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New records of *Charybdis japonica* (A. Milne-Edwards, 1861) (Crustacea: Decapoda: Portunidae) in the Adriatic Sea

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Fifteen years after the first capture of a specimen of Charybdis japonica *in the Adriatic Sea, we report the collection of two more specimens near the port of Ravenna. This swimming crab, native from the North Western Pacific, has already proved its invasive capacity in New Zealand coastal waters. Its possible establishment in the northern Adriatic lagoons may represent a treat for the local Manila clam fishery and aquaculture activities.*

Key words: Portunidae, *Charybdis japonica*, alien species, Adriatic Sea, Mediterranean Sea, shipping

INTRODUCTION

The continuous increase of maritime traffics and the current speed of commercial vessels, that reduces the duration of trips between distant ports, have greatly increased the probability of unintentional transport of marine organisms from their native area to distant regions, either hidden in vessel hull (COUTS *et al*., 2003; FREY *et al*., 2014) or with ballast waters (BAILEY, 2015).

The growing concern, among the community of users of marine spaces, on the possible impact of these non-indigenous species (NIS) on the local biota, has also increased the probability their arrival being earlier detected by research projects carried out with cooperation of citizen-scientists (HOURSTON *et al.*, 2015; EARP & LICONTI, 2020).

The Mediterranean Sea, with its large commercial ports is crossed by a heavy maritime traffic that, through the Suez Canal, connects the Atlantic-Mediterranean region with the Indo-Pacific region (GALIL *et al.*, 2015). It has the highest number of reports of introduction of NIS, numerous species are now established, others were recorded only once (GALIL *et al*., 2018; ZENETOS *et al*., 2017).

When native and recipient habitats are similar, the probabilities of settlement for a non-indigenous species increase and any subsequent record is a warning of its possible settlement. Especially when the species has already proved

its invasive capacity in other regions. Fifteen years after the first capture of *Charybdis japonica* (A. Milne-Edwards, 1861) in the Adriatic Sea (FROGLIA, 2012), we report the capture of two more adult specimens.

The swimming crab *C. japonica* is native of the North-West Pacific, and has already invaded several bays in the North Island of New Zealand (AHYONG & WILKENS, 2011; FOWLER & MCLAY, 2013; WONG *et al*., 2016), and has been recorded also in Western Australia, near Fremantle international port (HOURSTON *et al*., 2015).

MATERIAL AND METHODS

The first crab was caught the 5 June 2019 by a professional fisher in traps for cuttlefish (*Sepia officinalis*) placed at depth of 8 m on a sandy bottom, South of entrance to the harbor of Ravenna, northern Adriatic Sea. He noticed unusual size and color of the crab and brought it to the "Centro Sperimentale per la Tutela degli Habitat" (CESTHA), where it was placed in a large tank aquarium (234 x 40 x 60 cm) with other organisms, and latter photographed (Fig. 1A).

The tank is supplied with recirculating sea water, renewed weekly through an intake pipe in the pier of the harbor entrance. Sea water temperature in the tank ranges between 26°C in summer (room temperature) and 18°C in winter (heated). The tank has a bare bottom with few sparse rocks, under which the crab used to hide. The crab, fed with morsels of fish and black mussel, survived in the tank for ten months, till the10th April 2020, without molting. It is now preserved in ethanol 75% in the didactic collection of CESTHA.

When the crab died, the tooth on posterior margin of merus of swimming legs was almost completely worn out (compare Fig. 1A and Fig 2C). In addition, the surface of the chela looked eroded and, small areas of the body and the legs had cuticle damages, as from action of chitinolitic bacteria.

In spring 2021, a leaflet, with photo of *C. japonica* and the main distinctive characters to recognize it from common native swimming crabs, was circulated by CESTHA among artisanal fishers based in Ravenna, and in July 2021 another specimen was found inside a trap for cuttlefish placed not far from the place of capture of the previous specimen (Fig. 1B). It has been kept alive in the same tank aquarium at CESTHA premise until November 2021, when it died. It has been preserved in ethanol and deposited in the zoological collection of the Museo civico di Storia naturale in Verona (Italy).

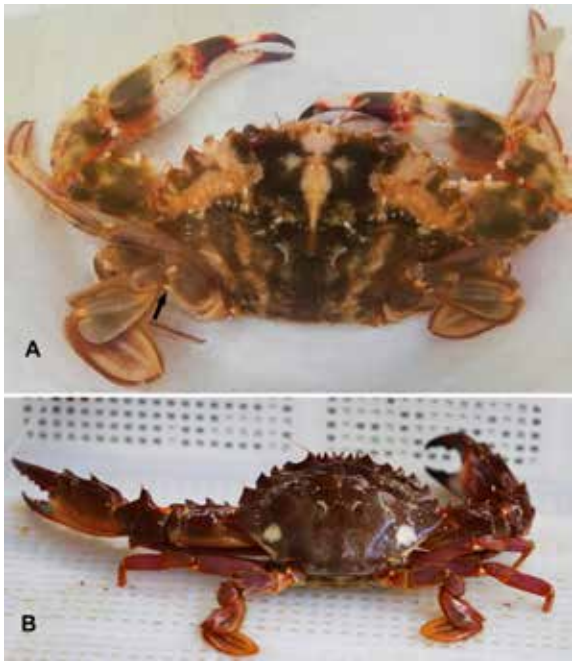

Fig. 1. Charybdis japonica*, color in life:* ***A****) male cl. 54.0 mm, off Marina di Ravenna, 5 June 2019 (arrow points to the acute postero-distal tooth on 5th pereopod merus);* ***B****) male cl. 72.3 mm, 1-mile South of the entrance to Ravenna harbor, 22 July 2021*

The two specimens have been identified as *Charybdis japonica* (A. Milne-Edwards, 1861) on morphological characters, with the aid of the identification keys and the descriptions in LEENE (1938), WEE & NG (1995), YANG *et al.* (2012), and compared with the other specimen collected in the Adriatic in 2006 (FROGLIA, 2012).

The following morphometric measurements were taken with a quadrant caliper of 0.05 mm accuracy: carapace length (CL), from tip of the frontal teeth to the posterior end of the carapace; carapace width (CW), from tip to tip of the posterior anterolateral teeth; sixth abdominal somite length and proximal width; crusher chela length,

from tip to posterior end, on ventral side of the propodus; dactylus length.

RESULTS AND DISCUSSION

Systematics
Order DECAPODA Latreille, 1802
Family Portunidae Rafinesque, 1815
Genus *Charybdis* De Haan, 1833
Species *Charybdis japonica*
(A. Milne-Edwards, 1861)

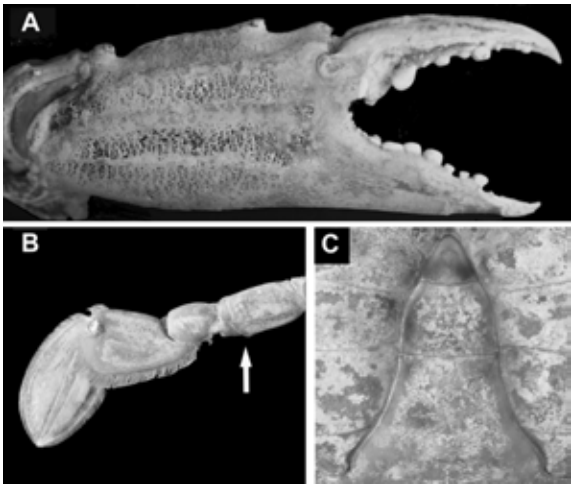

Fig. 2. Charybdis japonica*, preserved male cl. 54.0 mm, off Marina di Ravenna:* ***A****); crusher chela, surface appears worn;* ***B****) fifth pereopod, arrow points to the totally worn postero-distal tooth on merus;* ***C****) telson*

Material examined: Adriatic Sea: 1 male CL 54.0 mm, CW 80.2 mm, off Marina di Ravenna, 44°27.81'N 12°19.11'E, 8 m depth, 5 June 2019; 1 male CL 72.3 mm, CW 105.5 mm, 1-mile South of the entrance to Ravenna harbor, [44°28.8'N 12°19.3'E], 8 m depth, 22 July 2021.

Description: Carapace 1.46 - 1.49 times as broad as long, dorsal surface bare or with sparse very short setae, with minutely granulate protogastric, mesogastric, metagastric and epibranchial ridges; without ridges behind the epibranchial ridge; anterolateral margin with six sub-equal acute teeth; five on the left side in the largest specimen, by fusion of 4th and 5th tooth in a single large tooth (Fig. 3); front with 3 pairs of triangular teeth, the median slightly overreaching the others. Sixth abdominal somite 1.5 times wider than long, with lateral margins evenly convex. Chelipeds stout, merus inner margin with 3 triangular teeth, outer margin unarmed, crusher chela with squamiform markings on proximal half of under surface, 3 granulose costae on outer surface and 5 acute teeth on upper surface, partly worn in the first crab (Fig. 2B). Fifth pereopods with posterior margin of propodus not denticulate, fringed with short plumose setae, merus length/width ratio 1.6, with acute postero-distal tooth (Figs. 1, 3), almost completely worn out in the first crab, when died (compare Fig. 1A and Fig 2C).

The first specimen (Fig. 1A) had a lighter and more mottled coloration compared with the specimen caught off Ancona in 2006 (FROGLIA 2012, fig. 1), the second (Fig. 1B) had a more uniform brown-violet color. All specimens with a whitish spot on branchial region, and teeth on chelae and antero-lateral margins of carapace with brownish tip and a narrow white ring. Considerable variability in color patterns was also observed in the New Zealand population (SMITH *et al*., 2003) (Fig. 2.)

The size of the second specimen (CW 105.5 mm, weight 300 g) approaches the maximum size (CW 116 mm) recorded for the species in the northernmost population of the West Pacific (KOLPAKOV & KOLPAKOV, 2011). Biometrical data for the specimens collected in the Adriatic Sea are summarized in Table 1.

The native range of *C. japonica* in the West Pacific extends for over 40° latitude, from Malaysia (WEE & NG, 1995) to northern Japan Sea: East Hokkaido (KOMAI *et al*., 1992) and Peter the Great Bay, Russia (KOLPAKOV & KOLPAKOV, 2011). It was also reported from India (TRIVEDI *et al.*, 2018) and the northern sector of the Bay of Bengal (AHMED et al., 2021). We consider doubtful the presence of *C. japonica* in the Red Sea (WEE

Table 1. Biometrical data (mm) for the 3 males Charybdis japonica collected in the Northern Adriatic Sea

	Ravenna 2021	Ravenna 2019	Ancona 2006
Carapace Length	72.3	54.0	70.0
Carapace Width	105.5	80.2	102.7
Chela propodus length	94.8	62.7	85.5
Chela dactylus length	42.5	28.9	42.3

Fig. 3. Charybdis japonica*, carapace of the male cl. 72.3 mm*

& NG, 1995), based on two specimens found in the old Rüppell's collection housed in the Naturalis Museum, Leiden (LEENE, 1937). This shallow waters species is not mentioned in subsequent reviews of the swimming crabs of the Arabian Gulf and Red Sea (APEL & SPIRIDONOV, 1998) and of Pakistan (TIRMIZI & KAZMI, 1996).

Charybdis japonica may have arrived in the Adriatic Sea either as adults, hidden in hull sea-chests (COUTTS *et al.*, 2003), or as larvae, carried in ballast waters. Its complete larval development takes about 3 weeks (YATSUZUKA, 1952), a time compatible with duration of a bulk carrier trip from Far-East ports to the Adriatic Sea, moreover larvae can stand a wide range of temperatures and salinities (FOWLER *et al.,* 2011).

Unlike most Portunid crabs, *C. japonica* adult females' mate in the hard-shell stage (BAKER *et al*., 2018; KOBAYASHI & VAZQUEZ-ARCHDALE, 2018), and store in the spermathecae viable sperms used to fertilize eggs in successive broods (WONG & SEWELL, 2015). In its native area and in New Zealand, spawning occurs in the warm season and the average fecundity is around 400,000 eggs per clutch (FOWLER & MCLEAY, 2013). These reproductive strategies favor the shipping mediated spread of the species outside its native range. WONG *et al.* (2016), after comparison of population's genetic structure in crabs collected in several localities in New Zealand and in the native area, suggested the arrival of a small number of adult impregnated females may determine a propagule pressure sufficient to establish a new population.

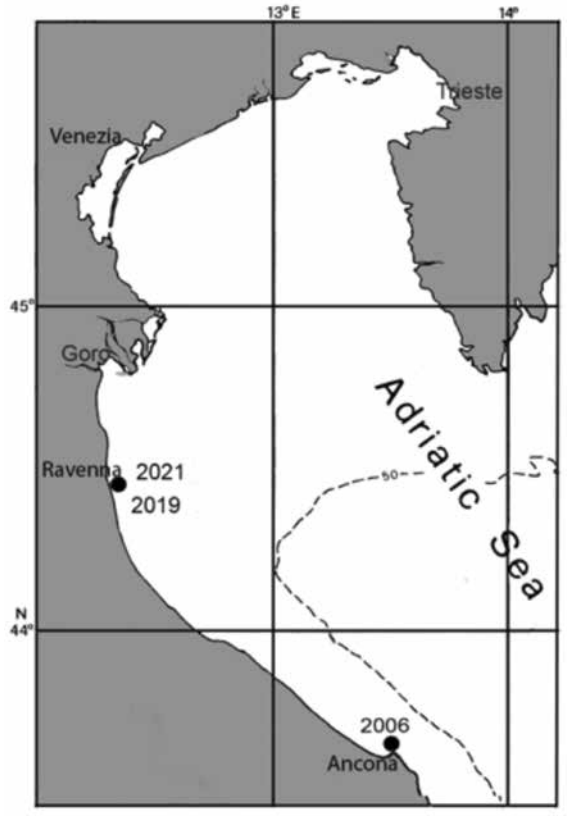

Fig. 4. North Adriatic Sea: • collection sites, with dates, of Charybdis japonica

The three specimens collected in the Adriatic Sea were found near the entrance of international commercial ports with shipping lines to the eastern Mediterranean and the Far East: Ancona, in 2006, and Ravenna, second Adriatic port by volume of goods handled, in 2019 and 2021 (Fig. 4).

The annual range of temperatures in the coastal waters off Ravenna (min. 4 – 6°C, max. 24 – 26°C) (ARPAE, REGIONE EMILIA-ROMAGNA. 2017) is similar to that reported for the *C. japonica* population thriving in South Korea bays (PARK *et al.* 2020).

The low winter temperatures of the northern Adriatic are not favorable for the establishment of Lessepsian immigrants, that nowadays characterize the eastern sector of the Mediterranean Sea (GALIL *et al.,* 2018), whereas species native of the temperate North-western Pacific may find a suitable habitat. Some of them are already locally invasive, as the shrimp *Palaemon macrodactylus* (CUESTA *et al.,* 2014) and the

bivalve *Arcuatula senhousia* (= *Musculista senhousia*) (MISTRI *et al.*, 2004; MORELLO *et al.*, 2004). Another West-Pacific bivalve, the Manila clam (*Ruditapes philippinarum*), intentionally introduced for aquaculture in 1980's, has colonized all brackish habitats and is currently harvested in the Sacca di Goro and in the other northern Adriatic lagoons, making Italy the second world producer, after China (TUROLLA *et al.*, 2019).

Like other portunid crabs, *C. japonica*, preys mainly on bivalve mollusks (SEO & HONG, 2009). TAKAHASHI *et al*. (2016a) listed, among the causes of depletion of Manila clam in Maizuru Bay, Sea of Japan, the predation by *C. japonica* upon *R. philippinarum* from juveniles to adults, and investigated in laboratory possible techniques to reduce its impact (TAKAHASHI *et al*., 2016b). The abundance in the northern Adriatic of the same bivalves (*R. philippinarum* and *A. senhousia*) that *C. japonica* preys in its native area, may enhance, in a kind of "invasion meltdown" (SIMBERLOFF & VON HOLLE, 1999), the probability it becomes established, with possible negative impact on the local Manila clam production.

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Novi nalazi vrste *Charybdis japonica* (A. Milne-Edwards, 1861) (Crustacea: Decapoda: Portunidae) u Jadranskom moru

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SAŽETAK

Petnaest godina nakon prvog ulova primjerka *Charybdis japonica* u Jadranskom moru, izvještavamo o prikupljanju još dva primjerka u blizini luke Ravenna.

Ovaj rak porijeklom iz sjeverozapadnog Pacifika, već je dokazao svoju invazivnu sposobnost u obalnim vodama Novog Zelanda. Njegovo moguće nastanjenje u lagunama sjevernog Jadrana moglo bi predstavljati bojazan za lokalne aktivnosti u ribarstvu i akvakulturi školjke *Ruditapes philippinarum*.

Ključne riječi: Portunidae; *Charybdis japonica*; strane vrste; Jadransko more; sredozemno more; brodski transport