

PRESENCE OF THE GENUS *NAPAEUS* (GASTROPODA: PULMONATA: ENIDAE) LIVING IN ALL THE ISLANDS OF THE CANARIAN ARCHIPELAGO: *NAPAEUS LICHENICOLA* SP. NOV. FROM FUERTVENTURA ISLAND

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Abstract *Napaeus lichenicola* sp. nov. from Jandía, Fuerteventura Island, is described, the main differences with the nearest species are discussed and data on distribution and conservation status are presented. The functional meaning of the epiphallar caecum and a chambered epiphallar region are inferred for the accommodation, respectively, of the spermatophoral spurlike hook and sharp-pointed denticles.

Key words *Enidae, taxonomy, spermatophore, conservation status, Canary Islands.*

INTRODUCTION

The Canary Islands are of particular interest due to their isolation, origin, climate and consequent biological peculiarities, as are other oceanic islands, terrestrial gastropods being a good example of these peculiarities. The two most easterly islands are characterised by an arid climate and they are considered to be the western outpost of the Saharan Zone (Ortiz *et al.*, 2006), whereas the other five islands possess a considerable range of habitats generated high mountains that intercept the moist trade winds coming from the North East.

Many groups of plants and invertebrates show high levels of endemism, land snails having a level higher than 84%. Several genera have experienced a remarkable radiation, *Napaeus* Albers, 1850 being the most species-rich, with 51 species (Alonso *et al.* 2006a; Castillo *et al.*, 2006). They are shared between two subgenera, *Napaeus* (*Napaeus*) Hesse, 1933 and *Napaeus* (*Napaeinus*) Hesse, 1933, which are indistinguishable by the shell alone and whose distribution known overlaps on Tenerife and Gran Canaria (Fig. 1).

In the small southern part of the island, the Jandía Peninsula, rises the Jandía massif, whose steep north-facing slopes (Fig. 4B) are the result of the abrupt collapse of a much larger volcanic building and whose main peaks directly receive the humidity of the trade winds. There are nine Jandía-endemic land snail species incapable to cross the barrier of sand dunes of "El Jable", as well as some other species living at north of the

isthmus, because all they can live alone in places at a higher altitude, with more environmental humidity than that of El Jable (Ibáñez *et al.*, 2006a). They are less adapted to the driest conditions than *Candidula ultima* (Mousson, 1872), which lives at both sides of El Jable (Alonso *et al.*, 1996).

In this paper a new *Napaeus* (*Napaeinus*) species from the Jandía mountains is described and the functional meaning of some epiphallar structures are inferred in comparison with that of

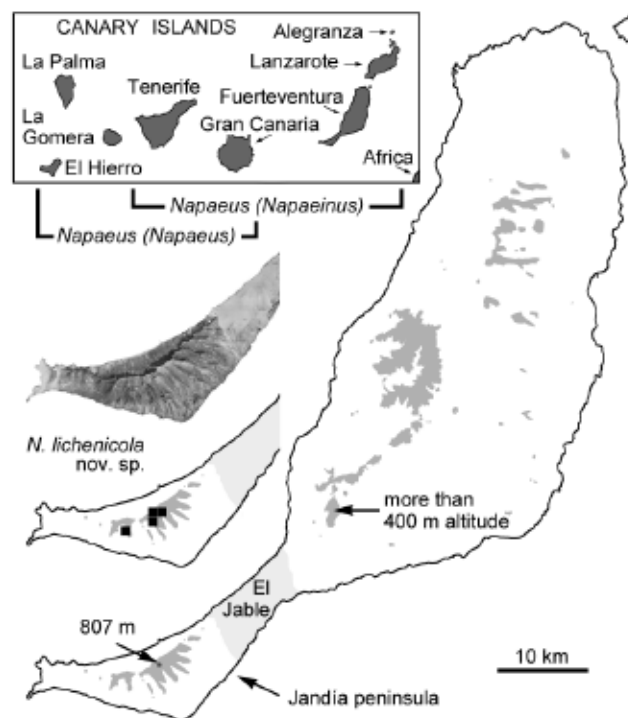


Figure 1 Geographic distribution of *Napaeus lichenicola* sp. nov. Symbols represent 1 x 1 km UTM squares.

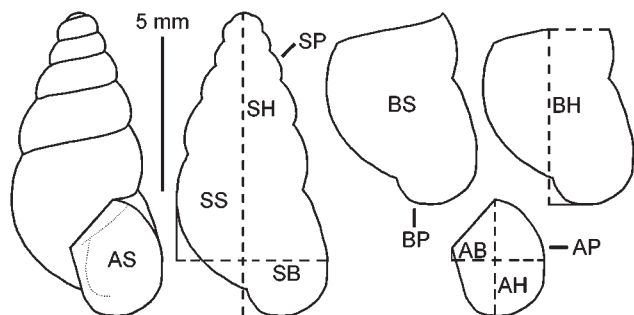


Figure 2 Drawings of the *Napaeus lichenicola* sp. nov. holotype shell, showing the placement of the measurements obtained (in mm or mm²). AB, aperture breadth; AH, aperture height; AP, aperture perimeter; AS, aperture surface (plane view); BH, body whorl height (at columella level); BP, body whorl perimeter; BS, body whorl surface (plane view); SB, shell breadth; SH, shell height; SP, shell perimeter; SS, shell surface (plane view).

Table 1 Biometric data (in mm or mm²) of the *Napaeus lichenicola* sp. nov. shell (7 adult specimens measured). SD, standard deviation; Min, minimum; Max, maximum; other abbreviations, same as in Fig. 2.

Character					
/ Index	Mean	SD	Min	Max	Holotype
SH	9.78	0.45	9.03	10.31	9.91
SB	5.25	0.32	4.88	5.74	4.96
SS	32.60	2.03	29.75	36.09	31.66
SP	24.52	0.97	22.71	25.79	24.46
BH	5.73	0.21	5.31	5.91	5.72
BS	22.77	1.63	20.77	24.99	21.52
BP	18.98	0.93	17.77	20.21	18.28
AH	3.82	0.29	3.47	4.14	3.69
AB	3.22	0.26	2.85	3.60	3.02
AS	8.72	1.22	7.19	10.10	8.08
AP	11.04	0.82	9.98	11.95	10.53
SB/SH	0.54				0.50
BH/SH	0.59				0.58
AH/SH	0.39				0.37
AB/SB	0.61				0.60
BS/SS	0.70				0.68

the spermatophore found in other species of the subgenus.

The shells of some species of the “conchological group of *N. variatus* (Webb & Berthelot, 1833)” (Alonso *et al.*, 1995) are illustrated for comparison with the new species, namely those of the five species placed in the subgenus *Napaeinus*, to which the new species belongs, and the three species “incertae sedis” (because their genital system anatomy is unknown), with the addition of that of *N. gruereanus* (Grasset, 1857), from El Hierro, and *N. roccelicola* (Webb & Berthelot, 1833), from Tenerife, which have the same life style as the new species and similar shell morphology. We only describe the distal genitalia (excluding the spermoviduct, albumen gland and gonad).

METHODS

The photographic methodology is the same as that of Ibáñez *et al.* (2006b). “Proximal” and “distal” refer to the position in relation to the ovotestis. Standardized measurements of shells were taken as shown in Figure 2. The measurements (Table 1) were obtained following Alonso *et al.* (2006b) with the software analysIS® (Soft Imaging System GmbH). All the shells were oriented with the shell axis (columella) to the Y axis of coordinates and the maximum shell breadth represented accurately in plane view, the straight linear shell measurements being obtained as the projections on the X and Y axes of the respective structures. Calculation of number of shell whorls follows Kerney & Cameron (1979: 13). The conchological terminology, based on the biometric data provided in Table 1, is the same that used by Henríquez *et al.* (1993; see Table 2). The terminology of some parts of the distal male genital system, including the penis-epiphallus delimitation, is used in the same way as that of Alonso & Ibáñez (2007).

ABBREVIATIONS

AIT Alonso & Ibáñez collection, Department of Animal Biology, University of La Laguna, Tenerife, Canary Islands, Spain
 CEC Commission of the European Communities
 CGH K. Groh private collection, Hackenheim, Germany

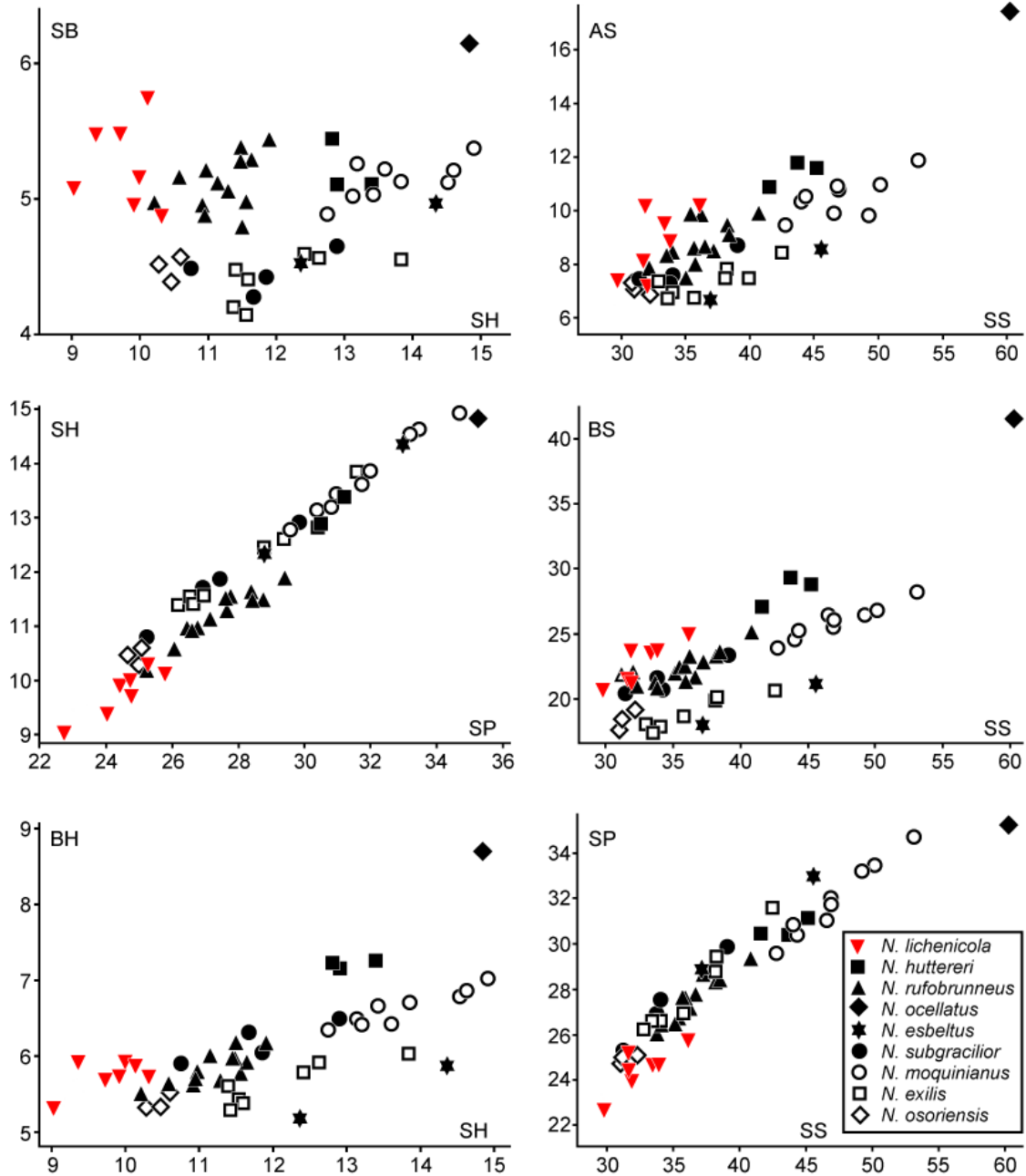


Figure 3 Scatter plots of some shell measurements for *Napaeus lichenicola* sp. nov. and the nearest species of its “conchological group”. Abbreviations same as in Fig. 2.

CHB R. Hutterer private collection, Bonn, Germany
 CKW Klaus Kittel private collection, Wiesthal, Germany
 CRJ Carsten Renker private collection, Jena, Germany
 IUCN International Union for Conservation of Nature and Natural Resources

MNHN Muséum National d’Histoire Naturelle, Paris, France
 TFMC Museo de Ciencias Naturales de Tenerife, Canary Islands, Spain
 UTM Universal Transverse Mercator, cartographic projection system

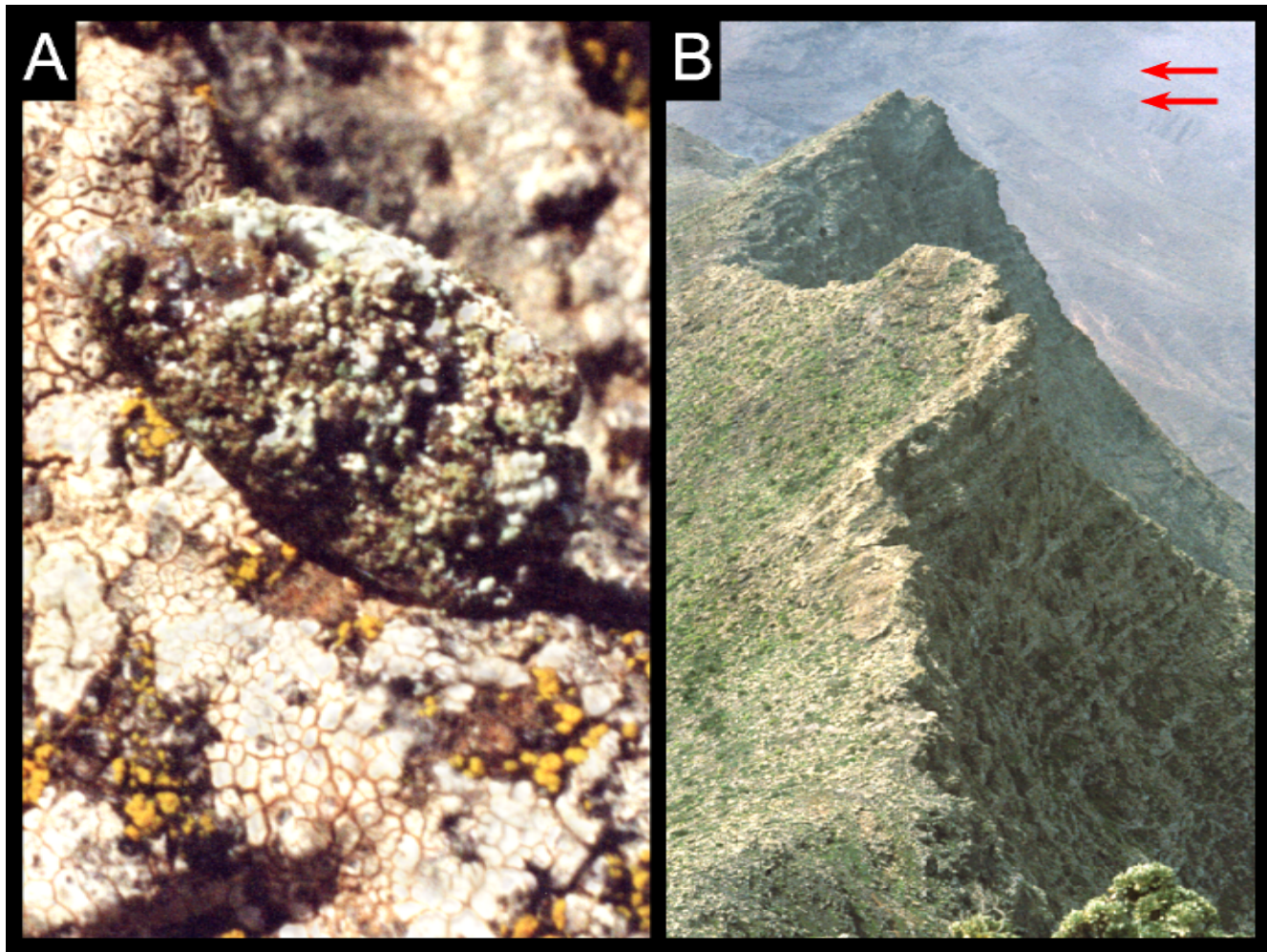


Figure 4 A, specimen of *Napaeus lichenicola* sp. nov. from Pico de La Palma, Fuerteventura, showing the entire shell camouflaged with the same lichens as those from the open rock faces; B, steep slopes of the Jandía mountains; the arrows indicate the direction of the trade winds.

SYSTEMATICS

FAMILY ENIDAE B. B. WOODWARD, 1903

Genus *Napaeus* Albers, 1850

Type species *Bulimus baeticatus* Webb & Berthelot, 1833

Subgenus *Napaeinus* Hesse, 1933

Type species *Bulimus moquinianus* Webb & Berthelot, 1833

Napaeus (*Napaeinus*) *lichenicola* Alonso & Ibáñez new species

Holotype 1 sh, TFMC (MT 0389), leg. K. Groh, M. Ibáñez and C. E. Ponte-Lira, 8-03-1990 (Fig. 5A).

Paratypes 11 sh and 20 sp, collected between 1989 and 2006: TFMC (MT 0141), 1 sh; MNHN, 1 sh;

AIT, 17 sp and 7 sh; CGH, 3 sp; CKW, 1 sh; CRJ, 1 sh.

Type locality Morro del Cavadero (Fuerteventura; UTM: 28RES6207, 720 m altitude).

Description A small species with a blackish-grey to black body. Shell (Fig. 5A) dextral, fragile, translucent, very obese (SB/SH index), with 5½-6 convex whorls and a deep suture. Body whorl intermediate (BH/SH index), occupying more than of the shell surface (BS/SS index). Protoconch smooth, with 1½ whorls. Aperture long (AH/SH index) and wide-very wide (AB/SB index). Peristome delicate, without a lip. Shell uniformly pale-brown coloured. Shell surface shiny with a weak oblique radial striation.

Genital system (Fig. 6A-D, seven specimens dissected). Atrium very short. Penis approximately

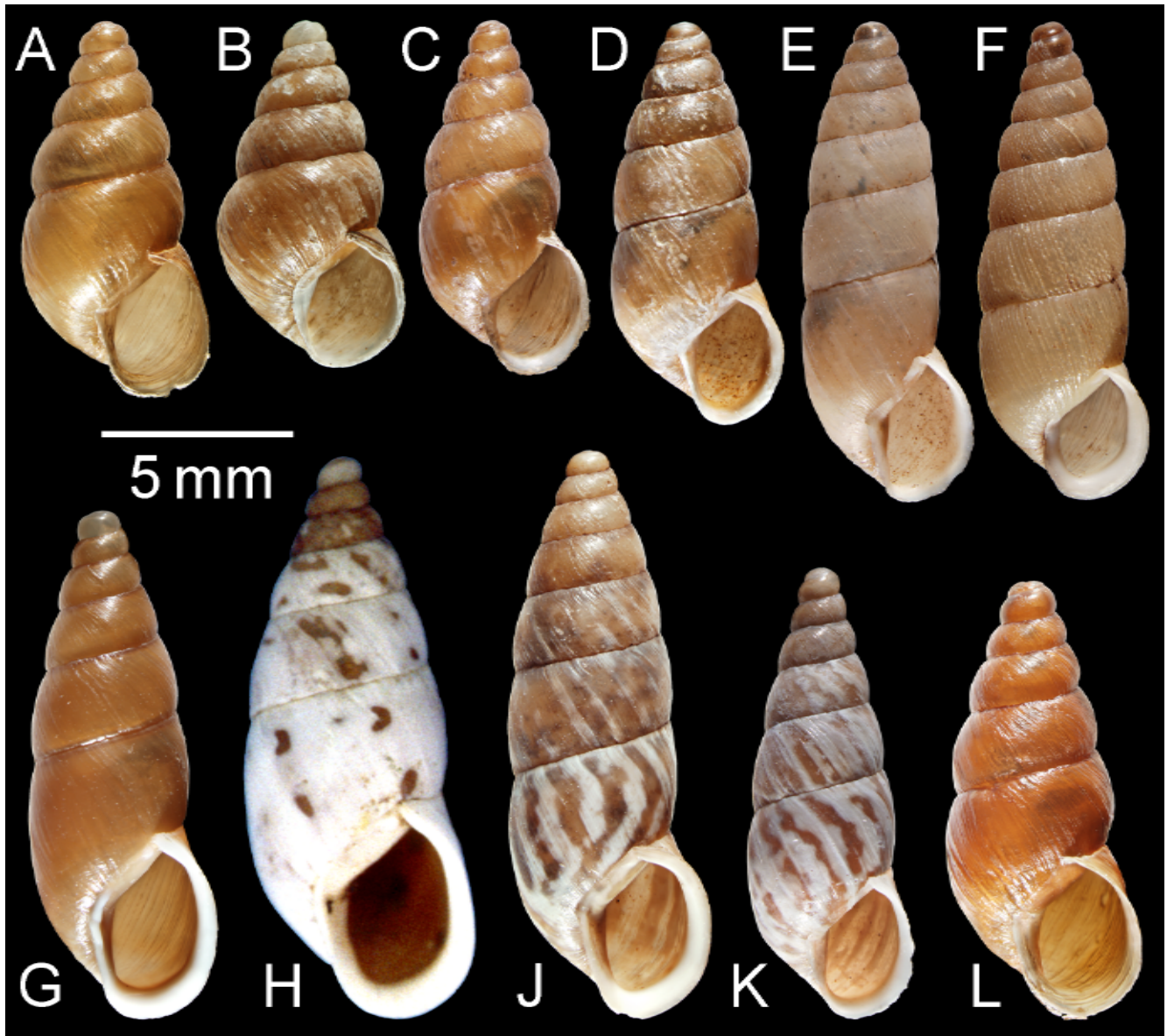


Figure 5 Shells. A, Holotype of *Napaeus lichenicola* sp. nov.; B, *N. gruereanus*, from Valverde (El Hierro); C, *N. roccellicola*, from Tamargo (Teno, Tenerife); D, *N. osoriensis*, from Osorio (Gran Canaria); E, Holotype of *N. exilis*, from Siete Puertas (Gran Canaria); F, Holotype of *N. esbeltus*, from Bajamar (Tenerife); G, Holotype of *N. huttereri*, from La Caldera (north slope, Alegranza); H, Syntype of *N. ocellatus*, from El Hierro; J, *N. moquinianus*, from Brezal del Palmital (Gran Canaria); K, *N. subgracilior*, from Lomo de los Mestres (La Palma); L, *N. rufobrunneus*, from El Castillojo (Lanzarote).

as long as the epiphallus and almost twice as large as the A_1 portion of the penial appendix. Penis with two portions, defined by the insertion of the penial retractor muscle: a distal tubular portion and a swollen, proximal portion, which has an incipient, proximal penial papilla, visible as a muscular sphincter between epiphallus and penis (Fig. 6B: s). Proximal penis portion with a very thin wall, several small longitudinal pleats and two well developed longitudinal, penial

folds, between the muscular sphincter and the insertion of the penial retractor muscle.

Epiphallus (Figs. 6B-D) tubular, with two regions defined by the presence of a caecum, the proximal region being widened and the distal, slender region being subdivided in two areas: Proximal area with eight longitudinal, lamellar folds equipped with small digitations, appearing as “rows of small papillae” (Fig. 6D: sp) as described in *Henríquez et al.* (1993); distal

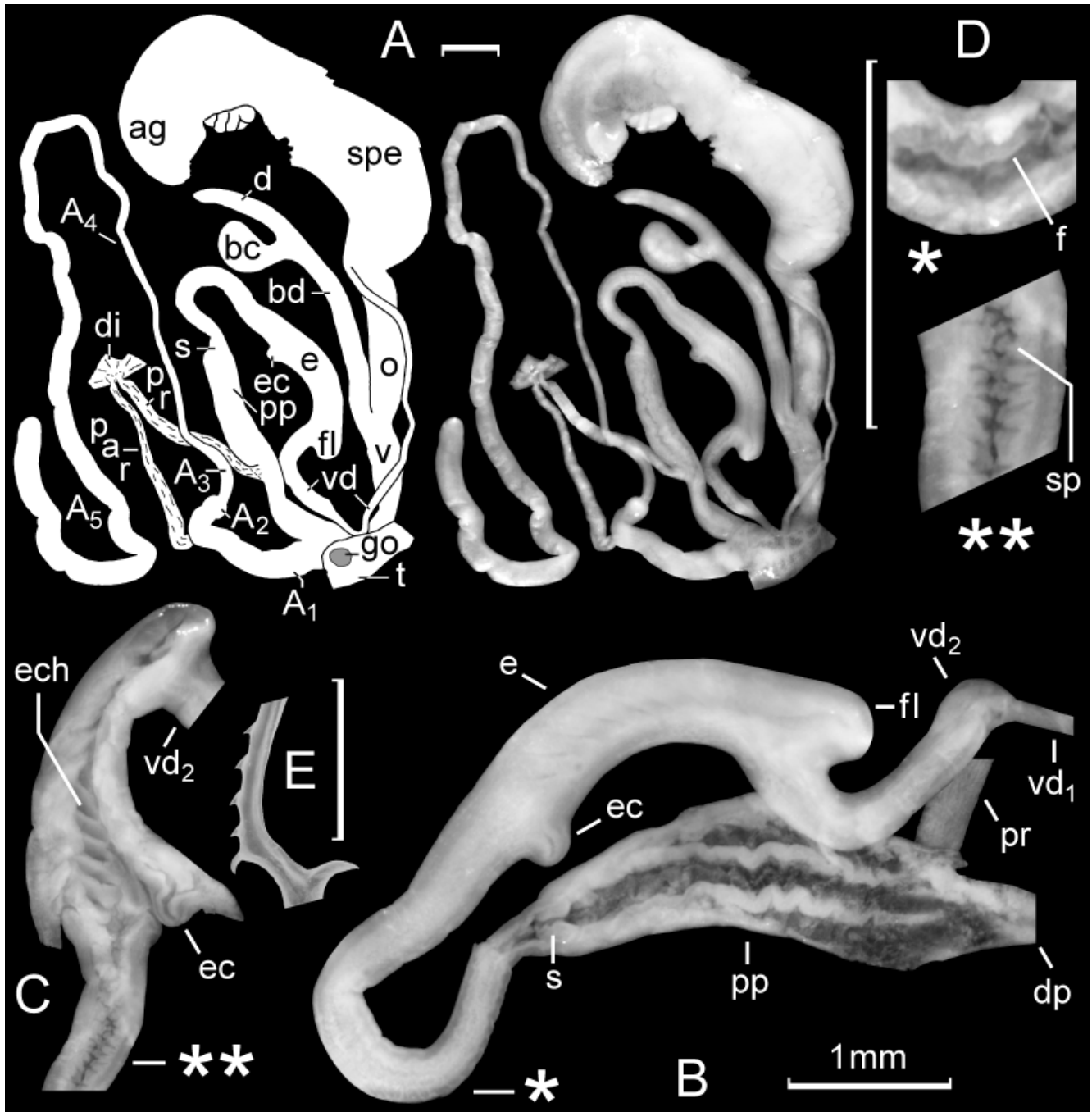


Figure 6 A-D. *Napaeus lichenicola* sp. nov. genital system and details; scale bars: 1mm. A, The whole genital system; B-D, Details of a part of the male genital system, between the vas deferens and the distal penis beginning (explanations, in the text); E, A part of a *N. (Napaeimus)* spermatophore (of *N. bechi*); A₁-A₅, parts of the penial appendix (terminology after Schileyko (1984: 39, fig. 18); ag, albumen gland; bc, bursa copulatrix; bd, bursa copulatrix duct; d, diverticulum; di, diaphragm; dp, distal penis; e, epiphallus; ec, epiphallar caecum; ech, epiphallar chamber; f, fold; fl, flagellum; go, genital orifice; o, free oviduct; par, penial appendix retractor; pp, proximal penis; pr, penis retractor; s, sphincter; sp, small papilla; spe, spermoviduct; t, body tegument; v, vagina; vd, vas deferens; vd₁, proximal vas deferens (normal thickness); vd₂, distal vas deferens (swollen portion).

area with folds without digitations (Fig. 6D: f). Widened proximal epiphallar region with a thick, chambered wall in which there are transversal, incomplete walls opposite to the caecum, delimiting

10-12 epiphallar chambers (Fig. 6C: ech). Flagellum very short, globular and muscular, anatomically undifferentiated from the proximal epiphallus. Vas deferens opens sub-terminally at

Table 2 Conchological terminology, based on the indexes of Table 1

Slenderness index (SB/SH)		Body whorl height index (BH/SH)		Aperture height index (AH/SH)		Aperture breadth index (AB/SB)	
very slender	< 0.350	small	< 0.50	very short	< 0.30	narrow	< 0.60
slender	0.350 - 0.425	intermediate	0.50 - 0.60	short	0.30 - 0.38	wide	0.60 - 0.70
obese	0.426 - 0.500	large	0.61 - 0.66	long	> 0.38	very wide	> 0.70
very obese	> 0.50	very large	> 0.66				

the proximal end of the epiphallus, on the same side as the epiphallar caecum. Near this opening, the distal portion of the vas deferens is swollen, reaching 2-3 times the diameter of the remaining duct.

Penial appendix arises near the distal end of the penis and it is approximately 6-7 times longer than the penis. All the appendix sections are distinctly separated from one another. Appendicular retractor muscle inserts laterally near the proximal top of the section A_1 and fuses with the penis retractor muscle just before the insertion on the lower lung wall; during the handling process for placing the male genital system in the photographic position (Fig. 6A), both retractor muscles were accidentally separated from each other.

Vagina shorter than the penis. Free oviduct similar in length than to the vagina. Bursa copulatrix duct long with a short diverticulum, distally with four lamellar, longitudinal folds.

Derivation of name lichenicola refers to the lichens that cover the shell of the living specimens.

Distribution and habitat (Fig. 1) A species endemic to the Jandía Peninsula (southern Fuerteventura), occurring in a small area (of approximately 4-5 km²) on the tops and northern slopes of the Jandía mountains, at 300-807 m altitude (Fig. 4B), where *Canariella jandiaensis* Ibáñez & Ponte-Lira, 2006 also lives, although they are not competitors: the latter species is a ground dweller snail (Alonso *et al.*, 2006c) while *N. lichenicola* is a rock dweller species: the snails live hidden between lichens on open rock exposed to the humid trade winds, with their shells camouflaged by the same lichens as the rocks (Fig. 4A).

Comparisons *Napaeus lichenicola* sp. nov. is comparable with the *Napaeus* (*Napaeinus*) species of the “*Napaeus variatus* species group” (Alonso *et al.*, 1995). This conchological group includes, besides eight *Napaeus* (*Napaeus*) species, five of *Napaeus* (*Napaeinus*): *N. moquini-anus* (Webb & Berthelot, 1833) (Fig. 5J) and *N. exilis* Henríquez, 1995 (Fig. 5E), from Gran Canaria, *N. esbeltus* Ibáñez & Alonso, 1995 (Fig. 5F), from Tenerife, *N. rufobrunneus* (Fig. 5L) from Lanzarote and, fossil, from the north of Fuerteventura, near Corralejo (Fischer, 2003) and *N. huttereri* (Fig. 5G) from the islet of Alegranza (north of Lanzarote). Moreover, another three species should be compared with the new species because of their genital system anatomy is as yet unknown and they cannot be placed in the appropriate subgenus: *N. ocellatus* (Mousson, 1872) (Fig. 5H), from El Hierro, *N. subgracilior* (Wollaston, 1878) (Fig. 5K), from La Palma and *N. oso-riensis* (Wollaston, 1878) (Fig. 5D), from Gran Canaria.

The species most similar to *N. lichenicola* regarding the genital system are *N. huttereri* and *N. rufobrunneus*, the other three species above-mentioned having a long to very long diverticulum of the bursa copulatrix duct. Unfortunately, the specimens studied of the two former species were immature hindering a good comparison, but *N. lichenicola* has a penial appendix clearly larger than that of both species.

Conchologically, *N. lichenicola* differs from all the above mentioned species because it has the smallest shell height and the largest obesity index (SB/SH). Also, it only shares the body whorl height index (BH/SH) with *N. ocellatus*, which is the largest species of the conchological group (Fig. 3).

With respect to the life style, *N. lichenicola* and *N. rufobrunneus*, together with *N. roccellicola*, are the only rock dweller species of the “*N. variatus* species group”, the remaining species being ground dwellers. The *N. lichenicola* shell is also comparable with that of another rock dweller species, *N. gruereanus* (Fig. 5B) from El Hierro, the westernmost island of the archipelago. But *N. gruereanus* and *N. roccellicola* belong to the subgenus *N. (Napaesus)* because their genital system lacks the bursa duct diverticulum. *N. gruereanus* also lacks the appendicular retractor muscle, which is present in *N. lichenicola* (the *N. gruereanus* genital system information is personal, unpublished data).

Remarks No spermatophore has been found but it is probably similar to that of other *N. (Napaesus)* species, as that of *N. bechi* Alonso & Ibáñez, 1993 (Fig. 6E): with a strong spurlike hook and a “spermatophore posterior area” (as named in Henríquez *et al.*, 1993) with an opposite series of sharp-pointed denticles, arranged as saw teeth. This allows us to infer the functional meaning of the epiphallar caecum and the chambered epiphallar region of *N. lichenicola*, for accommodation of some spermatophore parts (Figs. 6C,E): the spurlike hook probably lodges at the epiphallar caecum (ec) and the sharp-pointed denticles probably lodge at the proximal, epiphallar chambers (ech).

THREAT AND CONSERVATION STATUS

Napaesus lichenicola has a very small distribution area belonging to the Jandía Natural Park, one of the sites of interest for biodiversity and nature protection to be designed as a Special Area of Conservation: the ES7010033 Site, compiled in the framework of Natura 2000, EU Habitats and Birds Directives (CEC, 2002). Unfortunately, its habitat is threatened by the very abundant and free-range livestock present, mainly goats. The goats also include the lichens in their varied diet, eating them for food and to obtain water as well, when the atmosphere is very dry (L. Sánchez-Pinto, personal communication). Obviously, the goats also eat the *N. lichenicola* specimens located on and between the lichens. Tourism also has a significant impact on the entire zone.

Thus, we propose for *N. lichenicola* the same IUCN (2001) category that has intended for her partner *Canariella jandiaensis*: “Critically Endangered”, according with the **CR B2ab(iii)** criteria. *N. lichenicola* should also be included in the Habitats Directive Annexes II and IV of the European Union. The main measure necessary for the conservation of *N. lichenicola* and the other endemic species from the Jandía mountains is appropriate habitat protection, mainly with strict livestock control.

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