Rapid Communication

The spread of the alien oriental river prawn *Macrobrachium nipponense* (De Haan, 1849) (Decapoda: Palaemonidae) in the lower Danube, with the first record from Romania

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Abstract

While monitoring the invasive freshwater invertebrates in Romania, specimens of a previously unknown prawn were reported on social media (Facebook) to occur in the lower reaches of the Danube and Pruth rivers. First individuals, including ovigerous females, were captured at Galați in a floodplain pond of the Danube in August 2021 and kept in an aquarium by a local hobbyist until their release back in the same place. In November 2021, several other specimens were observed and photographed in the lower Pruth at Slobozia Mare (Republic of Moldova). One adult male was captured by a crayfish catcher in November 2021 on the Chilia arm of the Danube Delta at Ceatalchioi. There were already several reports of numerous individuals captured by local crayfish trappers in the lakes Ligheanca, Băclăneștii Mari and Fortuna in the Romanian Danube Delta in July 2022. All these individuals were identified as the oriental river prawn *Macrobrachium nipponense*. The invasion history of *M. nipponense* in the area is inferred based on currently available literature and social media sources.

Key words: citizen science data, Danube River basin, early detection, freshwater prawn, invasion pathway, neozoa, secondary range expansion

Introduction

Biological invasions represent a major threat to global biodiversity, which may also have a considerable impact on the economy and human and environmental health (Ricciardi and MacIsaac 2011). Among alien invasive species, freshwater decapods are especially notorious for their invasive potential worldwide (Holdich et al. 2009; Strauss et al. 2012; James et al. 2016). Thus, out of 88 invasive alien species of EU concern, 7 belong to freshwater Decapoda (https://ec.europa.eu/environment/nature/invasivealien/list/index_en.htm). Freshwater decapods are large invertebrates that inhabit almost all types of water bodies, playing an important ecological role as a bioindicator, keystone or ecosystem engineer species (Reynolds et al. 2013). Some species represent a valuable food resource, heavily traded and representing an important part of the total freshwater aquaculture (FAO 2020). Also, there is growing trade of decapods as ornamental aquatic pets in Eastern Europe, with their intentional and unintentional release in the wild (Raghavan et al. 2013). In thermal waters, those decapods can establish persistent populations and possibly spread further, especially as the temperatures rise (Klotz et al. 2013; Jabłońska et al. 2018; Weiperth et al. 2019; Bláha et al. 2022).

To date, five alien decapod species were identified in freshwaters of Romania: the white-tipped mud crab *Rhithropanopeus harrisii* (Gould, 1841), the Chinese mitten crab *Eriocheir sinensis* H. Milne Edwards, 1853, the blue crab *Callinectes sapidus* Rathbun, 1896, the spiny-cheek crayfish *Faxonius limosus* (Rafinesque, 1817), and the marbled crayfish *Procambarus virginalis* Lyko, 2017 (Petrescu et al. 2010; Pârvulescu et al. 2012, 2017; N. Poştaru *pers. comm.*). The first four species occur in different sectors of the Danube River and the Danube Delta, while the last one is confined to the thermal waterbodies of Băile Felix, in the vicinity of Oradea. With the continuous increase in human-mediated translocations (through the shipping, construction of canals, ornamental pet trade, or aquaculture), we may expect that the number of potential decapod invaders will grow in the near future. The global increase in water temperature also contributes to speeding up of the rate of aquatic bioinvasions (Sentis et al. 2021).

Recent reports on social media of a previously unknown large-sized prawn in the Romanian lower Danube have raised the interest of the public and scientists. In this paper, the first occurrence of the oriental river prawn *Macrobrachium nipponense* (De Haan, 1849) in Romania is reported, and the possible pathways of its introduction and spread in the Danube River Basin are discussed.

Materials and methods

Specimen collection and processing

A living specimen of an unknown prawn caught by local a fisherman in November 2021 in a crayfish trap was provided by a border policeman to the "Gavriă Simion" Danube Delta Eco-Tourism Museum Centre, Tulcea. This specimen was fixed in 70% ethanol by the museum staff and its morphology was examined by the author of this paper. Suitable habitats for the prawn were prospectively sampled in May and June 2022 by a hand net with a 1.0-mm mesh. In July 2022, additional specimens were caught by crayfish trappers and provided to the author for the study. These latter specimens were initially fixed in brandy (the only preservative available *in situ*) and afterwards transferred into 96% ethanol.

Citizen science data collection

The data posted in public or private Facebook groups, such as Ichthyology of Romania (https://www.facebook.com/groups/ichthyologyofromania), Fauna României – Conservare prin educație (www.facebook.com/groups/Fauna Romaniei), Excursii Delta Dunării Tulcea – SAFCA Danube Delta Tours (https://www.facebook.com/SafcaDeltaTours/), or in iNaturalist (https://www.inaturalist.org/taxa/435085-Macrobrachium-nipponense), were surveyed for photographs of the unusual freshwater invertebrates. Authors of respective postings were contacted and asked to provide additional information on the date, location and number of the observed/captured specimens. In some cases, the authors of the postings shared interesting information on the behaviour of captured prawns in aquaria.

Morphological examination

The preserved specimens were examined under a binocular microscope and photographed using a digital camera. Some morphometric measurements were taken with a vernier calliper to the nearest 0.02 mm. Photographs of other specimens posted by citizens on social media (Facebook) were also examined. The distribution map of the records of *M. nipponense* was prepared using SimpleMappr (Shorthouse 2010). Final maps and the plates were prepared using Adobe Photoshop and Adobe Illustrator.

Results and discussion

The large size of the second pair of pereiopods, the presence of mandibular palp, the absence of branchiostegal spine and the presence of hepatic spine indicated that the specimens belong to the genus *Macrobrachium* Spence Bate, 1868. There are currently 265 accepted species of *Macrobrachium* (WoRMS 2022). The main morphological diagnostic characters in the genus *Macrobrachium* are represented by the relative length of the articles of the second pereiopods in adult males, the proportion of the dactylus to the palm of pereopod 3, the rostrum shape, the rostral formula, and the body colouration (Chong et al. 1987; Kusamura and Suzuki 1997; Hanamura et al. 2011; Zheng et al. 2019; Son et al. 2020). Based on the morphological examination, all specimens correspond well with the description of *Macrobrachium nipponense* (De Haan, 1849).

Diagnosis

The maximum total length of a male specimen (from the tip of rostrum to the end of telson) is 89.3 mm, the carapace length is 21.9 mm, and the rostral length is 19.6 mm (Figure 1A, B). The largest female specimen has a total length of 81.4 mm, carapace length of 20.2 mm, and rostral length of 16.1 mm. Rostrum is long and almost straight, reaching to or slightly exceeding the distal end of scaphocerite (antennal scale), with 12–14 dorsal teeth (apex of the rostrum not considered), of which 3 posterior to orbital margin, and 2–4 ventral teeth (Figure 1C). The space between the 1st and the 2nd dorsal rostral tooth is 1.45 times as long as the space between 2nd and 3rd. Ventral margin of the rostrum is convex, with a double row of setae. The carapace is finely tuberculated. The antennal spine is situated just behind

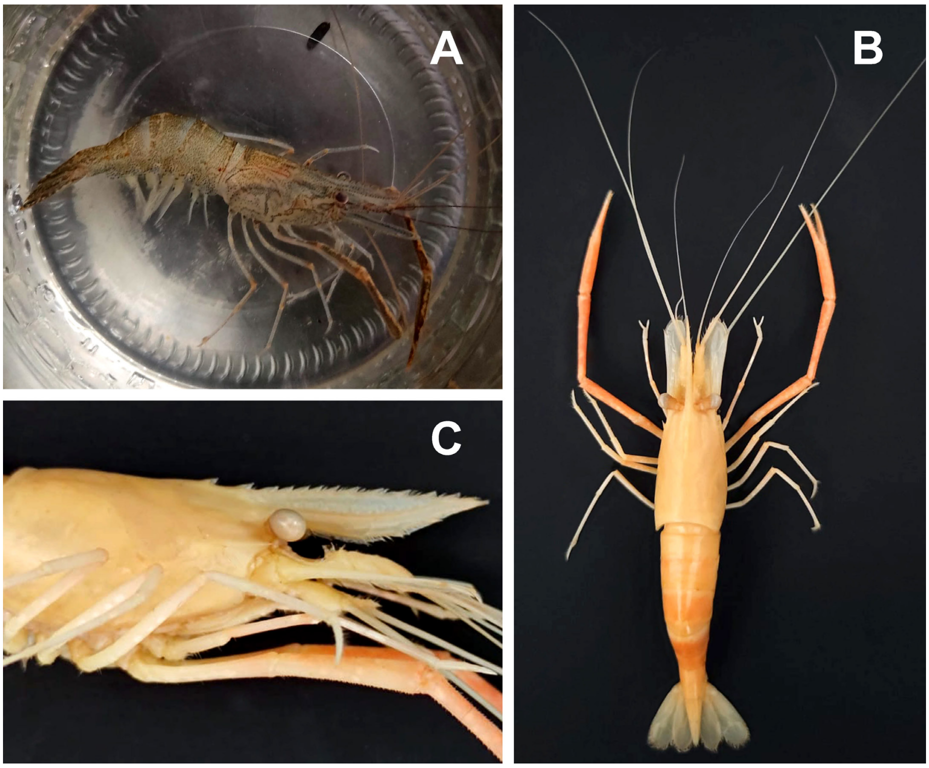

Figure 1. *Macrobrachium nipponense*, ♂ specimen from Chilia arm of the Danube Delta captured on November 28, 2021. A, general lateral view, a living specimen with characteristic pigmentation pattern; B, general dorsal view, preserved specimen; C, carapace with cephalic appendages, lateral view, preserved specimen. Photographs: A by M. Danilov, B, C by M. Sciotnic.

the lateral margin of the carapace; the hepatic spine is slightly larger than the antennal spine and is situated behind and slightly below the level of the antennal spine. The antennules are triramate; the shorter ramus of the outer flagellum of antenulla is fused to the longer for about 17% of its length. Males with the second pereiopods sub-equal in length but significantly (2.2–2.3 times) longer than the other legs (Figure 1B). Claws uniformly covered with long and dense setae on the cutting edges of fingers. Two small tubercles present in the proximal 1/3 to 1/6 of the moveable finger of chelae. Fingers without longitudinal grooves. All segments covered with small spinules. Pereiopods 3–5 with simple long and slender dactyla. The telson with posterior apex not reaching beyond the posterolateral spines. The exopod of uropod slightly longer than the endopod. Eggs measured 0.51–0.64 mm in width and 0.64–0.87 mm in length. Some of the morphometric characteristics of the examined individuals are presented in Table 1.

In living specimens, the body is almost translucent or light brownish, with fine dark-brown dots and characteristic pigmented marks on the sides of the carapace (Figure 1A). Pereiopods with yellow tinge at articulations.

Specimens from Romania match the description of *M. nipponense* in having the rostrum length subequal to scaphocerite; 12–14 rostral teeth (however one female had 17 teeth), with feathery setae between them, with 3 of the teeth postorbital, plus 2–3 (exceptionally 4) ventral teeth. However,

Table 1. Morphometric characteristics of *Macrobrachium nipponense* found in the present study (n = 15) compared to those from literature sources (the number of specimens in each category is provided between parentheses).

Character	Present study			Literature data[a]
	♀♀ (9)	♂♂ (3)	Juv. (3)	
Ratio of rostrum length to carapace length	0.69–0.79	0.68–0.89	0.69–0.92	0.60–0.81
Ratio of maximum rostrum height to rostrum length	0.28–0.36	0.23–0.28	0.23–0.24	0.24
Scaphocerite ratio of length to width	2.67–3.14	2.92–3.45	2.88–3.50	2.7–3.1
Ratio of scaphocerite length to carapace length	0.59–0.70	0.62–0.77	0.58–0.69	0.6–0.8
Pereiopod 1 ratio of dactylus (finger) to palm	0.67–0.94	0.64–0.94	0.86–0.94	0.8–0.91
Pereiopod 2 ratio of palm length to width	3.81–4.70	4.46–6.85	4.14–4.44	4.7–7.0
Pereiopod 2 ratio of dactylus to palm	0.66–0.87	0.61–0.79	1.09–1.17	0.6–0.7
Pereiopod 2 ratio of palm to carpus	0.58–0.75	0.70–0.77	0.53–0.56	0.7
Pereiopod 2 ratio of carpus to chela	0.81–0.96	0.75–0.84	0.86–0.87	0.8
Pereiopod 2 ratio of carpus to merus	1.24–1.59	1.17–1.52	1.34–1.47	1.4–1.7
Pereiopod 2 ratio of ischium to merus	0.90–1.01	0.68–0.87	0.97–1.01	0.74–0.90
Pereiopod 2 ratio of dactylus to merus	0.58–0.71	0.62–0.80	0.81–0.91	< 1
Pereiopod 3 ratio of dactylus to propodus	0.36–0.54	0.33–0.43	0.40–0.47	0.30–0.39
Pereiopod 3 ratio of dactylus maximum width to length	0.14–0.18	0.15–0.19	0.13–0.16	0.10–0.17
Telson ratio of posterior width to length	0.08–0.13	0.10–0.14	0.08–0.09	0.08–0.12
Ratio of lengths of 6th to 5th abdominal somite	1.29–1.67	1.39–1.64	1.46–1.58	1.3–1.6
Ratio of lengths of telson to 6th abdominal somite	1.37–1.56	1.60–1.83	1.44–1.45	1.4–1.7

[a] Kusamura and Suzuki (1997), Cai and Ng (2002), Hanamura et al. (2011), and Zheng et al. (2019).

the Romanian specimens have a slightly longer rostrum, scaphocerite, telson and dactylus of pereiopod 2 (Table 1).

Geographical distribution and invasion history

Macrobrachium nipponense is a subtropical freshwater decapod. It is native to and widely distributed in South-East Asia: mainland China (Zheng et al. 2019), Japan (Kusamura and Suzuki 1997 and references therein), Korea (Kim 1976), Vietnam (Dang and Nguyen 1972), Myanmar (Cai and Ng 2002), and Taiwan (Yu and Miyake 1972; Chen et al. 2009).

It is considered introduced to Singapore (Chong et al. 1987), Peninsular Malaysia (Ng and Choy 1990), the Philippines (first record in 1985; Cai and Shokita 2006), Bangladesh (Ahmed et al. 2008), Laos (Hanamura et al. 2011), Iran (first record in 1998; De Grave and Ghane 2006; Gorgin and Sudagar 2008), and Iraq (first record in 2002; Salman et al. 2006).

In the former Soviet Union, larvae of *M. nipponense* were accidentally introduced in the early 1960s into the cooling reservoir of the State District Power Plant (SDPP) no. 3 in Elektrogorsk (approximately 80 km away from Moscow), together with juvenile grass carp *Ctenopharyngodon idella* (Valenciennes, 1844) from the Yangtze River (Ivanov and Starobogatov 1974; Leontyev 2015). The species adapted well to local conditions and formed stable populations. In the same way, the oriental river prawn was accidentally introduced during the acclimatization of carp species from China into some water bodies of Uzbekistan (Mirabdullaev and Niyazov 2005). In 1967 the cooling reservoir of the Zainsk SDPP was deliberately populated with *M. nipponense* from the Amur River basin to improve the food supply of the silver carp *Hypophthalmichthys molitrix* (Valenciennes,

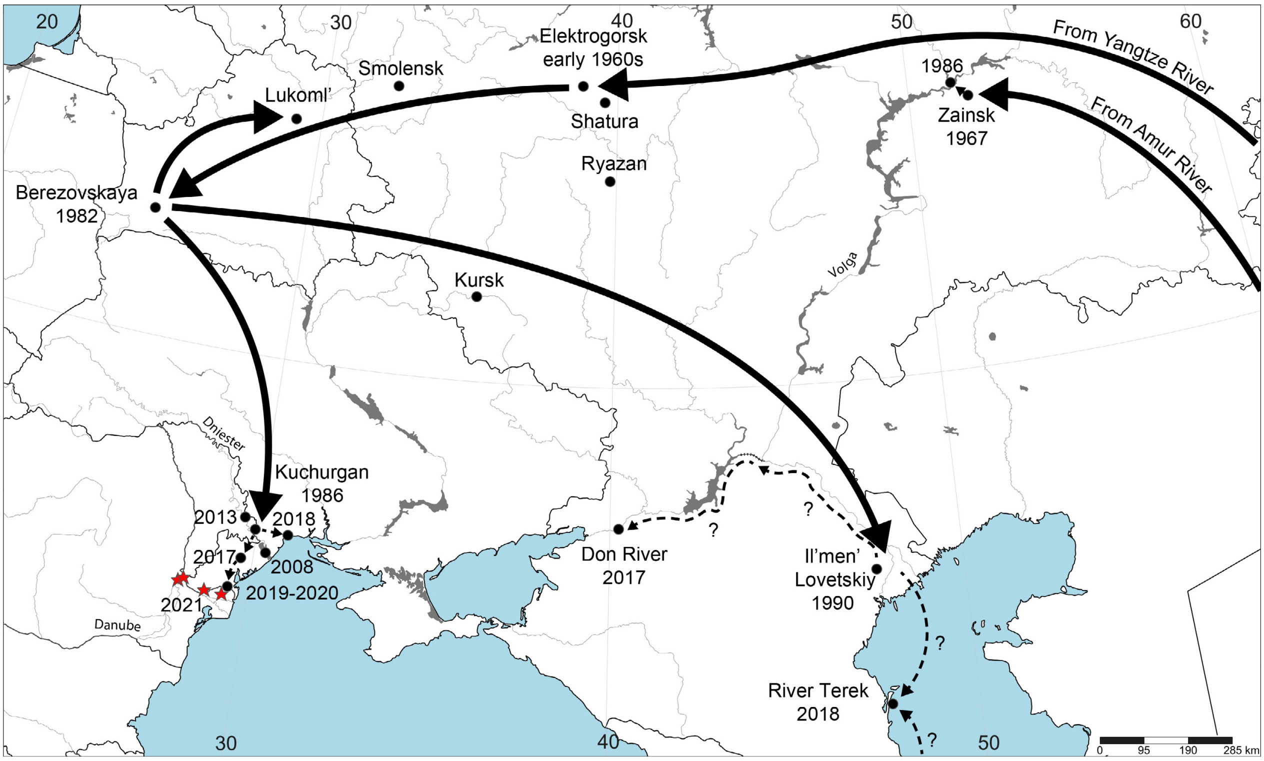

Figure 2. Location of some populations of *Macrobrachium nipponense* in Central Russia, Belarus, Republic of Moldova, and Ukraine (based on literature sources, solid circles), as well as new records from Romania (present study, red stars), with an indication of the year of the first occurrence (when available) and possible routes of dispersal (solid lines – deliberate direct introduction; dashed lines – natural range expansion).

1844) and the bighead carp *Hypophthalmichthys nobilis* (Richardson, 1845), which were also introduced here for intensive aquaculure (Leontyev 2015). The prawns from the Zainsk Reservoir (on the Zaya River) were repeatedly observed during the summer, well away from the warmer waters of the cooling water discharges. Thus, in 1986 individuals of *M. nipponense* were reported in the Kama reach of the Kuybyshev Reservoir at the Vyatka River mouth (Pirogov et al. 1990). Established wild populations of this species were also reported in Kazakhstan (Alekhnovich and Kulesh 2001).

In 1982 adult prawns of *M. nipponense* (apparently from Elektrogorsk, see Son et al. 2020) were acclimatized in the cooling reservoirs of the Berezovkaya thermal power plant in Belarus (Giginyak et al. 2006). To increase the biological productivity in cooling reservoirs of thermal plants, the oriental river prawn from Berezovskaya SDPP was intentionally introduced into outlets of other electric power stations in Belarus (Lukoml' SDPP) and Russia (Primorskaya SDPP) (Kulesh 2013; Leontyev 2015; Afanasyev et al. 2020; Zhivoglyadova et al. 2021b). In 1990 the species was naturalized in the Il'men' Lovetskiy near the Volga Delta (Kulesh 2013; Afanasyev et al. 2020). In 2017 *M. nipponense* was reported in the lower reaches of the Don River (Azov Sea Basin; Afanasyev et al. 2020), and, in 2018, in the lower reaches of the Terek River (Caspian Sea Basin; Shokhin 2018; Zhivoglyadova et al. 2021a, b). This spread could occur from the Volga River Basin through the Volga-Don Canal (Figure 2).

In 1986 the prawn was intentionally introduced from SDPP Berezovskaya into the Kuchurgan reservoir (SDPP Moldova; Vladimirov et al. 1989). Likely due to climate warming, the species penetrated the Turunchuk River and then the Dniester River up to the Tiraspol (Filipenko 2014; Shekk 2021). Starting from 2008, it was found in the Dniester Delta, the Dniester estuary and the nearby fishponds (Son et al. 2013; Stepanok 2014). In the lower Dniester and its estuary, *M. nipponense* is already well established and has locally become a common component of the benthic fauna, reaching densities of up to 17 ind. m^{-2} (Shekk and Astafurov 2020). Son et al. (2020) reported its occurrence in 2018 and 2020 in some small river basins discharging directly into the Black Sea. They also mention that on social media, there are reports of an unusual freshwater prawn, presumably *M. nipponense*, in some fishponds near the town of Sarata, Ukraine.

Molecular analyses of *M. nipponense* from Ukraine revealed a low genetic diversity, which is characteristic for many introduced populations because of the founder effect, bottlenecks, gene selection and homogenization (Estoup et al. 2016). The *COI* sequences of *M. nipponense* from the Dniester, Don and Terek basins were identical to the haplotype sequences of *M. nipponense* from China, confirming their Chinese origin (Afanasyev et al. 2020; Son et al. 2020; Zhivoglyadova et al. 2021b). However, the haplotypes from the Don and the Terek rivers fall into different clades (see Figure 3 in Zhivoglyadova et al. 2021b), suggesting two or more separate introduction events.

Since summer of 2019, *M. nipponense* was continuously found between the 18^{th} and 80^{th} rkm of the Kiliya arm of the Danube Delta (Zhmud et al. 2022). The most probable vector of its introduction into the Danube River Basin is a deliberate or accidental introduction from the Dniester Basin into fish farms near Sarata town (Zhmud et al. 2022). This species probably reached the Sasyk Liman through the Sarata River, and, through a canal connecting the Sasyk to the Danube, entered the Kiliya arm. Now it spreads further upstream and is reported up to Galați (present paper). Moreover, in July 2022 numerous individuals, including ovigerous females and juveniles, were captured by fishermen in the lakes between Kiliya and Sulina arms of the Danube Delta, where they most likely arrived through the Stipoc-Pardina canal (Supplementary material Table S1).

Macrobrachium nipponense *biology*

Macrobrachium nipponense is a non-obligatory amphidromous species as it can tolerate certain salinity levels in the early life stages (Chen et al. 2009). It is an opportunistic omnivore that feeds largely on larvae of aquatic insects (chironomids, *Chaoborus*), molluscs, crustaceans (mysids, ostracods, amphipods, cladocerans, copepods), and annelids (*Tubifex*, *Stylaria*). However, it also consumes filamentous algae, decomposing plants (*Myriophyllum*, *Ceratophyllum*, *Azolla*, etc.) or carcasses of fishes and gastropods (Leontyev

2015; Mirzajani et al. 2020). The species can also attack small fish (A.A. Roșu *pers. comm.*) or its congeners (Mirzajani et al. 2020). The high fecundity (up to 5630 eggs/female in a spawning; Vladimirov et al. 1989; Alekhnovich and Kulesh 2001), capacity to tolerate salinities from fresh water to 10 PSU (Kulesh 2013), tolerance to low temperatures (2–4 °C) for extended periods (De Grave and Ghane 2006), dispersal by planktonic larvae (Giginyak et al. 2006), a relatively long life span (3 years; Giginyak et al. 2006), and rapid growth with early sexual maturity with up to 6–8 recruitments per season (Vladimirov et al. 1989; Giginyak et al. 2006), render this species effective in dispersing to and surviving in new environments.

It is difficult to estimate the potential impact of the oriental river prawn on the Danube ecosystem. However, it can be presumed that the oriental river prawn, together with the other alien crayfish and crabs, will enhance the competitive pressure on the native narrow-clawed crayfish *Pontastacus leptodactylus* (Eschscholtz, 1823), as well as the entire community. In addition, *Macrobrachium* species can contribute to the spread of the crayfish plague pathogen *Aphanomyces astaci* Schikora – a further vector at the end threatening the narrow-clawed crayfish (Svoboda et al. 2014; Mrugała et al. 2019).

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Supplementary material

The following supplementary material is available for this article:

Table S1. Primary geo-referenced species record data and other relevant information.

This material is available as part of online article from:
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