

Terrestrial Molluscs of the United Arab Emirates

By

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With 1 figure and 2 plates

Summary: A survey of UAE land molluscs has recorded a total of seven native species and at least six introduced species. All of the native species are land snails found primarily or exclusively in mountain and perimontane environments. *Zootecus insularis* and *Pupoides coenopictus* are widespread throughout the mountain areas of the UAE but are also common in other suitable environments. *Xeropicta mesopotamica* is limited to agricultural and peri-agricultural settings within and adjacent to the mountains. *Granaria persica*, *Gibbulinopsis signata* and *Mordania omanensis* are restricted to higher elevations in the mountains of the Musandam region. *Pseudonapaeus jousseumei* is present in small numbers in the Hajar Mountains, generally at higher elevations, but is absent from the Musandam region

The native species have their closest evolutionary affinities either in the Eremic Zone generally (in the case of the widespread *Z. insularis* and *P. coenopictus*) or in the neighbouring Mesopotamian or Iranian regions of the Palaearctic Zone (in the case of all other species). No native species are traceable to West Arabian, African or Oriental origins.

A similar number of additional terrestrial mollusc species have been introduced into more mesic habitats, many but not all of them apparently in recent times through extensive public and private landscaping and agricultural activities using imported plants, soil and fertilizer. The most common among these are the cosmopolitan *Allopeas gracilis*, the slug *Laevicaulis alte*, and the Florida snail *Polygyra cereolus*. The latter two species are present in pest proportions in some lawn and garden environments. A Succineid identified as *Calcisuccinea luteola*, an unidentified Hygromiid, and the garden snail *Macrochlamys indica* are believed to represent first reports for Arabia.

Introduction

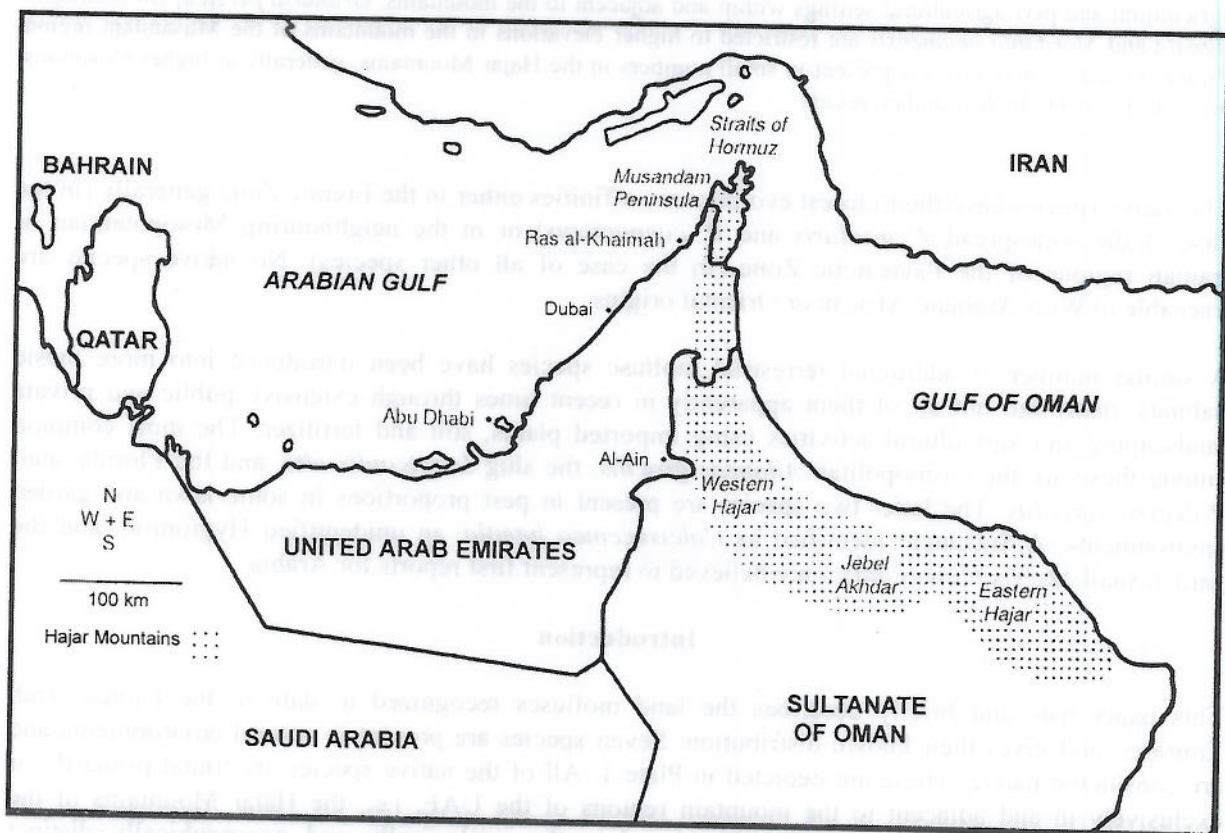
This paper lists and briefly describes the land molluscs recognized to date in the United Arab Emirates, and gives their known distribution. Seven species are present in natural environments and are considered native. These are depicted in Plate 1. All of the native species are found primarily or exclusively in and adjacent to the mountain regions of the UAE, i.e., the Hajar Mountains of the eastern UAE and their northern continuation into the geologically and geographically distinct Musandam range.

Six introduced species have also been collected, of which five have been professionally identified. These are depicted in Plate 2. The sixth may represent an as yet undescribed species. Most introduced species have been found only in artificial environments, including agricultural land, public parks and plantings, and suburban lawns and gardens. Additional introduced species not reported here are undoubtedly present as well, in discrete synanthropic contexts. However, apart from suburban and agricultural areas, which are artificially watered, the non-montane areas of the UAE consist of sand and gravel desert unsuitable for most terrestrial molluscs.

No comprehensive investigation of UAE terrestrial molluscs has previously been conducted, although collections have been made in the Omani portions of the Hajar Mountains, the Musandam region and elsewhere in Oman (see, e.g., SMYTHE & GALLAGHER 1977, BANK & NEUBERT 1998, and NEUBERT 1998).

All identifications reported here were determined or confirmed by Dr. EIKE NEUBERT based on material collected by the authors. Nomenclature follows NEUBERT (1998). All UAE distributions reported here are based on field investigations by the authors commenced in mid-1997. Geographic coverage has been extensive throughout the mountain regions and selective within suburban Dubai. Specimens were also solicited from other areas of the UAE through interested professional and amateur organizations. That solicitation resulted in the addition of one introduced species not encountered by the authors and a second location for an as yet unidentified introduced species, but otherwise did not contribute significantly to the results. One of the authors (GRF) has also made field excursions to study the occurrence of land snails in the Jebel Akhdar region of Oman, for comparison with UAE mountain environments, and was permitted to examine the reference collection of terrestrial molluscs maintained at the Oman Natural History Museum in Muscat.

Figure 1: Geography of the northern United Arab Emirates.



A brief description of the geology and geography of the UAE mountains is important to an understanding of terrestrial mollusc distribution. The northern Emirates of the UAE, particularly Ras al-Khaimah and Fujairah (Figure 1), are dominated by the rugged Hajar Mountains, which parallel the Gulf of Oman coast, reaching summit elevations of more than 1000 metres and with fringing and relatively fertile gravel plains having a width of as much as 15 km. The Hajar Mountains are composed primarily of a suite of igneous rocks of basic and ultrabasic composition (i.e., relatively rich in Fe, Mg and Ca), collectively called "ophiolite," which represent former oceanic crust and upper mantle. At the extreme north of the Hajar range, the UAE includes a small area of the higher mountains of the Musandam peninsula region, most of which lies within the Musandam province of the Sultanate of Oman. The Musandam range is composed of thick sequences of shallow water carbonate sediments (limestone and dolomite). Its rolling summit plateaux range from 700-1500 metres, with peaks to 2000 metres.

Systematic List of Species

The following is a systematic list of the terrestrial molluscs collected and identified to date in the UAE:

Class GASTROPODA

Order Pulmonata

Family Veronicellidae

Laevicaulis alte (FÉRUSAC 1821)

Family Succineidae

Calcisuccinea luteola (GOULD 1848)

Family Pupillidae

Pupoides coenopictus (HUTTON 1834)

Gibbulinopsis (Primipupilla) signata (MOUSSON 1873)

Family Chondrinidae

Granaria perisca GITTENBERGER 1973

Family Subulinidae

Zootecus insularis (EHRENBERG 1831)

Allopeas gracilis (HUTTON 1834)

Family Buliminidae

Mordania omanensis (E.A. SMITH 1894)

Pseudonapaeus jousseaumei (E.A. SMITH 1894)

Family Polygyridae

Polygyra cereolus (MEGERLE VON MÜHLFELDT 1816)

Family Ariophantidae

Macrochlamys indica GODWIN-AUSTEN 1883

Family Hygromiidae

Xeropicta mesopotamica (MOUSSON 1874)

Hygromiidae gen. sp. indet.

Description, Habitat and Range

Native Species

Pupoides coenopictus (Fig. 1). This species is perhaps the most abundant and widespread land snail in the UAE, but because of its small size (c.5 mm) it generally escapes casual notice. The tapered conical shape of the shell is distinctive, as are its round aperture, noticeably offset from the axis of coiling, and its slightly flared apertural lip. Empty shells may be white or pale brown. In living snails, the shell appears brown.

P. coenopictus is found throughout almost the whole of the mountain regions of the UAE. It has not yet been observed at higher summit elevations in the Hajar Mountains (c.1000-1600 metres) although it has been collected at widespread Musandam locations up to c.1450 metres and in the Jebel Akhdar of Oman up to c.2350 metres. In the Musandam its habitat overlaps above c.700 metres with that of the similarly-sized *Granaria persica* and *Gibbulinopsis signata*. Shells of all three of these tiny Musandam snails were found within a single dropping of BLANFORD'S fox (*Vulpes cana*) collected from the area, raising the interesting question whether they were ingested by the fox, either accidentally or by design, or whether the snails were attracted to the dropping in life.

In natural environments in the UAE, *P. coenopictus* shells are typically found in settings like those of the larger and more visible *Zootecus insularis*, weathering out of silty soil among rocks and vegetation on mountain slopes or in silty patches in wadis or on gravel plains or terraces. In fact, shells of the two species typically occur together in the Hajar Mountains. There, if *Z. insularis* is seen, inspection more often than not reveals *P. coenopictus* in the immediate vicinity, although their different sizes may cause them to sort somewhat differently. *P. coenopictus* is also found in traditional agricultural plots

and in soil in suburban gardens, especially under stones, but it does not seem to be successful as a lawn species.

P. coenopictus is widespread in the Eremic Zone (also called the Saharo-Sindian region), the arid or semi-arid biogeographic region that stretches from North Africa to northwestern India (MORDAN 1980, NEUBERT 1998).

Gibbulinopsis signata (Fig. 2). This tiny (c.4.0-4.5 mm), relatively cylindrical shell is inconspicuous but distinctive. The whorls are narrow, the apex is flattened and the sides are parallel, so that the body of the shell resembles overall a miniature beehive, or the Michelin man. The round, slightly flared aperture protrudes sub-perpendicularly from the final whorl via a narrowed and creased "neck." Within the aperture, a single tooth ridge can be seen on the columella.

G. signata is distributed from the Caucasus Mountains and eastern Turkey to Iran and Central Asia (NEUBERT, *pers. comm.*). In Arabia it is restricted to the Musandam region, where shells have been found at widespread localities and in habitats ranging from open slopes and traditional cultivation at 850m to rocky summits at 1900+ metres. No live specimens have yet been found. In its shell morphology, *G. signata* very closely resembles *Gulella protruda*, NEUBERT & FRANK 1996, which is endemic to higher elevations in the Jebel Akhdar of Oman. The most readily observable difference is that in *G. signata*, the proximal edge of the flared apertural margin remains in contact with the main body of the shell, whereas in *G. protruda* the entire apertural margin is free.

The genus *Gulella* belongs to the Family Steptaxidae, a group considered to have Afro-tropical origins, and NEUBERT (1998, *pers. comm.*) has indicated that *G. protruda* is more likely to belong to the genus *Gibbulinopsis*, which has Iranian affinities. A definitive conclusion awaits the collection of live material for investigation of the anatomy of the genital organs.

Granaria persica (Fig. 3). This 5-6 mm snail has a smooth, high-spiraled shell. It resembles *P. coenopictus* but is somewhat less conical and more spindle-shaped, with a U-shaped aperture that is more nearly in line with the axis of coiling. Its most distinctive feature is the presence of four small tooth ridges (lamellae) within the aperture. In technical terms, consistent with the original description by Gittenberger, the parietal wall contains a strong parietalis and a short spiralis deep in the aperture. The columellaris and infracolumellaris are of the same size. The palatalis inferior is always the strongest and longest palatal lamella, and the palatalis superior and suprapalatalis are of similar size.

G. persica was first described from SE Iran, where it was found at Kerman and at "Seauch, in the mountains SE of Kerman." This remains its only known locality, although it can be expected to have a much wider range (NEUBERT, *pers. comm.*). In Arabia it is restricted to the Musandam mountains, where it has been found at widespread locations and at all elevations from c.700 metres to the highest summits at 1900+ metres, normally in association with *Gibbulinopsis signata*. Live specimens were found in surface soil under a dense clump of *Cymbopogon* grass at c.900 metres. In life, the shell is a pale golden brown.

GITTENBERGER (1973) believes that *G. persica* forms a group of closely related species with *G. arabica* (DOHRN, 1860) from Yemen and *G. lapidaria* (HUTTON, 1849) from Quetta, Pakistan. This group of similar species forms the southern and easternmost distribution area of both the family and the genus (NEUBERT, *pers. comm.*).

Zootecus insularis (Fig. 4). This is the most commonly encountered native land snail in the UAE. It is bullet-shaped and adults are approximately 12-14 mm long with a U-shaped aperture and a slit-like umbilicus. The rim of the aperture may be slightly thickened. The shell of juveniles is shorter and therefore more equidimensional, and has a more angular aperture.

Z. insularis is widespread throughout the Hajar Mountains and the adjacent gravel plains, occurring at all elevations. It is generally rare in the Musandam, but has been found at a few sites in the southeastern Musandam from wadi level up to as high as 1600 metres. It is also present in traditional

cultivation along the narrow coastal plain to the west of the Musandam range, in the villages north of Ras al-Khaimah city. In Oman's Jebel Akhdar it can be found up to c.1900 metres. In natural environments, *Z. insularis* shells are often seen weathering out of silty soil among rocks and vegetation on mountain slopes or in silty patches on gravel plains or terraces, especially at the site of dead and collapsed *Euphorbia larica*. Empty shells are typically bright white in colour, and opaque. Live shells are pale buff colour with a greyish apex, and are slightly glossy.

Live, active and/or aestivating *Z. insularis* have been observed among the shallow roots of *E. larica*, *Cymbopogon* sp., *Helianthemum lippii* and other mountain plants. Specimens can also be found in and around traditional agriculture and in suburban lawns and gardens. Shells from the latter environments are often somewhat broader than those from natural environments.

Like *P. coenopictus*, *Z. insularis* is a widespread species, occurring throughout the Eremic Zone (MORDAN 1980, NEUBERT 1998). *Z. insularis* has been recognized in Quaternary lake sediments in the Empty Quarter of Saudi Arabia dated at c.7,000-9,500 years B.P. (MCCLURE 1984).

Mordania omanensis (Fig. 5). This is the largest native land snail found in the UAE. Adult shells are bullet-shaped but fattened, approximately 20 mm long by 8 mm wide. Adults have a broad, flared and slightly recurved lip around the large aperture.

M. omanensis has so far been found only at northern and central Musandam locations, including summits of 1900+ metres. The lowest *M. omanensis* shells were found within disused traditional cultivation at an elevation of 500 metres above Rams, Ras al-Khaimah. Live, active specimens were found in the UAE in upper Wadi Shah, in deep, narrow crevices in a steep, north-facing limestone cliff, a few days after moderate rain in January 2000. *Pupoides coenopictus* was present in the same habitat. Aestivating specimens of *M. omanensis* were found attached to dried brush under a discarded grindstone near a crude mountain cistern at 1300 metres in the NE Musandam. Dead shells have been found weathering out of silty soil, especially under rock overhangs but also under wild almond trees (*Prunus arabicus*).

M. omanensis is present further south in Oman, in the Jebel Akhdar region, at elevations from c.1700 metres to the summit of Jebel Shams (c.3000 metres). Shells are particularly abundant at broken ledges in the bedded carbonate rocks. *M. omanensis* has also been reported from the Jebel Bani Jaber, the easternmost of the mountain ranges of northern Oman, as well as from cultivation in the Jebel Akhdar at c.800 metres (SMYTHE & GALLAGHER 1977) and the Buraimi oasis at c.300 metres (NEUBERT 1998). *M. omanensis* is so far unreported from the Hajar Mountains between the Musandam and the Jebel Akhdar, an area which remains poorly explored at higher elevations. However, its presence in the Buraimi oasis, situated on the gravel plains west of the Hajar Mountains, suggests that it may yet be found in the Hajar Mountains as well.

The genus *Mordania* is a relatively new one and has its only other representative, *M. carduchus*, in the mountains of northwestern Iran (BANK & NEUBERT 1998).

Pseudonapaeus jousseaumei (Fig. 6). This is a bullet-shaped species approximately 10-13 mm long, superficially resembling *Zootecus insularis*, from which it can nevertheless be readily distinguished by the wavy, transverse (longitudinal) striping on the shell, pale grey-brown and white, which persists even in empty shells. Adult *P. jousseaumei* is also distinguishable by slight flaring of the rim of the aperture and the presence of a small but distinct umbilical cavity. Juveniles resemble juveniles of *Z. insularis*, but usually show striping and have a more angular keel.

P. jousseaumei is endemic to the mountains of the UAE and Oman, including the Hajar Mountains and the Jebel Akhdar of Oman (MORDAN 1980, BANK & NEUBERT 1998), but apparently excluding the Musandam. The genus *Pseudonapaeus* is mainly distributed in Central Asia. Geographically, the nearest congener is the widespread *P. oxianus*, found in central Iran (BANK & NEUBERT 1998).

In Oman *P. jousseaumei* is found to elevations of almost 3000 metres in the Jebel Akhdar but it has been said to occur below 500 metres only in synanthropic environments (MORDAN 1986). In the UAE, shells been found at 200-400 metres within agricultural terraces at Masafi, Wadi Diftah and Wadi Hayl, but only a single shell has been found in an unequivocally natural environment, as flotsam along a wadi bank. Live (but aestivating) specimens have been found only within actively cultivated fields. In areas of northern Oman along the UAE border, on the western flank of the Hajar Mountains, *P. jousseaumei* is present but uncommon in natural environments. The authors have found it at sites ranging from mountain wadi banks at elevations of 700 metres to rocky summits from 1100-1600 metres. In the same area it is also found in traditional cultivation along the mountain front at elevations of 500-600 metres.

P. jousseaumei has not been found in the mountains of the Musandam region. This is considered anomalous, in view of (a) the similarities between the Musandam and the Jebel Akhdar in terms of geology and elevation, (b) the otherwise relatively continuous montane distribution of *P. jousseaumei*, (c) its Iranian phylogenetic affinities, and (d) the fact that all of the other species native to the UAE are present in the Musandam. The northernmost *P. jousseaumei* shell was found as flotsam beside a coarse gravel wadi bed at c.300 metres in Wadi Mowred, some 20 km south of the Musandam. A synanthropic origin for that shell cannot be ruled out, although the site is more than 5 km downstream from the nearest cultivation.

Xeropicta mesopotamica (Fig. 7). This species has a turban-shaped shell with a diameter of up to 14 mm, but often much smaller. The shell has a thin brown stripe along the center of each whorl, visible in earlier whorls just above the suture of the succeeding whorl. In fresh shells the earlier whorls also bear closely-spaced, faint transverse (radial) brown lines resembling the spokes of a wheel. The umbilicus is deep and fully exposed. The rim of the aperture is never thickened. *X. mesopotamica* can climb rocks, walls or palm trees to a height of at least 60 cm.

X. mesopotamica has been found at elevations of up to c.850m, but, with two exceptions (both in the Musandam), all occurrences have been within or immediately adjacent to cultivation. In one instance, at Sal Dhayah, shells were found in abundance at c.500 metres on a natural slope of loose rock and vegetation some 5-10 metres above cultivated terraces on a mountain plateau. In the other, live snails were encountered on a large, low, pockmarked limestone slab set in a silted and well vegetated plain formed behind a natural dam in upper Wadi Shah at c.775m, where parts of the natural plain are used for palm cultivation.

As its name suggests, *X. mesopotamica* is found in the Tigris-Euphrates basin, where it is considered to originate (NEUBERT 1998). There it is a lowland species, giving way in the mountains to *X. millepunctata* (NEUBERT, pers. comm.).

Introduced Species

Laevicaulis alte (Fig. 8). This is a flattened, grey-brown to mottled black slug with a thin, pale yellow dorsal line. On the underside is a long, thin, segmented central foot. *L. alte* can reach sizes in excess of 80 mm x 15 mm (extended) but in the UAE few are more than 60 mm long. Like most terrestrial slugs, *L. alte* is primarily nocturnal. By day it is found in soil and under stones, where, inactive and contracted, it resembles a rounded elliptical piece of rubber. A larger specimen might measure 40 mm x 24 mm when contracted.

L. alte is found in the UAE only in areas that are regularly watered, principally landscaped areas and cultivation. It has never been found in "wild" areas. The authors have not found it in traditional cultivation, but there is no reason to conclude that it is absent from well-watered plantations. Since it does not leave a shell, its presence would not necessarily be disclosed by inspection of surface debris.

The Family Veronicellidae originates in Africa, but *L. alte* is easily spread by man and now exists throughout the Indo-Pacific area, including landscaped and cultivated sites at many places along the Arabian Gulf (NEUBERT 1998).

The largest *L. alte* found in the UAE (larger than any Arabian or African specimens reported in NEUBERT (1998)) was a c.90 mm slug recovered from the nostril of a thoroughbred racehorse in Abu Dhabi. The horse had shown signs of discomfort, attracting the solicitous attention of its caretakers. Ultimately, the horse snorted vigorously, dislodging the slug. Reconstruction of the chain of events indicates that the slug was most probably introduced via the horse's morning meal of fresh alfalfa or lucerne (*Medicago sativa*) from a well watered fodder farm.

Calcisuccinea luteola (Fig. 9). This snail closely resembles the common Arabian freshwater snail *Radix natalensis*, formerly *Lymnaea natalensis* (see, e.g., NEUBERT 1998, FEULNER & GREEN 1999). Its most characteristic feature is the very large, scoop-like aperture, approximately 55% the length of the shell. Shell length ranges from 6.5-11 mm, with most being 8-10 mm. Empty shells are opaque white with well developed growth lines on the final whorl.

This snail was found only in a small area of landscaped garden within the recreation club of a residential apartment complex in Dubai, where live specimens were collected on soil at the base of clumps of decorative grasses and around the mossy bases of decorative date palm trees, including some found on the palm trunks as high as 60 cm. That population is believed to have become extinct following destruction of the garden in mid-2001 to accommodate construction on neighbouring land. A smaller area was subsequently restored and re-planted, but no Succineids have been found thereafter.

Succineids are also known as amber snails. Most have relatively delicate shells and favor very moist environments. Many are closely associated with water and live on freshwater reeds just above the waterline. In both respects the Dubai Succineid is atypical, having a relatively sturdy shell and surviving on daily sprinkler irrigation. Succineids are notoriously difficult to distinguish by shell characteristics alone, and study of the soft anatomy is required. The only Succineid previously reported from the Arabian Peninsula is *Quickia concisa*, a tropical African species that has been found in the Asir region of Saudi Arabia and in a date garden in the Wahiba Sands of eastern Oman. The Dubai Succineid is readily distinguishable from *Q. concisa* as depicted in NEUBERT (1998). The dissection of two specimens has revealed it to be *Calcisuccinea luteola*, a native of the southeastern United States, a determination which was reconfirmed by Dr. David Robertson of Philadelphia (NEUBERT, *pers. comm.*).

Allopeas gracilis (Fig. 10). *A. gracilis* has a 7-10 mm, thin, conical shell with a U-shaped aperture. Live specimens often appear to be two-tone in colour, with a grey apex and pale yellow anterior. This species is now common in public and private lawns in Dubai. It is also found in traditional agricultural plantations and has been found on the base of sprinkler-watered palm trees to a height of at least 60 cm. A single shell has been found in an indisputably "wild" site in a coarse gravel wadi bed in the mountains of the East Coast.

A. gracilis is widespread in the Indo-Pacific area and seems to be easily spread by human activity. NEUBERT (1998) attributes to it an origin in the New World tropics but, if this is correct, its presence in pre-Columbian archeological contexts at the site of Kush (c.400-1300 AD) in Ras al-Khaimah requires an explanation other than human introduction.

Polygyra cereolus (Fig. 11). This species is native to the southeastern United States, particularly Florida (NEUBERT 1998), but it is now common in well watered lawns and gardens in Dubai and other Arabian Gulf locations, where it can reach pest proportions. The shell is a very flattened turban shape, almost discoidal, up to 9 mm in diameter. The whorls are narrow with fine, closely spaced transverse ribs. Viewed dorsally it resembles a tiny coil of rope. The aperture is relatively small and U-shaped, with a thickened rim and a prominent tooth at the base of the opening, on the columella. The umbilicus is large, deep and open. The snail can climb walls or trees to a height of about one metre.

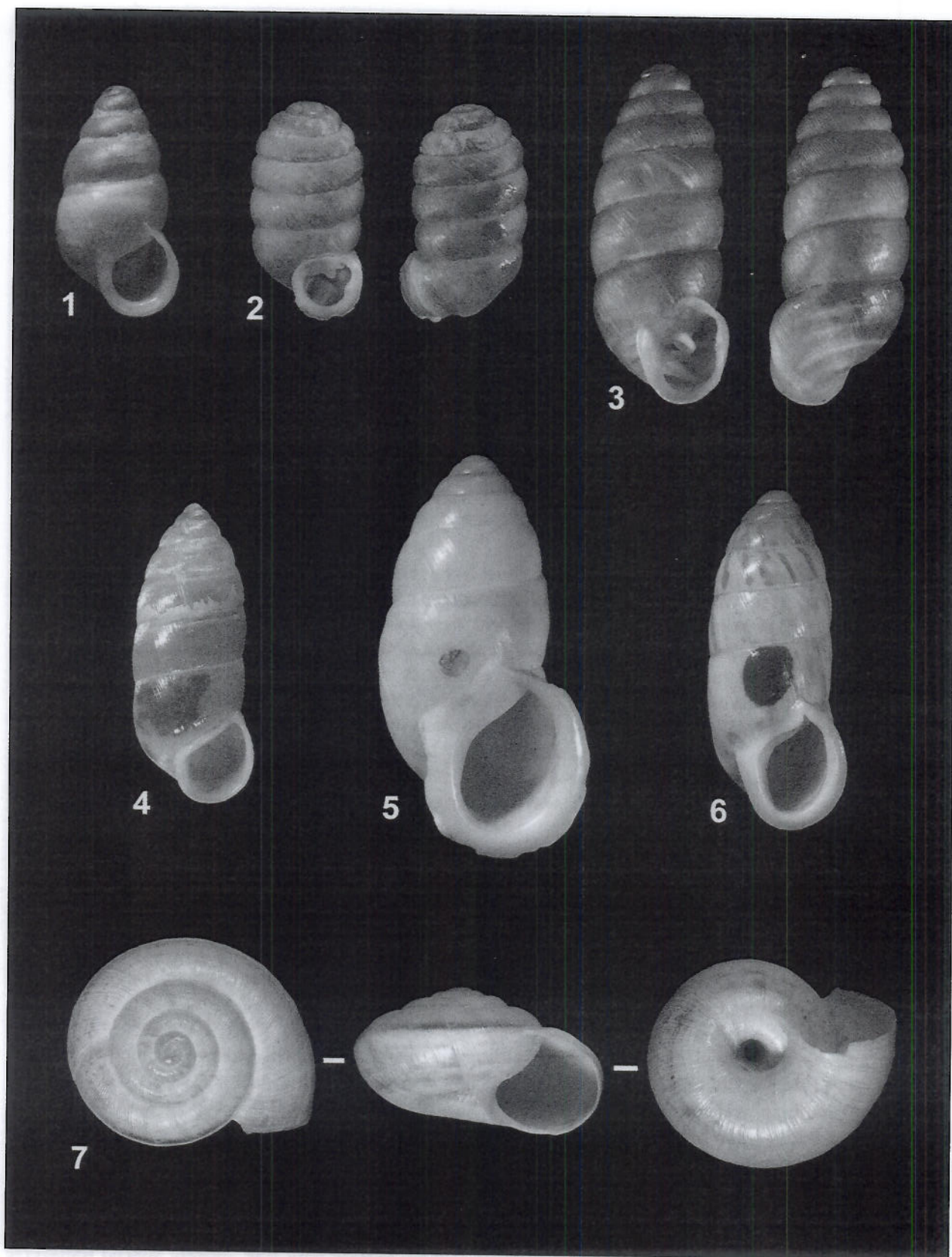


Plate 1: Native UAE land snails: **Fig. 1.** *Pupoides coenopictus*, Iraq, Samara. H = 4.1 mm, x10. **Fig. 2.** *Gibbulinopsis signata*, Oman, Jiddat al Sahasa, W of Jabel Harim. H = 3.9 mm, x10. **Fig. 3.** *Granaria persica*, Oman, Ruus al Jibal, Qasaydat. H = 6.05 mm, x10. **Fig. 4.** *Zootecus insularis*, Yemen, Cameran Isld. H = 10.7 mm, x5. **Fig. 5** *Mordania omanensis*, Oman. H = 23.9 mm, x3. **Fig. 6.** *Pseudonapaeus jousseaumi*, Oman. H = 12.1 mm, x5. **Fig. 7.** *Xeropicta mesopotamica*. Iraq, Samara. D = 8.75 mm, x5. phot. E. NEUBERT.

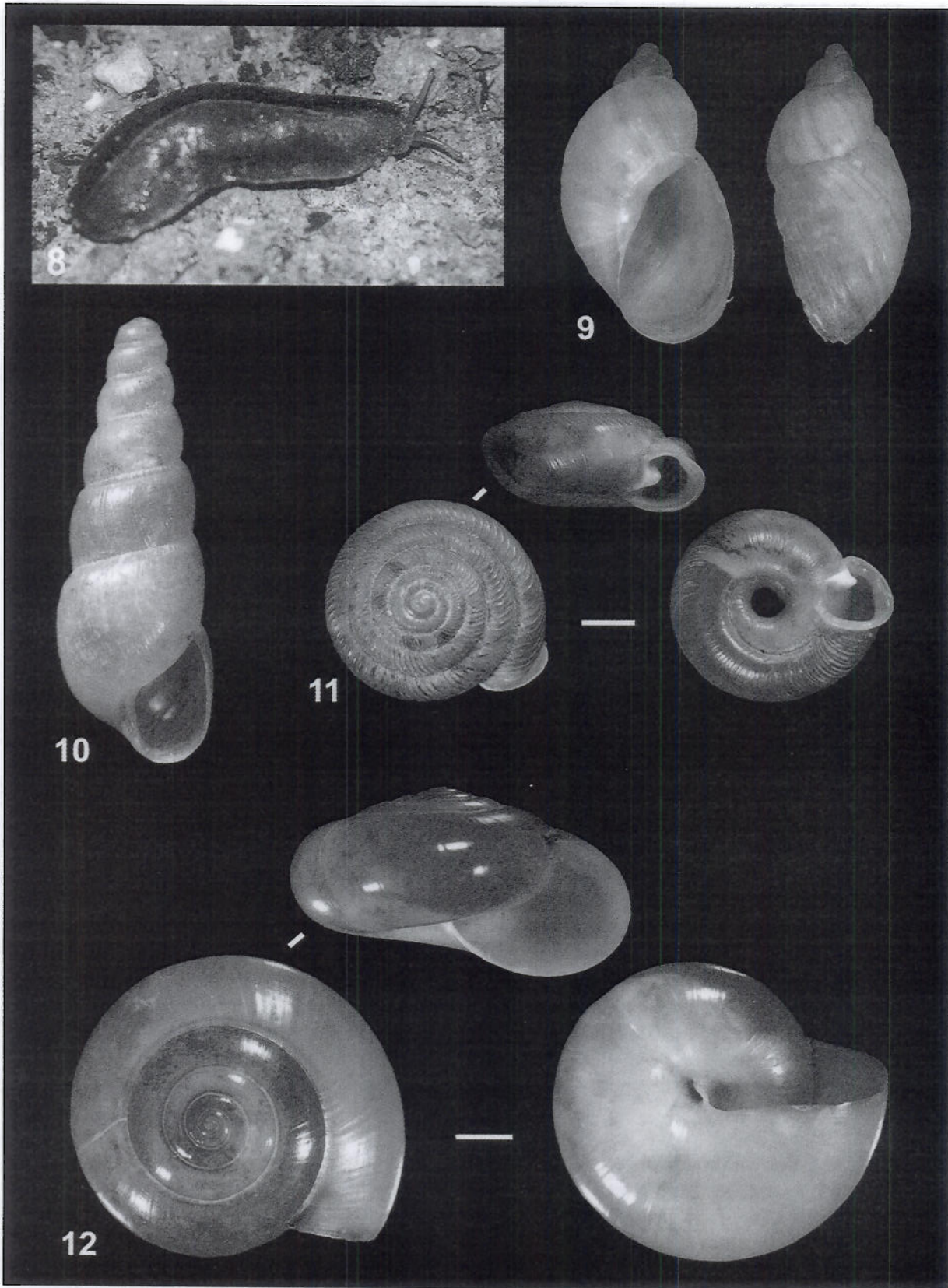


Plate 2: Some introduced land snail species present in the UAE: **Fig. 8.** the slug *Laevicaulis alte*. **Fig. 9.** *Calcisuccinea luteola*, United Arab Emirates, Dubai. H = 10.4 mm, x5. **Fig. 10.** *Allopeas gracilis*, Oman, Oasis N of Nizwa. H = 7.7 mm, x10. **Fig. 11.** *Polygyra cereolus*, Saudi-Arabia, Jubail, al Deffi. D = 3.7 mm, x10. **Fig. 12.** *Macrochlamys indica*, United Arab Emirates, Abu Dhabi. D = 19.0 mm, x3. Fig. 9-12 phot. E. NEUBERT.

Macrochlamys indica (Fig. 12). This flattened turban-shaped snail is the largest land snail so far found in the UAE. Four specimens have been collected from two private gardens, one in Abu Dhabi (1989 and 1991) and one in Al-Ain (2001), measuring from 13.5 to 22.5 mm. Fresh shells are very glossy, with the early whorls greyish and the final whorls translucent beige. The umbilicus is partly concealed by flaring and curving of the adjacent lip of the apertural wall. The upper surface of the shell displays a characteristic pattern of microscopic spiral lines (NEUBERT, *pers. comm.*).

M. indica originates from the Indian subcontinent and is now widespread throughout the Indian Ocean region, including oceanic islands such as Mauritius, but it has not previously been reported from Arabia (NEUBERT, *pers. comm.*).

Unidentified Hygromiid. This 8-12 mm diameter turban-shaped snail has so far been found only on the grounds of a single landscaped apartment complex in suburban Dubai and at an ostrich farm in an agricultural area at Marqab, some 50 km from urban Dubai. Unweathered shells show a thin, pale brown band along the center of each whorl, which remains visible just above the suture of the succeeding whorl. The shell closely resembles *Xeropicta mesopotamica* but the brown band is thicker, the apex is slightly less flattened and the umbilicus is partly concealed by flaring and curving of the rim of the aperture at the point of attachment. The rim of the aperture is often slightly thickened.

This Hygromiid can climb walls and palm trees to a height of about one metre. It is thought to be anatomically distinctive, perhaps sufficiently so to warrant its assignment to a new genus (NEUBERT, *pers. comm.*). This argues for its origin in an area not yet well studied malacologically. One possibility suggested in connection with the ostrich farm occurrence is that it has been introduced with manure privately imported from Pakistan as fertilizer.

The main apartment complex population was found on a small, isolated patch of lawn from which *Polygyra cereolus*, rampant on neighbouring lawn areas, was absent. Shells and a few live individuals were also found in garden areas where *P. cereolus* was likewise rampant. In mid-2001, approximately two years after the discovery of the isolated lawn population, *P. cereolus* was found there following the planting of several date palms for decorative purposes. Since that time the numbers of *P. cereolus* have increased rapidly, apparently at the expense of the unknown Hygromiid. In February 2002, hundreds of live *P. cereolus* were found, but only three live Hygromiids, all within a single patch of the prostrate, moisture-loving weed *Lippia nodiflora*.

Other introduced species. At least two additional species of land snails were collected by one of the authors (SAG) in suburban Dubai residential gardens, along with a single probable *Macrochlamys indica*, and have been described in field notes. The actual specimens unfortunately went astray in the process of initial professional identification and the residential properties in question have since changed hands, making re-collection problematic. The continuing development of the UAE, and in particular the increase in public and private landscaping using exotic plant species, makes it virtually certain that additional species of land molluscs are present in the country and that more will be introduced in the future.

Discussion

The UAE, like the whole of Arabia, lies within the vast desert zone, sometimes called the Eremic Zone, that today stretches from North Africa to northwest India. Biologically, however, much of the country's interest arises from its historical position at the junction of the Palaearctic, Afrotropical and Asian biogeographic zones (OSBORNE 1996, NEUBERT 1998). The composition and distribution of the native land snail fauna emphasize two of the most significant aspects of the UAE's biogeographic history.

First, apart from the two widespread Eremic Zone snails (*Zooteucus insularis* and *Pupoides coenopictus*), all of the UAE's native land snails have their closest evolutionary relationships with groups found to the north in either Iran (4 species) or Mesopotamia (1 species). In particular the native species are all quite distinct from the terrestrial molluscs found in western or southwestern Arabia -

- Dhofar, Yemen and the mountains of southwestern Saudi Arabia (MORDAN 1980, NEUBERT 1998) – areas that are influenced to the greatest extent by the flora and fauna of the Western Palearctic and Afrotropical regions (NEUBERT 1998). Thus the composition of the terrestrial mollusc fauna reinforces the general conclusion, drawn from studies of various other taxonomic groups (e.g., plants, freshwater fish, non-migratory birds, and even butterflies), that the mountain regions of the UAE and northern Oman constitute a distinct biogeographic province having its closest affinity with the Iranian region of the Palearctic Zone. This in turn emphasizes the relative unimportance of the present day Arabian Gulf as a long-term biogeographic barrier.

Second, the mountain regions of Arabia generally are recognized to have served as a modern day refuge for a number of Palearctic species that entered originally when the climate was cooler and/or wetter than it is today. Many of those species once had more extensive ranges but now survive as relict populations only in higher mountain regions or in artificial habitats. The mountains of the UAE and northern Oman are no exception to this generalization, and the terrestrial molluscs of the UAE provide a good example of relict distribution. All of the UAE's native snails are centered in or around mountain environments and four of the seven native species are restricted to elevations of c.600 metres or above, except in synanthropic environments. A fifth is limited to agricultural or peri-agricultural settings.

With the exception of certain species readily spread by human activities (some evident and notorious in the modern UAE), terrestrial molluscs disperse relatively slowly, so that the extent of the geographic range of a taxon is an indicator of its evolutionary age. The widespread *Zootecus insularis* and *Pupoides coenopictus*, both of which are found throughout the entire Eremic Zone, are therefore considered examples of relatively "old" lineages that may date from pre-Oligocene times, i.e., more than c.40 million years B.P. (NEUBERT 1998). The UAE's other native species are considered most likely to have invaded and/or arisen only subsequent to the onset of mountain building in the Zagros Mountains in the late Miocene, and therefore probably no more than about 5 million years ago (NEUBERT 1998).

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