

See discussions, stats, and author profiles for this publication at: <https://www.researchgate.net/publication/297577979>

Heteromysis (Heteromysis) microps (Crustacea, Mysidae), a commensal species for Upogebia pusilla (Crustacea, Upogebiidae) in Arcachon Bay (NE Atlantic Ocean)

Article in *Marine Biodiversity Records* · March 2016

DOI: 10.1186/s41200-016-0001-1

CITATIONS

8

READS

313

6 authors, including:



Nicolas Lavesque

French National Centre for Scientific Research

73 PUBLICATIONS 1,119 CITATIONS

SEE PROFILE



Ludovic Pascal

Université du Québec à Rimouski UQAR

20 PUBLICATIONS 173 CITATIONS

SEE PROFILE



Benoit Guillieux

French National Centre for Scientific Research

46 PUBLICATIONS 302 CITATIONS

SEE PROFILE



Guy Bachelet

French National Centre for Scientific Research

96 PUBLICATIONS 2,871 CITATIONS

SEE PROFILE

RESEARCH

Open Access



Heteromysis (Heteromysis) microps (Crustacea, Mysidae), a commensal species for *Upogebia pusilla* (Crustacea, Upogebiidae) in Arcachon Bay (NE Atlantic Ocean)

Nicolas Lavesque^{1,2*}, Ludovic Pascal^{1,2}, Benoit Gouillieux^{1,2}, Jean-Claude Sorbe^{1,2}, Guy Bachelet^{1,2} and Olivier Maire^{1,2}

Abstract

Background: The mysid *Heteromysis (Heteromysis) microps* is reported for the first time in the Bay of Biscay. During surveys carried out between March and September 2015 in Arcachon Bay, mysid specimens were fortuitously collected from *Upogebia pusilla* burrows.

Results: Details on morphology, colour pattern and behaviour of *H. microps* are provided.

Conclusions: Commensalism was frequently mentioned for *Heteromysis* species but never reported for *H. microps*. In this study, commensalism seems to be proved between the mysid and its host *U. pusilla*.

Keywords: *Heteromysis (Heteromysis) microps*, *Upogebia pusilla* burrows, Commensalism

Background

The thalassinidean mud shrimp *Upogebia pusilla* (Petagna, 1792) occurs in high densities in intertidal flats in the NE Atlantic and in shallow lagoons in the Mediterranean Sea. As its Y-shaped burrows penetrates deep into the sediment (up to 1 m), this shrimp is considered an important ecosystem engineer (Jones et al., 1994; Pillay and Branch, 2011). Indeed, through its intense bioturbation activity, it greatly influences sedimentary biogeochemical processes and enhances fluxes across the sediment-water interface with knock-on effects on the whole benthic communities (Ziebis et al., 1996; D'Andrea and DeWitt, 2009; Pascal et al., 2016). *Upogebia* also intensively ventilate their burrows through pleopod beating (Dworschak, 1981) for respiratory and trophic requirements (Sato et al., 2001). Deep and well irrigated

mud-shrimp burrows represent efficient refuges against predation for a variety of commensal species such as shrimps (e.g. *Betaeus longidactylus* Lockington, 1877) (Campos et al., 2009), pea crabs (e.g. *Scleroplax granulata* Rathbun, 1894) (Campos, 2006), bivalves (e.g. *Peregrinamor ohshimai* Shôji, 1938) (Kato and Itani, 1995), polychaetes (e.g. *Hesperonoe hwanghaiensis* Uschakov & Wu, 1959) (Sato et al., 2001), phoronids (e.g. *Phoronis pallida* Silén, 1952) (Santaga, 2004) and goby fishes (e.g. *Eutaeniichthys gilli* Jordan & Snyder, 1901) (Henmi and Itani, 2014). During a recent study aiming at quantifying the influence of *U. pusilla* on porewater exchanges and nutrient cycling (Pascal et al., 2016), specimens of *Heteromysis (Heteromysis) microps* (G.O. Sars, 1877) were fortuitously collected in their burrows from tidal flats of Arcachon Bay, thus providing the opportunity for new observations on the morphology and behaviour of this rare species in European waters.

* Correspondence: n.lavesque@epoc.u-bordeaux1.fr

¹University Bordeaux, EPOC, UMR 5805, Station Marine d'Arcachon, 2 Rue du Professeur Jolyet, Arcachon 33120, France

²CNRS, EPOC, UMR 5805, Station Marine d'Arcachon, 2 Rue du Professeur Jolyet, Arcachon 33120, France



Results

Systematics

Family MYSIDAE Haworth, 1825

Subfamily Heteromysinae Norman, 1892

Genus *Heteromysis* S.I. Smith, 1873

Subgenus *Heteromysis* (*Heteromysis*) S.I. Smith, 1873

Heteromysis (*Heteromysis*) *microps* (G.O. Sars, 1877)

Type species: *Heteromysis* (*Heteromysis*) *formosa* Smith, 1873

Material examined

For the 68 specimens of *H. microps* collected, size and sex were determined. The sex-ratio of the population was 2:3 (male:female). Brooding females were absent from March samples and represented 44.4 % and 60 % of the total females in July and September, respectively. The size range of individual body length BL was measured in each demographic category: 5.59–9.27 mm (7.42 ± 1.10 mm; $\bar{x} \pm s$) in males, 5.27–8.73 mm (6.44 ± 0.84 mm) in females and 6.99–9.44 mm (8.07 ± 0.87 mm) in brooding females. Juveniles were never collected during our survey.

Generic diagnosis (according to Wittmann, 2000)

Heteromysinae with eyes normal. Appendix masculina representing a very small setose lobe or reduced to a setose ridge. Antennal scale usually short, setose all around, without or with a small apical article. Mouthparts normal; labrum not produced into a spiniform process. First thoracic endopod with a large endite on the basis, and smaller endites on ischium and merus (an additional small, conical endite may be present on the coxa, although rarely noted by previous authors). Third thoracic endopod subchela-like (gnathopod), with enlarged carpopropodus and strong dactylus. Carpopropodus of fourth to eighth thoracic endopods with 3–7 articles. Penis long and more or less cylindrical. Pleopods entire, reduced to small plates in both sexes; non-dimorphic (subgenus *Heteromysis*) or dimorphic (some other subgenera). Uropods normal, entire; exopod with setae all around; endopod without or in most species with stout setae along inner margin. Telson with stout setae on lateral margins; distinct apical cleft present, margins of cleft with a number of laminae.

Description

Based on two males (Arcachon Marine Station Collection), BL = 7.52 mm and 7.89 mm, Arcachon Bay, March 2015.

Antennal scale small, shorter than antennular peduncle. *Sternal processes* absent in females, present on second to eighth sternites in males: first anterior one with blunt bifid apex, subsequent ones with more or less acute bifid tip and the last posterior one very reduced and cone-shaped (Fig. 1a). *Endopod of thoracopod 3* (gnathopod)

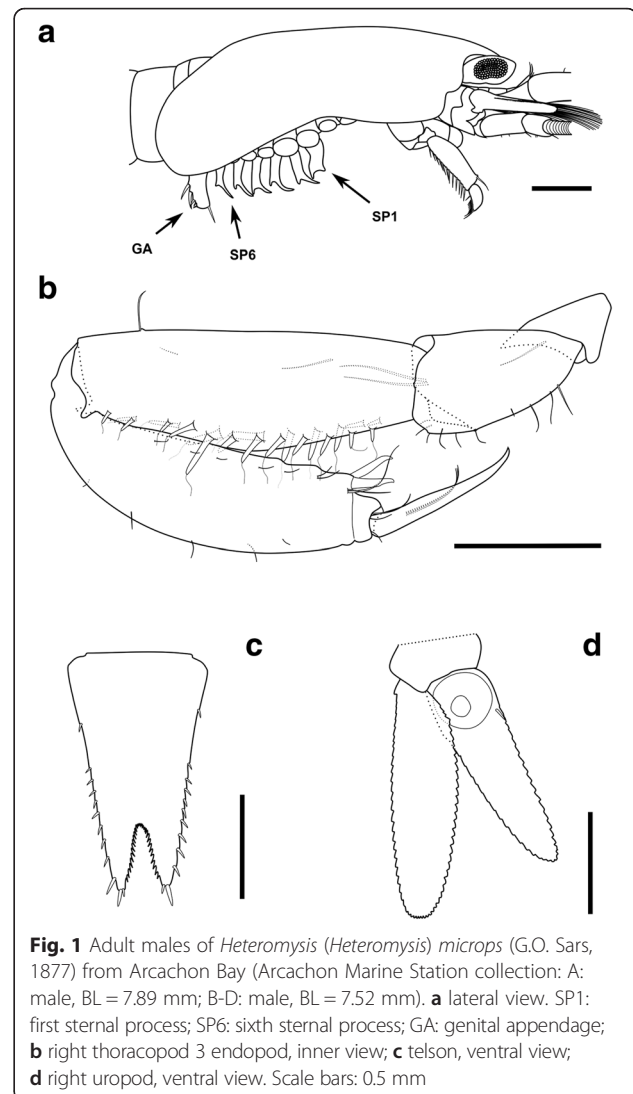


Fig. 1 Adult males of *Heteromysis* (*Heteromysis*) *microps* (G.O. Sars, 1877) from Arcachon Bay (Arcachon Marine Station collection: A: male, BL = 7.89 mm; B-D: male, BL = 7.52 mm). **a** lateral view. SP1: first sternal process; SP6: sixth sternal process; GA: genital appendage; **b** right thoracopod 3 endopod, inner view; **c** telson, ventral view; **d** right uropod, ventral view. Scale bars: 0.5 mm

very robust, longer than cephalothorax, non-dimorphic; merus large, bearing 12 cuspidate setae on ventral margin of inner face (from 11 to 16 for other specimens), 9 cuspidate setae on ventral margin of outer face (from 8 to 11 for other specimens), 1 sub-distal seta on dorsal margin (Fig. 1b), ventrodistal part with an inner roundish lobe and an outer acute lobe between which carpopropodus folds down; carpopropodus with one pair of cuspidate setae at ventrodistal angle between which dactylus bends down to form a powerful subchela; dactylus with 3 long, tip-curved setae along outer face (Fig. 1b). *Pleopods* normal, non-dimorphic. *Telson* cleft, with 1 stout seta on basal third of lateral margin, followed by a naked portion and then 9 stout setae on distal half (7 to 10 stout setae on other specimens) (Fig. 1c). *Uropod* endopod with 1 stout seta on proximal part of inner margin, near statocyst (Fig. 1d).

Remarks (based on Sars (1877) and Tattersall and Tattersall (1951))

Sars (1877) described only adult females and Tattersall and Tattersall (1951) described only a single adult male. All the data on females given by the last authors were depicted from Sars (1877).

Telson:

Tattersall and Tattersall (1951) re-described *H. microps* with a telson armed with 12-14 stout setae on each side. The Arcachon specimens show no more than 11 stout setae (one near the base and 10 on the distal half) as first described by Sars (1877) in the original description of *H. microps*.

Thoracopod 3:

All the Arcachon specimens bear 3 long setae on their dactylus. Tattersall and Tattersall (1951) mentioned the presence of two subdistal pairs of small stout setae as well as a pair of distal finger-like projections along the ventral margin of the carpopropodus (proximal article). However, in Sars's original description of this species (1877; Fig. 20-9), the subdistal stout setae are clearly more developed and the 'distal finger-like projections' are in fact represented as a pair of articulated stout setae (shorter than the other ones). Our own observations on Arcachon specimens confirm Sars's original interpretation (a pair of distal stout setae, not finger-like projections), but without two pairs of stout setae along the carpopropodus inner margin (rarely with one short pair). Tattersall and Tattersall (1951) mentioned the presence of 10 sensitive stout pedestal setae (probably 12 of these setae in Sars's original description) and one distal setal tuft along the merus inner margin. Such a setal tuft was not observed in Arcachon specimens and 11–16 sensitive stout pedestal setae were counted on their merus inner margin. Furthermore, setal ornamentation shows some slight differences between right and left thoracopod 3 endopods, when considering a single specimen.

Coloration

As the specimens were observed alive after capture, new data on their colour pattern can be provided. General appearance orange (Fig. 2a). Cornea brown-golden, surrounded by pink-red coloration (Fig. 2b). Eyes and antennae iridescent (Fig. 2b). Cephalon rust-coloured (Fig. 2a). Rust-coloured chromatophores scattered dorsally and laterally over carapace and between 6th abdominal segment and telson. Appendages and uropods not pigmented. Eggs brown. The body coloration disappeared within a few minutes after fixation (alcohol or formalin).

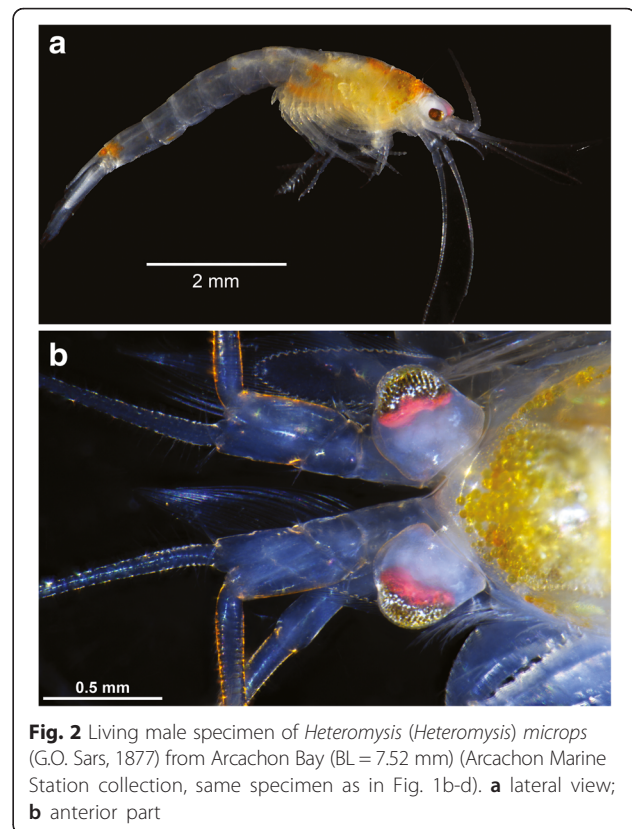


Fig. 2 Living male specimen of *Heteromysis (Heteromysis) microps* (G.O. Sars, 1877) from Arcachon Bay (BL = 7.52 mm) (Arcachon Marine Station collection, same specimen as in Fig. 1b-d). **a** lateral view; **b** anterior part

Geographical distribution and habitat

Relatively rare species, from Norwegian coast to Mediterranean Sea (Tattersall and Tattersall 1951; Tattersall, 1967; Dauvin and Vallet, 1997). In coastal areas, from 6 to 33 m depth, on mud to pebble bottoms (Zouhri et al., 1998), *Posidonia oceanica* (Linnaeus) Delile, 1813 meadows (Wittmann, 2001) and, according to the present study, within burrows of *U. pusilla* in intertidal *Zostera noltei* meadows.

Discussion

The genus *Heteromysis* is divided in 4 subgenera and is the most speciose of the Mysidae with 82 species currently considered valid (Mees, 2015). Only one species was previously mentioned from the southern Bay of Biscay: *Heteromysis (Heteromysis) norvegica* G.O. Sars, 1882, on bathyal bottoms (Frutos and Sorbe, 2014). Members of this genus are generally distributed in coastal warm-water regions and most of the species are restricted to small geographical areas (Fukuoka, 2005). This study reports on the first record of *H. microps* in the Bay of Biscay, and most importantly, its first record in association with another invertebrate species. Despite an important number of macrobenthic studies since the 1960s in Arcachon Bay (see Blanchet, 2004) and particularly in *Z. noltei* meadows (Blanchet et al., 2004), *H.*

microps was never found in that bay. Therefore, this mysid should not be considered as a new inhabitant of Arcachon Bay, and its absence in previous ecological studies can be explained by the lack of specific investigations on *Upogebia pusilla* burrows before 2015. *H. microps* is probably commensal with this burrowing shrimp. As it usually occurs on soft bottoms (Zouhiri et al., 1998) and in seagrass meadows (Wittmann, 2001), the association found in this study could be a local phenomenon.

Coastal mysids, and particularly species belonging to the genus *Heteromysis*, are known to prefer complex habitats such as dense vegetation, shells and gravels or to live in association with different invertebrate species (Wittmann, 2008). Commensalism in the genus *Heteromysis* was first demonstrated by Clarke (1955), describing an association between *Heteromysis actiniae* Clarke, 1955 and the sea-anemone *Bartholomea annulata* (Lesueur, 1817) in Bahamas Islands (Tattersall, 1967). *Heteromysis* species are known to have various hosts like sponges, corals, gorgonians, sea anemones, brittle stars and hermit crabs inhabiting empty shells (Wittmann, 2008; Wittmann et al., 2014). In Arcachon Bay, *Upogebia* burrows provide peculiar microhabitats where mysids can live more safely against predation and environmental perturbations as well as against desiccation at low tide.

According to Dworschak (1987), *U. pusilla* is primarily a filter-feeding species, generating a water flow into its burrow by pleopods beating. Astall et al. (1997) demonstrated that the mean irrigation rate into the burrows of *Upogebia deltaura* (Leach, 1815) and *U. stellata* (Montagu, 1808) were 149.5 ml.h⁻¹ and 139.7 ml.h⁻¹, respectively. The suspended material associated with water flow is driven to the “basket” formed by the long setae beared by pereopods 1-2, then transferred to the mouthparts by maxilliped 3 (Dworschak, 2004). As *H. microps* is a suspension feeder (Mees, 2016), this species could take advantage of the particle flow generated by the *Upogebia* host within its burrow. This nutritional model has been previously reported by Vannini et al. (1994) for *Heteromysis* (*Gnathomysis*) *harpax* (Hilgendorf, 1878). This latter species is associated with hermit crabs belonging to the genus *Dardanus* Paulson, 1875 and ingests suspended particles brought into the gill chamber by the host. According to Dworschak (1987), *U. pusilla* is also a deposit feeder via a ‘gardening’ behaviour. Indeed, this decapod can actively store detritus and plant fragments in the walls of its burrow, consuming them with their associated microflora. Mysids are also able to pick up detritus particles with their anterior thoracopods (Albertson, 2004). Unexpectedly, the huge thoracopod 3 of *H. microps* (a morphological peculiarity of this genus) does not appear to be related to a predator behaviour but could be used to consume the organic particles stored in *Upogebia* burrows. Furthermore, San Vicente

and Monniot (2014) suggested that the enlarged thoracopod endopods of Heteromysinae could be used as weapons. With the adoption of a symbiotic life in these taxa, it is suggested that these weaponries probably have played an important role in determining the behaviour and morphological evolution of such mysids (Vannini et al. 1994).

Conclusions

In this study, commensalism seems to be proved between the mysid and its host. As the mysid associate remains external and was never found in another habitat in Arcachon Bay, the association between *H. microps* and *U. pusilla* may be classified as obligatory ectocommensalism (Nardon and Charles, 2002; San Vicente and Monniot, 2014). *H. microps* seems to take advantage of the filter feeding and the gardening behaviour of *U. pusilla*. Furthermore, *H. microps* is clearly protected from predators within *U. pusilla* burrows.

Further studies will be conducted to understand the behaviour of both species (laboratory experiments in thin aquariums, each colonized by one *U. pusilla* specimen). These mesocosm observations will allow answering different questions: (1) what is the behaviour of mysids during night time? Indeed, *Heteromysis* species become actively pelagic at night while they live sheltered during daytime (Tattersall, 1967; Wittmann, 2008); (2) are mysids able to breed within *Upogebia* burrows, thereby benefiting from some protection for their offspring?; (3) are mysids expelled from burrows during the breeding period of *U. pusilla*?

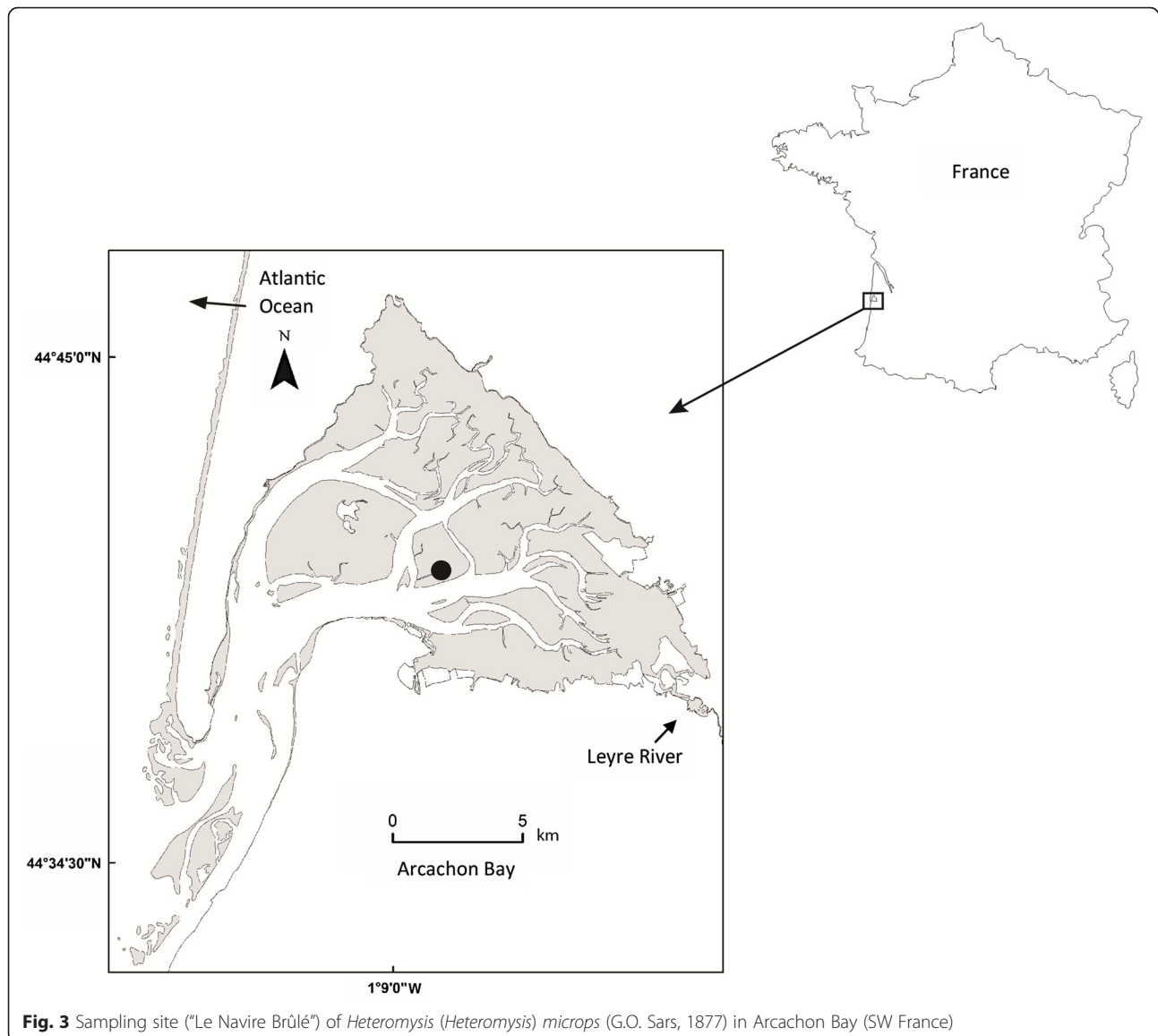
Methods

Study area

Arcachon Bay is a 180-km² macrotidal coastal lagoon (maximum tidal range: 4.9 m) located on the south-western coast of France (Fig. 3). This lagoon is connected with the Atlantic Ocean by a narrow channel and receives freshwater inputs in its south-eastern part (Leyre River). It is characterized by large intertidal flats (115 km²), the lower parts of which are used for cupped oyster [*Crassostrea gigas* (Thunberg, 1793)] farming. Most of the intertidal area (46.2 km²) is covered by seagrass beds, *Zostera noltei* Hornemann, 1832 (Plus et al., 2010). In the inner lagoon, tidal channels represent an area of 71 km², with 1.02 km² occupied by eelgrass beds, *Zostera marina* Linnaeus, 1753 (Plus et al., 2010).

Material examined

During surveys carried out between March and September 2015, 68 mysid specimens were fortuitously collected from *Upogebia pusilla* burrows (0-1 individual per burrow), using a bait piston pump and later on identified as *H. microps* according to the identification key published by Wittmann (2008) for Atlantico-Mediterranean



species. Sampling was carried out at low tide within a homogeneous patch of *Z. noltei* at "Navire Brûlé" site (temperature from 7 to 21 °C, salinity from 21.9 to 32.8) (Fig. 3). All specimens were examined under a Nikon SMZ25 stereomicroscope and photographed with a Nikon DS-Ri 2 camera, after anaesthetizing them with magnesium chloride (MgCl₂). An image of one specimen was drawn with a Wacom Intuos 5 tablet, using Inkscape software (v.0.48). Body length BL was measured with the NIS-Elements Analysis software from the rostrum anterior margin to the telson apex.

Availability of supporting data

Five specimens from Arcachon Bay were deposited in the Muséum National d'Histoire Naturelle, Paris (MNHN-IU-2014-10181).

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

OM and LP discovered for the first time *H. microps* in *U. pusilla* burrows. NL, BG and JCS identified and described *H. microps* specimens. OM is responsible of the project and LP supervisor. NL wrote the manuscript and BG, JCS, OM, LP, GB significantly improved the final manuscript. All authors read and approved the final manuscript.

Acknowledgments

Authors thank F. Prince and P. Dusoewoir, captain and crew member of R/V Planula IV for help during field work. They also thank three anonymous reviewers for helpful comments on the manuscript. This work is part of Ludovic Pascal's doctoral thesis (University of Bordeaux) financed by a PhD fellowship from the French "Ministère de l'Enseignement Supérieur et de la Recherche". This study has been carried out in the framework of the Cluster of Excellence COTE and was financially supported by the UPO (EC2CO-DRIL) project.

Received: 27 January 2016 Accepted: 8 February 2016

Published online: 08 March 2016

References

- Albertson J. Trophic interactions involving mysid shrimps (Mysidacea) in the near-bottom habitat in the Baltic Sea. *Aquat Ecol.* 2004;38:457–69. doi:10.1023/B:AECO.0000035163.30037.38.
- Astall CM, Taylor AC, Atkinson JA. Behavioural and physiological implications of a burrow-dwelling lifestyle for two species of upogebiid mud-shrimp (Crustacea: Thalassinidea). *Estuar Coast Mar Sci.* 1997;44:155–68. doi:10.1006/ecss.1996.0207.
- Blanchet H. Structure et fonctionnement des peuplements benthiques du bassin d'Arcachon. Bordeaux: University of Bordeaux; 2004.
- Blanchet H, de Montaudouin X, Lucas A, Chardy P. Heterogeneity of macrozoobenthic assemblages within a *Zostera noltii* seagrass bed: diversity, abundance, biomass and structuring factors. *Estuar Coast Mar Sci.* 2004;61:111–23. doi:10.1016/j.ecss.2004.04.008.
- Campos E. Systematics of the genus *Scleroplax* Rathbun, 1893 (Crustacea: Brachyura: Pinnotheridae). *Zootaxa.* 2006;1344:33–41.
- Campos E, De Campos AR, Manriquez I. Intertidal thalassinidean shrimps (Thalassinidea, Callinassidae and Upogebiidae) of the west coast of Baja California, Mexico: Annotated checklist, key for identification, and symbionts. *Crustaceana.* 2009;82:1249–63. doi:10.1163/001121609X12481627024454.
- Clarke WD. A new species of the genus *Heteromysis* (Crustacea, Mysidacea) from the Bahama Islands, commensal with a sea-anemone. *Am Mus Novit.* 1955;1716:1–13.
- D'Andrea AF, DeWitt TH. Geochemical ecosystem engineering by the mud shrimp *Upogebia pugettensis* (Crustacea: Thalassinidea) in Yaquina Bay, Oregon: Density-dependent effects on organic matter remineralization and nutrient cycling. *Limnol Oceanogr.* 2009;54:1911–32. doi:10.4319/lo.2009.54.6.1911.
- Dauvin JC, Vallet C. Apports d'échantillonnages suprabenthiques à la faunistique de la Manche et à la biogéographie du plateau continental nord-ouest européen. *Crustacés et Pycnogonides.* Cah Biol Mar. 1997;38:251–66.
- Dworschak PC. The pumping rates of the burrowing shrimp *Upogebia pusilla* (Petagna) (Decapoda: Thalassinidea). *J Exp Mar Biol Ecol.* 1981;52:25–35.
- Dworschak PC. Feeding behavior of *Upogebia pusilla* and *Callianassa tyrrenha* (Crustacea, Decapoda, Thalassinidea). *Invest Pesq.* 1987;51:421–29.
- Dworschak PC. Biology of Mediterranean and Caribbean Thalassinidea (Decapoda). In: Tamaki A, editor. Proceedings of the Symposium "Ecology of large bioturbators in tidal flats and shallow sublittoral sediments – from individuals behavior to their role as ecosystem engineers". Nagasaki: Nagasaki University; 2004. p. 15–22.
- Frutos I, Sorbe JC. Bathyal suprabenthic assemblages from the southern margin of the Capbreton Canyon ("Kostarrenkala" area), SE Bay of Biscay. *Deep Sea Res II.* 2014;102:291–309. doi:10.1016/j.dsr2.2013.09.010.
- Fukuoka K. A new species of *Heteromysis* (Mysida, Mysidae) associated with sponges, from the Uraga Channel, Central Japan, with notes on distribution and habitats within the genus *Heteromysis*. *Crustaceana.* 2005;77:1353–73. doi:10.1163/1568540043165976.
- Henmi Y, Itani G. Burrow utilization in the goby *Eutaenichthys gilli* associated with the mud shrimp *Upogebia yokoyai*. *Zool Sci.* 2014;31:523–28.
- Jones CG, Lawton JH, Shachak M. Organisms as ecosystem engineers. *Oikos.* 1994;69:373–86.
- Kato M, Itani G. Commensalism of a bivalve, *Peregrinamur ohshimai*, with a thalassinidean burrowing shrimp, *Upogebia major*. *J Mar Biol Assoc UK.* 1995;75:941–47. doi:10.1017/S0025315400038261.
- Mees J. *Heteromysis*. In: Mees, J. and Meland K. (Eds) (2012 onwards) World List of Lophogastrida, Stygiomysida and Mysida. World Register of Marine Species. 2015. <http://marinespecies.org/aphia.php?p=taxdetails&id=119863>. Accessed 27 Jul 2015.
- Mees J. *Heteromysis (Heteromysis) microps*. In: Mees, J. and Meland K. (Eds) (2012 onwards) World List of Lophogastrida, Stygiomysida and Mysida. World Register of Marine Species. 2016. <http://marinespecies.org/aphia.php?p=taxdetails&id=120037>. Accessed 3 Jan 2016.
- Nardon P, Charles H. Morphological aspects of symbiosis. In: Seckbach J, editor. *Symbiosis: Mechanisms and Systems*. Dordrecht: Kluwer Academic Publishers; 2002. p. 15–44.
- Pascal L, Maire O, Volkenborn N, Lecroart P, Bichon S, de Montaudouin X, Grémare A, Deflandre B. Influence of the mud shrimp *Upogebia pusilla* (Decapoda: Gebiidea) on solute and porewater exchanges in an intertidal seagrass (*Zostera noltii*) meadow of Arcachon Bay: An experimental assessment. *J Exp Mar Biol Ecol.* 2016;477:69–79. doi:10.1016/j.jembe.2016.01.008.
- Pillay D, Branch GM. Bioengineering effects of burrowing thalassinidean shrimps on marine soft-bottom ecosystems. *Oceanogr Mar Biol.* 2011;49:137–92.
- Plus M, Dalloyau S, Trut G, Aubry I, de Montaudouin X, Emery E, Noel C, Viala C. Long-term evolution (1988–2008) of *Zostera* spp. meadows in Arcachon Bay (Bay of Biscay). *Estuar Coast Shelf Sci.* 2010;87:357–66. doi:10.1016/j.ecss.2010.01.016.
- San Vicente C, Monniot F. The ascidian-associated mysid *Corellamysis eltanina* gen.nov., sp.nov. (Mysida, Mysidae, Heteromysinae): a new symbiotic relationship from the Southern Ocean. *Zootaxa.* 2014;3780:323–46. <http://dx.doi.org/10.11646/zootaxa.3780.2.6>.
- Santaga A. Waterborne behavioral cue for the actinotroch larva of *Phoronis pallida* (Phoronida) produced by *Upogebia pugettensis* (Decapoda: Thalassinidea). *Biol Bull.* 2004;207:103–15.
- Sars GO. Nye bidrag til Kundskaben om Middelhavets Invertebratfauna. I. Middelhavets Mysider. *Arch Math Naturvid.* 1877;2:10–119. Tabs 1-36.
- Sato M, Uchida H, Itani G, Yamashita H. Taxonomy and life history of the scale worm *Hesperonoe hwanghaiensis* (Polychaeta: Polynoidae), newly recorded in Japan, with special reference to commensalism to a burrowing shrimp, *Upogebia major*. *Zool Sci.* 2001;18:981–91. doi:10.2108/zsj.18.981.
- Tattersall OS. A survey of the genus *Heteromysis* (Crustacea: Mysidacea) with descriptions of five new species from tropical coastal waters of the Pacific and Indian Oceans, with a key for the identification of the known species of the genus. *Trans Zool Soc London.* 1967;31:157–93.
- Tattersall WM, Tattersall OS. The British Mysidacea. London: The Ray Society; 1951.
- Vannini M, Ruwa RK, Innocenti G. Notes on the behavior of *Heteromysis harpax*, a commensal mysid living in hermit crab shells. *Ethol Ecol Evol.* 1994;3:137–42.
- Wittmann KJ. *Heteromysis ariani* sp. n., a new benthic mysid (Crustacea, Mysidacea) from coralloid habitats in the Gulf of Naples (Mediterranean Sea). *Ann Nat Hist Mus Wien.* 2000;102:279–90.
- Wittmann KJ. Centennial changes in the near-shore mysid fauna of the Gulf of Naples (Mediterranean Sea), with description of *Heteromysis riedli* sp. n. (Crustacea, Mysidacea). *Mar Ecol.* 2001;22:85–109.
- Wittmann KJ. Two new species of Heteromysini (Mysida: Mysidae) from the island of Madeira (N.E. Atlantic), with notes on sea anemone and hermit crab commensalisms in the genus *Heteromysis* S.J. Smith, 1873. *Crustaceana.* 2008; 81:351–74. doi:10.1163/156854008783564037.
- Wittmann KJ, Ariani AP, Lagardère JP. Chapter 54. Orders Lophogastrida Boas, 1883, Stygiomysida Tchindonova, 1981, and Mysida Boas, 1883 (also known collectively as Mysidacea). In: Vaupel Klein JC, von Charmanier-Daures M, Schram FR, editors. *Treatise on Zoology - Anatomy, Taxonomy, Biology. The Crustacea*. Revised and updated, as well as extended from the *Traité de Zoologie* [founded by P.-P. Grassé], Volume 4 Part B. Leiden: Brill; 2014. p. 189–396.
- Ziebis W, Forster S, Huettel M, Jørgensen BB. Complex burrows of the mud shrimp *Callianassa truncata* and their geochemical impact in the sea bed. *Nature.* 1996;382:619–22.
- Zouhiri S, Vallet C, Mouny P, Dauvin JC. Spatial distribution and biological rhythms of suprabenthic mysids from the English Channel. *J Mar Biol Assoc UK.* 1998;78:1181–202.

Submit your next manuscript to BioMed Central and we will help you at every step:

- We accept pre-submission inquiries
- Our selector tool helps you to find the most relevant journal
- We provide round the clock customer support
- Convenient online submission
- Thorough peer review
- Inclusion in PubMed and all major indexing services
- Maximum visibility for your research

Submit your manuscript at
www.biomedcentral.com/submit

