



CONTRIBUTION TO THE KNOWLEDGE OF THE TERRESTRIAL SLUGS OF PAKISTAN

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ABSTRACT: Material collected during malacological surveys in Pakistan in 1990–1992 is discussed. Previously, only one slug species, *Anadenus altivagus* Theobald, 1862, was recorded from Pakistan. *Deroceras laeve* (O. F. Müller, 1774) and *Candaharia rutellum* (Hutton, 1849) are documented for the first time from the country. Distribution maps and ecological notes are provided for the Pakistan records of these three slug species.

KEY WORDS: Pakistan, terrestrial slugs, Gastropoda, Pulmonata, *Anadenus*, *Deroceras*, *Candaharia*

INTRODUCTION

Terrestrial slugs belong to a large, artificial, polyphyletic group which differs from other Gastropoda in that their external shells are reduced, some to the point of complete absence. This reduction of the shell has led to the development of various complex morphological characters, as well as physiological and behavioural adaptations to their respective environments. Unfortunately, slugs often have frustratingly similar external morphologies and many require dissection for confident identification at the species level. Hence, these molluscs have often been avoided in biological surveys and field studies, especially by early workers.

Until the 1990–1992 surveys on which this report is based, the terrestrial mollusc fauna of Pakistan was

poorly sampled and understood (AUFFENBERG 1997). Relatively recent work has been undertaken in adjacent areas (Afghanistan, northern India and the former Soviet Union) (LIKHAREV & STAROBOGATOV 1967, ALTENA 1970, RAJAGOPAL & SUBBA RAO 1972, SOLEM 1979, LIKHAREV & WIKTOR 1980, UVALYEVA 1996), but the terrestrial of Pakistan has remained virtually unstudied. However, through these recent surveys, it is now realized that Pakistan shares numerous genera and species with its neighbours. Undoubtedly, Pakistan is far from being well-explored malacologically, owing to its large physical size, the great altitudinal range encountered within its borders (0 to > 8,600 m a.s.l.), and the diverse and very often rugged terrain throughout most of the country.

MATERIAL

A total of 223 specimens from 33 collecting sites located throughout much of Pakistan were examined. Locality records follow each species account. Specimens were collected by K. AUFFENBERG unless otherwise noted. All specimens are housed in the Malacolo-

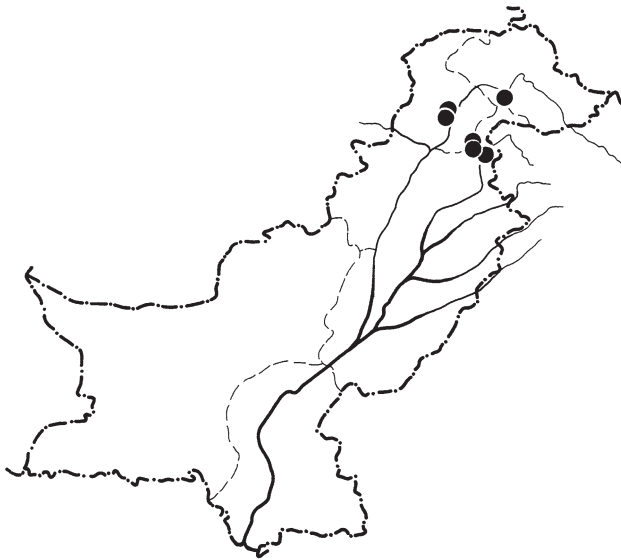
gy collections of the Florida Museum of Natural History, University of Florida (UF), except a synoptic series retained at the Museum of Natural History, Wrocław University.

FAMILY ANADENIDAE

ANADENUS (ANADENUS) ALTIVAGUS
(Theobald, 1862)

Anadenus altivagus THEOBALD 1862: 489. Typus: may no longer exist. Locus typicus: "montibus cis-Sutlejensibus prope Fagu Narkanda, Saraon" (? India).

Synonyms: *Limax modestus* Theobald, 1862, *Anadenus Schlagintweiti* Heynemann, 1862, *Anadenus Jerdoni* Godwin-Austen, 1882, *Anadenus beebei* Cockerell, 1913, *Anadenus dalhousiensis* Bhatia, 1926, ?*Anadenus lahorensis* Bhatia, 1926, *Anadenus (Gymnanadenus) matthaii* Bhatia, 1926 – see WIKTOR (2001) for discussion of the synonymy.



Map 1. Localities of *Anadenus altivagus* (Theobald, 1862)

Examined Material (Map 1)

Azad Kashmir Province: Punch Dist., Bagh Tehsil, S of Haji Pir Pass, Lasdanna, 2,500 m a.s.l., 33°56'N, 74°03'E, National Museum of Pakistan staff, 6 Aug. 1991 – UF 196895/2 (unicoloured).

Northern Areas: Nanga Parbat, 10 km W of Astor Rama, on damp pine straw, 4,500 m a.s.l., Shamin Fakhri. KA-1060. Aug. 1992 – UF 202638/1.

North-West Frontier Province: Abbottabad Dist., 0.8 km S of Khaira Gali, along rd. to Murree, in coniferous forest, 2,250 m a.s.l., 33°58'N, 73°25'E. KA-988. 18 Sept. 1991 – UF 197305/14; Abbottabad Dist., Ayubia National Park, Dunga Gali, on dead leaves around a fallen beech tree, 2,340 m a.s.l., 34°03'N, 73°25'E. KA-983. 18 Sept. 1991 – UF 197281/4; Abbottabad Dist., Ayubia National Forest, Dunga Gali pipeline area, on a fallen log, 2,400 m a.s.l., 34°04'N, 73°23'E. KA-816. 22 Sept. 1990 – UF 181144/1; Abbottabad Dist., Thandiani, Forestry Department Rest House, pine/fir/cedar forest, among limestone boulders, on pine straw, 2,692 m a.s.l., 34°13'N,

73°21'E. KA-811. 21 Sept. 1990 – UF 181117/2; Abbottabad Dist., Thandiani, 2,377 m a.s.l., WA-91-598, W. AUFFENBERG, 22 May 1991 – UF 201187/3; Abbottabad Dist., Nathia Gali, slope behind Green's Hilltop Hotel, on damp pine straw, pine tree bases, emerging from limestone rock piles, 2,480 m a.s.l., 34°07'N, 73°22'E. KA-981. 17 Sept. 1991 – UF 197271/4; Swat Dist., 49.5 km, W of Besham, Yakh Tangi, along stream just below Forestry Rest House, among pine straw, 1,800 m a.s.l., 34°57'N, 72°35'E. KA-945. 11 Sept. 1991 – UF 197155/7; Swat Dist., top of Malam Jabba Mt., blue pine forest, 1,940 m a.s.l., WA-91-214, W. AUFFENBERG, 27 May 1991 – UF 201130/3; Swat Dist., ca. 12 km ENE of Saidu Sharif, Malam Jabba, 2,420 m a.s.l., KA-1095. 25 Sept. 1992 – UF 202772/10.

Punjab Province: Rawalpindi Dist., N slope of Murree Mt., 2.8 km E of Sunny Bank, hiking trail to Kashmir Pt., among grass and herbs, 2,050 m a.s.l., 33°55'N, 73°24'E. KA-997. 20 Sept. 1991 – UF 197348/13.

The material includes specimens with both unicoloured and mottled body colour patterns (Figs 1, 2). Some populations are entirely greenish-yellow, with a slate-grey head in life, while others consist of individuals having mottled patterns with irregular blotches of colour, ranging from black, brown, reddish to olive-green.

Fig. 3 illustrates the reproductive system of a typical specimen from Pakistan.

In Pakistan *Anadenus altivagus* is relatively commonly found in montane coniferous forests at elevations from about 1,800 to 4,500 m a. s. l. Our locality in Nanga Parbat represents a new altitudinal record (4,500 m a.s.l.). The elevations at which anadenids are often found are unusual when compared to the upper altitudinal limits of other slug species.

In Pakistan this species was encountered active at night and during the day when relative humidity was high. One series (UF 197305) was collected at 2:30 PM, the slugs feeding upon wilting herbs that had fallen to the ground. It has been observed mating during August in Kashmir (RAJAGOPAL & SUBBA RAO 1972).

Distribution

This species occurs in Pakistan within the Himalayan Foothills Subprovince (AUFFENBERG 1997). This distinct region, with mountain ranges of medium-high altitude (1,500–4,500 m a.s.l.), spans from Azad Kashmir, west through the Swat River valley to lower Chitral and into eastern Afghanistan. The affinities of the terrestrial molluscs occurring at the higher elevations of these generally north-south trending mountain ranges are decidedly with those



Figs 1–2. *Anadenus altivagus* (Theobald, 1862) – different types of coloration after preservation in alcohol. Dorsal view. 1 – a unicoloured specimen from Thandiani. 2 – a mottled specimen from Malam Jabba Mt. Scale bar 10 mm (photo J. MACIĄZEK)

of the southern Himalayas. However, this close association to the fauna of the Himalayas decreases rapidly to the west (SOLEM 1979, AUFFENBERG 1997). We have no evidence that *Anadenus altivagus* occurs west of the eastern side of the Swat Valley, but its occurrence at higher elevations in the lower Chitral region, and even eastern Afghanistan, would not be overly surprising. Numerous molluscan taxa have similar distributions in the region (i.e. clausiliids and various helicarionids – see AUFFENBERG & FAKHRI 1995, AUFFENBERG 1997), so we believe its occurrence in the western Himalayan foothills of Pakistan to be natural and not the result of introduction by humans.

Anadenus altivagus has been recorded from various localities along the southern flanks of the Himalayas and associated ranges from Sikkim to the Murree Hills in eastern Pakistan. This report extends its distri-

bution west to the eastern side of the Swat Valley. Earlier Pakistan records include the following Murree Hills localities: Changli Gali (NEVILL 1878a, b), Thandiani and Murree (THEOBALD 1881), Dunga Gali (WIKTOR 2001). RAJAGOPAL & SUBBA RAO (1972) report it from an unspecified locality in Nepal, the Indian localities of Simla, Kufri, and Dalhousie (all in Himachal Pradesh), Nainital (Uttar Pradesh) and Kashmir, and the Murree Hills of Pakistan. NEVILL (1878b), GODWIN-AUSTEN (1882), and GUDE (1914) include several Indian and Pakistan records for *A. altivagus*, most under the synonyms assigned by WIKTOR (2001). WIKTOR (2001) includes various Indian and Nepalese localities, as well as one lot with the unspecified locality of “Himalaya ad China”. The synonyms, *A. dalhousiensis* and *A. matthaii*, both described by BHATIA (1926), were reported from Dalhousie, Himachal Pradesh and Gulmarg, Kashmir, respectively.

A. lahorensis was described by BHATIA (1926) from a single specimen collected from a botanical garden in Lahore, Punjab Province, Pakistan (see WIKTOR 2001 for discussion). The location of the holotype is unknown to us. The environment in the region surrounding Lahore is extremely arid, very uncharacteristic of the natural occurrence of *Anadenus*. We believe *A. lahorensis* to represent an introduction, probably having arrived at the Lahore botanical gardens among transplanted plant specimens.

Anadenus altivagus is also recorded here from the flanks of Nanga Parbat at an elevation of 4,500 m. This locality is in the Pamir-Karakorum Subprovince of AUFFENBERG (1997). This occurrence leads us to speculate that this species may be found throughout northern Pakistan at appropriate elevations in montane coniferous forests.

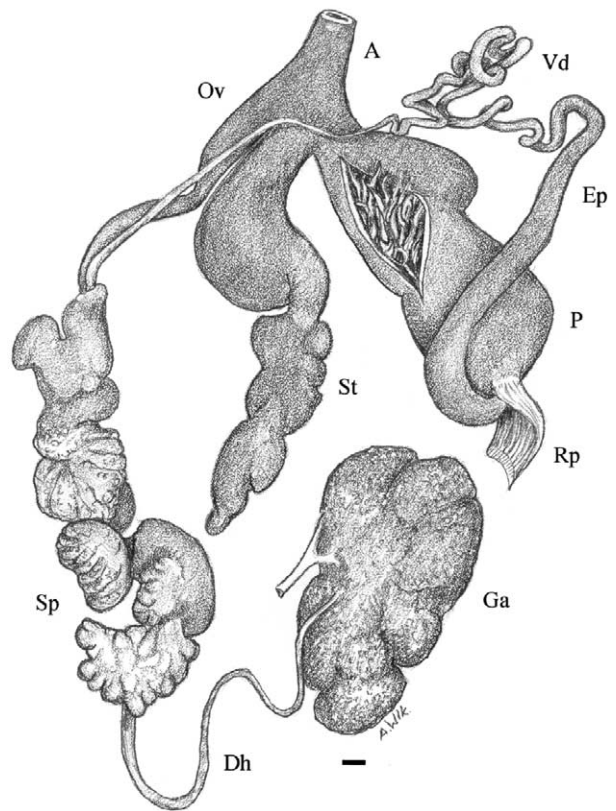


Fig. 3. *Anadenus altivagus* (Theobald, 1862) – reproductive system of a specimen from Thandiani. A – atrium, Dh – ductus hermaphroditicus, Ep – epiphallus, Ga – glandula albuminalis, Ov – oviductus, P – penis, Rp – musculus retractor penis, Sp – spermoviductus, St – spermatheca, Vd – vas deferens. Scale bar 1 mm

FAMILY AGRIOLIMACIDAE

DEROCERAS (DEROCERAS) LAEVE (O. F. Müller, 1774)

Limax laevis O. F. MÜLLER 1774: 1. Locus typicus: Frideriksdal (near Copenhagen, Denmark). Holotypus: probably does not exist.

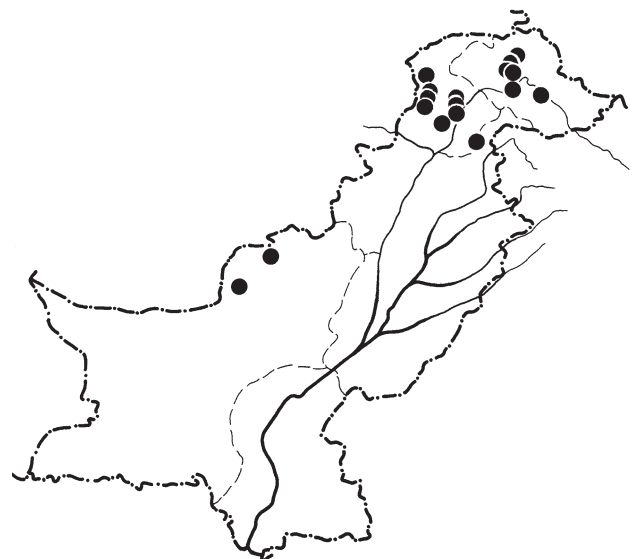
Synonyms: WIKTOR 2000: 462 lists 21 synonyms.

Examined Material (Map 2)

Baluchistan Province: Quetta Dist., Quetta, Lourdes Hotel Grounds, among herbs. KA-1061. 3 Sept. 1992 – UF 202642/7; Sibi Dist., 5.6 km NWW of Ziarat, Sandeman Tangi, 2,550 m a.s.l. KA-1068. 10 Sept. 1992 – UF 202679/8; Sibi Dist., Ziarat, 2,450 m a.s.l., Shamim Fakhri. Sept. 1991 – UF 196940/4.

Northern Areas: Gilgit Dist., 5 km W of Shatial, creek along Karakoram Hwy., 1,000 m a.s.l. KA-937. 10 Sept. 1991 – UF 197119/4; Gilgit Dist., 36.8 km SW of Karimabad, stream on N side of Rakaposhi Mt., just W of Karimabad Village, in grass along a torrent stream, 2,000 m a.s.l., 36°15'N, 74°31'E. KA-927. 6 Sept. 1991 – UF 197089/8; Gilgit Dist., 5.8 km NW of Gilgit, along Gilgit R., 1,640 m a.s.l., 35°58'N, 74°19'E.

KA-918. 3 Sept. 1991 – UF 197040/29; Gilgit Dist., 5.4 km NW, 0.9 km W of Gilgit, Napura Basin Village, Kargah Buddha, 1,750 m a.s.l., 35°57'N, 74°13'E.



Map 2. Localities of *Deroceas laeve* (O. F. Müller, 1774)

KA-920. 3 Sept. 1991 – UF 197042/10; Gilgit Dist., 19.4 km NNW of Gilgit, S side of Nomal Village, under stones, 1,560 m a.s.l., 36°07'N, 74°17'E. KA-914. 2 Sept. 1991 – UF 197014/15; Gilgit Dist., 4.8 km SW of Karimabad, 2,280 m a.s.l., 36°19'N, 74°39'E. KA-926. 6 Sept. 1991 – UF 197076/14; Gilgit Dist., 40.7 km S of Gilgit, stream along Karakoram Hwy., under stones, 1,400 m a.s.l., 35°49'N, 74°35'E. KA-929. 7 Apr. 1991 – UF 197103/10; Hunza Dist., 14.2 km SW of Karimabad, under stones in poplar forest, 2,150 m a.s.l., 36°17'N, 74°37'E. KA-922. 4 Sept. 1991 – UF 197057/5; Skardu Dist., ca. 25 km NW of Skardu Kachura Village, Shangrilla Resort, in grass on wet soil, 2,220 m a.s.l., 35°22'N, 75°24'E. KA-901. 28 Aug. 1991 – UF 196960/22.

North-West Frontier Province: Abbottabad Dist., 8.2 km SE of Abbottabad, Sirban Mts., Tamtour Village, 1,160 m a.s.l., 34°07'N, 73°15'E. KA-956. 13 Sept. 1991 – UF 197190/4; Swat Dist., 2 km N of Bahrain, in moss, 1,700 m a.s.l., 35°19'N, 72°37'E. KA-785. 17 Sept. 1990 – UF 181027/1; Chitral Dist., Arundu Tehsil, 6 km S of Drosh, 1,200 m a.s.l., 35°30'N, 71°47'E, Mohammad Zubair. MZ-33. 12 July 1991 – UF 196918/1; Chitral Dist., 14 km N of Drosh, S side of Gabrait (village), *Quercus incana* zone, under planted *Alliathus* trees, moist soil, 1,600 m a.s.l., Hafiz Rehman, HR-39. 22 June 1993 – UF 207993/1; Dir Dist., Dir Tehsil, 17 km S of Dir, on rd to Timargargh, 1,200 m a.s.l., 34°58'N, 69°30'E, Mohammad Zubair. MZ-34. 12 July 1991 – UF 196924/12; Swat Dist., 10 km N of Kalam, Matitlan (village), under rock, 3,100 m a.s.l., 35°10'N, 72°35'E. Mohammad Zubair. KA-783. 16 Sept. 1990 – UF 181014/1; Swat Dist., 24.7 km W of Besham, marble quarry along road to Shangla Pass, under rock, 1,200 m a.s.l., 34°52'N, 72°44'E, KA-943. 11 Sept. 1991 – UF 197141/1; Swat Dist., 5 km S of Kabal, on W side of Swat R. W. AUFFENBERG, WA-91-590. 25 May 1991 – UF 201163/1.

Deroceras laeve has a very short life span, living only a month or so even under optimal conditions. It often reproduces uniparentally (a self-fertilizing hermaphrodite). Partial reduction or complete loss of the penis (aphallism) is extraordinarily common (Fig. 4). *D. laeve* is extremely hydrophilous, occurring near many types of hydric habitats (i.e. wetlands, streams, rivers, lakes, irrigation ditches). It even occurs in frequently flooded areas where it is able to survive submergence in water for many hours. These adaptations, undoubtedly, have allowed this species to successfully disperse (naturally, as well as with the intervention of humans) over extensive areas of the world.

In Pakistan this species was commonly encountered in various moist habitats from grassy stream banks to irrigated agricultural land, often found on the undersurfaces of rocks. It was observed active at various times of the day after rain and at night.

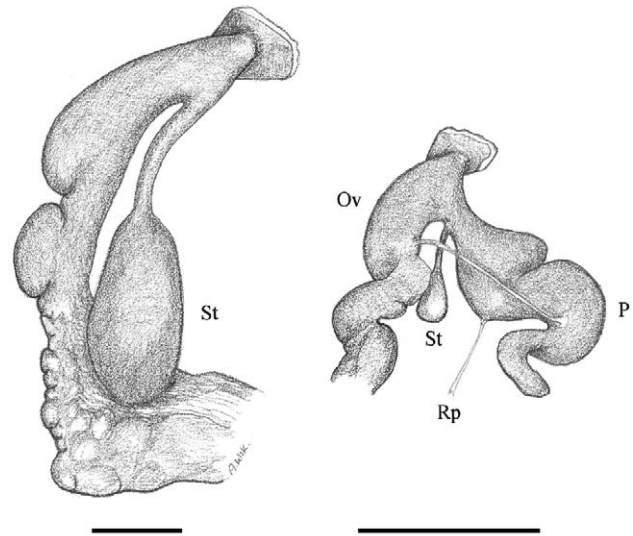


Fig. 4. *Deroceras laeve* (O. F. Müller, 1774) – copulatory organs of an aphyllid specimen with the male section completely reduced (on the left) and of an ephyllid specimen (on the right). Both specimens were collected in the environs of Ziarat. Please note the scale bar. As usual in this species, the ephyllid specimen is considerably smaller. For lettering see Fig. 3. Scale bar 1 mm

Distribution

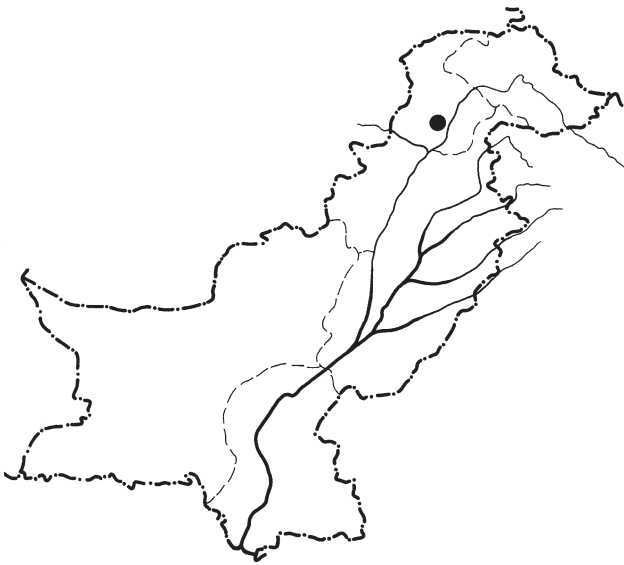
The natural range of *Deroceras laeve* certainly encompasses much of the Holarctic region between the subpolar and subtropical climatic zones. In the Old World it occurs naturally in this zone from Europe to China. It has been recorded from the Kabul District of Afghanistan (LIKHAREV & STAROBOGATOV 1967). Its distribution in northern India is unknown, but the Himalayan foothill region may be its southernmost natural occurrence in south Asia. *D. laeve* inhabits large portions of North America, where it is presumably indigenous. This nearly cosmopolitan species is evidently introduced in Africa and in other areas, such as New Guinea and various Pacific islands (LIKHAREV & WIKTOR 1980, WIKTOR 2000, WIKTOR et al. 2000). All evidence suggests that it is native to Pakistan, where it is widely distributed at higher elevations throughout the northern half of the country. It is apparently lacking from the savannas of central and southern Pakistan, but may be found introduced in metropolitan and agricultural areas. The hiatus between the localities of north-western Baluchistan and northern North-West Frontier Province (Map 2) is an artifact of collecting efforts. The North-West Frontier Province south of the Kabul River was very poorly sampled. *Deroceras laeve* probably occurs at appropriate elevations throughout the various mountain ranges from the Quetta region of north-western Baluchistan north to the Northern Areas.

FAMILY PARMACELLIDAE

CANDAHARIA (CANDAHARIA) RUTELLUM
(Hutton, 1849)

Parmacella rutellum HUTTON 1849: 649. Locus typicus: Kandahar, Afghanistan. Type: may not exist, but NEVILL (1878b) lists one specimen originating from Hutton. If still extant, this specimen in the Indian Museum, Calcutta, may be a syntype.

Synonym: *Parmacella kainarensis* Simroth, 1912 (see LIKHAREV & STAROBOGATOV 1967, SOLEM 1979, LIKHAREV & WIKTOR 1980).



Map 3. Localities of *Candaharia rutellum* (Hutton, 1849)

Examined Material (Map 3)

North-West Frontier Province: Swat Dist., 16.0 km S of Mingora, in grass along a moist ditch, 870 m a.s.l., W. AUFFENBERG. 14 March 1987 – UF 119999/6.

The series collected in Pakistan was found on damp soil among grass along a roadside ditch.

The external appearance and reproductive system of the specimens from Pakistan are typical (Figs 5–6).

Distribution

Although the occurrence of this species in Pakistan may represent an introduction, we believe the distribution to be a natural one. Originally described from Kandahar, Afghanistan, *Candaharia rutellum* has also been recorded from several localities in eastern and northern Afghanistan and the Alayskiy Khr (Mts.) and Pamir Mts. in Tadzhikistan (LIKHAREV &



Fig. 5. *Candaharia rutellum* (Hutton, 1849) – view from the right side of a specimen from Mingora. Shell partly visible on the rear end of mantle. Scale bar 10 mm (photo J. MACIĄZEK)

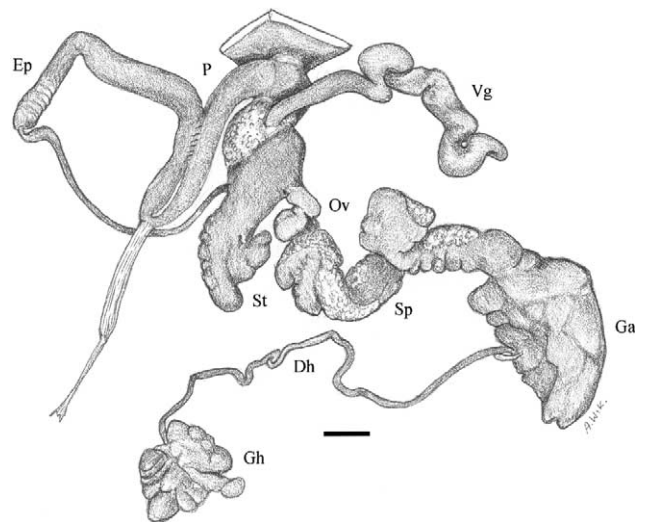


Fig. 6. *Candaharia rutellum* (Hutton, 1849) – reproductive system of a specimen from the environs of Mingora. Gh – glandula hermaphroditica, Vg – vaginal gland, for the remaining lettering see Fig. 3. Scale bar 1 mm

STAROBOGATOV 1967, SOLEM 1979, LIKHAREV & WIKTOR 1980). Apparently, it is widely distributed along the Kabul River. The Swat River is a major tributary of the Kabul River, so a natural occurrence in the lower Swat Valley of north-western Pakistan is not considered remarkable.

COMMENTS

The material collected during the 1990–1992 surveys of Pakistan demonstrates that the slug fauna is very depauperate. The country is inhabited by three

slug species, all probably native. *Anadenus altivagus* occurs throughout the southern Himalayas and perhaps reaches its western distribution limit in north-central



Pakistan. The virtually cosmopolitan *Deroceras laeve*, herein recorded from Pakistan for the first time, is widely distributed in lower elevations in the northern portion of the country. *Candaharia rutellum*, another slug species not previously known from Pakistan, is recorded from a single locality in the lower Swat River valley.

Much research on the slug fauna of Pakistan remains to be done. A few somewhat anticipated species were not encountered during these surveys, i.e. *Deroceras (Liolytopelte) kandaharensis* Altena, 1970, *D. (Deroceras) altaicum* (Simroth, 1886). Undoubtedly, other new records of slug species will be discovered as more remote areas of Pakistan are being explored.

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