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# *Leucothoe denticulata* Costa, 1851 (Crustacea: Amphipoda: Leucothoidae): a Mediterranean species belonging to the *Leucothoe spinicarpa* (Abildgaard, 1789) complex well present along the French Atlantic coasts

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**Abstract:** Specimens of *Leucothoe* were collected during specific surveys on the benthic fauna of the Arcachon Bay and Brittany. Original and subsequent descriptions, as well as comparison with specimens from type locality, confirm the identification of the Mediterranean species *Leucothoe denticulata*, a species morphologically close to the frequently recorded species *L. spinicarpa*. Setation of mandibular palp, gnathopod 1 propodus and gnathopod 2 basis is herein used to distinguished the two closely species. A description of the Atlantic *L. denticulata* specimens is provided with some ecological notes, as well as an actualized identification key to *Leucothoe* species from European waters.

**Résumé :** Leucothoe denticulata *Costa, 1851 (Crustacé : Amphipode : Leucothoidae) : une espèce méditerranéenne appartenant au complexe* Leucothoe spinicarpa *(Abildgaard, 1789) bien présente sur les côtes atlantiques françaises.* Des spécimens de *Leucothoe* ont été récoltés lors d'études spécifiques de la faune benthique dans le bassin d'Arcachon et en Bretagne. La description originelle et les suivantes, ainsi que la comparaison avec des individus de la localité type, confirment l'identification de l'espèce méditerranéenne *Leucothoe denticulata*, une espèce morphologiquement proche de *L. spinicarpa* fréquemment recensée. Les soies du palpe mandibulaire, du propode du gnathopode 1 et du basis du gnathopode 2 sont utilisées ici pour distinguer les deux espèces proches. Une description des individus d'Atlantique est fournie avec quelques notes écologiques, ainsi qu'une clé d'identification actualisée des espèces de *Leucothoe* des eaux européennes.

*Keywords*: Amphipoda ● *Leucothoe denticulata* ● French Atlantic coasts ● *Leucothoe spinicarpa* complex

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## Introduction

According to the World Register of Marine Species (WORMS), the Leucothoidae Dana, 1852 are a marine family composed by 192 species dispatched between 5 genera: *Anamixis* Stebbing, 1897, *Leucothoe* Leach, 1814, *Nepanamixis* Thomas, 1997, *Paraleucothoe* Stebbing, 1899 and *Paranamixis* Schellenberg, 1938. Most of the Leucothoidae species belong to *Leucothoe* genus with 146 species (Horton et al., 2019). *Leucothoe* is distributed around the world from 0 to 3570 m in ascidians, sponges, bivalve, algae, and coral rubble (White, 2011). In European waters, 21 *Leucothoe* species occur: *Leucothoe articulosa* (Montagu, 1804), *Leucothoe atosi* Bellan-Santini, 2007, *Leucothoe brunonis* Krapp-Schickel & Menioui, 2005, *Leucothoe cathalaa* Frutos & Sorbe, 2012, *Leucothoe denticulata* Costa, 1851, *Leucothoe euryonyx* (Walker, 1901), *Leucothoe furina* (Savigny, 1816), *Leucothoe incisa* Robertson, 1892, *Leucothoe lilljeborgi* Boeck, 1861, *Leucothoe oboa* Karaman, 1971, *Leucothoe occulta* Krapp-Schickel, 1975, *Leucothoe pachycera* Della Valle, 1893, *Leucothoe procera* Spence Bate, 1857, *Leucothoe richiardii* Lesson, 1865; *Leucothoe rostrata* Chevreux, 1908, *Leucothoe serraticarpa* Della Valle, 1893, *Leucothoe spinicarpa* (Abildgaard, 1789), *Leucothoe spinulosa* Chevreux, 1919-20, *Leucothoe uschakovi* Gurjanova, 1951, *Leucothoe vaderotti* Krapp-Schickel, 2018 and *Leucothoe venetiarum* Giordani-Soika, 1950. The type species, *L. spinicarpa*, originally described from Norway, was considered as a cosmopolitan species but recent studies, with among others the redescription of the species (Crowe, 2006), would imply that most of references are suspect and represent a complex of species: the *Leucothoe spinicarpa* complex. This complex is currently composed by *L. articulosa*, *L. brunonis*, *L. denticulata*, *L. occidentalis* Reid, 1951, *L. occulta*, *L. serraticarpa*, *L. spinicarpa* and *L. vaderotti* (Krapp-Schickel & Menoui, 2005; Crowe, 2006; De Broyer et al., 2007; White, 2011; Thomas, 2015; Krapp-Schickel, 2018). In European waters, some of these suspect references were already corrected: *L. spinicarpa* refers to *L. articulosa* in Lincoln (1979) or to *L. denticulata* in Krapp-Schickel in Ruffo ed. (1989). Krapp-Schickel & Menoui (2005) attributed *L. spinicarpa* in Chevreux & Fage (1925) to *L. denticulata*, but male's description does not present subdistal tooth on gnathopod 2 carpus and its morphological characters make probably an undescribed species belonging to the *L. spinicarpa* complex.

Records in European waters need to be taken with caution and traditional identification keys for European *Leucothoe* species (Chevreux & Fage, 1925; Lincoln, 1979; Krapp-Schickel, 1989) should not be used anymore to avoid identification errors. Krapp-Schickel & Vader (2013) provided an illustrated key to Atlantic *Leucothoe* species, but did not include *L. furina* and *L. spinulosa*, and characters used to distinguish *L. spinicarpa* from *L. denticulata* and *L. articulosa* can be subjective (eyes rounded vs eyes roundish or irregular squarish). This paper presents records of *L. denticulata* with a complete description of the species from French Atlantic coast, and an actualized identification key of European *Leucothoe* species, based on Frutos & Sorbe (2012) and White (2011) keys.

## Material and methods

Between 2017 and 2019, *Leucothoe denticulata* was collected in Arcachon Bay and in Brittany (Fig. 1) and conserved in alcohol (75%). In Arcachon Bay, specimens were recovered in a 1 mm sieve of mesh vacuum as associated species after crumbled and rinsed of its habitats (sponge, oysters' shells or slipper limpet bed sampled by snorkeling). In Brittany, specimens were collected in *Phallusia mammillata* (Cuvier, 1815), themselves collected by hand in Brest and Logonna-Daoulas ports pontoons. Additionally, "*Leucothoe spinicarpa"* (= *Leucothoe denticulata*) specimens from the Royal Belgian Institute of Natural Sciences (Brussels, loanRBINS/R.I.2018.11) collected in Camaret (Brittany, France) by C. d'Udekem in *P. mammillata* were examined. Atlantic specimens were compared to material from the Mediterranean Sea: Rhodes marina (Greece), Grand Harbour (Malta), Licata marina (Sicily), Venice marina (Italy) (specimens from A. Marchini personal collection) as well as to *Leucothoe denticulata* from Museo Civico di Storia Naturale, Verona collected in Gulf of Napoli (Vervece; Nap. 83; Nap. XLVII; Nap. LIV; Nap. LXXX) (see Krapp-Schickel & Menioui, 2005 for more details).

*Leucothoe* specimens were observed under stereomicroscope and compound microscope, and some of them were dissected and mounted on permanent slides using Dimethyl Hydantoin Formaldehyde. Drawings were carried out from pictures using Inkscape software (v.0.92). Body length (BL) was measured with NIS-Elements Analysis software from the anterior margin of head to the posterior end of telson. For Scanning Electron Microscope (SEM) studies, specimens were dehydrated in two ethanol bath (20 min in 96%

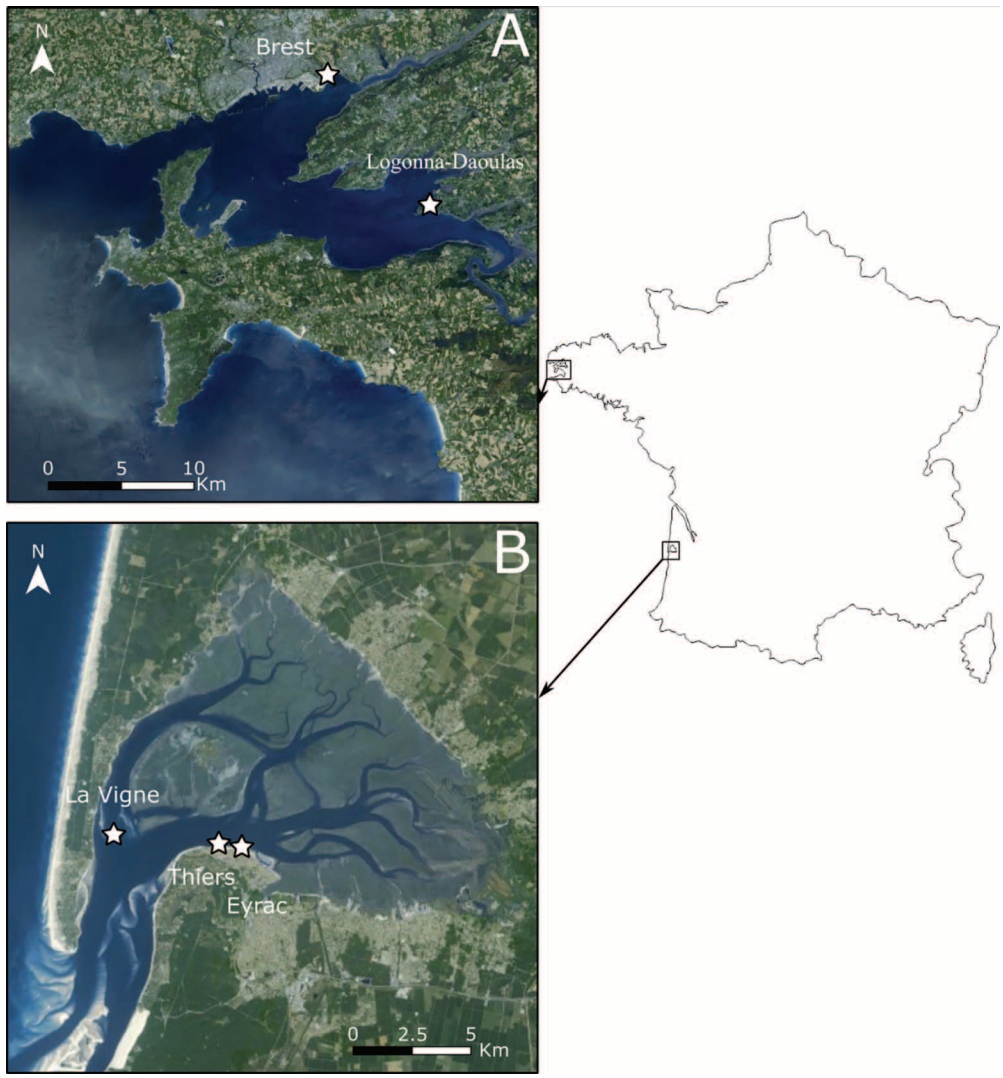


**Figure 1.** *Leucothoe denticulata*. Sampling stations in **A.** Brittany. **B.** Arcachon Bay.

ethanol, 20 min in absolute ethanol), critical point dried (3 x 5 min in 50% of absolute ethanol + 50% of pure Hexamethyldisilazane, 2 x 5 min in pure Hexamethyldisilazane), dried out 2h at 60°C, sputter coated with gold and examined with a Hitachi TM3030Plus SEM. Some specimens were deposited in the Muséum National d'Histoire Naturelle (MNHN, Paris, France) (Arcachon specimens: MNHN-IU-2016-3395 to MNHN-IU-2016-3400, 32 specimens; Brittany specimens: MNHN-IU-2016-3393 and MNHN-IU-2016-3394, 34 specimens).

## Results

*Leucothoe denticulata* was collected in Arcachon Bay in several subtidal stations in shallow waters (depth range: 3-7 m) where the temperature and the salinity ranged between 6.6 to 24.9°C and 25.1 to 33.9 respectively (data acquired between January 01 to October 14, 2018, data from Ifremer LER Arcachon). In 'Thiers' station, the species was recorded as an associated species to the invasive non-indigenous sponge *Celtodoryx ciocalyptoïdes* (Burton, 1935), itself collected on hard substrates (pillar pontoon, dead oysters' shells). Many others non-indigenous species (NIS) as the polychaete *Polydora colonia* Moore, 1907, the isopods *Ianiropsis serricaudis* Gurjanova, 1936 and *Paranthura japonica* Richardson, 1909, and the amphipod *Aoroides longimerus* Ren & Zheng, 1996 co-occurred in the *C. ciocalyptoïdes* samples. Compared to those NIS, *L. denticulata* was recorded at a low abundance. In 'Eyrac' and 'La Vigne' stations, the species was recorded with *Magallana gigas*

(Thunberg, 1793) dead oysters' shells and with *Crepidula fornicata* (Linnaeus, 1758) respectively which provide tridimensional structures serving as a shelter for many other species. In Brittany, *Leucothoe* specimens were collected under port pontoons and on port pillars in *Phallusia mammillata*. At Brest port, 16 of the 20 tunicates (BL: 8 to 13.5 mm) shelter *L. denticulata* in their branchial cavities, with 1 to 4 specimens per tunicate, whereas in Logonna-Daoulas port, only 1 on the 8 *P. mammillata* (BL: 4 to 12 mm) sampled present a single *L. denticulata* specimen in the branchial cavity.

One brooding female was sampled (27/11/2017 - Arcachon Bay, station 'Eyrac', BL: 5.06 mm); the eggs showed an ovoid shape with mean major and minor diameters of 0.537 ± 0.042 mm and 0.427 ± 0.029 mm, respectively ($\bar{x}$ ± s; n = 6).

## Systematics

Order AMPHIPODA Latreille, 1816
Suborder AMPHILOCHIDEA Boeck, 1871
Family LEUCOTHOIDAE Dana, 1852
Genus *Leucothoe* Leach, 1814
***Leucothoe denticulata*** Costa, 1851
(Figs 2-7)

Description based on adult female (BL: 5.73 mm) Arcachon Bay, Station 'Thiers', 06/06/2018, MNHN-IU-2016-3400.

Head (Figs 2, 3 & 7A-F). Anterior margin rounded, anterodistal margin rounded, eyes present. Antenna 1, 0.25 times as long as body; peduncle article 1, 2 times as long as broad, with ventrodistal spine and tooth, width less than twice article 2; article 2 slightly smaller than article 1, 3.1 times as long as broad; article 3 about a third as long as article 2, 3 times as long as broad; accessory flagellum present, minute, 0.3 times as long as main flagellum article 1, one articulated; main flagellum of 8 articles, slightly longer than peduncle article 1, aesthetascs present. Antenna 2 shorter than antenna 1; peduncular article 5, 0.9 times as long as article 4; flagellum of 6 articles. Mouthparts. Upper lip asymmetrically lobate, anterior margin setose. Mandibles lacking molars; mandibular palp 3-articulate, ratio of articles 1-3 1.0:2.3:1.2; article 2 with 5 lateral and 2 distal setae; article 3 with two unequal distal setae; incisor dentate, with row of 13 serrate robust setae; left lacinia mobilis large, distally as long as incisor; right lacinia mobilis small, weakly dentate. Maxilla 1 palp two-articulate, distal article with three distal robust setae; outer plate with eight apical robust setae and five facial setae; inner plate small, ovate, with single apical seta. Maxilla 2 outer plate with three distal robust setae, outer margin setulose on the two-third of its length; inner plate with nine robust setae along inner and distal margins. Maxilliped inner plate distal margin flat with two short robust setae; outer plate with distal spine; palp articles 3-4 with facial setae, article 4 slightly longer than article 3.

Pereon (Figs 4, 5 & 7G-H) Gnathopod 1 coxa as long as broad, without facial setae, produced anteriorly, posterior margin deeply concave, posteroventral corner with two small serrations; basis anterior and posteromesial margins sparsely setose; ischium naked; merus distally acute with a small distal

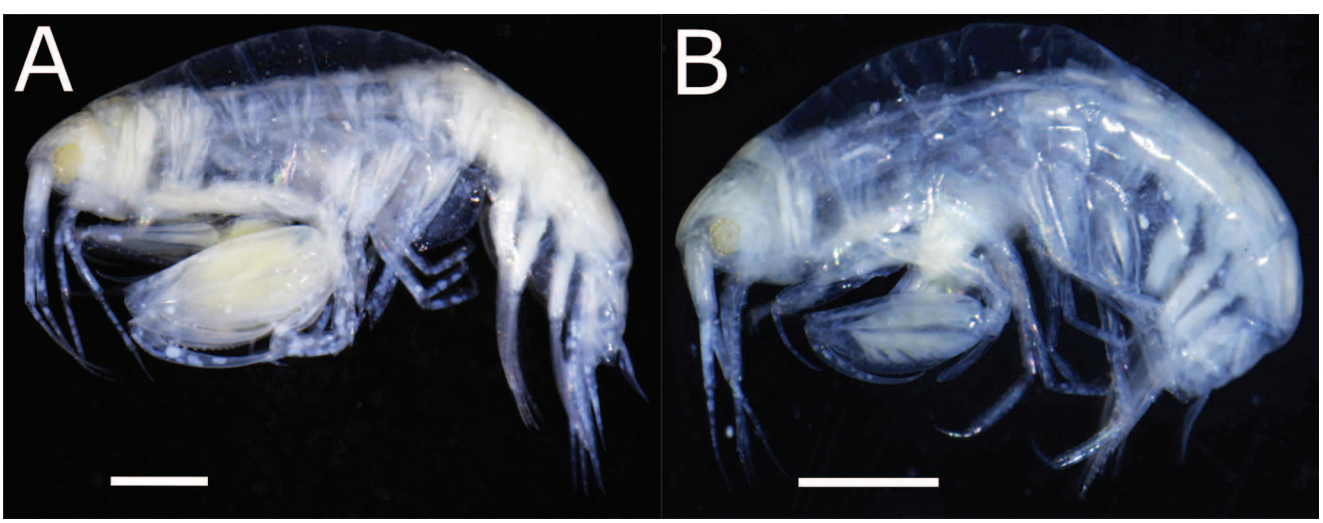


**Figure 2.** *Leucothoe denticulata*. Gulf of Napoli (Nap. LXXX). **A.** Adult male, BL = 9.28 mm. **B.** Adult female, BL = 7.67 mm. Scale bars: 1 mm.

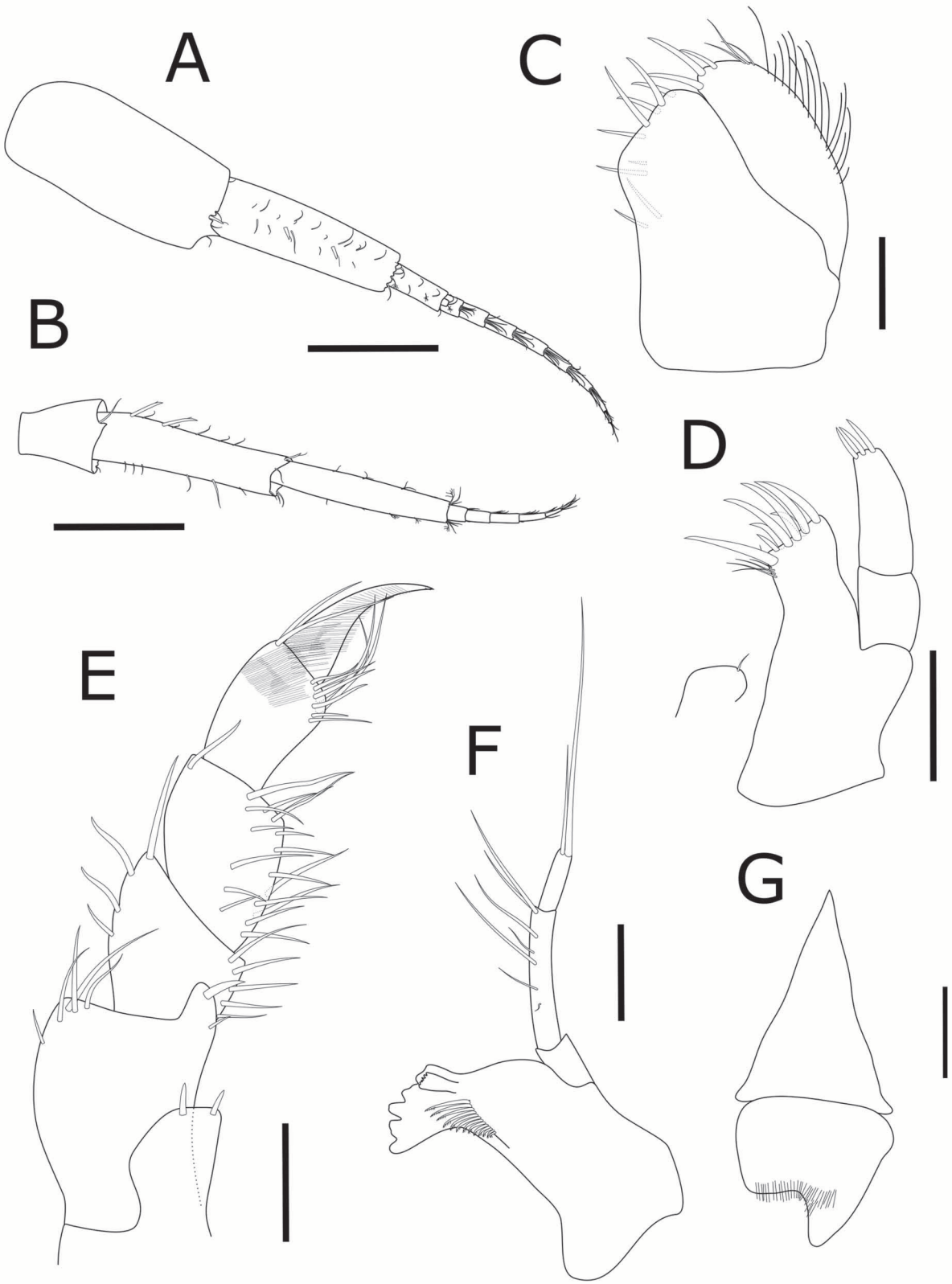


**Figure 3.** *Leucothoe denticulata*. Adult female, BL = 5.73 mm, Arcachon Bay, Station "Thiers", 06/06/2018. MNHN-IU-2016-3400. **A.** Antenna 1. **B.** Antenna 2. **C.** Maxilla 2. **D.** Maxilla 1. **E.** Maxilliped. **F.** Right mandible. **G.** Upper lip and epistome. Scale bars: A & B: 0.25 mm; C: 0.05 mm; D-G: 0.1 mm.

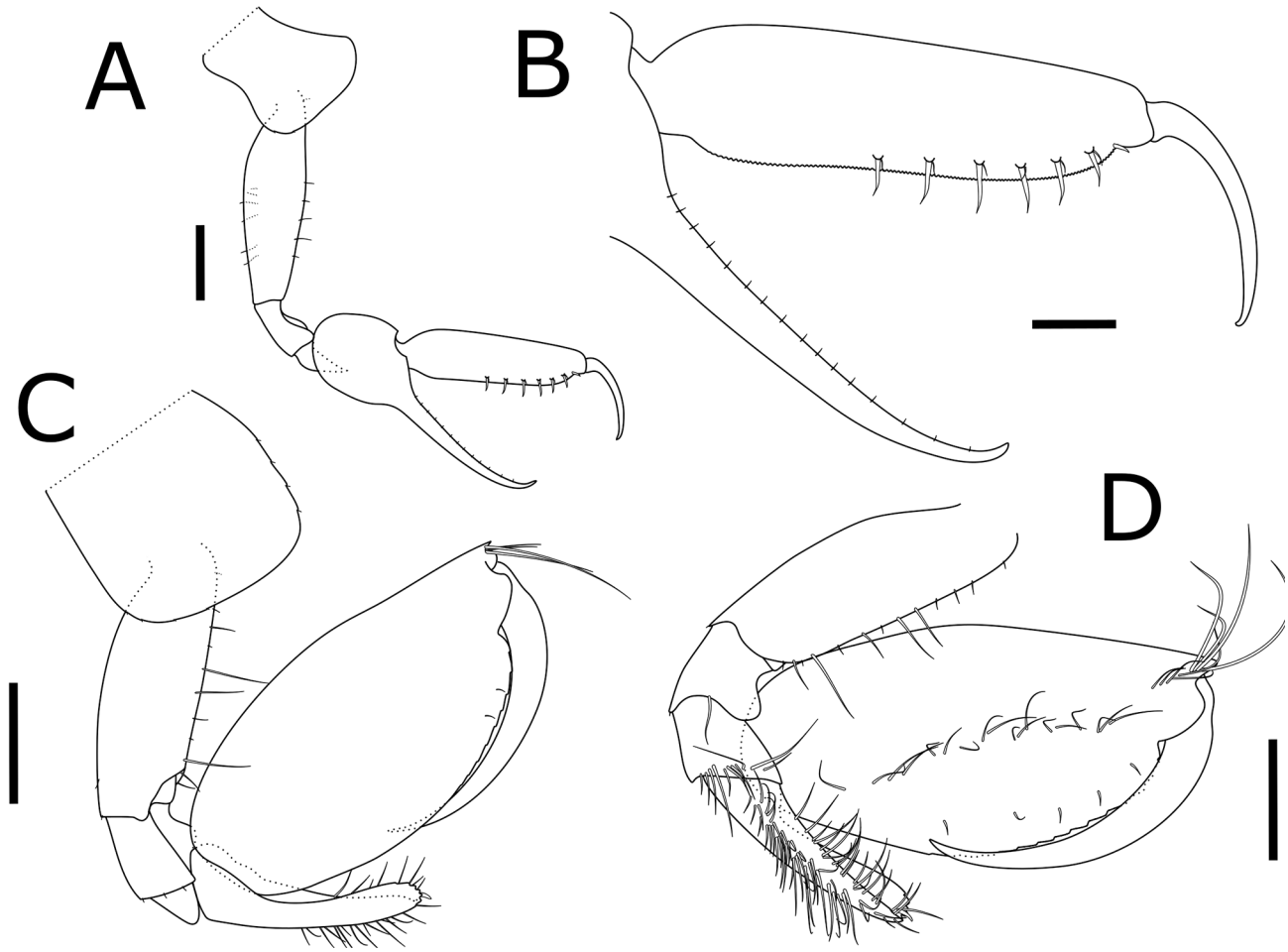


**Figure 4.** *Leucothoe denticulata*. Adult female, BL = 5.73 mm, Arcachon Bay, Station "Thiers", 06/06/2018. MNHN-IU-2016-3400. **A.** Gnathopod 1, outer view. **B.** Gnathopod 1, outer view, dactylus, propodus and distal part of carpus. **C.** Gnathopod 2, outer view. **D.** Gnathopod 2, inner view. Scale bars: A, C, D: 0.25 mm; B: 0.1 mm.

seta on inner face; carpus with minute setae along anterior margin; propodus 3.6 times as long as broad, straight, palm with minute serrations and row of 6 setae and a distal spine; dactylus smooth, reaching 0.45 of propodus length. Gnathopod 2 coxa slightly longer than broad, without facial setae, anterior and posteroventral margins with small serrations; basis anterior margin with more than 10 setae, posterior margin and posterodistal corner with one minute seta; ischium sparsely setose on inner face; merus distal setae on inner face; carpus reaching 0.3 of propodus length, distally subtruncated, with one robust seta, densely setose on inner face; propodus twice as long as broad, anterodistal margin with short, blunt prolongation bearing a tuft of setae, outer face with 2 setae near palmar margin, inner face with three facial rows of setae, one near palmar margin, one mediofacial and reaching 2/3 the length of propodus, one displaced dorsodistally, palm convex, slightly crenulated; dactylus smooth, reaching 0.6 length of propodus. Pereopod 3 coxa longer than broad, antero- and posteroventral margins serrate without facial setae; basis narrow, anterior margin with seven setae, posterior margin with two minute setae; merus anterior margin with two robust setae, anterodistal corner lengthened with one spine, posterior margin with one minute seta; carpus with one anterior minute seta and three posterior robust setae; propodus anterior margin with two minute setae and an anterodistal seta, posterior margin with a row of seven robust setae. Pereopod 4 coxa longer than broad, produced posteriorly, antero- and posteroventral margins serrate, without facial setae; basis narrow, anterior margin with ten setae, posterior margin with two minute setae; merus anterior margin with one spine, anterodistal corner lengthened with one spine,

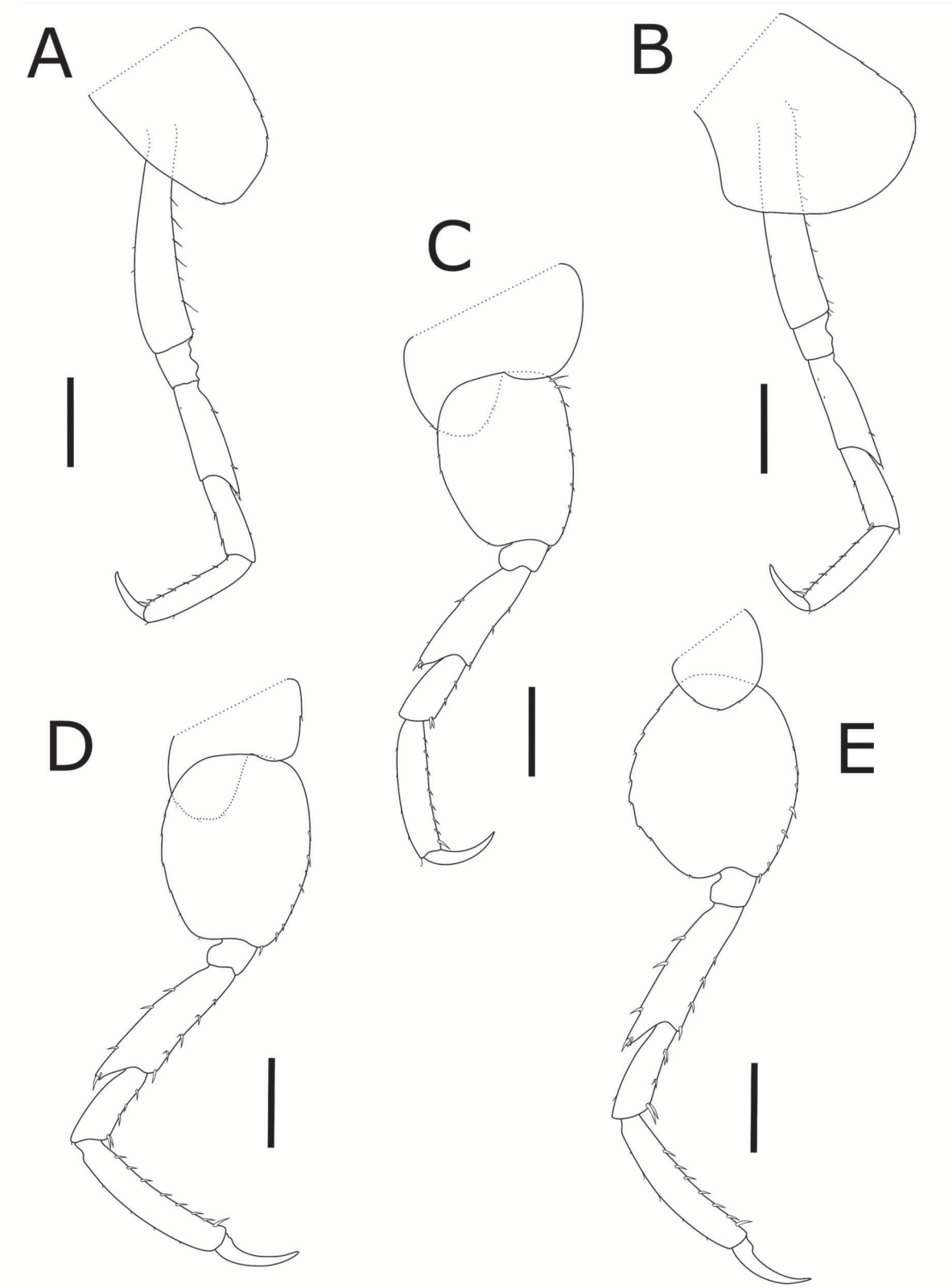


**Figure 5.** *Leucothoe denticulata*. Adult female, BL = 5.73 mm, Arcachon Bay, Station "Thiers", 06/06/2018. MNHN-IU-2016-3400. **A-E.** Pereopods 3-7, outer view. Scale bars: 0.25 mm.

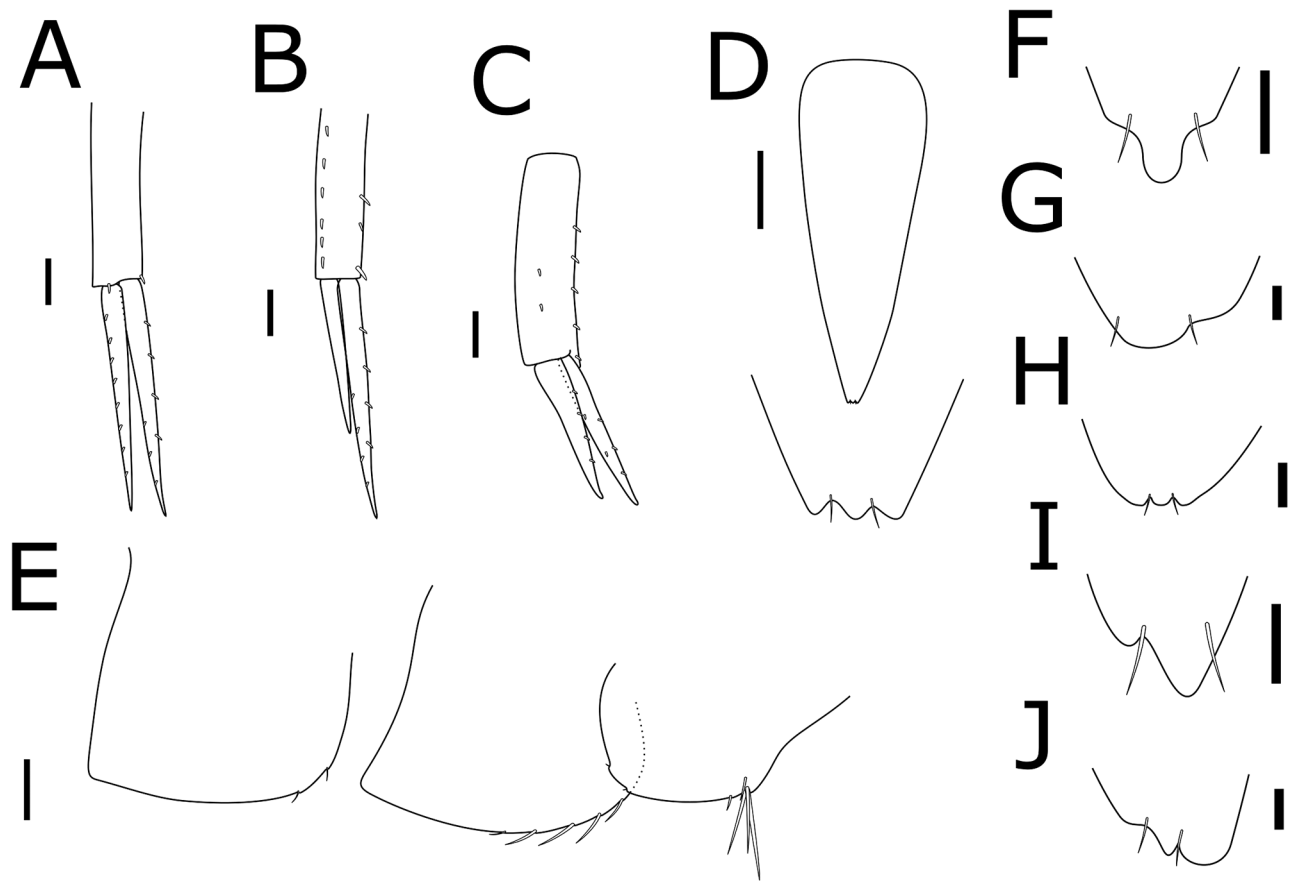


**Figure 6.** *Leucothoe denticulata*. Adults' females. **A-E.** Arcachon Bay, Station 'Thiers', 06/06/2018, BL = 5.73 mm, MNHN-IU-2016-3400. **F-J.** Telson distal end of specimens from Gulf of Napoli. **A.** Uropod 1. **B.** Uropod 2. **C.** Uropod 3. **D.** Telson. **E.** Epimeral plates 3-1. **F.** 'Vervece', BL = 10.56. **G.** 'Napoli XLVII', BL = 9.74 mm. **H.** 'Napoli 83', BL = 7.93 mm. **I.** 'Napoli LIV', BL = 12.76 mm. **J.** 'Napoli 83', BL = 6.46 mm. Scale bars: 0.1 mm.

posterior margin with two minute setae; carpus with a minute anterior seta, one anterodistal and three posterior robust setae; propodus anterior margin with three minute setae and an anterodistal seta, posterior margin with a row of seven robust setae. Pereopod 5–7 basis broadly expanded, length about 1.2 x width, anterior margin with robust setae, posterior margin increasingly serrated; merus posterodistal corner lengthened with two robust setae, anterior and posterior margins with robust setae, carpus and propodus anterior margin with robust setae, posterior margin minute setae; dactylus naked. Coxa 5 bilobed, anterior lobe naked, posterior lobe ventral margin serrated, without facial setae. Coxa 6 bilobed, anterior margin with a single serration, posterior lobe ventral margin serrated, without facial setae. Coxa 7 subrounded, shorter than broad, posteroventral margin serrated, without facial setae.

Pleon (Figs 6A-E & 7J-L). Epimeron 1 anteroventral corner with cluster of long setae, posteroventral corner slightly serrated. Epimeron 2 anteroventral margin with setae, posteroventral corner slightly produced, not upturned. Epimeron 3 anteroventral corner slightly serrated, posteroventral corner subquadrate. Uropod 1 peduncle with two distal robust setae; outer ramus subequal to inner ramus, with eight robust setae; inner ramus with three lateral and four mesial robust setae. Uropod 2 somewhat shorter than uropod 1, peduncle with six robust setae along outer margin and three robust setae on distal half of inner margin; outer ramus distinctly shorter than inner ramus, naked; inner ramus with four lateral and four mesial robust setae. Uropod 3 peduncle with five robust setae on outer margin and two robust setae on inner margin; outer ramus slightly longer than inner ramus with three lateral and two mesial robust setae; inner ramus with four lateral robust setae. Telson 2.6 times as long as broad, distal tip tridentate with two minute setae.

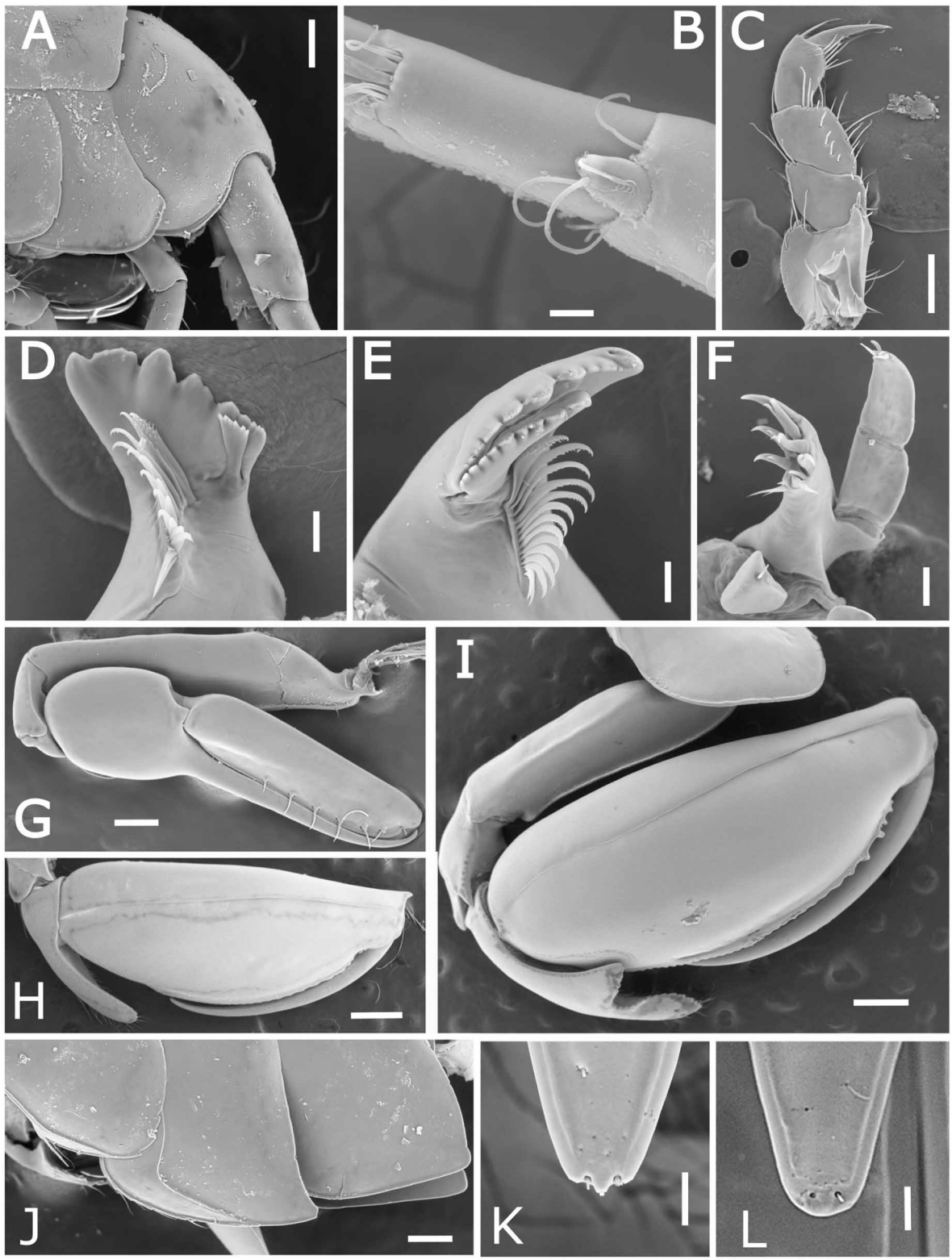


**Figure 7.** *Leucothoe denticulata*. **A-G, J, L**: Arcachon Bay specimens; **H, I, K, L**: Brittany specimens. **A.** Head, BL = 4.56 mm. **B.** Antenna 1 accessory flagellum, BL = 4.56 mm. **C.** Maxilliped, BL = 4.85 mm. **D.** Right mandible, BL = 4.85 mm. **E.** Left mandible, BL = 4.85 mm. **F.** Maxilla 1, BL = 4.85 mm. **G.** Gnathopod 1, BL = 4.85 mm. **H.** Gnathopod 2, female, BL = 15.26 mm. **I.** Gnathopod 2, male, BL = 15.67 mm. **J.** Epimeral plate 1-3, BL = 4.85 mm. **K.** Telson distal end, BL = 13.45 mm. **L.** Telson distal end, BL = 15.26 mm. Scale bars: A, C, G, J: 0.1 mm; B: 0.01 mm; D, E, F, K, L: 0.02 mm; H, I: 0.4 mm.

*Male (sexually dimorphic characters).*

Similar to females except for gnathopod 2: gnathopod 2 carpus with distinct subdistal tooth, crenulation on palmar margin slightly more pronounced (Fig. 7I).

*Variability*

Mandible with a row of 13 to 15 serrate robust setae, with no left-right symmetry. Gnathopod 1 propodus palmar margin with number of setae size dependent, from 4 to 6 setae and a distal spine, dactylus length size dependent, reaching between 0.35 (juvenile specimen, BL: 2.25 mm) and 0.56 (adult specimen, BL: 12.76 mm) of propodus length. Telson distal tip rounded, bidentate to generally tridentate.

## Discussion

Despite a well-done redescription of *Leucothoe denticulata*, Krapp-Schickel & Menioui (2005) remained superficial on some morphological characters. Indeed, examination of *L. denticulata* specimens from the Museo Civico di Storia Naturale, Verona used by Krapp-Schickel & Menioui (2005) for the redescription of the species reveals (1) gnathopod 1 basis with or without few setae on posteromesial margin (with no correlation with specimens' size or sex), (2) dactylus between 0.45 and 0.56 x propodus length except for specimens less than 4 mm where the ratio is smaller (until 0.35 for juvenile BL = 2.25 mm), (3) telson apex variable, rounded to slightly tridentate. These variabilities were also observed in Atlantic specimens. Furthermore, Atlantic specimens revealed that the shape of gnathopod 2 carpus is function of the maturity and sexuality and the presence of a distinct subdistal tooth on male's carpus is probably a character to be taken with caution for identification. As it was also observed in others species, shape of some morphological male's characters depends of maturity degrees, as the number of gnathopod 2 carpus teeth in *Ericthonius* H. Milne Edwards, 1830 species (Myers & McGrath, 1984), or the size of gnathopod 2 propodus tooth in *Jassa* Leach, 1814 species (Gouillieux, 2017). Thus, to avoid identification errors, juveniles and subadults specimens should remain as *Leucothoe* indeterminate.

White (2011) published a world key to *Leucothoe* species, with no distinction of sex. In this key, some updating is required on the shape of gnathopod 2 carpus of *L. denticulata*. Krapp-Schickel & Menioui (2005) provided some SEM pictures of *L. denticulata*, but the submitted male specimen pictures probably refer in fact to a female specimen due to absence of gnathopod 2 carpus tooth. According to examination of specimens from type locality and from French Atlantic coast, as some descriptions (Krapp-Schickel, 1975 & 1989), females have no subdistal tooth whereas males present a distinct subdistal tooth on gnathopod 2 carpus. However, in couplet 52 of White's key, *L. denticulata* is classified in the species group characterized by "Gnathopod 2 carpus without subdistal tooth". Thereby, we propose to place *L. denticulata* in the other species group of couplet 52 ("Gnathopod 2 carpus with subdistal tooth"), with *L. diemenensis* Haswell, 1879, *L. articulosa* and *L. spinicarpa*.

*Leucothoe spinicarpa*-complex refers to a set of species originally described as *L. spinicarpa* in the world, identification based only on the presence of a long dactylus on gnathopod 2 and epimeral plate 3 not incised. With the taxonomy evolution and the detailed descriptions of specimens, some *L. spinicarpa* specimens were subsequently described as new species or synonymized with others (Krapp-Schickel, 1975; Krapp-Schickel & Menioui, 2005; Krapp-Schickel, 2018). Concerning *L. brunonis*, *L. occulta* and *L. serraticarpa*, these species can no longer be maintained in *Leucothoe spinicarpa*-complex due to presence of a distinct incision on epimeral plate 3 posterodistal corner. The others species can be distinguished by presence (*L. articulosa*, *L. denticulata* and *L. spinicarpa*) or absence (*L. occidentalis* and *L. vaderotti*) of a distinct tooth on gnathopod 2 carpus in adult males. Thus, *Leucothoe denticulata* is very close to *L. articulosa* and *L. spinicarpa* but can be distinguished by maxilliped palp dactylus longer than propodus (versus shorter in *L. articulosa*) and few (≤ 10) setae on gnathopod 1 propodus posterior margin and gnathopod 2 basis anterior margin (versus ≥ 10 in *L. spinicarpa*).

*Habitat*

In Arcachon Bay and Brittany, the species was recorded in different subtidal marine habitats, in shallow water (max depth: 7 m) and can support some salinity and temperature variations. The species was sampled with *Celtodoryx ciocalyptoïdes,* an invasive Pacific sponge species newly recorded in the Bay of Biscay and probably present from many years (Gouillieux et al., pers. obs.). On the other hand, in Hossegor Lake, a small marine lake situated at 110 km southerly of Arcachon Bay where the sponge was also sampled, no Leucothoidae species were recorded with *C. ciocalyptoïdes*. This tends to prove that *L. denticulata* is not especially commensal to the

sponge, not more than to oysters' shells, *Crepidula fornicata* or *Phallusia mammillata* but can be recorded in many habitats which can provide shelter. However, depending on the geographical area, the species can present some affinity to *P. mammillata*. These results confirm previous observations: Krapp-Schickel & Menioui (2005) described *L. denticulata* as living in the branchial cavity of ascidians and rarely among sponges, between 20 and 75 m. This affinity to tunicates was already observed in others *Leucothoe* species (Krapp-Schickel & Menioui, 2005; Crowe, 2006; White, 2011).

**Identification key for adult males European *Leucothoe* species, based on Frutos & Sorbe (2012) and White (2011) keys.**

**1.** Eyes absent .....2
**-** Eyes present .....4
**2.** Rostrum long (0.4 head length) and acutely pointed; telson short (length 1.2 maximum width) and heart-shaped ..... .
.....*Leucothoe rostrata* Chevreux, 1908
**-** Rostrum short (~0.18 head length) and rounded; telson elongate (length ~2.2 maximum width) and more or less triangular .....3
**3.** Antenna 1 flagellum 4-articulate, article 2 equal to article 1; mandibular palp article 3 with one distal seta; maxilliped inner plates with apical margin rounded, outer plates with facial setae; epimeron 2 with posterodistal corner rounded..... .
.....*Leucothoe atosi* Bellan-Santini, 2007
**-** Antenna 1 flagellum 15-articulate, article 2 1.6 x article 1 length; mandibular palp article 3 with two distal setae; maxilliped inner plates with apical margin flat, outer plates without facial setae; epimeron 2 with posterodistal corner acutely pointed.....*Leucothoe uschakovi* Gurjanova, 1951
**4.** Epimeron 3 posteroventral corner sinuous with cusp .....5
**-** Epimeron 3 posteroventral corner not sinuous, without cusp .....17
**5.** Epimeron 3 posteroventral corner with bidentate cusp (eye hardly visible in preserved specimens, but clearly visible in live specimens)..... .
.....*Leucothoe cathalaa* Frutos & Sorbe, 2012
**-** Epimeron 3 posteroventral corner with simple cusp .....6
**6.** Gnathopod 2 basis with a mid-distal tubercle ..... .
.....*Leucothoe incisa* Robertson, 1892
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**7.** Antenna 1 peduncle article 1 width greater than 2 x article 2; pereopods 5-7 basis with facial setae ..8
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.....*Leucothoe occua* Krapp-Schickel, 1975
**-** Antenna 1 flagellum 6–10 articulate; gnathopod 1 carpus proximal margin serrate; gnathopod 2 carpus curved, distally truncate, propodus palm with 1–6 small tubercles; coxa 3 anterior and distal margins serrate, facial setae absent; pereopods 5-7 basis posterior margins serrate; telson with facial setae.....*Leucothoe pachycera* Della Valle, 1893
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**-** Gnathopod 2 dactylus less than 0.7 x propodus length.....11
**11.** Gnathopod 2 propodus palm sub-rectangular, dactylus reaching less than 0.5 x propodus length .
.....*Leucothoe euryonyx* (Walker, 1901)
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**15.** Gnathopod 1 basis posterior margin setose; gnathopod 2 propodus palm smooth; telson length less than 1.8 x width .....
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- Gnathopod 1 basis posterior margin bare; gnathopod 2 propodus palm with ornamentation; telson length greater than 1.8 x width .....16

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**18.** Gnathopod 2 carpus without subdistal tooth in adult males; epimeron 3 posterodistal corner rounded (small species, adult ≤ 6 mm) ..... . .....*Leucothoe vaderotti* Krapp-Schickel, 2018*

- Gnathopod 2 carpus with subdistal tooth in adult males; epimeron 3 posterodistal corner subquadrate .....19

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- Maxilliped palp propodus length less than 2 x width, dactylus longer than propodus .....20

**20.** Mandibular palp article 2 densely setose (about 20 setae); gnathopod 1 propodus posterior margin with ≥ 10 setae; gnathopod 2 basis anterior margin strongly setose (≥ 10 setae) ..... . .....*Leucothoe spinicarpa* (Abildgaard, 1789)

- Mandibular palp article 2 sparsely setose (≤ 15 setae); gnathopod 1 propodus posterior margin with ≤ 10 setae; gnathopod 2 basis anterior margin sparsely setose (≤ 10 setae)and heart-shaped .... . .....*Leucothoe denticulata* Costa, 1851

* Krapp-Schickel (2018) did not describe adult males or observed ovigerous females of *L. vaderotti*, and presume its specimens as a new species mainly due to its size, whereas larger specimens from same locations were identified as *L. spinicarpa*. Until a study of morphological development of *L. spinicarpa* to confirm *L. vaderotti* as a new species, authors consider herein as a valid species.

Note: *Leucothoe occidentalis* is the only *Leucothoe* species belonging to the *Leucothoe spinicarpa* complex which is out of European waters (West coasts of Africa). Following the present identification key, *L. occidentalis* could be included in couplet 19. The species can mainly be distinguished from *L. articulosa*, *L. spinicarpa* and *L. denticulata* by its small size (size max: 5 mm) and the gnathopod 2 carpus with subdistal incision (not clearly toothed). But as it was observed, the shape of gnathopod 2 carpus is function of the maturity. Further investigations are needed to determine whether *Leucothoe occidentalis* is a separate species or a juvenile form of a species already described.

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## References

Chevreux E. & Fage L. 1925. *Amphipodes. Faune de France 9*. Lechevalier: Paris. 488 pp.

Crowe S.E. 2006. A redescription of *Leucothoe spinicarpa* (Abildgaard, 1789) based on material from the North Atlantic (Amphipoda, Leucothoidae). *Zootaxa,* 1170: 57-68. Doi: 10.11646/zootaxa.1170.1.3

De Broyer C., Lowry J.K., Jazdzewski K. & Robert H. 2007. *Catalogue of the Gammaridean and Corophiidean Amphipoda (Crustacea) of the Southern Ocean with distribution and ecological data*. In: *Census of Antarctic Marine Life: Synopsis of the Amphipoda of the Southern Ocean*. Vol. 2. (C. De Broyer ed), Bulletin de l’Institut Royal des Sciences Naturelles de Belgique 77 (suppl. 1), Royal Belgian Institute of Natural Sciences: Brussels.

Frutos I. & Sorbe J.C. 2012. *Leucothoe cathalaa* sp. nov. (Crustacea: Amphipoda: Leucothoidae), a new bathyal benthic species from the Le Danois Bank (’El Cachucho’ Spanish MPA), southern Bay of Biscay. *Journal of the Marine Biological Association of the United Kingdom,* 93: 659-666. Doi: 10.1017/S0025315412000574

Gouillieux B. 2017. New records of benthic amphipods, *Jassa slatteryi* Conlan, 1990 and *Ampithoe valida* Smith, 1873 (Crustacea: Peracarida: Amphipoda) for the Bay of Biscay, France, with morphological notes. *Cahiers de Biologie Marine*, 58: 279-289, Doi: 10.21411/CBM.A.F205EFDE

Horton T., Lowry J., De Broyer C., Bellan-Santini D., Coleman

C.O., Corbari L., Costello M.J., Daneliya M., Dauvin J-C., Fišer C., Gasca R., Grabowski M., Guerra-García J.M., Hendrycks E., Hughes L., Jaume D., Jazdzewski K., Kim Y.H., King R., Krapp-Schickel T., LeCroy S., Lörz A.N., Mamos T., Senna A.R., Serejo C., Sket B., Souza-Filho J.F., Tandberg A.H., Thomas J., Thurston M., Vader W., Väinölä R., Vonk R., White K. & Zeidler W. 2019. World Amphipoda Database. *Leucothoe* Leach, 1814. Accessed through: World Register of Marine Species at: http://www.marinespecies.org/aphia.php?p=taxdetails&id=101580 on 2019-04-05

Krapp-Schickel G. 1975. Revision of Mediterranean *Leucothoe* species (Crustacea, Amphipoda). *Bollettino del Museo Civico di Storia Naturale di Verona,* 2: 91-118.

Krapp-Schickel G. 1989. Family Leucothoidae. *Mémoires de l'Institut Océanographique*, 13: 443-459.

Krapp-Schickel T. 2018. *Leucothoe vaderotti*, a new Atlantic *Leucothoe* (Crustacea, Amphipoda) belonging to the "*spinicarpa*-clade" (Crustacea, Amphipoda). *ZooKeys,* 731: 135-144. Doi: 10.3897/zookeys.731.19813

Krapp-Schickel T. & Menioui M. 2005. *Leucothoe* species from Moroccan Atlantic coasts with redefinition of some species within the *Leucothoe spinicarpa* clade. *Bollettino Museo Civico di Storia Naturale Verona Botanica-Zoologia,* 29: 63-83.

Krapp-Schickel T. & Vader W. 2013. Leucothoid and Maerid Amphipods (Crustacea) from deep regions of the North Atlantic. *Helgoland Marine Research*, 67: 383-396. Doi: 10.1007/s10152-012-0330-3

Lincoln R.J. 1979. *British marine Amphipoda: Gammaridea*. British Museum (Natural History): London. 658 pp.

Myers A.A. & McGrath D. 1984. A revision of the North-east Atlantic species of *Ericthonius* (Crustacea: Amphipoda). *Journal of the Marine Biological Association of the United Kingdom* 64: 379-400. Doi: 10.1017/S002531540003006X

Thomas J.D. 2015. *Leucothoe eltoni* sp. n., a new species of commensal leucothoid amphipod from coral reefs in Raja Ampat, Indonesia (Crustacea, Amphipoda). *ZooKeys,* 518: 51-66. Doi: 10.3897/zookeys.518.9340

White K.N. 2011. A taxonomic review of the Leucothoidae (Crustacea: Amphipoda). *Zootaxa,* 3078: 1-113. Doi: 10.11646/zootaxa.3078.1.1