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# MYSIDA (CRUSTACEA) FROM APULIAN (SE-ITALY) WATERS. FIRST RECORD OF *GASTROSACCUS ROSCOFFENSIS* BĂCESCU, 1970 FOR ITALY

## RIASSUNTO

Si riportano i *taxa* di Crostacei Mysida noti per la Puglia, in base ai dati bibliografici e a reperti inediti, entrambi frutto di ricerche in massima parte degli Autori. Nell'ambito dei 30 *taxa* citati – tra cui una specie nuova per la fauna italiana – particolarmente interessante risulta la componente salmastricola, la cui entità e diffusione riflette l'abbondanza e la diversificazione degli ambienti salmastri della regione. Si ripercorre l'iter delle ricerche faunistiche e il loro sviluppo in vari campi della Biologia: la tassonomia, con la descrizione di nuove specie e sottospecie del genere *Diamysis*; la biomineralogia, con la segnalazione della rara vaterite ($CaCO_3$ esagonale metastabile) nei corpi statici di *Diamysis* e successivi risultati riguardanti: i rapporti tra composizione minerale degli statoliti, tassonomia, ecologia e corologia delle specie; lo sviluppo di uno statolite vateritico e le sue implicazioni a livello filogenetico; gli aspetti quantitativi della precipitazione minerale nella statocisti di Mysida marini. Di rilievo appaiono le implicazioni della composizione minerale degli statoliti a livello di biogeografia storica, con la distinzione – in ambito mediterraneo – tra le poche specie a statoliti carbonatici (in particolare, di *Diamysis* e *Paramysis*) di verosimile origine paratetidiana e quelle a statoliti fluoritici di evidente origine atlantica: con l'indiretta conferma dell'ipotesi di Hsü *et al.* (1977) sulla *salinity crisis* messiniana del Mediterraneo e il contestuale drenaggio della Paratetide.

## SUMMARY

Thirty *taxa* of Crustacea Mysida from marine and continental waters of Apulia are listed using published and unpublished data, mostly based on investiga-

tions by the present Authors. The brackish-water *taxa* are outstanding due to their abundance and variety, clearly reflecting the local environmental characteristics. The history of the primarily faunal studies is reported, supplemented with information on their implications and ongoing developments in diverse biological domains.

## INTRODUCTION

The faunal inventory given below is based on published data plus the results of investigations on a number of Apulian sites (brackish and coastal marine waters) by A. P. Ariani in the 1970s to 2000s, and by K. J. Wittmann in 1981-1991. We also rely on combined investigations during these periods.

The taxonomy from subfamily to tribe level is adopted from Wittmann *et al*. (2014) with additions by Wittmann *et al*. (2016).

The present review on the faunal characteristics is followed by a short outline of the history of the local faunistic investigations on Mysida, as well as of the importance of these efforts for further studies in diverse biological domains.

The official abbreviations are used below for the Italian provinces of Brindisi (BR), Foggia (FG), Lecce (LE), and Taranto (TA).

## RESULTS AND DISCUSSION

### *Faunal inventory*

**Order MYSIDA** Boas, 1883
**Fam. Mysidae** Haworth, 1825
**Subfam. Siriellinae** Czerniavsky, 1882
**Tribe Siriellini** Czerniavsky, 1882

*Siriella armata* (Milne-Edwards, 1837). Marine coastal. Adriatic Sea near Torre Canne (BR) (Ariani, 1967); harbor of Torre Canne (leg. Wittmann; **unpubl.**); rocky shore at Monticelli (BR), Adriatic Sea (leg. Ariani and Wittmann; **unpubl.**); Lido Verde, beach south of Torre Canne, Adriatic Sea (leg. Ariani and Wittmann; **unpubl.**); polyhaline lagoon Lago di Acquatina, near Frigole (LE), Adriatic Sea (leg. Ariani; **unpubl.**); Torre Colimena (TA), Ionian Sea (leg. Wittmann; **unpubl.**).

*Siriella clausii* (G. O. Sars, 1877). Marine coastal. Adriatic Sea near Torre Canne (BR) (Ariani, 1967); harbor of Torre Canne (leg. Wittmann; **unpubl.**); rocky shore at Monticelli (BR), Adriatic Sea (leg. Ariani and Wittmann; **un-**

**publ.**); Lido Verde, beach south of Torre Canne (BR), Adriatic Sea (leg. Ariani and Wittmann; **unpubl.**); mixoeuhaline lagoon Mar Piccolo di Taranto (TA), Ionian Sea (leg. Ariani and Wittmann; **unpubl.**); marine shore at Torre Colimena (TA), Ionian Sea (leg. Wittmann; **unpubl.**).

*Siriella crassipes* G. O. Sars, 1877. Mixoeuhaline lagoon Mar Piccolo di Taranto (TA), Ionian Sea (leg. Wittmann; **unpubl.**).

*Siriella gracilipes* Nouvel, 1942. Marine coastal. Adriatic Sea near Torre Canne (BR) (Ariani, 1967); inside marine cave Grotta delle Corvine, Gulf of Taranto, Ionian Sea (leg. G. Belmonte; **unpubl.**); brackish channel 10 km NE of Porto Cesareo (LE), Gulf of Taranto, Ionian Sea (leg. Ariani; **unpubl.**); intertidal marine caves at the coast of Monticelli (BR), Adriatic Sea (leg. Wittmann and Ariani; **unpubl.**); inside marine cave Grotta di Ciolo, Salento Peninsula, Otranto Channel (as *S. jaltensis*: Moscatello and Belmonte, 2007).

*Siriella jaltensis* Czerniavsky, 1868. Marine coastal. Mixoeuhaline lagoon Mar Piccolo di Taranto (TA), Ionian Sea (leg. Ariani and Wittmann; **unpubl.**); polyhaline lagoon Lago di Acquatina, near Frigole (LE), Adriatic Sea (leg. Wittmann; **unpubl.**).

*Siriella norvegica* G. O. Sars, 1869. Marine coastal. Adriatic Sea near Torre Canne (BR) (Ariani, 1967).

**Subfam. Gastrosaccinae** Norman, 1892
**Tribe Gastrosaccini** Norman, 1892

*Gastrosaccus mediterraneus* Băcescu, 1970. Marine coastal and psammophilic. Sandy beaches of Lido Morelli near Torre Canne (BR) (Ariani *et al*., 1993), Torre Fortore (FG) and San Cataldo (LE) on the Adriatic coast (leg. Ariani; **unpubl.**); sandy beaches near mouth of Fiume Piccolo, Torre Canne (BR), Adriatic Sea (leg. Wittmann; **unpubl.)**; night plankton near S. Maria di Leuca (leg. G. Belmonte; **unpubl.**); Salento Peninsula, Otranto Channel (Moscatello and Belmonte, 2007).

*Gastrosaccus roscoffensis* Băcescu, 1970. Marine coastal and psammophilic. Sandy beach of Lido Morelli near Torre Canne (BR) on the Adriatic coast (Ariani, 1967, figs. 7b and 8b, as *Gastrosaccus sanctus*; and further samples, leg. Ariani; **unpubl.**). Sandy beach of Ginosa Marina (TA) on the Ionian coast (leg. Ariani; **unpubl.**).

*Gastrosaccus sanctus* (van Beneden, 1861). Marine coastal. Adriatic Sea near Torre Canne (BR) (Ariani, 1967).

*Haplostylus lobatus* (Nouvel, 1951). Marine coastal. Adriatic Sea near Torre Canne (BR) (Ariani, 1967, as *Gastrosaccus lobatus* Nouvel, 1951).

**Tribe Anchialinini** Wittmann, Ariani and Lagardère, 2014

*Anchialina agilis* (G. O. Sars, 1877). Marine coastal. Adriatic Sea near Torre Canne (BR) (Ariani, 1967); night plankton near S. Maria di Leuca (leg. G. Belmonte; **unpubl.**); Salento Peninsula, Otranto Channel (Moscatello and Belmonte, 2007).

**Subfam. Leptomysinae** Czerniavsky, 1882
**Tribe Mysidopsini** Wittmann, Ariani and Lagardère, 2014

*Mysidopsis gibbosa* G. O. Sars, 1864. Marine coastal. Adriatic Sea near Torre Canne (BR) (Ariani, 1967); rocky shore at Monticelli (BR), Adriatic Sea (leg. Ariani and Wittmann; **unpubl.**); ancient harbor of Egnatia (BR), Adriatic Sea (leg. Ariani and Wittmann; **unpubl.**); Torre Colimena (TA), Ionian Sea (leg. Wittmann; **unpubl.**).

**Tribe Leptomysini** Czerniavsky, 1882

*Leptomysis buergii* Băcescu, 1966. Marine coastal. Ionian Sea, Gulf of Taranto (Ariani *et al*., 1993); Torre Colimena (TA), Ionian Sea (leg. Wittmann; **unpubl.**); Adriatic Sea near Torre Canne (BR) (leg. Ariani and Wittmann; **unpubl.**); Lido Verde, beach south of Torre Canne (BR), Adriatic Sea (leg. Ariani and Wittmann; **unpubl.**).

*Leptomysis lingvura adriatica* Wittmann, 1986. Marine coastal. Ionian Sea, Gulf of Taranto (Ariani *et al*., 1993); Torre Colimena (TA), Ionian Sea (leg. Wittmann; **unpubl.**); Adriatic Sea near Torre Canne (BR); rocky shore at Monticelli (BR), Adriatic Sea (leg. Ariani and Wittmann; **unpubl.**); marine coast (Adriatic) in front of brackish pond Pilone (BR) (leg. Ariani and Wittmann; **unpubl.**).

*Leptomysis mediterranea* G. O. Sars, 1877. Marine coastal. Adriatic Sea near Torre Canne (BR) (Ariani, 1967); brackish, Torre Canne (BR), Chianca di Palo, mouth of river Fiume Piccolo into the Adriatic Sea (Wittmann and Stagl, 1996).

*Leptomysis posidoniae* Wittmann, 1986. Marine coastal. Adriatic Sea near Torre Canne (BR) (leg. Wittmann; **unpubl.**).

*Leptomysis truncata sardica* G. O. Sars, 1877. Marine coastal. Sea shore at Torre Colimena (TA), Ionian Sea (leg. Wittmann; **unpubl.**); mixoeuhaline lagoon Mar Piccolo di Taranto (TA, Ionian Sea) (leg. Ariani and Wittmann; **unpubl.**).

*Leptomysis truncata truncata* (Heller, 1863). Marine coastal. Rocky shore at Monticelli (BR), Adriatic Sea (leg. Wittmann; **unpubl.**).

**Subfam. Mysinae** Haworth, 1825
**Tribe Mysini** Haworth, 1825

*Mesopodopsis aegyptia* Wittmann, 1992. Marine coastal. Rocky shore at Monticelli (BR), Adriatic Sea (Wittmann, 1992; Wittmann and Stagl, 1996); Adriatic Sea near Torre Canne (BR), marine coast 200 m NW of the Pilone springs (BR) (leg. Wittmann; **unpubl.**).

*Mesopodopsis slabberi* (van Beneden, 1861). Marine coastal. Adriatic Sea near Torre Canne (BR) (Ariani, 1967); mixoeuhaline lagoon Mar Piccolo di Taranto (TA, Ionian Sea) (Wittmann, 1992); Ionian Sea, Gulf of Taranto (Ariani *et al*., 1993).

**Tribe Diamysini** Wittmann, Ariani and Lagardère, 2014

*Diamysis bacescui* Wittmann and Ariani, 1998. Marine coastal. Adriatic Sea near Torre Canne (BR) (Wittmann and Ariani,1998).

*Diamysis camassai* Ariani and Wittmann, 2002. Brackish, semi-hypogean. Spunnulate dolina system in Torre Castiglione near Porto Cesareo (LE) on the Ionian coast (Ariani and Wittmann, 2002).

*Diamysis cymodoceae* Wittmann and Ariani, 2012. Brackish. Brackish pond Sette Nani near Porto Cesareo (LE) on the Ionian coast (Wittmann and Ariani, 2012a).

*Diamysis mesohalobia mesohalobia* Ariani and Wittmann, 2000. Brackish running waters Fiume Morello, Fiume Bizzarro, Fiume Piccolo, and Fiume Grande near Torre Canne (BR) on the Adriatic coast (Ariani and Wittmann, 2000); dolina Palude del Capitano, Gulf of Taranto, Ionian Sea (leg. Ariani and Wittmann; **unpubl.**).

*Diamysis mesohalobia gracilipes* Ariani and Wittmann, 2000. Brackish, rarely marine coastal. Brackish waters Mar Piccolo di Taranto (TA), Ionian Sea, Fiume Chidro near S. Pietro in Bevagna (TA) and Lago Alimini Grande near Otranto (LE) on the Ionian coast; Acquatina lagoon near Frigole (LE), sea shore at Monticelli (BR), and brackish pond of Pilone (BR) on the Adriatic coast (Ariani and Wittmann, 2000). Sea shore at Torre Guaceto (BR), Adriatic Sea (leg. G. Belmonte, **unpubl.**).

*Diamysis mesohalobia heterandra* Ariani and Wittmann, 2000. Brackish. Varano and Lesina lagoons (FG) on the Adriatic coast (Ariani and Wittmann, 2000).

**Tribe Neomysini** Wittmann, Ariani and Lagardère, 2014

*Acanthomysis longicornis* (Milne-Edwards, 1837). Marine coastal. Adriatic Sea near Torre Canne (BR) (Ariani, 1967).

**Tribe Hemimysini** Czerniavsky, 1882

*Hemimysis lamornae mediterranea* Băcesco, 1937. Marine coastal. Adriatic Sea near Torre Canne (BR) (leg. Ariani and Wittmann; **unpubl.**).

*Hemimysis margalefi* Alcaraz, Riera & Gili, 1986. Inside marine cave Grotta delle Corvine, Gulf of Taranto, Ionian Sea (Denitto *et al*., 1999); inside marine cave Grotta di Ciolo, Salento Peninsula, Otranto Channel (Moscatello and Belmonte, 2007).

**Tribe Paramysini** Wittmann, Ariani and Daneliya, 2016

*Paramysis helleri* (G. O. Sars, 1877). Marine coastal. Adriatic Sea near Torre Canne (BR) (Ariani, 1967); rocky shore at Monticelli (BR), Adriatic Sea (leg. Ariani and Wittmann; **unpubl.**).

**History of the faunal investigations and their importance for correlated biological studies**

The above-reported 27 species plus three non-nominotypical subspecies represent the highest number of Mysida *taxa* known for any Italian region with the exception of Campania, where the presence of the Stazione Zoologica di Napoli has probably favored studies on aquatic animals since its foundation in 1872. First studies on Mysida living along the Apulian shores were conducted (Ariani, 1967) after the discovery of very rich populations of *Diamysis* inhabiting brackish karst rivers near the Adriatic coast NE of Brindisi (Ariani, 1966). The main objective of these investigations was to examine potential displacements of the mysids towards the sea, where a few *Diamysis* individuals were actually collected. The latter, however, were later ascribed to a strictly marine species, typically living in *Posidonia* beds: *Diamysis bacescui* Wittmann and Ariani, 1998. In the meantime, studies were performed (Ariani, 1981a; Ariani and Wittmann, 2000) to clarify the taxonomic status of the *Diamysis* living in brackish waters, both in Apulia and elsewhere in the Mediterranean region – populations previously ascribed to *D. bahirensis* (G. O. Sars, 1877). This led to the establishment of the polytypic species *D. mesohalobia* Ariani and Wittmann, 2000, with its subspecies *mesohalobia*, *gracilipes*, and *heterandra*, which differed at morphological, chorological and ecological level.

A further step was the exploration of Apulian brackish-water bodies showing peculiar environmental characteristics: first the "Spunnulate" dolinas of Torre Castiglione (LE), from where the semi-hypogean species *Diamysis camassai* was described (Ariani and Wittmann, 2002). More recently, the pond "Sette Nani" in the Gulf of Taranto yielded *Diamysis cymodoceae* Wittmann

and Ariani, 2012, a species already described from marine material of Hvar (Croatia). At "Sette Nani", this species was found in its most characteristic habitat: stands of the seagrass *Cymodocea nodosa*. Here, this mysid was studied in its morphological (Wittmann and Ariani, 2012a), ecological and biological characteristics (Ariani and Wittmann, 2015; Ariani *et al.,* 2016).

The richness in *Diamysis* populations, highly differentiated at the species level, within the brackish water bodies of Apulia, merits some discussion. A number of data – starting from the carbonatic instead of the otherwise most common fluoritic composition of statoliths in all Mediterranean species of this genus – suggest (Ariani, 1981b; Ariani *et al*., 1993; Ariani and Wittmann, 2000; Wittmann *et al*., 2016) an origin in the brackish Paratethys (as discussed below), where fossil carbonatic statoliths are known from Miocene deposits (Voicu, 1981). In this ecological context, and for potential colonization, the Apulian region shows peculiar, favorable characteristics such as: 1) the presence of a variety of surface brackish environments, mostly of karstic origin; 2) a short distance between the Adriatic and the Ionian coasts, favoring possible migration of taxa across the contact zone between the two seas; 3) the presence and the large extension of the phenomenon of seawater deeply intruding into the land masses, and 4) the formation of a thick layer of brackish water above that seawater and below fresh water of meteoric origin (Ariani, 1982, 1986). No other region in Italy shows comparable characteristics.

We also report here original results of marine catches in Apulia, particularly those from a number of sandy beaches in the 1970s, performed after Băcescu's (1970) description of new psammophilic Gastrosaccinae from the Mediterranean and the East Atlantic. The species *Gastrosaccus roscoffensis* is here first reported for the Italian coasts. Diagnostic features of carapace and antennula are shown in Fig. 1. Previously, this species has been already known from NE-Atlantic coasts of Brittany (France) to Spain, Portugal, and the Canary Islands (Wittmann *et al.*, 2011), in the Mediterranean only from Balearic coasts of Spain (San Vicente and Sorbe, 1999; San Vicente, 2010). Our new records from the Adriatic and the Ionian coasts of Apulia mean a strong eastward extension of the known distribution range within the Mediterranean.

The results of our investigations on the Apulian Mysida go beyond their significance at the ecological, faunal and taxonomic level. In fact, the first studies on the mineral composition of statoliths, performed on the Apulian *Diamysis*, revealed the carbonatic nature of their static bodies (Ariani, 1981b): $CaCO_3$ in the crystal phase of metastable vaterite (Ariani *et al.*, 1981, 1993). This implies that such populations probably had their ancestors in the brackish Paratethys and were drained into the Mediterranean basin at the time of the *salinity crisis* (ended about 5.5 million years ago: Hsü *et al*., 1977), as suggested by Ariani (1981b) and Ariani and Wittmann (2000). More recent, large-

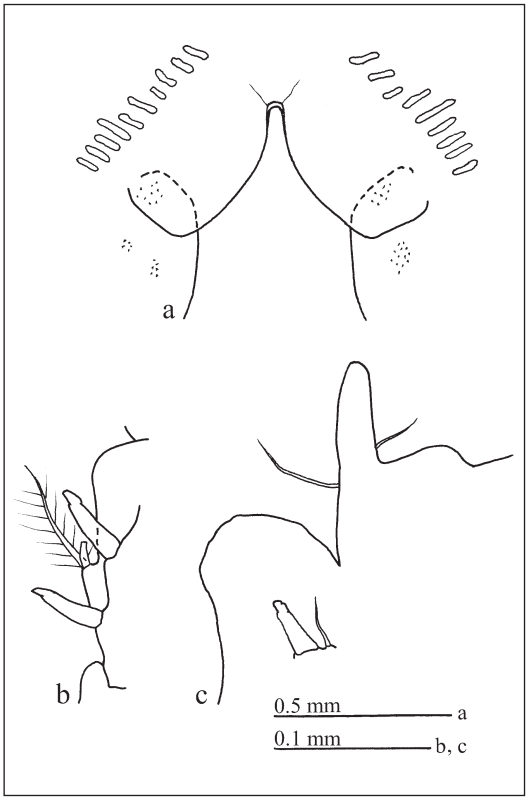


Fig.1. Adult male of *Gastrosaccus roscoffensis* Băcescu, 1970 from sandy beach of Lido Morelli near Torre Canne (BR, 12 Sept. 1975, leg. A. P. Ariani). Cleft of the posterior margin of the carapace (a); latero-dorsal margin of the median segment of the antennula showing only two spines and their peculiar morphology (b); distal part of the third segment of the antennula showing the dactyloid apophysis and the paradactyloid spine (c).

scale investigations on Mediterranean Mysida of the genera *Diamysis* and *Paramysis* provide further arguments supporting this hypothesis (Wittmann and Ariani, 2011, 2012b; Wittmann *et al*., 2016). Finally, a number of studies are addressed to: a) the developmental process of a carbonatic statolith (by *in vivo* observations on *D. mesohalobia*) along with its evolutionary implications (Ariani *et al*., 1982); b) correlations on a world-wide scale between mineral composition of statoliths and taxonomy, ecology and geographical distribution of the species (Ariani *et al*., 1983, 1993); c) dynamic aspects of fluorite and vaterite precipitation in the static organs of marine Mysida species (Wittmann and Ariani, 1996).

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