013; Chicaro *et al.*, 2009; Cuesta *et al.*, 2014; Vazquez *et al.*, 2012). Our results seem to confirm these preferences, indeed densities of *P. macrodactylus* were correlated with low values of salinity and high values of turbidity of the water, with the highest densities of individuals recorded between 4 and 23 PSU of salinity and between 90 and 200 FNU of turbidity. The higher densities of the oriental shrimp observed in more confined sampling stations of the northern sub-basin of the Venice lagoon could be related with the relatively lower salinity values of this sub-basin compared with central and southern sub-basins. The northern sub-basin is indeed characterized by the presence of the principal freshwater tributaries (Dese, Vela, Osellino rivers) that account for more than 50% of the total fresh water inputs into the lagoon (Zonta *et al.*, 2005; Zuliani *et al.*, 2005). Moreover, the distance between sea inlet and lagoon edge is longer in the north sub-basin than central and south sub-basin: this probably change the water residence time and slow down the arrival of salty sea water in more confined areas. Contrarily, the central sub-basin of the Venice lagoon is characterized by strong tidal currents and a wide maritime ship channel while the south sub-basin owns the lower freshwater inputs (Cucco & Umgiesser, 2006; Rapaglia *et al.*, 2011). These characteristics probably make the central and southern sub-basins more suitable for the initial arrival of this invasive species, but less suitable for a long-term colonization, as confirmed by the different salinity tolerance between larvae, juveniles or adults (Gonzalez-Otregon *et al.*, 2007; Vazquez *et al.*, 2015). The presence of *P. macrodactylus* in a marine station of the southern sub-basin could also be related to the short distance between sea inlet and lagoon edge, which can favor the escape of individuals from the lagoon into the sea as a result of climatic weather events such as floods or strong outgoing tides. Regarding the habitat distributions, in literature *P. macrodactylus* is commonly associated with seagrass beds (Omori & Chida, 1988) and can endure high salinity values, as the one present in marine waters (Ashelby *et al.*, 2013; Spivak *et al.*, 2006; Vazquez *et al.*, 2012); however, in this work, although seagrass beds were also sampled, this species was found especially in saltmarsh habitats along the lagoon edge, and the highest densities were associated with bare flat saltmarsh edge characterized by low values of salinity and high values of turbidity.

Taking into account all the sampling years together, from 2014 to 2020, the presence of small young individuals of *P. macrodactylus*, characterized by a TL smaller than 20 mm (Siegfried, 1982), in March, May and October confirms the long reproductive period of this species, comprised between Spring (mid-April) and Autumn (October) (Muci & Nita, 2009; Omori & Chida, 1988). Moreover, the results seem to confirm Muci & Nita (2009): females spawn more than one time for breeding period. The long breeding period with multiple spawning makes it understandable how this species, once it has found the suitable chemical-physical conditions, can rapidly and massively colonize estuarine ecosystems.

Length-weight relationship of *P. macrodactylus* was calculated to provide useful information to better understand the characteristics of this alien species. The value for parameter *b* (3.12) in *P. macrodactylus* LWR remained within the range suggested by Froese (2006) and showed a tendency towards slightly positive-allometric growth (increase in relative body thickness or

plumpness). In general, values of *b* > 3 could be related with eutrophic conditions or abundant food (Froese, 2006). Moreover, the correlation coefficient r^2 (0.90) indicate the existence of a strong positive linear correlation. Similar results of *b* have been observed in North America considering the same species (Warkentine & Rachlin, 2010) or in Greece, considering three freshwater shrimps (Anastasiadou *et al.*, 2017). Conversely, *P. adspersus* individuals, in Croatia, Balearic Island, Caspian Sea and Greece showed values of *b* below 3, indicating negative-allometric growth (Glamuzina *et al.*, 2014 and citation therein). However, *P. macrodactylus* collected in Gironde Estuary (France) and Salado River, Mar del Plata (Argentina) showed a negative-allometric growth too (Beguer *et al.*, 2011; Bonel *et al.*, 2013). It should be noted that in this work a differentiation between the sexes was not made and therefore the LWR could be influenced by the presence of ovigerous females; indeed, further studies should be conducted to deepen the knowledge on the LWR of this species.
It is difficult to predict the impact of this alien species on the native fauna but competition with the congeneric species *Palaemon adspersus* and *P. elegans* can be easily hypothesized since the species were found at the same sites (Ashelby *et al.*, 2004; Cuesta *et al.*, 2014). Many introduced species have been shown a detrimental effect on indigenous biota (Chicaro *et al.*, 2009). Two important threats that an alien species could pose against native species are the competition for food resources and the transmission of pathogenic agents, such as fungi (Gil-Turnes *et al.*, 1989). Indeed, estuaries are particularly susceptible to biological invasions (Lejusne *et al.*, 2014; Ruiz *et al.*, 1997). Therefore, the increasing presence of *P. macrodactylus* in the Venice lagoon, which is considered the "main hotspot of introduction" of alien species in Italian coastal waters (Occhipinti-Ambrogi *et al.*, 2011), could affect the distributions of the local shrimp *P. adspersus*, *P. elegans* and *Crangon crangon* Linnaeus 1758. Indeed, when occurring in sympatry, *P. macrodactylus* has a clear competitive advantage over native prawn species, due to its reproductive strategy, its length of spawning season and its strong environmental parameters toleration (Gonzalez-Otregon *et al.*, 2007; Muci & Nita, 2009). Moreover, in case of deterioration of environmental conditions it might be favored compared to the native species (Cuesta *et al.*, 2014). Some authors (Rikketts *et al.*, 1968; Sitts & Knight, 1979; Siegfried, 1982) found that *P. macrodactylus* in California have been considered a threat for the native shrimps *Crangon franciscorum*, causing also its disappearance. However, Muci & Nita (2009) showed that the abundance of trophic resources and the nocturnal habits of this species could mitigate the niche overlap with other decapods.
More studies should be conducted on presence and distribution of *P. macrodactylus*, to evaluate the impact of this species over ecology and fisheries of Venice lagoon and European estuaries. Moreover, continuous monitoring program, coupled with observations on artisanal fisheries catches, should be performed to study the further expansion of oriental shrimp within Venice lagoon.

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