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Professional paper

AMPHIPOD COMMUNITY ASSOCIATED WITH CANOPY-FORMING ALGAE STRUCTURE AND SPATIAL VARIABILITY OF CRUSTACEA: AMPHIPODA IN *CYSTOSEIRA SENSU LATO* ASSEMBLAGES

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Abstract

In the Mediterranean Sea, the canopy-forming algae formerly belonging to the genus *Cystoseira sensu lato*, are the most important algal canopy-forming underwater forests. Given the importance of these canopy-form algae and the habitat they constitute, it is important to know the species that these algae are associated with. A study was conducted to investigate the amphipod species associated with four species of Cystoseira *sensu lato* overo *Cystoseira compressa*, *Ericaria crinita* and *E. amentacea* and *Gongolaria barbata*, near Vlora Bay, in Southern Albania. The samples were collected in the spring and autumn of 2021. In 4 different algal species of the genus Cystoseira sensu lato, 1448 individuals were collected in two sampling seasons (965 in spring and 483 in autumn), belonging to 52 Amphipoda species. An attempt to study the spatiotemporal variability and faunal composition of each alga has been made. In addition, the Bray – Curtis Similarity index was calculated to compare the distance between the four species of canopy-forming algae. According to the frequency analysis, it emerges that on average there are only one or two species that populate these algae with greater frequency (more than 30% of the total sample), instead the other species of amphipods occur with a minimum frequency of less than 5% of the sample. However, the composition of the dominant species in each algal species is different.

Keywords: Cystoseira sensu lato; Ericaria; Gongolaria; spatial scales; biodiversity; amphipoda; Mediterranean Sea; Albania

1. Introduction

Macroalgae beds dominate shallow Mediterranean benthic habitats where they play a key role. Among these, the species of the genus *Cystoseira sensu lato*, recently resurrected generates, namely *Gongolaria* and *Ericaria* (Novoa & Guiry, 2019), which form the crown represent the highest level of structural complexity and provide unique habitats with ecological services comparable to terrestrial forests. These canopy-forming algae provide habitat, and protection and amplify the biodiversity and productivity of coastal ecosystems through their structural complexity (Chapman et al., 1995; Bruno et al., 2003; Piazzi et al., 2018). Consequently, the ecological role of these species in defining the structure and biodiversity of coastal marine areas is fundamental (Thomsen et al., 2011; Piazzi et al., 2018).

The interaction between these species and their associated biota is an important element that must be considered for conservation programs in coastal habitats (Benedetti-Cecchi et al., 2001; Thomsen et al., 2011; Fraschetti & Terlizzi, 2005). Cystoseira sensu lato species are the most important canopy-forming algae in the shallow rocky bottoms of the Mediterranean Sea (Ballesteros, 1990). These canopy-forming species build secondary substrates in rocky bottoms providing habitats for epiphytic and mobile organisms thus determining biodiversity models (Sales and Ballesteros, 2010; Sales et al., 2012; Piazzi et al., 2018). The ecological pressure from the increase of pollution, overfishing, and urbanization in recent years, has questioned the survival of these marine forests, leading more and more to the deterioration of their habitat (Mangialajo et al., 2008; Blanfuné et al., 2016). As a consequence of the loss of habitat, the fauna associated with these algal species continues to have the same consequences (Cheminée et al., 2013; Piazzi et al., 2018).

Given the importance of these canopy-form algae and the habitat they constitute, it is important to know the species that these algae associate with (Benedetti-Cecchi, 2001; Fraschetti et al., 2005). In the case of invertebrate fauna, studies on the fauna associated with the Cystoseira sensu lato algae are numerous (Arrontes and Anadon, 1990; Faucci and Boero, 2000; Athanasios & Chariton, 2000; Chemello and Milazzo, 2002; Fraschetti et al., 2002; Valério-Berardo & Flynn , 2002; Kocataş et al., 2004; Pitacco et al., 2014; Sanfilippo et al., 2017; Sciuto et al., 2017; Piazzi et al., 2018; Rosso et al., 2019; Iwasa-Arai et al., 2021), however in some particular taxa, data is still missing, due to the difficulty in the taxonomy of these specimen. This paper aims to study the associated fauna of Crustacea - Amplipoda in four different species of the genus Cystoseira sensu lato near the bay of Vlora, Albania. The species analyzed are *Cystoseira compressa* (Esper) Gerloff & Nizamuddin, 1975, *Gongolaria barbata* (Stackhouse) Kuntze 1891; *Ericaria crinita* (Duby) Molinari & Guiry 2020 and *Ericaria amentacea* (C.Agardh) Molinari & Guiry 2020.

2. Material and methods

To determine the species of Amphipoda associated with Cystoseira sensu lato spesies, samplings were carried out in three different areas in southern Albania near the Bay of Vlora (Zvernec, Karaburun penisula, Vlora Bay) in the upper part of the rocky infralittoral (Figure 1). The sampling was carried out in an area of 400 cm2 in facies composed only of a single species of *Cystoseira sensu lato*, according to the methodology of Bellan-Santini (1969).

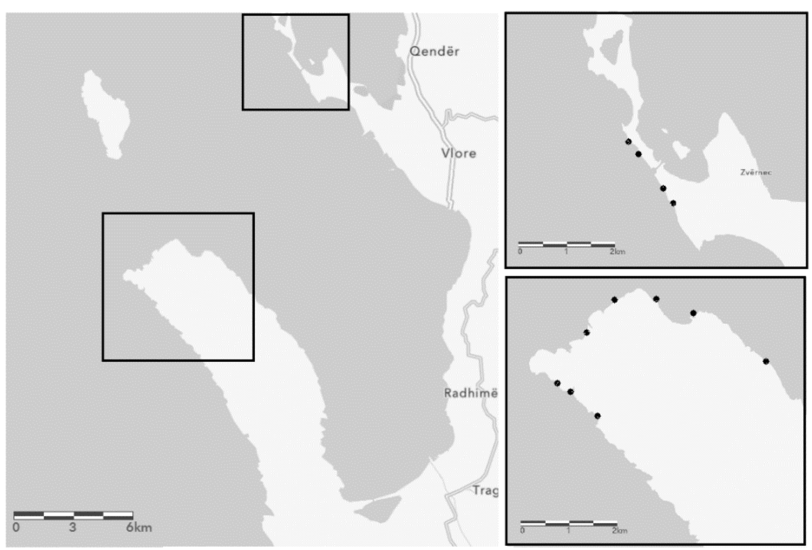

Figure 16. Map of the sampling area

The sampling was carried out during the spring and autumn of 2021, exactly in May and October. For the sampling, a metal structure (20 x 20 cm) covered with a zoobenthos net with 0.5 mm holes was used. The roots of the *Cystoseira* algae were excavated and completely removed from the substrate, collecting all the material present in the algae. All the collected material was stored in 4% formaldehyde for further laboratory analysis. The samples were washed in a 0.5 mm sieve and the fauna of the invertebrates was selected and collected using an optical stereomicroscope. All species were determined by taxonomic keys with the aid of the optical stereomicroscope. For the interpretation of the data obtained, the index of uniformity (Pielou, 1975), the total number of species for each species of algae, and the frequency and abundance were calculated.

3. Results

Following the samplings carried out in 4 different algal species of the genus *Cystoseira sensu lato*, 1448 individuals were collected in two sampling seasons (965 in spring and 483 in autumn), belonging to 52 amphipoda species (Figure 2, Table 1). The highest number of species was observed in the autumn season in Ericaria crinita beads with an average of 20 species, followed by *Ericaria amentacea* with 18 species. The minimum number of species occurred in *Cystoseira comressa* beads in spring with 11 species identified. Although the *C. compressa* was in full reproductive period during sampling in spring, the biodiversity of this species in spring was low compared to other species.

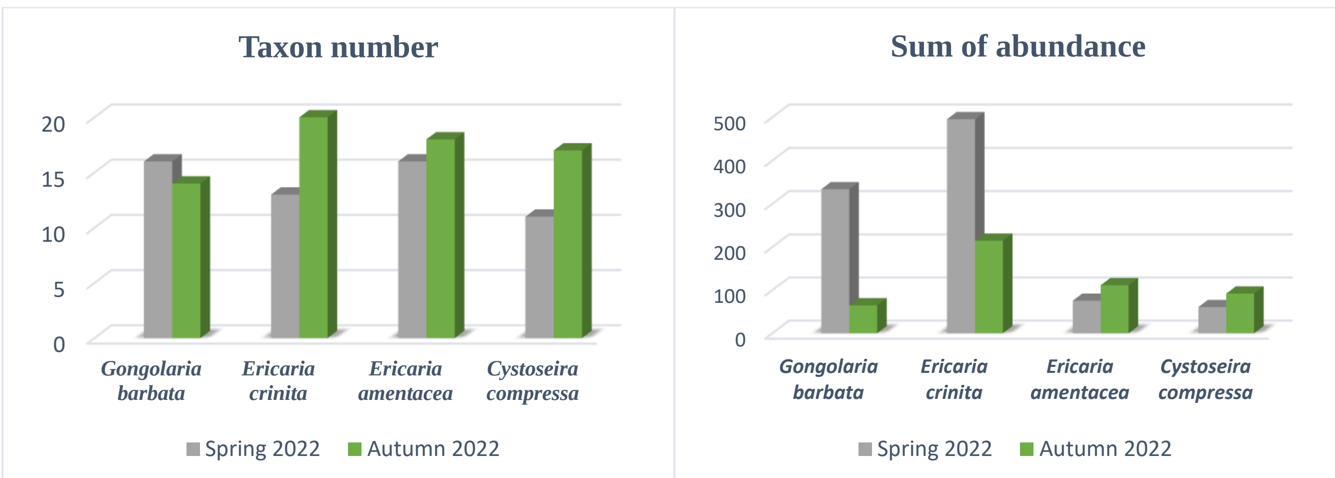

Figure 17. Taxon number for each Cystoseira species and total abundance in two different seasons

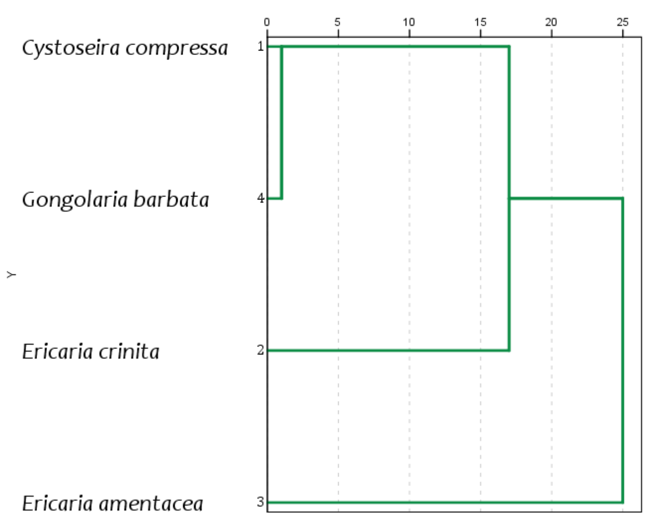

Figure 18. Bray – Curtis Similarity index between species

In the case of the abundance sum between the samples of different species of *Cystoseira sensu lato*, the species *Ericaria crinita* and *Gongolaria barbata* show the greatest difference between the two seasons (Figure 2), in which the spring season is the most abundant both in number of species and of individuals. Being the species *E. crinita* and *G. barbata* in a habitat with less hydrodynamics than the other two species, it is assumed that the greater number of species prefer these habitats due to their limited ability to swim and cling to algae (Valério-Berardo & Flynn, 2002).

From the Bray – Curtis Similarity index (figure 3) between species analysis, it appears that the composition of the species is more similar between

Table 10. Amphipoda community identified in Cystoseira sensu lato assemblages.

Species	***Cystoseira compressa***	***Ericaria crinita***	***Ericaria amentacea***	***Gongolaria barbata***
Leucothoe spinicarpa (Abildgaard, 1789)				+
Apolochus picadurus (J.L. Barnard, 1962)		+		
Acidostoma sp. Lilljeborg, 1865		+		
Nototropis massiliensis (Bellan-Santini, 1975)		+		+
Dexamine spinosa (Montagu, 1813)		+		+
Ampelisca antennata Bellan-Santini & Kaim-Malka, 1977	+		+	
Ampelisca anophthalma Bellan-Santini & Kaim-Malka, 1977		+	+	
Caprella mitis Mayer, 1890				+
Caprella grandimana Mayer, 1882				+
Caprella danilevskii Czerniavski, 1868		+		
Caprella andreae Mayer, 1890			+	
Caprella rapax Mayer, 1890				+
Caprella penantis Leach, 1814	+			
Caprella sp. Lamarck, 1801			+	
Ericthonius sp. H. Milne Edwards, 1830		+		
Aora sp. Krøyer, 1845			+	
Microdeutopus anomalus (Rathke, 1843)	+		+	
Aurobogidiella italica (G. Karaman, 1979)	+	+		+
Aora maculata (Thomson, 1879)		+		
Microdeutopus gryllotalpa Costa, 1853	+		+	
Ampithoe ramondi Audouin, 1826		+	+	
Medicorophium annulatum (Chevreux, 1908)				+
Monocorophium acherusicum (Costa, 1853)	+		+	
Pleonexes helleri (Karaman, 1975)	+		+	
Ampithoe valida S.I. Smith, 1873	+			
Ampithoe ferox (Chevreux, 1901)	+	+		
Sunamphitoe pelagica (H. Milne Edwards, 1830)	+			
Corophium sp. Latreille, 1806	+			
Cymadusa ledoyeri Peart, 2004				+

Apocorophium acutum (Chevreux, 1908)		+		
Ampithoe sp. Leach, 1814		+	+	
Monocorophium sextonae (Crawford, 1937)			+	
Gammarus sp. Fabricius, 1775	+			+
Amphithopsis Boeck, 1861		+		
Amphithopsis depressa Schiecke, 1976		+		
Neogammarus adriaticus Karaman, 1973			+	
Gammarella fucicola (Leach, 1814)				+
Elasmopus rapax Costa, 1853	+	+		
Elasmopus brasiliensis (Dana, 1853)	+	+	+	+
Elasmopus pectenicrus (Spence Bate, 1862)			+	
Maera schieckei Karaman & Ruffo, 1971	+	+		+
Maerella tenuimana (Spence Bate, 1862)	+		+	
Melita palmata (Montagu, 1804)	+			
Elasmopus rapax Costa, 1853			+	
Protohyale (Protohyale) grimaldii (Chevreux, 1891)		+	+	
Apohyale crassipes (Heller, 1866)	+			+
Hyale sp. Rathke, 1836		+		
Ptilohyale eburnea (Krapp-Schickel, 1974)		+	+	
Hyale stebbingi Chevreux, 1888			+	
Parhyale plumicornis (Heller, 1866)	+			
Pereionotus testudo (Montagu, 1808)	+	+		+

Cystoseira compressa, Gongolaria barbata and *Ericaria crinita*.

There is a bias in this analysis regarding the species composition in *Ericaria amentacea*. The presence of *E. amentacea* in areas with greater hydrodynamics may be one of the reasons for the deviation in the faunal composition of this species.

About the analysis of the composition of the Amphipoda fauna associated with *Cystoseira sensu lato* species, we analyzed the frequency of each Amphipoda species present in the algal assemblages (figure 4).

According to the analysis, it emerges that on average there are only one or two species that populate these algae with greater frequency, instead the other species of amphipods occur with a minimum frequency of less than 5% of the sample. However, the composition of dominant species in each algal species is different.

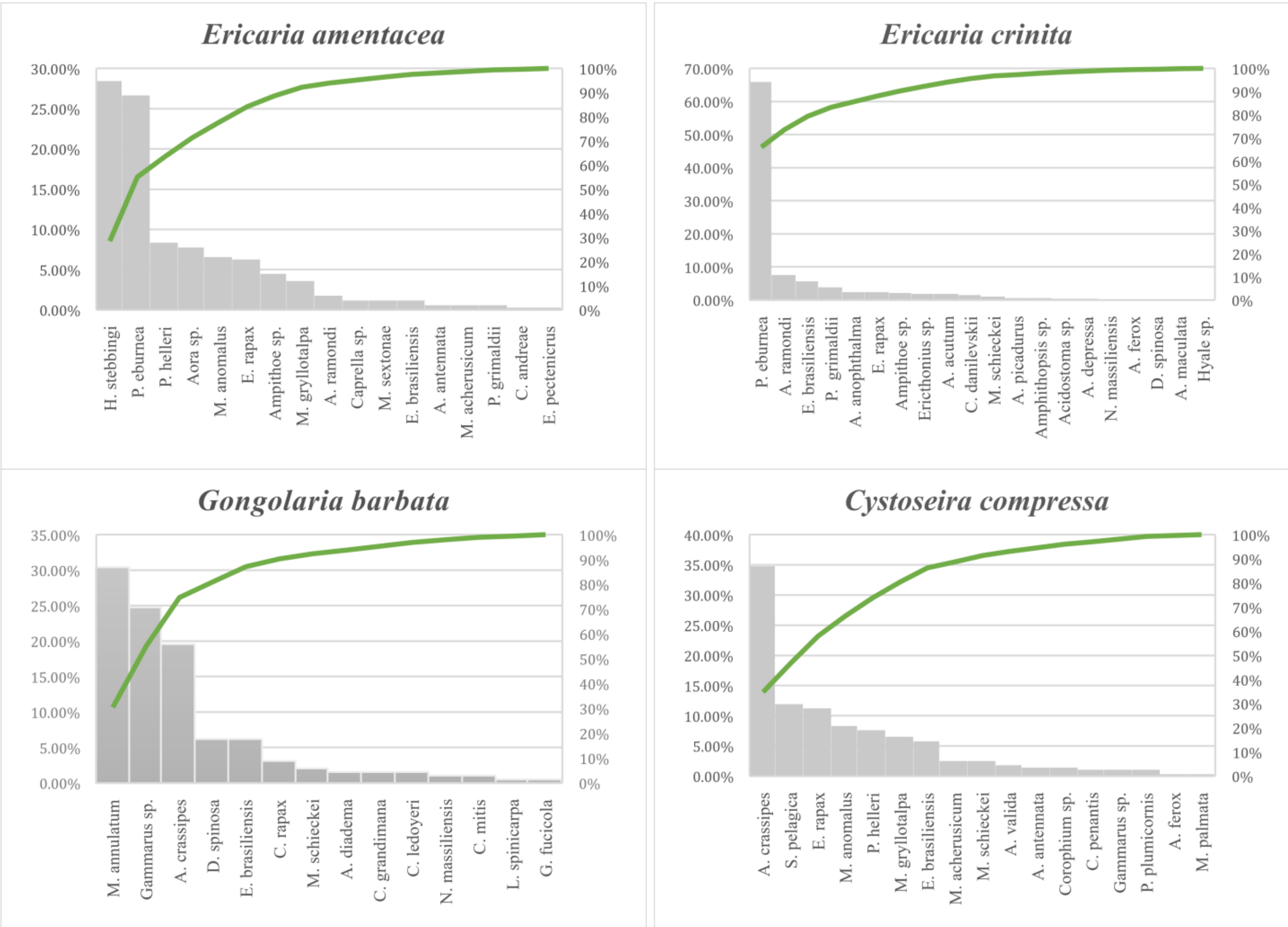

Figure 19. Species frequency composition for each algal facies

For example, the species *Ericaria amentacea* is mostly dominated by *Hyale stebbingi* and *Ptilohyale eburnea* which make up 28% and 27% of the analyzed samples. In the case of *E. crinita* and *C. compressa*, most of the sample is dominated by a single species. In *E. crinita* 67% is dominated by *Ptilohyale eburnea* and in *C. compressa* by *Apohyale crassipes* in 37% of the samples. Only in the case of G. barbata did the composition become more homogeneous, where the presence of more than one species dominates, *Medicorophium annulatum* with 30%, *Gammarus sp*. with 25%, and *Apohyale crassipes* 20%. The species more rarely present in the samples were selected and presented with all the taxonomic characteristics in Figure 5 below.

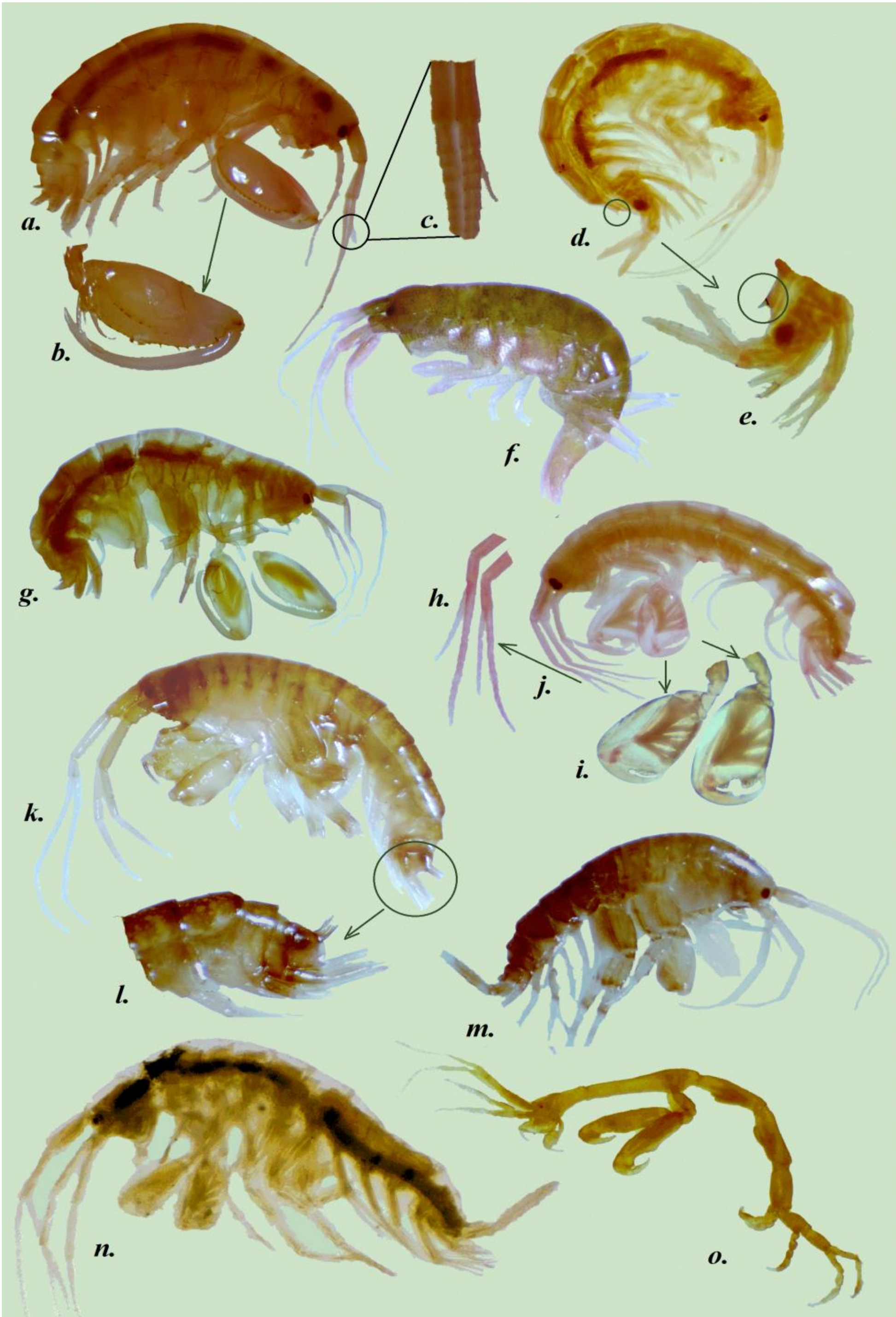

Figure 4. a, b, c - Elasmopus rapax Costa, 1853; **d, e** – Aurobogidiella italica (G. Karaman, 1979); **f** - Cymadusa filosa Savigny, 1816; **g.** Gammarella fucicola (Leach, 1814); **h, I, j** - Quadrimaera inaequipes (A. Costa in Hope, 1851); **k, l** - Maerella tenuimana (Spence Bate, 1862); **m** - Melita palmata (Montagu, 1804); **n** - Neogammarus adriaticus Karaman, 1973; **o** - Caprella danilevskii Czerniavski, 1868

4. Discussion and Recommendation

According to the temporal analysis between the two seasons, we concluded that there is no stable pattern between different species of Cystoseira sensu lato on the seasonal variability of the amphipod fauna (Valério-Berardo & Flynn 2002). According to Nelson, (1979), the regulation of the abundance of amphipods is not influenced by physical factors however we think that the three-dimensional structure of the algal species and the hydrodynamism play a fundamental role in the composition of the species present in each algal species (Athanasios & Chariton, 2000).

In the present study, there was a marked variation in the total seasonal abundance of amphipods during the spring season in *Ericaria crinita* and *Gongolaria barbata* species. In the species *Ericaria amentacea* and *Cystoseira compressa* the seasonal variation of the abundance of the amphipod fauna remains almost constant. If we compare the morphology of the habitats where these species live, it can be assumed that the associated amphipod fauna prefer environments with less hydrodynamics (Iwasa-Arai et al. 2021).

The rapid increases in the frequency of one or two species in the composition of the associated fauna in each algae assemblage are explained in terms of increased reproduction and rapid growth rates of brooding invertebrates (Edgar & Moore, 1986).

A study of the variation of associated amphipods fauna each month is recommended to study the spatiotemporal variability of these species. Also, the 24-hour variability if there is a migration of some of these species into deeper habitats during the day.

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