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Notas / *Notes*

BOSMINA (EUBOSMINA) COREGONI BAIRD, 1857 (CRUSTACEA, BRANCHIOPODA, ANOMOPODA): NEW PLANKTONIC INVADER IN THE IBERIAN PENINSULA

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ABSTRACT

Bosmina (*Eubosmina*) *coregoni* Baird, 1857 has been recorded for the first time in the Iberian Peninsula. It is a planktonic cladoceran widely distributed in the Holarctic region which was never previously referred in the Iberian Peninsula in spite of the numerous and intensive studies on freshwater planktonic fauna in this geographic area in the last three decades. The species appeared in five reservoirs located in the Northwest quadrant. Excepting Valdecañas reservoir, which can be considered eutrophic, the others (Bárcena, Peares, Belesar and Aguieira) were classified as meso-eutrophic. The only morphotype found corresponds to *Bosmina (Eubosmina) coregoni* ssp. *coregoni*. The maximum abundance of this species occurred during the winter period. It is plausible to consider that waterfowl migration and the presence of recreational boats might be the dispersion vector of this species in Iberian Peninsula.

Key words: *Bosmina coregoni*; Reservoirs; Iberian Peninsula.

RESUMEN

***Bosmina* (*Eubosmina*) *coregoni* Baird, 1857 (Crustacea, Branchiopoda, Anomopoda): un nuevo invasor planctónico en la península ibérica**

Se cita *Bosmina* (*Eubosmina*) *coregoni* Baird, 1857 por vez primera en la península ibérica. Se trata de un cladócero planctónico ampliamente distribuido en la región holártica, que no había sido previamente referido en la península ibérica a pesar de los numerosos e intensivos estudios sobre la fauna planctónica de agua dulce realizados durante las últimas tres décadas en este ámbito geográfico. La especie ha aparecido en cinco embalses situados en el cuadrante noroccidental. Con excepción del Embalse de Valdecañas, que se puede considerar eutrófico, los restantes (Bárcena, Peares, Belesar y Aguieira) fueron clasificados como meso-eutróficos. El único morfotipo encontrado corresponde a *Bosmina (Eubosmina) coregoni* ssp. *coregoni*. La abundancia máxima de la especie ocurrió durante el período del invierno. Es plausible considerar que las aves acuáticas y la presencia de embarcaciones de recreo pudieron ser un vector importante de la dispersión de esta especie en la península ibérica.

Palabras clave: *Bosmina coregoni*; embalses; península ibérica.

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Bosmina (Eubosmina) coregoni Baird, 1857 has a Holarctic distribution. Evidences from mtDNA, nuclear DNA, and paleolimnological data are consistent with the hypothesis that the European *Eubosmina* (*Bosmina coregoni* included) phylogroup is of post-glacial origin from a *Bosmina* (*Eubosmina*) *longispina*-like ancestor (Haney & Taylor, 2003). Paleolimnological data obtained by Nauwerck (1991) also indicate an ongoing centrifugal spreading from an origin center located in north-eastern Europe. Apart from Northeastern Europe (e.g. Kernan *et al.,* 2009) it was mentioned in Poland (Kuczynska-Kippen, 2006; Adamczuk, 2009), Germany (Nauwerck, 1991; Hofmann, 1996; Straile & Müller, 2010), Denmark (Brucet *et al*., 2009), Belgium (Malbrouck *et al*., 2005) and in Northern Italy (Margaritora, 1983). In the Iberian Peninsula *B.* (*E.*) *coregoni* had not been reported in any of the extensive studies of zooplankton in reservoirs and lakes in Spain (Armengol, 1978; Miracle, 1978; Jaume, 1993; Alonso, 1996, 1998), nor in Aguieira reservoir in Portugal (Oliveira & Monteiro, 1992). However, recently specimens belonging to subgenus *Eubosmina* were referenced for the first time in the following reservoirs: Valdecañas (2010 and 2014), Bárcena and Belesar (2007), Peares (2008), and Aguieira (2010 and 2011). Since the mentioned subgenus exhibit a huge morphological diversification (Kerfoot, 2006; Korosi *et al*., 2013), the objective of the present paper has been to describe the morphotype that has colonized the afore mentioned reservoirs. Based on the ecology of this species as well as the environmental conditions of the reservoirs, the main factors that may have determined the apparently successful colonization of this species are also discussed.

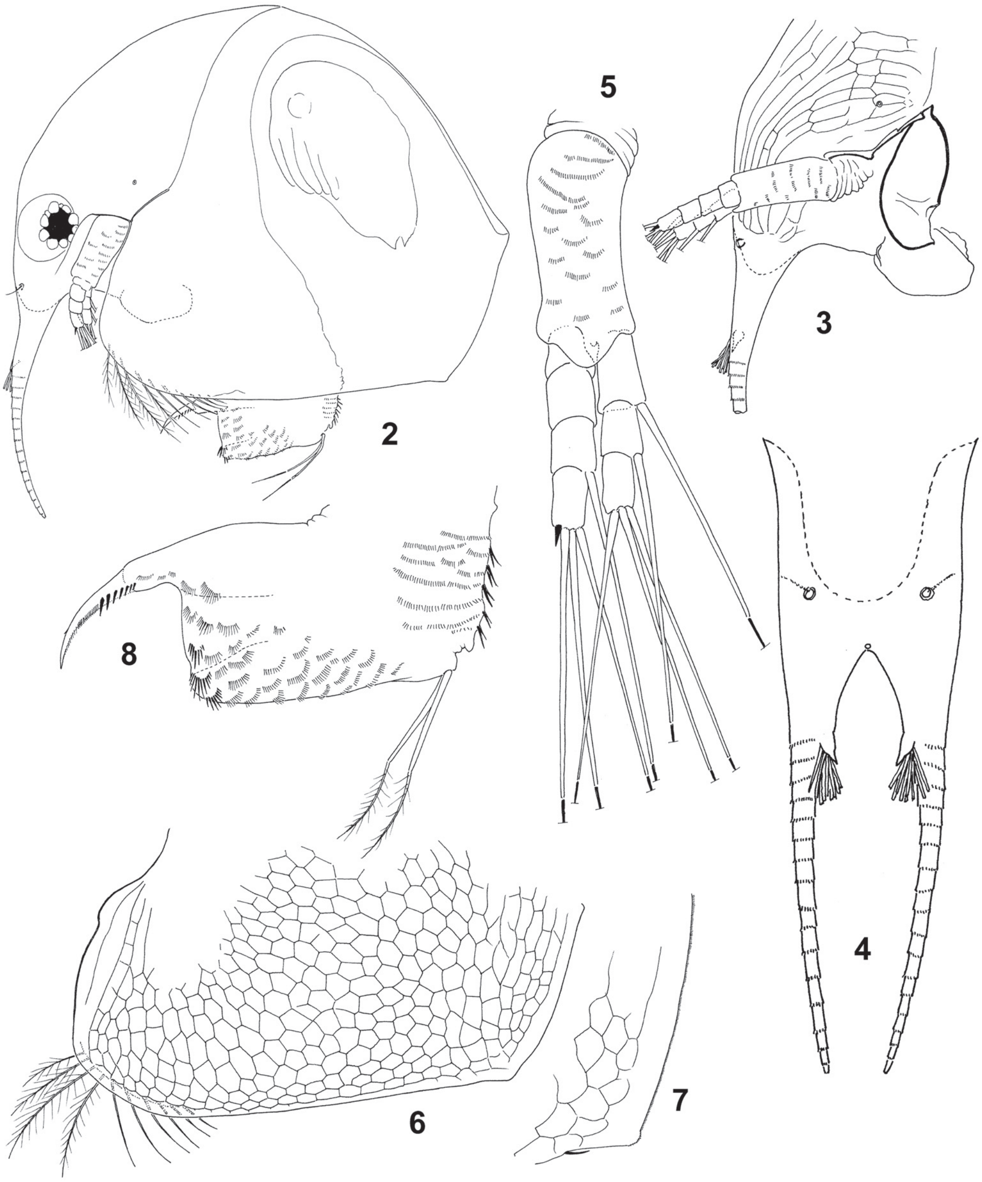
Sampling location

Sampling was performed in the following reservoirs (Fig. 1): Valdecañas (39°46'N, 5°36'W), Bárcena (42°34'N, 6°33'W), Peares (42°27'N, 7°43'W), Belesar (42°24'N, 7°38'W) and Aguieira (40°20'N, 8°11'W; Mondego Catchment; Portugal).

According to Lieder (1983) the morphotype found corresponds to *Bosmina (Eubosmina) coregoni* ssp. *coregoni* which has the dorsal profile of the carapace evenly rounded, body little bit longer than higher (1.2-1.3 times) without cyclomorphosis and rounded posteroventral carapace corner (Fig. 2). Head shield sculptured with longitudinal lines with crossings in proximal part; lateral head pores separated from the ridge of fornix (Fig. 3). Antennules (Figs. 3-4) of variable length but generally long (about 50 % the length of the body or longer); aestetascs relatively short located in the proximal third; frontal sensory setae close to the end of rostrum. Second antennae as figured (Fig. 4). Carapace (Fig. 6) sculptured with polygons; ventral anterior edge with a series of setae inserted at the inner surface; setae anterior to the posterior ventral angle short; posteroventral

Fig. 1.— Location of the reservoirs where *Bosmina (E.) coregoni* was collected in the Iberian Peninsula.

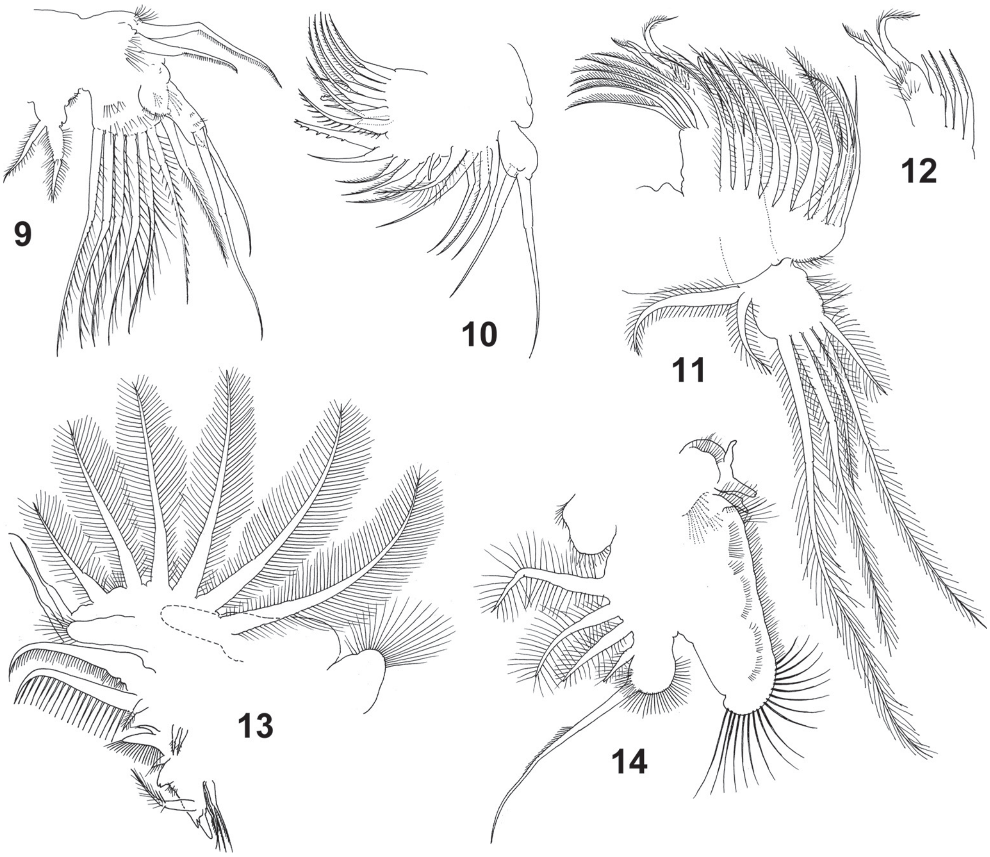
Fig. 1.— Localización de los embalses donde apareció *Bosmina (E.) coregoni* en la península ibérica.



Figs. 2-8.— *Bosmina* (*E.*) *coregoni*; parthenogenetic female from Belesar reservoir. 2, lateral view of the whole animal; 3, head shield and second antenna; 4, antennulae, ventral view; 5, second antenna; 6, carapace; 7, posteroventral corner; 8, postabdomen.

Figs. 2-8.— *Bosmina* (*E.*) *coregoni*; hembra partenogenética del embalse de Belesar. 2, vista lateral del cuerpo; 3, yelmo cefálico y segunda antena; 4, vista ventral de las anténulas; 5, anténula; 6, caparazón; 7, ángulo posteroventral; 8, postabdomen.

carapace mucro little developed being generally blunt pointed or widely rounded; posterior margin gently convex with a row of marginal fine setulae (Fig. 7). Postabdomen (Fig. 8) 1.6 longer than high; anus opening in distal edge; a conical projection with two postabdominal claws 2.5 longer than the conical projection itself; postabdominal claws provided with a row of robust inclined denticles in its basal part followed with a row of hair-like spines. First trunk limb (Fig. 9) with a wide endopodite provided with five setulated setae and one long spine forming a brush, and one separated shorter spine in more ventral position; exopodite consisting in a small lobe provided with two setae; ejector hooks chitinized of different lengths. Second trunk limb (Fig. 10) with the endopodite provided with an internal row of spines and an external row of more slender setae; near the gnathobase there is a characteristic denticulated spine; exopodite as in the first trunk limb. Third trunk limb (Fig. 11) with an external row of eight soft setae and a distal group of three long spines in the endopodite; gnathobase with three stark setae close to its base, three distal setulated setae and six elements in the filter plate (Fig. 12); exopodite well developed, subquadrangular and provided with five terminal setae of different length and two proximal setae. Fourth trunk limb (Fig. 13) with big exopodite provided with six feathered long setae and two small spines located ventrally; endopodite with four setae setulated in one side, two of them very developed,



Figs. 9-14.— *Bosmina* (*E.*) *coregoni*; parthenogenetic female from Belesar reservoir. 9, first trunk limb; 10, second trunk limb; 11, third trunk limb; 12, gnathobase of third trunk limb; 13, fourth thoracic limb; 14, fifth thoracic limb.

Figs. 9-14.— *Bosmina* (*E.*) *coregoni*; hembra partenogenética del embalse de Belesar. 9, primer apéndice torácico; 10, segundo apéndice torácico; 11, tercer apéndice torácico; 12, gnatobase del tercer apéndice torácico; 13, cuarto apéndice torácico; 14, quinto apéndice torácico.

Table 1.— Values of the environmental variables analyzed when *Bosmina* (*E.*) *coregoni* showed higher abundances (* February; ** December-March)

Tabla 1.— Valores de las variables analizadas cuando *Bosmina* (*E.*) *coregoni* mostró abundancias más elevadas (* Febrero; ** Diciembre-Marzo)

	Peares*	**Bárcena***	**Belesar***	**Valdecañas***	**Aguieira****
Water temperature (°C)	10.7	8.6	9.7	8.6	12.3-15.8
Conductivity (µS/cm)	119	144	74	1184	76-102
pH	7.7	7.5	7.5	7.7	7.3-8.1
Secchi depth (m)	6.6	3.2	3.2	-	3.0-5.0
Nitrite (mg/L)	0.002	0.003	0.010	0.102	0.01-0.03
Nitrate (mg/L)	4.9	1.6	5.1	12.2	4.4
Ammonia (mg/L)	<0.20	<0.20	<0.20	0.17	0.05-0.06
Phosphate (mg/L)	0.064	<0.03	<0.5	0.23	<0.23
Chlorophyll a (µg/L)	3.1	2.3	0.7	0.6	0.77-1.6

and four small setae; gnathobase with two rudimentary setae and a long distal seta; filter plate with four setae. Fifth thoracic limb with the endopodite without setae and a group of long setae in its terminal part (Fig. 14); exopodite with three lateral feathered setae and two terminal unequal setae, one short and the other very long provided with a row of small setulae.

The reservoirs where *Bosmina coregoni* was referenced were similar from the limnological point of view (Table 1). Excepting Valdecañas reservoir, which can be considered eutrophic, the others were classified as meso-eutrophic according to criteria defined by Carlson (1977). Maximum abundance of *B.* (*E.*) *coregoni* occurred during the winter period (December-March). Considering its relative abundance, *B.* (*E.*) *coregoni* was the most abundant cladoceran. Zooplankton community was similar among reservoirs (Table 2). *Keratella cochlearis* (Gosse, 1851) and *Polyarthra* sp. pl. were the most abundant rotifers. However, copepod assemblage showed significant differences among the studied reservoirs; *Cyclops vicinus* Uljanin, 1875 is another invader also referred in the Iberian Peninsula by Caramujo & Boavida (2000) in two reservoirs located in River Tagus basin.

In the area of origin *B.* (*E.*) *coregoni* is typically found in mesotrophic lakes (Nauwerck, 1991; Dimante-Deimantovica *et al.*, 2012). This species shows higher abundances in lakes in which mean total phosphorous concentrations, mean water conductivity and mean suspended matter were 30 µg/l, 100 µS/cm

Table 2.— Zooplankton communities and average of relative abundances of species during the period of higher abundance of *Bosmina* (*E.*) *coregoni* (*no quantitative data)

Tabla 2.— Comunidades de zooplancton y abundancia relativa promedio de las especies durante el período de mayor abundancia de *Bosmina* (*E.*) *coregoni* (*datos no cuantitativos)

	Peares	**Barcena**	**Belesar**	**Valdecañas***	**Aguieira**
ROTIFERA					
Asplanchna priodonta		0.8			0.1
Brachionus sp.				x	
Conochylus sp.					
Filinia sp.					
Gastropus sp.					0.1
Hexarthra mira					
Keratella cochlearis	24.2		9.1	x	1.4
Keratella cochlearis f. *tecta*				x	
Keratella quadrata				x	
Keratella tropica				x	
Lecane stichaea			4.3		
Lepadella ovalis			5.7		
Ploeosoma sp.					
Polyarthra sp. pl.		61.9	41.4		23.9
Synchaeta pectinata	2.0	0.1			0.1
Synchaeta oblonga		12.9	5.4		
CLADOCERA					
Alona sp.					
Alona rectangula					
Bosmina (*E.*) *coregoni*	14.1	3.5	18.6	x	14.9
Bosmina longirostris	5.3	1.0		x	0.4
Ceriodaphnia pulchella		0.6		x	1.0
Ceriodaphnia quadrangula					0.1
Chydorus sphaericus				x	0.1
Daphnia galeata				x	
Daphnia longispina	4.0	2.3	5.2		1.5
Daphnia parvula					
Daphnia pulicaria		0.4			
Diaphanosoma brachyurum					0.2
COPEPODA					
Acanthocyclops robustus	5.9			x	0.7
Copidodiaptomus numidicus	10.2				7.5
Cyclops vicinus	8.1	1.7	0.6		
Tropocyclops prasinus		6.8			10.4
Nauplii	26.2	8.0	9.7	x	37.6

and 60 mg/l, respectively (Berzins & Bertilsson, 1989). Nauwerck (1991) and Hofmann (1996) also reported that when water conditions shift from eutrophic to oligotrophic, *B.* (*E.*) *coregoni* becomes more prominent. Bertilsson *et al*. (1995) reported that this species occurring in Sweden lakes prefers water temperature between 13 and 18 °C showing peaks in summer and early autumn. This pattern was also corroborated by several authors (e.g. Geller & Müller, 1981; Straile & Müller, 2010) also for North America where this species was assumed to have been introduced with ballast water (e.g. Lieder, 1991; Havel & Medley, 2006; Smits *et al*., 2013). In the present study it was observed that the maximum abundance occurred in winter period, when the temperature is more similar to that is produced in northern areas in summer time. Therefore, this species could be considered as cold water stenotherm.

Cladocerans have several life history traits which favor their capability for high dispersal rates. They are capable of asexual reproduction and hence a single individual can found a new population and forming resting eggs which, in many genera, are encased in a hard capsule: the ephippium. Ephippia can resist freezing and desiccation, which allows surviving hostile terrestrial conditions. Resting eggs thus allow cladocerans to take advantage of a number of potential transport vectors including wind and rain. Several studies have demonstrated that waterbirds can transport those viable eggs both internally or externally, being one of the most important long-distance dispersal vectors (Figuerola *et al*., 2003, 2005; Louette & De Meester, 2004; Green & Figuerola, 2005). Data obtained by Charalambidou & Santamaría (2002) indicate that maximum dispersal distances of propagules via endozoochory may easily exceed 1,000 km. However, the overall effective dispersal and colonisation will depend on a complex interaction between (1) propagule characteristics; (2) abundance, behavior and morphology of each disseminator species and (3) the survival and establishment probabilities of transported propagules, which is influenced by local species composition, genetic features and environmental/climate interactions (De Meester *et al.,* 2002, 2007; Jocque *et al*., 2010; Louette & De Meester, 2005). The role of birds in spreading alien invertebrates has received little attention. However, the observed dispersal kernel for *Daphnia lumholtzi* G.O. Sars, 1885 in reservoirs is consistent with transport by birds (Green & Figuerola, 2005). Therefore, it is plausible to think that waterfowl might be an important dispersion vector of this species in Europe, and the Iberian Peninsula serves as an *important* stop for *migrating birds* (e.g. Newton, 2008). Recreational boats have also been identified as a common anthropogenic dispersal vector. In fact, canoe hulls and incubation of canoe rinse water indicated a high potential for portage (Stasko *et al*., 2012). In fact, the colonization of *B.* (*E.*) *coregoni* in Agueira reservoir can be explained not only by bird migration but also by recreational boats. In fact, every year this reservoir is chosen by canoeing and kayaking high competition from central Europe and Russia teams, for training for international competitions such as the Olympic Games. Intense hydromorphological fluctuations occurring in many Iberian reservoirs induce the existence of higher instability and consequently zooplankton communities are not well established and more simplified. Therefore, reservoirs are easier to invade than natural lakes (Havel & Medley, 2006) and it is expected in the future to find more Iberian reservoirs colonized by exotic species. It is the case of Serra Serrada reservoir (41°57'N, 6°46'W) which was colonized between 2003 and 2010 by *Holopedium gibberum* Zaddach, 1855 (Geraldes & Alonso, unpubl. data). In this case bird dispersion or other natural vector is the most logical hypothesis because there is no boat traffic in this reservoir. Considering the large distribution range of *B. coregoni* in the Iberian Peninsula, it is desirable that any further studies contribute to fully understand the consequences of *B. coregoni* invasion on community assemblages and on ecosystem functioning. These studies will be crucial to develop management strategies in order to mitigate potential negative impacts.

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