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Systematic revision and Distribution of the Genus *Xeroplana* from Tunisia (Gastropoda, Pulmonata, Hygromiidae)

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Abstract; The present work provides a revision of the *Xeroplana* genus from Tunisia on the basis of historical, morphological, and anatomical data, Distribution maps of this genus are presented for the first time. The anatomy of genital organs of all recorded species and classified under this genus are presented. And a new description of the genitalia of *Xeroplana zeugitana* is presented. For each species described, a synonymy list of names is provided and all cited specimens are illustrated.

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1. Introduction

In Tunisia, knowledge relating to the systematics of terrestrial molluscs is still limited and this group presents a real taxonomic problem related to great ambiguity due in part to the high number of species grouped together in the genus *Helix* of the family Helicidae and the multitudes of species and subspecies described without foundation.

Furthermore, data relating to the ecological status of species and their geographical distribution limits are rare and even non-existent.

In the 19th century, the terrestrial malacofauna of Tunisia was known mainly through the work of Bourguignat (1868) who is among the first prolific authors who were interested in this group. His approach to malacology, often criticized, is based on Neo-Lamarckian conceptions of the species which led the author to describe several hundred species on the basis of indistinct characters, while eliminating intermediate forms. These works are distinguished by very personal views on specific cuts and are based on insufficient studies of polymorphism; it considers two individuals to be specifically distinct as soon as they differ by three characters (Falkner et al. 2002).

In addition to Bourguignat's work, other researchers have also contributed to the inventory of Tunisia's malacofauna: Issel (1880 and 1885) reported 28 species from Tunisia; Hagenmüller (1884) studied the new Clausiliae and Valveae from North Africa and reported 6 species belonging to the family Clausillidae in Tunisia; Germain (1907 and 1908) identified 24 species of terrestrial gastropods, including *Agriolimax kervillei* sp. nov. has been described; Pallary (1939) listed 22 species from northern Tunisia, particularly from Ichkeul National Park; Ktari & Rezig (1976) studied the terrestrial gastropods of northern Tunisia, of which all the species of the Hygromiidae family were considered Helicidae. Abbes et al. (2009, 2010 and 2011) revised the Enidae from North west Africa, slugs and semi-slugs of Tunisia and Sphinchterochilidae from the same region.

The bibliographic analysis of this fauna thus shows a multitude of controversies and problems of nomenclature and taxonomy of the Tunisian malacofauna mainly affecting the Hygromiidae family. However, these works have not been useless since the collections used for these studies are available in various museums in Europe and can be examined and reviewed to solve the problems posed. In this context, we relied mainly on the Bourguignat reference collection deposited at the Natural History Museum of Geneva, from which the author described 400 Tunisian species. This work was also based on a large number of samples that we have collected in 5 years in different regions of Tunisia.

2. Material and methods

This study was based mainly on our own samples collected for 5 years since the year 2004 during multiple surveys in different regions of Tunisia. The sampling was carried out, particularly in the natural parks, the forest domain, the islands, the wetlands, and more generally in the different ecosystems of Tunisia. Thus, the surveyed stations covered a large part of the Tunisian territory and particular attention was paid to the type localities where several researchers described

new species; Figure 1 shows the geographical distribution map of the various surveyed stations. The station numbering was done randomly. Part of the sample was deposited at the National Museum of Natural History in Bern, Switzerland (NMBE) and at the Senckenberg Research Institute, Frankfurt in Germany (SMF); the rest is kept at the Laboratory of Biodiversity and Population Biology at the Faculty of Sciences of Tunis. In addition to the study of our own samples, we also examined the standard collections of molluscs from Tunisia and other North African countries deposited at the National Museum of Natural History in Paris and at the Institut Senckenberg Research Center in Frankfurt, Germany, which has a large Kobelt type collection, and the Geneva Natural History Museum (MHNG), which holds most of Bourguignat's collection. The purpose of the study of these collections was to revise the nomenclature of the species according to the bibliographic data, to draw up the list of synonymies, and to solve the problems of systematics and determination of the species with certainty.

After fieldwork, the individuals, adults, are sorted by morphospecies based on convergences of shapes and general characteristics of the individuals. This method makes it possible to group together individuals belonging to the same species or genus. The characters most often used are the shape of the shell, the presence or not of certain ornamentations, colour, the number and convexity of the whorls, and the size of the adult shells.

Shell Measurements are taken using digital calipers. The measurements presented in the assessment (in the description part of each species) were estimated according to the following height variation limits: H ≤ 5 mm: very small shell size. 5 mm< H ≤ 12 mm: small size shell. 12 mm < H ≤ 18 mm: medium-sized shell. H > 18 mm: large shell.

In order to study the anatomical details, living specimens were preserved in alcohol 70%.

Abbreviations:

[1]. MHNG: Muséum d'Histoire Naturelle Genève, Switzerland

[2]. MHNL: Musée des Confluences, Lyon, France

[3]. MNHN: Muséum Nationale d'Histoire Naturelle, Paris, France

[4]. NMBE: Natural History Museum of the burgergemeinde, Bern, Stwitzerland

[5]. SMF: Senckenberg Research Institute, Frankfurt in Germany

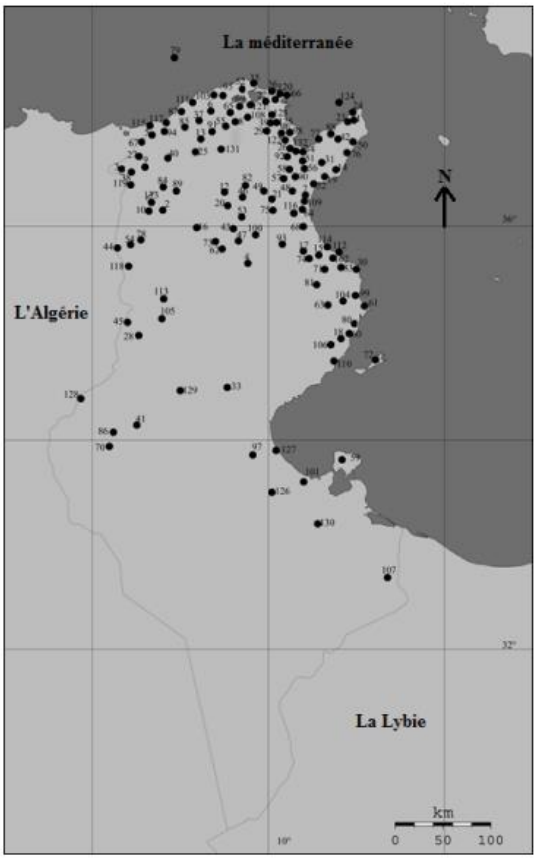

Figure 1: Geographical distribution mapdes stations prospectées en Tunisie. 1: Dar chichou; 2: Aïn Bidha (route Borj Ifa-Sers); 3: Aïn Draham; 4: Aïn Chrichira (Kairouan); 5: Aïn Delya (14 km avant Feïja); 6: Aïn ennfeja (24 km avant sejnene); 7: Ain Errahma; 8: Aïn ezzommita (Dkhila); 9: Aïn Ksir (Jendouba-Kef); 10: Aïn oued errmal (route Tejerouine el Kef à 9 km); 11: Aïn oued Saaden (Bizerte); 12: Ain tejra; 13: Aïn Touta (Fjeyich, 28 km après Tebourba); 14: Al mazraa (Nabeul-Korba); 15: Al ksiba (Sousse); 16: Al khalsa (Sers El Kef); 17: Allkala al kobra;18: Al Amra (Sfax); 19: Assomaa; 20: Barrage el batta (à la sortie de Bargou); 21: Barrage El khadhra (entre Kairouan e Fahs); 22: Barrage El khirba (Bizerte); 23: Diar el Ousfen; 24: Beb errih el 10 Haouaria; 25: Beja; 26: Ben Arous; 27: Béni Mtir; 28: Feriana; 29: Bejaoua; 30: Bkalta; 31: Bou Argoub (Cap Bon); 32: Bouficha; 33: Bouhedma; 34: Borj Sedriyya; 35: Cap Blanc; 36: Cap Zebib; 37: Djebel Zelba; 38: Chemtou; 39: Sidi thebet; 40: Djebba; 41: Djebel Asker (Dghoumes); 42: Djebel Abderrahman; 43: Djebel Bargou; 44: Djebel boujeber (Kalaat Snen); 45: Djebel Chaambi; 46: Djebel Chrich; 47: Djebel el oueslet; 48: Djebel Fawwara Jradou; 49: Djebel Fkirine; 50: Barrage Lebna; 51: Djebel Reças; 52: Djebel Saaden (Bizerte); 53: Djebel Serj; 54: Djebel Slata; 55: Djebel Tehint (Bizerte); 56: Djebel Trif (Morneg); 57: Djebel Zaghouan; 58: Djebel Zriba; 59: Djerba; 60: Dowwar Echatt (Sfax); 61: Dowwira; 62: El quaria (après kesra); 63: Eljem; 64: Enfidha; 65: Essoudiya (début oued Joumine); 66: Ghar el Melh; 67: Hammem Bourguiba; 68: Hergla; 69: Ichkeul; 70: Oasis Tozeur; 71: Karkar (Mehdia); 72: Kerkennah; 73: Kesra; 74: Kneiss; 75: Kondaar; 76: Korba; 77: Korbos; 78: ksour essef; 79: La Galite; 80: Malloulech; 81: Menzel Kemel (al borjin); 82: Djebel Mansour (Siliana); 83: Moknine; 84: Nebr (route jendouba el Kef); 85: Nefza; 86: Oasis Deguech; 87: Ouechteta; 88: Oued Abid (Cap Bon); 89: Oued Amir (route El Kef sers); 90: Ahd jedid (Morneg); 91: Oued joumine; 92: Oued Mizet (Hammem Lif); 93: Oued Nebhena (à l'entrée de Kairouan); 94: Oued Renegha (route Tabarka-Aïna Draham); 95: Oued Sejnene; 96: Parc Ennahli; 97: Oasis Cheninni; 98: Ariana; 99: Salakta; 100: Sbikha (5km de sbikha); 101: Kettena; 102: Sebkha sehline; 103: Sejnene; 104: Sekiet el Khadem (Mehdia route el Jem); 105: Sbeïtla; 106: Sidi Saleh; 107: Sidi twiy; 108: Mateur; 109: Sidi Khelifa; 110: Sidi Mansour; 111: Sidi Mhibis (route Nefza Sidi Mechreg); 112: Skanes (Monastir); 113: Sbiba; 114: Sousse; 115: Cap Roux; 116: Tekrouna; 117: Tabarka; 118: Table de Jugurtha; 119: Tbainia (route Beja Aïn draham); 120: Raf Raf; 121: Tinja; 122: Rades (Tunis); 123: Utique; 124: Zembra; 125: Zhena (Bizerte); 126: Matmata; 127: Gabes; 128: Temeghza; 129: Djebel Orbata; 130: Médenine; 131: Oued Zarga; 132: Djebel Boukornine; 133: Reserve Seddine (El Kef)

3.1 Systematic account

3.1 *Xeroplana doumeti* (Bourguignat, 1876)

[Shell: Plate1. 2: A-C; Genitalia: fig. 2-3; geographical distribution map: fig. 4]

1876 *Helix doumeti*, Bourguignat.

1881 *Helix lacosteana*, Morlet.

1887 *Helix doumeti*, Letourneux & Bourguignat.

1939 *Xerophila doumeti*, Pallary.

Material examined:

Type specimens: Helix doumeti: Lectotype MHNG 15388, Djebel bou Hedma (= Jabal Bu Hadmah) entre Sfax et Gafsa. Djebel de Seftimi (au Sud de la Tunisie); Paralectotypes MHNG 15389, Djebel bou Hedma (= Jabal Bu Hadmah) entre Sfax et Gafsa. Djebel de Seftimi (au Sud de la Tunisie); Paralectotypes MHNG 15390, Djebel bou Hedma (= Jabal Bu Hadmah) entre Sfax et Gafsa. Djebel de Seftimi (au Sud de la Tunisie).

Non- type specimens: MHNG 15391, Guélaat-es-Snam (= Kalaat-es-Snam = Qa'lat As Sanam); MHNG 15392, Feriana et plaine du Thalat entre Sfax et Gafsa; Aïn Chrichira (Kairouan) 14.12.2008, coll. Abbès/7; Bouhedma 11.05.2008, coll. Abbès/6; Sbikha (5km de sbikha) 14.12.2008, coll. Abbès/5.

Dimensions (n=10): Height= 13 ± 0.85 mm; Diameter= 22 ± 0.95 mm.

Description: **Shell** dextral, medium to big sized, discoidal, slightly flattened above and distinctly domed below, white to yellowish in colour,5 flat and regularly growing whorls, superficial suture; external surface finely and irregularly ribbed; last whorl sharply keeled; aperture lenticular and large, simple and discontinuous peristome; umbilicus funnel shaped revealing the inner winding. **Genitalia**: penial complex composed of penis, epiphallus, and lagellum, long, swollen penis containing a penial papilla; epiphallus longer and thinner than the penis (about 3 times longer than the penis); flagellum slightly longer than the penis. Female part consisting of a vagina, two stylophores, two multifid glands, a peduncle and a bursa copulatrix, a long vagina; the dart sac complex not surrounded by a sheath and formed by a pair of stylophores located at the level of only one side of the vagina; unfused and identically sized stylophores; multifid glands inserted above (at the side of the apex) the insertion sites of the dart sacs either side of the vagina; from the proximal vagina starts the initially wide peduncle then becomes thinner and ends in the Bursa copulatrix; elongated bursa copulatrix.

Distribution: this species is reported only in Tunisia; it is therefore endemic there. Its geographical distribution, presented in figure 4, shows that the species is limited to the upper arid bioclimatic level.

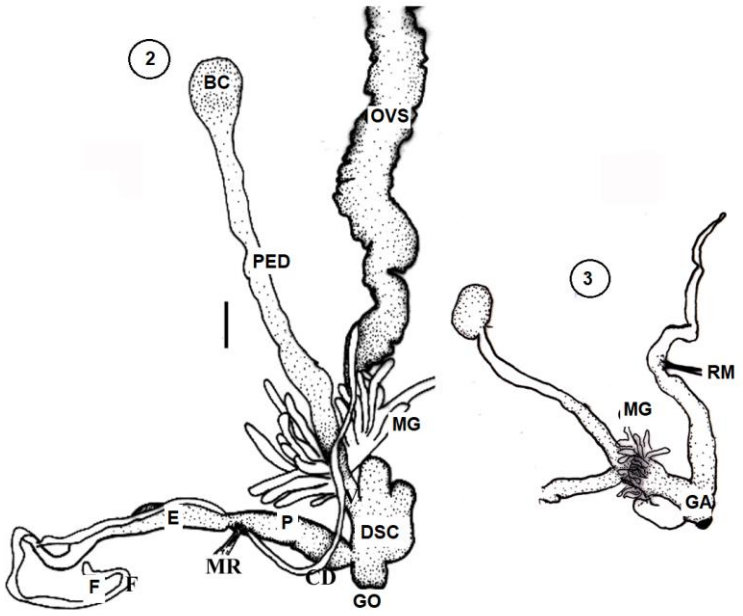

Figure 2-3 *Xeroplana doumeti:* Genitalia (2); distal part of genitalia (3). Scale = 1 mm. GA: genital atrium; DSC: dart sac complex; E: epiphallus; F: flagellum; MG: multifides glandes; RM: retractor muscle; GO: genital orifice; OVS: ovispermiduct; P: penis; BC: bursa copulatrix; PED: pediculus; V: vagina.

2. *Xeroplana idia* (Issel, 1885)

[Shell: Plate1: D-F; Genitalia: fig. 5; geographical distribution map: fig. 4]

1887 *Helix idia* Letourneux & Bourguignat.

1939 *Xerophila idia*, Pallary.

1976 *Helicella (Jacosta) idia*, Ktari & Rezig.

Material examined: MHNG 15393, Oued el Hammam dans les Zaghouan (Helix enica); MHNG 15394, Djebel Bou Kornin (= Jabal bu Qarnayn) (Helix enica); MHNG 15402, Hammam Lif (Helix enica); MHNG 15403, Djebel Reças (= Jabal Ar Rasas) (Helix idia); Ain tejra 7.11.2008, coll. Abbès/5; Djebba 24.06.07, coll. Abbès/1; Djebel Reças 12.05.09, coll. Abbès/9; Djebel Zaghouan 02.02.2008, coll. Abbès/9; Djebel Zriba: Rass essada à Hammem 20.08.2008, coll. Abbès/4; El quaria (aprés kesra) 27.12.2008, coll. peristome discontinuous, simple and slightly reflexed; open, deep, funnel-shaped umbilicus bounded by a sharp, crenate edge forming a septum.

Genitalia: penial complex composed of penis, epiphallus and flagellum, long, swollen penis containing a penial papilla; epiphallus longer and thinner than the penis (about 2.5 times longer than the penis); flagellum slightly longer than the penis. Female part consists of a vagina, two stylophores, two multifid glands, a peduncle, and a bursa copulatrix, long vagina; the dart sac complex, not surrounded by a sheath and formed by a pair of stylophore fused to the wall of the vagina and located at only one side of the vagina; inner stylophore more swollen then the Abbès/22; Kesra 27.12.2008, coll. Abbès/3; Korbos 03.02.09, coll. Abbès/2; Djebel Mansour (Siliana) 13.01.2008, coll. Abbès/1; Tekrouna 25.08.2008, coll. Abbès/2; Djebel boukornine 4.01.2007, coll. Abbès/2.

Dimensions (n=10): Height= 6 ± 0.95 mm; Diameter= 14 ± 1.25.

Description: Shell small to medium sized,, clearly flattened above (on the side of the apex) and not domed below (on the side of the aperture); lenticular shape and clearly keeled; yellowish color with more or less continuous brown bands; 5 to 6 flattened or very slightly raised whorls; superficial suture; external surface opaque and finely ribbed; ribs slightly raised and becoming thicker and more prominent around the keel; last whorl of wide spire and sharply keeled; oblique aperture with angular outer end;

outer stylophore and dartless,; multifid glands inserted above (at the side of the apex) the insertion sites of the dart sacs either side of the vagina; from the proximal vagina starts the initially wide peduncle then becomes thinner and ends in the Bursa copulatrix; elongated bursa copulatrix.

Distribution: the biotopes of this species range from sub-humid to lower semi-arid; it is most often found under limestone rocks in sunny places. Distribution: this species has a North West African distribution. Its geographical distribution in Tunisia is shown in Figure 4.

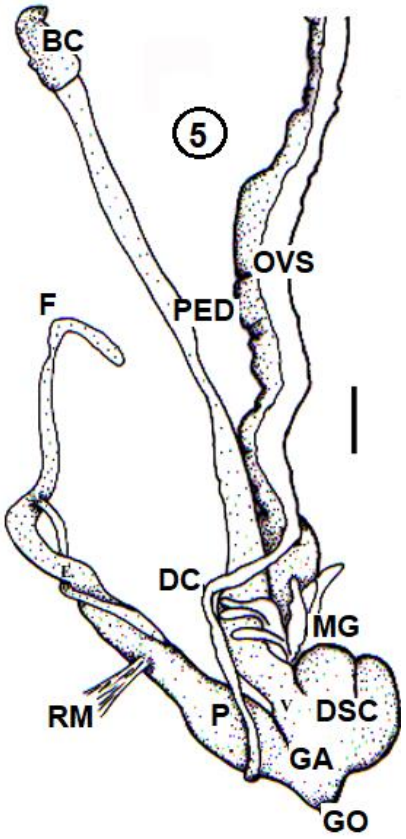

Figure 5 *Xeroplana idia:* Genitalia. Scale = 1 mm. GA: genital atrium; DSC: dart sac complex; E: epiphallus; F: flagellum; MG: multifides glandes; RM: retractor muscle; GO: genital orifice; OVS: ovispermiduct; P: penis; BC: bursa copulatrix; PED: pediculus; V: vagina.

3. Xeroplana zeugitana (Letourneux & Bourguignat, 1887)

[Shell: Plate 1: G-I; Genitalia: fig. 6-8; geographical distribution map: fig. 4]

1887 *Helix zeugitana* Letourneux & Bourguignat.

1887 *Helix tissotiana* Bourguignat in Letourneux & Bourguignat.

Material examined: **type Specimens**: Helix zeugitana: Syntypes MHNG 15434 Djebel Zaghouan.

Non-types Specimens: MHNG 15431 Entre Oudena (= Oudna) et le Djebel Recas (= Jabal Ar Rasas) (Helix tissotiana); Djebel Bargou 28.12.2008, coll. Abbès/10; Djebel Serj 28.12.2008, coll. Abbès/3; Djebel Zaghouan 02.02.2008, coll. Abbès/8; Ghar elMelh 07.05.2005.

Dimensions (n=10): Height= 5.4 ± 0.75 mm; Diameter= 13.2 ± 0.9.

Description: Shell small to medium-sized, clearly flattened above (on the side of the apex) and domed below (on the side of the aperture); lenticular and clearly keeled shape; yellowish in colour with more condensed brown spots at the level of the first whorls; 5 whorls flattened or very slightly elevated; superficial suture; external surface opaque and finely ribbed; fine and regularly spaced streaks; last turn of whorl wide and sharply keeled; aperture lenticular with angular outer end; discontinuous and simple peristome; umbilicus open, deep and revealing all the internal rolling up of the shell.

Genitalia: Complex penial formed of penis, epiphallus and flagellum; penis long, swollen and containing a penial papilla; epiphallus almost as long as the penis; flagellum long (3 times longer than the penis. Female part consists of a vagina, simple dart sac, two multifid glands, a peduncle and a bursa copulatrix, vagin long; simple dart sac inserted at the surface of the proximal vagina; multifid glands inserted just above the insertion site of the dart sac on either side of the vagina and each formed of three tubules; from the proximal vagina starts the initially wide peduncle then becomes thinner and ends in the bursa copulatrix; circular bursa copulatrix.

Distribution: this species has a North West African distribution. Its geographical distribution in Tunisia is shown in Figure 4.

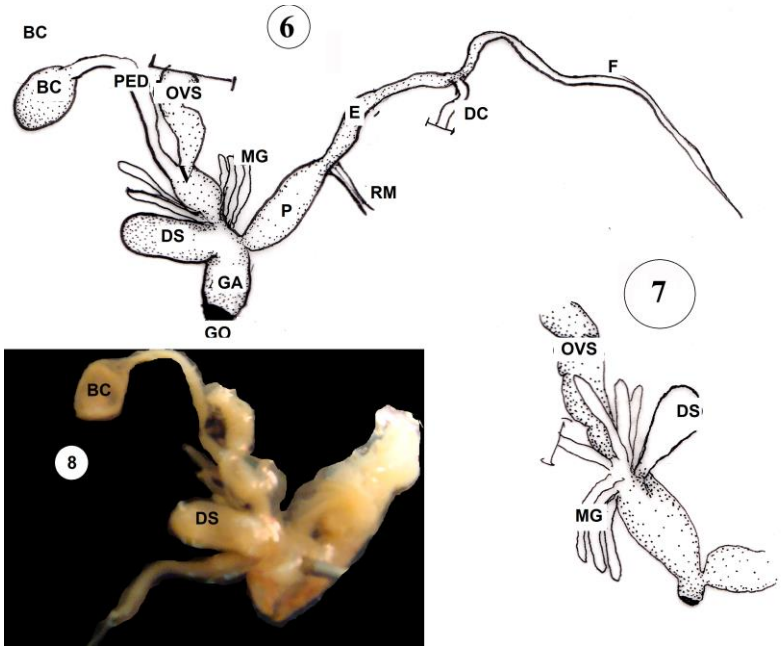

Figure 5 *Xeroplana zeugitana:* Genitalia. Scale = 1 mm. GA: genital atrium; DSC: dart sac complex; E: epiphallus; F: flagellum; MG: multifides glandes; RM: retractor muscle; GO: genital orifice; OVS: ovispermiduct; P: penis; BC: bursa copulatrix; PED: pediculus; V: vagina.

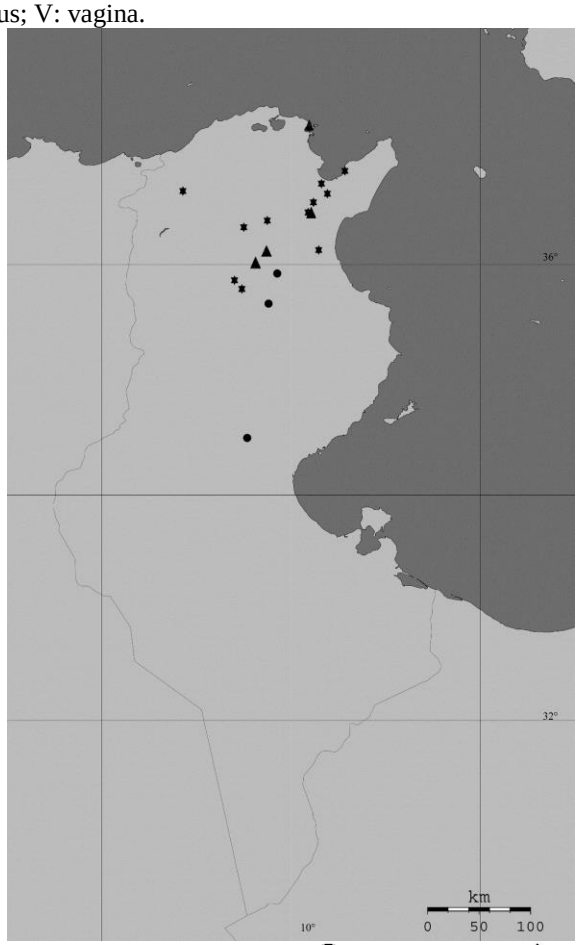

Figure 4: Geographical distribution map of: *Xeroplana doumeti* (●),*Xeroplana idia* (★)and *Xeroplana zeugitana* (▲).

Discussion

The genus *Xeroplana* is distinguished anatomically and morphologically from the genus *Cernuella* by the following criteria: shell is depressed; umbilicus broad, flagellum slightly longer than penis, stylophores not fused, not surrounded by a sheath and of the same size. This confirms the results of Manganelli et al., 1997 who reported also 2 species belonging to this genus: *X. doumeti* and *X. idia*.

Comparative survey between *Helix enica* and *Xeroplana idia* shows that both taxa are too similar to each other. The difference lies mainly in the dorsal side of the shell, which is clearly domed in *Helix enica*, the samples observed do not show any intermediate form between these two taxa. Thus *H. enica* could be considered a subspecies of *X. idia*.

For taxonomic position of *Xeroplana zeugitana*, although the morphological similarity between the former species and *Xeroplana idia*, the anatomical details of the first species highlight the following criteria: the presence of a single simple dart, the multifid glands are few and inserted on either side of the vagina. In fact, these criteria do not correspond to those of the species belonging to this genus and particular attention must therefore be paid to the taxonomy of this species.

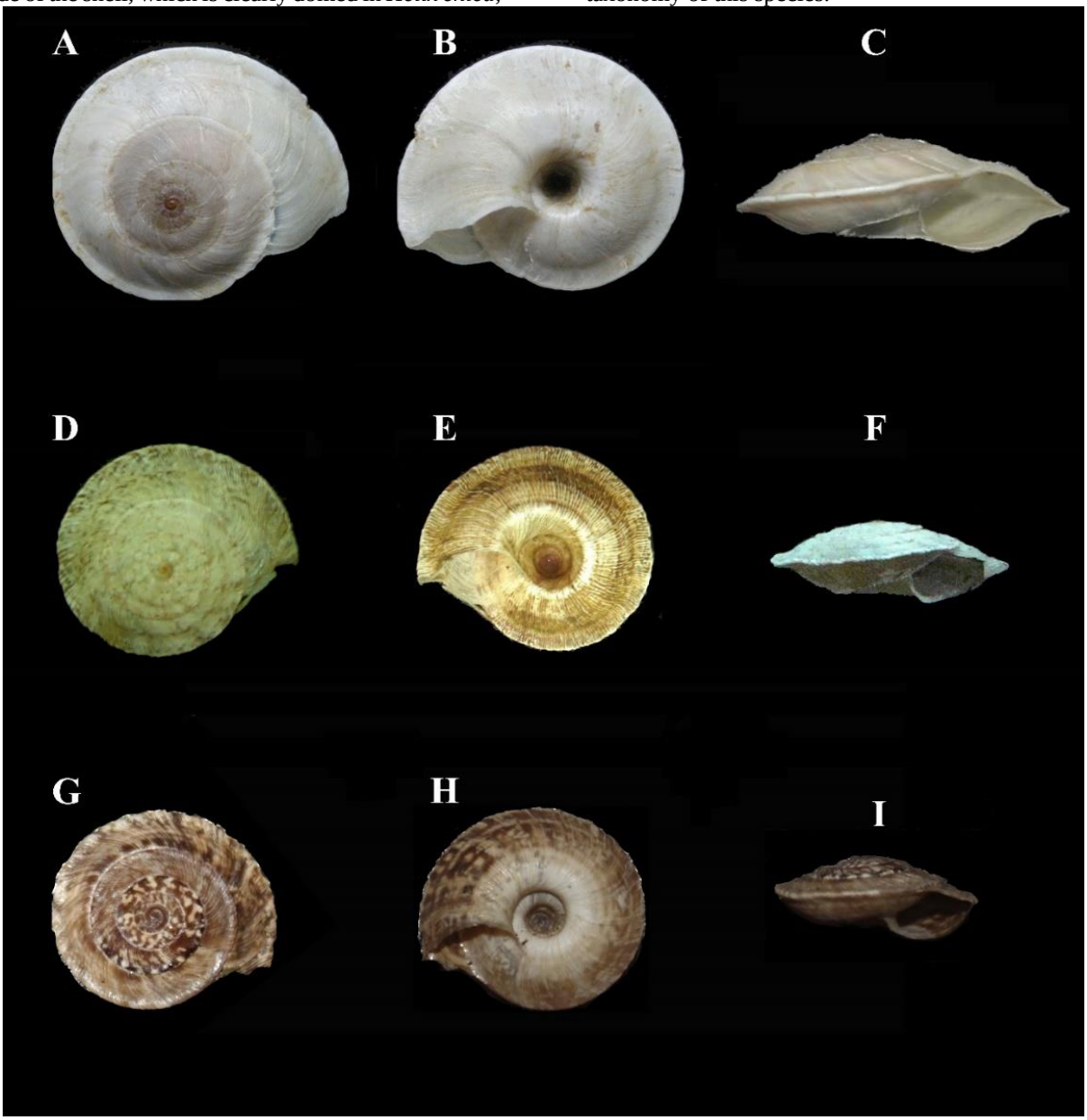

Planche 1: figure A-C: *Xeroplana doumeti* (D = 21 mm); **figure D-F**: *Xeroplana idia* (D = 15.2 mm); **figure G-I**: *Xeroplana zeugitanica* (D = 12 mm).

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