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The Messinian decapod assemblage of Sierra de Hurchillo (Alicante, Spain) and the unexpected presence of *Aethra* (Decapoda: Brachyura: Aethridae)

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Abstract

A new reef-associated decapod assemblage from one locality of the Messinian (late Miocene) of the Alicante province (Spain) is described herein. This assemblage is similar to other Messinian reef-associated fauna from different localities of the circum-Mediterranean area. Surprisingly, *Aethra stalennyii*, an aethrid crab is reported from the same outcrop, being the second fossil record for the genus and the westernmost occurrence. This discovery sheds light and provides clues on the migration pattern of the Paratethyan decapods in the middle and late Miocene.

Key words: Miocene, Messinian, Paratethys, Mediterranean, Crustacea, *Aethra*

1. Introduction

The Messinian crustacean fauna of Alicante province (for instance from the outcrops near Elche dam), has always been well-known among the collector's community and the local museums. However, little has been written about, with the exception of Müller (1984a) who described new taxa from the Messinian reef of Santa Pola (Alicante), aside from some works with divulgative purposes, depicting specimens from that area (e.g., Ferratges, 2017).

Documentation works of the 'Col·lecció Museogràfica Paleontològica i de les Ciències Isurus' of Alcoy (Alicante, Spain), sheds light on a small, but interesting collection of fossil decapods from the Sierra de Hurchillo, in the surroundings of Arneva, municipality of Orihuela (Alicante) (Fig. 1). That collection represents the typical reef-associated decapod fauna of the Mediterranean Messinian. Moreover, among the specimens in that collection, a specimen of *Aethra stalennyii* Ossó, 2018 is described for the first time from the late Badenian (Serravallian, middle Miocene) coralgal buildups of Ukraine, and whose extant representatives have a Indo-West Pacific affinity. Thus, the new discovery of *Aethra* in the Messinian of the southeast of the Iberian Peninsula is paramount, being the second fossil record of the species and the westernmost record of the genus, either fossil or extant.

The aim of this work is: i) to report and describe the decapod assemblage of the Messinian of the Sierra de Hurchillo, and compare it with coeval reef-associated faunas from different localities of the circum-Mediterranean area; and ii) to discuss the palaeobiogeographic significance of the presence of *Aethra* in the Iberian Peninsula and possible faunal migration patterns.

Repository: Col·lecció Museogràfica Paleontològica i de les Ciències Isurus' of Alcoy (Alicante, Spain) under acronym CIAI.

2. Geological setting

The outcrop bearing decapods is located on the NNW flank of the Sierra de Hurchillo (Fig. 2A), in the Neogene Bajo Segura Basin, in the contact between the so-called External and Internal Zones of the Betic ranges (see Pineda-González and Soria-Mingorance, 2021, p. 58, 59). The strata that yielded the material studied herein correspond to the La Virgen Limestones Formation (Montenat et al., 1990), that crops out on the La Sierra de Hurchillo anticline (see Medina-Cascales et al., 2016, figs. 1, 2B). In the outcrop, this formation is composed of detritic, parareefal and reefal limestones, indicative of a storm-dominated shallow platform (see Soria et al., 2008, p. 274). There, a level of bio-built micritic limestones with algae, contains numerous decapod remains (Figs. 2B, C). According to Corbí et al. (2010), and based on planktonic foraminifera, the age of the La Virgen Limestones Formation is late Messinian.

Fig. 1. Location map. Fossil Locality is marked with a star.

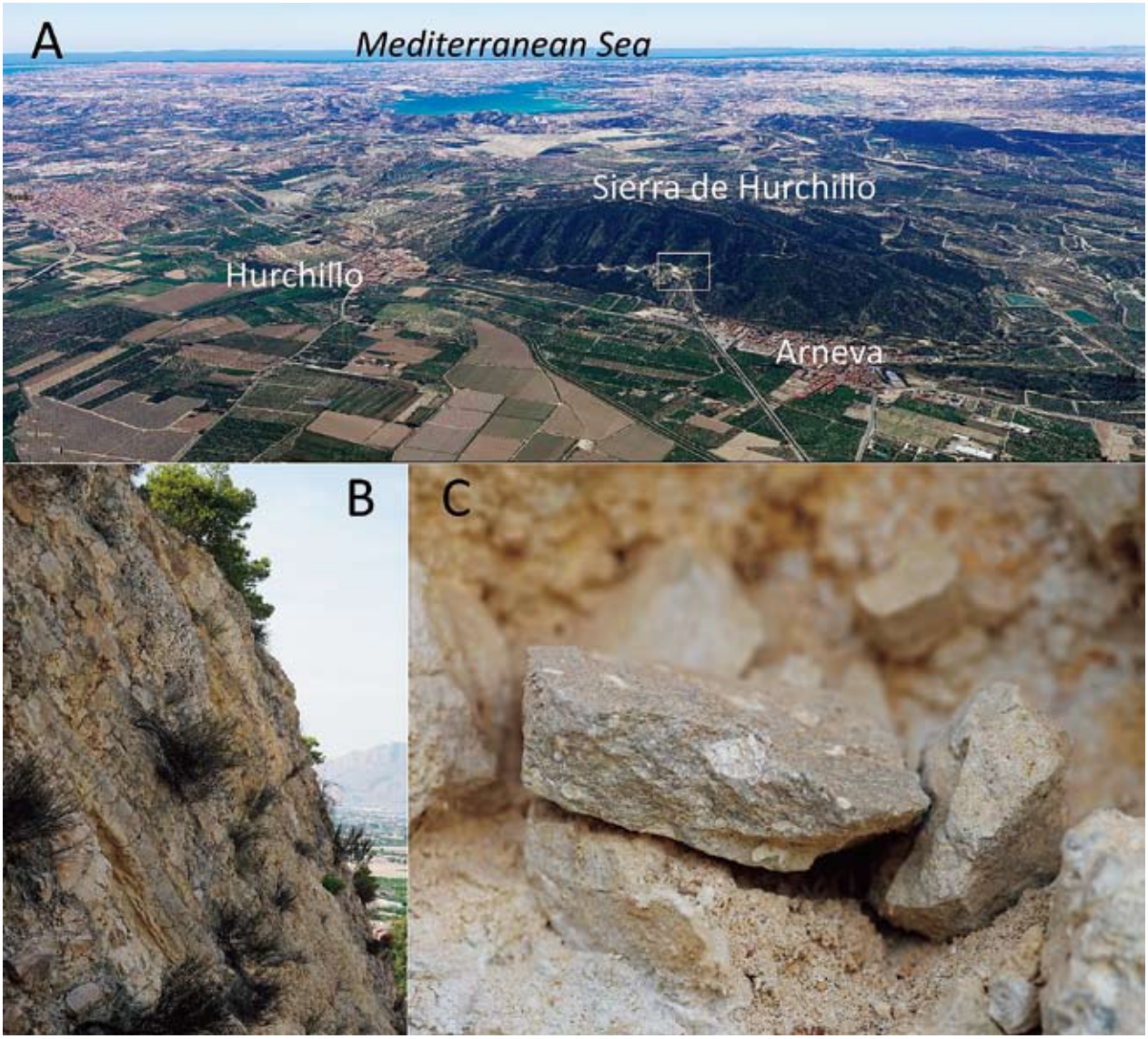

Fig. 2. A, Landscape of the Bajo Segura basin and the Sierra de Hurchillo (Alicante, Spain) (from Google Earth), white rectangle indicates the outcrop. **B,** view of La Virgen limestones Formation at the outcrop. **C,** close-up of the limestone containing crab remains.

3. Systematic palaeontology

Order Decapoda Latreille, 1802
Infraorder Anomura MacLeay, 1838
Superfamily Galatheoidea Samouelle, 1819
Family Galatheidae Samouelle, 1819

Undetermined galatheid

(Fig. 3A)

Material examined: One lateral portion of dorsal carapace, embedded in limestone, CIAI 01517. Length = 10.5 mm; width = 6 mm.

Description: Half right lateral portion of carapace, transversely vaulted, crossed by transverse striae. Epibranchial region with short striae. Branchial posterior region crossed by large transverse striae, subdivided near the lateral margin. Small portion of cardiac region preserved. Remains of cervical groove in anterior portion. Branchiocardiac grooves fairly marked.

Remarks: The fragmentary condition of the sample, which lacks complete outline, rostrum and axial regions, prevents placement in a specific taxon. Although at first sight it could be related to the commonest and most widely distributed squat lobster in the circum-Mediterranean Miocene, *Galathea weinfurteri* Bachmayer, 1950 (cf. Hyžný and Dulai, 2021, p. 126–128, figs. 44.1–14, and references therein), or with the similar *G.*

squamifera Leach, 1814, the studied specimen differs from them by the lack of the transverse secondary striae that both species possess.

Infraorder Brachyura Latreille, 1802
Section Eubrachyura de Saint Laurent, 1980
Subsection Heterotremata Guinot, 1977
Superfamily Aethroidea Dana, 1851
Family Aethridae Dana, 1851

Genus *Aethra* Latreille in Cuvier, 1816

Type species: *Cancer scruposus* Linnaeus, 1764 by monotypy.

***Aethra stalennyii* Ossó, 2018**

(Figs. 3B, C)

2018 *Aethra stalennyii* Ossó, p. 585−593, figs. 3, 4.
2018 *Aethra stalennyii* Ossó; Górka, p. 519.

Material examined: One specimen, CIAI 01518, in dorsal position embedded in limestone matrix, cuticle barely preserved. Length = 17 mm; width = 22 mm.

Description: Carapace small, transversely subovate, wider than long, subclypeiform, with lateral expansions. Dorsal surface uneven. Regions defined by irregular prominent lobes. Front narrow, bilobed, subtruncate, slightly projected. Anterolateral and posterolateral margins not clearly demarcated; both margins cristate, upturned in anterior margin; eight antero- and posterolateral subquadrate teeth each with three points, separated by closed fissures opened at the proximal end forming small holes. Posterior margin narrow, straight. Orbits very small, barely distinguishable. Protogastric lobes strongly elevated posteriorly, divided anteriorly by longitudinal groove reaching frontal margin. Meso- and metagastric lobe sub-rhomboidal, below the level of protogastric lobes. Urogastric lobe depressed. Cardiac region slightly swollen, bearing two small tubercles. Epibranchial lobes prominent, oblique. Mesobranchial region weakly inflated, lower than epibranchial lobe. Metabranchial region slightly inflated. Intestinal region flattened. Hepatic region depressed. Rounded granules irregularly dispersed on carapace surface, ornamenting the top of the more elevated lobes. Ventral parts and appendages not present.

Remarks: The specimen from the Sierra de Hurchillo, surely a juvenile given its small size (cf. Ng, 1999, figs. 1A, B), fits perfectly with the diagnosis of *Aethra stalennyii* described from the coral-gal reefs of Maksymivka (Ukraine), despite the difference of size, 22 mm width of the Spanish specimen *vs* 52 mm width of the Ukrainian samples (see Ossó, 2018). Moreover, the dorsal features warrant the conspecificity of both. The broadly convex anterior margin clearly differentiates the fossil species from all the extant species (cf. Ossó, 2018, fig. 5). *Aethra stalennyii* is the only fossil species of the genus, whose extant species nowadays mainly inhabit the Indo-West Pacific waters and the southern coasts of Africa (Emmerson, 2017, p. 268−272), even though it is also known in the Pacific coast of America (Hendricks et al., 1997, p. 52, 53). The presence of this species in the southeast of the Iberian Peninsula represents the westernmost record for *Aethra*.

Superfamily Dairoidea Serène, 1965
Family Dairidae Serène, 1965

Genus *Daira* De Haan, 1833

Type species: *Cancer perlatus* (Herbst, 1790, subsequent designation by ICZN plenary powers. [ICZN Opinion 73, Direction 78]

***Daira speciosa* (Reuss, 1871)**

(Fig. 3D)

1871 *Phymatocarcinus speciosus* Reuss, p. 325−330, figs. 1−4.
1877 *Phymatocarcinus speciosus* Reuss; Bittner, p. 437, pl. 1.
1929 *Daira speciosa* (Reuss, 1871); Lőrenthey in Lőrenthey and Beurlen, pp. 197, 198, pl. 12, figs. 10, 11.
For more synonymies see Hyžný and Dulai (2021, p. 163).

Material examined: One specimen, CIAI 01519, internal mold of dorsal carapace, cuticle not preserved. Length = 23; width = 32 mm.

Description: Carapace transversely ovate, wider than long, strongly vaulted anteriorly, surface completely covered by irregular tubercles resulting from

degradation of the cuticle. Front bilobed, notched medially. Orbits small, round, rimmed by granules. Anterolateral margins strongly convex, armed with five trifid teeth (internal mold of the lobes when the cuticle is preserved). Posterolateral margin very short, concave, rimmed. Posterior margin straight, slightly wider than frontal margin. Regions defined by rows of irregular tubercles. Mesogastric regions subpentagonal, narrow and elongated anteriorly. Protogastric lobes large; hepatic region with two main tubercles. Urogastric region narrow. Cardiac region wide. Branchial regions inflated. Ventral elements and appendages not preserved.

Remarks: *Daira speciosa* is an omnipresent decapod in all the reefal outcrops from the circum-Mediterranean area, from the middle to the upper Miocene. Furthermore, it is by far the most abundant species in the decapod assemblages in each and every one of the localities yielding crabs, see for instance Gatt and De Angeli (2010, text-fig. 2) or Hyžný and Dulai (2021, p. 163−165). Usually, specimens of *Daira speciosa* from the Sierra de Hurchillo are preserved as internal molds, thus subduing the real dorsal aspect (cf. Ossó and Stalennuy, 2011, figs. 3.13, 3.14). However, the outline and sculpted dorsal surface of specimens of *Daira speciosa* make their identification unmistakable.

Superfamily Xanthoidea MacLeay, 1838

Family Xanthidae MacLeay, 1838

Subfamily Chlorodiellinae Ng and Holthuis, 2007

Genus *Chlorodiella* Rathbun, 1897

Type species: *Cancer niger* Forskål, 1775, subsequent designation by ICZN plenary powers. [ICZN Opinion 2204]

***Chorodiella mediterranea* (Lőrenthey in Lőrenthey and Beurlen, 1929)**

(Fig. 3E)

1929 *Zozymus mediterraneus* Lőrenthey in Lőrenthey and Beurlen, p. 34, 215, pl. 11, fig. 9.

1953 *Chlorodopsis mediterraneus* (Lőrenthey in Lőrenthey and Beurlen, 1929); Bachmayer, p. 253, pl. 3, fig. 5.

1984b *Chlorodiella mediterranea* (Lőrenthey in Lőrenthey and Beurlen, 1929); Müller, p. 88, pl. 76, figs. 1−6, pl. 77, figs. 1−4.

For more synonymies see Hyžný and Dulai (2021).

Material examined: One specimen CIAI 01520, decorticated dorsal carapace. Length = 10.5 mm; width = 16.5 mm.

Description: Carapace transversely subovate, wider than long, surface smooth, regions barely defined; postfrontal blunt ridge, weakly marked, paralleling all the anterior margin. Wide orbito-frontal margin. Font bilobed, weakly notched medially. Orbits rounded. Anterolateral margins convex, with four teeth barely defined, the fourth one (epibranchial) the most prominent. Posterolateral margin slightly convex. Posterior margin short, straight, about same width as the front. Posterior lobe of mesogastric region slightly swollen. Urogastric region depressed. Cardiac region rhomboidal. Intestinal region transversely narrow, weakly swollen. Epibranchial ridge slightly raised.

Remarks: In spite of the poorly preservation of the specimen, it preserves enough elements to identify it as *Chlorodiella mediterranea*, and at the same time is easily distinguishable from the other extinct *Chlorodiella* species by its surface almost smooth and the less defined regions (cf. Hyžný and Dulai, 2021, p. 235−241, figs. 93.1−7, 94.1−7, 95.1−9, 96.1−9), namely *C. tetenyensis* Müller, 1984b, *C. loczyi* Müller, 1984b, and *C. juglans* Müller, 1984b that inhabited the Paratethyan area during the Miocene. With respect to *Chlorodiella junghuhni* (Martin, 1880), as *Chlorodius junghuhni*, moved to *Chlorodiella* genus by Müller (1984b, p. 88), after examination of the description and figure of Martin (1880, p. 128, pl. 22, fig. 4), it looks very similar to specimens from West Java (Indonesia, without geological references but probably Neogene), recently examined by the first author. It could also be attributable to *Liomera* Dana, 1851. A close examination of the type of Martin (1880) could resolve the question of whether the generic placement of *Chlorodius junghuhni* within *Chlorodiella* is appropriate.

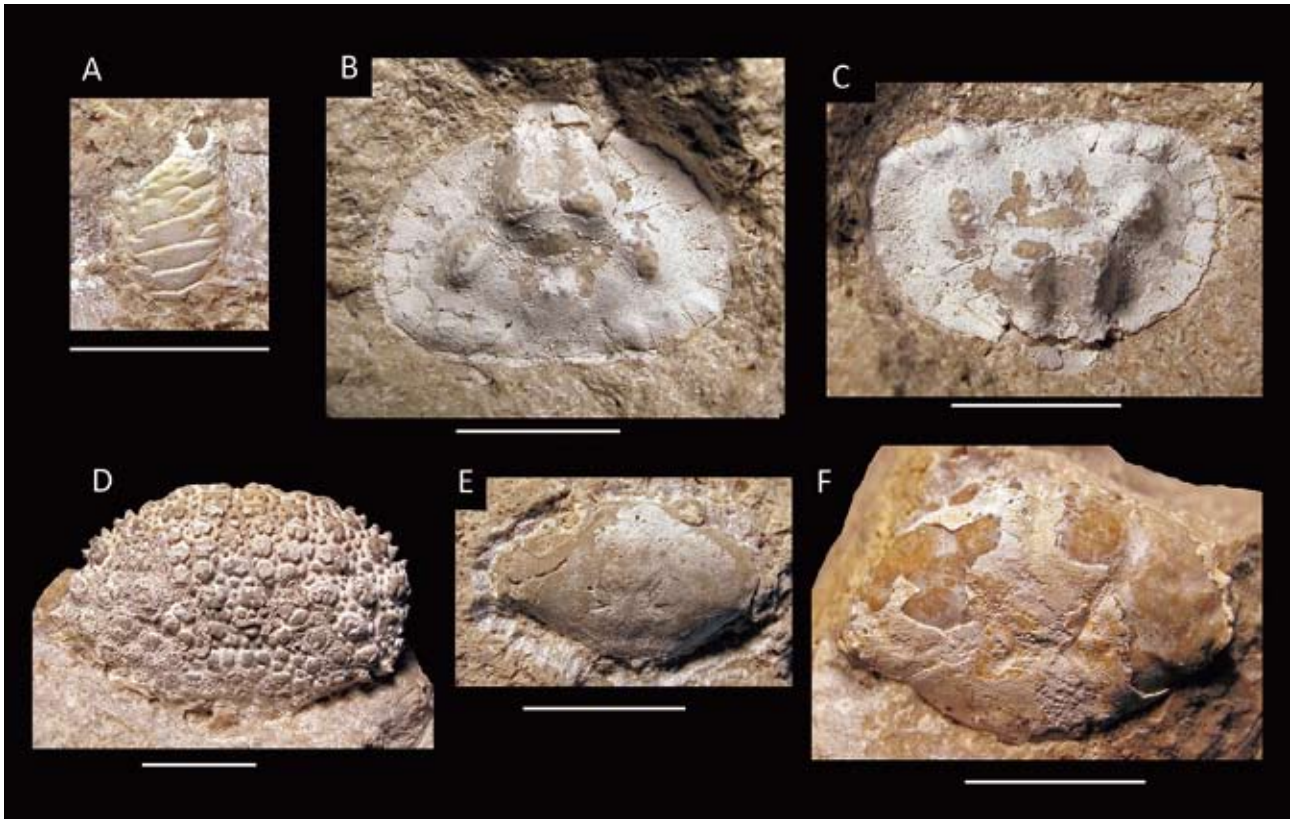

Fig. 3. A, Undetermined galatheid, CIAI 01517. **B–C, *Aethra stalennyii* Ossó, 2018**, CIAI 01518. B, dorsal view; C, frontal view. **D, *Daira speciosa* (Reuss, 1871)**, CIAI 01519, dorsal view. **E, *Chorodiella mediterranea* (Lőrenthey in Lőrenthey and Beurlen, 1929)**, CIAI 01520, dorsal view. **F, *Xantho moldavicus* (Yanakevich, 1977)**, CIAI 01521, dorsal view. Scale bars = 10 mm.

Subfamily Xanthinae MacLeay, 1838

Genus *Xantho* Leach, 1814

Type species: *Cancer incisus* Leach, 1814 by monotypy. [ICZN Opinion 423]

***Xantho moldavicus* (Yanakevich, 1977)**

(Fig. 3F)

1908 *Titanocarcinus pulchellus* A. Milne-Edwards, 1864 *non*1865 (*sic*); Couffon, p. 4–5, pl. 2, fig. 6, text-fig. unnumbered p. 4.

1953 *Titanocarcinus vulgaris* Glaessner, 1928; Bachmayer, p. 254, pl. 4, figs. 1–9, pl. 6, figs. 1–2.

1974 *Xantho* cfr. *X. incisus*; Müller, p. 123, pl. 3, figs. 1–2.

1977 *Medaeus moldavicus* Yanakevich, p. 80, pl. 10, fig. 4.

1979 *Xantho* cfr. *X. incisus*; Müller, p. 274, pl. 20, figs. 1–5.

1979 *Xantho* cf. *X. vulgaris*; Förster, p. 263–264, pl. 5, fig. 4.

1984b *Xantho moldavicus* (Yanakevich, 1977); Müller, p. 92, figs. 5–8, pl. 86, figs. 1–5, pl. 87, fig. 1.

For more synonymies see Hyžný and Dulai (2021).

Material examined: One specimen CIAI 01521, dorsal carapace partially decorticated. Length = 15.5 mm; width = 22 mm.

Description: Carapace transversely subhexagonal, regions well marked, wider than long. Front bilobed, with medial notch. Orbits small, rounded, forwardly directed; supraorbital margin with two fissures; infraorbital margin visible dorsally. Anterolateral margin bearing four subtriangular blunt teeth, the fourth the smallest. Posterolateral margins straight, rounded in cross section. Posterior margin straight, short. Frontal region divided medially by groove. Protogastric region swollen, anterior portion of lobes divided medially, the inner portion confluent

with epigastric lobes. Mesogastric region slightly swollen, slender anteriorly, broader and rhomboidal posteriorly. Metagastric region not differentiated. Urogastric region very narrow. Cardiac region slightly swollen, laterally confluent with metabranchial lobes. Intestinal region narrow, transversely swollen. Epibranchial regions transversely elongate, sigmoidal. Mesobranchial region short, laterally placed, confluent with the distal lobe of epibranchial lobe. Metabranchial region broad, swollen, separated from epi- and mesobranchial regions by transverse grooves. Hepatic region slightly swollen. Preserved cuticle smooth. Cervical, branchiocardiac and accessory grooves delimiting regions and lobes well marked but shallow, smooth. Sternopleonal elements and appendages not preserved.

Remarks: The examined sample, in spite of its partial preservation, preserves enough features to identify it as *Xantho moldavicus* (cf. Hyžný and Dulai, 2021, figs. 98.1–11).

Xantho moldavicus is another ubiquitous crab, present in all the reef-associated crab assemblages in the Paratethys and the circum-Mediterranean area during the middle and late Miocene (e.g., Gatt and De Angeli, 2010, text-fig. 2; Hyžný, 2016, t. 1). It is also present in the Atlantic coast of France in non-reefal Langhian (middle Miocene) outcrops (see Ossó and Gagnaison, 2019, p. 378, figs. 5F–I; Ossó et al., in press, t. 1, figs. 6D–G).

4. Discussion

Each the taxa of the Sierra de Hurchillo assemblage is already known from the middle Miocene of the Western and Central Paratethys reefal environments, as can be seen in the references of each of the species here described.

In this regard, Hyžný (2016, p. 487–489, and references therein), discussed extensively the similarities between the Mediterranean and the Paratethyan faunas during the middle and late Miocene, pointing out the relative homogeneity of the decapod fauna of both domains, whereas the similarities with the Miocene Atlantic decapod fauna appear to be smaller. And how the faunal exchange was controlled by water circulation between the Mediterranean and the Paratethys. And contrary to what could have occurred in the middle Miocene, the reef-associated late Miocene fauna could represent descendants of the Paratethyan migrants (e.g., Müller, 1993, t. 1; Gatt and De Angeli, 2010, text-fig. 2; Hyžný, 2016, t. 1).

However, for instance the non-reef associated leucosiid *Iphiculus eliasi* Hyžný and Gross, 2016, and the portunid *Achelous monspeliensis* (A. Milne-Edwards, 1860), have been reported both in the middle Miocene of the Central Paratethys and Mediterranean, but also on the Atlantic coast of south Portugal (see Gašparič and Ossó, 2016; Ossó et al., 2020). Furthermore, up to nine species and fifteen genera non-exclusively-reef-associated, out of a total of nineteen taxa examined, reported by Ossó and Gagnaison (2019) and Ossó et al. (in press, t.1), from the middle and late Miocene non-reefal outcrops of the Atlantic coast of France, are as well known in the Mediterranean and Paratethys. This would indicate that the faunal differences are more due to the lack of suitable habitats, such as the absence of reefal environments on the Atlantic coast of Europe and Africa during the Miocene, than to the dispersal capacity of decapods, in agreement to Hyžný (2016, p. 487).

The case of *Aethra* is outstanding, and the discovery of this genus in the southeastern Iberian Peninsula, whose extant representatives inhabit primarily West Indo-Pacific waters (Ossó, 2018, and references therein), indicates that *Aethra* migrated westward from the Central Paratethys to the Mediterranean before the closure of the seaways connecting both domains (see Hyžný and Dulai, 2021, figs. 5, 6, and references therein). *Aethra* appears to have also migrated from the Central Paratethys to the East, before the closure of the Tethyan Seaway (see Hyžný et al., 2021, fig. 4, and references therein). Later Messinian salinity crisis (e.g., Hsü et al., 1977) impeded the survival of *Aethra* in the Mediterranean domain. This is contrary to what occurred with their conspecifics that migrated eastward, to the Indo-Pacific waters, where they found suitable habitats for their persistence in time to the present day.

5. Conclusions

The reef-associated Messinian decapod assemblage of the Sierra de Hurchillo is almost identical to other Messinian reef-associated decapod assemblages scattered throughout the circum-Mediterranean area (e.g., Gatt and De Angeli, 2010; De Angeli et al., 2011). The presence of *Aethra stalennyii* in the southeastern Iberian Peninsula is the westernmost record of the genus known. Its presence shows how the widely accepted eastward migratory trend of decapods during the middle to late Miocene (see Ossó, 2018, p. 590, and references therein), was not the only migratory trend, since they also migrated westward, where they settled until the reefal environments disappeared at the end of the Miocene.

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