THE BITHYNIIDAE OF GREECE (GASTROPODA: BITHYNIIDAE)

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Abstract *Newly studied material of A. Falniowski's collection of Bithyniidae from Greece and samples collected by V. Pešić revealed three new species:* Pseudobithynia ambrakis *n. sp.,* P. euboeensis *n. sp., and* P. zogari *n. sp., and in addition we could redescribe* Bithynia hellenica *Kobelt 1892. In total, 16 taxa of the Bithyniidae are now known from Greece, and the species here described gave us new insight as to their distribution pattern.*

Key words Pseudobithynia ambrakis *n. sp.,* P. euboeensis *n. sp., and* P. zogari *n. sp., dispersal, species richness gradient, reproductive strategies*

INTRODUCTION

In the 19th Century, 9 *Bithynia* spp. from Greece were described (for reference see Glöer *et al*. 2007: 15), but in the course of the 20th Century these were taxonomically lumped together and reduced to only three *Bithynia* spp. (Willmann & Pieper, 1978), and two species (Schütt, 1987), respectively. However, both sets of authors mentioned distinct species. While Willmann & Pieper (1978) reported a higher α-diversity in the Iberian Peninsula (5 *Bithynia* spp.) and Italy (9 *Bithynia* spp.), unexpectedly they did not accept such richness of species for Greece, which has already been criticised by Bănărescu (1991: 695). But Hof *et al*. (2008), who evaluated the entire results of the Limnofauna Europaea (Illies, 1978) statistically, pointed out that the β-diversity in European freshwater animals increases latitudinally from North to South, with a β-diversity of about 60–80% in Greece, depending on the particular habitats, and Strong *et al.* (2008) mentioned Greece as one of the worldwide hot spots of freshwater gastropod diversity.

More recent investigations revealed that Greece is a hot spot of radiation of the Bithyniidae (Glöer & Pešić, 2006, Glöer *et al*. 2007, Glöer & Maassen, 2009). With the exception of *Bithynia hellenica* (Kobelt 1892), all species that were described in the 19th Century have already been identified by syntypes or topotypes (Glöer & Pešić, 2006).

Investigations in Greece which were carried out by Andrzej Falniowski in the 1980s and Vladimir Pešić in 2007, gained new insight into the distribution pattern of the Bithyniidae in Greece, which remained enigmatic until now (Glöer *et al*., 2007). This paper is intended to elucidate (i) the distribution pattern of the Bithyniidae, (ii) to redescribe *Bithynia hellenica*, and (iii) to describe the new species *Pseudobithynia ambrakis* n. sp., *P. euboeensis* n. sp., and *P. zogari* n. sp.

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MATERIAL AND METHODS

The snails were collected with a sieve and the samples were put into 75% ethanol. The dissections and measurements of the genital organs and the shells were carried out using a stereo microscope (Zeiss); the photographs were made with a digital camera system (Leica).

To clarify the status of *Bithynia hellenica* we borrowed the syntypes from the Senckenberg Museum (Frankfurt) and a lot from Westerlund's collection (Natural History Museum Goeteborg) collected in Euboea. To study the species richness and the distribution of the *Bithynia* and *Pseudobithynia* spp. we summarised all the results of our previous studies.

The type material is stored in the RMNH, Nationaal Natuurhistorisch Museum Naturalis, Leiden (The Netherlands) (formerly: Rijksmuseum van Natuurlijke Historie).

RESULTS

The material of Falniowski's wet collection of Bithyniidae revealed two previously unknown species. We have identified *B. hellenica* as being conspecific with a species from Lake Taka (Figs 1, 2), 10 km to the south of Tripoli (Peloponnes).

Figure 1 The sampling sites. **1:** Litohoro (*Pseudobithynia zogari* n. sp.), **2:** Preveza (*P. zogari*), **3:** Lake Ambrakia (*P. ambrakis*), **4:** Euboea, (*P. euboeensis*), **5:** Euboea, (*P. zogari*), **6:** Taka Lake (*Bithynia hellenica*), **7:** Skala town, canal (*P. zogari*), **8:** Evrotas river near Skala town city (*P. zogari*).

In his original description, Kobelt (1892: 67) mentioned that the surface of the shell was latticely sculptured, and he used this feature as a means of distinguishing *B. hellenica* from *B. orsinii*. However, in none of the 8 syntypes that we were able to study could we find this feature. Concerning the distribution, he mentioned that this species populated Greece and the islands of the archipelago.

In addition, Falniowski collected in Lake Ambrakia a *Pseudobithynia* species which is distinct from the Bithyniidae from this region (Lake Lysimachia, Lake Trichonis, Fig. 1), and an unknown species from the Island Evia (Euboea).

The new species have been compared with the already known species *Bithynia graeca* (Westerlund 1879), of which it is not known if it belongs to the genus *Bithynia* or *Pseudobithynia*, as well as with *Bithynia hellenica* (Kobelt 1892), and all other *Bithynia*/*Pseudobithynia* spp. known so far (Glöer & Pešić, 2006, Glöer *et al*., 2007, Glöer & Maassen, 2009).

One sample was collected from Evia Island, the region of Ochi, Limni vidras pond near Karystos town (01.07.2007, leg. Pešić), which contained many juvenile specimens, among which there was a broken adult shell. Thus, it was not possible to determine if this species is distinct from those collected at the region of Githio city. Examination of a lot from Westerlund's collection from Evia Island (determined as *B. goryi*), which contained one juvenile as well as one adult specimen (Fig. 5), made it possible to solve this problem, because juvenile specimens are sometimes characteristic for species determination; all three samples under discussion contained the same species. *Bithynia goryi* was described by Bourguignat (1856: 185) from Egypt (Nile), although Locard (1894: 84) referred to it as a variety of *Bithynia tentaculata* (Linnaeus 1758). From the zoogeographical point of view it is unlikely that the species from Euboea is conspecifical with *B. goryi* from Egypt because we do not know any other *Bithynia* species in the Balkans and the Near East which shows such a large distribution range.

At present, in addition to numerous *Pseudobithynia* spp., only five *Bithynia* species are known from Greece: *Bithynia hellenica* Kobelt 1891, *B. prespensis* Hadžišče 1963, *B. cretensis* Glöer & Maassen, 2009, and *B. kastorias* Glöer, Albrecht & Wilke 2007. While the two latter species live endemically in Lake Prespa (1000 m asl.) and Lake Kastorias (700 m asl.), respectively, only *B. hellenica* and *Pseudobithynia zogari* n. sp. seem to be widespread in Greece like *Pseudobithynia zogari* n. sp. In neighbouring countries many *Bithynia* species are known (Glöer & Yildirim, 2006, Glöer & Pešić, 2007) while *Pseudobithynia* species are rare or absent.

Formerly it was believed that many *Bithynia* species from Greece were conspecific with species from the West-Mediterranean region, e.g. *Bithynia boissieri* (Küster 1852), which was mentioned by Westerlund & Blanc (1879), but *B. boissieri* with

its type locality near Rome is a *Bithynia* with a penial appendix instead of being a *Pseudobithynia*. However, according to our research to date, the Bithyniidae of the W-Mediterranean region have nothing in common with those from the E-Mediterranean region.

Family **Bithyniidae** Gray 1857
Genus ***Bithynia*** Leach 1818

Type species Bithynia tentaculata (Linnaeus 1758)

Bithynia hellenica Kobelt 1892 (Fig. 2)
Bithynia (orsinii var. ?) hellenica Kobelt 1892

Description Shell with a silky sheen, yellowish horn-coloured, surface finely striated, 4.5 whorls slightly convex with a deep suture, umbilicus open, the aperture height takes 0.5 of the shell height, edge of aperture sharp, outer margin of aperture a little sinuated (fig. 2.2); the males are slimmer than the females; nucleus of operculum cochleate. Shell height 5.5 – 5.9 mm, width 3.8 – 4.5 mm.

Anatomy Distal part of the penis is as long as the penial appendix and is strongly tapered. The flagellum is approximately three times longer than the penis (fig. 2.7).

Table 1 Measurements of the syntypes of *B. hellenica*

Shell height [mm]	4.2	4.2	5.0	5.1	5.4	5.5	5.9
Shell width [mm]	2.6	2.6	3.4	3.2	3.3	3.8	3.9

Remarks Topotypes of *B. hellenica* have not been available to us but specimens from Falniowski's collection from Lake Taka (10 km S. of Tripolis, Peloponnes) of which the shells are equal to each other (fig. 2) could be indentified as *B. hellenica*. The measurements of the syntypes (Tab. 1) show that the shell proportions are a little variable. Kobelt (1892: 67) mentioned this species from the type locality (Lepanto = Nafpaktos, Greece) as well as from Greece Islands.

Genus ***Pseudobithynia*** Glöer & Pešić 2006

Type species Pseudobithynia irana Glöer & Pešić 2006

Pseudobithynia ambrakis n. sp. (Figs 3.1–3.4)

Material examined Greece, Lake Ambrakia, 1985, leg. A. Falniowski

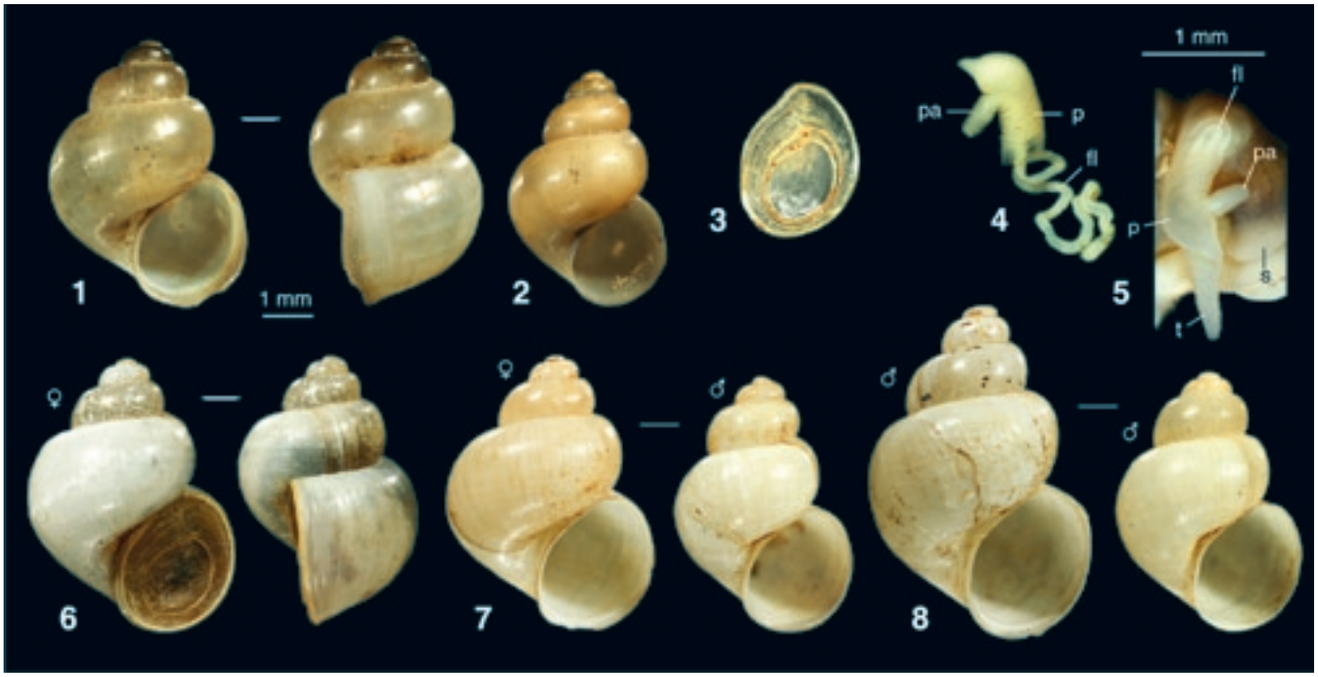

Figure 2 *Bithynia hellenica*. **1–2:** Syntypes, 1: this specimen was already depicted by Kobelt (1891, pl. 137, fig. 860), **3–9:** *B. hellenica* from Lake Taka. – fl = flagellum, p = penis, pa = penial appendix, s = snout, t = tentacle.

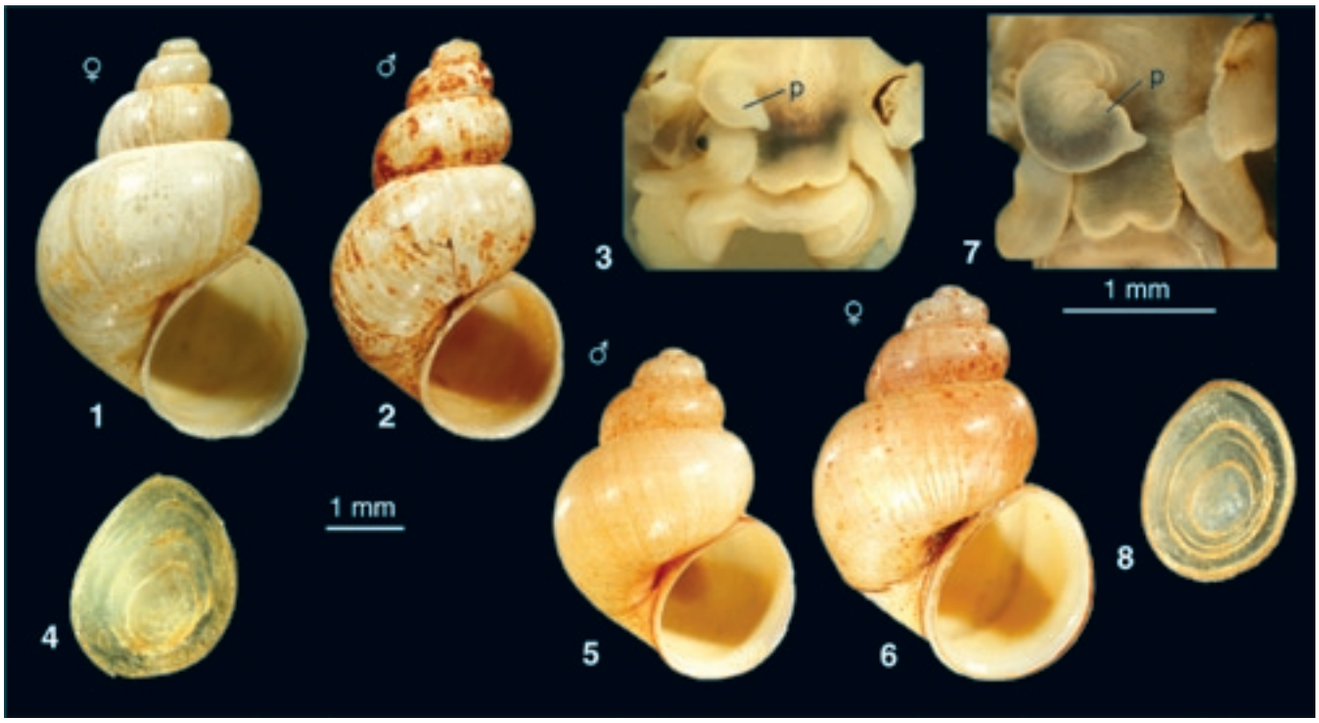

Figure 3 **1–4:** *Pseudobithynia ambrakis* n. sp. **1–2:** the shell, **3:** penis, **4:** operculum, **5–8:** *P. euboeensis* n. sp. **5–6:** the shell, **7:** penis, **8:** operculum. – p = penis.

Holotype Shell height 5.6 mm, width 3.5 mm, RMNH 112036.

Paratypes dry RMNH 112037/1, alcohol 70% RMNH 112038/2, rest collection of Glöer.

Locus typicus Lake Ambrakia

Description Shell glossy, yellowish horn-coloured, surface finely striated, 4.5 convex whorls with a deep suture, umbilicus open to slit-like, the aperture height takes 0.43 (male) – 0.46 (female) of the shell height, edge of aperture sharp, outer margin of aperture straight; the males are slimmer than the females; nucleus of the convex operculum not central. Shell height 5.0–5.6 mm, width 3.1–3.5 mm (female); height 5.0–5.5 mm, width 3.0–3.1 mm (male).

Etymology Named after the Lake Ambrakia, where this species lives.

Differential diagnosis The operculum of this species is not convex like in *P. ambrakis*.

Pseudobithynia euboeensis n. sp. (Figs 3.5–3.8)

Material examined 168 ex. from type locality, April 1985, leg. A. Falniowski

Holotype Shell height 6.5 mm, width 4.5 mm, RMNH 112039.

Paratypes dry RMNH 1120414/3, alcohol 70% RMNH 112040/5, rest collection of Glöer.

Locus typicus Euboea Island, vicinity of Marmaris, from damp meadow (with some small water bodies, formed by the water running from the spring) at the seaside.

Description Shell glossy and light brownish to horn-coloured, surface finely striated, 4.5–5 whorls slightly convex with a deep suture, umbilicus open, the aperture height takes 0.5 of the shell height, edge of aperture sharp, outer margin of aperture a little sinuated; a clear dimorphism is not visible; nucleus of operculum not cochleate. Shell height 5.5–6.5 mm, width 4.3–4.5 mm.

Penis Simple and broad with a small penis tip.

Etymology Named after the island Euboea, where this species lives.

Differential diagnosis The species can be confused with *P. zogari*, but it can be distinguished

Figure 4 Sampling sites of the new *Pseudobithynia zogari*. **top:** Island Evia, **bottom:** Skala town, canal (type locality) (photographs: V. Pešić).

from this species by the operculum, which is in *P. euboeensis* not cochleate and the penis of the latter species is broader with a small penis tip.

Remark In 2003 the type locality of *P. euboeensis* was no longer extant. All the water from the spring was taken with pumps, thus this habitat disappeared as well.

***Pseudobithynia zogari* n. sp.** (Fig. 5)

Material examined about 240 specimens from: Evia Island, the region of Ochi, Limni vidras pond near Karystos town, 01.07.2007 leg. Pešić; Peloponnes, Region of Githyo city, Skala town, canal, 04.07.2007 leg. Pešić; Peloponnes, Region of Githyo city, Evrotas river near Skala town, 04.07.2007 leg. Pešić. From Wim Maassen's collection: Litohoro, Preveza.

Holotype Shell height 6.0 mm, width 4.2 mm, RMNH 112100,

Paratypes Paratypes dry RMNH 112101/8, Paratypes alcohol 70% RMNH 112102/10, rest collection of Glöer.

Locus typicus Peloponnes, Region of Githyo city, Skala town, canal (Fig. 4)

Habitat Collected among emergent (*Phragmites communis*,) vegetation in the littoral zone of a pond (Evia Island) and large canals and lowland rivers (Peloponnes) (Fig. 4).

Description Shell glossy and reddish horn-coloured, surface finely striated, 5–5.5 whorls

Figure 5 *Pseudobithynia zogari* n. sp. – **1–2:** "*Bithynia goryi* B. ?" from Westerlund's collection = *P. zogari* n. sp., **3–7:** *P. zogari* n. sp. – e = eye, p = penis, t = tentacle.

slightly convex with a deep suture, umbilicus open, the aperture height takes 0.45 of the shell height, edge of aperture sharp, outer margin of aperture a little sinuated; a clear dimorphism is not visible; nucleus of operculum cochleate, convex bended. The juveniles are globular and become more elongated while growing (Fig. 5). Shell height 4.5–6.0 mm, width 3.8–4.2 mm.

Male copulatory organ Penis simple, a little variable (Fig. 5.5).

Female organs Oviductual loop twice bended (S-shape).

Etymology The species is named after Mr Stamatis Zogaris (Hellenic Centre for Marine Research) in appreciation of his conservational work on the Evia Island and Evrotas river.

Differential diagnosis The only *Pseudobithynia* species from the Balkans that looks a little similar to our new species is *P. panetolis*. While in *P. panetolis* a clear dimorphism is visible (the males are much smaller) and the oviductual loop is coiled *P. zogari* is not.

Remarks In the sample from Skala town canal we found eggs of *Theodoxus* sp. on the shells.

Figure 6 The distribution of the Bithyniidae in Greece. The genus are marked by coloured dots: red = *Bithynia*, green = *Pseudobithynia*, cyan = unknown genus. **1:** Lake Prespa, *B. prespensis*, **2:** Lake Kastorias, *B. kastorias*, **3:** Lowlands of Greece, *P. zogari*, **4–6:** Lake Pamvotis (Lake Ioannina, **4:** *P. westerlundi*, **5:** *Bithynia graeca*; **6:** *P. hemmeni*, **7:** Corfu, *P. renei*, **8:** Lake Ambrakia, *P. ambrakis*, **9–11:** Lake Trichonis: **9:** *P. trichonis*, **10:** *P. panetolis*, **11:** *P. falniowskii*, **12:** *B. hellenica*, **13:** *P. euboeensis*, **14:** Crete, *Bithynia candiota*. **15:** Crete, *B. cretensis*, **16:** Samos: *P. gittenbergeri*.

Discussion

At the beginning of the research into the Bithyniidae of Greece only two *Bithynia* spp. were known from this region, now about 16 species are recognised which belong to two genus groups. In summary we can say that the distribution pattern of the Bithyniidae in Greece is not stochastical through passive dispersal, the main process that disperses freshwater mollusks into new lentic habitats outside drainage systems, is random. Despite this latter fact, the effective immigration rate resulted in a zoogeographical distribution pattern. We can split the Bithyniidae in Greece into three groups: (i) those that live endemically in ancient lakes, (ii) those that live endemically on islands, and (iii) those that are widely distributed in the lowlands of Greece (Fig. 6). The latter group seems to consist of only one *Bithynia* sp. and two *Pseudobithynia spp.* All the other fourteen species are, however, restricted in their distribution, like *Pseudobithynia renei* in Corfu.

Identification key: Bithyniidae

It is not possible to identify the genus by shell features alone – the genus groups can only be distinguished by the absence or presence of the penial appendix.

For the species *Bithynia graeca* and *B. renei* we use the traditional genus name *Bithynia*. Maybe one or both of these species belong to the genus *Pseudobithynia*, but in every case they can be distinguished by the shell's size, the stepped whorls, the very deep suture. In addition *B. renei* has a very prominent body whorl (Fig. 7.5).

1. Penis with penial appendix . . . . . ***Bithynia***
1′. penial appendix missing . . . ***Pseudobithynia***

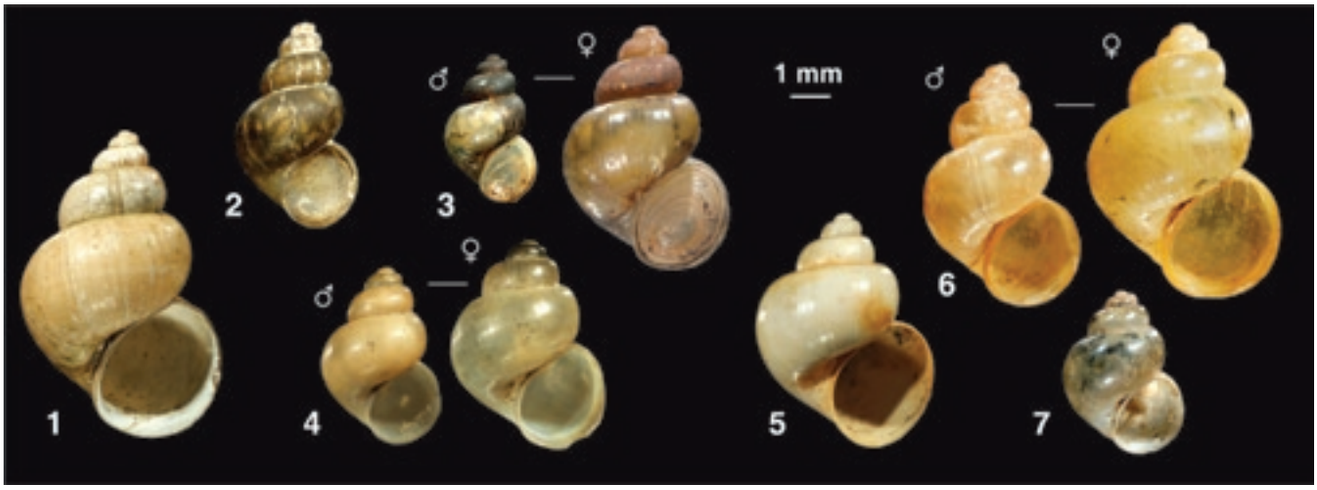

Figure 7 The *Bithynia* spp. of Greece. – **1:** *Bithynia graeca*, **2:** *B. prespensis*, **3:** *B. kastorias*, **4:** *B. hellenica*, **5:** *B. renei*, **6:** *B. cretensis*, **7:** *B. candiota*.

Identification key: *Bithynia*

1. Shell height about 9–11 mm, convex whorls with a deep suture, operculum oval and rounded angled, (Lake Pamvotis). . ***B. graeca***
1′. Shell smaller 2
2. Shell small, height up to 5 mm, whorls stepped, operculum angled, umbilicus closed, (Lake Prespa) . . . . . .***B. prespensis***
2′. Shell larger, umbilicus not closed 3
3. Shell conical with a prominent body whorl, whorls stepped, umbilicus opened, deep suture, operculum rounded angled (Corfu) . . . . . ***B. renei***
3′. Body whorl not prominent, operculum rounded. 4
4. Shell elongated conical, about 7 mm (male) – 8 mm (female), convex whorls, with a deep suture, operculum oval (Crete) . . ***B. cretensis***
4′. Shell smaller about 5–7 mm 5
5. extreme sexual dimorphism: 4 mm (male) – 6.5 mm (female), Shell elongated conical, umbilicus opened to slit-like, whorls convex, shell height up to 6.5 mm, operculum oval (Lake Kastorias) . . . . . ***B. kastorias***
5′. sexual dimorphism only slight 6
6. Shell oval conical, umbilicus opened to slit-like, suture clear, whorls rounded, shell height 4.7–5.5 mm, operculum rounded angled (Crete). . . . . .***B. candiota***
6′. Shell oval conical, umbilicus opened, suture clear, whorls rounded, operculum rounded angled, shell height 5.5–5.9 mm. ***B. hellenica***

Identification key: *Pseudobithynia*

1. Margin of the aperture sinuated (side view) 2
1′. Margin of the aperture straight (side view) 7
2. Males are slimmer and smaller than the females: about 7 mm: 4 mm or 6 mm: 4.5 mm in height 3
2′. A clear dimorphism in shell height is not visible 4
3. Female: H:W = 1.55, male: H:W = 1.46, umbilicus opened, body whorl of females not prominent, operculum oval, nucleus of operculum cochleate (Lake Trichonis, NW-shore). . . . . .***P. panetolis***
3′. Female: H:W = 1.45, male: H:W = 1.60, umbilicus slit-like, body whorl of females prominent, operculum acute oval, (Lake Trichonis, S-shore) . . . . . .***P. falniowskii***
4. umbilicus opened, whorls slightly convex with a clear suture nucleus of operculum cochleate, (Lake Trichonis, NE shore) . . . . . .***P. trichonis***
4′. umbilicus closed 5
5. Whorls slightly convex with a clear suture, operculum oval (Samos). . . . .***P. gittenbergeri***
5′. Whorls convex with a clear to deep suture, umbilicus opended 6
6. Nucleus of operculum cochleate, (lowlands of Greece) . . . . . ***P. zogari***
6′. Nucleus of operculum not cochleate, (Euboea) . . . . . ***P. euboensis***

Figure 8 The *Pseudobithynia* spp. of Greece. – **1:** *Pseudobithynia panetolis*, **2:** *P. falniowskii*, **3:** *P. trichonis*, **4:** *P. gittenbergeri*, **5:** *P. zogari*, **6:** *P. euboeensis*, **7:** *P. westerlundi*, **8:** *P. hemmeni*, **9:** *P. ambrakis*.

7. Shell elongated conical, umbilicus closed, slightly rounded whorls with a flat suture, body whorl not prominent, (Lake Pamvotis) . . . . . ***P. westerlundi***
7′. suture not flat. 8
8. Body whorl prominent, umbilicus opened, rounded whorls, operculum oval (Lake Pamvotis and vicinity) . . . . . ***P. hemmeni***
8′. Shell elongated conical, body whorl not prominent, operculum oval (Lake Ambrakia) . . . . . ***P. ambrakis***

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