



## A REVIEW OF ANADENIDAE (GASTROPODA: PULMONATA), WITH A DESCRIPTION OF A NEW SPECIES

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**ABSTRACT:** A restriction of the name Anadenidae Pilsbry, 1948 to Asian species, i.e. members of the genus *Anadenus* Heynemann, 1862, is proposed. *Anadenus* (*A.*) *nepalensis* **n. sp.** is described. The following names are synonymized: *Anadenus* Heynemann, 1862 = *Gymnanadenus* Bhatia, 1926 **syn. n.**; *Anadenus altivagus* (Theobald, 1862) = *Limax modestus* Theobald, 1862 **syn. n.** = *A. schlagintweiti* Heynemann, 1862 **syn. n.** = *A. jerdoni* Godwin-Austen, 1882 **syn. n.** = *A. beebei* Cockerell, 1913 **syn. n.** = *A. dalhousiensis* Bhatia, 1926 **syn. n.** = *A. (Gymnanadenus) matthaii* Bhatia, 1926 **syn. n.** Names of unclear status are regarded as nomina dubia: *Anadenus banerjeei* Rajagopal, 1973; *A. dautzenbergi*, Collinge, 1900; *A. giganteus* Heynemann, 1862; *A. insignis* Godwin-Austen, 1882 and *A. sinensis* Möllendorff, 1899. All the known species-level taxa are discussed, based on the type material, museum specimens and newly acquired material. The descriptions, illustrated with original figures and photos, include external appearance, taxonomically useful characters of internal structure, especially genitalia, localities and numerous comments on taxonomy; an original identification key to species is provided.

**KEY WORDS:** Gastropoda, Pulmonata, terrestrial slugs, Anadenidae, Pakistan, India, Nepal, taxonomy, morphology, distribution, key

### INTRODUCTION

PILSBRY (1948) introduced the name Anadeninae to distinguish a subfamily within the Arionidae Gray, 1840 (in TURTON 1840: 104). Most of the recent authors share the opinion that the family Arionidae sensu Pilsbry, 1948 was a group comprising several rather remotely related subfamilies which should be raised to the family rank within the superfamily Arionoidea. Consequently, the subfamilies Arioninae, Anadeninae, Ariolimacinae, Oopeltinae and Binneyinae acquired the status of separate families, which is supported by many morphological characters and distribution ranges of particular taxa.

Analogously, it seems that the subfamily Anadeninae sensu PILSBRY 1948, including three genera, namely *Anadenus* Heynemann, 1862, *Prophysaon* Bland et Binney, 1873 and *Anadenulus* Cockerell, 1890, is an artificial and heterogeneous group. *Anadenus* inhabits exclusively Asia (mainly the south-

ern part of the Himalayan massif in broad sense), whereas the other two genera (*Prophysaon*, *Anadenulus*) occur in North America. Besides the geographic distribution, the American genera differ in their habitus (body shape, skin wrinkles, colour pattern), sole musculature and, especially, structure of genitalia – characters which served as a basis for the family-level classification of other slugs. The common features of the Asian and American Anadeninae (sensu PILSBRY 1948) are also shared by other Arionoidea, e.g. nudeness, independent posterior insertions of the main retractor muscles of the right and left body side, odontognathic jaw, appearance of radular teeth, two-looped alimentary canal and the relative position of the loops, annular kidney, spermatophore, etc. In *Prophysaon* there is usually no penis, or the organ tends to get reduced and is devoid of retractor, but the slugs representing this genus have a specific ejacu-

latory cylinder (see PILSBRY 1948). *Anadenulus* is distinct in having a tripartite sole, with a median and two lateral zones, and a massive penis equipped with a retractor (PILSBRY 1948). Both American genera lack epiphallus. It seems artificial to classify slugs of such different characters in one family (see also WIKTOR et al. 2000). In my opinion, the Anadenidae should include only Asian species, the type genus being *Anadenus*. The American genera should be grouped in a separate family.

*Anadenus* is among the least investigated genera of the Palaearctic terrestrial slugs. Most of its species were described at the turn of the 19th century, the descrip-

tions being usually based on single specimens and considering mostly their external appearance. The scarcity of information about these slugs results from their occurrence in rarely explored mountainous territories, at high altitudes, difficult of access. Thus the knowledge of the distribution and bionomics of members of this genus derives almost exclusively from labels accompanying specimens found by accidental collectors. One gets the impression that the authors of the earlier specific names never saw live specimens themselves. It seems thus justifiable to summarize the knowledge of these slugs, the more so that type material of most taxa has been preserved until today.

## SYSTEMATIC INDEX OF GENERIC AND SPECIFIC NAMES

Family: Anadenidae Pilsbry, 1948

Genus: *Anadenus* Heynemann, 1862

Subgenus: *Anadenus* s. str.

*Anadenus* (*Anadenus*) *altivagus* (Theobald, 1862) (= *Anadenus schlagintweiti* Heynemann, 1862; *Limax modestus* Theobald, 1862; *Anadenus jerdoni* Godwin-Austen, 1882; *Anadenus beebei* Cockerell, 1913; *Anadenus dalhousiensis* Bhatia, 1926; *Anadenus lahorensis* Bhatia 1926; *Anadenus matthaii* Bhathia, 1926)

*Anadenus* (*Anadenus*) *blanfordi* Godwin-Austen, 1882

*Anadenus* (*Anadenus*) *nepalensis* n. sp.

*Anadenus* (*Anadenus*) *parvipenis* Wiktor, Chen et Wu, 2000

*Anadenus* (*Anadenus*) *sechuenensis* Collinge, 1899

*Anadenus* (*Anadenus*) *yangtzeensis* Wiktor, Chen et Wu, 2000

*Anadenus* (?*Anadenus*) *yunnanensis* Wiktor, Chen et Wu, 2000

Subgenus: *Neoanadenus* Wiktor, Chen et Wu, 2000

*Anadenus* (*Neoanadenus*) *gonggashanensis* Wiktor, Chen et Wu, 2000

Nomina dubia

*Anadenus* (?) *banerjeei* Rajagopal, 1973

*Anadenus* (?) *dautzenbergi* Collinge, 1900

*Anadenus* (?) *giganteus* Heynemann, 1862

*Anadenus* (?) *insignis* Godwin-Austen, 1882

*Anadenus* (?) *sinensis* Möllendorff, 1899

## ABBREVIATIONS OF REPOSITORIES

**CB** – private collection of U. BÖSSNECK, Erfurt (Germany)

**MIZ** – Museum and Institute of Zoology, Polish Academy of Sciences, Warsaw (Poland)

**MNHW** – Museum of Natural History, Wrocław University, Wrocław (Poland)

**NHM** – The Natural History Museum, London (Great Britain)

**NMW** – Naturhistorisches Museum, Vienna (Austria)

**NSE** – Naturkunde Museum der Stadt, Erfurt (Germany)

**PB** – PREM BUDHA, Kathmandu collection (Nepal)

**ZIAS** – Institute of Zoology, Academia Sinica, Beijing (= Peking) (China)

**ZIN** – Zoologicheskiy Muzei, St. Petersburg (= Leningrad) (Russia)

**ZSI** – Zoological Survey of India, Calcutta (India)

## IDENTIFICATION KEY

1(2) – On the lateral wall of penis there is an additional, vesicular organ opening through a single duct (Fig. 52).

**subgen. *Neoanadenus***

*Anadenus* (*N.*) *gonggashanensis*  
(p. 22, Figs 50–53)

2(1) – No additional sac-like organ on penis (Fig. 45).

**subgen. *Anadenus* s. str.**

**3**



- 3(4) – Skin sculpture on back composed of conspicuous, even up to 17 mm long, strongly arched wrinkles which are triangular in cross-section. Body black. Copulatory organs small relative to the body size. *Anadenus (A.) yunnanensis* (p. 20, Figs 46–49)
- 4(3) – Skin sculpture on back delicate, wrinkles considerably less pronounced. Coloration varied. Copulatory organs markedly larger compared to the body size. **5**
- 5(6) – Penis conical, small, i.e. 10 times shorter than the thick epiphallus. Inside penis a tongue-shaped ligula. *Anadenus (A.) parvipenis* (p. 17, Figs 31–34)
- 6(5) – Penis different: larger, claviform or cylindrical; epiphallus thinner and usually shorter in relation to penis. **7**
- 7(8) – Penis clavate, anteriorly distended. On its posterior end a short transverse appendix. Inside penis a large, wide ligula. A pale-coloured slug, its entire body densely black-spotted. *Anadenus (A.) yangtzeensis* (p. 18, Figs 39–45)
- 8(7) – No appendix on posterior end of penis. **9**
- 9(10) – Penis clavate, its anterior part broader. Inside penis numerous hooked, usually hard spines or soft, bent, bristly structures accreted to internal wall. *Anadenus (A.) altivagus* (p. 7, Figs 1–8)
- 10(9) – Penis variously formed, resembling the former, but inside it there are structures in the form of folds or ligulae – never hooked spines or similar soft bristly processes. **11**
- 11(12) – Inside penis a large ligula narrowed at its free end. Penis claviform, anteriorly broader. *Anadenus (A.) nepalensis* (p. 14, Figs 18–30)
- 12(11) – No ligula inside penis, internal walls of penis covered by longitudinal wrinkles or ledges. **13**
- 13(14) – Penis clavate, broadened in its posterior end. Slug ca 60 mm long; body thickset with a delicate skin sculpture. *Anadenus (A.) sechuenensis* (p. 18, Figs 35–38)
- 13(14) – Penis cylindrical, slightly medially constricted. A smaller slug, merely ca 44 mm long, slender, having a distinct skin sculpture. *Anadenus (A.) blanfordi* (p. 13, Figs 14–17)

## FAMILY ANADENIDAE PILSBRY, 1948

(in new sense – comprising only Asian slugs; see Introduction, p. 3)

**Diagnosis:** Mantle occupying less than 1/3 body length; its surface granular. Pneumostome antemedial or nearly medial. Shell completely buried in mantle. Sole undivided. Penis well developed; vas deferens long, epiphallus long and usually thick. Penial retractor inserted at posterior end of penis. Spermatheca large, thin-walled, its duct thick. Asia.

### DESCRIPTION

**Slugs** of rather thickset body. Posterior body end gently narrowed, cuneately terminating (Figs 24, 32). No caudal gland; keel absent. Mantle occupying less than 1/3 body length, its surface covered by fine “granular” structures. Pneumostome situated on the right side of mantle, almost medial but in some species ante- or slightly postmedial (Figs 10, 15). Head section short. Tentacles short. Sole wide, without longitudinal grooves, and thus not divided in zones. Coloration uniformly whitish, or of various hues of brown or orange (this concerns alcohol-preserved speci-

mens). In light-coloured specimens a blurred darker (blackish or brown) pattern often occurs on mantle. Symmetrically on the body axis, but in the hind section of mantle, there is a pale oval blot surrounded laterally and usually also from the front by areas which may be darker-coloured, but most often of varying colour intensity. Often local concentrations of this dark pigment produce irregular, still darker streaks. In some species, in the section beyond mantle, there are nearly transversely arranged rows of spots yielding interrupted lateral streaks (Figs 22, 41). Apart from the above described pattern, in some species, and sometimes only individual specimens, irregularly scattered, nearly circular, blackish freckles occur both on mantle and on the rest of the body, including sole (Figs 31–33, 39–42).

**Shell** entirely buried in mantle, flat, very thin, nearly symmetrical; nucleus situated almost centrally (Fig. 26).

**Alimentary canal.** Jaw odontognathic (Fig. 28). Radula – general appearance of teeth typical of

Arionoidea. In *Anadenus nepalensis* (see JUNGBLUTH et al. 1985: Fig. 22 – as *A. altivagus* but actually a holotype of *A. nepalensis* from Ghundruk) central tooth with large mesocone and barely marked lateral cones. Lateral teeth with a vestigial ectocone, endocone hardly visible. Marginal teeth cultrate. Figures by early authors (HEYNEMANN 1862, GODWIN-AUSTEN 1882, 1914, COCKERELL 1913, GUDE 1914) show that endo- and ectocones can be better developed than those shown in JUNGBLUTH et al. (1985). Pharynx rather small, the rest of alimentary canal making two loops, both somewhat twisted around the long body axis. The second loop is shifted more posterad than the first (Fig. 3).

**Pallial complex** (Fig. 27). Kidney irregularly ring-shaped, encircling heart, slightly broader in its anterior section. Long axis of heart and aorta tilted left relative to the long body axis (in dorsal view; in the figure it is shown in ventral view). No bladder.

**Main retractor muscles** (Fig. 27). Retractors of the right and left side have their independent posterior insertions, whereas left and right pharyngeal retractors fuse into a common trunk inserted posteriorly between the insertions of ommatophore retractors.

**Reproductive system** (Figs 4, 43). Hermaphroditic gland rounded or oval; its acini spherical and large in proportion to the whole gland. Hermaphroditic duct long and thin. Albumen gland relatively small, tongue-shaped. Spermoviduct in its posterior part larger than anteriorly. In most species vas deferens very long, multiply bent, the thinnest where it bends near atrium, farther posterad gradually thickening and passing into epiphallus without a clear border. Epiphallus also strongly elongated, tubular, the thickest in the middle, coiled, often forming a tight skein, and opening into the posterior end of penis. Penis cylindrical or clavate, nearly always elongated. In some species its posterior end bears a small, simple appendix (Fig. 43). In the subgenus *Neoanadenus*, roughly in the middle of penis, there is the opening of the duct of an additional accessory organ (gland?) of unknown function (Figs 51–52). Inside penis, at the outlet of vas deferens, there is a papilla usually covered with nodules. In the penis anterior section there may be various structures in the shape of longitudinal ledges, on which numerous sharp, bent, hard, mineralized spines may be pres-

ent (Figs 6–7, 13); in other species the penis contains a large ligula. Penial retractor muscle inserted apically, most commonly its insertion arcuately surrounding the outlet of vas deferens. Free oviduct section tubular, sometimes slightly distended. Spermatheca with a large soft container. In specimens which have not copulated it is strongly elongated. When filled with one or a few spermatophores, the container gets strongly distended, thus assuming a spherical or oval shape, its walls becoming very thin. In older individuals, probably after copulation, the spermatheca duct is fleshy, thick, often swollen.

**Spermatophore** (Figs 8, 53) – known only in two species. It is composed of a thin flagellate section terminating with a hook, and a broader part. This thin section is reinforced by three longitudinal ledges. The rest of spermatophore has thin and smooth walls, its cross-section being circular. This broader part, filled with sperm, has a shape of a very long spindle, which narrows at both ends. In relation to the whole body, the spermatophore is very large, when unwound its length exceeding the length of the whole slug. In a receiver the spermatophore anchors with its hook in the thick-walled part of spermatheca duct, while the whole rest of it winds almost regularly like a wire in an electric coil. The association is the more obvious since the spermatophore is metallic copper. A few spermatophores can be found in the spermatheca duct, but it is unknown if they come from one donor, or else the receiver has copulated with a number of partners.

**Bionomics and ecology** are so far unknown. Anadenidae seem to be phytophagous or omnivorous; some were observed to feed on mushrooms. Like other slugs, anadenids hide under stones. In the mountains they reach altitudes rarely recorded for other gastropods: they have been collected even at 4,200 m a.s.l.!

**Distribution.** The present data do not allow to define the distribution area of the family. The slugs are only known to occur in a vast area extending from southern China (provinces Guizhou, Yunnan and Sichuan), and probably along the southern slopes of the Himalayas in broad sense (Nepal, N India – Darjeeling, Simla, Garhwal) up to Kashmir and Pakistan (Ravalpindi).

## SYSTEMATIC REVIEW

### *Anadenus* Heynemann, 1862

*Anadenus* HEYNEMANN 1862: 138. Species typica: *Limax altivagus* Theobald, 1862, present designation (see also Comments)

*Gymnanadenus* BHATIA 1926: 881. Species typica: *Anadenus matthaii* Bhatia, 1926 = *Anadenus altivagus* (Theobald, 1862), by monotypy, **syn. n.**

For the characteristics see the description of the family.

**Comments.** In 2000 WIKTOR et al., not realizing the problematic status of the name *Anadenus giganteus* Heynemann, 1862 (see also this taxon in *Nomina dubia*, p. 24), designated it as the type species of *Anadenus* Heynemann, 1862. Because it could not be established with certainty to which slug the name actually referred, I now designate *Limax altivagus* Theobald, 1862 as the type species of the genus.

***Anadenus* s. str.**

It differs from the other subgenus, i.e. *Neoanadenus* Wiktor, Chen et Wu, 2000, in the lack of an additional capsular structure opening to the mid part of penis.

***Anadenus (Anadenus) altivagus* (Theobald, 1862)**

*Limax altivagus* THEOBALD 1862: 489. Typus: probably does not exist. Locus typicus: "montibus cis-Sutlejensibus prope Fagu Narkanda, Saraon" (India?).

*Limax modestus* THEOBALD 1862: 489. Typus: I have no information about its existence. See Comments. Locus typicus: "montibus cis-Sutlejensibus prope Fagu Narkanda, Saraon" (India?). **Syn. n.**

*Anadenus Schlagintweiti* HEYNEMANN 1862: 141, Pl. 1, Fig. 2 (radular teeth). Terra typica: Sikkim, Simla to Sultanpur, Bias at Bishisht, Kulu, Bias Kund, Rotang Pass. **Syn. n.**

*Anadenus Jerdoni* GODWIN-AUSTEN 1882: 52, Pl. VII, Fig. 7 (external appearance). Terra typica: Kashmir (India). Holotypus: NHM, reg. no. 1874.6.23.1.

*Anadenus beebei* COCKERELL 1913: 618, Figs 1–7. Typus: American Museum of Natural History. Locus typicus: Garhwal (India). **Syn. n.**

*Anadenus dalhousiensis* BHATIA 1926: 876, Figs 1a–d, Pl. I, Figs 1–5. Typus: I have no information about its existence. Locus typicus: Dalhousie, Punjab (India). **Syn. n.**

?*Anadenus lahorensis* BHATIA 1926: 879, Figs 2a–d, Pl. II, Figs 6–7 (shell, jaw). Typus: I have no information about its existence. Locus typicus: Botanic Garden Lahore, Punjab (India). **Syn. n.**

*Anadenus (Gymnanadenus) matthaii* BHATIA 1926: 881, Figs 3, 4a–d, P. II, Fig. 8 (reproductive system). Typus: I have no information about its existence. Locus typicus: Gulmarg, Kashmir (India). **Syn. n.**

*Anadenus altivagus*: NEVILL 1878: 21.

*Anadenus modestus*: NEVILL 1878: 21.

*Anadenus schlagintweiti*: GODWIN-AUSTEN 1882: 51.

*Anadenus Jerdoni*: COCKERELL 1890: 280.

*Anadenus* (section *Sulcati*) *jerdoni*: COCKERELL 1893: 192.

*Anadenus* (section *Altivagi*) *giganteus* and *schlagintweiti*: COCKERELL 1893: 192.

*Anadenus schlagintweiti*: COLLINGE 1893: 192; GUDE 1914: 477, Fig. 151 (shell).

*Anadenus jerdoni*: GUDE 1914: 478, Fig. 152.

Measurements of alcohol-preserved specimens: body length up to ca 75 mm, mantle length up to 43 mm, the greatest width 24 mm. According to BHATIA (1926 – as *A. dalhousiensis*) live extended specimens can attain even 200 mm in length and up to 40 mm in width.

I am not familiar with the coloration of live slugs. Fresh, i.e. recently preserved, specimens are orange-dirty cream. Probably, when alive, they were tomato red. This coloration seems to be the most common.



Figs 1–2. *Anadenus (A.) altivagus* – two differently coloured specimens from the same locality – Dunga Cali (Pakistan); scale bar 10 mm; (orig.) (photo J. MACIĄZEK)



Fig. 3. *Anadenus (A.) altivagus* – alimentary canal of a specimen from Simla (orig.)

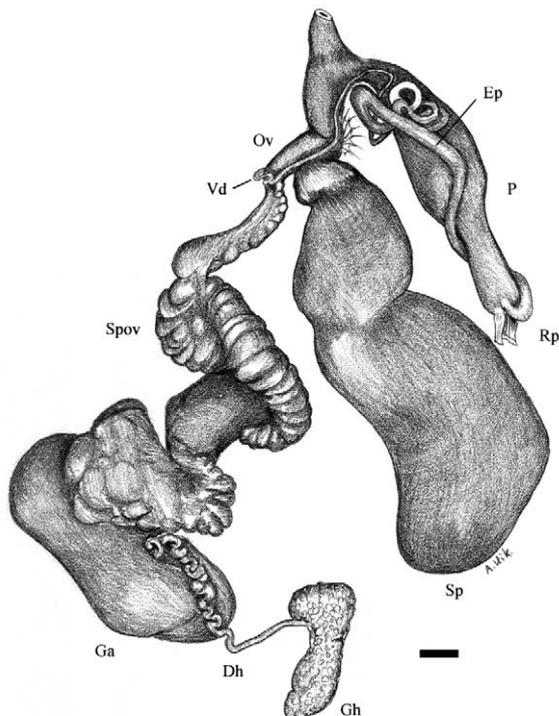


Fig. 4. *Anadenus (A.) altivagus* – reproductive system of a specimen from Naini Tal; scale bar 2 mm; (orig.). Dh – ductus hermaphroditicus, Ep – epiphallus, Ga – glandula albuminalis, Gh – glandula hermaphroditica, Ov – oviductus, P – penis, Rp – musculus retractor penis, Sp – spermatheca, Spov – spermoviductus, Vd – vas deferens

The majority of specimens are uniformly coloured. Some specimens of the Dunaga Cali series are irregularly black-spotted (Figs 1–2). Juveniles often have irregular lateral bands. The external appearance of the slug provides no diagnostic characters: with respect to coloration and body shape (after preservation) it is inconspicuous, but displays a striking similarity to *A. nepalensis*.

**Genitalia** (Figs 4–7). Vas deferens thin, in some places thread-like. Epiphallus gradually increases in diameter, being medium-length (compared with other species) and fairly narrow; it opens to penis apically. Penis narrowly claviform with an anterior enlargement; no appendix on its posterior end. Posteriorly inside penis an elongated smooth-surfaced papilla. Besides, on the internal wall of the posterior, narrower, part longitudinal ridges; in the anterior, broadened, section on one wall numerous large hard transparent hook-like spines (!) (Figs 6–7, 13). The latter character distinguishes the species from all its congeners. The number of these spines, their shape and length vary. Sometimes some of the hooks are bifurcated, at times falciform or – often – long and multiply bent. When the preservation period is long, the hard substance impregnating them may dissolve and then inside penis numerous soft processes are visible (Fig. 7). The spines develop relatively early in ontogeny, already occurring in juveniles with partly developed penes. They get everted along with the penis, and the slug can be identified also in this condition. Penial retractor muscle short and wide, attached apically, arcuately surrounding the outlet of vas deferens. Spermatheca with a short, widened duct and a huge container which is almost twice the penis length.

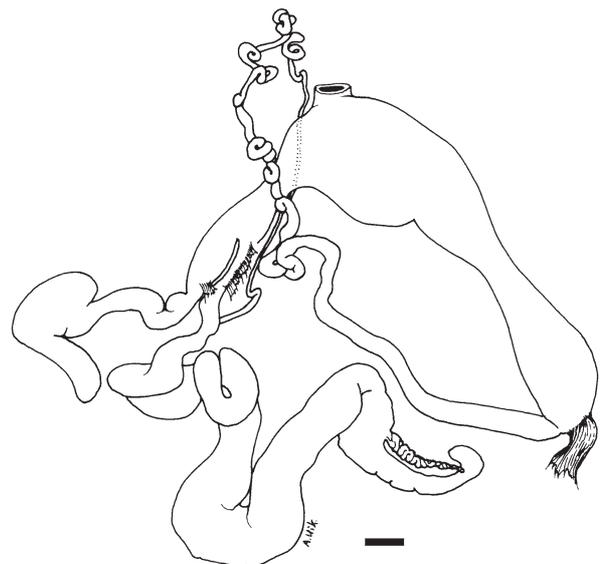
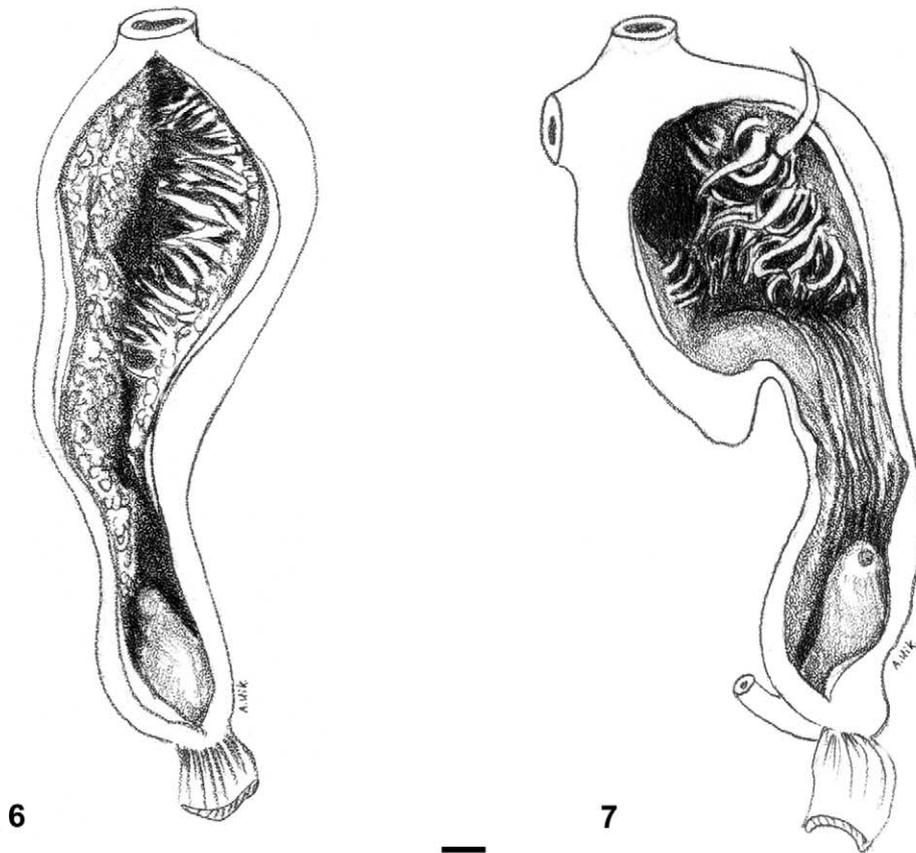


Fig. 5. *Anadenus (A.) altivagus* – reproductive system (without glandula hermaphroditica) of a specimen NMW no. 74004, from an unknown locality in “Himalaya ad China”; scale bar 2 mm; (orig.)



Figs 6–7. *Anadenus (A.) altivagus* – penes with their internal structures visible inside: 6 – specimen from Naini Tal; 7 – specimen from an unknown locality in “Himalaya ad China” (NMW no. 74004); scale bar 1 mm; (orig.)

**Spermatophore** (Fig. 8) has a smooth surface and does not seem to be different from that of *A. (N.) gonggashanensis*. However, I have failed to find a hook on its thin flagelliform end. Nevertheless, it seems to exist and serve as an anchor in the spermatheca duct but has been either dissolved or damaged.

**Material:**

**Pakistan:** **Dunga Cali, Murre Hills** (N of Ravalpindi), leg. Mrs CAREY 02.11.1921 (MHM no. 589) – 7 spec. (spermatophore, spotted specimens!);

**Kashmir:** leg. ? (NHM no. 593) – 3 spec.; **Naini Tal**, leg. ? 1906 (NHM) – 12 spec. (identified as *A. giganteus*); **Kashmir** (holotype of *A. jerdoni*) (NHM) – 1 spec.; **Naini Tal, Kamaon**, leg. ANNANDALE 1906 (NHM no. 592) – 2 spec.; **Naini Tal, Kamaon**, leg. ? (NHM no. 215) – 4 spec.; **Naini Tal**, leg. WINCKWORTH 1933 (NHM no. 1960275, Acc 1838) – 2 spec.; **Naini Tal**, leg. Dr. N. ANNANDALE 8.10.06 (NHM no. 590) – 1 spec.;

**India:** **Simla**, during rain, 1880 (det. GODWIN-AUSTEN 1889 as *A. altivagus* (NHM no. 108) – 2 spec.; **Simla**, 7,000 ft, leg. ANNANDALE (NHM no. 588) – 1 spec.; **Simla** (NMH no. 1888.12.4.764–5) (THEOBALD) – 2 spec.; **Simla**, NW Himalaya, leg. ? 1880 (NHM no. 74004) – 4 spec.; **Simla**, 7,000 ft. N.

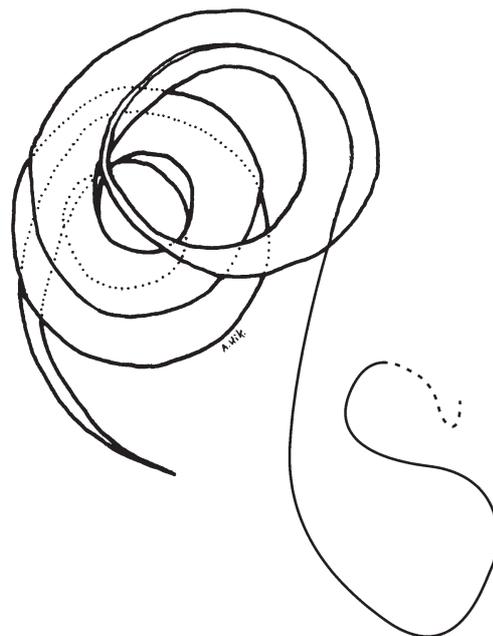


Fig. 8. *Anadenus (A.) altivagus* – spermatophore with its flagelliform part torn away, specimen from Naini Tal (orig.)

A., leg. (?) 24.04.07 (NHM – no number) – 5 spec.; **Simla to Sultanpur Himalayas**, leg. SCHLAGINTWEIT Group: X no. 61. (NHM no. 1860.6.2.76) – 1 spec.; **Phogu, Simla Hills**, 8,700 ft, under a stone on a hillside, leg. (?) 26.04.1907 (NHM – no number) – 2 spec.; **Sikkim Himalaya**, leg. SCHLAGINTWEIT, Group 10 no. 66 (NHM) – 1 spec;

**Nepal: Bakari Kharka**, 16 miles NE of Pokhara; 11,000 ft, on grass, leg. K. H. WYATT (B. M. Nepal Exp. 1954) 20.08.1954 (NHM no. 265) – 1 spec.; **Bakhari Kharka**, 16 miles, NE of Pokhara, 11,000 ft, in grass, leg. K. H. HYATT (B. M. Nepal Exp. 1954) 20.08.1954 (NHM no. 264) – 2 spec.; **Bakhari Kharka**, 16 miles NE of Pokhara, 11,000 ft, in grass, leg. K. H. HYATT (B. M. Nepal Exp. 1954) 13.08.1954 (NHM no. 260) – 2 spec.; **Bakhari Kharka**, 16 miles NE of Pokhara, 11,000 ft, in grass, leg. K. H. HYATT (B. M. Nepal Exp. 1954) 20.08.1954 (det. H. E. QUICK as *A. altivagus*) (NHM no. 262) – 2 spec.; **Bakhari Kharaka**, 16 miles NE of Pokhara, 11,000 ft, in grass, leg. K. H. HYATT (B. M. Nepal Exp. 1954) 13.08.1954 (NHM no. 261) – 1 spec.; **Bakhari Karaka**, 16 miles NE of Pokhara, in grass, leg. K. H. HYATT (B. M. Nepal Exp. 1954) 20.08.1954 (NHM no. 263) – 2 spec.; **Gurjakhani**, 28 miles NW of Beni, 10,500 ft, under a damp stone on an open hillside, leg. K. H. WYATT (B. M. Nepal exp. 1954) 1.07.1954 (MNH no. 197) – 1 + 2 juv. spec.; **Kumaon** (= Kamaon?), leg. J. COCKBURN (NHM, coll. Godwin-Austen ex Theobald no. 595 – pencilled label: “Theobald’s *Anadenus Kumaon* J. Cockburn”) – 2 spec. (Attention! Very large: length 78, width 25, mantle length 42 mm);

“**Himalaya ad China**”, leg. and det. ? (NMW no. 74004).

**Ecology.** No data. The labels indicate that the species inhabits mountain grasslands. Like other slugs, it hides under stones.

**Distribution** needs to be investigated; the slug has been recorded from N Pakistan, Kashmir, Nepal and N India, in the west reaching Ravalpindi, in the east up to the province Sikkim in India.

**Comments.** The specimen kept in the NMW collection, of unknown origin, has numerous, quite soft processes inside the penis (Fig. 7). I suspect that their mineral component has dissolved with time, the slug itself not differing from other individuals of the same species in any other characters.

*Limax modestus* Theobald, 1862 was described exclusively on the basis of its external appearance, beside *A. altivagus* and in contrast to it, both slugs having come from the same area. However, GODWIN-AUSTEN (1882: 53) considers *A. modestus* (= *L. modestus*) to be a good species.

*Anadenus schlagintweiti* Heynemann, 1862 should be regarded as a synonym. According to HEYNE-

MANN’s description the slug is 45–60 mm long, mantle length 25 mm, shell length 11 mm, its coloration being “aschgrau bis schwarzlich”, i.e. from ash grey to blackish. Juveniles have a dark blot on the posterior part of mantle; anteriorly the blot is surrounded by a lighter region. The sides of mantle are spotted. Posteriorly on back there are two lateral streaks, well-delimited from the top and blurred from the bottom. The upper part of back, i.e. the one behind mantle, is slightly darker. I have obtained one specimen from the NHM in London – “Kulu, Himalaya Coll. Schlagintweit Reg. no. 1860.6.2.49”. It is unknown who identified it. The specimen almost certainly is one of the syntypes (probably the one mentioned by HEYNEMANN (1862) from this locality) – it had not been dissected before. At present the specimen is uniformly coloured: nearly black, with the sole of the same colour, the coloration being probably a result of preservation. The slug is 47 mm long, mantle length 21 mm, body width 15.5 mm. Its skin wrinkles are uncountable, and strongly flattened. The genitalia (Fig. 9) indicate that the specimen is juvenile (spermatheca poorly developed and still not differentiated into container and duct). The penis is strongly elongated, anteriorly broadened. Inside it, on one wall, there are 7 longitudinal rows of pointed structures

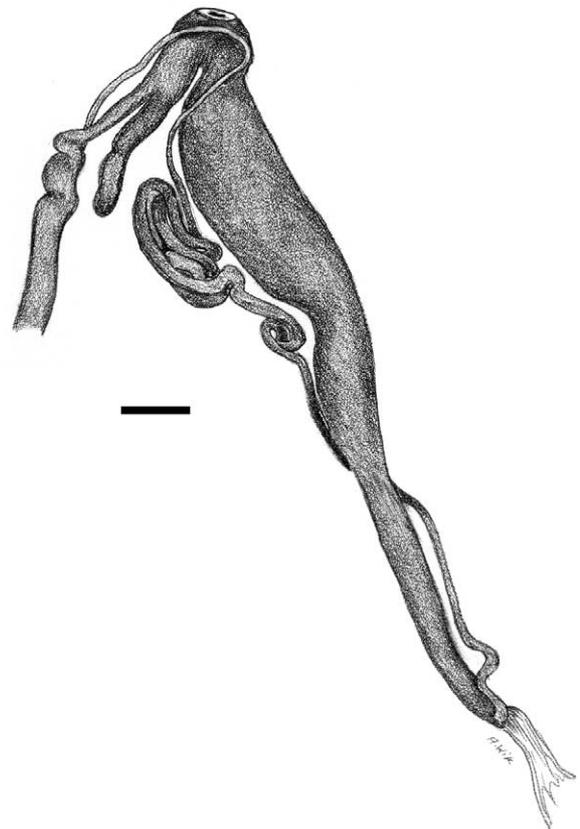
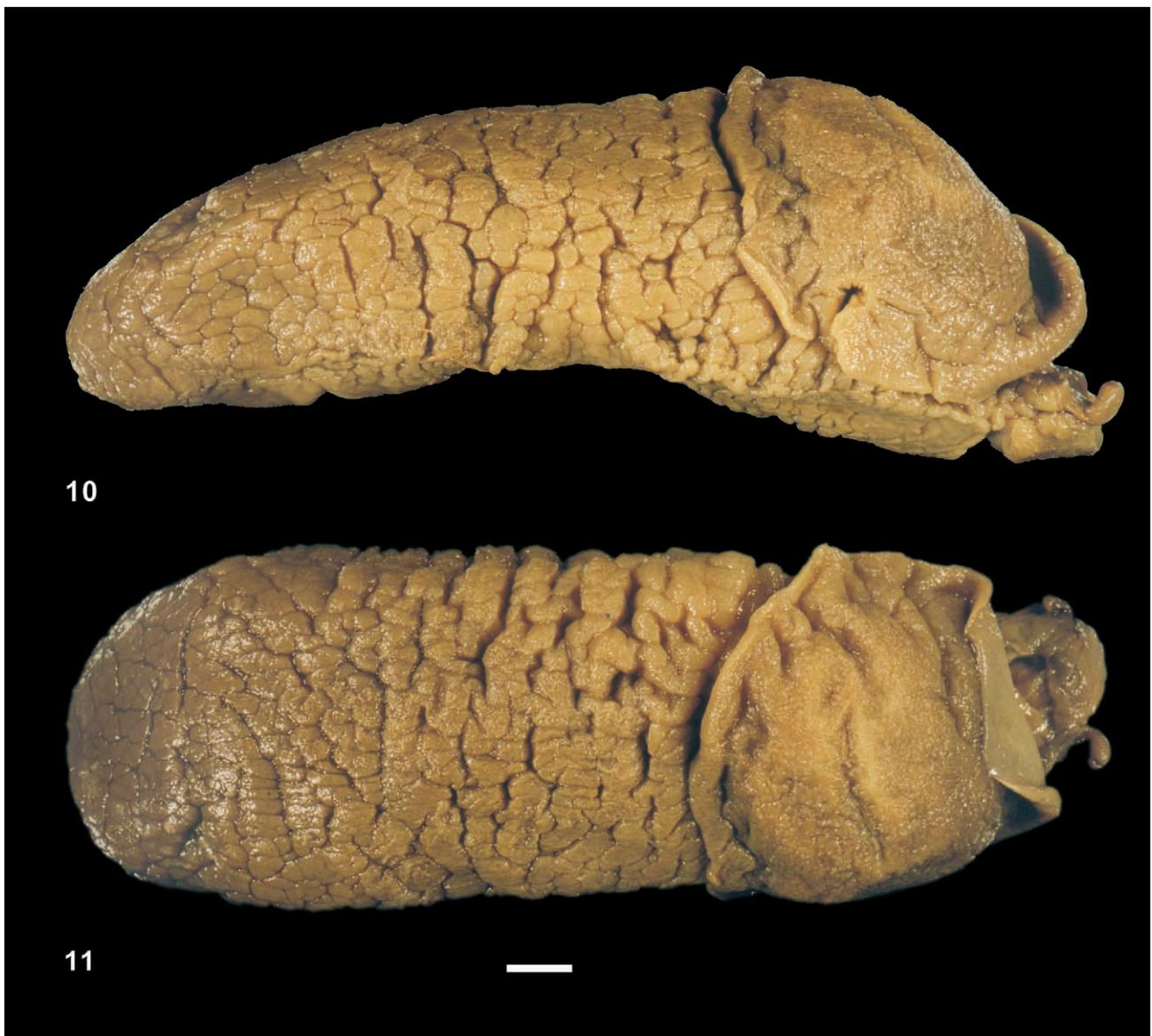


Fig. 9. Genitalia of a specimen from the NHM determined as *Anadenus schlagintweiti*, probably one of the syntypes; scale bar 1 mm; (orig.)

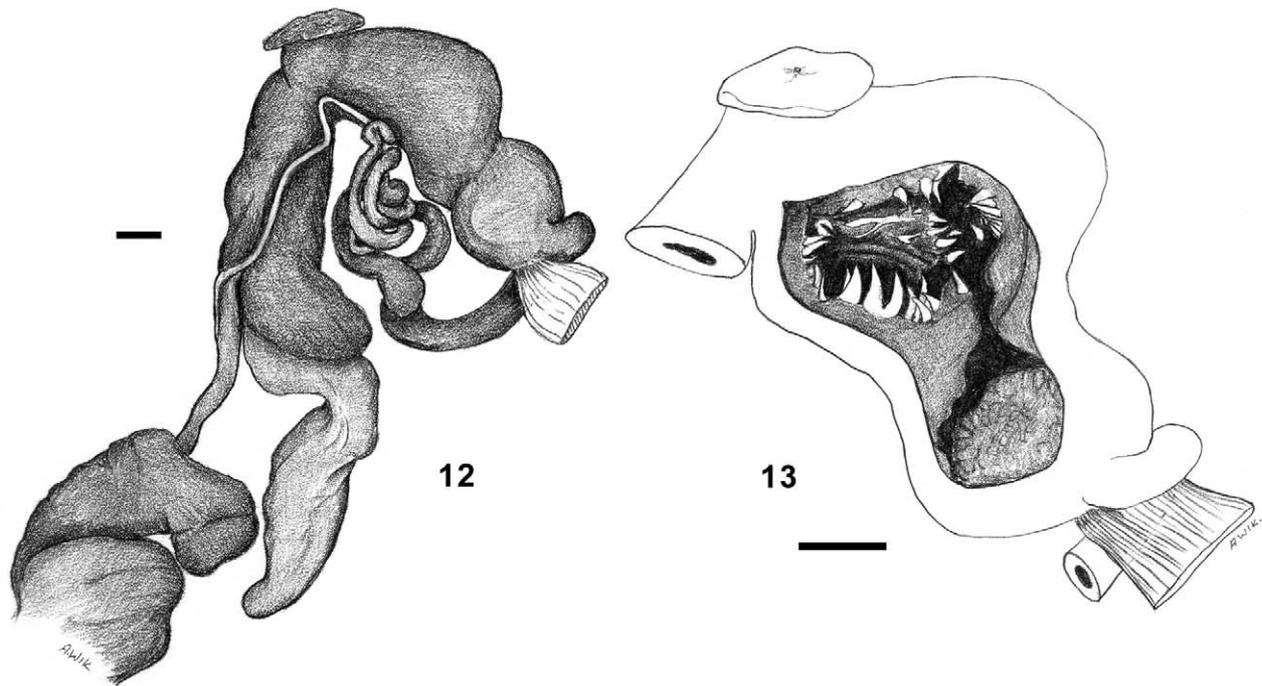
(spines – see the above comments on the specimen from the Vienna collection). The appearance of penis, and especially the presence of hard spines inside it, indicate that the specimen is *A. (A.) altivagus*. It does not follow from HEYNEMANN's (1862) description that another species could be concerned. The slug does not have any characters that could be regarded as distinctive. GODWIN-AUSTEN (1882) mentions two specimens housed at the British Museum. He states that they are “gray in colour and smaller than *altivagus*” but similar to this species, and expresses doubts regarding the locality in Sikkim. The specimen I have examined comes just from Sikkim. However, among the specimens from that locality there is one definitely representing *A. altivagus* (see Material). The similarity of its penis to that of *A. yangtzeensis* Wiktor, Chen et Wu, 2000 is apparent.

Thus, I have failed to finally establish what slug is hidden under the name *schlagintweiti*. Still, it seems to be a synonym of *A. altivagus*.

*Anadenus jerdoni* Godwin-Austen, 1882. According to GODWIN-AUSTEN's original description, its body length attains 101.6 mm, mantle length 38 mm, body width 31.8 mm. In live individuals the mantle was covered by papillae. The “pedal margin” was very thin and the pneumostome postmedial. I had an opportunity to examine the holotype, including its anatomy (Figs 10–13). Until then the specimen had not been dissected, its anatomy being unknown. At present, probably as a result of repeated exchange of the preservation liquid, the holotype has shrunk considerably and got discoloured. Yet, this is undoubtedly the very specimen that GODWIN-AUSTEN had at his disposal and named *A. jerdoni*. Now the specimen is brownish,



Figs 10–11. *Anadenus jerdoni* (holotype) = *Anadenus altivagus* – lateral and dorsal view; scale bar 10 mm; (orig.) (photo J. MACIAŹEK)



Figs 12–13. *Anadenus jerdoni* (holotype) = *Anadenus altivagus*: 12 – copulatory organs; 13 – penis with visible internal structures; scale bars 2 mm; (orig.)

the body lacking any pattern or spots. It is smaller than stated in the description: 88 mm long, mantle length 35 mm, body width 26 mm. The slug is very strongly dorso-ventrally flattened, simply flat. Its posterior body end is rounded, back gently arched and also rounded. There are 16 (? – difficult to count as some are indistinct) wrinkles between the mid-back and pneumostome (Figs 10–11; cf. also GODWIN-AUSTEN 1882: Pl. 7, Fig. 7 – this figure was also repeated by GUDE 1914 as Fig. 152). The internal organs are perfectly preserved, the genitalia undamaged (Figs 12–13). Inside penis, in its posterior part, there is a structure which is either a gofferred papilla or a partly invaginated vas deferens. Anteriorly inside penis numerous white-coloured spines (darts) of varying size occur (Fig. 13). The spermatheca is thin, elongated. In this particular specimen it has probably never been filled with spermatophores, those usually strongly expanding this organ. Having analysed all those characters, I have come to the conclusion that the name *jerdoni* is a junior synonym of *altivagus*.

*Anadenus beebei* Cockerell, 1913. Like many of his predecessors, the author of the description paid much attention to the appearance of shell, jaw and radular teeth. It follows from his description that these were the differences in the appearance of the organs mentioned that made the investigator describe a new species. The drawings indicate that the slug concerned must have been *A. altivagus*. Inside penis, COCKERELL did not find “calcareous spines ... but instead very numerous tapering fleshy processes”, which are depicted in the figure. They seem to be of

the same origin as spines, and certainly they have got decalcified by the preservation fluid. The slugs were collected in the region of India, where *A. altivagus* occurs. In my opinion, *beebei* should be regarded as a junior synonym of *altivagus*.

*Anadenus dalhousiensis* Bhatia, 1926. Both BHATIA’s description and figures, especially the hard darts inside penis, indicate that this slug is conspecific with *A. altivagus*. Consequently, *dalhousiensis* is a junior synonym of *altivagus*.

*Anadenus lahorensis* Bhatia, 1926. The original description by BHATIA pertains to external appearance and to those internal organs that have no taxonomic value. The figures depict also the shell and jaw, but they do not facilitate species identification. The specimen described was merely 20 mm long and 4 mm wide. The author of this name did not examine the reproductive organs. In all probability the studied specimen was a juvenile, and such slugs have a more intense coloration and body pattern. Based on the description and figures, it is impossible to decide if this was a new, previously unknown, species or *A. altivagus*, which inhabits this region of India. For these reasons, I treat the name as a probable junior synonym of *A. altivagus*.

*Anadenus matthaii* Bhatia, 1926. BHATIA’s description of this slug and figures of its genitalia indicate that the author actually dealt with *A. altivagus*. Judging from one of the figures, the spermatheca had never contained spermatophores and therefore it differs in shape from this organ in *A. altivagus*. It is unclear to me what the “calcareous plate” inside penis is. This must be penial structures combined with darts that are

concerned. These structures are formed with the development of penis. Everything bears evidence to the name *matthaii* being a junior synonym of *altivagus*.

? *Anadenus (Anadenus) blanfordi* Godwin-Austen, 1882

*Anadenus blanfordi* GODWIN-AUSTEN 1882: 53 (no figures). Locus typicus: Darjeeling (N India), ca 7,000 ft a.s.l. Holotypus: NHM Reg. No. 1998/72.

*Anadenus blanfordi* (emend.): COCKERELL 1893: 192.

Only the holotype is known. Its body length equals 44 mm, mantle length 16 mm, the greatest body width 11 mm. The wrinkles between the mid-back and pneumostome are difficult to count; there are probably 16 of them. The holotype has the terminal section of its genitalia partly everted. According to GODWIN-AUSTEN (1882), after preservation in alcohol the specimen was “dark ochraceous brown, with some dark grey mottlings on the upper part of the foot”. At present it is completely faded, uniformly creamy whitish (Figs 14–16).

**Genitalia** (Fig. 17). Before I dissected it, the specimen had not been cut. Vas deferens short, compared with other species; epiphallus short. Penis cylindrical,

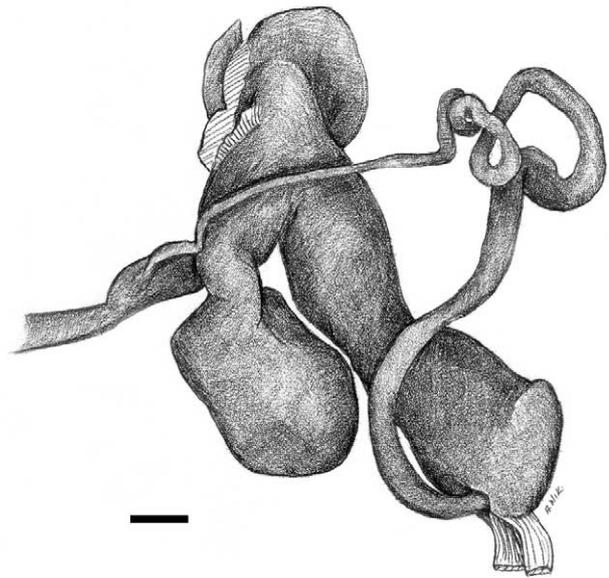


Fig. 17. ?*Anadenus (A.) blanfordi* (holotype) – copulatory organs; scale bar 1 mm; (orig.)

inconspicuously broadened in its anterior and posterior sections. Vas deferens opens to it laterally, at the



Figs 14–16. ?*Anadenus (A.) blanfordi* (holotype) – dorsal and lateral view, and a magnified fragment of back with visible skin sculpture; scale bars 10 mm; (orig.) (photo J. MACIAZEK)

apical end. Strong penial retractor arcuately surrounds the outlet of vas deferens. On one side of the apical end of penis there is a small swelling, which cannot, however, be called an appendix. Inside penis a system of longitudinal ledges (plicae), and a papilla in its posterior end. The everted part is wide and semi-circular. It probably comprises atrium and some of the internal structures of penis.

**Distribution.** Known only from the type locality.

**Comments.** The original coloration, measurements and appearance of genitalia indicate that the slug is *Anadenus altivagus*. However, the typical hard mineralized spines are lacking, for which reason I cannot ultimately decide on the synonymization. The spines may have dissolved or they had not yet been formed in a juvenile slug, the reproductive system of the specimen being apparently still not fully developed. GODWIN-AUSTEN (1882) did not examine the holotype anatomically. As its distinctive characters, he mentions a “very different arrangement of the warty protuberances on epidermis, these being well raised, isolated, and elongately diamond-shaped”. This is true: the skin sculpture is well pronounced, but this may result from the preservation mode.

*Anadenus (Anadenus) nepalensis* n. sp.

**Holotypus:** Nepal, Ghundruk, 20 km NW of Pokhara (S Annapurna), 2,000 m a.s.l., 16.09.1981, leg. A. KUŠKA. MNHW no. MP 817.

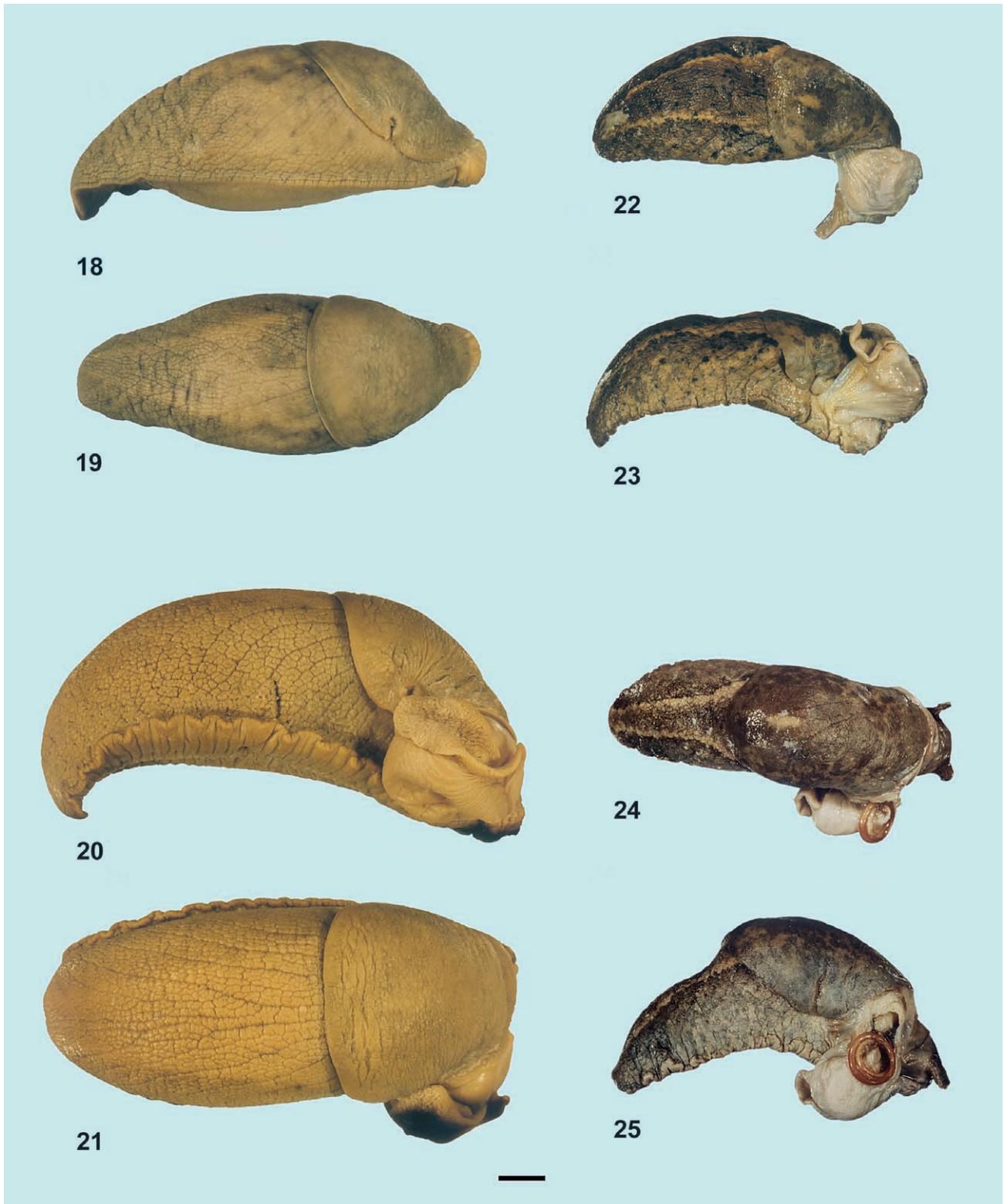
**Paratypi:** all from **Nepal** – 2 spec. collected with the holotype (1 spec. – MNHW no. MP 817, 1 spec. – MIZ); **Siklis**, 12 miles NE of Pokhara, 6,000 ft a.s.l., 11.08., 23.08. and 24.08.1924, leg. K. H. HYATT – 3 spec. (NHM no. 257, 269, 271); **Lantang National Park**, Chandrabar, 3,300 m a.s.l., fir forest, 27.09.1981, leg. A. KUŠKA – 1 spec. (MIZ); (?) **Lantang National Park**, Goisakund, 4,200 m a.s.l., 27.09.1981, leg. A. KUŠKA – 1 spec. + 1 juv. spec. (MIZ); **Kirtipur** (Kathmandu), 10.09.2000, leg. PREM BUDHA – 3 spec. (2 spec. – MNHW no. 817, 1 spec. – PB); **Maharajgunj**, Kathmandu, 12.09.2000, leg. ISAN GAUTAM – 5 spec. (3 spec. – MNHW no. MP 817, 2 spec. – PB); **Kathmandu** (Prov. Bagamati), Gorkhana-Park, ruderal habitat by a river, in a brick wall, 1,400 m a.s.l., 28.05.1997, leg. U. BÖSSNECK – 2 juv. spec. (1 spec. – NHM, 1 spec. – CB); **Kathmandu** (MNH no. 586 and 591 from 1906 and without no. together 8 spec.); **Godavari** (distr. Kathmandu/prov. Bagmati) Botanical Garden, 1,600 m a.s.l., 25.06.1997, leg. U. BÖSSNECK – 1 spec. (MNHW MP no. 817); **Churta** (Distr. Dolpa/Prov. Kamali), deciduous-mixed forest on granite, water-head area near Mauria Bhaniyan in the direction of Churta, 3,350 m a.s.l., 6.06.1997, leg. U. BÖSSNECK – 1 spec. (MNHW no. MP 817); **Churta** (Distr. Dolpa/Prov. Kamali), deciduous forest on granite rock, Churta Khola valley, ca 3,000 m a.s.l., 7.06.1997, leg. U. BÖSSNECK – 2 juv. spec. (1 spec. –

CB, 1 spec. NHM); **Balangchour**, Kaigaon, Chaurikot, Churta (Distr. Dolpa/Prov. Kamali), mixed deciduous forest on granite, 2,600–3,500 m a.s.l., 3–7.06.1997, leg. U. BÖSSNECK – 5 spec. (2 spec. – NSE, 1 spec. – CB, 2 spec. MNHW no. MP 817); **Maharigaun** (Distr. Jumla/Prov. Kamali), branch of the valley by the path to Lake Dhauli, fir-birch forest, granite, 3,350 m a.s.l., 20.06.1997, leg. U. BÖSSNECK – 1 spec. with everted ligula + 1 juv. (MNHW no. MP 817); **Maharigaun** (Distr. Jumla/Prov. Kamali), high plateau with a block of rocks and low shrubs by the path to Lake Dhauli, 3,720 m a.s.l., 16.06.1997, leg. U. BÖSSNECK – 2 juv. spec. (MNHW No. MP 817); **Gothichaur**, Talphi Maharigaun (Distr. Jumla/Prov. Kamali) in different brook valleys and between granite chips on rocks in the valleys, 2,700–3,400 m a.s.l., 13 and 16.06.1997, leg. U. BÖSSNECK – 4 juv. spec. (2 spec. – NHM, 2 spec. MNHW no. MP 817); **Nepal** – 3 spec. (MNH no. 596 from 1906).

Body size (after preservation in alcohol): entire body length 70 mm, mantle length 36 mm, body width 22 mm. Individuals 43 mm long can already have developed genitalia testifying to their sexual maturity, whereas some 65-mm-long slugs have merely primordial copulatory organs. When alive and fully extended, the largest specimen recorded was as long as 105 mm (BÖSSNECK in litt.). Body relatively stocky, also in comparison with some other members of this genus (Figs 18–25). Skin wrinkles low, poorly marked. Skin sculpture of fine irregularly polygonal structures, yielding longitudinal stretches separated by grooves; their number between mid-back and pneumostome equals ca 13. According to Dr. U. BÖSSNECK (in litt.), who collected most of the material, the slug varies widely in coloration. The variability is probably both intra- and interpopulational. The predominant colours are beige-creamy, olive or brown (various hues). Some individuals have darker, brown or black, lateral streaks; at times an additional pattern is present, which the observer mentioned defines as resembling fish bones (Fischgrätenmuster). Besides, darker spotting can occur. Neck and mantle darker. Sole uniformly pale orange-creamy. After preservation some specimens are nearly uniform in colour, freshly preserved specimens brownish-red; in alcohol-discoloured slugs the general coloration becomes grey beige, a very faint, slightly darker, irregular mosaic pattern becomes visible on mantle, and two indistinct darker – in some specimens orange – lateral streaks. Other specimens are uniformly graphite blackish or brown blackish. On mantle some have an elongated orange blot, and an indistinct orange line running on the sides behind mantle; below the latter there are irregular dark spots. In some, additionally, there are scattered black dots. Juveniles always have a clearer dark pattern on the body. Sole uniformly coloured, of the same colour as the rest of

the body. Small individuals which I have examined are darker than the adults and their body pattern

more intense. The external appearance of the slug bears no diagnostic characters.



Figs 18–25. *Anadenus (A.) nepalensis* n. sp.: 18–19 – lateral and dorsal view of a holotype from Ghundruk; 20–21 – lateral and dorsal view of a specimen with everted copulatory organs – a paratype from Ghundruk; 22–23 – a form with an intense pattern – a paratype from Kirtipur; copulatory organs visible; 24–25 – a form with an intense pattern – a paratype from Kirtipur; on the background of everted copulatory organs a coiled spermatophore, just transferred into the receiver's spermatheca during copulation; scale bar 10 mm; (orig.) (photo J. MACIAZEK)

**Shell** – Fig. 26.

**Pallial complex** – Fig. 27.

**Jaw** – Fig. 28.

**Mucus:** watery, colourless (BÖSSNECK in litt.).

**Genitalia** (Figs 29–30). External appearance of copulatory organs similar to that of *A. (A.) altivagus*. Vas deferens and epiphallus relatively short. Outlet of epiphallus and retractor muscle insertion situated on the apical end of penis. Penis claviform, with its anterior part distended, in shape resembling this organ in *A. altivagus*, but, compared with the rest of genitalia, it is larger. Inside penis a big ligula; in its general appearance it resembles a tongue of corrugated sides, but anteriorly strongly elongates passing into a cylindrical pointed process (!) (Fig. 30). Spermatheca with a narrow duct, container shorter than penis. Spermatophore like that in *A. (N.) gonggashanensis* (see Fig. 53).

**Ecology** poorly known. Dr. U. BÖSSNECK's observations indicate that the slug occurs both in natural habitats and as a synanthrope. The material comes from mixed deciduous forests, fir-birch woods, bush thickets, gardens and the neighbourhood of brick walls. The altitude of the localities ranges between 1,400 and 4,200 m! The slugs were collected from May to September. Since in this period adult individuals are found, it can be supposed that the life span of *A. nepalensis* exceeds one year.



Fig. 26. *Anadenus (A.) nepalensis* n. sp., a paratype from Ghundruk: shell; scale bar 1 mm; (orig.)

**Distribution.** At present the species is known only from Nepal, the records coming from the environs of Pokhara and provinces Bagamati and Kamali.

**Comments.** Photographs of radular teeth in this species are available in a paper by JUNGBLUTH et al. (1985: Pl. 4, Fig. 22) in the chapter on *Anadenus* sp., the radula depicted coming from the holotype of *A. nepalensis* n. sp.

When discussing *A. jerdoni*, GODWIN-AUSTEN (1882) mentions a slug from Nepal, whose body is less smooth than that of *A. giganteus* (compared with the figure in HEYNEMANN 1862, where this species is described). The author concludes: "The Nepalese spe-

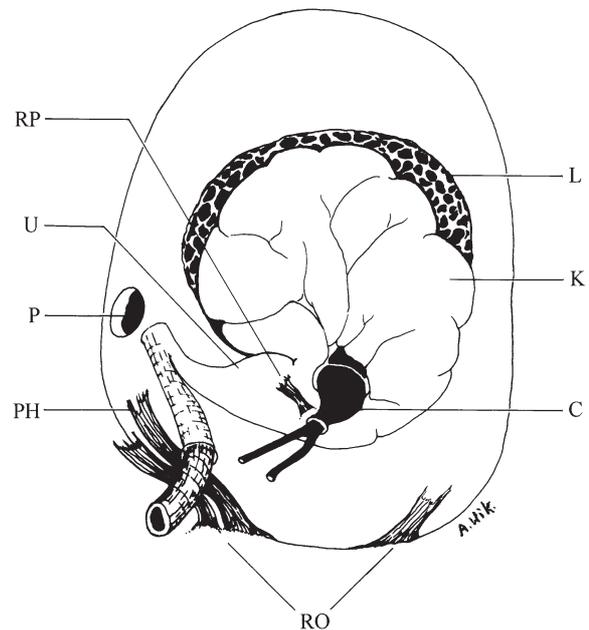


Fig. 27. *Anadenus (A.) nepalensis* n. sp., pallial complex (ventral view), diagrammatic; paratype from Bankanghour (orig.). C – heart; K – kidney; L – lung; P – pneumostome; PH – muscle connected with pharynx; RO – ommatophore retractors; RP – retractor penis; U – ureter

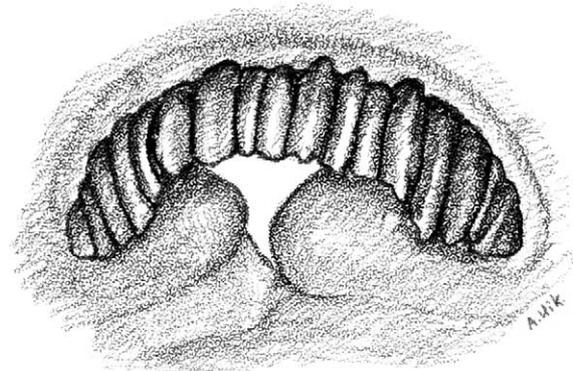


Fig. 28. *Anadenus (A.) nepalensis* n. sp., a paratype from Ghundruk: jaw; scale bar 1 mm; (orig.)

cies I propose to distinguish by the name *insignis*” (see also *A. insignis* – nomen dubium).

With respect to the shape of penis, *A. (A.) nepalensis* n. sp. somewhat resembles *A. (A.) yangtzeensis*.

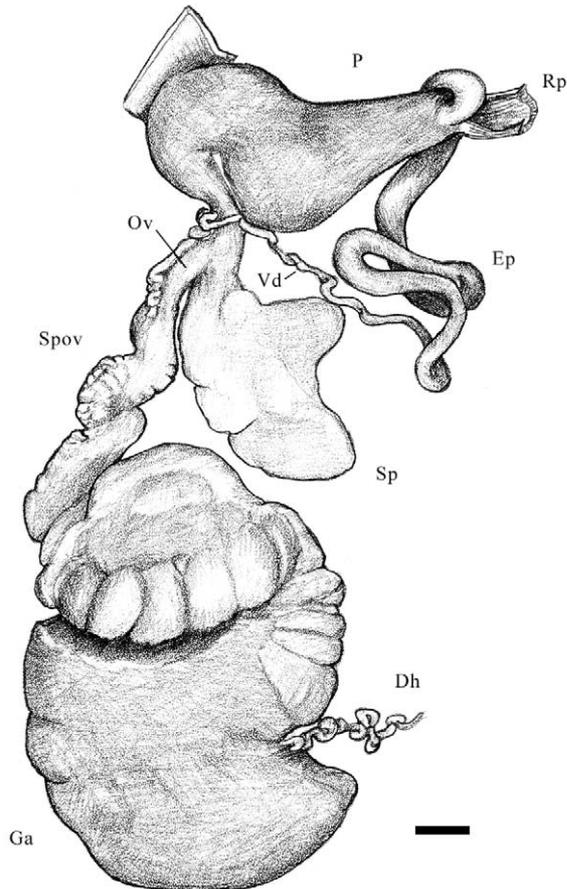


Fig. 29. *Anadenus (A.) nepalensis* n. sp. – reproductive system of the holotype; scale bar 2 mm; (orig.) (for lettering see Fig. 4)

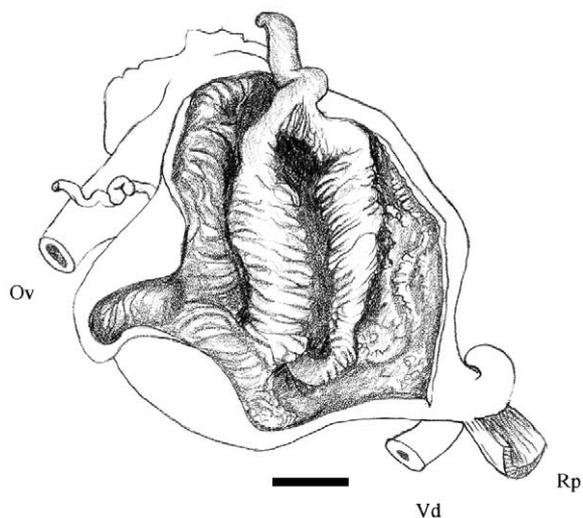


Fig. 30. *Anadenus (A.) nepalensis* n. sp. – structures inside penis; scale bar 2 mm; (orig.)

The latter slug, however, has a short appendix posteriorly on penis (see Fig. 43). Although there is also a large ligula inside its penis, this structure assumes a different shape being wider and not terminating with a cylindrical process (see Figs 44–45).

#### *Anadenus (Anadenus) parvipenis* Wiktor, Chen et Wu, 2000

*Anadenus (Anadenus) parvipenis* WIKTOR et al. 2000: 15, Figs 21–25, map 6. Holotypus: ZIAS. Locus typicus: Gonggashan Mts., ca 3,000 m a.s.l., Luding County, Sichuan Province, China.

Measurements: body length 41 mm, mantle length 23 mm, the largest sole width 18 mm. General coloration olive brown (Figs 31–33).

**Genitalia** (Fig. 34). Vas deferens thin, quite abruptly turning in a long, gradually broadening epiphallus. Inside penis a tongue-shaped ligula.



Figs 31–33. *Anadenus (A.) parvipenis* – lateral, dorsal and ventral view of the holotype; scale bar 10 mm; (after WIKTOR et al. 2000)

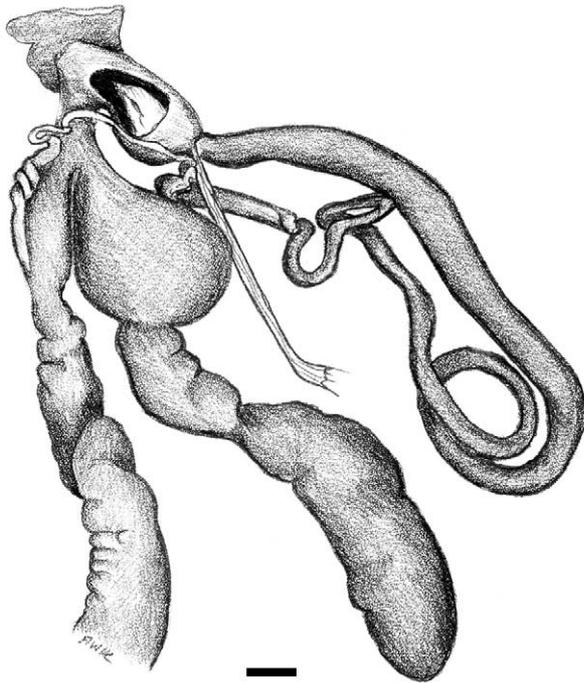


Fig. 34. *Anadenus (A.) parvipenis* – copulatory organs of the holotype; scale bar 1 mm; (after WIKTOR et al. 2000)

**Distribution.** Known exclusively from the type locality.

For more information see WIKTOR et al. (2000).

**Comments.** The slug differs from all other Anadenidae in its penis, which is small compared with other copulatory organs, in the appearance of the penial ligula, thick and long epiphallus and a narrow penial retractor.

#### *Anadenus (Anadenus) sechuenensis* Collinge, 1899

*Anadenus sechuenensis* COLLINGE 1899: 78, Pl. 4, Figs 1–2, 6–7, Pl. 5, Figs 8–13. Locus typicus: Sung pan, NW Sechuen (=Sichuan), China. Lectotypus and paralectotypus: NHM reg. no. 1899.1.13. 71–72.

*Anadenus sechuenensis*: SIMROTH & HOFFMANN 1928: 526, Fig. 172.

*Anadenus (Anadenus) sechuenensis*: WIKTOR et al. 2000: 17, Figs 26–28, map 7.

Lectotype measurements: body length 69 mm, mantle length 35 mm, the largest sole width 23 mm; paralectotype: 55/28/19 mm, respectively (Figs 35–36).

**Genitalia** (Figs 37–38). Vas deferens and epiphallus approximately of the same length. Epiphallus gradually thickening, somewhat narrowing at its opening to penis. Penis clavate due to posterior spherical swelling. Inside the swollen section a papilla of corrugated surface (Fig. 38), and more anterad the walls of penis are covered by longitudinal folds.

**Distribution.** Known only from the type locality.

For more information see WIKTOR et al. (2000).



Figs 35–36. Specimen from the NHM identified as *Anadenus sechuenensis*, probably one of the syntypes – lateral and dorsal view; scale bar 10 mm; (orig.) (photo J. MACIAZEK)

**Comments.** *A. sechuenensis* differs from other species of the subgenus *Anadenus* in its claviform penis lacking appendix and in the penial internal structures.

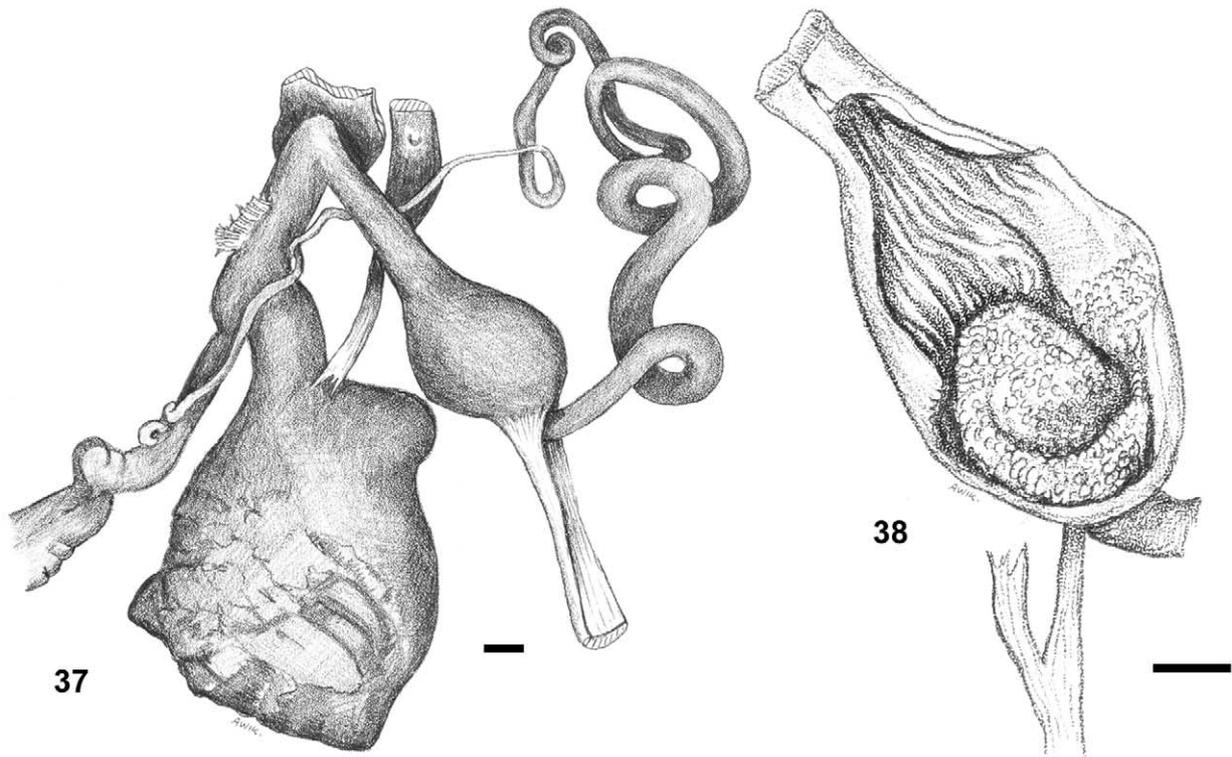
#### *Anadenus (Anadenus) yangtzeensis* Wiktor, Chen et Wu, 2000

*Anadenus (Anadenus) yangtzeensis* WIKTOR et al. 2000: 18, Figs 29–36, map 8. Holotypus: ZIAS. Locus typicus: Army Station, Yajiang County, Sichuan Province, China.

Measurements: length 68 mm, mantle length 30 mm, the largest sole width 20 mm. General coloration (specimens at present alcohol-preserved) brown with a slight reddish tint. On this background, on mantle, back and sides, few irregular black spots ca 0.5 mm in diameter (Figs 39–42).

**Genitalia** (Fig. 43). Both vas deferens and epiphallus thin compared to these organs in other species. The border between the two is difficult to draw as vas deferens gradually thickens and passes into epiphallus. Penis posteriorly narrow, gradually broadening anterad. On the very end of this organ there is an inconspicuous appendix (!), usually bent or in the form of a transverse process. Inside penis a huge ligula, its surface covered by wrinkles (Figs 44–45).

**Distribution.** So far known only from the localities where the type material was collected: Army Station, Yajiang County, Sichuan Prov.; Zhongwure, Xiangcheng County, Sichuan Prov.; Mt. Meilixueshan, Deqing County, Yunnan Prov.; Yakou of Dexueshan



Figs 37–38. *Anadenus (A.) sechuenensis* – lectotype: 37 – copulatory organs; 38 – structures inside penis; scale bars 1 mm; (after WIKTOR et al. 2000)



Figs 39–42. *Anadenus (A.) yangtzeensis* – different views; scale bar 1 mm; (after WIKTOR et al. 2000)

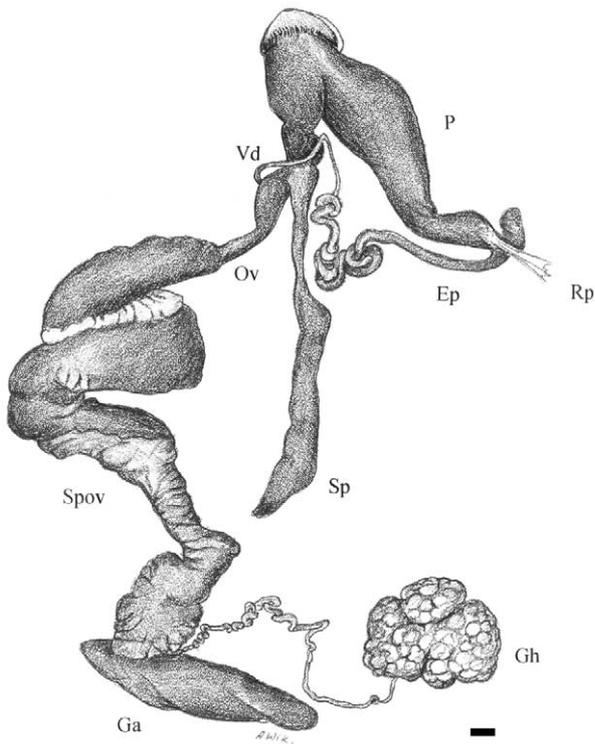


Fig. 43. *Anadenus (A.) yangtzeensis* – reproductive system of the holotype; scale bar 1 mm; (after WIKTOR et al. 2000) (for lettering see Fig. 4) (for lettering see Fig. 4)

Mt., Zhongdian County, Yunnan Prov. (all localities from China, and all ca 3,500–4,000 m. a.s.l.)

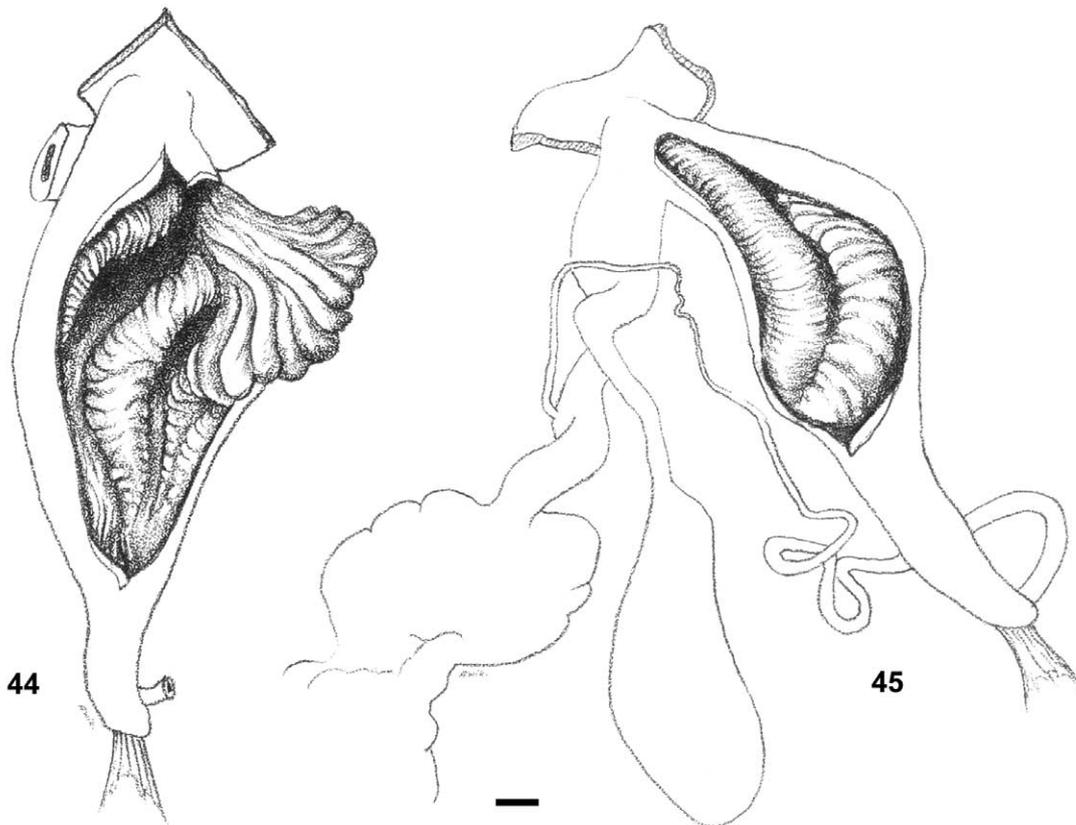
**Comments.** The slug differs from *A. sechuenensis* Collinge, 1899, recorded from the same province, Sichuan, among other characters in posteriorly narrowing penis, the presence of an inconspicuous appendix at the posterior end of penis of most specimens, and a huge, wrinkle-covered ligula inside the penis. The characters distinguishing *A. yangtzeensis* from other anadenids include: fine black spots on the body, thin vas deferens and epiphallus, a huge wide ligula inside penis, and – in most specimens – presence of appendix on posterior end of penis.

***Anadenus* (?*Anadenus*) *yunnanensis* Wiktor, Chen et Wu, 2000**

*Anadenus* (?*Anadenus*) *yunnanensis* WIKTOR et al. 2000: 20, Figs 37–40, map 9. Holotypus: ZIAS.

Locus typicus: Zhibengshan Mt., Yonlong County, Yunnan Province, China.

Measurements: length 93 mm, mantle length 37 mm, the largest sole width 30 mm. The most distinctive character in the external appearance is skin sculpture of the section behind mantle (Figs 46–48). The wrinkles are exceptionally large and markedly pronounced, contrary to those in all other known species. The largest wrinkles are 17 mm long (!) and 3.5 mm wide. Those occurring on sides are shorter and



Figs 44–45. *Anadenus (A.) yangtzeensis* – structures inside penis; scale bar 1 mm; (after WIKTOR et al. 2000)



Figs 46–48. *Anadenus (A.) yunnanensis*—lateral, dorsal and ventral view of the holotype; scale bar 10 mm; (after WIKTOR et al. 2000)

thinner, and also less pronounced. The shape of wrinkles is also different from that in other *Anadenus*: in cross section the most pronounced ones are simply triangular, whereas those on sides are semicircular, like in other species. General coloration after preservation in alcohol evenly black.

**Genitalia** (Fig. 49). The only specimen known is at an early phase of sexual activity (large gonad, smallish

albumen gland). In comparison with this organ in other species, vas deferens is relatively short. Epiphallus, also short, broadens gradually. It opens into penis somewhat asymmetrically at its posterior end. In the examined specimen the penis is nearly spherical but this is probably an effect of the organ having been partially everted; it is likely that before eversion the penis was cylindrical or elongatedly oval.

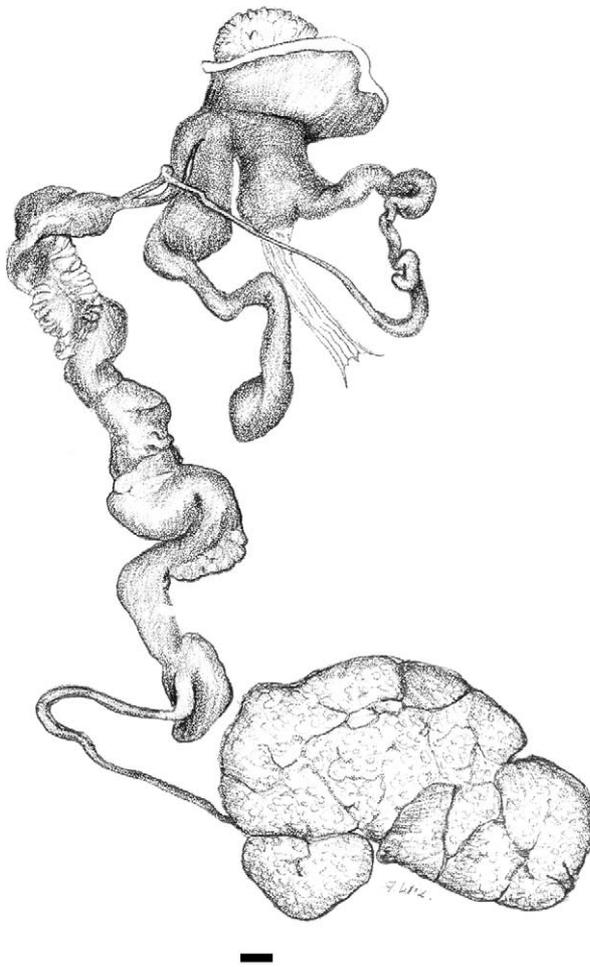


Fig. 49. *Anadenus (A.) yunnanensis* – reproductive system of the holotype; scale bar 3 mm; (after WIKTOR et al. 2000)

**Distribution.** Known only from the type locality. For more information see WIKTOR et al. (2000).

**Comments.** The unique external appearance of this slug makes it distinguishable from all other mem-

bers of Anadenidae. Its genitalia seem to exhibit all characters specific to *Anadenus* s. str. However, some doubts arise with respect to the uniqueness of skin wrinkles: I do not know the taxonomic value of the character and if it is species-specific, for which reason I place this slug within *Anadenus* s. str. but provided with a question mark.

#### **Subgenus *Neoanadenus* Wiktor, Chen et Wu, 2000**

*Neoanadenus* WIKTOR et al. 2000: 21. Species typica: *Anadenus gonggashanensis* Wiktor, Chen et Wu, 2000, by original designation.

The character distinguishing the subgenus from *Anadenus* s. str. is an additional organ in the form of a vesicle, which laterally adheres to the anterior part of penis and opens through a duct (directed posterad) to the medial section of penis (Figs 51–52).

Up till now there is only one species known to represent this subgenus.

#### ***Anadenus (Neoanadenus) gonggashanensis* Wiktor, Chen et Wu, 2000**

*Anadenus (Neoanadenus) gonggashanensis* WIKTOR et al. 2000: 21 Figs 41–46, map 10. Holotypus: ZIAS. Locus typicus: Moxi, E slope of the Gonggashan Mts, ca 2,500 m a.s.l., Luding County, Sichuan Province, China.

Measurements (alcohol-preserved body): length 52 mm, mantle length 22 mm, the largest sole width 17 mm. Coloration of alcohol-preserved specimens: mantle unicoloured except for a paler blot in the middle. On sides there are two nearly continuous streaks (Fig. 50).

**Genitalia** (Figs 51–52). Vas deferens comparatively long. Like in all other anadenids, it is the thinnest near atrium, then gently broadening into a very long and coiled epiphallus. Penis generally narrow, both anteriorly and posteriorly distended. Roughly at its half-length a specific organ in the form of a vesicle



Fig. 50. *Anadenus (N.) gonggashanensis* – a paratype from Moxi; scale bar 10 mm; (orig.) (photo J. MACIAŹEK)

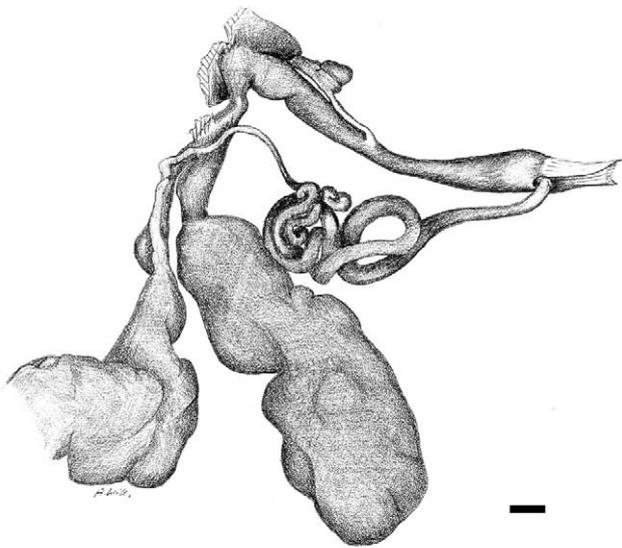


Fig. 51. *Anadenus (N.) gonggashanensis* – copulatory organs of the holotype; scale bar 1 mm; (after WIKTOR et al. 2000)

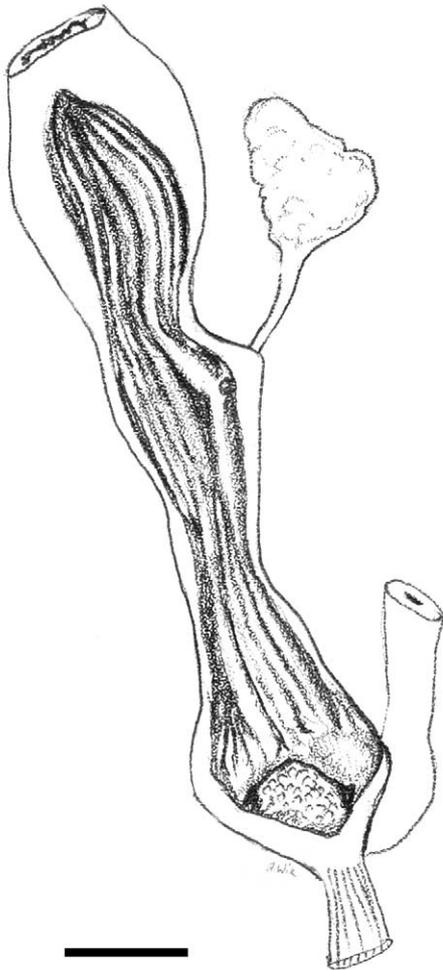


Fig. 52. *Anadenus (N.) gonggashanensis* – structures inside penis; scale bar 1 mm; (after WIKTOR et al. 2000)

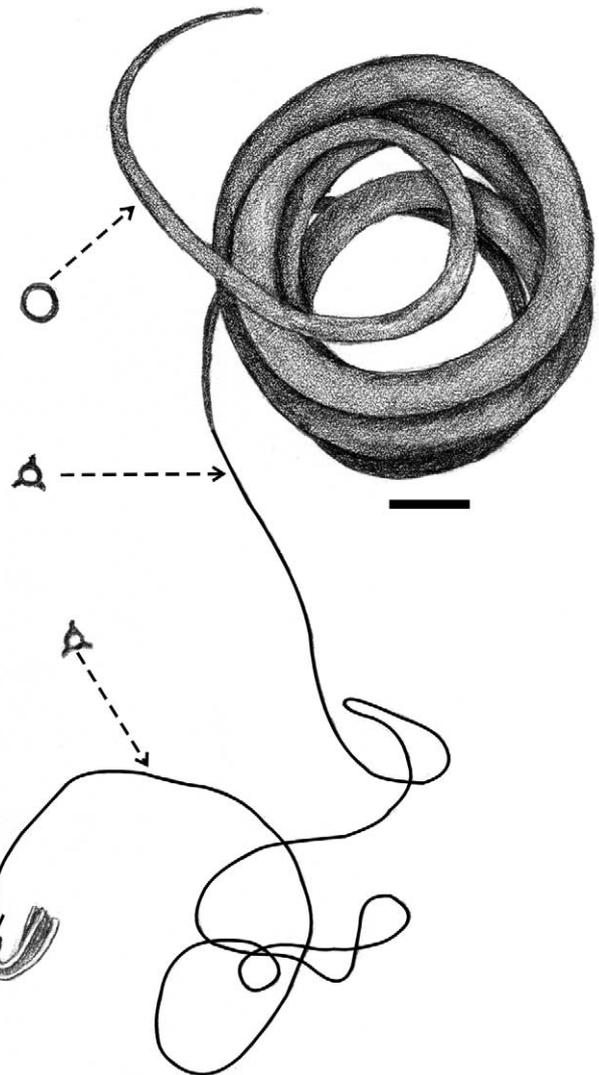


Fig. 53. *Anadenus (N.) gonggashanensis* – spermatophore; the figure shows cross-sections of particular parts of this structure and a magnified hook at the end of flagelliform part; scale bar 1 mm; (after WIKTOR et al. 2000)

opens through a narrow duct to its lateral wall. This organ is fairly varied in shape, usually, however, oval in outline. Inside the posterior, broadened, section of penis (Fig. 52) there is a semi-spherical papilla, its surface covered by fine tubercles. In the remaining part of penis irregular longitudinal folds.

**Spermatophore** (Fig. 53) cylindrical, ca 100 mm long, gradually narrowing at one end, whereas the other passes into a thin flagellum terminating with a tiny hook. Except for the flagelliform section, the spermatophore surface is smooth.

**Ecology.** The slug lives on rocks in high mountains at an altitude of 2,000–4,000 m a.s.l.

**Distribution.** So far the species has been recorded only from the type locality and the localities of paratypes; all the sites are situated in the Province Sichuan: Moxi, E slope of the Gonggashan Mts, ca 2,500 m a.s.l, Luding County, Sichuan Prov., China; Yanzigou, E slope of the Gonggashan Mts, ca 2,500 m

a.s.l., Luding County, Sichuan Prov., China; Jiulaodong, Mt. Emei, ca 2,000 m a.s.l., Sichuan Prov., China; (?) Leigongshan Mt., Guizhou Prov., China.

For more information see WIKTOR et al. (2000).

**Comments.** The species differs from all other members of *Anadenus* in the subgeneric characters, and besides, from *A. sechuenensis* Collinge, 1899 in the shape of penis which is narrow, both anteriorly and posteriorly distended, with longitudinal folds inside.

## NOMINA DUBIA

### *Anadenus* (?) *banerjeei* Rajagopal, 1973

*Anadenus banerjeei* RAJAGOPAL 1973: 416, Figs 1–4.

Holotypus: no. M. 19752/3 (ZSI). Locus typicus: Gunji village, 15 km NE of Garbyang, Kuti Valley, Pithoragarh Distr. (U.P.), Kumaun Himalaya, alt. ca 3,200 m a.s.l.

The description is completely vague. The distinctive character mentioned (RAJAGOPAL 1973) is the body being covered by barbed bristles. The diagnosis reads: “Slug with barbed bristles covering the body, bristles distributed sparsely or in dense patches”. To quote the collector’s remark, the slug in living condition has bristles covering the body “like in the *Lepidoptera* caterpillar”. Further the description says that the body is “dark black” (sic!). “Respiratory orifice behind mantle-slit, at right margin, slightly posterior to middle of mantle”. Foot – “tripartite, a median and two lateral stripes”. The other characters discussed, both referring to the external appearance and shell, correspond with those of all *Anadenidae*. The anatomy of *Anadenus banerjeei* is not dealt with, whereas the description considers the bristles. The drawings show the slug from three sides, the bristles being depicted under two different magnifications.

**Comments.** Unfortunately, my request to loan the types, directed to the ZSI, has been left unanswered. Also, I have failed to establish if any other collector has ever found a slug covered by bristles.

There is no gastropod I know having bristles in the skin. In all, the body is entirely soft-covered; the only hard element being the shell. The appearance of bristles as shown in RAJAGOPAL’s (1973) figures, especially 4B (a bristle in cross-section), indicates that they are probably of plant origin, and thus an alien element. Unfortunately, it cannot be inferred from either the pictures or the description how the bristles are connected with the integument. The figures show that the bristles are provided with barbs which might have got tightly stuck in the skin, for example during contraction of an irritated slug or on some other occasion.

I guess that the author’s statement that the foot is “tripartite” pertains to its coloration, and does not mean – as one may presume – that it is divided in three zones, the more so that further in the text the word “stripes” appears.

Concluding, I am unable to ascertain what species RAJAGOPAL (1973) dealt with, having no opportunity to examine the types. Considering the anatomy of slugs, bristles occurring on their body seem quite improbable; the ones concerned were probably alien elements. Also, the foot in *Anadenidae* is not tripartite, and the slug in the figure is undoubtedly an *anadenid*.

### *Anadenus* (?) *dautzenbergi* Collinge, 1900

*Anadenus dautzenbergi* COLLINGE 1900: 134, Pl. VI, Figs

1–8. Locus typicus: Qua Toun Mts, SE of Fo Kien, Fujian Prov., China. Typus: probably not preserved (it was a part of Collinge’s collection).

The species was described on the basis of its external appearance, shell, jaw and alimentary tract. The characters do not allow species recognition and decision whether the name refers to a distinct species or is a synonym of another name (see: WIKTOR et al. 2000).

### *Anadenus* (?) *giganteus* Heynemann, 1862

*Anadenus* (?) *giganteus* HEYNEMANN 1862: 140, Pl. I,

Figs 1a–h. Loci typici: Shimpti, Kumaon, Badrinath to Massuri Garhval (India). Typus: unknown to me.

As the only essential characters, the author of the name mentions the alloy, brownish, colour (“isabela-farbig, bräunlich”) and large size of the slug, which was to reach 80–100 mm when extended. Further in the description there are data about the characters of radula, jaw and shell. All those features, however, are of little taxonomic value and do not allow to unequivocally ascertain what species was concerned. The appearance of its genitalia remains unknown, the type probably non-existent. To find the missing details now seems impossible, the more so that the material used by HEYNEMANN (1862) for description, i.e. the syntypes, had come from a few different localities. GODWIN-AUSTEN (1882) regards the name *giganteus* as synonymous with *altivagus*, and this seems convincing. Examining specimens collected in the western Himalayas (GODWIN-AUSTEN 1882: 49) housed at the British Museum, he tried to establish which of the specimens is the type of *A. giganteus*. As a result of this study, the author changed his initial opinion, which is mentioned by GUDE (1914: 474). In the NHM collection there are specimens from Naini Tal identified by an unknown investigator as *giganteus*. I have seen them – they are identical with *altivagus* (Figs 4, 6–8).

### *Anadenus* (?) *insignis* Godwin-Austen, 1882

*Anadenus* (?) *insignis* GODWIN-AUSTEN 1882: 53.

*Anadenus insignis*: COCKERELL 1893: 192.

*Anadenus insignis*: GUDE 1914: 474.

The name was introduced by GODWIN-AUSTEN (1882: 53) for a slug that differed in skin sculpture from *A. altivagus*. The author mentions the name when describing *A. jerdoni* Godwin-Austen, 1882 (syn-



onym of *A. altivagus*) and refers to a paper by NEVILL (1878) who expressed an opinion that the name *A. giganteus* Heynemann, 1862 should be synonymized with *A. altivagus* (Theobald, 1862). GODWIN-AUSTEN (1882) refers also to HEYNEMANN's (1862) Figure 1h (and reproduces it in his paper), showing skin sculpture of *A. giganteus* Heynemann, 1862, purportedly different from such sculpture of specimens examined by GODWIN-AUSTEN in Calcutta, for which he proposes the name *A. insignis*.

At present I have decided to describe a new species under the name of *Anadenus nepalensis* n. sp. The slug occurs among others also in the region of Kathmandu, and its skin sculpture is slightly different from that of *A. altivagus* (the latter species also occurs in Nepal), though the difference is difficult to describe. However, the skin sculpture depends partly on the method of killing a slug, its preservation and age (size). In GODWIN-AUSTEN's (1882: 52) opinion, the slug for which he proposed the name *A. insignis* was much similar to *A. jerdoni* Godwin-Austen, 1882 (synonym of *A. altivagus*). GODWIN-AUSTEN mentioned that he remembered that the specimens he examined at the Museum in Calcutta, originating from Nepal and earlier examined by NEVILL (1878) and recognised as *A. altivagus*, had a different skin sculpture.

My written requests for the loan of the specimens from the Museum in Calcutta remained unanswered. The case is so complicated and unclear that it is impossible to ascribe any definite characters to the slug named *insignis* by GODWIN-AUSTEN (1882), and thus I have decided to place the name among nomina dubia.

#### *Anadenus* (?) *sinensis* Möllendorff, 1899

*Anadenus* (?) *sinensis* MÖLLENDORFF 1899: 49. Locus typicus: village Tapa, province Sythuan (=Sichuan), China. Holotypus: totally dry (ZIN).

The description, based on a strongly dried (sehr eingetrockneten) specimen kept in alcohol, pertains to characters of little taxonomic importance, and thus it seems impossible to establish if *A. sinensis* is a good

species or a synonym of some slug already known. It is also unclear what made MÖLLENDORFF (1899) describe this slug as new to science, since the author does not mention its distinctive features (see MÖLLENDORFF 1899: 49 and WIKTOR et al. 2000: 18). Although still available, the holotype does not suit the purpose of anatomical examination.

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