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Class Malacostraca (subclass Eumalacostraca)

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1 **Chapter 7: Class Malacostraca (SubClass Eumalacostraca)**

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47

48 **Abstract**

49 This chapter present an updated taxonomic review of Freshwater Malacostraca. It is organized
50 into an introduction to Malacostraca followed by 7 other sections corresponding to the main
51 orders of freshwater Eumalacostraca (Amphipoda, Bathynellacea, Decapoda, Ingolfiellida,
52 Mysida and Stygomysida, Isopoda, and Thermosbaenacea) present in Mediterranean Basin.
53 Each section contains the ecology and distribution of orders, the necessary material preparation
54 methods, the relevant morphological terms, and current limitations in our knowledge of the
55 group. Dichotomous identification keys to family, genus and even species are provided for most
56 of groups (only genera with more than 15 species were not include in keys to species).

57

58 **Keywords:** Crustacea, Mediterranean Basin, taxonomy, biogeography

59

60 1. Introduction to Malacostraca

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65 INTRODUCTION

66 Malacostraca are the most diversified class of Crustacea and represent more than half of total
67 crustacean diversity. They are characterized by the development of ambulatory legs and
68 specializations for benthic life, the absence of free-living larval development (brooding eggs),
69 and the colonization of every kind of fresh and salted aquatic environments. Their body size
70 range is very wide, from a few millimetres up to 3 m, even if the largest freshwater specimens
71 (i.e. the Tasmanian giant freshwater crayfish) do not exceed 80 cm.

72 Malacostraca are composed of three subclasses (Eumalacostraca, Hoplocarida,
73 Phyllocarida); two of them exclusively include marine species, and all the freshwater species
74 of the class belong to the subclass Eumalacostraca. They constitute a very diversified group that
75 includes around 75% of all freshwater crustacean species (Balian et al., 2008), and are
76 represented by eight orders and at least 1,086 species in the Mediterranean basin (Table 1). The
77 Mediterranean basin can be considered as a hotspot for Malacostraca: it harbors 18% of the
78 world freshwater species, up to one third of the world known species of almost all orders, and
79 up to more than 50% of Thermosbaenacea (Table 1). Only Decapoda are less diversified in this
80 area, with only 2% of the world diversity of this order.

81

82 ECOLOGY AND DISTRIBUTION

83

84 Among freshwater Malacostraca of the Mediterranean basin, most species ($\approx 73\%$) inhabit
85 groundwaters, and the remaining species colonize running waters ($\approx 18\%$), lakes or ponds
86 ($\approx 5\%$), and only 3.5% survive in brackish waters. The Mediterranean basin is therefore
87 characterized by a very high proportion of groundwater species, which represent around 24%
88 of freshwater crustaceans in the world (Gibert & Culver, 2009). The proportion of obligate
89 groundwater species in the Mediterranean basin is likely related to two major historical events:
90 i) a strong vicariance related to the paleological instability of the Mediterranean Sea and the sea
91 level fluctuations (e.g. Messinian crisis) (Ayati et al., 2019), and ii) the relative long-term
92 climatic stability observed throughout the Pleistocene period, when speciation events
93 accumulated over time (Zagmajster et al., 2014).

94 Malacostraca are widely distributed throughout the Mediterranean basin (Fig. 7.1A), but
95 80% of species are endemic (i.e. restricted to one country or one archipelago) (Fig. 7.1B). There
96 also exists a clear positive correlation ($R^2 = 0.91$) between the total number of species in each
97 country and the number of endemic ones. Groundwater species are generally restricted to less
98 than two countries, whereas epigeal species can be widely distributed, especially species able
99 to survive in brackish waters. However, it is difficult to draw robust conclusions on the species
100 distribution because information is lacking in many countries such as the Middle-East countries
101 and about some groups (e.g. groundwater species). For example, countries in the north of the
102 Mediterranean basin harbor a higher diversity than southern countries do, but this difference
103 might be related to poor knowledge about the southern part of the basin (Kayo et al., 2012;
104 Zagmajster et al., 2018).

105
 106 General diversity patterns can be drawn despite this limitation. If we analyze diversity in the
 107 north and in the south separately, total diversity tends to decrease from west to east (Fig. 7.1A).
 108 In the Mediterranean islands, the Balearic Islands and Sardinia are the richest as regards total
 109 species richness as well as the proportion of endemic species (48% and 37.5%, respectively).

110 The analysis of presence/absence data for all Malacostraca clearly highlights four
 111 main groups of faunal assemblages (Fig. 7.2). One group includes countries from the northern
 112 part of the Mediterranean basin, and is divided into 4 sub-groups: Iberian countries (sub-group
 113 N1); France, Italy and Slovenia (sub-group N2); Balkanian countries from Croatia to Greece
 114 (sub-group N3); and Turkey (sub-group N4). The second group includes eastern countries and
 115 Egypt (group S1), the third one includes Maghreb (group S2), and finally the fourth one
 116 includes the Mediterranean islands and Lybia (group S3).

117
 118

119 **KEY TO ORDER OF EUMALACOSTRACA**

120 **(Cumacea and Tanaidacea not include in the key)**

121

| | | |
|-----|---|-----------------|
| 122 | 1 Carapace reduced or absent | 2 |
| 123 | 1' Carapace well developed (Fig. 7.3B,F) | 5 |
| 124 | | |
| 125 | 2(1) Thoracopods uniramous, body vermiform or not | 3 |
| 126 | 2' Thoracopods biramous, body vermiform, less than 2 mm (Fig. 7.3E) | Bathynellacea |
| 127 | | |
| 128 | 3(2) Body laterally compressed (Fig. 7.3A), telson and abdominal segments free | 4 |
| 129 | 3' Body dorsoventrally compressed (Fig. 7.3C), telson and abdominal segments fused into a pleotelson | |
| 130 | ..... | Isopoda |
| 131 | | |
| 132 | 4(3) Cephalothorax composed of head and first segment of the mesosome fused together (Fig. 7.10); | |
| 133 | presence or not of vestigial pedunculate eyes; eyes lacking; pleosome without epimera and with | |
| 134 | reduced pleopod/uropod appendages | Ingolfiellida |
| 135 | 4' Head not fused with the first segment of the mesosome (Fig. 7.4); vestigial pedunculate not present; | |
| 136 | eyes present or lacking; pleosome with three epimera and normally developed appendages | |
| 137 | ..... | Amphipoda |
| 138 | | |
| 139 | 5(1') Compounds eyes generally present, but absent in some groundwater genera, when present they are | |
| 140 | pedonculate; pleopods always developed | 6 |
| 141 | 5' Eyes absent, Pleopods reduced and only on the two first abdominal segments, absent from remaining | |
| 142 | segments, eight pairs of thoracopods, first modified as a maxilliped | Thermosbaenacea |
| 143 | | |
| 144 | 6(5) Seven pairs of thoracopods (Fig. 7.3D) | 7 |
| 145 | 6' Five pairs of walking legs, including chelae | Decapoda |
| 146 | | |

- 147 7(6) Eyes normally developed, endopod of uropods with very large statocyst; sympod without ventral
 148 lobe; cornea mostly well-developed, rarely reducedMysida
- 149 7' Eyes reduced to flat ocular plate, endopod of uropods without statocyst; sympod with spiny ventral
 150 lobe; cornea reducedStygomysida
 151

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182 **2. Malacostraca: Amphipoda**

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187 **INTRODUCTION**

188 Amphipoda Latreille 1816 are present in all types of continental waters (springs, rivers, lakes)
189 and in groundwaters (subterranean interstitial and cave systems) on all continents. Apart from
190 a few exceptions, they are easily recognizable in the field from their shrimp-like habitus.

191 Biogeographic analysis indicates that amphipods were likely widespread in Pangea, Gondwana,
192 and Laurentia (Väinölä et al., 2008). These studies were confirmed by the discovery of the
193 oldest fossil *Rosagammarus minichiellus* in late Triassic limestone in Nevada (McMenamin et
194 al., 2013). Marine ancestors subsequently colonized very early freshwaters during the Jurassic
195 period before a probable massive diversification during the Cretaceous (Copilaş-Ciocianu et
196 al., 2019) and Paleogene (Hou et al., 2014) periods.

197 The ancestors of Mediterranean amphipods may have an Atlantic origin around 40 Mya
198 (Hou & Sket, 2016). They conquered its freshwater confluent, like *Iberogammarus* and
199 *Echinogammarus sensu stricto* did. Finally, some crossed the proto-Mediterranean sea to the
200 lands located at its eastern edges, (the *Typhlogammarus* group and part of the
201 *Sarothrogammarus* group), or also spread along the future Mediterranean coasts
202 (*Rhipidogammarus*). Other groundwater groups (e.g. hadzioid-thalassoid Metacrangonyctidae
203 amphipods) result from ancient continental-level vicariance (Bauzà-Ribot et al., 2012), or from
204 more recent vicariance and long-distance dispersal (Pseudoniphargidae; (Stokkan et al., 2018).

205 Among the 1,870 amphipod species and subspecies recorded from fresh or inland waters
206 worldwide (Horton et al., 2020), more than 31% are present in the Mediterranean basin, where
207 a total of 14 families, 50 genera and 581 species are recorded; most of them are endemic to the
208 region.

209

210 **GENERAL ECOLOGY AND DISTRIBUTION**

211 Amphipoda are widely distributed and colonize all types of marine and continental waters on
212 all continents. They represent one of the highest invertebrate biomass values and are prey for
213 many other organisms. They also support many functional processes in these ecosystems like
214 organic matter recycling and bioturbation.

215 In the Mediterranean basin, Amphipods are present in all countries and big islands. We
216 recorded 559 species (96%) restricted to only one type of environment (running water, lake,
217 groundwater, brackish water) and only 22 euryecous species (i.e. present in a least two types of
218 aquatic ecosystems). Euryecous species are present mainly in running waters, lakes and
219 brackish water, and only a few species (e.g. *Niphargus zagrebensis*) can live permanently either
220 in groundwater or in surface waters.

221 The highest diversity is found in groundwaters, which represent 74% of the total
222 amphipod richness with 429 species, followed by running waters (127 species) and lakes (31
223 species). Only 17 species live solely in lakes and originally came from Ohrid Lake (8 species)
224 or from Turkey (9 species); the other lacustrine species are euryecous species that also live in
225 running waters (14 species) or in brackish environments (4 species).

226 Among the 14 families recorded so far, most of them are widespread worldwide, with members
227 living in both fresh and marine waters. Others (Crangonyctidae, Niphargidae,
228 Pontogammaridae, and Typhlogammaridae) have a Eurasian distribution and are only present
229 in the central and eastern parts of the Mediterranean basin, except *Crangonyx africanus* in
230 Morocco. Metacrangonyctidae and Pseudoniphargidae are mainly distributed in the
231 Mediterranean area but also have a few members in the Canary and Caribbean islands. Finally,
232 only two families are endemic to the Mediterranean basin: Salentinellidae with 14 species
233 widely distributed around the Mediterranean Sea between Greece and Algeria, and
234 Sensoratoridae with only one known species in Spain (*Sensorator valentienensis* Notenboom,
235 1986).

236

237 **TERMINOLOGY AND MORPHOLOGY**

238 Amphipoda are medium/large-size Malacostraca (from 0.1 up to 35 mm in the Mediterranean
239 basin). Their body is typically compressed laterally, though less so for Corophiidae. It is divided
240 into 13 segments that can be grouped into the head, the mesosome, the metasome, and the
241 urosome (Fig. 7.4).

242 The head is fused to the thorax and bears two pairs of antennae. The upper pair is
243 antennae 1, with a basal peduncle composed of three articles and a distal flagellum composed
244 of many articles. The third peduncular article also bears an accessory flagellum on its distal
245 end, usually composed of a reduced number (less than 10) of tiny cylindrical articles. The
246 second pair of antennae (antennae 2) has a flagellum composed of several small articles and a
247 peduncle composed of five articles; articles 4 and 5 are much longer than the first 3 articles (the
248 first one is hidden by the head). Most epigean species (with few exceptions like epigean
249 *Niphargus zagrebensis* S. Karaman, 1950) have one pair of more or less developed sessile
250 compound eyes. Eyes are absent in obligate groundwater species. However, we often found
251 eyed species in groundwaters, especially in the Mediterranean basin, where epigean species can
252 be present in a large proportion of groundwaters round the year. The mouthpart is on the ventral
253 surface of the head and is composed of the labrum, labium, mandibles, maxillae I and II, and
254 maxilliped.

255 The mesosome (or thorax or pereon) bears different kinds of legs, but no carapace. It
256 has eight pairs of uniramous appendages, the first of which are used as accessory mouthparts.
257 Two pairs of gnathopods (modified pereopods 1 and 2) are used for grasping, usually with a
258 last subchelate article; the next five pairs (pereopods 3-7) are walking legs. Gnathopods and
259 pereopods 3 and 4 have modified coxae transformed into large coxal plates. Coxal gills are
260 present on mesosome segments in various numbers according to species, and sternal gills are
261 known only in Crangonyctidae.

262 The metasome (or abdomen or pleion) is divided into two parts – the pleosome and
263 urosome segments. Each segment bears one pair of legs. The pleosome bears three pairs of
264 swimming legs named pleopods, with multi-articulated rami. The urosome bears three pairs of
265 uropods. The length and the shape of uropod 3 can be highly variable among genera. The basal
266 part of the uropod is the peduncle, that branches into an exopodite (with one or two articles, the
267 second one can be short and hidden by the apical spines of article 1) and a medial branch named
268 the endopodite (only one article or no article at all).

269 The telson – the final body segment – is attached above uropod 3.

270

271

272

273

274 **COLLECTION, PREPARATION, AND IDENTIFICATION**

275 Amphipoda are widely distributed in all aquatic environments, including groundwaters.
276 Therefore, the sampling methods and devices are numerous and depend on the specific habitats
277 where the fauna is found.

278 In surface waters, we can sample them using all kinds of sampling tools and methods
279 (sweep net, kick sampling, grab sampler, dredges, and even artificial substrates) or just by
280 taking stones, leaf litter or macrophyte by hand or with a kitchen colander. There are rarely
281 more than 3 species in any given site. However, it is strongly recommended to sample the
282 different substrates because many species have different microdistribution patterns when they
283 co-occur (Piscart et al., 2007).

284 In groundwaters, any kind of specific material for this environment can be used (Malard et al.,
285 2002). Baited bottle traps or nets exposed overnight are also very efficient for many
286 groundwater organisms.

287 Amphipoda can be easily fixed and preserved in 70% ethanol or another fixative for
288 morphological analysis and in 95% ethanol for molecular analysis.

289 Many species can be identified under a stereomicroscope, but identification at the species
290 level may require dissection, mounting body parts and appendages on slides, and subsequent
291 examination using a 400x or greater magnification microscope. Specimens in glycerol or
292 ethanol can be handled under a low-power microscope with needles. Glycerol is used as an
293 embedding medium for short-term slides. Baths in clearing solution (e.g. soft acids) or
294 permanent mounting media are only required for depositing museum specimens. A same
295 specimen can be used for both studies: the abdomen for DNA extraction and the other parts for
296 dissection and mounting. This procedure ensures that the sequenced genes correspond to the
297 same morphotype.

298 Taxonomic identification to the species level is generally only possible in males, but females
299 can be used for higher taxonomic levels. The most important body parts for identification are
300 the antennae, mouthpart, coxae, gnathopods, pereopods 5 and 7, epimera, telson, and uropods;
301 but additional body parts need to be examined to identify certain species.

302

303 **LIMITATIONS**

304 Amphipoda are a highly diversified group with almost 600 known species, and even more
305 remain undescribed. The keys below are designed to cover the 14 families and 49 genera; keys
306 at the species level are provided only for the genera with a low number of species (usually less
307 than 15). Rare records are included, unless they are insufficiently documented. Taxonomic
308 synonymy has been updated, but taxonomy is not well established for some genera (e.g.
309 *Echinogammarus*, *Laurogammarus*, and *Typhlogammarus*.) and even families (e.g.
310 Pontogammaridae), especially following recent molecular studies. For those genera and till a
311 clear consensus is found, we assume the use of the most parsimonious point of view, even if
312 alternate classifications may be found in other keys. As a consequence, some family, genus and
313 species names may change in the future.

314 Finally, even if our keys were designed to be as clear as possible, we should never forget
315 that identifying certain groups of amphipods (especially groundwater species) can be very
316 difficult and requires strong expertise. Do not hesitate to use alternative information or keys to
317 consolidate your conclusions. We should keep in mind that keys, even at the family level, are
318 designed for species of the Mediterranean basin; they are not adapted to other amphipods
319 worldwide.

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KEYS TO AMPHIPODA

Key to Amphipoda families

- 1 Antenna 1 significantly shorter than antenna 2 2
- 1' Antenna 1 subequal or longer than antenna 2 4
- 2(1) Antenna 1 accessory flagellum absent; eyes well developed 3
- 2' Antenna 1 accessory flagellum small, eyes absent *Sensonatoridae*
(one genus: *Sensonator*)
[Spain]
- 3(2) Antenna 2 enlarged; mandibular palp present; urosomite dorsally flat *Corophiidae*
[North-Eastern Mediterranean, Central Europe]
- 3' Urosomite enlarged, antenna 2 not enlarged, mandibular palp absent..... *Talitridae*
[Peri-Mediterranean]
- 4(1) Sternal gills absent 5
- 4' Sternal gills present *Crangonyctidae*
[Europe, Morocco]
- 5(4) Mandibular palp normally developed; eyes present or absent 6
- 5' Mandibular palp vestigial; eyes absent *Metacrangonyctidae*
[Peri-Mediterranean]
- 6(5) Coxae 1-3 subequal or size progressively increasing, coxae 4-5 of various size; uropod 1-2 peduncles with lateral spines; eyes present or absent 7
- 6' Coxae 1-3 small, size progressively decreasing, and coxa 4-5 larger; uropod 1-2 peduncles without lateral spines; eyes absent *Salentinellidae*
[Peri-Mediterranean]
- 7(6) Antenna 1 longer than antenna 2; maxilla 1 inner plate with at least one apical setae and/or marginal setae, telson notched, emarginate or entire..... 8
- 7' Antenna 1 and 2 equal or subequal in length; maxilla 1 inner plate reduced with only 0 or 1 apical setae; telson entire..... *Ischyroceridae* (one genus *Jassa*)
[Sicily]
- 8(7) Telson lobes almost completely separated, rami of uropod 3 lanceolate 9
- 8' Telson lobes partially fused, even sometime very slightly; uropod 3 rami straight more or less long 10

- 361
- 362 9(8) Coxae 1-3 longer than wide or sub-rectangular; gnathopod 2 propodus elongated slightly
 363 stronger than gnathopod 1; labium inner lobe vestigial or absent; uropod 3 rami sub-equal
 364 Hadziidae
 365 [Western Europe]
- 366 9' Coxae 1-3 small wider than long; gnathopod 2 propodus much stronger than gnathopod 1;
 367 labium inner lobe normally developed, except in the genus *Gammaropisa*; uropod 3 rami
 368 unequal, exopodite much longer than endopoditeEriopisidae
 369 [Turkey, Tunisia]
- 370
- 371 10(8') Telson entire or slightly emarginate (notch < 30% of the lobe), eyes absent 11
- 372 10' Telson deeply notched almost entirely, eyes present or absent 12
- 373
- 374 11(10) Pleopods uniramous or inner ramus reduced or vestigial; uropod 3 rami subequal in
 375 length Bogidiellidae
 376 [cosmopolitan]
- 377 11' Pleopods biramous, inner ramus well developed; uropod 3 exopodite much longer than
 378 endopodite Pseudoniphargidae
 379 [Western Europe and North Africa]
- 380
- 381 12(10') Inner lobe of maxilla 2 with oblique row of facial setae; eyes generally present of
 382 various sizes 13
- 383 12' Inner lobe of maxilla 2 without oblique row of facial setae ; Labium without a more or less
 384 developed inner lobes, eye absent Niphargidae
 385 [Southern and Eastern Europe, Minor Asia]
- 386
- 387 13(12) Maxilla 1 outer plate with apical spines comb-like with few lateral teeth (except
 388 *Longigammarus*); pereopod 7 longer than 5; uropod 3 endopodite shorter than exopodite;
 389 eyes present or absent 14
- 390 13' Maxilla 1 outer plate with apical spines comb-like with numerous lateral teeth (>10);
 391 pereopod 7 subequal in length than 5; uropod 3 sub-equally biramous; eyes absent
 392Typhlogammaridae
 393 [Balkan and Eastern Europe]
- 394
- 395 14(13) Antenna 2 peduncle article 1 enlarged, bulbous; antenna 1 longer or sub-equal in length
 396 than antenna 2, antenna 1 slender, generally longer than a half of the body length, the
 397 diameter of the articles of the peduncle is not much different; uropod 1 with or without
 398 basofacial robust setae; urosomite 2 with multiple small robust setae across the somite
 399 Gammaridae
 400 [Cosmopolitan]
- 401 14' Antenna 2 peduncle article 1 subequal than article 3; antennae 1-2 sub-equal in length and
 402 short (\leq an half of the body length), antenna 1 stout, shorter than a half of the body length,
 403 the diameter of the articles of the peduncle strongly decrease in length and in width from

404 article 1 to article 3; uropod 1 without basofacial robust setae; urosomite 2 without dorsal
405 setae Pontogammaridae
406 [Western Europe (invasive), Eastern Europe and Minor Asia]

407

408 **Key to Bogidiellidae genera**

409 1 Molar non-tritulative; maxilla 1 palp with 2 articles 2

410 1' Molar tritulative; maxilla 1 palp with 1 or 2 articles 3

411

412 2(1) Epistomal ridge with a sclerified subcircular area; pleopod rami very long with 9 articles

413 *Maghrebidiella*

414 (one species: *M. maroccana* Diviacco & Ruffo, 1985)

415 [Morocco]

416 2' Epistomal ridge without sclerified area; pleopod rami with 3 articles

417 *Hebraegidiella*

418 (one species: *H. bromleyana* G. Karaman, 1988)

419 [Israel]

420

421 3(1) Pleopods 2, ramus article 2 of males with a modified seta *Stygogidiella*

422 (one species: *S. cypria* G. Karaman, 1989)

423 [Cyprus]

424 3' Pleopods 2, ramus article 2 of males without modified seta 4

425

426 4(3) Uropods not sexually dimorphous, uropods without transformed spines, pleopods

427 endopodites small, vestigial or absent 5

428 4' Uropods sexually dimorphous, uropod 1 or 2 rami with transformed (rasp-like, spoon-like)

429 spines; pleopods endopodites absent *Medigidiella*

430 [Western Mediterranean]

431

432 5(4) Maxilla 1 outer lobe with 6 distal spines, telson deeply cleft *Racovelia*

433 (one species: *R. birramea* Jaume, Gràcia & Boxshall, 2007)

434 [Balearic Islands]

435 5'. Maxilla 1 outer lobe with 7 distal spines, telson entire or weakly cleft (<30%) ... *Bogidiella*

436 [cosmopolitan]

437

438 **Key to species of *Medigidiella***

439 1 Lenticular organ \leq a half of the basis width or absent (not visible) 2

440 1' Lenticular organ very large, almost as large as the basis of pereopods 3-6, absent on pereopod

441 7 *M. paolii* Hovenkamp, 1983

442

443 2(1) Lenticular organ absent (not visible) 3

| | | |
|-----|--|---|
| 444 | 2' Lenticular organ visible on pereopod 3-7..... | 7 |
| 445 | | |
| 446 | 3(2) Pleopod inner rami absent; telson with apical spines only; basis of gnathopods 1 and 2 with | |
| 447 | only one posterior setae | 4 |
| 448 | 3' Pleopod inner rami reduced but present; telson with apical and subapical spines; basis of | |
| 449 | gnathopods 1 and 2 with 2 posterior setae <i>M. hebraea</i> (Ruffo, 1963) | |
| 450 | | |
| 451 | 4(3) Antenna 2 without groups of setae on peduncle articles; maxilliped outer lobe with 2 | |
| 452 | spines; gnathopod 1 propodus without short spines; uropod 1 peduncle with one spine | 5 |
| 453 | 4' Antenna 2 with groups of setae on peduncle articles; maxilliped outer lobe with 3 spines; | |
| 454 | gnathopod 1 propodus with 2 or 3 short spines; uropod 1 peduncle without spine | |
| 455 | <i>M. paraichnusae</i> (Karaman, 1979) | |
| 456 | | |
| 457 | 5(4) Gnathopod 2 propodus with 2 short spines; pereopod 7 propodus with 4-6 anterolateral | |
| 458 | setae; uropod 3 rami with 7-11 lateral spines | 6 |
| 459 | 5' Gnathopod 2 propodus with 3 short spines; pereopod 7 propodus with 7-9 anterolateral setae; | |
| 460 | uropod 3 rami with 3-6 lateral spines <i>M. dalmatina</i> (S. Karaman, 1953) | |
| 461 | | |
| 462 | 6(5) Gnathopods 1-2 propodi short; uropods 1-2 rami with short distal spines | |
| 463 | <i>M. chappuisi chappuisi</i> (Ruffo, 1952) | |
| 464 | 6' Gnathopods 1-2 propodi longer; uropods 1-2 rami with relatively long distal spines | |
| 465 | <i>M. chappuisi pescei</i> (G. Karaman 1989) | |
| 466 | | |
| 467 | 7(2') Antenna 1 accessory flagellum \leq two articles of the flagellum, peduncle articles with two | |
| 468 | spines; maxilliped outer lobe with bifid spines; gnathopod 1 propodus with 4-5 short spines | |
| 469 | ..... | 8 |
| 470 | 7' Antenna 1 accessory flagellum longer than the three articles of the flagellum, peduncle | |
| 471 | articles without spine; maxilliped outer lobe with simple spines; gnathopod 1 propodus with | |
| 472 | 7 short spines <i>M. antennata</i> Stock & Notenboom, 1988 | |
| 473 | | |
| 474 | 8(7) Antenna 2 with aesthetascs; maxilla 2 without plumose setae; gnathopod 1 basis with only | |
| 475 | one long posterior seta; gnathopod 2 propodus with 4 short spines; telson with 4 plumose | |
| 476 | setae | 9 |
| 477 | 8' Antenna 2 without aesthetascs; maxilla 2 without plumose setae; gnathopod 1 basis with 2 | |
| 478 | long posterior setae; gnathopod 2 propodus with 3 short spines; telson with at least 6 plumose | |
| 479 | setae <i>M. aquatica</i> Karaman, 1990 | |
| 480 | | |
| 481 | 9(8) Lenticular organ small, about 1/3 of the basis width; labium outer lobe with spines; | |
| 482 | pereopod 7 propodus with less than 9 anterolateral setae, dactylus equal or longer than a half | |
| 483 | of the propodus; uropod 2 rami with modified distal spines in males | |
| 484 | <i>M. minatorus</i> Ruffo & Schiecke, 1976 | |

485 9' Lenticular organ large, about 1/2 of the basis width; labium outer lobe with spines; pereopod
 486 7 propodus with at least 9 anterolateral setae, dactylus shorter than a half of the propodus
 487 uropod 2 rami with unmodified distal spines in males
 488 *M. uncanata* Stock & Notenboom, 1988

489

490 **Key to Corophiidae genera and species**

491 1 Antenna 2 article 2 with gland very small 2 (genus: *Chelicorophium*)
 492 [invasive in Western Europe]

493 1' Antenna 2 article 2 with gland cone large, conspicuous
 494 *Corophium*
 495 (one species: *C. orientalis* Schellenberg 1928)
 496 [Southern Europe]

497

498 2(1) Antenna 2 peduncle article 5 with 1 distal teeth or without teeth 3

499 2' Antenna 2 peduncle article 5 with 2 distal teeth on the lower margin
 500 *Ch. maeticum* (Sowinsky, 1898)

501

502 3(2) Antenna 2 peduncle article 5 with 1 distal teeth (short or long) 4

503 3' Antenna 2 peduncle article 5 without distal teeth on the lower margin
 504 *Ch. sowinskyi* (Martynov, 1924)

505

506 4(3) Antenna 2 peduncle article 5 with 1 long distal teeth; uropod 2 outer rami with 6 marginal
 507 spines *Ch. robustum* (G.O. Sars, 1895)

508 4' Antenna 2 peduncle article 5 with 1 short distal teeth; uropod 2 outer rami with 3 marginal
 509 spines *Ch. curvispinum* (Martynov, 1924)

510

511 **Key to Crangonyctidae genera and species**

512 1 Urosomites coalesced; uropod 3 inner ramus absent 2

513

514 1' Urosomites free; uropod 3 inner ramus small or scale-like 6 (genus: *Crangonyx*)
 515 [Morocco, Invasive in Western Europe]

516

517 2(1) Body pigmented; pleopods with 2 coupling spines (retinacules); uropod 3 endopodite
 518 without terminal "squamous knob" 3 (genus:
 519 *Synurella*)
 520 [Balkan, Central Europe]

521 2' Body not pigmented; pleopods with 5-6 coupling spines (retinacules); uropod 3 endopodite
 522 with a terminal "squamous knob" *Pontonyx*
 523 (one species: *P. osellai* (Ruffo, 1974))

524 [Turkey]

525

- 526 3(2) Epimera 2 with spines at distal margin but never setae 3 (*Synurella ambulans*)
- 527 3' Epimera 2 with numerous setae at distal margin*S. longidactylus* S. Karaman, 1929
- 528
- 529 4(3) Females's oostegite broader; Eyes present or absent; pereopod dactyls in males longer and
530 slenderer than in females 4
- 531 3' Female's oostegite narrow; Eyes absent; pereopod dactyls subequal in shape between males
532 and females *S. ambulans montenegrina* (G. Karaman 1974)
- 533
- 534 5(4) Eyes present; gnathopod 2 propodus in females is short and broad than in males
535 *S. ambulans ambulans* (F. Müller, 1846)
- 536 5' Eyes absent; gnathopod 2 propodus in males is strongly dilated
537 *S. ambulans subterranean* (S. Karaman, 1931)
- 538
- 539 6(1') Eyes present, epigeal species; gnathopod 2 palm with notched spines; pereopod 6
540 propodus much shorter than basis *C. pseudogracilis* Bousfield, 1958
- 541 6' Eyes absent, hypogean species; gnathopod 2 palm with simple spines; pereopod 6 propodus
542 longer than basis and carpus *C. africanus* Messouli, 2006
- 543

544 **Key to Eriopisidae genera and species**

- 545 1 Labium inner lobe absent; gnathopod 1 carpus slightly shorter than propodus; pleopod 3
546 greatly modified in males *Gammaropisa*
547 (one species: *G. argonoi* Ruffo & Vigna-Taglianti, 1988)*
548 [Turkey]
- 549 1' Labium inner lobe present; gnathopod 1 carpus longer than propodus; pleopod 3 not modified
550 *Tunisopisa*
551 (one species: *T. seurati* (Gauthier, 1936))
552 [Tunisia]

553 * the position of *Gammaropisa* in Eriopisidae remains doubtful because it did not match to the
554 revision of Lowry and Myers 2013, who defined Eriopisidae with an internal lobe in the labium
555 but this lobe is not drawn by Ruffo 1987.

556

557 **Key to Gammaridae genera**

- 558 1 Antenna 2 gland cone small, conical and straight 2
- 559 1' Antenna 2 gland cone extremely elongated and recurved going back toward coxae 1
560 *Laurogammarus*
561 (one species: *L. scutarensis* (Schaferna, 1922))
562 [Skadar Lake drainage]
- 563

| | | |
|-----|--|-------------------------|
| 564 | 2(1) Pleonites and pereonites without mediodorsal keels; pereopod 7 basal article with or | |
| 565 | without large posteriodistal lobe, urosome generally not carinate (except in some <i>Gammarus</i> | |
| 566 | and <i>Echinogammarus</i>) | 3 |
| 567 | 2' Pleonites and some pereonites with mediodorsal keels; pereopod 7 basal article with a large | |
| 568 | posteriodistal lobe, urosome carinate | <i>Amathillina</i> |
| 569 | (one species: <i>A. cristata</i> Sars, 1894) | |
| 570 | [Turkey] | |
| 571 | | |
| 572 | 3(2) Uropod 3 endopodite well developed, overreaching 25% of the exopodite | 4 |
| 573 | 3' Uropod 3 endopodite very reduced, scale like, <25% of the exopodite | 6 |
| 574 | | |
| 575 | 4 Maxilla 1 outer lobe with 17 curved spines; coxal gill 7 absent; eyes absent | |
| 576 | ..... | <i>Albanogammarus</i> |
| 577 | (one species: <i>A. inguscioi</i> Ruffo, 1995) | |
| 578 | [Balkans] | |
| 579 | 4' Maxilla 1 outer lobe with straight simple or pectinate spines; coxal gill 7 present; eyes present | |
| 580 | or absent | 5 |
| 581 | | |
| 582 | 5 Gnathopod 1 propodus in males larger than gnathopod 2; Gnathopod 2 carpus elongated | |
| 583 | ..... | <i>Iberogammarus</i> |
| 584 | [Spain, France] | |
| 585 | 5' Gnathopod 1 in male propodus smaller than gnathopod 2; uropod 3 endopodite \geq 25% | |
| 586 | exopodite | <i>Gammarus</i> |
| 587 | [Cosmopolitan] | |
| 588 | | |
| 589 | 6 Uropod 1 reduced, not reaching apices of uropod 2, rami without lateral spines | 7 |
| 590 | 6' Uropod 1 longer than uropod 2 | 8 |
| 591 | | |
| 592 | 7 Maxilla 1 outer lobe with many densely pectinate setae (like Typhlogammaridae), inner lobe | |
| 593 | wider than long | <i>Longigammarus</i> |
| 594 | [Peri-Mediterranean] | |
| 595 | 7'. Maxilla 1 outer lobe with less densely pectinate setae (like Gammaridae), inner lobe longer | |
| 596 | than wide, pereopod 7 base elongated more than twice as long as wide ... | <i>Rhipidogammarus</i> |
| 597 | [Peri-Mediterranean] | |
| 598 | | |
| 599 | 8(6') Uropod 1 longer than uropod 2 and reaching its apex, uropod 1 rami with several distal | |
| 600 | spines | 9 |
| 601 | 8' Uropod 1 longer than uropod 2 but not reaching its apex, uropod 1 rami with only one strong | |
| 602 | distal spine | <i>Tyrrhenogammarus</i> |
| 603 | [Sardinia, Sicily] | |
| 604 | | |
| 605 | 9(8) Urosomites 1 et 2 without dorsal elevations | 10 |

| | | |
|-----|--|--|
| 606 | 9' Urosomites 1 et 2 with dorsal humps or cones with some apical spines | <i>Dikerogammarus</i> |
| 607 | [Turkey, invasive in Western Europe] | |
| 608 | | |
| 609 | 10(9) Pereopod 7 ventroposterior lobe absent or small; uropod 1 outer ramus subequal to the | |
| 610 | inner ramus | 11 |
| 611 | 10' Pereopod 7 ventroposterior lobe well developed, uropod 1 outer ramus reaching at least | |
| 612 | 60% of inner ramus | 13 |
| 613 | | |
| 614 | 11(10) Setae on at least either on pereopods 5 to 7, urosomite and/or epimera | 12 |
| 615 | 11' Setae almost completely lacking on pereopods 5 to 7, urosomites and epimeron | |
| 616 | <i>Chaetogammarus</i> (one species: <i>C. saisensis</i> Fadil et al, 2009) | |
| 617 | [Morocco] | |
| 618 | | |
| 619 | 12(11) Gnathopod 1 propodus in males much larger than gnathopod 2, eyes elongate 2x longer | |
| 620 | than wide | <i>Echinogammarus sensu stricto</i> |
| 621 | [Peri-Mediterranean] | |
| 622 | 12' Gnathopod 1 propodus in males equal of slightly longer than gnathopod 2, eyes ovoid or | |
| 623 | 1.5x longer than wide | <i>Echinogammarus / Homoeogammarus</i> |
| 624 | [Peri-Mediterranean] | |
| 625 | | |
| 626 | 13(10') Pereopod 7 ventroposterior lobe broad and rounded; uropod 1 outer ramus reaching | |
| 627 | 60% of inner ramus; uropod 3 with very long setae and marginal spines; telson with marginal | |
| 628 | spines | <i>Ilvanelia</i> |
| 629 | (one species: <i>I. inexpectata</i> Vigna-Taglianti, 1971) | |
| 630 | [Italia, Tuscan Archipelago] | |
| 631 | 13' Pereopod 7 ventroposterior lobe rounded-triangular; uropod 1 outer and inner rami subequal | |
| 632 | in length; uropod 3 with very few setae; telson without marginal spines | |
| 633 | ..... | <i>Jugogammarus</i> |
| 634 | (one species: <i>J. kusceri</i> S. Karaman, 1931) | |
| 635 | [Slovenia] | |

636

637 **Key to species of *Dikerogammarus***

| | | |
|-----|---|---|
| 638 | 1 Antenna 1 peduncle segments long and slender | 2 |
| 639 | 1' Antenna 1 peduncle segments short and swollen | <i>D. gruberi</i> (Mateus & Mateus, 1990) |
| 640 | | |
| 641 | 2(1) Pereopod 7 basal segment with setae in the inner surface | 3 |
| 642 | 2' Pereopod 7 basal segment without setae in the inner surface | 4 |
| 643 | | |
| 644 | 3(2) Antenna 1 peduncle segment 2 and antenna 2 segment 4-5 with few short setae (shorter | |
| 645 | than the diameter of the segment) on the inferior margin | |
| 646 | ..... | <i>D. istanbulensis</i> Özbek and Özkan, 2011 |

647 3' Antenna 1 peduncle segment 2 and antenna 2 segment 4-5 with many long setae (longer than
648 the diameter of the segment) on the inferior margin *D. bispinosus* Martynov, 1925
649

650 4(2') Antenna 2 flagellum with long setae forming a brush, urosomites 1 et 2 with dorsal humps
651 well developed and armed with 3-6 upright apical spines and forming like a crater
652 *D. villosus* (Sowinskyi, 1894)

653 4' Antenna 2 flagellum with short setae never forming a brush, urosomites 1 et 2 with small
654 dorsal humps armed with 1-3 apical spines slightly oriented towards the telson
655 *D. haemobaphes* (Eichwald, 1841)
656

657 **Key to species of *Iberogammarus***

658 1 Antenna 2 of male with many groups of long and densely implanted curled setae. Third
659 segment of mandible palp with less than 6 terminal setae 2

660 1' Antenna 2 of male with straight setae. Third article of mandible palp with more than 6
661 terminal setae *I. anisocheirus* (Ruffo, 1959)

662
663 2(1) Gnathopod 1 propodus of males without the medial palmar spine. Basis of P7 with strong
664 backward projecting ventro-posterior corner *I. macrocarpus* (Stock, 1969)

665 2' Gnathopod 1 propodus of males with a strong medial palmar spine. Basis of P7 with rounded,
666 non-projecting, ventro-posterior corner *I. toletanus* (Pinkster & Stock, 1970)
667

668 **Key to species of *Longigammarus***

669
670 1 Eyes present; maxilla 1 outer plate with 11 apical spines, slightly recurved
671 *L. bruni* G. Karaman, 1969

672 1' Eyes present; maxilla 1 outer plate with 22 apical spines distally spatulate
673 *L. planisae* Messana & Ruffo, 2001
674

675 **Key to species of *Rhipidogammarus***

676 1 Antenna 1 peduncle article 2 with at least 4 groups of setae 2

677 1' Antenna 1 peduncle article 2 with 2-3 groups of setae 3

678
679 2(1) Coxae 1-5 with long ventral setae, anterior margin of carpus of P7 with setae longer than
680 spines *Rh. triumvir* Nottenboom, 1985

681 2' Coxae 1-5 with short ventral setae only, anterior margin of carpus of P7 without long setae
682 *Rh. gordankaramani* Özbek & Sket 2019
683

684 3(1') Antenna 1 flagellum with more than 35 articles; uropod 3 exopodite shorter (no more than
685 7x longer than endopodite) without seta or few long setae 4

686 3' Antenna 1 flagellum with more than 30 articles; uropod 3 exopodite long (10x longer than
687 endopodite) with many long setae (2x longer than spines) *Rh. variicauda* Stock, 1978
688

689 4(3) Mandibular palp article 2 with long setae reaching the setae type D on the article 3; uropod
690 3 exopodite without seta *Rh. karamani* Stock 1971

691 4' Mandibular palp article 2 with setae never reaching the setae type D on the article 3; uropod
692 3 exopodite with few setae 2x longer than spines *Rh. rhipidiophorus* (Catta, 1878)

693

694 **Key to species of *Tyrrhenogammarus***

695 1 Pereopod 3 carpus with a fan of long setae; uropod 1 with sub-equal rami; epimera 3 with a
696 slightly marked ventroposterior corner *Th. catacumbae* (G. Karaman & Ruffo, 1977)

697 1' Pereopod 3 carpus without long setae; uropod 1 inner ramus longer than outer ramus; epimera
698 3 without distinct ventroposterior corner *Th. sardous* Karaman & Ruffo, 1989

699

700 **Key to Hadziidae genera and species**

701 1 Uropods 1 and 2 with row of 5 plumose setae, exopodite with dorsal setae; telson with only
702 apical spines 2

703 1' Uropods 1 and 2 with row of 5 plumose setae, exopodite with dorsal setae; telson with
704 marginal spines *Parhadizia*
705 (one species: *P. sbordonii* Vigna Taglianti, 1988)
706 [Turkey]

707

708 2 Mandibular palp article 2 as long as article 1 3 (genus: *Hadzia*)

709 2' Mandibular palp article 2 longer than article 1 7 (genus: *Metahadzia*)
710

711 3(2) Gnathopod 2 propod in females with entire convex palm; gnathopod 2 propod in males as
712 wide as carpus; uropod 3 rami broad 4

713 3' Gnathopod 2 carpus in females with excavated, propodus palm concave; gnathopod 2
714 propodus in males wider than carpus; uropod 3 rami narrow 6
715

716 4(3) Pleopods 1-3 each with 2 retinacula accompanied by one strong seta 5

717 4' Pleopods 1-3 each with 2 retinacula without strong seta
718 *H. fragilis stocki* G. Karaman, 1989

719

720 5 Pereopods 3-7 and antennae long and slender, including dactyl of pereopods 3-7; telson lobes
721 with 2, occasionally 3 distal spines and without outer marginal spines
722 *H. fragilis fragilis* S. Karaman, 1932

723 5' Pereopods 3-7 and antennae shorter and stouter; telson lobes with 3-4 distal spines and 0-1
724 outer marginal spines *H. fragilis drinensis* G. Karaman, 1984

725

| | | |
|-----|--|--|
| 726 | 6(3') Pleopod 3 peduncle with 1-2 median spine on posterior margin | |
| 727 | ..... | <i>H. gjorgjevici crispata</i> G. Karaman, 1974 |
| 728 | 6' Pleopod 3 peduncle without median spine on posterior margin | |
| 729 | ..... | <i>H. gjorgjevici gjorgjevici</i> S. Karaman, 1932 |
| 730 | | |
| 731 | 7(2') Uropod 2 peduncle distal end with a protuberance | 8 |
| 732 | 7' Uropod 2 peduncle without protuberance | 9 |
| 733 | | |
| 734 | 8(7) Uropod 2 endopodite of males with transformed apical spine, peduncle with dorsomedial | |
| 735 | comb-like spines | <i>M. uncispina</i> Notenboom, 1988 |
| 736 | 8'. Uropod 2 endopodite of males without transformed apical spine, peduncle without | |
| 737 | dorsomedial comb-like spine..... | <i>M. tavaresi</i> (Mateus & Mateus, 1972) |
| 738 | | |
| 739 | 9(7') Lobe of telson with spines along both margins | 10 |
| 740 | 9' Lobe of telson without spine along outer margin | <i>M. minuta</i> Ruffo, 1947 |
| 741 | | |
| 742 | 10(9) Maxilla 1 inner lobe long reaching the basis of spines of outer lobe, distally prominent | |
| 743 | ..... | <i>M. adriatica</i> Pesce, 1979 |
| 744 | 10' Maxilla 1 inner lobe short never reaching the basis of spines of outer lobe | |
| 745 | ..... | <i>M. helladis</i> Pesce, 1980 |
| 746 | | |
| 747 | Key to Metacrangonyctidae genera and species | |
| 748 | 1 Gnathopod 2 propodus not modified, palm slightly convex; gnathopod 1 merus without brush; | |
| 749 | coxae 1-3 sub-equal and longer than coxae 4-5 | 2 (Genus <i>Metacrangonyx</i>) |
| 750 | [peri-Mediterranean] | |
| 751 | 1' Gnathopod 2 propodus modified in males, palm strongly concave; gnathopod 1 merus with | |
| 752 | many short setae forming a brush; coxae 1-5 decreasing progressively in length | |
| 753 | ..... | <i>Longipodacrangonyx</i> |
| 754 | (one species: <i>L. maroccanus</i> Boutin & Messouli, 1988) | |
| 755 | [Morocco] | |
| 756 | | |
| 757 | 2(1) Uropod 3 exopodite longer than peduncle, marginal spines present | 3 |
| 758 | 2' Uropod 3 exopodite equal or shorter than peduncle, marginal spines absent | 4 |
| 759 | | |
| 760 | 3(2) Uropod 1 peduncle basofacial robust setae present | |
| 761 | ..... | <i>M. spinicaudatus</i> Karaman & Pesce, 1980 |
| 762 | 3' Uropod 1 peduncle basofacial robust setae absent | <i>M. longicaudatus</i> Ruffo, 1954 |
| 763 | | |
| 764 | 4(2') Uropod 3 exopodite with several terminal robust setae | 5 |
| 765 | 4' Uropod 3 exopodite without one terminal robust seta | 7 |

| | | |
|-----|---|---|
| 766 | | |
| 767 | 5(4) Antenna 1 accessory flagellum with 2-3 articles | 6 |
| 768 | 5' Antenna 1 accessory flagellum with 5 articles | <i>M. longipes</i> Chevreux, 1909 |
| 769 | | |
| 770 | 6(5) Telson with distal spines | <i>M. remyi</i> Balazuc & Ruffo, 1953 |
| 771 | 6' Telson without apical spines | <i>M. knidiiri</i> Oulbaz et al., 1998 |
| 772 | | |
| 773 | 7(4') Uropod 1 peduncle basofacial robust setae present | 8 |
| 774 | 7' Uropod 1 peduncle basofacial robust setae absent | <i>M. ortali</i> G. Karaman 1989 |
| 775 | | |
| 776 | 8(7) Mandibular palp with 2 or 3 articles | 9 |
| 777 | 8' Mandibular palp with only one article | 10 |
| 778 | | |
| 779 | 9(8) Antenna 1 flagellum with only 10 articles in females (male unknown) | |
| 780 | ..... | <i>M. ilvanus</i> Stoch, 1997 |
| 781 | 9' Antenna 1 flagellum with 14 articles in females | <i>M. sinaicus</i> Ruffo, 1982 |
| 782 | | |
| 783 | 10(8') Antenna 1 flagellum with 11-14 articles | 11 |
| 784 | 10' Antenna 1 flagellum with more than 15 articles | 13 |
| 785 | | |
| 786 | 11(10) Uropode 3 endopodite present but reduce, scale-like | 12 |
| 787 | 11' Uropode 3 uniramous, endopodite absent | |
| 788 | ..... | <i>G. ruffoi</i> Messouli, Boutin & Coineau, 1991 |
| 789 | | |
| 790 | 12(11) Antenna 1 article 1 with 2 fines facial spines; uropod 3 peduncle with 1 or 2 spines and | |
| 791 | one seta on ventral margin | <i>M. aroudanensis</i> Messouli, Boutin & Coineau, 1991 |
| 792 | 12' Antenna 1 article 1 with 3 or 4 facial spines; uropod 3 peduncle with 2 spines and without | |
| 793 | seta on ventral margin | <i>M. gineti</i> Boutin & Messouli, 1988 |
| 794 | | |
| 795 | 13(10') Uropod 1 endopodite without baso-facial seta, telson with 2 apical setae clearly | |
| 796 | separated to each other, peduncle with one terminal seta | 14 |
| 797 | 13' Uropod 1 endopodite with a slender baso-facial seta, telson with 2 apical setae very close | |
| 798 | to each other | <i>M. panousei</i> Ruffo, 1953 |
| 799 | | |
| 800 | 14(13) Habitus stocky; antenna 2 peduncle article 1 with 2 sub-terminal spines; uropod 3 | |
| 801 | peduncle with 1-3 dorso-apical spines ; telson apex flat of slightly emarginate | |
| 802 | ..... | <i>M. delamarei</i> Messouli, Boutin & Coineau, 1991 |
| 803 | 14' Habitus slender; antenna 2 peduncle article 1 with 2 sub-terminal spines; uropod 3 peduncle | |
| 804 | with 1 dorso-apical spine; telson apex rounded | |
| 805 | ..... | <i>M. goulminensis</i> Messouli, Boutin & Coineau, 1991 |

806

807 **Key to Niphargidae genera**

- 808 1 Urosomite not enlarged, not carminate; uropod 3 biramous, outer ramus with one or 2 articles
809 2
- 810 1' Urosomite enlarged, dorsally carinate, hiding urosomites 2 and 3; uropod 3 very short, outer
811 ramus with 1 article, inner ramus absent *Carinurella*
812 (one species: *C. paradoxa* Sket, 1964)
813 [Italia, Slovenia]
814
- 815 2(1) Uropod 3 exopodite of one article 3
- 816 2' Uropod 3 exopodite of two articles 6
817
- 818 3(2) Uropod 3 exopodite very short, twice as long as its terminal spines; maxilla 1 palp with
819 one article 4
- 820 3' Uropod 3 exopodite long, several times longer than peduncle; maxilla 1 palp with 2 articles
821 *Haploglymus*
822 [Iberian Peninsula]
- 823
- 824 4(3) Mandibular palp with 3 noticeable articles 5
- 825 4' Mandibular palp very short, reduced to only one small article *Chaetoniphargus*
826 (one species: *C. lubuskensis* Karaman G.S. & Sket, 2019)
827 [Croatia]
- 828
- 829 5(4) Antenna 1 accessory flagellum with one article; mandibular palp article 3 with only
830 terminal E-setae; telson slightly cleft *Niphargobates*
831 (one species: *N. orophobata* Sket, 1981)
832 [Slovenia]
- 833 5' Antenna 1 accessory flagellum with two articles; mandibular palp article 3 with A, B, C, D
834 and E-setae; telson deeply cleft *Niphargobatoides*
835 (one species: *N. lefkodemonaki* (Sket, 1990))
836 [Crete Island]
- 837
- 838 6(2') Maxilliped palp article 4 with one, rarely 2 distal nails 7
- 839 6' Maxilliped palp article 4 with 3 distal nails *Exniphargus*
840 (one species: *E. tzanisi* G. Karaman, 2016)
841 [Crete Island]
- 842
- 843 7. Maxilliped inner and outer plate short and broad; maxilla 2 both plates are short and broad;
844 maxilla 1 inner plate very strong, broader than palpus, outer plate with 9-10 pectinate spines,
845 palp short, not exceeding basis of outer plate spines *Foroniphargus*
846 (one species: *F. pori* G. Karaman 1985)
847 [Israel]

848 7' Maxilliped inner and outer plate slender; maxilla 2 both plates are slender; maxilla 1 inner
849 plate is slender, narrowed distally, outer plate with 7-9 simple to pectinate spines, palp
850 longer, exceeding basis of outer plate spines *Niphargus*
851 [peri-mediterranean except North Africa]

852

853 **Key to Pontogammaridae**

854 1 Urosomites 1 et 2 with dorsal humps armed with apical spines (as in *Dikerogammarus*, but
855 differing from it by strongly setose margins of coxae 1-4 and pereopods 5-7 basis)
856 2 (genus : *Turcogammarus*)
857 [Greece, Turkey]

858 1' Urosomites 1 et 2 without dorsal elevations 3 (genus : *Pontogammarus*)
859 [Central Europe, Turkey]

860

861 2(1) Presence of a keel on the dorsum; telson lobes with setae longer than spines; antenna 1
862 peduncle with short setae, antenna 2 and pereopod 5-7 much less setose.... *T. spandli* (S.
863 Karaman 1931)

864 2' No keel on the dorsum; telson lobes with setae shorter than spines; antenna 2 peduncle with
865 some long setae; antenna 2 and pereopod 5-7 very setose *T. turcarum* (Stock, 1974)

866

867 3(1') Mandibular palp article 3 with 3 rows of setae type B and articles 2-3 with less and shorter
868 setae; urosomite 2 with spines 4

869 3' Mandibular palp article 3 with 5 rows of setae type B and articles 2-3 with very long and
870 numerous setae, much longer than the width of articles; Urosomite 2 without spines
871 *P. maeticus* (Sowinsky, 1894)

872

873 4(3) Urosomite 1 armed without setae only; coxae 1-4 and pereopods 3-5 bases with dense and
874 numerous long setae *P. aestuarius* (Derzhavin, 1924)

875 4' Urosomite 1 armed with spines and setae; coxae 1-4 and pereopods 3-5 bases with shorter
876 and less numerous setae *P. robustoides* (Sars, 1894)

877

878 **Key to Pseudoniphargidae genera**

879 1 Body compressed and strongly curved; head anterior lobe strongly developed; coxa 1
880 ventrally wide; uropod 3 short, exopodite slightly (1.5 times) longer than peduncle
881 *Parapseudoniphargus*
882 (one species: *P. baetis* Notenboom, 1988)
883 [Spain]

884

885 1' Body outspread; head anterior lobe weakly developed; coxa 1 sub-rectangular; uropod 3
886 long, exopodite much longer than peduncle, at least 3 times *Pseudoniphargus*
887 [Western Mediterranean Basin]

888

889 **Key to Salentinellidae genera and species**

| | | |
|-----|---|---|
| 890 | 1 Uropod 1 longer than uropod 2; epimeral plates 2-3 as long as wide; telson cleft, elongated | |
| 891 | ..... | 2 (genus: <i>Salentinella</i>) |
| 892 | [Western Mediterranean Basin] | |
| 893 | 1' Uropod 1 shorter than uropod 2; epimeral plates 2-3 elongated forming plates; telson uncleft | |
| 894 | with concave margins | <i>Parasalentinella</i> |
| 895 | (one species: <i>P. rouchi</i> Bou, 1971) | |
| 896 | [France] | |
| 897 | | |
| 898 | 2(1) Posterodistal lobe of pereopod 7 merus almost reaching end of carpus | 3 |
| 899 | 2' Posterodistal lobe of pereopod 7 merus not reaching beyond half the length of carpus | 4 |
| 900 | | |
| 901 | 3(2) Telson partially cleft | <i>S. sevilienis</i> Platvoet, 1987 |
| 902 | 3' Telson uncleft | <i>S. carracensis</i> Platvoet, 1987 |
| 903 | | |
| 904 | 4(3') Antennae 1 and 2 peduncles without distal spines; pleopod peduncles with coupling | |
| 905 | spines; telson longer than wide | 5 |
| 906 | 4' Antennae 1 and 2 peduncles with distal spines; pleopod peduncles without coupling spines; | |
| 907 | telson wider than long | <i>S. anae</i> Messouli, Coineau & Boutin, 2002 |
| 908 | | |
| 909 | 5(4) Urosomite 3 lengthened, about 1.5 times as long as high | 6 |
| 910 | 5' Urosomite 3 not lengthened, about as long as high | 7 |
| 911 | | |
| 912 | 6(5) Telson with dorsal setae implanted near apex of lobes | <i>S. petiti</i> Coine!au, 1968 |
| 913 | 6' Telson with dorsal setae not implanted near apex of lobe | <i>S. longicaudata</i> Platvoet, 1987 |
| 914 | | |
| 915 | 7(5') Telson deeply cleft over more than a half of lobes | 8 |
| 916 | 7' Telson not cleft over 1/3 of lobes | <i>S. delamarei</i> Coineau, 1962 |
| 917 | | |
| 918 | 8(7) Uropod 3 endopodite more than 15% of the exopodite | 9 |
| 919 | 8' Uropod 3 endopodite less than 15% of the exopodite | <i>S. meijersae</i> Platvoet, 1987 |
| 920 | | |
| 921 | 9(8) Uropod 1 peduncle without ventrodistal projection | 10 |
| 922 | 9' Uropod 1 peduncle with a strong ventrodistal projection | <i>S. cazemierae</i> Platvoet, 1987 |
| 923 | | |
| 924 | 10(9) Antenna 1 and 2 sub-equal in length, accessory flagellum shorter than the first peduncle | |
| 925 | article; Uropod 3 endopodite longer than a half of the exopodite, exopodite article 2 less | |
| 926 | developed | 11 |
| 927 | 10' Antenna 1 shorter than antenna 2, accessory flagellum longer than the first peduncle article; | |
| 928 | Uropod 3 endopodite shorter than a half of the exopodite, exopodite article 2 well developed | |
| 929 | ..... | <i>S. angelieri</i> Ruffo & Delamare Debutteville, 1952 |

- 930
 931 11(10) Uropod 3 short, endopodite equal or less than 2/3 of exopodite; gnathopod 2 propodus
 932 palm strongly convex asymmetrically (largest part at 1/3 of the palm) 12
 933 11' Uropod 3 slender, endopodite around 3/4 of exopodite; gnathopod 2 propodus palm convex
 934 symmetrically (largest part in the middle of the palm) *S. gracillima* Ruffo, 1947
 935
 936 12(11) Pereopod 4 dactylus shorter than a half of the propodus
 937 *S. formenterae* Platvoet, 1984
 938 12' pereopod 4 dactylus equal to a half of the propodus *S. gineti* Balazuc, 1957
 939

940 **Key to Typhlogammaridae genera and species**

- 941 1 Body not carinate; maxilla 1 palp symmetric; uropod 3 exopodite article 2 vestigial or absent
 942 2
 943 1' Body dorsally carinate, third mesosome segment and all metasome segments with one pair
 944 of dorso-lateral teeth each; maxilla 1 palp asymmetric (right maxilla different from the left
 945 one); uropod 3 exopodite article 2 ordinary *Metohia*
 946 (one species: *M. carinata* Absolon, 1927)
 947 [Balkans]
 948
 949 2(1) Antenna 2 gland cone shorter than article 3 of the peduncle; coxae 1-7 short diamond
 950 shaped or trapezoidal; uropod 3 longer, much exceeding the top of uropods 1-2
 951 *Typhlogammarus*
 952 (one species: *A. mrazeki* (Schäferna, 1907))
 953 [Balkans]
 954 2' Antenna 2 gland cone very long overreaching article 3 of the peduncle; coxae 1-7 elongated
 955 sub-rectangular; uropod 3 short, not exceeding the top of uropods 1-2 *Accubogammarus*
 956 (one species: *A. algor* (G. Karaman, 1973), subspecies not include in the key)
 957 [Balkans]
 958

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990 **3. Malacostraca: Bathynellacea**

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1000 **INTRODUCTION**

1001 Bathynellacea Chappuis, 1915 are obligate groundwater inhabitants (stygobionts) (limnic and oligo- to
1002 polyhaline waters) of all continents except Antarctica. Their interstitial life style would correlate with a
1003 decrease of the body size as well as with the reduction or loss of appendages and other organs (Coineau
1004 & Camacho 2013), these features may be interpreted as evidence of an evolutionary process involving
1005 progenesis (Schminke 1981a; Schram 1982).

1006 The origin of Bathynellacea could be pre-Pangean. They might have been highly diversified in the
1007 Paleozoic seas, especially during the Carboniferous period. Some of these ancestors may have colonized
1008 the continental subterranean freshwaters of the Pangea as early as in the Permian and Triassic periods,
1009 and also part of the Gondwana (Camacho *et al.*, 2018c) before the Pangea break up. Thereafter, the
1010 fragmentation of Laurasia and Gondwana during the Mesozoic period (Golonka 2007) led to the current
1011 disjunct distribution of syncarids (Schram, 1977), and induced their independent evolution on each
1012 landmass. All the genera belonging to Parabathynellidae Noodt, 1965 from peninsular India show a
1013 Gondwanan heritage (Ranga Reddy 2011, Bandari *et al.*, 2016). The most recent common ancestor of
1014 bathynellaceans can be dated back to the Triassic or Jurassic periods, as showed by our analysis
1015 (Camacho *et al.*, 2021).

1016 Their current distribution is important, because they are restricted to freshwaters from remote geological
1017 times. They are one of the oldest groups of freshwater fauna and have no marine relatives for future
1018 colonizations, so they serve as indicators of ancient connections between the continents. They are
1019 considered a very suitable group for zoogeography studies, as they are old enough phylogenetically
1020 speaking, their capacity for dispersal is severely limited, and even today they are represented by a high
1021 number of species distributed worldwide. They can provide information on possible dispersal routes in
1022 past and present geological periods.

1023

1024 **GENERAL ECOLOGY AND DISTRIBUTION**

1025 Bathynellacea exclusively live in groundwater sensu lato (caves, springs, wells and hyporrheic zones of
1026 rivers): they are interstitial stygobionts (they inhabit in the water filling the interstices between sand
1027 grains and gravels in sediments). Little is known about their life cycles. They live long, e.g.
1028 *Paraiberobathynella fagei* (Delamare Deboutteville & Angelier, 1950) can live up to two and a half
1029 years. Fertilization is internal, but copulation has not been observed; they are K-strategists, i.e. the
1030 female produces a single large egg that occupies almost its entire abdomen for almost nine months (in
1031 the few cases observed to date), deposits it on the substrate and a larva identical to the adult is
1032 immediately born but with only 3 or 4 pairs of legs, depending on the species. Metamorphosis takes
1033 place inside the egg. Due to the absence of a swimming larva, their ability to disperse is very low. The
1034 post-embryonic development or parazoeal phase (Schminke, 1981a) (= larval phase 1, Serban, 1985),
1035 which occurs after birth, consists of 8 to 11 stages marked by molts, depending on the species.

1036 They do not generally swim, except some species (e.g. Cho & Humphreys 2010 observed
1037 *Brevisomabathynella uramurdaliensis* swimming quite powerfully in an aquarium). They walk with

1038 their thoracopods. Some species show a swimming escape reaction. They touch the sand grains with
1039 their antennules, explore the interstices, resulting in discontinuous movements interrupted by frequent
1040 stops. Then they flex their pleon and leaning on their uropod and furca, they suddenly launch themselves
1041 forward, or change direction and move backwards. Thanks to their body flexibility, they can clean their
1042 antennae with the spines of their uropods and furca (personal observation). Their thigmotaxis will
1043 generally keep them in contact with the sandy sediment so that they can know their position (they are
1044 devoid of statocysts).

1045 They graze and scrape deposits from sediment grains and also eat protists, fungi and bacterial films.
1046 According to Serban (1980), Bathynellidae Grobben, 1905 comprise “filter and large food feeders”,
1047 whereas Parabathynellidae would be “large food feeders”. Some parabathynellids are carnivorous, eat
1048 harpacticoid copepods (*Iberobathynella* Schminke, 1973) or ostracods (*Brevisomabathynella*).
1049 Cannibalism has been observed by Morimoto (1970), who reported large specimens of *Allobathynella*
1050 Morimoto & Miura, 1957 preying on young ones (Schminke & Cho 2013).

1051 Bathynellacea are preyed upon by amphipods and subterranean fish.

1052 They live in freshwater, although some species have been found in brackish groundwater, near the sea
1053 coastline. They can be considered cold stenotherms, they do not usually survive above 20°C. However,
1054 the genus *Thermobathynella* Capart, 1951 has been found in a hot spring (water at 55°C) and we found
1055 *Paraiberobathynella cf fagei* in the Sima de la Higuera (Murcia, Spain) living at 27°C.

1056 Bathynellacea have been found from Alaska (Camacho *et al.*, 2016b) to New Zealand (Schminke 1973)
1057 and their distribution is worldwide with high degrees of local endemic species (Camacho 2019) and
1058 cryptic species (Camacho *et al.*, 2011, 2012, 2018c). The order Bathynellacea is composed of three
1059 families (338 species and 89 genera) (Camacho *et al.*, 2021): Parabathynellidae, Bathynellidae and
1060 Leptobathynellidae Noodt, 1965. Parabathynellidae (210 species, 45 genera) are currently known in
1061 temperate to tropical zones in both hemispheres; Bathynellidae (110 species, 37 genera) are known
1062 mainly in temperate zones of the northern hemisphere and some areas of the southern hemisphere (they
1063 are very frequent in Australia); while Leptobathynellidae (18 species, 7 genera) are only known in South
1064 America (Brazil, Argentina, Paraguay and Chile), Africa (Ivory Coast and South Africa), California and
1065 India. Parabathynellidae are most frequently found in samples than members of the other two families
1066 are, perhaps due to their larger size and consistency. Furthermore, their study is easier not only because
1067 of their size, but also because their morphological variability is greater and therefore it is easier to
1068 discriminate between genera and species. All Leptobathynellidae species are very thin and fragile, their
1069 dissection is very difficult and their identification almost impossible; to date they are not known in the
1070 Mediterranean area, but perhaps they have gone unnoticed in the samples, or have escaped from the
1071 sampling nets or perhaps they live in areas without sampling coverage, but maybe they will be found
1072 one day. The same happened in India: as soon as the sampling effort intensified, three *Parvulobathynella*
1073 Schminke, 1973 species were found. The Bathynellidae family is characterized by its great homogeneity,
1074 so that it is very difficult to find characters that differentiate morphotypes. Large collections of
1075 specimens from this family collected all over the world have not yet been studied, because they are too
1076 difficult to identify. Morphological studies need to be supplemented with molecular data for researchers
1077 to discriminate species.

1078 Following the emergence of molecular studies, cryptic species are being discovered in the group, both
1079 in Europe and Australia, and show that diversity is even greater than suspected. To this we must add a
1080 significant unexplored and unsampled "underground aquatic world" (in caves and unconsolidated
1081 sediments), which will give many surprises.

1082 In the Mediterranean area in question, 71 species belonging to 20 genera are formally described: 36
1083 Parabathynellidae species (7 genera) and 35 Bathynellidae species (13 genera). The Iberian Peninsula is
1084 the area exhibiting the highest diversity: 41 species altogether, 30 Parabathynellidae species (5 genera)
1085 and 11 Bathynellidae species (5 genera). The *Iberobathynella* genus, with 22 species belonging to 3 sub-
1086 genera from the Iberian Peninsula, is one of the most diverse in the world, behind *Allobathynella* with
1087 25 species, and the cosmopolitan *Hexabathynella* Schminke, 1972 with 23 species distributed
1088 throughout the world (5 species in the area and four of them in the Iberian Peninsula) (Camacho, 2019).

1089 The greatest Bathynellidae diversity is found in France; thanks to the work of Serban, Coineau &
1090 Delamare Deboutteville (1971, 1972), 17 species (8 genera) are well known; however, only 3 species of
1091 the family Parabathynellidae live in France (several populations of *Parabathynella stygia* Chappuis,
1092 1926 (= *phreatica*), *Paraiberobathynella fagei* and *Hexabathynella knoepfflery* (Coineau, 1964) from
1093 Corsica). The other findings are sporadic: one species in Israel, one in Morocco, and one in southern
1094 Tunisia.

1095 All known species are short-range endemisms, as recent molecular studies revealed. Some species
1096 considered to be widely distributed in Spain, such as *Iberobathynella imuniensis* Camacho, 1987
1097 (inhabitant of the Cantabrian coast, from the Pyrenees to Galicia) and *Paraiberobathynella fagei*
1098 (described in France, in the Roussillon region, and believed to live throughout eastern Spain, in Andalusia
1099 and Mallorca), only live in the type locality and areas nearby, while the rest of the populations is surely
1100 composed of different cryptic species, morphologically indistinguishable from the type species.

1101 A small territory like the Iberian Peninsula is the most diverse area on Earth in terms of bathynellids.
1102 The Ojo Guareña Natural Monument (Burgos) (a karst complex with more than 110 km of
1103 development), where eight species of Bathynellacea have been found (4 are still undescribed: a new
1104 genus, two cryptic species of *Vejdovskybathynella edelweiss* and a cryptic species of *I. imuniensis*), is
1105 the most diverse place in the world and the biodiversity hotspot of the group (Camacho *et al.*, 2010).

1106

1107 TERMINOLOGY AND MORPHOLOGY

1108 Microscopic Malacostraca are 0.5-3.0 mm in length, sometimes up to 6.3 mm, e.g. *Billibathynella*
1109 *humphreysi* Cho, 2005. Eumalacostraca do not have a carapace and have biramous thoracopods. Their
1110 body is elongate and more or less straight (Fig. 7.5), worm-like and depigmented, female do not have a
1111 brood pouch. Eyes and statocysts are absent.

1112 Their body is divided into the: head, eight free thoracic segments with eight pairs of biramous
1113 thoracopods (thoracopod VIII is modified as a copulatory organ in the male and reduced in the female),
1114 five free abdominal segments without pleopods or with one or two uniramous pleopods and a pleotelson
1115 with biramous uropods and furcal rami with spines (Fig. 7.5).

1116 Head longer than wide, with a fine cephalic capsule (Fig. 7.5). Anterior part with a couple of antennules
1117 (A.I) (article with sexual dimorphism in some genera) and a pair of antennae (A.II) with a variable
1118 number of articles. The five mouth pieces are located ventrally: labrum (single piece), a pair of
1119 paragnathes (present in all Bathynellidae species and a few species of genera belonging to
1120 Parabathynellidae and Leptobathynellidae) (Camacho *et al.*, 2021), mandibles (Md), maxillules (Mx.I)
1121 and maxillae (Mx.II). (Fig. 7.5).

1122 The oral opening is located at the posterior end of the rostral third.

1123 Thorax (Fig. 7.5), with eight well-defined segments (ancestral structure); circular cross section of
1124 segments; diameter and length increasing towards the distal end. Eight pairs of thoracopods: the first
1125 seven ones are used for locomotion and the eighth one is transformed into a copulatory organ (penis) in
1126 males, and is greatly reduced (or even absent) in females. Limit between thorax and abdomen not very
1127 clear. Thoracopod I (Fig. 7.5) is the smallest, thoracopods II to IV or V increasing in length and the last
1128 ones of the same length. Biramous thoracopods (ThI, ThII... ThVII), with exopod (1-12 articles in
1129 Parabathynellidae, two in Leptobathynellidae, and one in Bathynellidae) and endopod (four articles in
1130 Parabathynellidae and Leptobathynellidae, and three or four articles in Bathynellidae) which can exhibit
1131 sexual dimorphism on the third article of Th VI (*Pacificabathynella* Schminke & Noodt, 1988 and
1132 *Paradoxibathynella* Serban, 2000) and on coxa of ThVII (*Altainella* Camacho, 2020); respiratory epipod
1133 (absent on ThI and sometimes on ThII and/or III), connected with coxa and basipod. Usually ctenidia
1134 present at the base of the setae on the exopod and along one of the articles on the endopod.

1135 ThVII absent in *Hexabathynella* and *Hexaiberobathynella*.

1136 Female ThVIII (Fig. 7.5) smaller than other legs. Very reduced in *Hexabathynella* and *Iberobathynella*
1137 (Fig. 7.5B), remains of articles indistinguishable. It is still possible to identify the articles in some
1138 Bathynellidae (Fig. 7.5A) genera, although they are always very reduced.

1139 Male ThVIII: massive, more or less rounded or curved; strongly modified but distinguishable articles
1140 (like lobes) of a typical leg. The terms used to designate each part are equivalent in the three families:
1141 a) protopod, penial complex and basipod; basal region, outer lobe, inner lobe and dentate lobe constitute
1142 the penial complex (these last 3 lobes are well distinguishable in Parabathynellidae (Fig. 7.5B)); genital
1143 opening located between the lobes; some setae usually on basipod; b) endopod, only one article and
1144 setae; c) exopod, only one article with some setae on ventral edge. Some structures such as basipod and
1145 penial complex are complicated in the Bathynellidae family (Fig. 7.5A).
1146 Five segments on abdomen and pleotelson with furcal rami and uropods (Fig. 7.5 Habitus). Sometimes
1147 vestigial pleopods on first and second segments. Setae smooth, barbed or plumose basidorsally or
1148 basiventrally present on pleotelson. Uropod lateral: sympod (with spines), exopod and endopod, with
1149 specific setation. Furcal rami (with spines) located on pleotelson lobes.
1150 Anus located in the terminal part of the pleotelson and covered by an operculum (anal operculum) in
1151 some Parabathynellidae species.
1152

1153 **COLLECTION, PREPARATION AND IDENTIFICATION**

1154 The specific methods for collecting samples depend on the specific habitat where the fauna is found in
1155 groundwater *sensu lato*. However, almost all of them are based on substrate removal and on filtration of
1156 the cloudy water with hand nets of *ad hoc* designs and a mesh size < 0.1mm.
1157 The aquatic environments sampled within caves are gours, puddles, pools, drips, lakes and underground
1158 rivers. Outside, springs, wells, boreholes, permanent cores (for example in mining surveys) that intersect
1159 aquifers and a hyporheic substratum (in lakes and rivers) are sampled. Bathynelids have recently been
1160 found in samples from the Mesovoid Shallow Substratum (MSS) of the Sierra de Guadarrama (Madrid,
1161 Spain) arranged for the collection of terrestrial fauna (Camacho & Ortuño, 2019). Therefore, sampling
1162 methods and devices are numerous and varied. A comprehensive compilation can be viewed at:
1163 *Sampling Manual for the Assessment of Regional Groundwater Biodiversity*, PASCALIS 2002 (Ed. by
1164 F. Malard, Associate editors: Dole-Olivier, M.-J., J. Mathieu & F. Stoch).
1165 Field samples can be kept alive in a refrigerator or frozen in absolute or 70% ethanol (this is a
1166 conservative liquid, but not a fixative one, so that the specimens deteriorate over time). In the case of
1167 living samples, it is convenient to wash and separate them as soon as possible. In this way, each type of
1168 fauna can be fixed in the most suitable fixative and according to the subsequent study you want to carry
1169 out. For morphological studies it is appropriate to use 4% formalin for 48 hours, while keeping the
1170 specimens in a refrigerator at 4°C. After washing, they can be prepared for dissection right away and
1171 assembled in permanent preparations (Perina & Camacho, 2016), or the entire specimens can be
1172 preserved in 70% ethanol for subsequent studies. Bathynelids have thin and fragile cuticles. If the
1173 specimens are to be preserved for long-term morphological studies, they must be fixed properly before
1174 being stored in the preservative liquid. When absolute or 70% ethanol is used for field samples, the
1175 specimens should also be washed and processed as soon as possible and thus be suitable for immediate
1176 molecular studies and short-term morphological studies as well. This way, the same specimen can and
1177 should be used for both studies: the abdomen for DNA extraction and the other parts for dissection and
1178 mounting in permanent preparations (after dipping in 4% formalin for 48 hours), with the same routine
1179 as in the previous case (Perina & Camacho, 2016). This procedure ensures that the sequenced genes
1180 correspond to a given morphotype. Samples frequently contain a mixture of species indistinguishable
1181 under the binocular microscope. If some specimens are used entirely for morphological studies and
1182 others are entirely destroyed by DNA extraction, it will be impossible to associate each gene sequence
1183 to a specific morphotype.
1184 Taxonomic identification and the description of new species require a complete morphological study of
1185 specimens, males and females if possible. Anatomical observations can be performed using an oil
1186 immersion lens (100× magnification) with an interference microscope equipped with a drawing tube.
1187 Photographs are not a substitute for drawings in taxonomic works but can complement them.

1188 Well-prepared permanent preparations ensure good preservation of the specimens in scientific
1189 collections. They guarantee their survival and availability, at least on the medium term just as well-
1190 preserved DNA extracts and DNA collections of public institutions ensure access to them for future
1191 scientific studies.

1192

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1196

1197

KEYS TO BATHYNELLACEA

1199

1200 **Key to Bathynellacea families**

1201 1 Lengthened powerfully cephalic capsule; AI with 6 or 7 articles; 6 to 8 articles in AII, directed forward
 1202 or perpendicular, with very well developed exopod (Fig. 7.5A); labrum with smooth distal free edge
 1203 (Fig. 7.6D); paragnathes present; Md, length/width= 3 (very long) (Fig. 7.6G), prehensile palp with 1
 1204 to 3 articles (Fig. 7.6H) in antero-ventral position, reduced *pars incisiva* (in antero medial part) and
 1205 typical lobe (plate like) of *pars molaris* absent; MxII not prehensile (Fig. 7.6K); exopod of thoracopods
 1206 with 1 article (Fig. 7.7A,B); male ThVIII remembers “a leg” (Fig. 7.6D); pleopods of 2 articles; 3 or
 1207 more oblique spine rows on sympod of uropod (Fig. 7.7F,H); dorsal seta on pleotelson
 1208 Bathynellidae (Fig. 7.5)

1209 2 Weakly elongated cephalic capsule; AI with 6 to 10 articles; 1 to 6 articles in AII, directed backwards,
 1210 without exopod (Fig. 7.6B); labrum with dentate distal free edge (Fig. 10.2.E); paragnathes absent or
 1211 rarely present; Md, length/width= 0.8 (high), with palp not prehensile of 1 article (Fig. 7.6I) in antero-
 1212 dorsal position, large *pars incisiva* (occupying entire distal part) and typical lobe (plate like) of *pars*
 1213 *molaris* present; MxII not prehensile (Fig. 7.6L); exopod of thoracopods multiarticled (Fig. 7.7C);
 1214 male ThVIII different of “a leg” (Fig. 7.7E); when present (rarely) pleopod reduced; 5 to 30 inner spine
 1215 row on sympod of uropod (Fig. 7.7G); ventral or dorso-lateral seta on pleotelson
 1216 Parabathynellidae (Fig. 7.6)

1217 3 Elongated cephalic capsule; AI with 6 articles; 5 to 7 articles in AII, directed backwards, with very
 1218 rudimentary exopod (Fig. 7.6C); labrum with poorly armed distal free edge (Fig. 7.6F); paragnathes
 1219 present; Md, length/width= 1.5 (long), palp not prehensile with 1 or 2 articles (Fig. 7.6J), in antero-
 1220 dorsal position, reduced *pars incisiva* (occupying antero-distal part) and typical lobe (plate like) of
 1221 *pars molaris* absent; MxII prehensile (Fig. 7.6M); exopod of thoracopods with 2 articles; male ThVIII
 1222 not remembering “a leg”; absent pleopods; 2 similar distal spines on sympod of uropod; no seta on
 1223 pleotelson Leptobathynellidae (Fig. 7.7)
 1224

1225 **Key to Bathynellidae sub-families**

1226

1227 1 Penial region of male ThVIII with 3 lobes; AI with 7 articles; AI >, = or < AII; 3 articles in mandibular
 1228 palp without sexual dimorphism; endopod of ThI to VII with 4 articles; female ThVIII with 1 article;
 1229 4 spines as minimum on sympod of uropod; 3-4 claws on endopod of uropod (Fig. 7.7H)
 1230 Bathynellinae

1231 1' Penial region of male ThVIII with 1 lobe; AI with 6 or 7 articles; AI > or = AII; 1 to 3 articles in
 1232 mandibular palp with or no sexual dimorphism; endopod of ThI to VII with 3 or 4 articles; endopod
 1233 of female ThVIII with 1 or 2 articles; 4 spines as maximum on sympod of uropod; 2-4 claws on
 1234 endopod of uropod (Fig. 7.7F) Gallobathynellinae

1235

1236 **Key to Bathynellinae genera**

1237 1 Six similar spines on sympod of uropod (Fig. 7.7I); 4 claws on endopod of uropod; 1st & 2^d spines of
 1238 furca the largest (Fig. 7.7J); mandibular palp without sexual dimorphism with 3 articles; 7 articles in
 1239 AII; AI=AII; seta on medial segment of exopod of AII; 4 articles in endopod of ThI to VII
 1240 *Bathynella*

1241 1' Four different spines on sympod of uropod (Fig. 7.7H); 3 claws on endopod of uropod; 2^d spines of
 1242 furca the largest (1.1 times 3th) (Fig. 7.7K); mandibular palp with sexual dimorphism and 3 articles; 7

1243 articles in AII; AI=AII; seta on medial segment of exopod of AII; 4 articles in endopod of ThI to VII
 1244 *Antrobathynella*
 1245 (one species: *A. stammeri* (Jakobi, 1954))
 1246 [Slovenia]

1247

1248 **Key to Gallobathynellinae genera**

1249 1 AI with 6 articles; AII with 6 or 7 articles; AI>AII; Md palp with 3 articles without sexual dimorphism;
 1250 ThI endopod with 4 articles 2

1251 1' AI with 7 articles; 7 or 8 articles in AII; AI>, < or =AII; Md palp of 3 articles, with or without sexual
 1252 dimorphism; ThI endopod with 3 or 4 articles 4
 1253

1254 2(1) AI with 6 articles; medial seta absent on exopod of AII; 3 articles on Md palp; ThI endopod of 4
 1255 articles; ThII to V endopod with 3 articles and ThVI-VII endopod with 3 or 4 articles; female ThVIII
 1256 of 1 simplified article, without epipod 3

1257 2' AII with 7 articles; medial seta present on AII exopod; Md palp of 3 articles; endopod ThI to VII with
 1258 4 articles; large female ThVIII epipod with 2 articles *Parameridiobathynella*
 1259 (one species: *P. gardensis* Serban & Leclerc, 1984
 1260 [France: Gard]

1261

1262 3(2) ThII to VII with 3 articles; 5 spines on furca, the second longest *Meridiobathynella*

1263 3' ThII to V endopod with 3 articles; ThVI-VII endopod with 4 articles; 5 spines on furca, the second
 1264 very, very long *Hispanobathynella*
 1265 (one species: *H. catalanensis* (Serban, Coineau & Delamare Deboutteville, 1971))
 1266 [Spain: Gerona]

1267

1268 4(1) AI with 7 articles; AII with 7 articles; AI> or =AII; Md palp sexually dimorphic with 3 articles;
 1269 ThI-V four-segmented endopod 5

1270 4' AI with 7 articles; AII with 7 or 8 articles; AI>, < or =AII; Md palp sexually or not dimorphic with 1
 1271 to 3 articles; ThI-VII endopod with 4 articles or ThI to V endopod with 3 articles 6
 1272

1273 5(4) ThI-VII with 4 articles on endopod; epipod present on female ThVIII; 4 spines on sympod and 2
 1274 claws on endopod of uropod; 5 spines of different size on furca
 1275 *Vejdovskybathynella*

1276 5' ThI-V endopod with 4 articles and ThVI and VII endopod with 3 articles; female ThVIII without
 1277 epipod; 3 spines on sympod and 4 claws on endopod of uropod; 5 spines of similar size on furca
 1278 *Sardobathynella*
 1279 (one species: *S. cottarelli* Serban, 1973)
 1280 [Italy: Sardinia]
 1281

1282 6(4') AI with 7 articles; AII with 7 or 8 articles; ThI to V endopod with 3 articles; 1 to 3 articles on Md
 1283 palp (dimorphic or not)
 1284 7

| | | |
|------|--|----------------------------|
| 1285 | 6' AI with 7 articles; AII with 8 articles; ThI-VII endopod with 4 articles; Md palp sexually dimorphic | |
| 1286 | with 3 articles | 10 |
| 1287 | | |
| 1288 | 7(6) AI with 7 articles; AII with 7 articles; AI=AII; Md palp with 2 articles; well developed endopod | |
| 1289 | and exopod of female ThVIII; 4 spines on sympod and 2 claws on endopod of uropod; 5 spines of | |
| 1290 | different size on furca | <i>Clamousella</i> |
| 1291 | (one species: <i>C. delayi</i> (Serban, Coineau & Delamare Deboutteville, 1971)) | |
| 1292 | [France: Hérault] | |
| 1293 | 7' AI with 7 articles; AII with 8 articles; AI> or < AII; Md palp with 1 to 3 articles; endopod and exopod | |
| 1294 | of female ThVIII well developed or endopod absent; 3 or 4 spines on sympod and 2 or 3 claws on | |
| 1295 | endopod of uropod; 5 spines of similar or different size on furca | 8 |
| 1296 | | |
| 1297 | 8(7) AI>AII; medial seta of AII exopod absent or present; Md palp with 2 or 3 articles; female ThVIII | |
| 1298 | with well developed endopod and exopod; 4 spines on sympod and two or three claws on endopod of | |
| 1299 | uropod; 5 spines of similar or different size on furca | 9 |
| 1300 | 8' AI<AII; medial seta of exopod of AII present; Md palp of 1 article; endopod and exopod of female | |
| 1301 | ThVIII absent; 3 spines on sympod and 2 claws on endopod of uropod; 5 spines of similar size on | |
| 1302 | furca | <i>Vandelibathynella</i> |
| 1303 | (one species: <i>V. vandeli</i> (Delamare Deboutteville & Chappuis, 1954)) | |
| 1304 | [France: Ariège] | |
| 1305 | | |
| 1306 | 9(8) Medial seta of exopod of AII absent; Md palp not dimorphic with 2 or 3 articles; female ThVIII | |
| 1307 | with large endopod and exopod; 4 spines on sympod and 2 or 3 claws on endopod of uropod; 5 spines | |
| 1308 | of similar or different size on furca | <i>Gallobathynella</i> |
| 1309 | 9' Medial seta of exopod of AII present; Md palp dimorphic or not, with 3 articles; very small endopod | |
| 1310 | of female ThVIII; 4 spines on sympod and 2 claws on endopod of uropod; 5 spines of similar size on | |
| 1311 | furca | <i>Paradoxiclamousella</i> |
| 1312 | | |
| 1313 | 10(6) Medial seta of exopod of AII present; sexual dimorphism on mandibular palp; very short basipodal | |
| 1314 | seta and well developed endopod and exopod of female ThVIII; 3 or 4 spines on sympod and 4 claws | |
| 1315 | on endopod of uropod | <i>Pseudobathynella</i> |
| 1316 | (one species: <i>Ps. magniezi</i> (Serban, Coineau & Delamare Deboutteville, 1972)) | |
| 1317 | [France: Allier] | |
| 1318 | 10' Medial seta of exopod of AII absent; sexual dimorphism on labrum and mandibular palp; <i>pars</i> | |
| 1319 | <i>molaris</i> of Md with complex morphology; very long basipodal seta and well developed endopod and | |
| 1320 | exopod on female ThVIII; 4 spines on sympod and 2 claws on endopod of uropod | |
| 1321 | ..... | <i>Delamareibathynella</i> |

1322

1323 **Key to species of *Delamareibathynella***

| | | |
|------|---|---------------------------------------|
| 1324 | 1 One dentate lobe on <i>pars molaris</i> of Md | <i>D. debouttevillei</i> Serban, 1989 |
| 1325 | [France: Ardèche] | |
| 1326 | 1' Two dentate lobes on <i>pars molaris</i> of Md | <i>D. motasi</i> Serban, 1992 |
| 1327 | [France: Allier] | |
| 1328 | | |

1329

Key to species of *Gallobathynella*

1330 1 Three or 4 teeth on *pars molaris* of Md 2

1331 1' Two teeth on *pars molaris* of Md *G. hispanica* (Delamare Deboutteville, 1954)
1332 [Spain: Tarragona]

1333
1334 2(1) *Pars molaris* of Md with 3 teeth and 2 setae on mandibular palp of Md; 2 claws and 3 or 4 setae on
1335 endopod and 3 or 4 setae on exopod of uropod 3

1336 2' *Pars molaris* with 4 teeth and 3 setae on mandibular palp of Md; 2 claws and 4 setae on endopod
1337 and 2 setae on exopod of uropod; second spine three times longer than first spine which is twice as
1338 long as dorsal spine and similar to fourth of furca
1339 *G. juberthie* Serban, Coineau & Delamare Deboutteville, 1971
1340 [France: Pyrénées-Orientales]

1341
1342 3(2) Similar 3 or 4 spines on sympod of uropod; 3 setae on exopod of uropod; epipod longer than basipod
1343 of female ThVIII 4

1344 3' Uropod sympod with 4 spines, first the longest; 4 setae on exopod of uropod; epipod as long as
1345 basipod and exopod similar to endopod of female ThVIII; second spine 2.5 times longer than first
1346 spine which is as long as dorsal and fourth spines of furca
1347 *G. boui* Serban, Coineau & Delamare Deboutteville, 1971
1348 [France: Hérault]

1349
1350 4(3) Three spines on sympod of uropod; 4 setae on endopod of uropod; longer than basipod seta of the
1351 coxopod and exopod >> than endopod of female ThVIII; very small endopod of male ThVIII; second
1352 spine 4 times longer than first spine which is as long as dorsal spine of furca
1353 *G. coiffaiti* (Delamare Deboutteville, 1961)
1354 [France: Hérault]

1355 4' Four spines on sympod of uropod; 3 setae on endopod of uropod; no seta on coxopod and exopod >
1356 than endopod of female ThVIII; distal mamill on frontal projection of basipod and small endopod of
1357 male ThVIII; second spine almost as long as first spine which is longer than third and fourth, similar
1358 length of dorsal spine of furca *G. tarissei* Serban, Coineau & Delamare Deboutteville, 1971
1359 [France: Aude]

1360

1361 **Key to species of *Paradoxyclamourella***

1362 1 Barbed terminal claws of Md palp; two barbed setae on basipod of ThI-II; 12 setae on endopod of ThI;
1363 4 setae on third article of endopod of ThII to IV; 5 setae on exopod of ThI to VII; almost square
1364 basipod of male ThVIII without seta; epipod and coxal seta smaller than basipod of female ThVIII;
1365 exopod as long as basipod of female ThVIII; 2 setae on endopod of female ThVIII (Fig. 7.7L); 6 setae
1366 on pleopod; third spines twice as long as the first and second on furca
1367 *P. pirata* Camacho, Dorda & Rey, 2013
1368 [Spain: Cantabria]

1369 1' Smooth terminal claws (very long on male) of Md palp; 2 smooth setae on basipod of ThI-II; 10 setae
1370 on endopod of ThI; ThII to IV endopod with 3 setae on third article; ThI to VII exopod with 4 setae;
1371 rectangular basipod of male ThVIII with one seta; epipod and coxal seta longer than basipod of female
1372 ThVIII; exopod as long half basipod of female ThVIII; one seta on very small endopod of female
1373 ThVIII (Fig. 7.7M); 5 setae on pleopod; third spines slightly longer than others of furca
1374 *P. fideli* Camacho, Dorda & Rey, 2013

1375 [Spain: Asturias]
1376

1377 **Key to species of *Vejdovskybathynella***

1378 1 Fifth article without setae and 1 or 2 setae on second article of AII; medial seta of exopod of AII absent
1379 or present; no or 1 seta on first article and 1 or 2 setae on second article of ThIV endopod; very large,
1380 large or small frontal projection with spur on basipod of male ThVIII; 3 or 4 spines on sympod and 2
1381 or 3 claws on endopod of uropod; furca with second spine longer than first 2

1382 1' Second article of AII without setae and one seta on fifth article; medial seta of AII exopod absent; 2
1383 setae on first and second articles of endopod of ThII to IV; very large, frontal projection without spur
1384 on basipod of male ThVIII; 4 spines on sympod and 2 claws on endopod of uropod; second spine twice
1385 as long as the first on furca *V. leclerci* Serban, 1989
1386 [France: Ardèche]
1387

1388 2(1) One seta on second article of AII; medial seta of exopod of AII absent or present; ThIII to V
1389 endopod with 3 setae on fourth article; dorsal spine as long as first spine and second spine four times
1390 as long as the first on furca 3

1391 2' Two setae on second article of AII; medial seta of exopod of AII absent or present; ThI to IV endopod
1392 with 4 setae on fourth article; dorsal spine > or < than first spine and second spine 1.5, 2.0 or 2.5 times
1393 as long as the first on furca 5
1394

1395 3(2) AII exopod with medial seta; exopod > endopod of female ThVIII; large endopod of male ThVIII;
1396 5 or 7 setae on pleopod; 4 similar spines on sympod of uropod; 2 claws on endopod of uropod 4
1397

1398 3' AII exopod without medial seta; exopod >> endopod of female ThVIII; small endopod of male
1399 ThVIII; six setae on pleopod; uropod sympod with distal spines longer than other three spines; 3 claws
1400 on endopod of uropod *V. caroloi* Camacho, 2007
1401 [Spain: Cantabria]

1402 4(3) Very large frontal projection of basipod of male ThVIII; exopod of male ThVIII four times longer
1403 than wide; 5 setae on pleopod *V. balazuci* Serban & Leclerc, 1984
1404 [France: Ardèche]

1405 4' Male ThVIII basipod with large frontal projection; exopod of male ThVIII three times longer than
1406 wide; 7 setae on pleopod *V. espattyensis* Serban & Leclerc, 1984
1407 [France: Ardèche]
1408

1409 5(2') AII exopod with or without medial seta; Md palp with sexual dimorphism; exopod = or >> endopod
1410 of female ThVIII; male ThVIII with small outer protuberance; male ThVIII exopod two or three times
1411 longer than wide; 4 spines on sympod and 2 or 3 claws on endopod of uropod; dorsal spine > than first
1412 spine of furca 6

1413 5' AII exopod with medial seta; Md palp without sexual dimorphism; exopod < endopod of female
1414 ThVIII; male ThVIII with medium sized outer protuberance; exopod of male ThVIII four times longer
1415 than wide; 3 similar spines on sympod and 2 claws on endopod of uropod; dorsal spine < than first
1416 spine of furca *V. vasconica* Camacho, Dorda & Rey, 2013
1417 [Spain: Vizcaya]

1418
1419 6 (5) Fourth article of AII with one seta and no seta on first article; AII exopod with medial seta; exopod
1420 = endopod of female ThVIII; male ThVIII with small frontal projection on basipod and large endopod;

- 1421 exopod of male ThVIII two times longer than wide; 4 similar spines on sympod and 3 claws on
 1422 endopod of uropod *V. edelweiss* Camacho, 2007
 1423 [Spain: Burgos]
- 1424 6' Fourth article of AII with two setae and one seta on first article; AII exopod without medial seta;
 1425 exopod >> endopod of female ThVIII; male ThVIII with large frontal projection on basipod and very
 1426 large endopod; exopod of male ThVIII three times longer than wide; 4 different spines (the basal
 1427 smallest) on sympod and 2 claws on endopod of uropod *V. pascalis* Camacho, 2007
 1428 [Spain: Cantabria]

1429

1430 **Key to Parabathynellidae genera**

- 1431 1 Six pairs of thoracopods 2
 1432 1' Seven pairs of thoracopods 3
- 1433
 1434 2(1) AI with 6 articles; AII with 5 articles (Fig. 7.8A) *Hexabathynella*
 1435 2' AI with 7 articles; AII with 3 articles (Fig. 7.8B) *Hexaiberobathynella*
- 1436
 1437 3(1) AI with 6 or 7 articles; AII with 4 or 5 articles (Fig. 7.8C) 4
 1438 3' AI with 6 or 7 articles; AII with 3 articles (Fig. 7.8D) 5
 1439
- 1440 4(3) AI with 6 articles; AII with 5 articles (Fig. 7.8C); Furca with 3 spines (Fig. 7.8E)
 1441 *Cteniobathynella*
 1442 (one species: *Ct. Calmani* (Por, 1968))
 1443 [Israel: Tiberias Lake]
- 1444 4' AI with 7 articles; AII with 4 or 5 articles; furca with 5 or 6 spines (Fig. 7.8F) *Parabathynella*
- 1445
 1446 5(3') AI with 6 or 7 articles; 2 articles on exopod of ThII to V 6
 1447 5' AI with 7 articles; 3 or 4 articles on exopod of ThII to V *Paraiberobathynella*
- 1448
 1449 6(5) AI with 6 or 7 articles; labrum with hook-like teeth (Fig. 7.8G); claws very curved on distal endite
 1450 of MxI (Fig. 7.8I) *Guadalobathynella*
 1451 (one species: *G. puchi* Camacho & Serban, 1998)
 1452 [Spain: Teruel]
- 1453 6' AI with 7 articles; labrum with "normal teeth" (Fig. 7.8H); "normal claws" on distal endite of MxI
 1454 (Fig. 7.8J) *Iberobathynella*

1455

1456 **Key to species of *Hexabathynella***

- 1457 1 Md *pars molaris* with 5 or 6 teeth; 4 teeth on distal endite of Mx; 1 or 2 setae on first article of MxII;
 1458 article fourth of ThI endopod with 2 or 3 setae; first pleopod absent or present; uropod inhomonomous
 1459 or homonomous with 3 to 7 spines on sympod; uropod with 3 or 4 setae on exopod and 2 or 3 on
 1460 endopod; 3 or 9 to 13 spines on furca 2
- 1461 1' Md *pars molaris* with 4 teeth; distal endite of Mx with 5 teeth; one setae on first article of MxII;
 1462 fourth article of ThI endopod with 3 setae; first pleopod present; 2 spines on sympod of inhomonomous
 1463 uropod; uropod with 2 setae on exopod and 2 on endopod; 6-7 spines on furca

- 1464 *H. knoeffleri* (Coineau, 1964)
 1465 [France: Corsica]
- 1466
 1467 2(1) *Md pars molaris* with 5 or 6 teeth; 2 setae on first article of MxII; fourth article of ThI endopod
 1468 with 2 setae; first pleopod absent or present; 6 or 7 spines on inhomonomous or homonomous sympod
 1469 of uropod; 3 spines on furca 3
- 1470 2' *Md pars molaris* with 5 teeth; 1 setae on first article of MxII; fourth article of ThI endopod with three
 1471 setae; first pleopod present; 3 spines on inhomonomous sympod of uropod; 3 setae on exopod and 3
 1472 on endopod of uropod; 9 to 13 spines on furca..... *H. minuta* (Noodt & Galhano, 1969)
 1473 [Portugal: Barça. Spain: Sevilla]
- 1474
 1475 3(2) Fourth article of AII without seta or 1 seta; *Md pars molaris* with 5 teeth; first pleopod absent;
 1476 sympod of uropod inhomonomous 4
- 1477 3' Fourth article of AII with 2 setae; *Md pars molaris* with 6 teeth; first pleopod present; sympod of
 1478 uropod homonomous; 3 setae on exopod and 2 on endopod of uropod
 1479 *H. sevillaensis* Camacho, 2003
 1480 [Spain: Sevilla]
- 1481
 1482 4(3) Fourth article of AII with 1 seta; distal spine of *Md* not modified; second article of MxII with 3
 1483 setae; 4 setae on exopod and 3 on endopod of uropod *H. valdecasasi* Camacho, 2003
 1484 [Spain: Toledo]
- 1485 4' Fourth segment of AII without seta; distal spine of *Md* modified; second segment of MxII with 4
 1486 setae; 3 setae on exopod and 2 on endopod of uropod *H. nicoleiana* Camacho, 1986
 1487 [Spain: Madrid, Guadalajara]

1488
 1489 **Key to species of *Hexaiberobathynella***

- 1490 1 Mandibular palp not exceeding distal part of *Md pars incisiva*; 1 tooth on female ThVIII (Fig. 7.8K);
 1491 5 to 8 spines on sympod of uropod; 5 to 8 spines on furca *Hi. mateusi* (Galhano, 1967)
 1492 [Portugal: Coimbra, Barcelos. Spain: Castellón, Granada, Guadalajara, Huesca, Jaén, Madrid, Soria,
 1493 Teruel, Toledo]
- 1494 1' Mandibular palp exceeding distal part of *Md pars incisiva*; 3 teeth on female ThVIII (Fig. 7.8L); 10
 1495 to 13 spines on sympod of the uropod; 8 to 10 spines on furca
 1496 *Hi. hortezuelensis* Camacho & Serban, 1998
 1497 [Spain: Soria]

1498
 1499 **Key to species of *Parabathynella***

- 1500 1 AII with 5 articles; 9 teeth on labrum; 5 teeth on distal endite of MxI; 1 seta on first article of MxII; 2
 1501 setae on second and third articles of endopod of ThI; 5 spines on furca
 1502 *P. motasi* Dancau & Serban, 1973
 1503 [Slovenia]
- 1504 1' AII with 4 articles; 12 teeth on labrum; 6 teeth on distal endite of MxI; 2 setae on first article of MxII;
 1505 3 setae on second and 1 on third article of ThI endopod; 6 spines on furca
 1506 *P. stygia* Chappuis, 1926
 1507 [Slovenia]

1508

1509

Key to species of *Paraiberobathynella*

1510 1 Labrum with 8 main teeth; Md *pars incisiva* with 6 to 8 teeth; Md *pars molaris* with 6 to 11 teeth;
1511 inhomonomous sympod of the uropod; 7 or 8 spines on furca; exopod of ThI with 2 or 3 articles... 2

1512 1' Labrum with 9 to 11 teeth; Md *pars incisiva* with 5 to 9 teeth; Md *pars molaris* with 12 teeth;
1513 homonomous sympod of the uropod; 8 to 12 spines on furca; exopod of ThI, II, VI and VII with 3
1514 articles (Fig. 7.7C), and ThIII to V with 4 articles *Pi. notenboomi* (Camacho, 1989)
1515 [Spain: Alicante]

1516

1517 2(1) Exopod of ThI, II and VI with 3 articles and 4 on ThIII to VI
1518 *Pi. fagei* (Delamare Deboutteville & Angelier, 1950)
1519 [France: Le Boulou. Spain: Alicante, Almería, Asturias, Cádiz, Castellón, Gerona, Granada, Huesca,
1520 León, Lérida, Málaga, Mallorca, Murcia, Navarra, Orense, Teruel, Valencia]

1521 2' Exopod of ThI with 2 articles and 3 on ThIII to VII
1522 *Pi. maghrebensis* (Boutin & Coineau, 1987)
1523 [Morocco: Marrakech, Nador]

1524

1525

Key to species of *Iberobathynella*

1526 1 Distal endite of MxI with 7 teeth (Fig. 7.8J); 0 or 1 seta on first article on MxII; 1 or 2 articles on
1527 exopod of ThI; inhomonomous or homonomous sympod of the uropod 2

1528 1' Distal endite of MxI with 6 teeth (Fig. 7.8M); 0 or 1 seta on first article of MxII; 1 article on exopod
1529 of ThI; cuticle of female ThVIII smooth (Fig. 7.8N) or wrinkled (Fig. 7.8P); inhomonomous (Fig.
1530 7.8Q) sympod of the uropod *Iberobathynella* (*Asturibathynella*)

1531

1532 2(1) One seta on first article on MxII; 1 or 2 articles on exopod of ThI; cuticle of female ThVIII smooth
1533 or wrinkled 3

1534 2' Zero seta on first article of MxII; 1 article on exopod of ThI; cuticle of female ThVIII smooth
1535 *I. pedroi* Camacho, 2003
1536 [Portugal: Coimbra]

1537

1538 3(2) First article of ThII to VII endopod without dorsal seta; 2 setae on first article of ThII to VII exopod;
1539 2 or 3 setae on second article of ThI endopod; 1 or 2 articles on ThI exopod; cuticle of female ThVIII
1540 smooth (Fig. 7.8R) or wrinkled (Fig. 7.8S); (Fig. 7.8T) uropod sympod inhomonomous or
1541 homonomous; 4 to 6 setae on exopod and 0, 1 or 3 on endopod of uropod
1542 *Iberobathynella* (*Espanobathynella*)

1543 3' First article of ThII to VII endopod with 1 dorsal seta; 3 setae on first article of ThII to VII exopod;
1544 3 setae on second article of ThI endopod; ThI exopod with 2 articles; cuticle of female ThVIII smooth
1545 (Fig. 7.8U); uropod sympod homonomous (Fig. 7.8V); 4 to 8 setae on exopod and 3 on endopod of
1546 uropod *Iberobathynella* (*Iberobathynella*)

1547

1548

Key to species of *Iberobathynella* (*Asturibathynella*)

1549

1550 1 AI with 6 articles..... 2

| | | |
|------|---|---|
| 1551 | 1' AI with 7 articles | 3 |
| 1552 | | |
| 1553 | 2(1) First article of MxII with 1 seta; first article of ThI endopod with 2 setae; cuticle of female ThVIII | |
| 1554 | smooth; 5 spines on sympod of uropod; 5 setae on exopod and 3 on endopod of uropod | |
| 1555 | <i>I. (A) celiانا</i> Camacho, 2003 | |
| 1556 | [Spain: Sevilla] | |
| 1557 | 2' First article of MxII without seta; first article of ThI endopod with 1 seta; cuticle of female ThVIII | |
| 1558 | wrinkled; 9 spines on sympod of uropod; 4 setae on exopod and 2 on endopod of uropod | |
| 1559 | <i>I. (A) guarenensis</i> Camacho, 2003 | |
| 1560 | [Spain: Burgos] | |
| 1561 | | |
| 1562 | 3(1') First article of MxII with 1 seta; first article of ThI endopod with 2 setae; cuticle of female ThVIII | |
| 1563 | smooth or wrinkled; anal operculum protuded or not | 4 |
| 1564 | 3' First article of MxII without seta; first article of ThI endopod with 1 or 2 setae; cuticle of female | |
| 1565 | ThVIII smooth or wrinkled; anal operculum protuded | 6 |
| 1566 | | |
| 1567 | 4(3) <i>Md pars molaris</i> with 7 teeth; <i>Md pars distales</i> with 6 or 7 teeth; cuticle of female ThVIII smooth | |
| 1568 | or wrinkled; 7 or 8 spines on sympod of uropod; 4 or 5 setae on exopod and 1 or 3 on endopod of | |
| 1569 | uropod; 6 to 10 spines on furca; anal operculum not protuded | 5 |
| 1570 | 4' <i>Md pars molaris</i> with 5 teeth; <i>Md pars distales</i> with 4 teeth; cuticle of female ThVIII smooth; 6 | |
| 1571 | spines on sympod of uropod; 5 setae on exopod and no seta on endopod of uropod; 5 spines on furca; | |
| 1572 | anal operculum protuded | <i>I. (A) cornejoensis</i> Camacho, 2005 |
| 1573 | [Spain: Burgos] | |
| 1574 | | |
| 1575 | 5(4) <i>Md pars distalis</i> with 7 teeth; cuticle of female ThVIII wrinkled; 7 spines on sympod of uropod; 4 | |
| 1576 | setae on exopod and 3 on endopod of uropod; 7 to 10 spines on furca | |
| 1577 | <i>I. (A) rouchi</i> Camacho & Coineau, 1987 | |
| 1578 | [Spain: Teruel, Huesca] | |
| 1579 | 5' <i>Md pars distalis</i> with 6 teeth; cuticle of female ThVIII smooth; 8 spines on sympod of uropod; 5 | |
| 1580 | setae on exopod and 1 on endopod of uropod; 6 or 7 spines on furca | |
| 1581 | <i>I. (A) imuniensis</i> Camacho, 1987 | |
| 1582 | [Spain: Álava, Asturias, Burgos, Cantabria, Huesca] | |
| 1583 | | |
| 1584 | 6(3') <i>Md pars molaris</i> with 6 to 7 teeth, <i>pars distalis</i> with 5 to 7 teeth; first article of ThI endopod with | |
| 1585 | 1 setae; cuticle of female ThVIII wrinkled or smooth; 5 to 9 spines on sympod of uropod; 3 or 4 setae | |
| 1586 | on exopod and 1 or 2 on endopod of uropod | 7 |
| 1587 | 6' <i>Md pars molaris</i> with 5 teeth, <i>pars distales</i> with 4 teeth; first article of ThI endopod with two setae; | |
| 1588 | cuticle of female ThVIII wrinkled; 9 or 10 spines on sympod of uropod; 4 setae on exopod and 2 on | |
| 1589 | endopod of uropod | <i>I. (A) parasturiensis</i> Camacho & Serban, 1998 |
| 1590 | [Spain: Asturias, Cantabria] | |
| 1591 | | |
| 1592 | 7(6) <i>Md pars molaris</i> with 7 teeth, <i>pars distalis</i> with 5 to 7 teeth; cuticle of female ThVIII smooth or | |
| 1593 | wrinkled; 5 to 7 spines on sympod of uropod; 3 or 4 setae on exopod and 2 on endopod of uropod | |
| 1594 | ..... | 8 |

- 1595 7' Md *pars molaris* with 6 teeth, *pars distalis* with 5 teeth; cuticle of female ThVIII smooth or wrinkled;
 1596 5 to 9 spines on sympod of uropod; 3 or 4 setae on exopod and one or two on endopod of uropod
 1597 9
- 1598
 1599 8(7) Cuticle of female ThVIII wrinkled; setules on distal end of inner lobe of male ThVIII present; 6 to
 1600 7 spines on sympod of uropod; 4 setae on exopod and 2 on endopod of uropod
 1601 *I. (A) asturiensis* Serban & Comas, 1978
 1602 [Spain: Asturias, Cantabria, León]
- 1603 8' Cuticle of female ThVIII smooth; distal part of inner lobe of male ThVIII without setules; 5 to 6
 1604 spines on sympod of uropod; 3 setae on exopod and 2 on endopod of uropod
 1605 *I. (A) cavadoensis* (Noodt & Galhano, 1969)
 1606 [Portugal: Barcelos. Spain: León, Pontevedra]
- 1607
 1608 9(7') Cuticle of female ThVIII smooth; 5 to 7 spines on sympod of uropod; 3 or 4 setae on exopod and
 1609 1 or 2 on endopod of uropod 10
- 1610 9' Cuticle of female ThVIII wrinkled; 9 spines on sympod of uropod; 4 setae on exopod and 2 on
 1611 endopod of uropod *I. (A) lamasonensis* Camacho, 2005
 1612 [Spain: Cantabria]
- 1613
 1614 10(9) Five spines on sympod of uropod; 4 setae on exopod and 2 on endopod of uropod
 1615 *I. (A) ortizi* Camacho, 1989
 1616 [Spain: Lugo]
- 1617 10' Seven spines on sympod of uropod; 3 setae on exopod and 1 on endopod of uropod
 1618 *I. (A) serbani* Camacho, 2003
 1619 [Portugal: Oporto]
- 1620
 1621 **Key to species of *Iberobathynella* (*Espanobathynella*)**
- 1622 1 ThII to VII exopod with 2 articles; ThI with 1 or 2 articles; ThI endopod with 2 or 3 setae on second
 1623 article; setules on distal part of inner lobe of male ThVIII present or absent; cuticle of female ThVIII
 1624 smooth or wrinkled; sympod of uropod inhomonomous or homonomous 2
- 1625 1' ThII, III and VI, VII exopod with 2 articles and ThIV and V exopod with 3 articles; ThI exopod with
 1626 2 articles; second article of ThI endopod with 3 setae; no setules on distal part of male ThVIII inner
 1627 lobe; cuticle of female ThVIII smooth; 12 or 13 spines on homonomous sympod, 6 setae on exopod
 1628 and 1 seta on endopod of uropod *I. (E) magna* Camacho & Serban, 1998
 1629 [Spain: Asturias, Cantabria]
- 1630
 1631 2(1) Uropod with sympod inhomonomous; 1 or 2 articles on exopod of ThI; 3 setae on second article of
 1632 ThI endopod; cuticle of female ThVIII smooth; anal operculum not pronounced 3
- 1633 2' Sympod of the uropod homonomous; 1 or 2 articles on exopod of ThI; second article of ThI endopod
 1634 with 2 setae; cuticle of female ThVIII smooth or wrinkled; anal operculum pronounced or not
 1635 4
- 1636
 1637 3(2) ThI exopod with 2 articles; setules on distal part of male ThVIII inner lobe present; 5 or 6 setae on
 1638 exopod and 1 seta on endopod of uropod; anal operculum not pronounced

- 1639 *I. (E) espaniensis* Serban & Comas, 1978
1640 [Spain: Asturias, Guadalajara]
- 1641 3' ThI exopod with 1 article; no setules on distal part of male ThVIII inner lobe; 5 setae on exopod and
1642 3 setae on endopod of uropod; anal operculum pronounced *I. (E) andalusica* Camacho, 2007
1643 [Spain: Córdoba, Sevilla]
- 1644
1645 4(2') ThI exopod with 1 article; cuticle of female ThVIII smooth; 7 to 9 spines on sympod, 5 setae on
1646 exopod and 1 seta on endopod of uropod *I. (E) cantabriensis* Camacho & Serban, 1998
1647 [Spain: Asturias, Cantabria]
- 1648 4' ThI exopod with 2 articles; cuticle of female ThVIII wrinkled; 10-12 spines on sympod, 4 setae on
1649 exopod and no seta on endopod of uropod *I. (E) burgalensis* Camacho, 2005
1650 [Spain: Burgos]
- 1651
1652
- 1653 **Key to species of *Iberobathynella* (*Iberobathynella*)**
- 1654 1 Md *pars incisiva* with 9 to 12 teeth, *pars molaris* with 6 to 16 teeth; 2 or 3 setae on first article of ThI
1655 exopod; 9 to 27 spines on sympod, 5 setae on exopod and 3 seta on endopod of uropod 2
- 1656 1' Md *pars incisiva* with 6 teeth, *pars molaris* with 10 teeth; 2 setae on first article of ThI exopod; 12 or
1657 13 spines on sympod, 6 to 8 setae on exopod and 3 setae on endopod of uropod
1658 *I. (I) valbonensis* (Noodt & Galhano, 1969)
1659 [Portugal: Areinho de Valbom, Spain: Salamanca]
- 1660
1661 2 (1) Md *pars incisiva* with 7 or 8 teeth, *pars molaris* with 6 to 10 teeth; 2 or 3 setae on first article of
1662 ThI exopod; 9 to 12 spines on sympod of uropod 3
- 1663 2' Md *pars incisiva* with 7 to 12 teeth, *pars molaris* with 8 to 16 teeth; 3 setae on first article of ThI
1664 exopod; 16 to 27 spines on sympod of uropod 4
1665
- 1666 3 (2) First article of ThI exopod with 2 setae; Md *pars incisiva* with 7 teeth, *pars molaris* with 6 to 8
1667 teeth; 9 to 12 spines on sympod of uropod; 9 to 13 spines on furca
1668 *I. (I) lusitanica* (Braga, 1949)
1669 [Portugal: Porto]
- 1670 3' First article of ThI exopod with 3 setae; Md *pars incisiva* with 7 or 8 teeth, *pars molaris* with 8 to 10
1671 teeth; 9 to 11 spines on sympod of uropod; 10 spines on furca
1672 *I. (I) barcelensis* (Galhano, 1970)
1673 [Portugal: Barcelos]
1674
- 1675 4 (2) First article of ThVI exopod with 3 setae; Md *pars incisiva* with 10 teeth, *pars molaris* with 8 to
1676 10 teeth; 16 to 19 spines on sympod of uropod; 6 or 7 spines on furca
1677 *I. (I) gracilipes* (Braga, 1960)
1678 [Portugal: Beira-Baixa]
- 1679 4' First article of ThVI exopod with 2 setae; Md *pars incisiva* with 9 to 12 teeth, *pars molaris* with 8 to
1680 16 teeth; 18 to 27 spines on sympod of uropod; 9 to 12 spines on furca
1681 *I. (I) paragrakilipes* Camacho & Serban, 1998
1682 [Spain: Huelva]

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1732 **4. Malacostraca: Decapoda**

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1737

1738 **INTRODUCTION**

1739 Decapoda Latreille 1802 is the most species-rich order within Malacostraca with nearly 15,000
1740 species (De Grave *et al.*, 2009). The order includes many familiar groups such as crabs, shrimps,
1741 crayfish, lobsters and hermit crabs that live in an impressive diversity of marine, freshwater,
1742 subterranean and terrestrial habitats. The majority of decapod species are found in marine
1743 habitats, whereas approximately 3,000 species live exclusively in freshwater habitats on almost
1744 all continents (Cumberlidge *et al.*, 2015). These include over 1,450 species of brachyuran crabs
1745 (Cumberlidge *et al.*, 2015), about 800 species and subspecies of caridean and sergestoid shrimps
1746 (De Grave *et al.*, 2015), around 669 species of crayfish (Crandall & De Grave, 2017) and 75
1747 species of anomuran crabs (Cumberlidge *et al.*, 2015; Bueno *et al.*, 2016).

1748 Freshwater crabs have a circumtropical distribution restricted to warm habitats covering five
1749 zoogeographical regions, from the Neotropical region to the Australasian region (Cumberlidge
1750 *et al.*, 2015). Evolutionary studies suggest that freshwater crabs diverged early in the
1751 brachyuran phylogenetic tree. They are thought to have at least two independent origins, with
1752 four of the five freshwater crab families sharing common ancestry (Klaus *et al.*, 2011; Tsang *et al.*,
1753 2014). Freshwater crabs are estimated to have diverged from their closest marine sister taxa
1754 after the break-up of Pangaea (~200 Mya), around 135 Mya (Tsang *et al.*, 2014). Although the
1755 origin of Mediterranean crabs (*Potamon* spp.) still remains unknown, their species diversity
1756 argues in favor of an East Asian origin (Jesse *et al.*, 2011). Freshwater crayfish and anomuran
1757 crabs are distributed in temperate parts of the two hemispheres (Cumberlidge *et al.*, 2015;
1758 Bueno *et al.*, 2016). The oldest crayfish fossils date back to the Permian and early Triassic
1759 periods, suggesting a widespread Pangaea distribution followed by a number of vicariance
1760 events that allowed the ancient crayfish population to diversify and spread throughout the
1761 continents of Laurasia and Gondwana (Crandall *et al.*, 2000; Cumberlidge *et al.*, 2015).
1762 Freshwater anomuran crabs, which mostly include *Aegla* species, seem to have a more recent
1763 origin – the early Tertiary period, about 60 Mya (Pérez-Losada *et al.*, 2004). Finally, freshwater
1764 shrimps occur in both tropical and temperate freshwater habitats. Phylogenetic studies have
1765 shown a distant affinity among freshwater shrimp families implying that each family
1766 independently invaded continental and subterranean waters from an ancestral marine stock at
1767 different times (De Grave *et al.*, 2008). The Mediterranean basin was colonized through
1768 multiple ancient transoceanic dispersal or vicariance events (von Rintelen *et al.*, 2012; Carvalho
1769 *et al.*, 2016).

1770 Three groups of freshwater decapods are found in the Mediterranean basin, namely crabs,
1771 shrimps, and crayfish. They belong to six families, 15 genera and 63 species (1 family, 3 genera
1772 and 3 species are non-native), representing about 2.1% of global diversity; most species are
1773 endemic to the region.

1774

1775 **GENERAL ECOLOGY AND DISTRIBUTION**

1776 Freshwater decapods successfully colonized a very diverse array of epigean and hypogean
1777 freshwater habitats reflected by a wide range of life histories as well as morphological and
1778 physiological adaptations. Because of their abundance and high biomass, they are integral
1779 components of food webs, represent a food source for a wide range of predators and play an
1780 important role in nutrient recycling in freshwater ecosystems (Cumberlidge *et al.*, 2015; De
1781 Grave *et al.*, 2015).

1782 A rich and highly endemic decapod fauna is found in the freshwater habitats of all
1783 countries and most islands of the Mediterranean basin (Jesse *et al.*, 2011; Kouba *et al.*, 2014;
1784 Christodoulou *et al.*, 2016). Their diversity comprises six families (15 genera, 63 species and
1785 subspecies) in this region. The freshwater crab family Potamidae (1 genus, 15 species) is found
1786 in the surface waters of North Africa and the eastern Mediterranean basin (Brandis *et al.*, 2000;
1787 Jesse *et al.*, 2011). Crayfish are represented in the Mediterranean basin by one native family –
1788 Astacidae (4 genera, 7 species) – and one non-native family – Cambaridae (2 genera, 2 species).
1789 Native crayfish species are distributed in the northern Mediterranean basin but are absent from
1790 continental North Africa (Kouba *et al.*, 2014; Cumberlidge *et al.*, 2015). The distribution of
1791 crayfish in the Mediterranean basin has been under great anthropogenic influence, resulting in
1792 three invasive species currently found in the western Mediterranean region, while numerous
1793 translocations of the native species took place across Europe (Kouba *et al.*, 2014). The largest
1794 shrimp family is Atyidae (6 genera, 26 species and subspecies) with representatives in epigean
1795 and subterranean systems throughout the Mediterranean basin (Christodoulou *et al.*, 2016),
1796 while Palaemonidae (1 genus, 9 species) are restricted to epigean systems throughout the basin
1797 (Christodoulou *et al.*, 2016). Both families occur in all biogeographical regions, except
1798 Antarctica, but are most diverse in the Indo-Malayan region where the majority of palaemonid
1799 species live in marine and brackish waters whereas Atyidae almost exclusively live in
1800 freshwater (De Grave *et al.*, 2015). The areas immediately surrounding the Mediterranean Sea
1801 harbour the world highest stygobiotic species diversity within Atyidae (16 species and
1802 subspecies) (Sket & Zakšek 2009; Christodoulou *et al.*, 2016). Finally, Typhlocarididae (1
1803 genus, 4 species) are strictly subterranean and are the only endemic decapod family in the basin
1804 (Christodoulou *et al.*, 2016), with species distributed in Israel, Italy and Libya.

1805

1806 **TERMINOLOGY AND MORPHOLOGY**

1807 Decapods exhibit a great variability in size and body form. Their size in freshwaters can vary
1808 from 1.0 cm for the bee shrimp (*Caridina cantonensis*) to more than 80 cm and 6 kg for some
1809 of the largest and heaviest freshwater invertebrates such as Tasmanian giant crayfish
1810 (*Astacopsis gouldi*). Mediterranean basin decapods are small- to medium-sized, from about 2
1811 cm (e.g. *Atyaephyra orientalis*) to about 20 cm (e.g. *Pontastacus leptodactylus*).

1812 The general decapod body is composed of a head, thorax, and abdomen (Fig. 7.9). The
1813 body is compressed laterally in shrimps, compressed dorsoventrally in crayfish, but strongly
1814 depressed and flattened in brachyuran crabs. The first three of the eight thoracic segments of
1815 shrimps, crayfish, and crabs are fused with the head to form a cephalothorax covered by a shield
1816 – the carapace that extends over the whole head and thorax. The carapace extends laterally
1817 along the sides of the cephalothorax forming branchial chambers that enclose the gills.

1818 The anterior part of the cephalothorax (head) carries a pair of compound stalked eyes,
1819 two pairs of antennae (antenna and antennula), and three pairs of mouth parts (mandible,
1820 maxillula, maxilla). The carapace of freshwater shrimps, crayfish and aeglids (not present in
1821 the Mediterranean basin) protrudes between the eyes and forms a rostrum, while it forms a front

1822 in freshwater crabs. The carapace can be ornamented with various spines, grooves and
1823 depressions. The first three abdominal segments bear three pairs of maxillipeds – specialized
1824 appendages for feeding and locomotion. The next abdominal segments bear five pairs of
1825 pereopods (ambulatory legs) modified either as walking legs or as chelate limbs (equipped
1826 with pinchers or setal brushes) termed chelipeds. In crayfish, the first three pairs of pereopods
1827 are chelate, while in caridean shrimps only the first two pairs are chelate and in brachyuran
1828 crabs only the first pair is chelate. The name of the group Decapoda (=ten legs) derives from
1829 the presence of ten pereopods. The pereopods have the typical biramous form of a crustacean
1830 limb composed from their proximal-most end to their distal-most end of a protopod with two
1831 podomeres (basis and coxa), an endopod with five podomeres (ischium, merus, carpus,
1832 propodus and dactylus), and an exopod that can be fully developed, vestigial or absent. A small
1833 process – the epipod – and multidenticulate setae – setobranch setae – can be present on coxae.
1834 The abdomen (pleon) follows the thorax. It is folded beneath the body in crabs, or extends
1835 posteriorly in shrimps and crayfish. Pleopods, modified for swimming, brooding eggs,
1836 ventilation and burrowing appendages extend in pairs from the first five abdominal segments.
1837 The abdomen terminates in a telson, with a uropod on each side. Both the pleopods and the
1838 uropods are biramous, composed of a basal peduncle bearing two branches – the endopod and
1839 the exopod. The first two pleopods are sexually modified in male decapods.

1840

1841 **COLLECTION, PREPARATION, AND IDENTIFICATION**

1842 Freshwater decapods are found in lotic, lentic, and subterranean environments. Different
1843 sampling methods are utilized depending on the species and the habitat. The freshwater shrimps
1844 that dwell in epigeal waters are usually collected using strong, long-handled, fine-meshed dip
1845 nets, while dredges, seine nets and sweep net electrofishing have also been reported as sampling
1846 techniques. In subterranean habitats, shrimps are caught with baited (e.g. with strips of raw
1847 beef) traps or by hand or with short hand nets and torchlight to illuminate the animals while
1848 scuba diving (Jaume & Brehier, 2005). Freshwater crayfish in shallow waters are collected by
1849 hand by turning rocks over. A dip net can be used in deeper waters while snorkeling or scuba
1850 diving, and seine nets or fyke nets can be used too. Finally, baited wire traps have proven
1851 especially efficient in deeper waters, especially at night. Crabs can be caught during the day by
1852 turning flat rocks over in rivers and streams. In deeper waters, baited traps or fyke nets can be
1853 used.

1854 After collection, shrimps, crayfish, and crabs should be preserved in 70% ethanol for
1855 morphological analyses and in 95% ethanol for molecular analyses. Mediterranean decapods
1856 can be identified under a stereomicroscope down to the genus level. However, determination at
1857 the species level most often requires dissection and mounting of the mouthparts and appendages
1858 on slides and examination using a microscope (10x-40x magnification). Specimens or body
1859 parts can be dyed using different stains or cleared by submersion in weak acid (HCl, chlorine).
1860 The morphological identification of shrimps at the species level requires adult individuals; as
1861 for freshwater crabs, only males can be identified at the species level. Key morphological
1862 characteristics include among others rostrum armature, mouthparts, male pleopods, gonopods,
1863 telson armature, and pereopod armature. Once the appendages are dissected, they are kept in
1864 smaller vials in the vial containing the specimen. It should be noted that many decapod species
1865 of the Mediterranean basin can only be identified with certainty by DNA barcoding (Sket &
1866 Zakšek 2009; Jesse *et al.*, 2011; Christodoulou *et al.*, 2016).

1867

1868 **LIMITATIONS**

1869 The taxonomy of freshwater decapods in the Mediterranean basin has been somewhat neglected
1870 in the past and has only recently grown more stable, as collections include more remote
1871 locations and molecular data are taken into account. Furthermore, high intra- and interspecific
1872 variability and sexual dimorphism complicate the morphological identification of decapods
1873 (Sket & Zakšek 2009; Jugovic *et al.*, 2010). Primary and secondary sexual characters in many
1874 decapods (Atyidae, Potamidae) are taxonomically important, but these characters are poorly
1875 developed in young animals (Sket & Zakšek, 2009; Jugovic *et al.*, 2010; Christodoulou *et al.*,
1876 2016). Moreover, reliable identification of many species requires examining adult males
1877 because characters of taxonomic value have not been observed so far in females (Brandis *et al.*,
1878 2000; Jugovic *et al.*, 2010). The current increased interest in Mediterranean epigean and
1879 hypogean decapods is based on more comprehensive sampling, molecular studies, and *a*
1880 *posteriori* examination of morphological characters that altogether improved taxonomy. Over
1881 the past two decades, the number of epigean freshwater shrimp species in the Mediterranean
1882 region has more than doubled, although controversies still remain about the precise number of
1883 species (e.g., *Atyaephyra* spp.), while new species may well still be awaiting discovery.
1884 Likewise, the number of troglobitic species has more than tripled, and more species are still
1885 awaiting description (Sket & Zakšek, 2009). Despite the increased interest in Mediterranean
1886 epigean and hypogean atyids and the new available methods, the taxonomy of these shrimps
1887 still remains unsettled.

1888 A number of Mediterranean decapods are cryptic species. Although they are genetically
1889 quite distinct, they appear morphologically identical to other species. Our keys can identify
1890 most species, but for some of them the key concludes to a species complex that molecular and
1891 geographical data can further distinguish. Finally, the keys are designed for Mediterranean
1892 freshwater decapods, they are not adapted for a global use.

1893

1894 **KEY TO DECAPODA**

1895

1896 **Key to Decapoda infraorders**

1897 1 Abdomen projecting posteriorly 2

1898 1' Abdomen folded beneath body, tightly pressed to thorax Brachyura, Potamidae

1899 [North Africa, Italian and Balkan Peninsulas, Middle East]

1900

1901 2(1) Abdomen laterally compressed; pleuron of second abdominal somite overlapping pleura
1902 of second and third somite Caridea

1903 [Mediterranean basin]

1904 2' Abdomen compressed dorsoventrally; pleuron of second somite not overlapping pleura of
1905 second and third somite Astacidea

1906 [Europe]

1907

1908 **Key to Potamidae genera and species**

| | | |
|------|--|--------------------------------------|
| 1909 | This <i>Potamon</i> key relies on the morphology of male first gonopod thus not suitable when only | |
| 1910 | female specimens are present (Brandis <i>et al.</i> 2000). The key includes a total number of 15 | |
| 1911 | species presented in Brandis <i>et al.</i> (2000) and Jesse <i>et al.</i> (2010, 2011). Four cryptic species | |
| 1912 | exist within the genus where no morphological characters have been found yet to distinguish | |
| 1913 | them and COI gene nucleic acid sequence differences are required to distinguish them to species | |
| 1914 | level (*). | |
| 1915 | | |
| 1916 | 1 Terminal article of first gonopod broad, more or less oval; mesial portion distinctly tumid; | |
| 1917 | apex long and slightly curve | 2 |
| 1918 | 1' Terminal article of first gonopod conical or slender; mesial part not tumid | 3 |
| 1919 | | |
| 1920 | 2(1) Flexible zone of first gonopod V-shaped | |
| 1921 | <i>Potamon fluviatile</i> (Herbst, 1785) species complex | |
| 1922 | (<i>Potamon fluviatile</i> , <i>Potamon pelops</i> *) | |
| 1923 | [Albania, Croatia, Greece, Italy, Macedonia, Malta, Montenegro] | |
| 1924 | 2' Flexible zone of first gonopod distinctly bilobed | <i>Potamon algeriense</i> Bott, 1967 |
| 1925 | [Algeria, Morocco, Tunisia] | |
| 1926 | | |
| 1927 | 3(1') First gonopod with conical, cylindrical or triangular terminal article | 4 |
| 1928 | 3' First gonopod with very slender and elongated fusiform terminal article; flexible zone of first | |
| 1929 | gonopod broad or only narrowed only in its lateral part | |
| 1930 | <i>Potamon ibericum</i> (Bieberstein, 1809) species complex | |
| 1931 | (<i>P. ibericum</i> , <i>P. kretaion</i> *) | |
| 1932 | [Greece, Turkey] | |
| 1933 | | |
| 1934 | 4(3) Terminal article of first gonopod elongated and conical, mesial edge slightly bulging | 5 |
| 1935 | 4' Terminal article of first gonopod stout and triangular; subterminal part with projecting mesial | |
| 1936 | edge | 8 |
| 1937 | | |
| 1938 | 5(4) Flexible zone of first gonopod flexible not symmetrically bilobed | 6 |
| 1939 | 5' Flexible zone of first gonopod symmetrically bilobed | |
| 1940 | <i>Potamon potamios</i> (Olivier, 1804) species complex | |
| 1941 | (<i>P. hippocratis</i> , <i>P. karpathos</i> , <i>P. potamios</i> *) | |
| 1942 | [Cyprus, Greece, Israel, Turkey] | |
| 1943 | | |
| 1944 | 6(5) Flexible zone of first gonopod not distinctly V-shaped | 7 |
| 1945 | 6' Flexible zone of first gonopod distinctly V-shaped | <i>Potamon rhodium</i> Parisi, 1913 |
| 1946 | [Greece, Turkey] | |
| 1947 | | |

| | | |
|------|---|---|
| 1948 | 7(6) Flexible zone of first gonopod with only one linguiform elongate lobe | |
| 1949 | ..... | <i>Potamon setigerum</i> Rathbun, 1904 |
| 1950 | [Lebanon, Syria, Turkey] | |
| 1951 | 7' Flexible zone of first gonopod slender, terminal article subcylindrical and narrow | |
| 1952 | ..... | <i>Potamon bileki</i> Pretzmann, 1971 |
| 1953 | [Turkey] | |
| 1954 | | |
| 1955 | 8(4) Flexible zone of first gonopod V-shaped or with one mesial or lateral lobe | 9 |
| 1956 | 8' Flexible zone of first gonopod bilobed; terminal article of first gonopod asymmetric in shape, | |
| 1957 | mesial margin bulging in its proximal half | <i>Potamon magnum</i> Pretzmann, 1962 |
| 1958 | [Turkey] | |
| 1959 | | |
| 1960 | 9(8) Flexible zone of first gonopod distinctly V-shaped | 10 |
| 1961 | 9' Flexible zone of first gonopod with one lateral located linguiform elongated lobe; | |
| 1962 | subterminal part of first gonopod with low mesial edge | |
| 1963 | ..... | <i>Potamon hueceste</i> Pretzmann, 1962 |
| 1964 | [Turkey] | |
| 1965 | | |
| 1966 | 10(9) Terminal article of first gonopod almost triangular; anterolateral margin of carapace | |
| 1967 | broad, serrated with unequally large teeth | |
| 1968 | ..... | <i>Potamon mesopotamicum</i> Brandis, Storch & Türkay, 1998 |
| 1969 | [Syria, Turkey] | |
| 1970 | 10' Terminal article of first gonopod proximal half with straight mesial margins, in distal half | |
| 1971 | becoming sharply deflected; anterolateral margin of carapace narrow serrated with very | |
| 1972 | small regular teeth | <i>Potamon persicum</i> Pretzmann, 1962 |
| 1973 | [Turkey] | |
| 1974 | | |
| 1975 | Key to Caridea families | |
| 1976 | 1 First and second pereopod with chelae fingers lacking dense apical setal tufts | 2 |
| 1977 | 1' First and second pereopod with chelae bearing dense apical setal tufts | Atyidae |
| 1978 | [peri-mediterranean] | |
| 1979 | | |
| 1980 | 2(1) Carapace lacking longitudinal sutures; flagellum of first antenna with rami fused basally .. | |
| 1981 | ..... | Palaemonidae, <i>Palaemon</i> |
| 1982 | [peri-mediterranean] | |
| 1983 | | |
| 1984 | 2' Carapace bearing pair of straight, longitudinal, dorsolateral sutures; cavernicolous | |
| 1985 | ..... | Typhlocaridae, <i>Typhlocaris</i> |
| 1986 | [Israel, Italy, Tunisia] | |

1987

1988 **Key to Atyidae genera**

- 1989 1 At least first three pereopods bearing exopods 2
- 1990 1' Only first and second pereopods bearing exopods *Atyaephyra*
- 1991 [Peri-Mediterranean]
- 1992
- 1993 2(1) Appendix masculina of male second pleopod bearing spines longer than appendix diameter
- 1994 3
- 1995 2' Appendix masculina of male second pleopod bearing spines much shorter than appendix
- 1996 diameter 5
- 1997
- 1998 3(2) Supraorbital spines on carapace present; exopods of fifth pereopods absent or reduced
- 1999 4
- 2000 3' Supraorbital spines on carapace absent; exopod of fifth pereopods well developed
- 2001 *Typhlatya*
- 2002 [France, Spain]
- 2003
- 2004 4(3) Eyes reduced, pigment absent; pterygostomian spine absent; rostrum short unarmed;
- 2005 dactylus of fifth pereopod with less than 10 spiniform spines *Gallocaris*
- 2006 (one species: *G. inermis* (Fage, 1937))
- 2007 [France]
- 2008 4' Eyes developed and pigmented; pterygostomian spine present; rostrum long and armed;
- 2009 dactylus of fifth pereopod with more than 10 spiniform spines (comp-like) *Dugastella*
- 2010 [Morocco, Spain]
- 2011
- 2012 5(2') Endopod of male first pleopod as a slightly bent plate, its appendix interna vestigial
- 2013 *Troglocaris*
- 2014 [Balkans, Italy]
- 2015 5' Endopod of male first pleopod shaped as '9', i.e. with a long, subapically-laterally positioned
- 2016 appendix interna *Spelaeocaris*
- 2017 [Balkans]

2018

2019 **Key to species of *Atyaephyra***

- 2020 This *Atyaephyra* key it is based on Christodoulou *et al.* (2012) and Jablonska *et al.* (2018) and
- 2021 it refers to individuals of carapace length $\geq 5.0\text{mm}$ ($\geq 3.5\text{ mm}$ for *A. orientalis*) but the reader
- 2022 should keep in mind that this genus is still under taxonomic revision. Two cryptic species exist
- 2023 within the genus where no morphological characters have been found yet to distinguish them
- 2024 and COI gene nucleic acid sequence differences are required to distinguish them to species level
- 2025 (*).

| | | |
|------|-------|---|
| 2026 | | |
| 2027 | 1 | Propodite of third maxilliped bearing 8–38 (rarely 8) strong mesial spiniform setae 2 |
| 2028 | 1' | Propodite of third maxilliped bearing 0–8 (rarely 8) strong mesial spiniform setae 3 |
| 2029 | | |
| 2030 | 2(1) | Endopod terminal part of first male pleopod slender, tapering; merus of third pereopod |
| 2031 | | with 4–6 (rarely 3–9) spiniform setae; merus of fourth pereopod with 3–5 (rarely 2–7) |
| 2032 | | spiniform setae 4 |
| 2033 | 2' | Endopod terminal part of first male pleopod broad; merus of third pereopod with 7–9 (rarely |
| 2034 | | 6–10) spiniform setae; merus of fourth pereopod with 6–8 (rarely 5–9) spiniform setae |
| 2035 | | <i>Atyaephyra orientalis</i> Bouvier, 1913 |
| 2036 | | [Israel, Syria, Turkey] |
| 2037 | | |
| 2038 | 3(1') | Absence of post orbital teeth, leaving an unarmed proximal gap on dorsal surface of |
| 2039 | | rostrum; basal endite of first maxilliped failing to reach or reaching distal end of exopod |
| 2040 | | <i>Atyaephyra strymonensis</i> Christodoulou, Antoniou, Magoulas & Koukouras, 2012 |
| 2041 | | [Greece] |
| 2042 | 3' | Post orbital teeth present without an unarmed proximal gap on dorsal surface of rostrum; |
| 2043 | | basal endite of first maxilliped over-reaching distal end of exopod |
| 2044 | | <i>Atyaephyra desmarestii</i> (Millet, 1831) species complex |
| 2045 | | (<i>A. acheronensis</i> , <i>A. desmarestii</i> , <i>A. tuerkayi</i>) |
| 2046 | | [Croatia, France, Italy, Montenegro, Portugal, Slovenia, Spain, Greece, Syria] |
| 2047 | | |
| 2048 | 4(2) | Propodite of third maxilliped bearing 16-30 (rarely 11-38) strong mesial spiniform setae |
| 2049 | | 5 |
| 2050 | 4' | Propodite of third maxilliped bearing 9-12 (rarely 8-20) strong mesial spiniform setae |
| 2051 | | <i>Atyaephyra vladoi</i> Jabłońska, Mamos, Zawal & Grabowski, 2018 |
| 2052 | | [Albania, Montenegro] |
| 2053 | | |
| 2054 | 5(4) | Stylocerite length 1.02-1.19 (rarely 0.97-1.19) times first antenullar segment length; fifth |
| 2055 | | pleuron distal end pointed with acute angle |
| 2056 | | <i>Atyaephyra thyamisensis</i> Christodoulou, Antoniou, Magoulas & Koukouras, 2013 |
| 2057 | | [Greece: Ipeiros, Ionian Islands] |
| 2058 | 5' | Stylocerite length 0.82-1.0 (rarely 0.82-1.08) times first antenullar segment length; fifth |
| 2059 | | pleuron distal end rounded, pointed with obtuse angle (rarely with acute) |
| 2060 | | <i>Atyaephyra stankoi</i> Karaman, 1972 |
| 2061 | | [Greece] |
| 2062 | | |

2063 **Key to species of *Typhlatya***

2064 1 Rostrum scarcely developed, shorter than reduced eye stalks; dactylus of fifth pereopod with
2065 row of 36 slender spiniform setae on flexor margin
2066 *Typhlatya miravetensis* Sanz & Platvoet, 1995
2067 [Spain]

2068 1' Rostrum length subequal to reduced eye stalks; dactylus of fifth pereopod with row of 19 –
2069 28 stout spiniform setae on flexor margin *Typhlatya arfaea* Jaume & Bréhier, 2005
2070 [France]

2071

2072 **Key to species of *Dugastella***

2073 1 Rivers and springs in Morocco *Dugastella marocana* Bouvier, 1912

2074 1' Rivers, springs and lagoons in southern Spain
2075 *Dugastella valentina* (Ferrer Galdiano, 1924)

2076

2077 **Key to species of *Troglocaris***

2078 This *Atyaephyra* key it is based on Sket & Zaksek (2009). Two cryptic species exist within the
2079 genus where no morphological characters have been found yet to distinguish them and COI
2080 gene nucleic acid sequence differences are required to distinguish them to species level (*).

2081

2082 1 Endopod of male first pleopod with more than 30, partially grouped, and long, inner marginal
2083 setae; rostrum with usually 15 ventral teeth *Troglocaris bosnica* Sket & Zakšek, 2009
2084 [Bosnia Herzegovina]

2085 1' Endopod of male first pleopod with shorter and scarcer marginal setae; rostrum with fewer
2086 than ten ventral teeth *Troglocaris anophthalma* (Kollar, 1848)
2087 species complex (*T. anophthalma*, *T. planinensis**)
2088 [Bosnia Herzegovina, Croatia, Italy, Slovenia]

2089

2090 **Key to *Spelaeocaris* species**

2091 This *Spelaeocaris* key it is based on Sket & Zaksek (2009) with the addition of one more species
2092 (*Spelaeocaris hercegovinensis*) according to the genetic study of Marin (2017).

2093

2094 1 Supraorbital spines on carapace absent; pereopod chelae and dactyli very stout 2

2095 1' Supraorbital spines on carapace present; pereopod chelae and dactyli very narrow
2096 *Spelaeocaris hercegovinensis* (Babić, 1922)
2097 [Bosnia Herzegovina, Montenegro]

2098

2099 2(1) Dactylus of fifth pereopod with more than 15 spines, comb-like; at least third and fourth
2100 mature male pereopods differentiated 3

- 2101 2' Dactylus of fifth pereopod with fewer than 15 spiniform setae, not comb-like; mature male
 2102 pereopods not differentiated; rostrum reduced, not serrated
 2103 *Spelaeocaris neglecta* Sket & Zakšek, 2009
 2104 [Croatia]
 2105
- 2106 3(2) Rostrum long or very short, but always with dorsal teeth; in mature males, only third and
 2107 fourth pereopods differentiated; endopod lamina of first male pleopod apically strongly
 2108 lobate 4
- 2109 3' Rostrum very short and not serrated; in mature males, apical parts of third, fourth and fifth
 2110 pereopods widened; endopod lamina of male first pleopod apically and obliquely cut and not
 2111 (or feebly) lobate *Spelaeocaris pretneri* Matjašič, 1956
 2112 [Bosnia Herzegovina, Croatia]
- 2113 4(3) Appendix masculina of male second pleopod only a slightly longer than appendix interna;
 2114 in adult males, propodi of third and fourth pereopod only slightly differentiated
 2115 *Spelaeocaris kapelana* Sket & Zakšek, 2009
 2116 [Croatia]
- 2117 4' Appendix masculina of male second pleopod nearly twice as long as appendix interna; in
 2118 adult males, propodi of third and fourth pereopod strongly differentiated
 2119 *Spelaeocaris prasence* Sket & Zakšek, 2009
 2120 [Bosnia Herzegovina, Montenegro]
 2121

2122 **Key to species of *Palaemon***

- 2123 This *Palaemon* key it is based on a recent revision (Tzomos & Koukouras 2015) of the
 2124 freshwater members of the genus in the Mediterranean basin.
 2125
- 2126 1 Fifth pleuron distal end not rounded 2
- 2127 1' Fifth pleuron distal end rounded 7
 2128
- 2129 2(1) Fifth pleuron distal end strongly pointed 3
- 2130 2' Fifth pleuron distal end subquadrate and not pointed 6
 2131
- 2132 3(2) Telson posterior margin with two plumose setae; third maxilliped exopod equal or longer
 2133 than isciomerus; endopod of male first pleopod clearly shorter than exopod; appendix
 2134 masculina shorter than the endopod of second pleopods 4
- 2135 3' Telson posterior margin with 2–6 plumose setae; third maxilliped exopod shorter than
 2136 isciomerus; endopod of male first pleopod slightly shorter than exopod; appendix masculina
 2137 longer than the endopod of second pleopod *Palaemon mesogenitor* (Sollaud, 1912)
 2138 [Algeria, Tunisia]
 2139

- 2140 4(3) Telson plumose setae fail to overpass the inner spiniform setae; first maxilliped endites
 2141 separated with their inner edges forming an obtuse angle; branchiostegal tooth originating
 2142 just before anterior margin of carapace 5
- 2143 4' Telson plumose setae over pass the inner spiniform setae; first maxilliped endites arranged
 2144 almost in a straight line forming just a notch between them; branchiostegal tooth marginal
 2145 *Palaemon varians* Leach, 1814
 2146 [Algeria, France, Morocco, Portugal, Spain, Tunisia]
 2147
- 2148 5(4) Telson with 40–50 pairs of marginal lanceolate setae; endopod of male first pleopod deeply
 2149 concave on the mesial portion of inner margin; endopod of female first pleopod with concave
 2150 inner margin and rounded tip *Palaemon colossus* Tzomos & Koukouras, 2015
 2151 [Greece: Rhodos Island, Turkey]
- 2152 5' Telson with 0–6 pairs of marginal lanceolate setae only on its proximal part; endopod of
 2153 male first pleopod lightly concave on the mesial portion of inner margin; endopod of female
 2154 first pleopod lanceolate *Palaemon antennarius* H. Milne Edwards, 1837
 2155 [Albania, Croatia, Italy, Montenegro, Slovenia, Greece]
 2156
- 2157 6(2') Telson posterior margin with two plumose setae; endopod of male first pleopod almost as
 2158 long as exopod; appendix masculina longer than the endopod of the male second pleopods
 2159 *Palaemon turcorum* (Holthuis, 1961)
 2160 [Turkey]
- 2161 6' Telson posterior margin with 4–6 plumose setae; endopod of male first pleopod clearly
 2162 shorter than the exopod; appendix masculina shorter than the endopod of male second
 2163 pleopods *Palaemon zariquieyi* (Sollaud, 1938)
 2164 [Spain]
 2165
- 2166 7(1') Telson posterior margin with 4–12 plumose setae 8
- 2167 7' Telson posterior margin always with two plumose
 2168 *Palaemon minos* Tzomos & Koukouras, 2015
 2169 [Greece: Crete Island]
 2170
- 2171 8(7) Telson posterior margin with 10–12 plumose setae; third maxilliped exopod shorter than
 2172 ischiomerus; outer margin of scaphocerite concave
 2173 *Palaemon mesopotamicus* Brandis, Storch & Türkay, 1998
 2174 [Syria, Turkey]
- 2175 8' Telson posterior margin with 4–7 plumose setae; third maxilliped exopod equal or longer
 2176 than ischiomerus; outer margin of scaphocerite straight
 2177 *Palaemon migratorius* (Heller, 1862)
 2178 [Egypt]
 2179

2180 **Key to species of *Typhlocaris***

2181 The genus *Typhlocaris* is in need of a revision as the descriptions of the genus species are based
2182 mainly on historical papers and the key characteristics are not well defined.

2183

2184 **Key to Astacidea families**

2185 For the Astacidea we follow the classification of Crandall & De Grave (2017). The reader
2186 should keep in mind that some controversy exist on the status and validity of species which
2187 is further complicated with the presence of invasive species and the many human translocations
2188 of native species.

2189

2190 1 Ischium of male third and/or fourth pereopods bearing conical hooks; females with annulus
2191 ventrali Cambaridae

2192 1' Ischium of male pereopods not bearing hooks; females lacking annulus ventralis
2193 Astacidae

2194

2195 **Key to Cambaridae genera and species**

2196 1 First pleopod of mature males terminating in two rounded lobes and spiniform structure;
2197 females with movable annulus ventralis, not fused anteriorly to sternum
2198 *Procambarus clarkii* (Girard, 1852)
2199 [Invasive: Cyprus, Egypt, France, Israel, Italy, Malta, Morocco, Spain, Tunisia]

2200 1' First pleopod of mature males terminating in two triangular or elongate lobes; females with
2201 annulus ventralis fused anteriorly to sternum *Faxonius limosus* (Rafinesque, 1817)
2202 [Invasive: France, Italy, Spain]

2203

2204 **Key to Astacidae genera**

2205 1 Telson with transverse suture 2

2206 1' Telson without transverse suture *Pacifastacus*
2207 (One species: *Pa. leniusculus* (Dana, 1852)
2208 [Invasive in Europe]

2209

2210 2(1) Two pairs of postorbital ridges; first pleopod distal lobes unequal; second pleopod
2211 exopodite length subequal to endopod; third maxilliped merus with one medial spine,
2212 occasionally also with distal spine 3

2213 2' Only one pair of postorbital ridges, or (rarely) with extremely reduced second pair; first
2214 pleopod distal lobes subequal; second pleopod exopod length distinctly smaller than
2215 endopod length; third maxilliped merus typically with medial spine row, rarely with one
2216 spine *Austropotamobius*
2217 [Europe]

2218

- 2219 3(2) Second to fourth abdominal somites with pleura bearing acute spines; second pleopod with
 2220 ventral process (talon) *Pontastacus*
 2221 (one species: *Po. Leptodactylus* (Eschscholtz, 1823))
 2222 [Bosnia Herzegovina, Croatia, France, Greece, Italy, Turkey]
- 2223 3' Second to fourth abdominal somites with pleura rounded or angular, lacking spines, fourth
 2224 somite with pleura bearing obscure spine or not; second pleopod without ventral process
 2225 *Astacus*
 2226 [Europe]
 2227

2228 **Key to species of *Austropotamobius***

- 2229 This *Austropotamobius* key it is based on Souty-Grosset *et al.* (2006) but the reader should keep
 2230 in mind that this genus is under constant revision. The separation of *A. fulsianus* which was
 2231 considered a subspecies of *A. pallipes* is not clear. COI gene nucleic acid sequence differences
 2232 are required to distinguish the two species (*).
 2233
- 2234 1 Area behind cervical groove smooth, cervical spines absent; rostral borders triangle; chelae
 2235 surface granulation very strong and rough; lower surface of antennal scale with denticulation
 2236 *Austropotamobius torrentium* (von Paula Schrank, 1803)
 2237 [Italian and Balkan Peninsulas]
- 2238 1' Area behind cervical groove with cervical spines present; rostral borders triangle or
 2239 trapezoid; chelae surface granulation small; lower surface of antennal scale with no
 2240 denticulation *Austropotamobius pallipes*
 2241 (Lereboullet, 1858) species complex (*A. pallipes*, *A. fulsianus**)

2242

2243 **Key to species of *Astacus***

- 2244 The key of *Astacus* is based on Storobogatov (1996). There is controversy whether *A.*
 2245 *balcanicus* is a species or a subspecies of *A. astacus*.
 2246
- 2247 1 Posterior part of telson completely separated from anterior part by a weak furrow; shape of
 2248 posterior part roundly trapeziform; posterior pair of postorbital ridges with spinules at
 2249 anterior ends; presence of few acute spines on each side immediately posterior to cervical
 2250 groove *Astacus balcanicus* (Karaman, 1929)
- 2251 1' Posterior part of telson incompletely separated from anterior one by a hardly distinct furrow;
 2252 shape of posterior part semi-circular; posterior part of postorbital ridges devoid of spinules;
 2253 presence of only one acute spine (usually) on each side immediately posterior to cervical
 2254 groove *Astacus astacus* (Linnaeus, 1758)

2255

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2342

2343

2344 **5. Malacostraca: Ingolfiellida**

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2348

2349 **INTRODUCTION**

2350 Since their first discovery by Hansen at the beginning of the 1900's (Hansen, 1903) and until
2351 recently, Ingolfiellids had been considered as a suborder of Amphipods. Several authors
2352 objected, and Lowry and Myers (2017) proposed to raise Ingolfiellids to the order status only
2353 recently, after a large revision of Amphipoda. This Ingolfiellida order is a sister group of
2354 Amphipoda characterized by the lack of a carapace and coxal gills and the presence of vestigial
2355 pedunculate eyes ("eye-stalks" noticed by Hansen), a pleosome composed of six segments
2356 devoid of epimera, and reduced pleopod/uropod appendages.

2357 This small order remains largely unknown and includes only two families – Ingolfiellidae (51
2358 species) and the very rare Metaingolfiellidae (one species) –, among which 20 are present in
2359 freshwaters (Horton et al., 2020). Species of this group are known on all continents and confirm
2360 that Ingolfiellida is a very old lineage that emerged around the Triassic Pangea (237 Mya) and
2361 diversified in interstitial freshwaters before further colonizing brackish and marine
2362 environments following evolutionary processes (Vonk and Schram, 2003).

2363 The presence of the sole representative of Metaingolfiellidae – *Metaingolfiella mirabilis* – in
2364 Italy and species of the *Ingolfiella* genus with ancestral morphological characteristics (Vonk
2365 and Schram, 2003) suggests ancient colonization of the Mediterranean basin by species of this
2366 order. The two Ingolfiellida families are present in this region and are represented by 9 species
2367 belonging to two genera (*Metaingolfiella* and *Ingolfiella*) that represent 45% of the total number
2368 of known freshwater Ingolfiellida.

2369

2370 **GENERAL ECOLOGY AND DISTRIBUTION**

2371 Their ecology remains almost unknown, and most of the species are know from only one
2372 specimen (Vonk and Jaume, 2013). Despite a wide distribution in fresh and marine waters, a
2373 few species have a euryhaline distribution, and only *Ingolfiella manni* was observed both in
2374 fresh and brackish water environments in Chile.

2375 Despite the small number of known species, Ingolfiellida are one of the most widespread groups
2376 in the crustacean world and have colonized an exceptional diversity of groundwaters and
2377 interstitial habitats ranging from deep sea water (-3,521 m on the deep sea bottom for *Ingolfiella*
2378 *abyssi*) to the top of mountainous freshwater streams (2,000 m asl. in the Andes Mountains for
2379 *Ingolfiella uspallatae*).

2380 All Mediterranean species are distributed among the northern countries located between Spain
2381 and Greece. They have been found either in river sediments (*I. catalanensis*, *I. macedonica*, *I.*
2382 *thibaudi* and *I. vandeli*), or in wells (*M. mirabilis*, *I. acherontis*, *I. petkovskii*), and caves (*I.*
2383 *cottarellii*, *I. beatricis*). The distribution of many species is restricted to a very small area, and
2384 several species are known only from one river or one well.

2385

2386 **TERMINOLOGY AND MORPHOLOGY**

2387 Ingolfiellida are small/medium-sized Malacostraca ranging from 1.5 up to 23 mm in length
2388 worldwide but less than 2.5 mm in the Mediterranean basin, except *M. mirabilis* which can
2389 reach 18.7 mm. Females are generally larger than males (when they are known). Their body is
2390 vermiform and adapted to life in interstitial environments such as those of bathynellacean and
2391 bogdiellid amphipods. Their body is divided into 13 segments, which can be grouped into the
2392 head, the mesosome, the metasome, and the urosome (Fig. 7.10). The cephalothorax is
2393 composed of the head fused either with the first segment of the mesosome for Ingolfiellidae or
2394 with segments 1 and 2 of the mesosome for Metaingolfiellidae (Fig. 7.10). Their general
2395 morphology is similar to that of Amphipoda (cf. section Amphipoda of the book). However,
2396 Ingolfiellida differ from Amphipoda by the absence of eyes in all species. A vestigial
2397 pedunculate eye can be present in many Ingolfiellid species but is rarely observed in European
2398 species. Mouthparts are also similar, but the maxilliped does not have the ischial endite (outer
2399 plate). The shape of their gnathopods strongly differs from the shape of Amphipoda
2400 gnathopods: the “hand” of their gnathopods is formed by the 5th article (carpus) and the “finger”
2401 consists of two articles (propodus and dactyl) instead of one, whereas the “hand” of Amphipoda
2402 gnathopods consists of the 6th article (propodus) and the “finger” corresponds to the sole dactyl.
2403 Their mesosome also differs by the absence of coxal gills on their pereopods, unsegmented and
2404 uniramous pleopods and the absence of epimera on their urosome.

2405

2406 **COLLECTION, PREPARATION, AND IDENTIFICATION**

2407 Ingolfiellida are distributed worldwide but are very rare locally. In the Mediterranean basin, all
2408 species are obligate groundwater species and can be sampled using any kind of sampling
2409 method adapted to hypogean species. Several kinds of specific materials (pumps, nets, traps)
2410 for this environment can be used (Malard et al., 2002).

2411 Ingolfiellida can be easily fixed and preserved in 70% ethanol or another fixative for
2412 morphological analysis, and in 95% ethanol for genetic analysis.

2413 The family and the genera can be identified under a stereomicroscope, but identification at the
2414 species level requires dissection, mounting of body parts and appendages on slides, and
2415 subsequent examination using a 400x or higher-magnification microscope. Specimens kept in
2416 glycerol or ethanol can be handled under a low-power microscope with needles. Glycerol is
2417 used as an embedding medium for short-term slides. Baths in clearing solution (e.g. soft acids)
2418 or permanent mounting media are only required when depositing museum specimens. The same
2419 specimen can be used for both studies: the abdomen for DNA extraction and the other parts for
2420 dissection and mounting. This procedure ensures that the sequenced genes correspond to the
2421 same morphotype.

2422 Taxonomic identification at the species level is generally possible using males, but only females
2423 are known for some species (*I. acherontis*, *I. beatricis*, *I. macedonica*). The most important
2424 body parts for identification are the head, mouthparts, gnathopods, pleopods and uropods.
2425 Additional body parts need to be examined to identify certain species.

2426

2427 **LIMITATIONS**

2428 The key below is designed to cover all currently recognized freshwater ingolfiellid species of
2429 the Mediterranean basin. Taxonomic synonymy has been updated. Rare records are included,

2430 unless they are insufficiently documented. For example, *Ingolffiella (Balchanella) acherontis* is
 2431 included in the key, but it is not clearly described and its identification key should be used with
 2432 caution. Species-specific secondary sexual characteristics (modified gnathopods or uropod 2,
 2433 oostegites, etc....), are important for the taxonomy of Ingolffiellida but limited because several
 2434 species are only known based on one sex (male or female). Another limitation of the key is that
 2435 most species are only known from a small number of specimens, so that intraspecific variability
 2436 generally remains unknown.

2437

2438

KEY TO ORDER INGOLFFIELLIDA

2439

Key to Amphipoda families

2440 1 Cephalothorax composed of head and first and second segment fused together; uropod 3
 2441 peduncles of right and left uropods fused together Metaingolffiellidae
 2442 (one species: *Metaingolffiella mirabilis* (Ruffo, 1969))

2443 1' Cephalothorax composed of head and first segment fused together; uropod 3 peduncles free
 2444 Ingolffiellidae (one genus : *Ingolffiella*)

2445

2446

Key to species of *Ingolffiella*

2447 1 Cephalic ocular lobes developed 2

2448 1' Cephalic ocular lobes absent 3

2449

2450 2(1) Gnathopods 1 and 2 with 4 denticles on posterior margin of dactylus
 2451 *I. beatricis* Ruffo & Vonk, 2001

2452 2' Gnathopods 1 and 2 with 3 denticles on posterior margin of dactylus
 2453 *I. acherontis* (S. Karaman, 1933)

2454

2455 3(1') First pereonite (second thoracic segment) free 4

2456 3' First pereonite (second thoracic segment) fused to cephalon *I. vandeli* Bou, 1970

2457

2458 4(3) Maxilla 1 palp sub-equal to outer lobe, inner lobe with 1 or 2 setae 5

2459 4' Maxilla 1 palp longer than outer lobe, inner lobe with 3 setae
 2460 *I. petkovskii* S. Karaman, 1957

2461

2462 5(4) Maxilla 1 inner lobe with 2 setae; gnathopods 1 and 2 with 3 denticles; pleopods 1-3 absent
 2463 in females 6

2464 5' Maxilla 1 inner lobe with one seta; gnathopods 1 and 2 with 4 denticles on posterior margin
 2465 of dactylus, pleopods 1-3 present in females *I. macedonica* S. Karaman, 1959

2466

2467 6(5) Uropod 1 outer ramus less than half of inner ramus length; uropod 2 longer than uropod 1;
 2468 pereopod 3-4 claw simple 7

- 2469 6' Uropod 1 outer ramus more than half of inner ramus length; uropod 1-2 sub-equal; pereopod
 2470 3-4 claw dentate or bifid *I. catalanensis* Coineau, 1963
 2471
- 2472 7(6) Antenna 1 accessory flagellum hardly longer than the first articles of the flagellum;
 2473 peduncle uropod 2 with 6-7 rows of setae
 2474 *I. cottarellii* Ruffo & Vigna Taglianti, 1989
- 2475 7' Antenna 1 accessory flagellum longer than the two first articles of the flagellum; peduncle
 2476 uropod 2 with 5 rows of setae *I. thibaudi* Coineau, 1968
 2477

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2493 **6. Malacostraca: Isopoda**

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2501

2502 **INTRODUCTION**

2503 Isopoda Latreille, 1817 are a very diverse order both in the number of species and in their
2504 morphology. About 10% of all isopods – more than ten thousand described species – live in
2505 continental waters, mostly in groundwater (Wilson 2008). They are easily recognizable in the
2506 field from their typical dorsally and ventrally flattened body shape, even if some groups of
2507 groundwater isopods (e.g. Microcerberidae) differ from this general habitus with a more or less
2508 thin and vermiform body.

2509 Biogeographic analysis indicates that isopods, like Amphipoda, were likely widespread in
2510 Pangea, Gondwana, and Laurentia (Wilson 2008). Freshwater colonization by isopods likely
2511 resulted from successive events, with the oldest events occurring during the Palaeozoic period
2512 (540-250 Mya) and involving ancestors of a few Asellota families and the entire suborder
2513 Phreatoicidea (not present in the Mediterranean basin nowadays). The most ancient fossil
2514 records – *Hesslerella shermani*, a Phreatoicidea – dates back to 307 Mya (Schram, 1970). This
2515 hypothesis is congruent with molecular studies suggesting diversification events in freshwaters
2516 400 to 500 Mya (Lins et al., 2012).

2517 Among the 1,000 species described in freshwaters, 336 are present in the Mediterranean
2518 basin. The main taxonomic groups are Cirolanidae (8 genera), Asellidae (5 genera),
2519 Stenasellidae (5 genera), and Sphaeromatidae (5 genera). A few taxa belonging to Janiridae,
2520 Lepidocharontidae, Microcerberidae and Microparasellidae are also present (Boyko et al.
2521 2008).

2522

2523 **GENERAL ECOLOGY AND DISTRIBUTION**

2524 Mediterranean freshwater isopods inhabit streams, rivers, ponds, lakes, and temporary pools
2525 where they can be found on the substrate or in the interstitial systems beneath the river bed
2526 (hyporheon). Most of the 299 described species are obligatory inhabitants of groundwaters
2527 (stygobionts), found in caves or other habitats where subterranean waters flow through; they
2528 are strictly endemic. Some taxa inhabit thermal waters (Rogers & Lewis 2019). Only the
2529 epigeal genus *Proasellus* (Asellidae) is widely distributed along the entire Mediterranean
2530 basin; one species – *P. coxalis* – is represented by various subspecies whose taxonomic rank
2531 should be accurately revised.

2532 The suborder Asellota includes the highest number of described freshwater species, mostly
2533 in the Asellidae and Stenasellidae families. Out of the five genera composing Stenasellidae,
2534 which are all strictly subterranean without any epigeal relative, *Stenasellus* has the widest
2535 distribution: it is present in the groundwaters of the Far East, Middle East, East Africa and the

2536 western Mediterranean basin, showing a biogeographic pattern linked to the ancient Thetys sea
2537 (Henry & Magniez 1983, Messina et al 2019). Some genera are much diversified but
2538 geographically restricted, e.g. *Bragasellus* (20 species), *Synasellus* (35 species), both restricted
2539 to the Iberian Peninsula. The janirid *Jaera sarsi*, originally from the Ponto-Caspian fauna but
2540 widely distributed in Western Europe has been included, even if it is invasive and present only
2541 in the largest rivers.

2542 The five genera of the 'Flabellifera' *sensu lato* group (e.g. Cymothoidea and Sphaeromatidea)
2543 present in the Mediterranean basin are the result of multiple colonizations of continental
2544 groundwater habitats (Thalassostygobionts) during several ancient marine incursions (Baratti
2545 et al. 1999, Wilson 2008). The genus *Sphaeromides* has a north Mediterranean distribution,
2546 *Typhlocirolana* a south-western one, while *Turcolana* has an eastern one. *Botolana* and
2547 *Moroccolana* are confined to Moroccan groundwaters with a strict relationship with
2548 *Typhlocirolana*, while *Faucheria* and *Kensleylana* are found in the groundwaters of southern
2549 France and the northern Iberian Peninsula, respectively.

2550 The subterranean taxa are represented by several mostly scavenger or omnivorous taxa, with a
2551 carnivorous tendency. Epigeal taxa feed on the periphyton or on detritus.

2552

2553 **TERMINOLOGY AND MORPHOLOGY**

2554 Freshwater taxa include the typical dorso/ventral flattened isopods or narrow-bodied
2555 forms, and a few vermiform ones (Fig. 7.11). Adaptations mostly depend on colonized habitats.

2556

2557 Epigeal species are variously pigmented, while their subterranean counterparts are
2558 unpigmented and whitish. Likewise, eyes are present in the surface species and vary from
2559 reduced to completely absent in subterranean species.

2560 The body is composed of three main sections (Fig. 7.12). In epigeal taxa, the globular
2561 head (cephalon) has a couple of big composed dorso-lateral sessile eyes and two pairs of
2562 unramous antennae (A1 and A2); antenna 2 bears a rudimental exopodite (squama) in the more
2563 primitive taxa. The mouthpart is on the ventral surface of the head and is composed of the
2564 labrum, labium, mandibles, maxillae I and II, and maxilliped. The first thoracic segment is
2565 always fused to the cephalon and bears a couple of modified legs (maxillipeds).

2566 The thorax (or pereon) is formed of 7 very similar thoracic metamers (2 to 8) bearing
2567 seven pairs of walking legs (pereopods). The first pair is usually modified for grasping in most
2568 species. A couple of genital openings are present on the sternal face of pereonite 7 in males
2569 (genital papillae) and 6 in females. The abdomen (pleon) has 6 well-developed segments. The
2570 first 5 segments are usually free, the sixth one is fused to the telson to form a pleotelson. The 5
2571 couples of appendices (pleopods) are biramous and mostly identical in the two sexes. Their
2572 rami have a respiratory and potential swimming role. The second pair of pleopods is modified
2573 into a copulatory organ in males (Fig. 7.13), to transfer sperm to the female genital opening. It
2574 has a unique construction in each species, and is frequently surrounded by accessory processes.
2575 The identification of most Isopoda, particularly Asellota, relies on the examination of this
2576 structure. The sixth pair (uropods) is variously modified in the diverse taxa.

2577

2578 Fertilized eggs develop in a ventral marsupium of the female, formed by the imbrication
2579 of lamellae originating from the coxopodites of pereopods: the oostegites. Isopoda have a
2580 typical biphasic moulting: the rear part of the body moults before the anterior part.

2581

2582 **COLLECTION, PREPARATION, AND PRESERVATION**

2583 Collection methods vary depending upon the habitat. For surface and cave species, small
2584 hand nets with an appropriate mesh dimension or baited traps can be used. For interstitial
2585 hyporheic taxa, the most effective methods are the Bou-Rouch pump and the Karaman-
2586 Chappuis method (Malard et al. 2004). Isopods can be easily fixed and preserved in 70%
2587 ethanol or another fixative for morphological analysis and in 95% ethanol for molecular
2588 analysis. If many specimens are taken, ethanol should be replaced after a few days to prevent
2589 dilution by the animal's body water content. For conservation purposes, an ethanol (70/75°)
2590 plus a 5% glycerol mix is best suited to avoid articulations hardening, and also avoids accidental
2591 desiccation.

2592 Specimens are best examined and viewed under low magnification for family or
2593 sometimes genus level identification. Species identification requires dissecting various parts of
2594 the body, which can be done by handling the specimen with fine forceps and pins. The simplest
2595 procedure consists in transferring the appendages into a drop of glycerin on a microscope slide.
2596 To see the fine details in heavily chitinized specimens, a semi-permanent slide with a clearing
2597 liquid such as Hoyers medium can be prepared (the slide should stay a few days at 35°C and
2598 then the cover should be sealed). Once dissected, the specimen is ready for examination, which
2599 may require a magnification of 100/1,000x for detailed examination depending on the size of
2600 the specimen. Scanning electron microscopy (SEM) observation is the best examination tool
2601 for fine details.

2602

2603 **LIMITATIONS**

2604 Isopoda are a much diversified group of taxa with almost 1,000 known freshwater species, and
2605 many more that remain undescribed. The keys proposed here are designed to cover the four
2606 sub-orders, the 8 families and the 33 genera. Oniscidea are not dealt with, although a few aquatic
2607 and several amphibious species are present in the Mediterranean basin. Keys at the species level
2608 are only provided for genera with a low number of species (usually less than 15). Rare records
2609 are included, unless they are insufficiently documented. Taxonomic synonymy has been
2610 updated, but taxonomy remains unclear for some genera. However, several cirolanid,
2611 sphaeromatid and asellid genera are badly described and need revision. As a consequence, some
2612 family, genus and species names may change in the future.

2613 Finally, even if our keys were designed to be as clear as possible, we should never forget
2614 that identifying certain groups, especially groundwater species, can be very difficult and
2615 requires strong expertise. Do not hesitate to use alternative information or keys to consolidate
2616 your conclusions. We should keep in mind that keys, even at the family level, are designed for
2617 species of the Mediterranean basin, they are not adapted to other isopods worldwide.

2618

2619

2620 **KEYS TO ISOPODA**

2621

2622 **Key to Isopoda suborders and Families**

2623 1 Uropods styliiform, inserted terminally on pleotelson 2
2624 1' Uropods lamellar, inserted at pleotelson base 8

| | | |
|------|--|--|
| 2625 | | |
| 2626 | 2(1) Antennules normal, or if reduced not minute; pleon variable, with or without fused | |
| 2627 | pleonites | 3 |
| 2628 | 2' Antennules vestigial, minute; pleon always of 5 free pleonites, plus the pleotelson | |
| 2629 | ..... | Oniscidea |
| 2630 | | |
| 2631 | 3(2) One or two, free pleonites; body length variable; antenna peduncle usually with a scale; | |
| 2632 | antennule rarely reduced, peduncle and flagellum distinct; maxilliped almost always with | |
| 2633 | coupling setae on endite; female pleopod 2 uniramous; male pleopod 2 endopod large and | |
| 2634 | geniculate | 4 (Asellota) |
| 2635 | 3' Two long pleonites, and a pleotelson, all cylindrical; body length at least six times width; | |
| 2636 | antenna peduncle without a scale; antennule reduced, peduncle indistinguishable from | |
| 2637 | flagellum; maxilliped without coupling setae on endite; female pleopod 2 biramous; male | |
| 2638 | pleopod 2 endopod not geniculate; interstitial | Microcerberidea |
| 2639 | (one family: Microcerberidae) | |
| 2640 | | |
| 2641 | 4(3) Two free pleonites | 5 |
| 2642 | 4' One or zero free pleonites | 6 |
| 2643 | | |
| 2644 | 5(4) Antenna 2 with an exopod; pleonite 1 and 2 wide, pronounced in dorsal view; pleopods 2 | |
| 2645 | bi-articulated | Stenasellidae |
| 2646 | 5' Antenna 2 without exopod; pleonite 1 and 2 short and narrow, not pronounced in dorsal view; | |
| 2647 | pleopods 2 with one article | Asellidae |
| 2648 | | |
| 2649 | 6(4') Pleotelson lateral margins parallel; uropods longer than pleotelson; body elongate, length | |
| 2650 | at least 6 times width | 7 |
| 2651 | 6' Pleotelson lateral margins converging; uropods shorter than pleotelson; body broad, length | |
| 2652 | less than four times width | Janiridae (one genus: <i>Jaera</i>) |
| 2653 | | |
| 2654 | 7(6) Uropods biramous, large; antennal podomeres shorter than flagellum; rostrum small or | |
| 2655 | absent | Lepidocharontidae (one genus: <i>Microcharon</i>) |
| 2656 | 7' Uropods uniramous; antennal podomeres longer than flagellum; head with prominent | |
| 2657 | rostrum | Microparasellidae |
| 2658 | | |
| 2659 | 8(1') Uropods not modified as a ventral operculum | 9 |
| 2660 | 8' Uropods modified as opercula, covering the entire pleopodal chamber; males with penes | |
| 2661 | arising on sternum of pleonite 1, or on articulation between pereonite 7 and pleonite 1; | |
| 2662 | mandibular molar process a stout, flattened grinding structure | Valvifera |
| 2663 | | |

2664 9(8) Uropods articulating mediolaterally; pleon dorsally with four or five free pleonites plus the
2665 pleotelson Cymothoida (one family: Cirolanidae)

2666 9' Uropods, particularly the peduncle/protopod, articulating dorsoventrally; pleon dorsally with
2667 four or fewer free pleonites plus the pleotelson
2668 Sphaeromatidea (one family: Sphaeromatidae)

2669

2670 **Key to Asellidae genera**

2671 1 Coxae not obscured by pereonite, visible dorsally 2

2672 1' Coxae reduced not visible dorsally *Bragasellus*
2673 [Iberian Peninsula]

2674

2675 2 Pleopod 1 peduncles fused at base on at least 20% 3

2676 2' Pleopod 1 peduncles free attached by at least 2 coupling hooks4

2677

2678 3 Mandibular palp absent *Synasellus*
2679 [Iberian Peninsula]

2680 3' Mandibular palp present *Chthonasellus*
2681 (one species: *C. Bodoi* Argano & Messina, 1991)
2682 [Italy]

2683

2684 4 Pleopod 2 endopod with basal spur and pronounced basal apophysis *Asellus*
2685 [Europe]

2686 4' Pleopod 2 endopod without basal spur and without pronounced basal apophysis
2687 *Proasellus*
2688 [Peri-Mediterranean]

2689

2690 **Key to species of *Jaera***

2691 1 Maxilliped palp article 2 wider than long; uropod exopodite and endopodite well developed,
2692 overlapping more than a half of the propodite 2

2693 1' Maxilliped palp article 2 almost as long as wide; uropod exopodite and endopodite minute,
2694 not overlapping a half of the propodite width *J. sarsi* Valkanov, 1936

2695

2696 2(1) Pleopod 1 ♂ praeoperculum narrow and pointed 3

2697 2' Pleopod 1 ♂ praeoperculum T-shaped *J. italica* Kesselyak, 1938

2698

2699 3(2) Pereopods 1 and 7 not sexually dimorphic; pleopods 1 praeoperculum wider at its distal
2700 end *J. schellenbergi* Kesselyak, 1938

2701 3' Pereopod 1 and 7 sexually dimorphic; pleopods 1 praeoperculum restangular
 2702 *J. nordmanni* (Rathke, 1837)
 2703 (super-species including 3 sub-species *J. n. nordmanni*, *J. n. balearica*, *J. n. brevicaudata*
 2704 not included in this key)

2705

2706 **Key to Microparasellidae genera and species**

2707 1 Somite lateral margins with denticles 2 (*Microparasellus*)
 2708 [Balkans, Greece, Middle East]

2709 1' Somite lateral margins smooth *Angeliara*
 2710 (one species: *A. pheraticola* Chappuis & Delamare-Deboutteville, 1952)
 2711 [France, Italy]

2712

2713 2(1) Uropods visible dorsally 3

2714 2' Uropods not visible dorsally 4

2715

2716 3(2) Pleopod 1 ♂ sub-triangular distally; transverse section of the pleotelson ovoid
 2717 *M. puteanus* Karaman, 1933

2718 3' Pleopod 1 ♂ rounded distally; transverse section of the pleotelson sub-circular
 2719 *M. hellenicus* Argano & Pesce, 1979

2720

2721 4(3') Lateral expansion of the first thoracic segment lacking; uropods exopodite reduce, scale
 2722 like *M. aloufi* Coineau, 1968

2723 4'. Lateral expansion of the first thoracic segment present; uropods exopodite developed
 2724 *M. libanicus* Chappuis & Delamare-Deboutteville, 1954

2725

2726 **Key to Stenasellidae genera and species (except *Stenasellus*)**

2727 1 Body thinner than the preceding; uropods longer than 1/3 of Pleotelson 2

2728 1' Body short, length around 2.5 width; uropods short, less than 1/5 of Pleotelson
 2729 *Johanella* (one species: *J. purpurea* Monod, 1924)
 2730 [Algeria]

2731

2732 2(1) Pleopod 2 endopodite ♂ composed by two article free, the proximal well developed, the
 2733 distal never jointed on its internal margin 3

2734 2' Pleopod 2 endopodite ♂ composed by two articles fused, proximal article very small, the
 2735 distal furrowed *Metastenasellus* (one species: *M. leysi* Magniez, 1986)
 2736 [Algeria]

2737

2738 3(2) Pleopod 1 ♂ propodite subquadrangular and well developed, exopodite flat 4

- 2739 3' Pleopod 1 ♂ exopodite externally curved *Balkanostenasellus*
 2740 (one species: *B. skopljensis* (Karaman, 1937), super-species including 4 sub-species: *B. s.*
 2741 *croaticus*, *B. s. meridionalis*, *B. s. skopljensis*, *B. s. thermalis* not included in this key)
 2742 [Balkan]
- 2743
 2744 4(3) Pleopod 2 endopodite ♂, distal article as a flat oval lamina, with a similar external
 2745 appendix; pleopod 1 ♂ sympodite without coupling hooks *Magniezia*
 2746 (one species: *M. gardei* Magniez, 1978)
 2747 [Morocco]
- 2748 4'. Pleopod 2 endopodite ♂, distal article long and thin, longitudinally folded with proximally
 2749 divergent margins, sometimes distally fused; pleopod 1 ♂ sympodite with or without
 2750 coupling hooks *Stenasellus*
 2751 [Western Europe]

2752

2753 **Key to species of *Stenasellus***

- 2754 1 Pleopod 2 ♂ endopodite, proximal article of the long and thin 2
- 2755 1' Pleopod 2 ♂ endopodite, proximal article short and stubby 9
- 2756
- 2757 2(1) Pleopod 1 ♂ protopodite without coupling hooks or with simple seta; pleopod 2 ♂
 2758 endopodite almost isodiametric with a large and denticulate terminal part; pleopods 4 and 5
 2759 exopodites ovoids, larger than endopodite 3 (*S. breuili*-group)
- 2760 2' Pleopod 1 ♂ protopodite with coupling hooks; pleopod 2 ♂ endopodite, distal article fusoid
 2761 with acute apex; distal article of exopodite medially bented and bearing about 15 marginal
 2762 setae; pleopods 4 and 5 exopodites varying from large and lamellar to thin or styliform
 2763 7 (*S. virei*-group)
- 2764
- 2765 3(2) Pereopod 1 propodite robust 4
- 2766 3' Pereopod 1 propodite thin and fragile *S. bragai* Magniez, 1976
- 2767
- 2768 4(3) Pleopod 2 sympodite subquadrangular, endopodite distal article falciform with about 20
 2769 sternal setae 5
- 2770 4' Pleopod 2 sympodite subpentagonal, endopodite distal article strong with a disto-externak
 2771 expansion 6
- 2772
- 2773 5(4) Pereopods 2-7 dactyli with one sternal spine *S. escolai* Magniez, 1977
- 2774 5' Pereopods 2-7 dactyli with two sternal spines *S. magniezi* Escola, 1975

2775

| | | |
|------|--|--|
| 2776 | 6(4') Pleopod 2 ♂ exopodite subovoid with 7 distal marginal plumose setae, endopodite distal | |
| 2777 | article with a disto-external rounded expansion bearing 4 tiny spines | |
| 2778 | <i>S. galhanoae</i> Braga, 1962 | |
| 2779 | 6' Pleopod 2 ♂ exopodite rounded with 18 distal marginal plumose setae, endopodite distal | |
| 2780 | article with an external expansion bearing 8 spines and an internal lobe covered by tiny setae | |
| 2781 | <i>S. breuili</i> Racovitza, 1924 | |
| 2782 | | |
| 2783 | 7(2') Pleopod 2 ♂ endopodite distal part stretched but not as an elongated beak | 8 |
| 2784 | 7' Pleopod 2 ♂ endopodite distal part stretched as an elongated beak | <i>S. buili</i> Remy, 1949 |
| 2785 | | |
| 2786 | 8(7) Pleopod 5 exopodite large almost totally covering endopodite and distally rounded | |
| 2787 | <i>S. racovitzae</i> Razzauti, 1925 | |
| 2788 | 8' Pleopod 5 exopodite styliform, 5-6 times longer than large, always thinner than endopodite | |
| 2789 | <i>S. virei</i> Dollfus, 1897 | |
| 2790 | | |
| 2791 | 9(1') Pleopod 2 ♂ distal article almost isodiametric, with an obtuse ending and a large terminal | |
| 2792 | orifice, distal external part more or less pointed | <i>S. nuragicus</i> Argano, 1968 |
| 2793 | 9' Pleopod 2 ♂ distal article almost isodiametric, with an obtuse ending and a large terminal | |
| 2794 | orifice, distal external part large | <i>S. assorgiai</i> Argano, 1968 |
| 2795 | | |
| 2796 | Key de Cirolanidae genera | |
| 2797 | 1 Eyes absent | 2 |
| 2798 | 1' Eyes minute; body length 5 mm | <i>Saharolana</i> (one species: <i>S. seurati</i> Monod, 1930) |
| 2799 | [Tunisia] | |
| 2800 | | |
| 2801 | 2(1) Pleotelson completely fused to pleon; uropods with one terminal ramus; body length ≤ 5 | |
| 2802 | mm | 3 |
| 2803 | 2' Pleotelson not as above; five free pleonite; uropods with two terminal rami; body length | |
| 2804 | variable | 4 |
| 2805 | | |
| 2806 | 3(2) Pleotelson with two sutures visible laterally for the fused segments; uropod peduncle | |
| 2807 | flattened dorsoventrally | <i>Faucheria</i> |
| 2808 | (one species: <i>F. faucheri</i> (Dollfus, A. and Viré, A. 1900)) | |
| 2809 | [France] | |
| 2810 | 3' Pleotelson with only one suture visible laterally; uropod peduncle elongate and cylindrical, | |
| 2811 | with a single, minute ramus | <i>Kensleyana</i> |
| 2812 | (one species: <i>K. briani</i> Bruce & Herrando-Perez, 2005) | |
| 2813 | [Spain] | |
| 2814 | | |

| | | |
|------|---|-----------------------|
| 2815 | 4(2') Pleonite 5 covered by pleonite 4; body length 1-10 mm | 5 |
| 2816 | 4' All five pleonite free; body length 10-33 mm | <i>Sphaeromides</i> |
| 2817 | [France, Balkans] | |
| 2818 | | |
| 2819 | 5(4) Not rolling into a ball; pleopods 1 not forming an operculum; pleotelson somewhat | |
| 2820 | produced | 6 |
| 2821 | 5' Adapted to roll into a ball; pleopods 1 forming an operculum; pleotelson never produced | |
| 2822 | ..... | <i>Turcolana</i> |
| 2823 | [East Mediterranean] | |
| 2824 | | |
| 2825 | 6(5) Cephalon not laterally overlapped by pereonite 1 | 7 |
| 2826 | 6' Cephalon posterior 50% embraced by pereonite 1; body length 7 mm | <i>Marocolana</i> |
| 2827 | (one species <i>Ma. delamarei</i> Boutin, 1993) | |
| 2828 | [Morocco] | |
| 2829 | | |
| 2830 | 7(6) Clypeus not projecting; pleonite 5 overlapped by pleonite 4 | 8 |
| 2831 | 7' Clypeus projecting; pleonite 5 overlapped by pleonite 4 | <i>Metacirolana</i> |
| 2832 | (one species: <i>Me. ponsi</i> Jaume & Garcia, 1992) | |
| 2833 | [Spain] | |
| 2834 | | |
| 2835 | 8(7) Uropod rami dorsoventrally flattened, triangular, subequal in length to peduncle, and | |
| 2836 | shorter than pleotelson | <i>Typhlocirolana</i> |
| 2837 | [South Europe, North Africa] | |
| 2838 | 8' Uropod rami subcylindrical, styliiform, length/width 1.5x peduncle, longer than pleotelson . | |
| 2839 | ..... | <i>Botolana</i> |
| 2840 | (one species: <i>B. leptura</i> (Botosaneanu, Boutin & Henry, 1985)) | |
| 2841 | [Morocco] | |

2842

2843 **Key to species of *Sphaeromides***

| | | |
|------|---|-----------------------------------|
| 2844 | 1 Pleonite 3 wider than others | 2 |
| 2845 | 1' Pleonite 3 not wider than the others | 3 |
| 2846 | | |
| 2847 | 2(1) Fifth antennal article with straight margins | <i>S. bureschi</i> Strouhal, 1963 |
| 2848 | 2' Fifth antennal article with inflat margins | <i>S. polateni</i> Angelov, 1968 |
| 2849 | | |
| 2850 | 3(1') Pleotelson apex truncate | <i>S. virei</i> (Brian, 1923) |
| 2851 | 3' Pleotelson apex acute | <i>S. raymondi</i> Dollfus, 1897 |

2852

| | | |
|------|--|---|
| 2853 | Key de Sphaeromatidae genera and species (except <i>Monolistra</i>) | |
| 2854 | 1 Pleopod 4 and 5 endopods smooth lacking pleats or fold | 2 |
| 2855 | 1' Pleopod 4 and 5 endopods with pleats or fold | 5 |
| 2856 | | |
| 2857 | 2(1) Pleotelson preceded by two or more pleonites fused at least dorsomedially | 3 |
| 2858 | 2' Pleotelson preceded by two free and articulated pleonites | <i>Monolistra</i> |
| 2859 | [Italy, Balkans] | |
| 2860 | | |
| 2861 | 3(2) Uropod short, around 0.25x the pleotelson length | <i>Merozoon vestigatum</i> Sket, 2012 |
| 2862 | [Croatia] | |
| 2863 | 3' Uropod length around 0.5x pleotelson length | 4 (<i>Caecosphaeroma</i>) |
| 2864 | [France] | |
| 2865 | | |
| 2866 | 4(3) All pleonite fused with telson; pleopods short; uropod short, exopodite distinct | |
| 2867 | ..... | <i>C. (Caecosphaeroma) virei</i> Dolfus, 1896 |
| 2868 | 4' First pleonite partially free; pleopod well developed; uropod reduce scale like, exopodite not | |
| 2869 | visible | <i>C. burgundum (Vireia) burgundum</i> Dollfus, 1898 |
| 2870 | | |
| 2871 | 5(1') Maxilliped articles 2-4 lacking lobes, inferior margins with dense fringes of plumose setae | |
| 2872 | ..... | <i>Sphaeroma</i> (one species: <i>S. podicipitis</i> Monod, 1931) |
| 2873 | [South Europe, North Africa] | |
| 2874 | 5' Maxilliped articles 2-4 more or less lobed, inferior margins with simple setae only | |
| 2875 | ..... | 6 (<i>Lekanesphaera</i>) |
| 2876 | [Morocco] | |
| 2877 | | |
| 2878 | 6(5) Pereopod 1 propodus with few to many distal setae next to rostror distal spine | 7 |
| 2879 | 6' Pereopod 1 propodus without distal setae next to rostro-distal spine | |
| 2880 | ..... | <i>L. hookeri</i> Leach, 1814 |
| 2881 | | |
| 2882 | 7(6) Pereopod 1, setae on ischium and merus smooth or sparsely plumose only on their distal | |
| 2883 | part | 8 |
| 2884 | 7' Pereopod 1, setae on ischium and merus entirely plumose, ending with long setules on their | |
| 2885 | distal part | <i>L. monodi</i> (Arcangeli, 1934) |
| 2886 | | |
| 2887 | 8(7) Pereopod 1 propodus with more than 3 setae inserted distally in transverse row next to | |
| 2888 | rostror distal spine. Antenna flagellum articles with fringe of long setae at distal interior angle, | |
| 2889 | seta 2-3 times length of article | 9 |
| 2890 | 8' Pereopod 1 propodus with 2-3 setae inserted distally in transverse row next to rostror distal | |
| 2891 | spine. Antenna flagellum articles with fringe of few short setae, seta 1.5 times length of article | |
| 2892 | ..... | <i>L. rugicauda</i> (Leach, 1814) |

- 2893
- 2894 9(8) Pleotelson subapically concave, slightly upcurved, dorsal surface slightly granular; Uropod
 2895 exopod, external margin with 5-7 little teeth, giving it crenate appearance
- 2896 *L. hoestlandti* (Daguerre de Hureaux, Elkaïm & Lejuez, 1965)
- 2897 9' Pleotelson subapically concave but not upcurved, dorsal surface with row of 6-7 partly fused
 2898 tubercles on each side of midline; Uropod exopod, external margin with 6-7 distinct teeth ...
- 2899 *L. panousei* (Daguerre de Hureaux, Elkaïm & Lejuez, 1964)

2900

2901 **Key de Microcerberidae genera and species**

2902 1 Coxae of pereopods 2-4 ring-shaped; male pleopod 2 with saber-shaped endopod with
 2903 pointed and laterally curved apex; Pleopod 4 with elongate sympod, with 3 rami of similar
 2904 size, only proximally covered by pleopod 3..... *Microcerberus stygius* Karaman, 1933

2905 1' Coxae of pereopods 2-4 more or less pointed; male pleopod 2 with elongate rectangular
 2906 sympod, tiny rounded exopod, and apically bifid; Pleopod 4 well covered by pleopod 3,
 2907 biramous, without articulations *Coxicerberus ruffoi* (Chappuis, 1953)

2908

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2934 **7. Malacostraca: Mysida and Stygiomysida**

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2938

2939 **INTRODUCTION**

2940 **Mysida**

2941 Peracarid crustaceans of the order Mysida are recognizable by their shrimp-like habitus, by
2942 separate, stalked eyes, fused cephalothorax, well-developed carapace and tail fan, by swimming
2943 and respiratory currents driven by rotating movements of their thoracic exopods, and by the
2944 absence of gills and of true chelae. The author's own global census (19 Feb. 2021) yielded a
2945 total of 178 genera and 1,190 species considered valid. Doubtful cases excluded, an additional
2946 three genera and nine species are known from the Miocene down to the Triassic (Voicu 1974;
2947 San Vicente & Cartanyà 2017). The main taxonomic groups are the family Petalophthalmidae
2948 with the subfamilies Petalophthalminae and Hansenomysinae, and the family Mysidae with ten
2949 subfamilies, namely Boreomysinae, Erythropinae, Gastrosaccinae, Heteromysinae,
2950 Leptomysinae, Mysidellinae, Mysinae, Palaumysinae, Rhopalophthalminae, and Siriellinae.

2951 Most extant species inhabit marine waters of all major sea basins from the shore down to
2952 the deep sea, usually with greatest species diversity in sublittoral habitats. Most marine and
2953 freshwater species live on or closely above the bottom, often in swarms; a few are pelagic.
2954 Some species burrow just below the sediment surface, others are associated with benthic
2955 invertebrates. Many species hide during the daytime and emerge at night to feed, mate, moult,
2956 and release young. Most species are omnivorous, some are micro-phytophagous, saprophagous,
2957 or carnivorous; none is parasitic. Dense populations can have marked effects on near-bottom
2958 plankton communities. High individual densities occur in turbid, meso- to oligohaline waters
2959 of lagoons and estuaries. Such habitats can provide main pathways for immigration and
2960 adaptation to freshwater. Quantitatively less important pathways involve marine and brackish
2961 groundwater. Reddell (1981) assumes a marine origin of the troglobitic mysids (*i.e.*
2962 Stygiomysida and Mysida) of Mexico, mainly found in brackish groundwater, less frequently
2963 in fresh groundwater. Such a distribution also holds true for the two Mediterranean
2964 Stygiomysida species (see below); however, the only troglobitic Mysida species (*Troglomysis*
2965 *vjetrenicensis*) of the Mediterranean lives exclusively in fresh groundwater.

2966 A total of 26 genera and 75 species of Mysidae (and no Petalophthalmidae) are recorded
2967 in freshwater globally, in part based on single freshwater records of euryhaline species. Within
2968 Mysidae, as many as 71 species belong to the subfamily Mysinae, two to Leptomysinae
2969 (*Americamysis almyra* and *Tenagomysis chiltoni*), one to Heteromysinae (*Deltamysis*
2970 *holmquistae*), and one to Rhopalophthalminae (*Rhopalophthalmus chilensis*). The remaining
2971 six subfamilies have not been recorded in freshwater.

2972 The bulk of freshwater records includes 24 Ponto-Caspian endemics, followed by 12
2973 species from Amazonia and adjacent freshwater systems, nine Mexican, Central American and
2974 Caribbean endemics, nine boreo-arctic species including extrazonal glacial relicts, and six
2975 Mediterranean endemics.

2976 Including species of NE-Atlantic and Ponto-Caspian origin, ten species (adult body size
2977 3–13 mm) have been recorded in Mediterranean freshwaters so far: all belong to the subfamily

2978 Mysinae within the family Mysidae. Among these, four Mediterranean endemics are restricted
2979 to freshwater, and two other endemics occur in fresh as well as brackish water. Among these
2980 six species, as many as four are stenoendemic in the Adriatic Sea, another one in the Eastern
2981 Mediterranean including the Adriatic. The predominance of Adriatic endemics in
2982 Mediterranean freshwaters may have been favoured by alternating marine, lagoony, and
2983 terrestrial phases (Correggiari *et al.*, 1996) of the shallow N-Adriatic shelf during Pleistocene
2984 sea-level changes.

2985 One brackish to marine NE-Atlantic species of Mysidae (*Neomysis integer*) occurs
2986 marginally in freshwaters of the Mediterranean basin. Two freshwater Ponto-Caspian endemics
2987 (*Hemimysis anomala* and *Limnomysis benedeni*) have recently expanded to the Rhône Delta on
2988 the Mediterranean coast of France. Finally, the details of when and how a third Ponto-Caspian
2989 endemic (*Paramysis lacustris*) arrived in an isolated freshwater lake without natural surface
2990 drainage in the highlands of Anatolia remain unknown.

2991

2992 **Stygiomysida**

2993 Two families (Stygiomysidae and Lepidomysidae), only two genera, and 16 species of
2994 Stygiomysida are known globally. They show a Tethyan distribution, extending from Central
2995 America and the Caribbean to Mediterranean and Indian basins (Porter *et al.*, 2008). Both
2996 known Mediterranean species (adult body size 6-13 mm) are stenoendemic in brackish
2997 groundwater in SE- Italy and are rarely found there in freshwater.

2998

2999 **GENERAL ECOLOGY AND DISTRIBUTION**

3000 **Stygiomysida**

3001 This order is represented by only two species in European waters. Both are stenoendemic of
3002 brackish groundwater in SE-Italy and are rarely found in freshwater. Although their eyes are
3003 rudimentary, unpigmented, *Spelaeomysis bottazzii* and to a minor extent also *Stygiomysis*
3004 *hydruntina* are not strictly photophobic: the former species is regularly found in the dimly lit
3005 zone of wells, where it feeds on photoautotrophic organisms (Ariani & Wittmann 2010).

3006 *Stygiomysis hydruntina* has been reported from a few caves and wells near the Adriatic and
3007 Ionian coasts of the Salento Peninsula (SE-Italy). It occurs mainly in deep brackish
3008 groundwater, rarely in near-surface low-salinity waters. Pesce *et al.* (1978) published three
3009 potential freshwater records without indication of salinity; however, a salinity of “0.3‰” is
3010 labelled on the slide containing parts of a male specimen from station PU/23 (own inspection
3011 of material kept at the Museo Civico di Storia Naturale, Verona). Besides, Pesce *et al.* (1978)
3012 indicated Monte Mario coordinates instead of Greenwich coordinates.

3013 *Spelaeomysis bottazzii* has been reported from a number of caves, dolinas, wells, and
3014 springs near the Adriatic and Ionian coasts of the Salento Peninsula and from the Adriatic coast
3015 of Apulia (SE-Italy). It occurs in deep brackish groundwater up to various near-surface
3016 mesohaline to anhaline waters (Inguscio 1998). Breeding females are rare near the surface; most
3017 of them probably inhabit deep groundwater for more than three months of incubation.
3018 Laboratory females assume strongly reduced brood lamellae at the moult following incubation.
3019 This is interpreted as a strategy to replenish the trophic reserves required for sustaining a long
3020 incubation period in deep and trophically poor groundwater (Ariani & Wittmann 2010).

3021 **Mysida**

3022 Only ten species have so far been found in true freshwater (0.0–0.5 psu) of the Mediterranean.
3023 The other two species given in the key below are expected but have not yet been recorded there
3024 in freshwater. Only four Mediterranean endemics are restricted to freshwater habitats:

3025 *Diamysis lacustris* is stenoendemic in Lake Scutari on the SE-coast of the Adriatic Sea,
3026 altitude 6 m; *Troglomysis vjetrenicensis* is stenoendemic in subterranean waters in the
3027 Vjetrenica cave system in Herzegovina, near the E-Adriatic coast, altitude about 224 m;
3028 *Paramysis (Longidentia) adriatica* is known only from tributaries along the northern and
3029 eastern coasts of the Adriatic Sea, altitude 0–2 m. *Paramysis (Serrapalpis) kosswigi* was
3030 reported from Lake Isikli and associated running waters of W-Anatolia draining into the Aegean
3031 Basin, altitude 135–1,007 m; previous records from tributaries of the Black Sea were referred
3032 to the sister species *P. (S.) lacustris* by Wittmann *et al.* (2016).

3033 An additional Mediterranean endemic, *Diamysis fluviatilis*, occurs mainly in freshwater
3034 and to a lesser extent in brackish running waters, wells and estuaries along the northern coasts
3035 of the Adriatic Sea, altitude 0–16 m. Freshwater populations of *D. mesohalobia heterandra* are
3036 confined to the Adriatic basin, altitude 0–3 m. Nonetheless, many more populations inhabit
3037 brackish waters of the E-Mediterranean and Marmora seas.

3038 The Mediterranean endemic *D. hebraica* has not yet been reported from true freshwater. It
3039 has been found in three oligohaline streams and their springs on the coast of Israel (salinity 0.7–
3040 5 psu). An occurrence in the anhaline range appears plausible during potential periods of strong
3041 freshwater input.

3042 *Paramysis (Serrapalpis) lacustris* is indigenous in anhaline to mesohaline waters of the
3043 Ponto-Caspian and Marmora basins. Within the boundaries of the Mediterranean climate, it is
3044 found in the freshwater lakes Kus Gölü and Uluabat Gölü near the southern coast of the
3045 Marmora Sea. Material from the isolated freshwater Lake Beyşehir in the highlands of Anatolia,
3046 altitude 1,115 m, was described as a separate subspecies, the here not acknowledged *Paramysis*
3047 *lacustris turcica* Băcescu, 1948. The hydrological situation is quite complex: according to
3048 Günay (2010), at least part of the runoff enters the Mediterranean catchment through
3049 underground connections. This provides sufficient support for attributing this population to the
3050 Mediterranean fauna. Intensive intentional introductions of *P. lacustris* were made in the
3051 1960s–1970s in waters of Eastern Europe, wherefrom it established in Lithuania and the Gulf
3052 of Finland (Audzijonytė *et al.*, 2017). Non-intentional expansion occurred from the lower to
3053 the middle reach of the Danube River (Borza *et al.*, 2019). If this expansion continues, this
3054 species may follow the below-discussed route to the Mediterranean coast of France.

3055 Two other Ponto-Caspian endemics, *Hemimysis anomala* and *Limnomysis benedeni*, occur
3056 mainly in freshwater but have also been reported in brackish waters. They expanded from the
3057 Black Sea westward along the rivers Danube, Rhine, Rhône, and their associated artificial
3058 canals, and finally southward down to the delta of the Rhône on the Mediterranean coast of
3059 France, where they were first detected in 2007 and 2009, respectively (Wittmann & Ariani
3060 2009; Wittmann *et al.*, 2014).

3061 Two indigenous NE-Atlantic species inhabit brackish to marine waters, and marginally
3062 also freshwaters. *Neomysis integer* inhabits the Mediterranean coasts of Spain and France, but
3063 not elsewhere in the Mediterranean. It occurs marginally in freshwater of the Rhône River delta.
3064 *Mesopodopsis slabberi* is present in great numbers in brackish and marine, rarely in metahaline
3065 waters of the NE-Atlantic, Baltic, Mediterranean, Marmora Sea, Black Sea, and the Sea of

3066 Azov. The lowest salinities for the Mediterranean (0.9–1.4 psu) were reported in the estuaries
3067 of the Rhône and Po rivers and in a brackish drain in Corfu Island (Pesta 1935; Aguesse &
3068 Bigot 1960; Brun 1967). True freshwater records stem only from the Black Sea coast in waters
3069 of the delta and ‘Predelta’ of the Danube (Dedju & Polischuk 1968; Begun & Gomoiu 2007;
3070 Wittmann *et al.*, 2016). Based on studies in Lake Sinoe, a barrier lagoon of the Predelta, Begun
3071 & Gomoiu (2007) concluded that this species is episodically found in freshwater but cannot
3072 form stable populations there. *M. slabberi* was recorded in this lagoon only under oligohaline
3073 conditions (1.1–2.1 psu) upon own sampling in 1985, 1998, and 2008.

3074

3075 TERMINOLOGY AND MORPHOLOGY

3076 The terminology used here is according to Wittmann *et al.* (2016). Only features using standard
3077 microscopy without dissection are considered below. Gross morphology and additional features
3078 are available in Daneliya *et al.* (2019), with a focus on Ponto-Caspian species.

3079 Among Malacostraca, the orders Stygiomysida and Mysida were formerly lumped
3080 together in the order Mysidacea based on their shared separate, stalked eyes at least in
3081 postnauplioid larvae (known so far), a respiratory carapace fused only with anterior thoracic
3082 somites, first and second antennae each with a three-segmented trunk, eight pairs of mostly
3083 biramous thoracopods (including maxillipeds), and the absence of gills. To our knowledge, the
3084 inner rami (endopods) are used for feeding and climbing, generally not for walking, and the
3085 outer rami (exopods) for swimming and driving respiratory currents through rotating
3086 movements. Both orders show five pairs of non-respiratory, non-natatory pleopods. A
3087 marsupium is formed by 1–7 pairs of oostegites (marsupial plates) arising as epipods in
3088 continuous series, starting with the ultimate thoracopod. The young pass through one embryonic
3089 (egg) and two non-feeding larval stages in the marsupium, where they receive parental care
3090 rather than being merely stored, at least Mysida do so.

3091 Based on genetic analyses, Meland & Willassen (2007) positioned the family
3092 Stygiomysidae closer to Mictacea than to Mysida, and proposed to establish Stygiomysida and
3093 Mysida as separate orders. The post-larval stages of Stygiomysida are distinguished from those
3094 of Mysida by reduced eyes, the presence of a spiny ventral lobe on the endopod of uropods
3095 (Figs. 7.16A,B; together with the telson forming a strong tail fan), by two laminar lobes flanking
3096 the male genital orifice instead of tubular penes, and by the absence of statocysts. All the
3097 Mysida dealt with here belong to the family Mysidae and are characterized by a large statocyst
3098 at the basis of the endopod of uropods. This organ contains one exceptionally large statolith
3099 (Fig. 7.16C) in the animal kingdom. The statoliths of most freshwater species, here represented
3100 by certain species of *Hemimysis*, *Limnomysis*, *Diamysis*, and *Paramysis*, are opaque because
3101 they are mineralized with vaterite, a metastable form of calcium carbonate. The statoliths of
3102 most marine and brackish-water species, and of just a few freshwater species (dealt with below:
3103 *Troglomysis*; rare in freshwater: *Mesopodopsis*, *Neomysis*) appear transparent and vitreous
3104 because they are mineralized with fluorite (CaF₂). However, statoliths can be damaged and may
3105 even vanish as fixation and preservation artefacts.

3106 Both Stygiomysida species known in the Mediterranean are readily distinguished by body
3107 shape (Figs. 7.14, 7.15) and size of the ventral lobe on the endopod of uropods (Figs. 7.16A,
3108 B). Careful inspection of antennal scale (Fig. 7.18) and telson (Fig. 7.19) are sufficient for
3109 identification of three Mysida species living in freshwaters of the Mediterranean. Among
3110 additional features, the strongly reduced, obviously dysfunctional cornea (Fig. 7.20B) is a key
3111 feature to identify *Troglomysis*, whereas the structure of the carapace (Fig. 7.20) and of the

3112 thoracic exopods (Fig. 7.21) are important diagnostic features for *Diamysis*. For certain
3113 *Paramysis*, inspection of the paradactylary setae (Fig. 7.22; modified setae flanking the dactylus
3114 of thoracic endopods 3–8) is necessary for identification.

3115

3116 **COLLECTION, PREPARATION, AND PRESERVATION**

3117 Mysids are sampled during day and night with nets operated from the shore, with diver-operated
3118 nets, bottom nets, and epibenthic sledges. Baited bottle traps exposed overnight, and empty
3119 mollusc shells, stones with holes, discarded bottles etc. collected during the day are treated *ex*
3120 *situ* with a few drops of clove oil to expel the animals. Fixation and preservation are performed
3121 with ethanol 80% for morphological analysis or 95% for genetic analysis. Identification at
3122 species level may require dissection, mounting of body parts and appendages on slides, and
3123 subsequent examination using a 400x or higher-magnification microscope. Specimens in
3124 propylene glycol, glycerol, or ethanol can be handled under a low-power microscope with
3125 needles. Glycerol is used as an embedding medium for short-term slides, particularly for
3126 inspection of mineral statoliths that can be damaged by other media. The water-tolerant Swan-
3127 medium makes minute, superimposed objects well discernible owing to its strong bleaching
3128 power. After hardening at 60°C for about 15 h, it requires very careful sealing within about one
3129 month to obtain multi-annual slides. Canada-Balsam requires dehydration in ascending ethanol
3130 series. It is recommended for permanent slides intended for deposition of museum specimens.

3131

3132 **LIMITATIONS**

3133 The key below is designed to cover all currently recognized freshwater mysidacean species of
3134 the Mediterranean. Rare records are included, unless they are insufficiently documented.
3135 Taxonomic synonymy is updated. Secondary sexual characteristics are crucial for the taxonomy
3136 of Mysida, but are restricted here in order to obtain a short-cut key applicable to specimens of
3137 any sex and stage of maturity (except juveniles in some cases).

3138 Freshwater is defined as water with a salinity range of 0.0–0.5 practical salinity units
3139 (psu). Two species occurring in brackish waters of the Mediterranean (but so far recorded only
3140 in near but not pure freshwater) are included for potentially prolonging the validity of the key:
3141 *Diamysis hebraica* from a documented lowest salinity of 0.7 psu, and *Mesopodopsis slabberi*
3142 found at a minimum of 0.9 psu. The latter species repeatedly found in true freshwaters of the
3143 Danube Delta along the Black Sea coast but not elsewhere in freshwater.

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3146 The author is greatly indebted to Salvatore Inguscio (Nardò) for providing photos of
3147 Stygiomysida. Sincere thanks to Mikhail Daneliya (Helsinki) and to W. Wayne Price (Tampa)
3148 for important information about freshwater distribution of mysids.

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KEY TO MYSIDA AND STYGIOMYSIDA

Key to orders Mysida and Stygiomysida

- 1 Endopod of uropods with very large statocyst; sympod without ventral lobe (Fig. 7.16C);
cornea mostly well-developed (Figs. 7.17; 7.20A, C–F), rarely reduced (Fig. 20B) Mysida
(one family: Mysidae)
- 1' Endopod of uropods without statocyst; sympod with spiny ventral lobe (Figs. 7.16A,B);
cornea reduced (Figs. 7.14, 7.15) Stygiomysida

Key to species of Stygiomysida

- 1 Habitus vermiform (Fig. 7.14), resembling the co-occurring thermosbaenacean *Monodella stygicola* Ruffo, 1949; sympod of uropods with ventral lobe more than half length of unsegmented exopod (Fig. 7.16A) Stygiomysidae
(One species: *Stygiomysis hydruntina* Caroli, 1937)
[SE-Italy; mostly in brackish groundwater, occasionally also in freshwater]
- 1' Habitus moderately stout, shrimp-like (Fig. 7.15); sympod of uropods with ventral lobe less than 1/4 length of two-segmented exopod (Fig. 7.16B) Lepidomysidae
(One species: *Spelaeomysis bottazii* Caroli, 1924)
[SE-Italy; mostly in brackish groundwater, also in freshwater]

Key to Genera of Mysidae

- 1 Antennal scale setose all around (Figs. 7.18C–H) 3
- 1' Antennal scale with setose margins except for a proximal bare portion of outer margin (Figs. 7.18A,B) 2
- 2(1') Outer margin of antennal scale with smooth portion ending in setae (Fig. 7.18B) *Hemimysis*
(One species: *H. anomala* G.O. Sars, 1907)
[Ponto-Caspian endemic; invasive in large parts of Europe and North America; expansion in the Rhône system down to the Mediterranean coast; mainly in freshwater]
- 2' Outer margin of antennal scale with smooth portion ending in a tooth (Fig. 7.18A) *Paramysis*

| | | |
|------|---|---------------------|
| 3189 | | |
| 3190 | 3(1) Telson entire, slender, subtriangular (Fig. 7.19A) | <i>Neomysis</i> |
| 3191 | (One species: <i>N. integer</i> (Leach, 1814)) | |
| 3192 | [NE-Atlantic and NW-Mediterranean; mainly in brackish and marine waters, marginally in | |
| 3193 | freshwater] | |
| 3194 | 3' Telson rhombohedral to subrectangular, with apical cleft (Figs. 7.19B, D–H) | 4 |
| 3195 | | |
| 3196 | 4(3) Telson without median lobe (Figs. 7.19D–H); eyestalks less than three times length of | |
| 3197 | cornea (Figs. 7.20C–F) | 5 |
| 3198 | 4' Telson with large median lobe emerging from broad apical cleft (Fig. 7.19B); eyestalks 3–4 | |
| 3199 | times as long as cornea (Fig. 7.20A) | <i>Mesopodopsis</i> |
| 3200 | (One species: <i>M. slabberi</i> (Van Beneden, 1861)) | |
| 3201 | [NE-Atlantic, Baltic, Mediterranean, Marmora, and Ponto-Azov Seas; in oligo- to euhaline, | |
| 3202 | rarely metahaline waters, episodically in freshwater of only the Danube Delta] | |
| 3203 | | |
| 3204 | 5(4) Apical segment less than 20% antennal scale length; scale terminally broadly rounded in | |
| 3205 | both sexes (Figs. 7.18G, H) | 6 |
| 3206 | 5' Apical segment of antennal scale 25–33% of scale length; scale terminally rounded in | |
| 3207 | females (Fig. 7.18F), bluntly pointed in males (Fig. 7.18E) | <i>Limnomysis</i> |
| 3208 | (One species: <i>L. benedeni</i> Czerniavsky, 1882) | |
| 3209 | [Ponto-Caspian endemic; introduced in Lake Balaton, Lake Aral, and waters of | |
| 3210 | Turkmenistan; expansion to large parts of Europe, including the Rhône Delta at the | |
| 3211 | Mediterranean coast; mainly in freshwater, also brackish] | |
| 3212 | | |
| 3213 | 6(5) Cornea rudimentary, without pigment (Fig. 7.20B) | <i>Troglomysis</i> |
| 3214 | (One species: <i>T. vjetrenicensis</i> Stammer, 1933) | |
| 3215 | [subterranean freshwaters in the cave Vjetrenica system, near the E-Adriatic coast] | |
| 3216 | 6' Cornea normal, well pigmented (Figs. 7.20 C–F) | <i>Diamysis</i> |

3217

3218 **Key to species of *Diamysis***

| | | |
|------|--|---|
| 3219 | 1 Rostrum well rounded or forming a wide convex angle with rounded tip (Figs. 7.20 D–F) .. | 2 |
| 3220 | 1' Rostrum angular, with acute or narrowly rounded tip (Fig. 7.20 C) | |
| 3221 | <i>Diamysis lacustris</i> Băcescu, 1940 | |
| 3222 | [freshwater Lake Scutari at the SE-coast of the Adriatic Sea] | |
| 3223 | | |
| 3224 | 2(1) Basal plate of thoracic exopods 1–3 terminally ending in a spiniform projection (Fig. | |
| 3225 | 7.21A) | 3 |
| 3226 | 2' Basal plate of thoracic exopods 1–3 terminally well rounded (Fig. 7.21B) | |
| 3227 | <i>Diamysis hebraica</i> Almeida Prado-Por, 1981 | |
| 3228 | [oligohaline streams at the coast of Israel; not yet found in true freshwater] | |

- 3229
- 3230 3(2) Rostrum well rounded; male carapace with fringes arranged in only one pair of submedian
 3231 stripes (Fig. 7.20D); female carapace without fringes
 3232 *Diamysis fluviatilis* Wittmann & Ariani, 2012
 3233 [tributaries of the N-Adriatic; mainly in freshwater]
- 3234 3' Rostrum forms a wide convex angle with rounded tip; male carapace with fringes arranged
 3235 in 1–2 pairs of submedian stripes plus a transverse row shortly in front of the posterior
 3236 margin (Fig. 7.20E); female carapace without fringes
 3237 *Diamysis mesohalobia heterandra* Ariani & Wittmann, 2000
 3238 [Adriatic, Ionian, and Marmora Seas; fresh and brackish waters]

3239

3240 **Key to species of *Paramysis***

- 3241 1 Telson with shallow cleft forming an angle of more than 120° (Fig. 7.19G) 2
- 3242 1' Telson with strong, subrectangular cleft (Fig. 7.19H)
 3243 *Paramysis (Longidentia) adriatica* Wittmann, Ariani & Daneliya, 2016
 3244 [freshwater tributaries of the Adriatic Sea]
- 3245
- 3246 2(1) Denticulate paradactylary setae of thoracic endopods 5–8 'serrated' only along proximal
 3247 50–65% length (Fig. 7.22A); cephalic region swollen (if well preserved)
 3248 *Paramysis (Serrapalpis) kosswigi* Băcescu, 1948
 3249 [freshwaters of W-Anatolia draining into the Aegean Basin]
- 3250 2' Denticulate paradactylary setae of thoracic endopods 5–8 'serrated' over 70–80% length (Fig.
 3251 7.22B); cephalic region not swollen
 3252 *Paramysis (Serrapalpis) lacustris* (Czerniavsky, 1882)
 3253 [expansive Ponto-Caspian endemic, also in (near)-Mediterranean freshwater lakes of
 3254 Turkey]

3255

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 3258 Stygiomysida. Sincere thanks to Mikhail Daneliya (Helsinki) and to W. Wayne Price (Tampa)
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3260

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3312 **8. Malacostraca: Thermosbaenacea**

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3316

3317 **INTRODUCTION**

3318 Thermosbaenacea Monod 1927 are an obscure group of small crustaceans living in
3319 groundwaters. Their taxonomic position was debated over for a long time before they were
3320 finally classified with Peracarida (see Wagner, 1994 for details). Their small size makes them
3321 difficult to identify in the field, and their elongate vermiform and somewhat dorsoventrally
3322 flattened body makes them look like microisopods or copepods. However, they are easily
3323 recognizable under a stereomicroscope from the presence of an obvious dorsal carapace. They
3324 differ from Mysidacea and Decapoda in that they are eyeless and have reduced pleopods present
3325 only on their first two abdominal segments.

3326 The biogeographic origin of Thermosbaenacea still remains to be elucidated because
3327 available information is very scarce. We already know that their distribution area falls within
3328 the boundaries of the ancient Tethys belt, indicating that they may have had a very old ancestor
3329 in the Mesozoic period (252 to 66 Mya), close to Halosbaenidae that are the only known family
3330 distributed worldwide.

3331 However, the diversification process likely occurred in the Mediterranean basin between
3332 the marine regression of the late Miocene period and the Messinian salinity crisis ($\cong 5.5$ Mya)
3333 for the *Tethysbaena atlantomaroccana* group and the marine transgression during the Pliocene
3334 period (2.5-5 Mya) for the *Tethysbaena argentarii* group (Wagner, 1994).

3335 Among the 40 Thermosbaenacea species recorded worldwide (Horton et al., 2020), less
3336 than 20 occur in freshwaters, among which 12 are present in the Mediterranean basin. A total
3337 of 3 families, 4 genera and 12 species are recorded in the Mediterranean basin, all of them
3338 endemic to the region.

3339

3340 **GENERAL ECOLOGY AND DISTRIBUTION**

3341 Thermosbaenacea are all obligate groundwater species and colonize all types of marine
3342 and continental waters, even if they are always located close to the sea and are more frequent
3343 in marine and brackish waters. Some species can colonize hot water springs; for example, the
3344 type locality of *Thermosbaena mirabilis* has a temperature ranging from 44.5 to 48°C. They
3345 have a strong affinity to low oxygen concentrations and are resistant to high temperatures and
3346 the presence of hydrogen sulfide (H₂S); near-anoxic conditions are even more favourable to
3347 them (Wagner, 2012). They are mainly found in detritus, but likely feed on bacteria and algae
3348 growing on detritus.

3349

3350 **TERMINOLOGY AND MORPHOLOGY**

3351 Thermosbaenacea are small-sized Malacostraca, generally less than 5 mm long. Their body is
3352 elongate, vermiform and slightly flattened dorsoventrally, except *T. mirabilis* whose body is
3353 wider and looks like a flabelliform isopod.

3354 Their body consists of a more or less developed carapace, a thorax formed of 8 segments
3355 (thoracomeres 1-8), a pleon with generally 6 segments (except Thermosbaenidae whose sixth
3356 pleonite is fused with the telson forming a pleotelson) (Figure 7.23).

3357 The cephalic capsule is fused with the thoracic tergum through the maxillipedal
3358 metamere, and partly fused with the second thoracomere to form the carapace. The upper pair
3359 is antennae 1, with a basal peduncle of three articles and a distal flagellum of several articles
3360 with aesthetascs. The third peduncular article also bears an accessory flagellum on its distal
3361 end, usually composed of a reduced number of tiny cylindrical articles. The second pair of
3362 antennae is shorter than the first one; it has a flagellum of 8-11 small articles and a peduncle of
3363 five articles. Eyes are absent, but ocular scales can be present in some genera (e.g.
3364 *Limnosbaena*). A dorsal brood pouch is formed in ovigerous females, as an extension of the
3365 carapace, wherein eggs and juveniles are incubated. Their mouthpart is on the ventral surface
3366 below their carapace and is composed of the labrum, labium, mandibles, maxillae I and II, and
3367 maxilliped, all laterally connected to the carapace (see Wagner, 1994 for details).

3368 The thorax bears different kinds of legs generally eight pairs of biramous appendages,
3369 except for *Limnosbaena* (uniramous), the first of which are used as accessory mouthparts. One
3370 pair of gnathopods (modified pereopod 1) is possibly used for grasping detritus, the next six
3371 pairs are walking legs (pereopods 2 – 7), except in *Thermosbaena* only has 5 pereopods.

3372 The pleon is composed of six segments (only five in *Thermosbaena*), but only three
3373 pairs of appendages. The first two pleonites bear a pair of reduced pleopods (pleopods 1-2); the
3374 first pair is scale-like in Halosbaenidae, and the last pleonite has a well-developed pair of
3375 biramous uropods. In *Thermosbaena*, the uropod is attached to the pleotelson and the
3376 endopodite is strongly reduced. Finally, a free telson (or pleotelson) is attached to the last
3377 pleonite and corresponds to the last part of the body. The shape and armature of the telson are
3378 typical of each genus and of each species to a lesser extent.
3379

3380 **COLLECTION, PREPARATION, AND IDENTIFICATION**

3381 Thermosbaenacea are very rare and present only in groundwaters (aquifers, caves or
3382 springs). Therefore, any kind of specific material for this environment (Malard et al., 2002) can
3383 be used to collect them. Some species were even collected using a suction bottle or jars operated
3384 by divers in caves. Thermosbaenacea can be easily fixed and preserved in 2% buffered
3385 glutaraldehyde or in 95% ethanol for genetic analysis.

3386 Determination at the species level requires dissection, mounting of body parts and
3387 appendages on slides, and subsequent examination using a 400x or higher-magnification
3388 microscope or even observation in scanning electron microscopy (SEM) (e.g. *Tethysbaena*
3389 *argentarii* group). Specimens in glycerol or ethanol can be handled under a low-power
3390 microscope with needles. Baths in clearing solution (e.g. soft acids) and cuticular staining (e.g.
3391 black chlorazol B) can be helpful. A same specimen can be used for both studies: the abdomen
3392 for DNA extraction and the other parts for dissection and mounting. This procedure ensures
3393 that the sequenced genes correspond to the same morphotype.

3394 Taxonomic identification to the species level is generally based on males (if available), but
3395 females can be used too. Chaetotaxy is complex but very important for identification. The most
3396 important body parts for identification are the antennae, mouthparts, pereopod, pleopods,
3397 uropods and telson, but additional body parts need to be examined to identify certain species.
3398

3399 **LIMITATIONS**

3400 Thermosbaenacea remain a poorly known order, with only ~ 40 species described
3401 worldwide and hardly any molecular study to confirm their taxonomy. As a consequence, some
3402 families, genera and species names may change in the future, and many species are still to be
3403 found. The keys below are designed to cover the 12 species inhabiting fresh and brackish waters
3404 of the Mediterranean basin. Rare records are included, unless they are insufficiently
3405 documented.

3406 Even if our keys were designed to be as clear as possible, we should keep in mind that
3407 identifying certain groups (e.g. the *Tethysbaena argentarii* group) is difficult and requires
3408 strong expertise. Do not hesitate to use alternative information or keys (e.g. Wagner 1994) to
3409 consolidate your conclusions. We should remain aware that the keys are designed for species
3410 of the Mediterranean basin; they are not adapted to other amphipods worldwide, even at the
3411 family level.
3412

3413 **KEYS TO THERMOSBAENACEA**

3414 Adapted from (Wagner, 1994)

3415 **Key to family of Thermosbaenacea**

3416 1 Body elongate; 7 pairs of pereopods; telson separate from pleonite 6 2

3417 1' Body distinctly wider than high; 5 pairs of pereopods; telson fused with pleonite

3418 Thermosbaenidae

3419 (one species: *Thermosbaena mirabilis* Monod, 1924)

3420 [Tunisia]

3421

3422 2(1) Ocular scales absent; gnathopods with one strong serrate seta forming the unguis; propodus
3423 of gnathopods with spur; pleopod 1 with basal articulation Monodellidae

3424 [Peri-Mediterranean]

3425 2' Ocular scales present; gnathopods with two or three (more or less modified) strong serrate
3426 seta forming a claw; propodus of gnathopods lacking spur; pleopod 1 with a small
3427 unarticulated lobe Halosbaenidae

3428 (one species: *Limnosbaena finki* (Mestrov & Lattinger-Penko, 1969))

3429 [Balkan]

3430 **Key to Monodellidae genera and species**

3431 1 Antenna 1 with 6 to 12 articles on the main flagellum; carpus of gnathopods with three long
3432 teasel setae; second segment of exopodite of pereopod 5 with medial plumose setae and with
3433 or without vestigial lateral seta; telson with group of three cuspidate setae on the distal
3434 corners 2 (genus *Tethysbaena*)

3435 [peri-mediterranean]

3436 1' Antenna 1 with 10 articles on the main flagellum; carpus of gnathopods with four long strong
3437 teazel setae; second segment of exopodite of pereopod 5 without medial and lateral plumose
3438 setae; telson with group of two cuspidate setae on the distal corners

3439 *Monodella*

3440 (one species *M. stygicola* Ruffo, 1949)

3441 [Italy]
3442
3443 2(1) Telson wider than long; anal lobes protruding beyond the terminal stretch of the telson
3444 3
3445 2' Telson longer than wide; anal lobes not protruding beyond the terminal stretch of the telson
3446 4
3447
3448 3(2) Antenna 1 main flagellum with 7 articles; Maxilla 1 palp second article with 9 setules;
3449 Uropod endopodite with 18-22 plumose setae *T. ophelicola* Wagner 2012
3450 3' Antenna 1 main flagellum with 8 articles; Maxilla 1 palp second article with 4 setules;
3451 Uropod endopodite with 18-22 plumose setae *T. relictata* (Pór, 1962)
3452
3453 4(2') Terminal stretch of the telson with one or more protuberances 5
3454 4'Terminal stretch of the telson with one or more protuberances *T. argentarii*-group
3455 (*T. argentarii* (Stella, 1951), *T. aiakos* Wagner, 1994, *T. halophile* (S. Karaman, 1953), *T.*
3456 *scabra* (Pretus, 1991) and *T. siracusae* Wagner, 1994)*
3457 *The accurate identification of each species of the group needs SEM microscopy.
3458
3459 Article 2 of the mandibular palp with 6 plumidenticulate setae; Maxilla 2 outer lobe with 17
3460 rake-like terminal setae; the presence of an additional dorsolateral subplumose seta on
3461 pleopod 2; Medial margin of the first segment of the exopodite of uropod with 5 stout
3462 plumose setae *T. atlantomaroccana* (Boutin & Cals, 1985)
3463 5'. Article 2 of the mandibular palp with 5 plumidenticulate setae; Maxilla 2 outer lobe with 25
3464 rake-like terminal setae; the absence of an additional dorsolateral subplumose seta on
3465 pleopod 2; Medial margin of the first segment of the exopodite of uropod with 4 stout
3466 plumose setae *T. tarsiensis* Wagner, 1994
3467
3468

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3477 <https://doi.org/10.1163/156854012X651646>

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3482 Table 1. Mediterranean and global species diversity per order belonging to Malacostraca. The
3483 reference values of global diversity are those provided in (Balian *et al.*, 2008) and updated with
3484 the World Register of Marine Species (Horton *et al.*, 2020) and the present study.

| | Mediterranean basin | Global |
|------------------------|----------------------------|---------------|
| Amphipoda | 581 | 1,866 |
| Bathynellacea | 71 | 219 |
| Decapoda | 63 | 2,832 |
| Ingolfiellida | 9 | 20 |
| Isopoda | 336 | 994 |
| Mysida | 12 | 60 |
| Stygiomysida | 2 | 5 |
| Thermosbaenacea | 12 | 20 |
| Total | 1,084 | 6,014 |

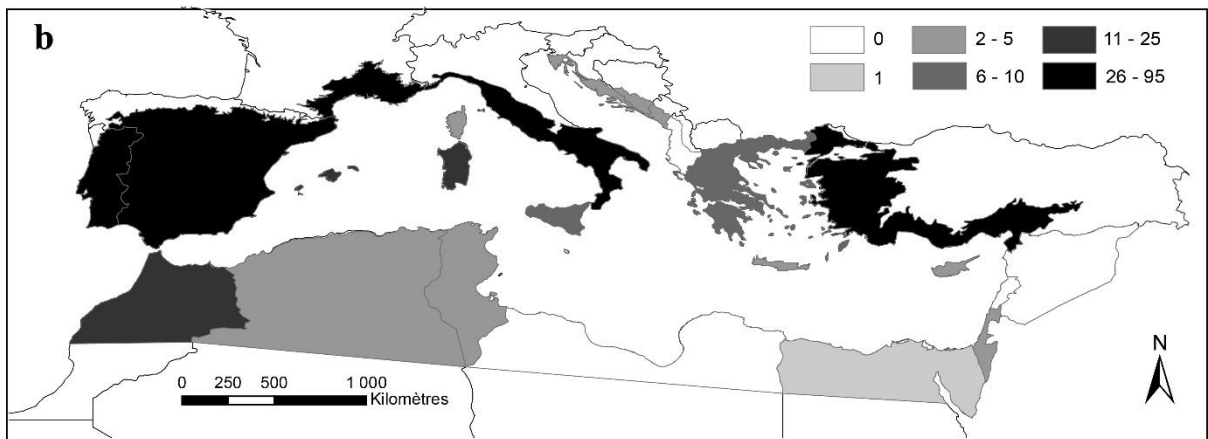
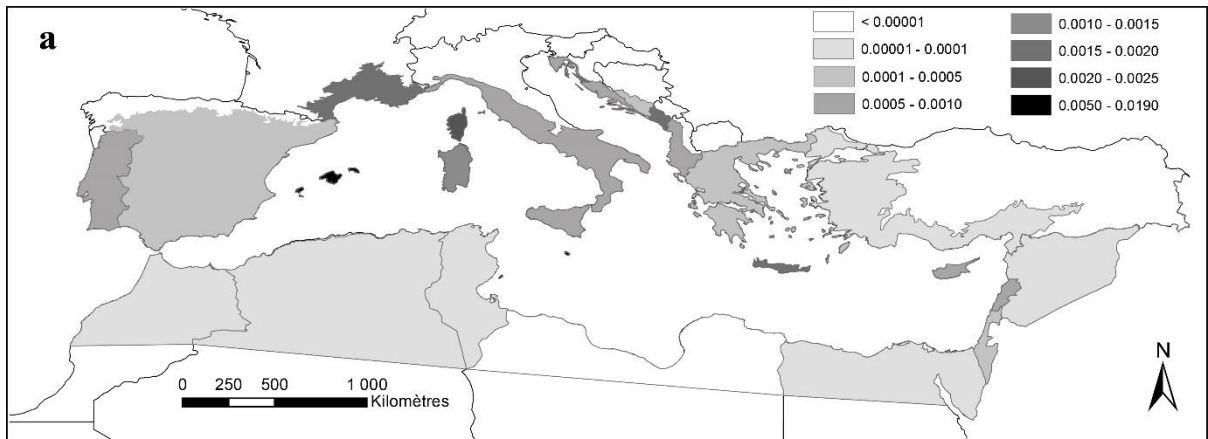
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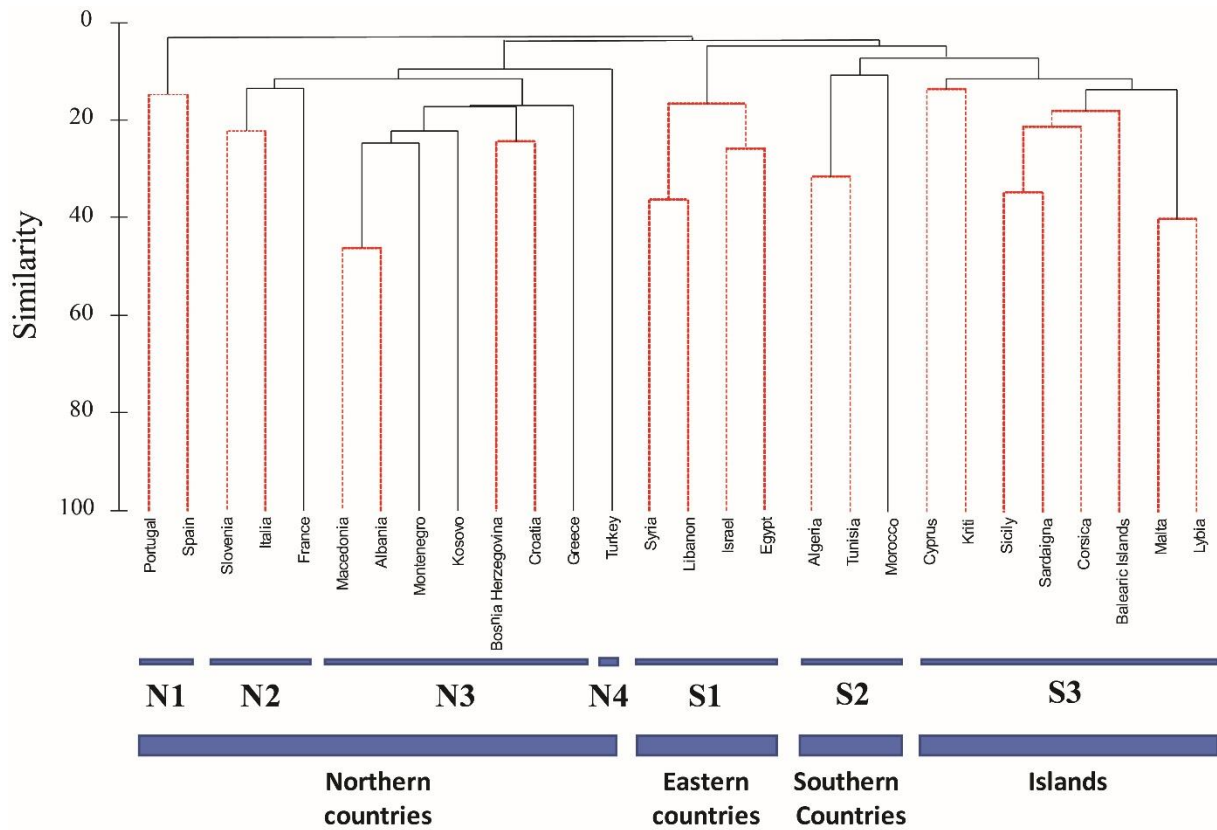
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3491 Fig. 7.1. Geographic distribution of Malacostraca in the Mediterranean bioclimatic area. A,
 3492 species richness was weighted by the country area (species.km⁻²); B, the number of endemic
 3493 species is given for each country.

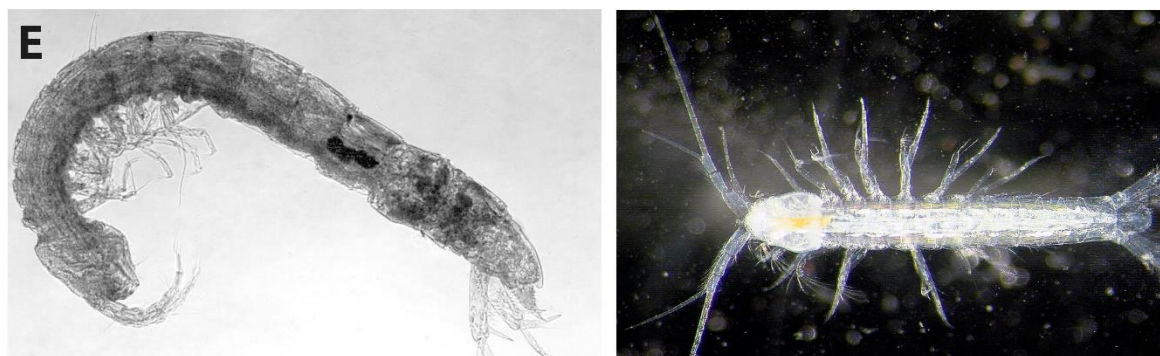
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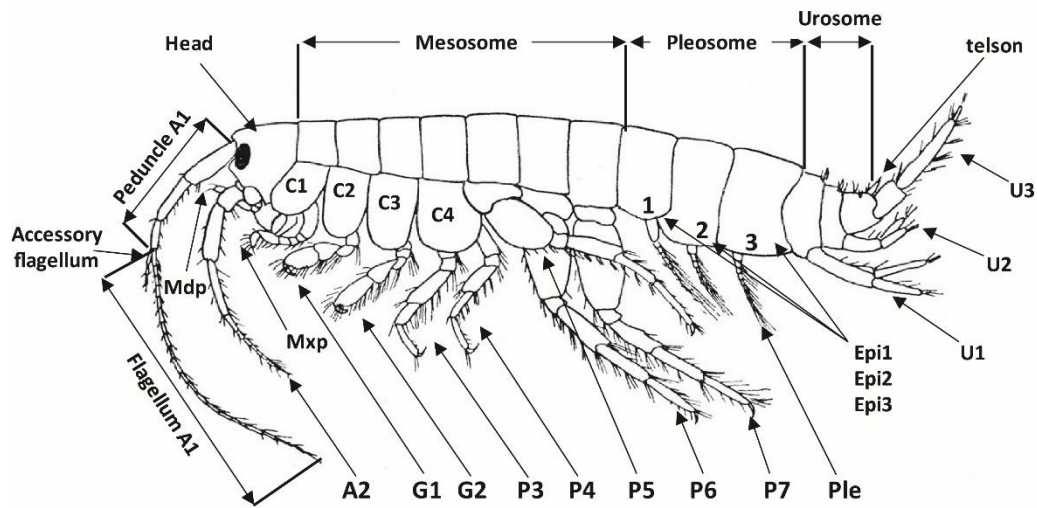
3496 Fig. 7.2. Results of the hierarchical cluster analysis of Bray Curtis similarity of faunal lists.
 3497 Solid lines indicate significant differences ($P < 0.05$) using SIMPROF tests (Clarke, Somerfield
 3498 & Gorley, 2008) and dashed lines indicate groups of samples not significantly separated by the
 3499 test.

3500



3501

3502 Fig. 7.3. General aspect of Malacostraca. A, from left to right *Dikerogammarus villosus*
 3503 (Amphipoda, Gammaridae), *Chelicorophium robustum* (Amphipoda: Corophiidae) and
 3504 *Niphargus schellenbergi* (Amphipoda: Nirphargidae), photograph courtesy of JF Cart; B, from
 3505 left to right *Pascifastacus leniusculus* (Decapoda: Astacidae), photograph courtesy of J.F. Cart,
 3506 *Atyaephyra thymisensis* (Decapoda: Atyidae) and *Potamon hippocratis* (Decapoda:
 3507 Potamidae), photograph courtesy of W. Klotz; C, *Asellus aquaticus* (Isopoda: Asellidae),
 3508 photograph credit of C. Piscart; D, *Hemimysis anomala* (Mysida: Mysidae), photograph
 3509 courtesy of J.F. Cart; E, *Iberobathynella andalusica* (Bathynellacea: Parabathynellidae),
 3510 photograph credit of I Camacho; F, *Tethysbaena ledoyeri* (Thermaosbaenacea: Monodellidae),
 3511 photograph courtesy of P. Chevaldonné/CNRS.



- A1 – A2 : Antennae 1 and 2
- Mdp : Mandibular palp
- C1 – C4 : Coxae 1 – 4
- G1 – G2 : Gnathopods 1 – 2
- P3 – P7 : Pereiopods 3 – 7
- Ple : Pleopods
- Epi 1 – Epi 3 : Epimeron 1 – 3
- U1 – U3 : Uropods 1 – 3

3512

3513 Fig. 7.4. General morphology of Amphipoda.

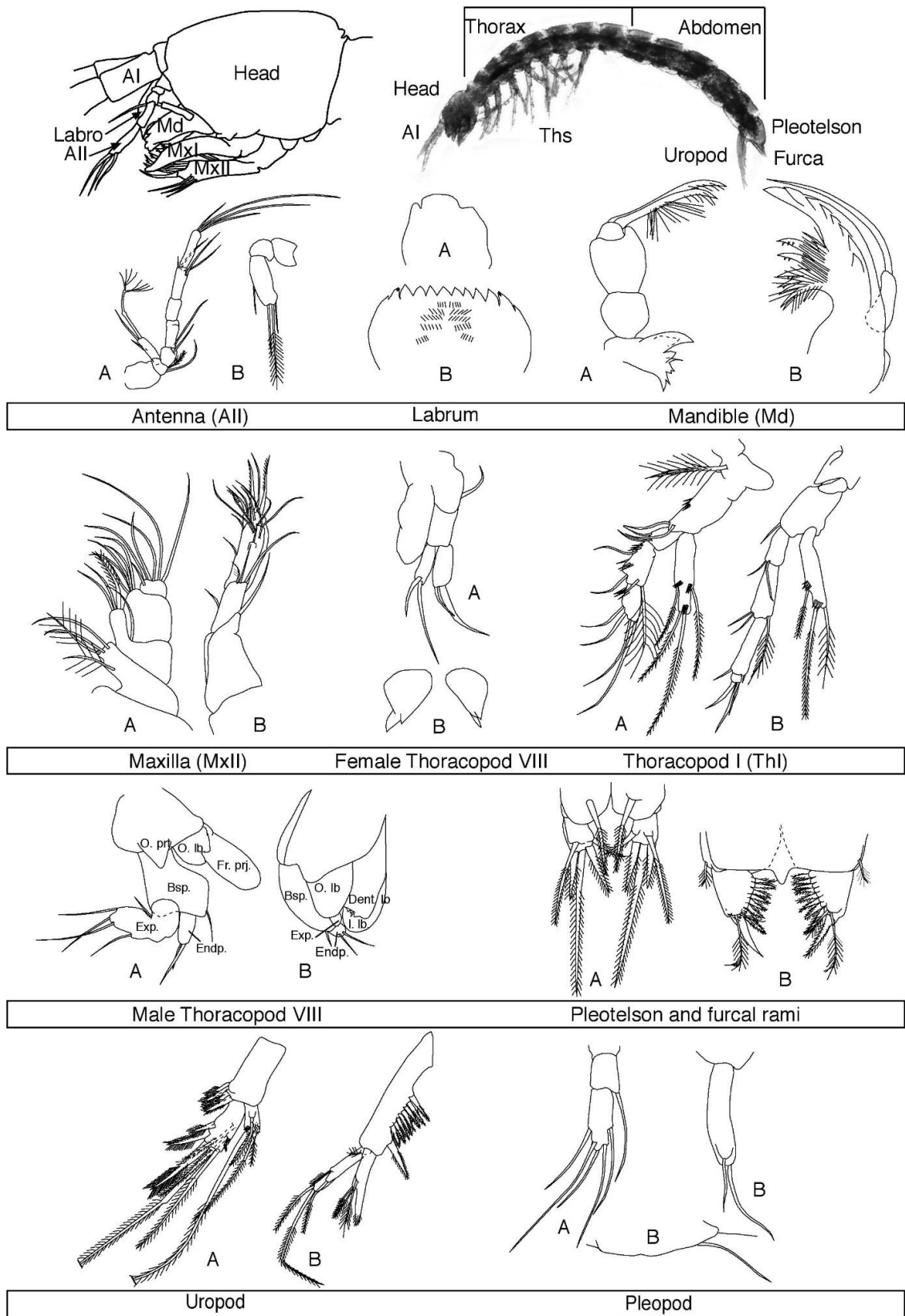
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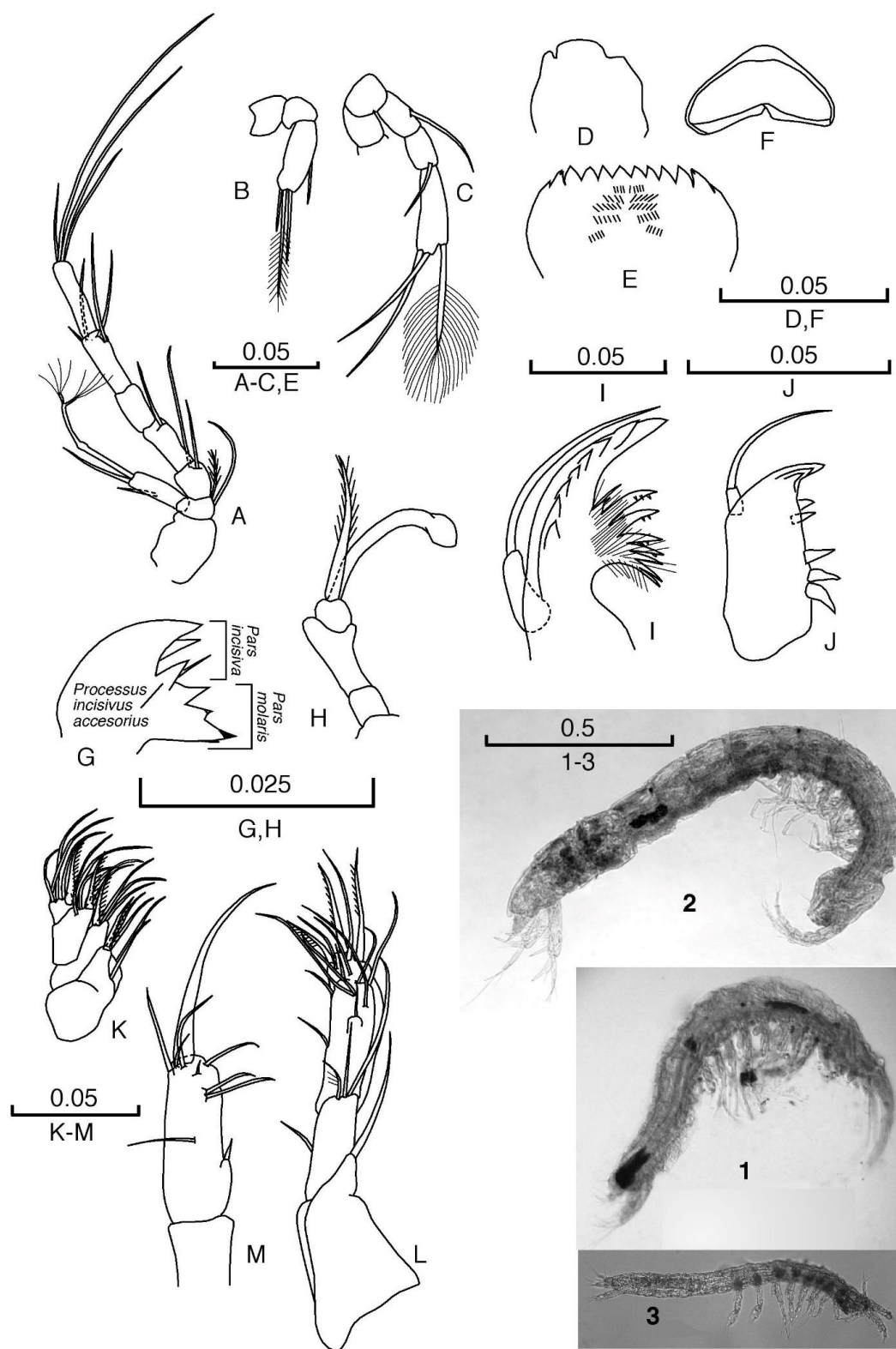
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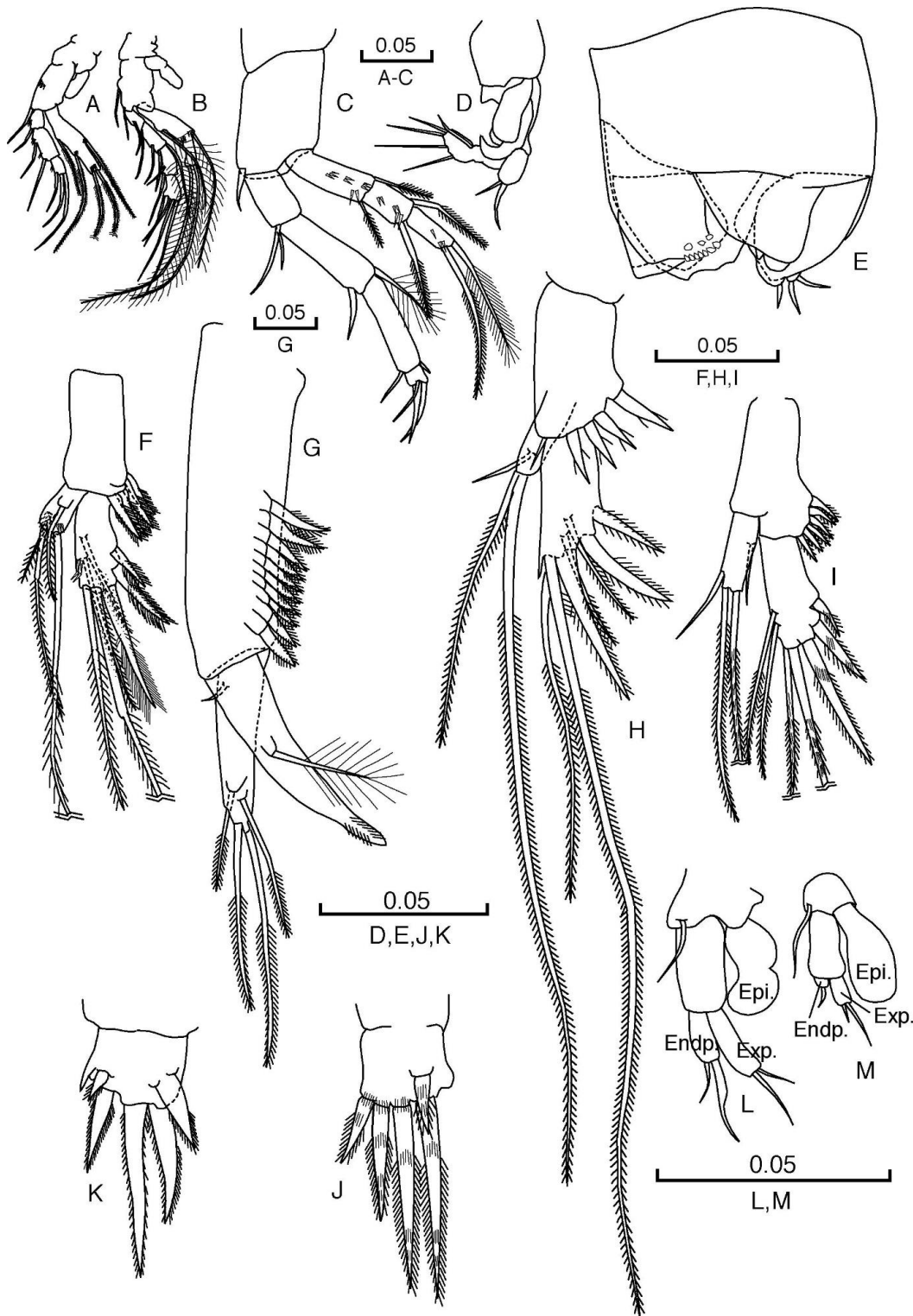
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3520 Fig. 7.5. Head of Parabathynellidae and habitus of *Iberobathynella*. Schematic parts of
 3521 Bathynellacea body. A Bathynellidae family and B Parabathynellidae family.



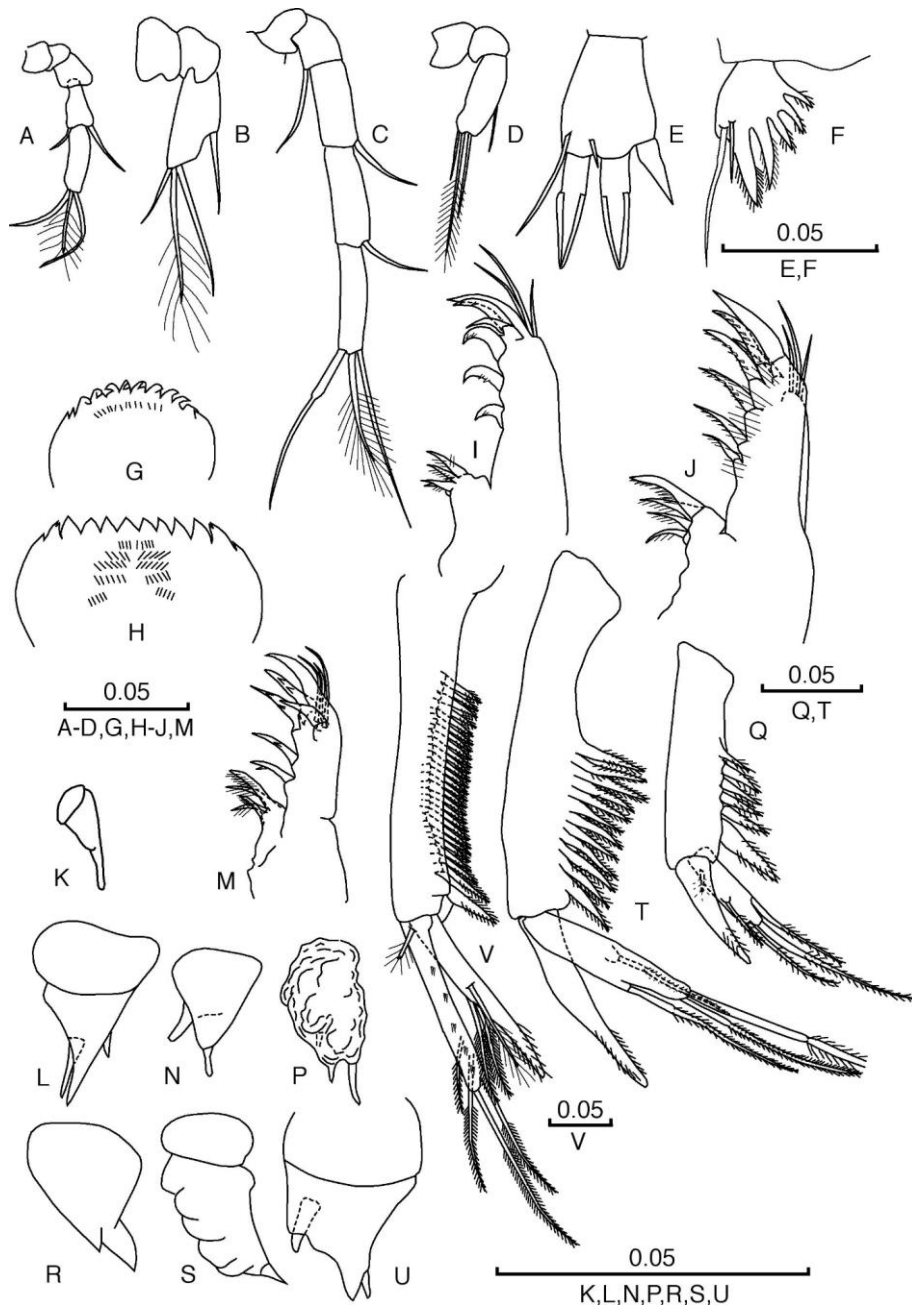
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3523 Fig. 7.6. Habitus: 1, *Vejdovskymbathynella edelweiss* Camacho, 2007; 2, *Iberobathynella*
 3524 *andalusica* Camacho, 2007 and 3, *Parvulobathynella distincta* Ranga Reddy, Bandari &
 3525 Totakura, 2011. AII: A, *Vejdovskymbathynella edelweiss*; B, *Iberobathynella andalusica* and C,
 3526 *Parvulobathynella distincta*. Labrum: D, *Vejdovskymbathynella edelweiss*; E, *Iberobathynella*
 3527 *andalusica* and F, *Parvulobathynella distincta*. Md: D, E, *Vejdovskymbathynella edelweiss*; I,
 3528 *Iberobathynella andalusica* and J, *Parvulobathynella distincta*. MxII: K, *Vejdovskymbathynella*
 3529 *edelweiss*; L, *Iberobathynella andalusica* and M, *Parvulobathynella distincta*.



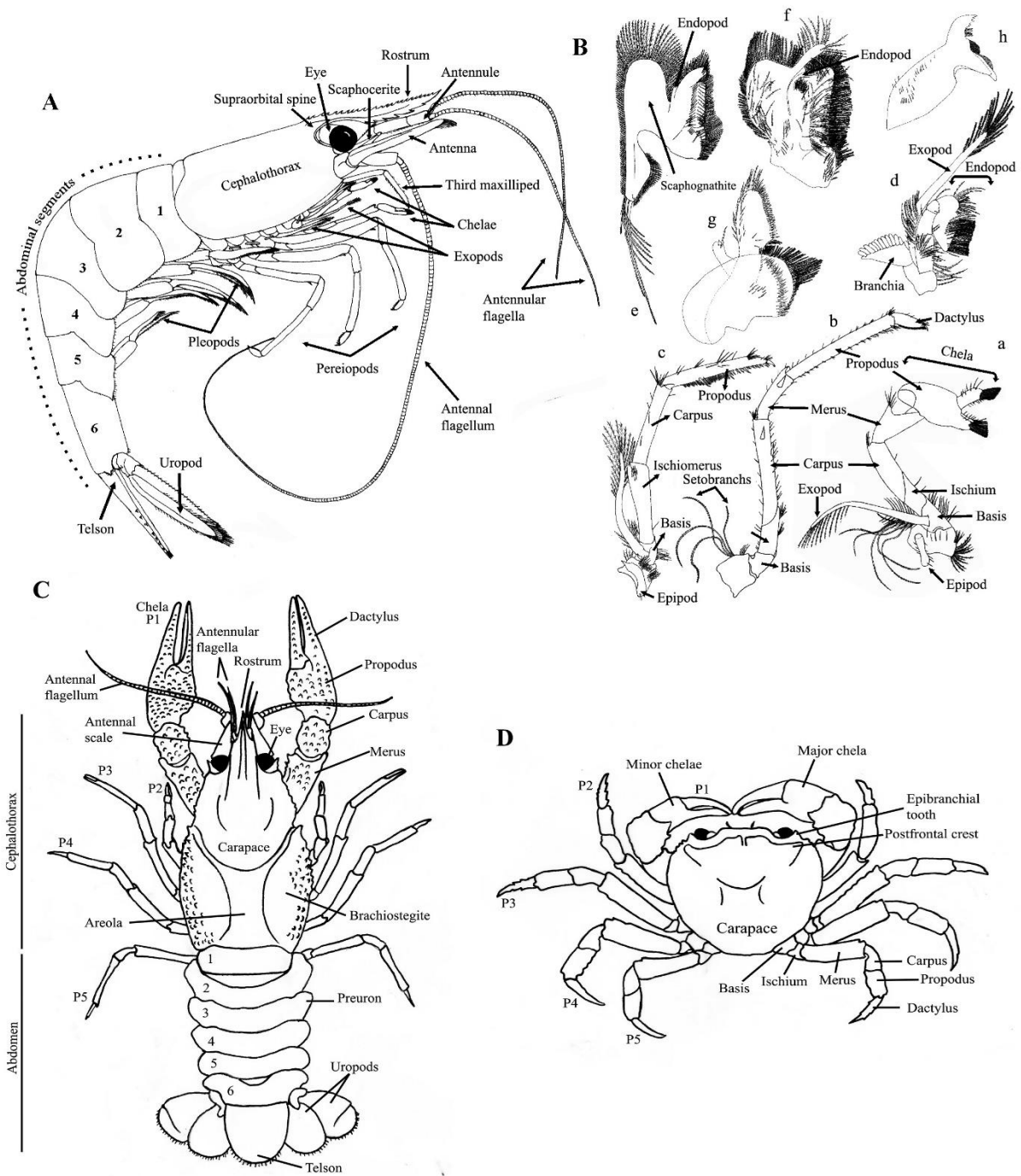
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3531 Fig. 7.7. Thoracopods: A, ThIII *Gallobathynella coiffaiti* (Delamare Deboutteville, 1961); B,
 3532 ThIII *Vejdovskybathynella edelweiss*; C, ThI *Paraiberobathynella notenboomi* (Camacho,
 3533 1989). Male ThVIII: D, *Vejdovskybathynella edelweiss*; E, *Paraiberobathynella notenboomi*.
 3534 Uropods: F, *Vejdovskybathynella edelweiss*; G, *Paraiberobathynella notenboomi*; H,
 3535 *Antrobathynella stammeri* (Jakobi, 1954); I, *Bathynella paranatans* Serban, 1971. Furca: J,
 3536 *Bathynella paranatans*; K, *Antrobathynella stammeri*. Female ThVIII: L, *Paradoxyclamousella*
 3537 *pirata* Camacho, Dorda & Rey, 2013; M, *Paradoxyclamousella fideli* Camacho, Dorda & Rey,
 3538 2013



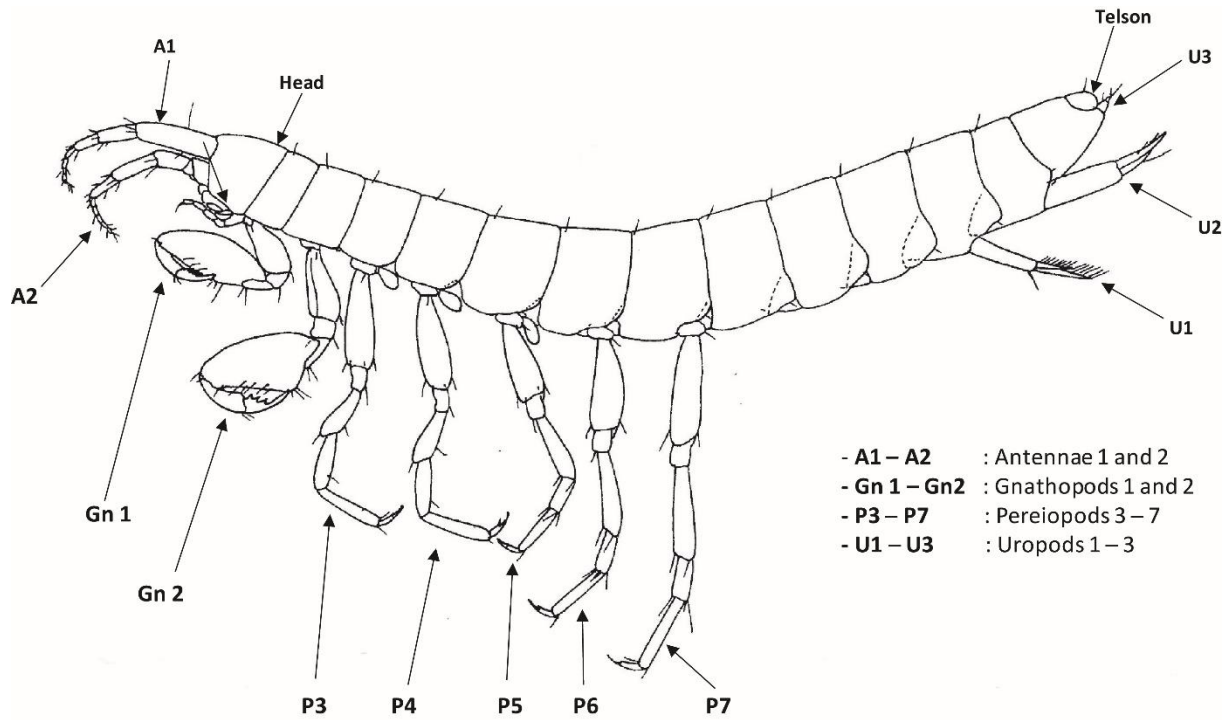
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3540 Fig. 7.8. AII: A, *Hexabathynella sevillaensis* Camacho, 2005; B, *Hexaiberobathynella*
 3541 *hortezuelensis* Camacho & Serban, 1998 and C, *Cteniobathynella* Schminke, 1973. Furca: E,
 3542 *Cteniobathynella* and F, *Parabathynella*. Labrum: G, *Guadalopebathynella puchi* Camacho &
 3543 Serban, 1998 and H, *Iberobathynella andalusica*. MxI: I, *Guadalopebathynella puchi*; J,
 3544 *Iberobathynella andalusica* and M, *Iberobathynella (Asturibathynella) lamasonensis*
 3545 Camacho, 2005. Female ThVIII: K, *Hexaiberobathynella mateusi* (Galhano, 1967); L,
 3546 *Hexaiberobathynella hortezuelensis* Camacho & Serban, 1998; N, *Iberobathynella*
 3547 *(Asturibathynella) ortizi* Camacho, 1989; P, *Iberobathynella (Asturibathynella) parasturiensis*
 3548 Camacho & Serban, 1998; R, *Iberobathynella (Espanobathynella) andalusica*; S,
 3549 *Iberobathynella (E.) burgalensis* Camacho, 2007; U, *Iberobathynella (Iberobathynella)*
 3550 *paragracilipes* Camacho & Serban, 1998. Uropod: Q, *Iberobathynella (Asturibathynella)*
 3551 *cornejoensis* Camacho, 2005; T, *Iberobathynella (Asturibathynella) burgalensis*; V,
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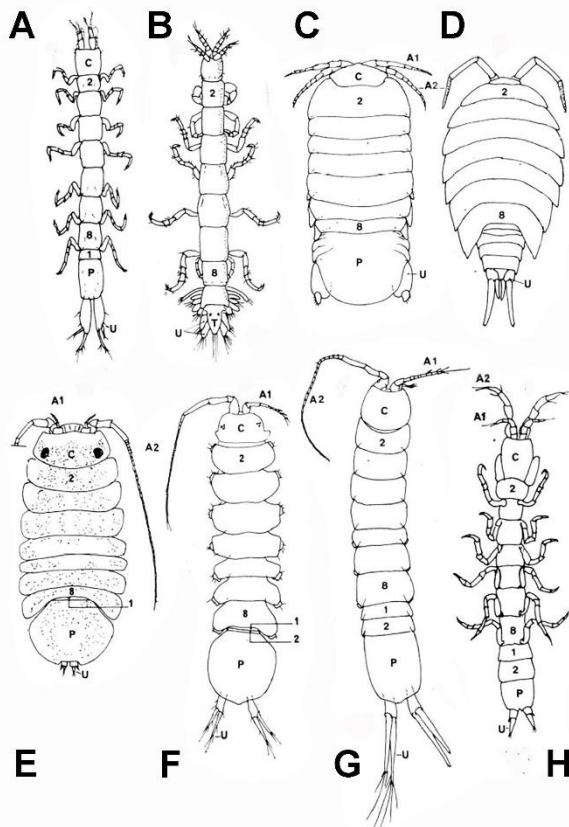
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3554 Fig. 7.9. A, General morphology of Caridea; B, Mouthparts and Pereiopods of Caridea: a, first
 3555 pereopod (Chela); b, fifth pereopod; c, third maxilliped; d, second maxilliped; e, maxilla; f,
 3556 maxillula; h, mandible; C, General morphology of Astacidea; D, General morphology of
 3557 Brachyura.



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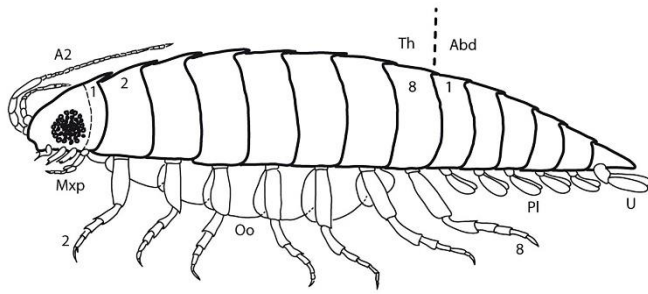
3559 Fig. 7.10. Habitus of *Ingolfiella cottarellii* Ruffo & Vigna Taglianti, 1989 (modified after
3560 Karaman 1993).



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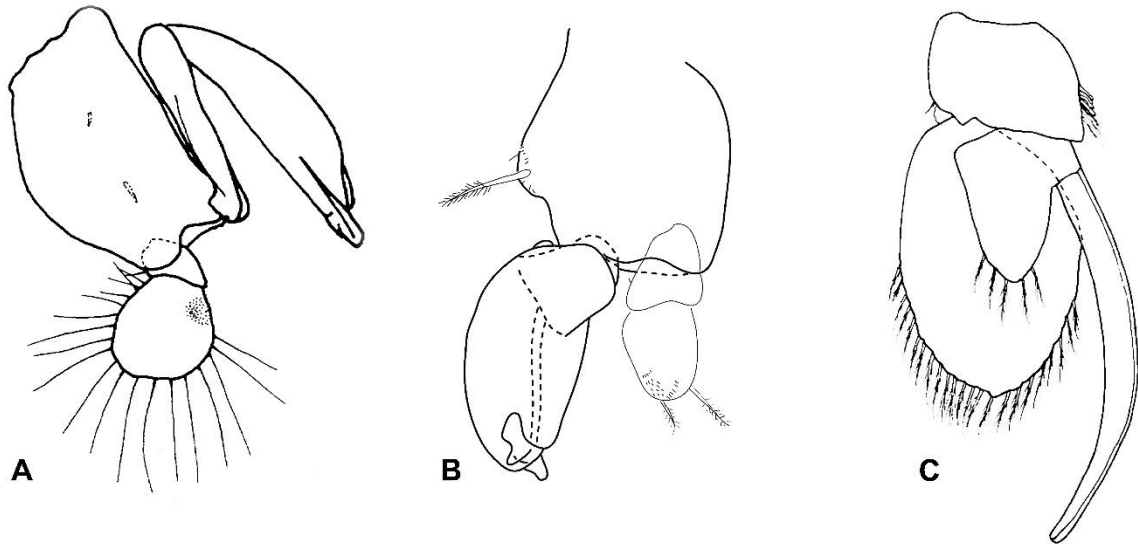
3562 Fig. 7.11. A, a psammic *Microcharon* sp. (Lepidocharontidae); B, a stygobiotic *Stygocyathura*
3563 *milloti* (Anthuridae); C, *Faucheria faucheri* (Cirolanidae); D, scheme of an Oniscidae from
3564 Vandel 1966; E, *Jaera* sp. (Janiridae); F, scheme of an Asellidae; G, scheme of a Stenasellidae;

3565 H, scheme of a Microparasellidae. C = cephalon; P = pleotelson; U = uropod; 2-8 = pereonites;
 3566 1-2 = pleonites.



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3568 Fig. 7.12. Schematic left lateral view of a female isopod. A2 = antennae; Abd = pleon;
 3569 maxilliped; Oo = oostegites; P = pleopods; U = uropods. 2-8 = free pereonites bearing
 3570 pereopods (the first one fused to the cephalon bears the maxilliped); 1-5 = pleonites.



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3572 Fig. 7.13. Second pleopod male of three different genera: 1. *Stenasellus*; 2. *Proasellus*; 2.
 3573 *Typhlocirolana*.



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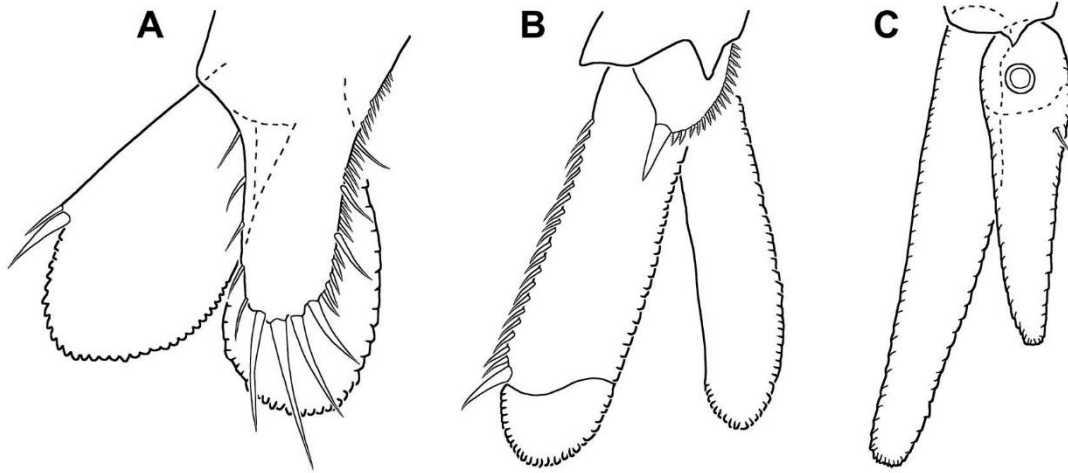
3576 Fig. 7.14. *Stygiomysis hydruntina*. Photograph courtesy of Salvatore Inguscio.



3577

3578 Fig. 7.15. *Spelaeomysis bottazzii*. Photograph courtesy of R. Pepe.

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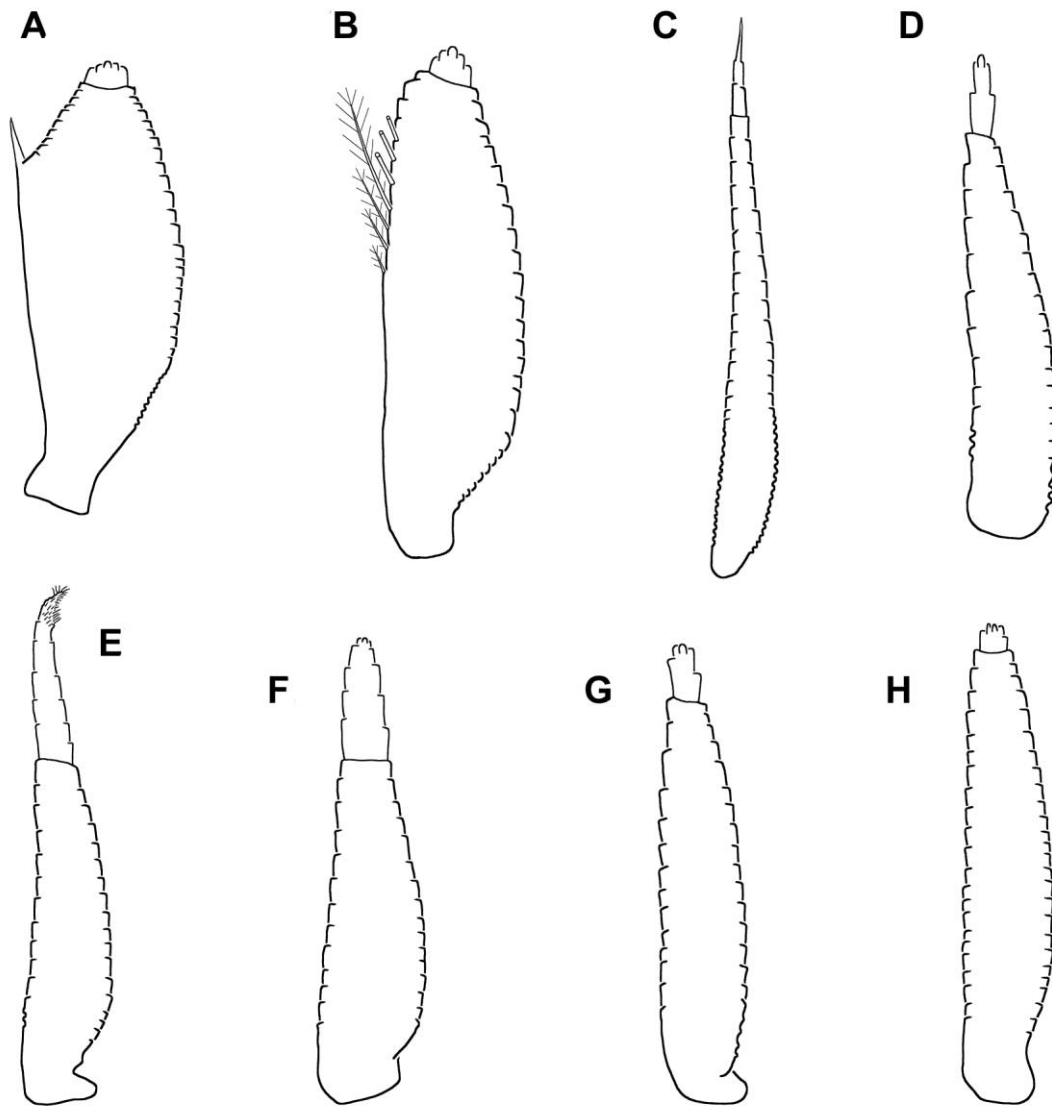
7.16. Uropods of (A) *Stygiomysis hydruntina*, (B) *Spelaeomysis bottazzii*, and (C) *Troglomysis vjetrenicensis*; (A–C) ventral view, setae omitted.

Fig.



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Fig. 7.17. *Neomysis integer*, ventral.



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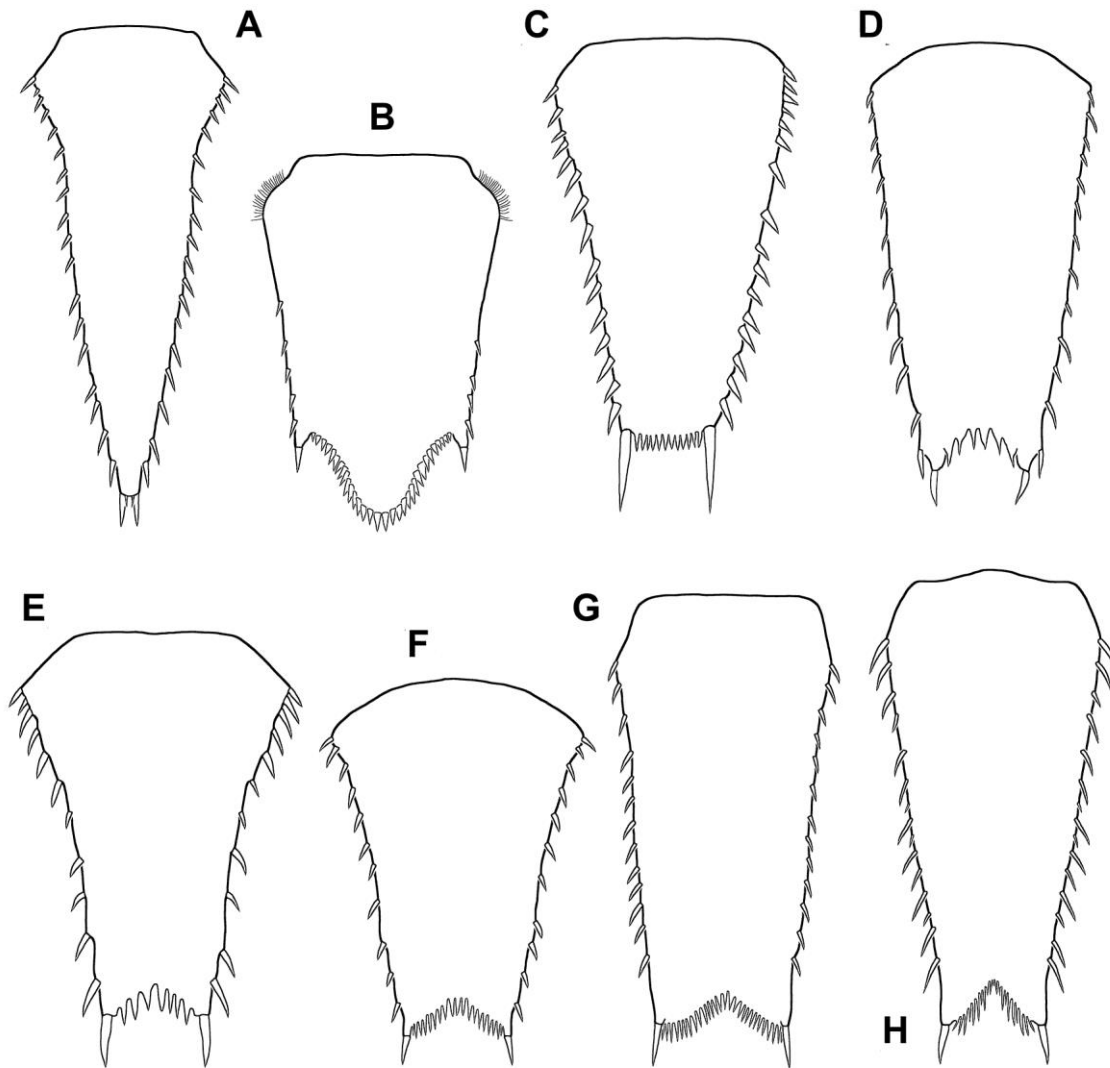
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Fig.

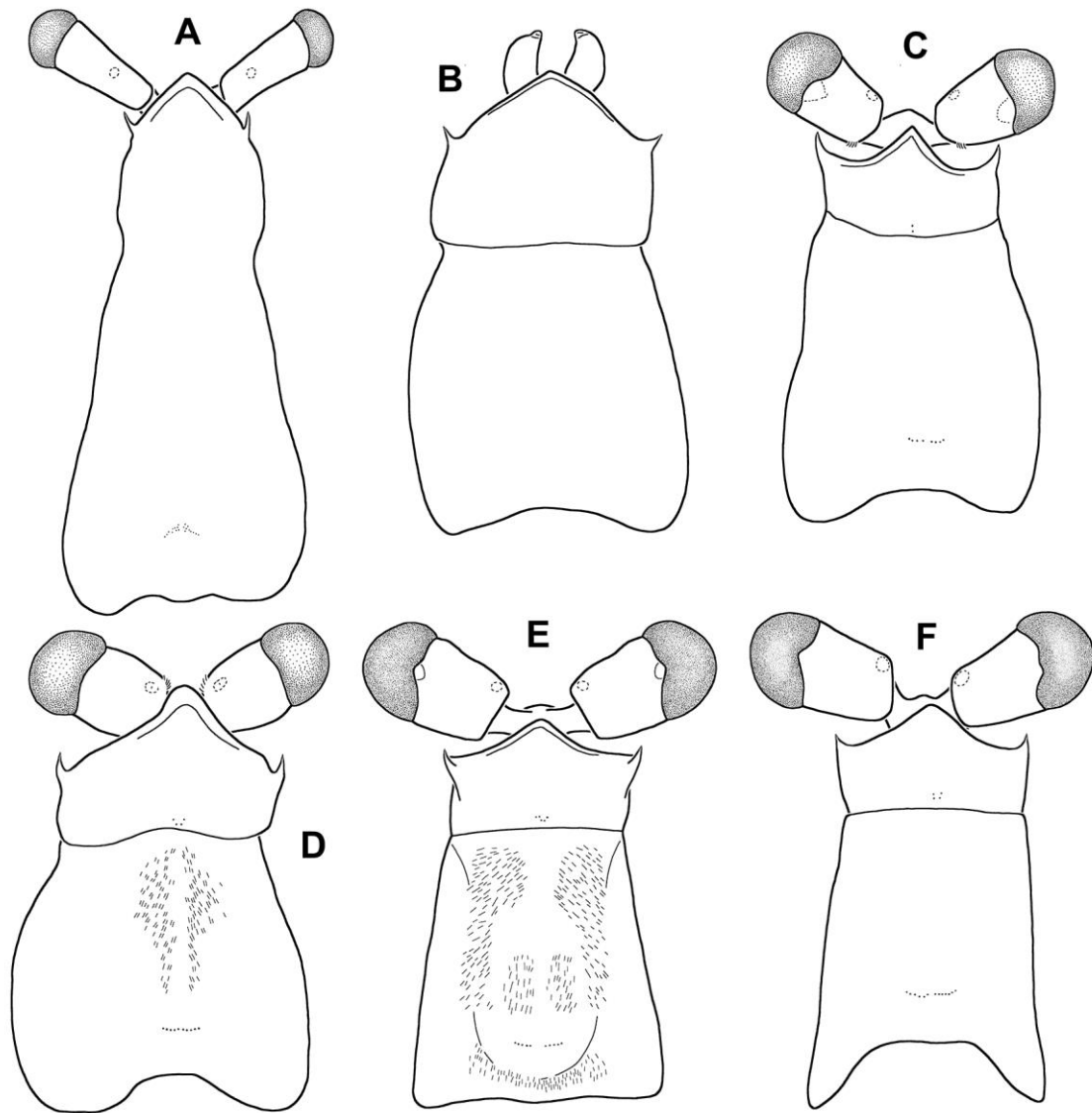
7.18. Antennal scale of (A) *Paramysis (Longidentia) adriatica*, (B) *Hemimysis anomala*, (C) *Neomysis integer*, (D) *Mesopodopsis slabberi*, (E) male *Limnomysis benedeni*, (F) female *L. benedeni*, (G) *Diamysis fluviatilis*, and (H) *Troglomysis vjetrenicensis*. Most (B and E) or all (A, C, D, and F–H) setae omitted, respectively.



3591

3592 Fig. 7.19. Telson of (A) *Neomysis integer*, (B) *Mesopodopsis slabberi*, (C) *Hemimysis anomala*,
 3593 (D) *Troglomysis vjetrenicensis*, (E) *Limnomysis benedeni*, (F) *Diamysis lacustris*; (G)
 3594 *Paramysis (Serrapalpis) kosswigi*, and (H) *Paramysis (Longidentia) adriatica*.

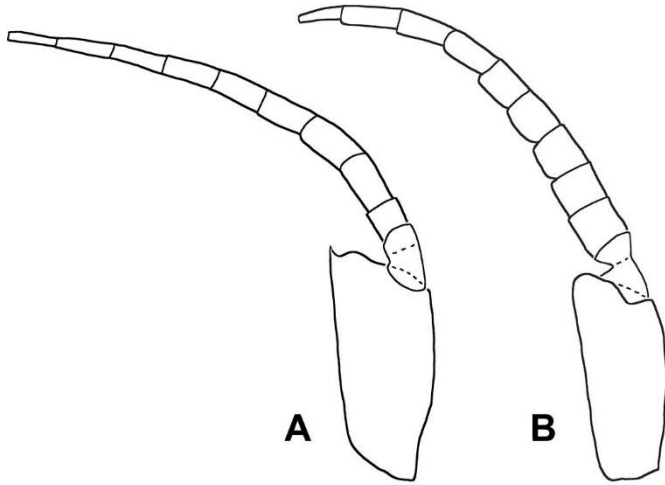
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Fig.

7.20. Eyes and carapace of (A) *Mesopodopsis slabberi*, (B) *Troglomysis vjetrenicensis*, (C) *Diamysis lacustris*, (D) male *Diamysis fluviatilis*, (E) male *Diamysis mesohalobia heterandra*, and (F) *Diamysis hebraica*.

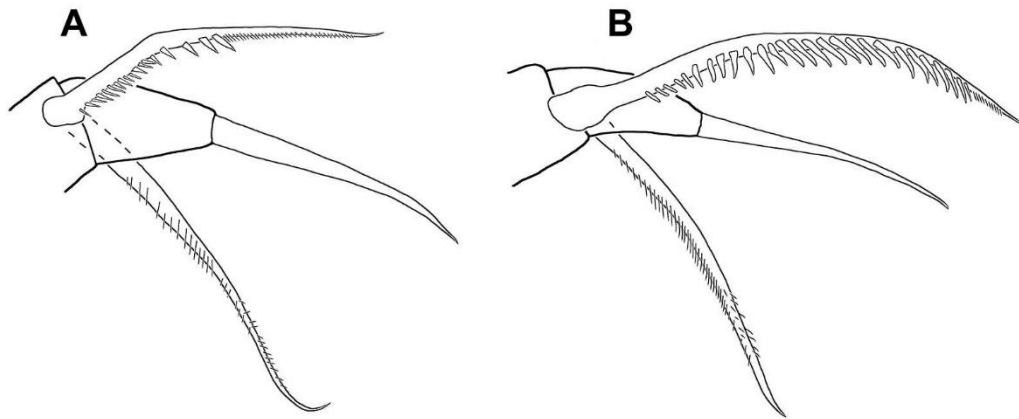


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3602 Fig. 7.21. Third thoracic exopods of (A) *Diamysis fluviatilis* and (B) *Diamysis hebraica*; (A
3603 and B) setae omitted.

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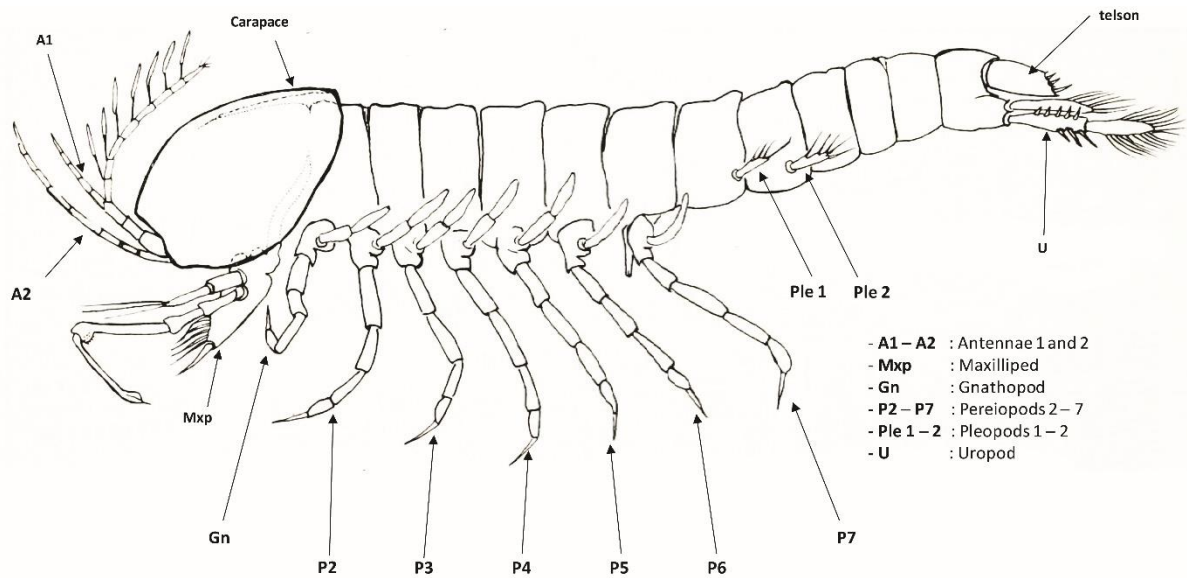
3605



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3607 Fig. 7.22. Dactylus with claw and paradactylary setae of fifth thoracic endopods of (A)
 3608 *Paramysis (Serrapalpis) kosswigi* and (B) *Paramysis (Serrapalpis) lacustris*; (A and B)
 3609 other types of setae omitted.

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3612 Fig. 7.23. General morphology of Monodellidae (modified after Monod & Cals 1988).