

A NEW SUBSPECIES OF *AMPHIDROMUS* (*AMPHIDROMUS*) *ATRICALLOSUS* FROM SINGAPORE (MOLLUSCA: GASTROPODA: CAMAENIDAE)

Siong Kiat Tan

*Raffles Museum of Biodiversity Research, Department of Biological Sciences, National University of Singapore,
Block S6, Science Drive 2, #03-01, Singapore 117546, Republic of Singapore
Email: dbstsk@nus.edu.sg*

Sow Yan Chan

*VBox 888313, Singapore 919191.
Email: chansowyan@gmail.com*

Somsak Panha

*Animal Systematics Research Unit, Department of Biology, Faculty of Science,
Chulalongkorn University, Bangkok, 10330, Thailand
Email: somsak.pan@chula.ac.th*

ABSTRACT. – The arboreal land snail of the genus *Amphidromus* Albers, 1850, found in Singapore is often identified in the literature as *Amphidromus atricallosus perakensis* Fulton, 1901. Studies of *A. atricallosus perakensis* material from various localities in Peninsular Malaysia showed that the Singapore population is distinct. Results from earlier studies on molecular phylogeny and allozyme analyses also suggest genetic discontinuity from other *A. atricallosus* subspecies. The Singapore population is herein described as *A. atricallosus temasek*, new subspecies, and can be differentiated from *A. atricallosus perakensis* by several morphological characters.

KEY WORDS. – Singapore, Gastropoda, Camaenidae, *Amphidromus atricallosus temasek*, new subspecies.

INTRODUCTION

The arboreal land snails of the genus *Amphidromus* Albers, 1850, are well known within Southeast Asia (Fulton, 1896; Collinge, 1903; Bartsch & Solem, 1971; Benthem-Jutting, 1949), particularly for their colourful shells and their curious dimorphic coiling (Pilsbry, 1900; Berry, 1963; Sutcharit et al., 2007; Schilthuizen & Looijestijn, 2009). Two distinct subgenera of the genus *Amphidromus* are currently recognised (Sutcharit et al., 2007; Chan & Tan, 2010), and within the respective subgenera, several species groups are known and members are characteristically similar in shell form (Pilsbry, 1900; Laidlaw & Solem, 1965). Based on locality information given in original descriptions and museum collections, many species and subspecies have been reported from West Malaysia and Singapore (Pilsbry, 1900; Berry, 1963; Laidlaw & Solem, 1961; Maassen, 2001). However, many of these records remain dubious and the taxonomic status of several species remains uncertain without reliable locality information (Laidlaw & Solem, 1961).

The recent revision of the subgenus *Amphidromus* by Sutcharit & Panha (2006) clarified some of the confusion. Four subspecies of *A. (Amphidromus) atricallosus* (Gould, 1843) with distinct shell characters and geographic distribution are currently recognized, the nominate subspecies, *A. atricallosus classarius* Sutcharit & Panha, 2006, *A. atricallosus leucoxanthus* (von Martens, 1864), and *A. atricallosus perakensis* Fulton, 1901. *Amphidromus atricallosus perakensis*, although first described from Perak, Malaysia, has been widely documented in Singapore (e.g., Ng & Lim, 1992; Chou et al., 1994; Ho, 1995 [as *A. atricallosus*]; Sutcharit & Panha, 2006; Chou & Tan, 2008). Records suggest that this subspecies is rather widespread in Peninsular Malaysia (Laidlaw & Solem, 1961; Sutcharit & Panha, 2006), but its elusiveness is illustrated by Sutcharit & Panha (2006) who mentioned the present distribution is confined to the southern part of Peninsular Malaysia and Singapore.

Recently, we had the opportunity to examine some topotypic material of *A. atricallosus perakensis* and comparison with material from Singapore revealed subtle but consistent differences in shell morphology. Additional material from

other localities in Peninsular Malaysia was obtained for examination (see **Comparative material**), and we conclude that the differences are consistent enough to recognise the *Amphidromus* from Singapore (hitherto referred to as *A. atricallosus perakensis*) as a distinct and yet undescribed subspecies. Additionally, results of recent phylogenetic studies imply that the Singapore population is not closely related to the other *A. atricallosus* subspecies (see Sutcharit et al., 2007; Prasankok et al., 2007). The description of this *Amphidromus* from Singapore as a new subspecies forms the basis of this study.

MATERIALS AND METHODS

The types are deposited in the Zoological Reference Collection (ZRC) of the Raffles Museum of Biodiversity Research, National University of Singapore, and Chulalongkorn University, Museum of Zoology (CUMZ), Bangkok, Thailand. Additional material mentioned in the text is identified by the following abbreviations: CBB (Collection of B. Boo), CSY (Collection of Chan S.-Y.), FJK (Collection of Foon J. K.), M.E. (Collection of M. E. Marzuki), TSK (Collection of Tan S. K.). Other abbreviations mentioned are: SH = shell height; SD = shell diameter; D = dextral; S = sinistral. Shell height is measured as the apex to the lowest part of the basal side of the peristome parallel to the coiling axis, and shell diameter is the widest part of the body whorl (including the lip) perpendicular to the coiling axis. Measurements were taken in mm. In lots with multiple specimens, sizes shown indicate the dimension of the smallest and largest specimens examined. Shells that have not developed the expanded and thickened outer lip are deemed juvenile (juv.), and are not taken into consideration.

TAXONOMIC ACCOUNT

CAMAENIDAE PILSBRY, 1895

Amphidromus ALBERS, 1850

Amphidromus (Amphidromus) atricallosus (Gould, 1843)

Amphidromus (Amphidromus) atricallosus temasek, new subspecies (Figs. 1A, 2A, 3A)

Amphidromus atricallosus perakensis – Ng & Lim, 1992: 262; Chou et al., 1994: 73; Sutcharit & Panha, 2006: 21–22, Fig. 4. F–G, Fig. 11. A–C, Fig. 12. C; Prasankok et al., 2007; Sutcharit et al., 2007; Chou & Tan, 2008: 57; Lok & Tan, 2008.
Amphidromus atricallosus – Ho, 1995: 108–109.

Material examined. – **SINGAPORE:** Holotype: 1 S SH 44 x SD 25.6 (ZRC.MOL.3058), Nee Soon Swamp Forest, Singapore, coll. S. K. Tan & S. Y. Chan, 03 Oct.2010. Paratypes: 2 D SH 42.7 x SD 26–SH 46.4 x SD 27.7, 2 S SH 40.1 x SD 25–SH 40.8 x SD 25.1 (ZRC.MOL.2992), Nee Soon, coll. E. Alfred; 1 D SH 46.9 x SD 28.3 (ZRC.1992.3163), Nee Soon Swamp Forest, coll.

National Park Survey, 30 Apr.1992; 1 D SH 45.0 x SD 26.4 (ZRC 1994.4118), outside Nee Soon range, Seletar Reservoir Park (NS 43), coll. H. K. Lua, 1994; 1 D (CUMZ 2133), Nee Soon Nature Reserve, coll. S. Panha, 26 Jun.1998; 2 D (CUMZ 2067), Nee Soon Nature Reserve, coll. S. Panha & Ms Loua, 19 Feb.2000; 10 D (CUMZ 2198), Nee Soon Nature Reserve, coll. S. Panha & C. Sutcharit, 19 Feb.2001; 11 D (CUMZ 2633), Nee Soon Nature Reserve, coll. S. Panha & P. Prasarnkok, 04 Mar.2004; 2 S (1 juv.) SH 43.4 x SD 26.8 (ZRC.MOL.2843), Nee Soon Swamp Forest, coll. H. H. Tan & A. F. S. L. Lok, 13 Oct.2008; 1 D (juv.) (ZRC. MOL.3059), Nee Soon Swamp Forest, coll. Y. C. Ng, Sep.2010; 1 D SH 43.5 x SD 27.1 (ZRC.MOL.3057), Nee Soon Swamp Forest, coll. S. K. Tan & S. Y. Chan, 03 Oct.2010; 1 S SH 38.9 x SD 25.1 (ZRC.MOL.3060), Nee Soon Swamp Forest, edge of swamp forest, behind Nee Soon Range, coll. P. X. Ng, B. Y. Q. Ng & C. K. Yeo, 03 Nov.2010.

Non-type material. – 3 D SH 42.1 x SD 24.9–SH 42.9 x SD 26.4 (ZRC 1989.1109–1111), no data; 10 D (9 juv.), SH 42.7 x SD 26.5 (ZRC 1989.1135–1144), no data. **SINGAPORE:** 1 D (juv.) (ZRC 1990.1528), Nee Soon, on tree along road, coll. CLM, Sep.1969; 3 S (juv.) (ZRC 1998.3373–3377), Nee Soon Swamp Forest, coll. C. M. Yang et al., 9 Sep.1988; 1 D SH 44.3 x SD 25.4 (ZRC 1990.10741), Nee Soon Swamp Forest, NW sector, in leaf litter on open scrubland, coll. K. Lim, 9 May 1990; 3 S (juv.), 2 D (broken, not measured) (ZRC.MOL.3061) Nee Soon Swamp Forest, dead on ground, coll. S. K. Tan, 2009; 2 D (juv.) (CSY 409.3.4.30), Pulau Tekong, dead on ground among low shrubs, coll. S. Y. Chan, 25 Dec. 1993; 1 S SH 43.7 x SD 26.2 (CSY 409.3.4.31), Dairy Farm, dead on road path beside forest, coll. S. Y. Chan, 25 Oct. 1994; 1 S SH 39.5 x SD 24.8, Central Catchment area, on artifact, coll. R. Koh, Apr. 1995; 1 D SH 37.4 x SD 25.1 (TSK 11017), Mandai Road Track 7, on fishtail palm, coll. S. K. Tan, 04 Apr.1999; 2 D (juv.), (ZRC.MOL.3065), Lower Peirce Reservoir, arboreal on leaves, forest edge, coll. A. F. S. L. Lok, 23 Jul.2010. **MALAYSIA:** 1 D (broken, not measured) (CSY 409.3.4.14), Gunung Ledang (Mount Ophir), Johor, dead, among leaf litter in forest, coll. S. Y. Chan et al, 13 Oct.1996.

Diagnosis. – Shell relatively large, ovate, chirally dimorphic coiling. Whorls $5\frac{1}{2}$ – $6\frac{3}{4}$, slightly convex, surface generally smooth with indistinct axial striations or growth lines. Colour uniformly yellow with a thin white subsutural line (shells of living animals yellowish-green due to the dark colouration of soft body showing through), varix always absent. Columella simple, straight. Periostracum thin, transparent. Peristome in mature animals white, thickened and expanded except for parietal side, outer lip reflected but not adnate. Parietal callus usually inconspicuous, very rarely thickened to being whitish or translucent.

Animal body very pale greyish white in colour, reticulated, the recessed parts being darker, light brown around the head to greyish on the body. Mantle edge dark cream coloured to brown around the peristome. Upper and lower tentacles dark yellow, central part of the head between the upper tentacles occasionally pigmented with yellow, foot with longitudinal yellow stripe on either side.

Distribution. – The distribution of *A. atricallosus temasek*, new subspecies, is largely confined to Singapore, and tentatively, Johor, southern Peninsular Malaysia (Sutcharit & Panha, 2006 [part]; Prasankok et al., 2007 [part]; this study). Known Singapore localities include: Seletar (Hanitsch, 1908),

Nee Soon Swamp Forest, Bukit Timah Nature Reserve, Mandai, and Pulau Tekong (Ng & Lim, 1992; Chou & Tan, 2008; Lok & Tan, 2008). Although a specimen from Johor (CSY 409.3.4.14) is provisionally determined to be this subspecies in the material examined, identification was based on a weathered and broken specimen with only the body whorl intact. Verification with better preserved material would be required. Available evidence suggests *A. atricallosus temasek* to be endemic, but this has to be verified with greater sampling effort, particularly around the

southern part of Peninsular Malaysia and the Riau islands of Indonesia. In Singapore, these arboreal snails are apparently restricted to the remnant forests. Preference for particular tree species has not been observed or reported, and the animals can be found on a wide variety of plants and on man-made structures.

Etymology. – The subspecies epithet is derived from Temasek, the historical name of the type locality Singapore. It is used as a noun in apposition.

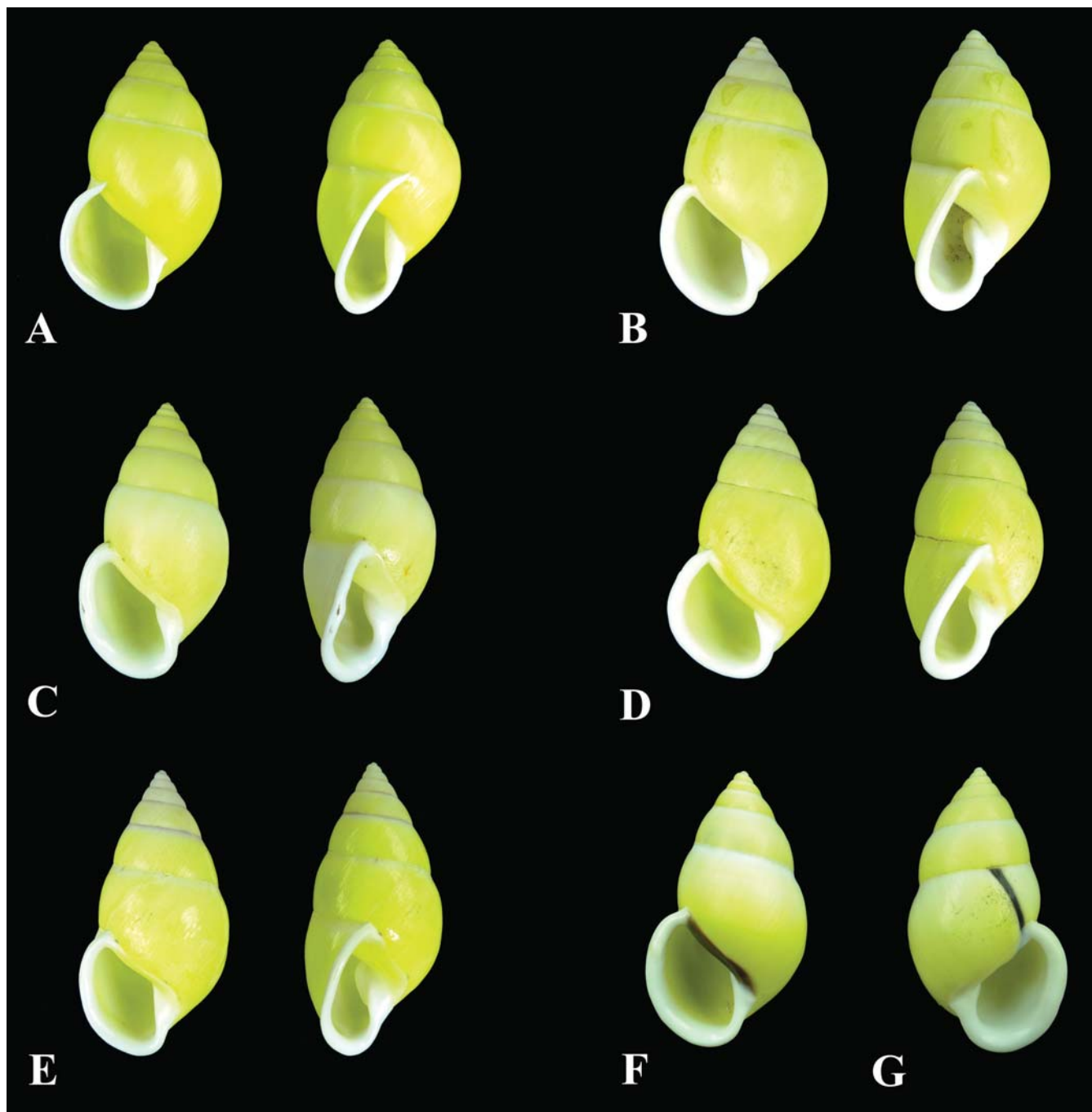


Fig. 1. **A**, *Amphidromus atricallosus temasek*, new subspecies: Holotype, SH 44 x SD 25.6 (ZRC.MOL.3058), Nee Soon Swamp Forest, Singapore; **B–E** *Amphidromus atricallosus perakensis* (Fulton, 1901): **B**, SH 45 x SD 26.4 (TSK 11041), Bukit Serdam, Pahang, West Malaysia; **C**, SH 47.1 x SD 25.3 (CBB), Tapah Hill, Perak, West Malaysia; **D**, SH 47.2 x SD 27.6 (ZRC.MOL.3064), Pulau Tulai, near Pulau Tioman, West Malaysia; **E**, SH 46.4 x SD 24.2 (ZRC.MOL.3062), Gunung Genting, Perak, West Malaysia; **F**, *Amphidromus atricallosus atricallosus* (Gould, 1843): SH 45 x SD 25.7 (CSY 409.4.4.16), Ranong, Thailand; **G**, *Amphidromus atricallosus leucoxanthus* (von Martens, 1864): SH 51 x SD 28.5 (CSY 409.3.49.1), Chantaburi, East Thailand.

Remarks. – The thin white subsutural line and simple and straight columella that is never twisted is diagnostic. Shells of juveniles can also be separated from *A. atricallosus perakensis* Fulton, 1901, by lack of a white zone around the columella (see Fig. 2). Although the convexity of the whorls of *A. atricallosus perakensis* is evidently variable throughout West Malaysia populations, shell whorls of *A. atricallosus temasek*, new subspecies, seem to be generally more convex in profile and resulting in the suture appearing more sunken in comparison. Living *A. atricallosus temasek* individuals are easily distinguished by the soft body colouration, and a pale yellowish-green shell with a thin white subsutural line (Fig. 3. A). The SEM images of the radula and genital system of *A. atricallosus temasek*, new subspecies, are described in detail and figured in Sutcharit & Panha (2006, as *A. (A.) atricallosus perakensis* [CUMZ 2198; herein designated paratypes]; radula, pg. 16: Fig. 11A–C; genital system, pg. 17: Fig. 12C).

DISCUSSION

Amphidromus atricallosus temasek, new subspecies, is most similar in shell morphology to *A. atricallosus perakensis* Fulton, 1901, which it has been hitherto confused with. *Amphidromus atricallosus perakensis* was first described as a distinct species based on the characteristic twisted plait of the columella (Fulton, 1901; Collinge, 1903; Laidlaw, 1933; Benthem-Jutting, 1949). Laidlaw & Solem (1961) and Solem (1965) regarded *perakensis* as a mere form of *A. atricallosus* which was described briefly in Gould, 1843, and more fully described and figured in Gould, 1844, which additionally mentioned a specimen without the dark parietal callus as possibly coming from Singapore. Current consensus recognises *perakensis* as a valid subspecies (Maassen, 2001; Sutcharit & Panha, 2006; Sutcharit et al., 2007; Prasankok et al., 2007; Lok & Tan, 2008). *Amphidromus atricallosus temasek*, new subspecies, is allopatric with the other recognised subspecies and with respective distinct shell characters, confusion is unlikely. *Amphidromus atricallosus atricallosus* (Gould, 1843), is characterised by its slightly flattened whorls, and a dark brown to black parietal callus (Fig. 1. F). *Amphidromus atricallosus classarius* Sutcharit

& Panha, 2006, is endemic to Koh Tachai, off Pangnga, in the Andaman Sea and is similar to the nominotypical subspecies, but can be separated by its consistently smaller size and being invariably sinistral. *Amphidromus atricallosus leucoxanthus* (von Martens, 1864), is also similar in shell form to the nominotypical subspecies, but differs by the lack of a darkened parietal callus (Fig. 1. G) and its colour varies from yellowish to white shells with brown streaks which is also called form *laidlawi* Solem, 1965. And except for *A. atricallosus perakensis*, one or more varices are usually present in shells of the other subspecies (e.g., Fig. 1. G). For details, see Sutcharit & Panha (2006).

Fulton (1901) who had numerous specimens (50 D, 48 S) remarked that the columellar character is constant in all examined specimens. However, Sutcharit & Panha (2006) observed that the columella varies from simple and straight to strong and folded, apparently based on insufficient material and the assumption that material examined, including lectotype and paralectotype of *A. perakensis*, and recent material from Pulau Tulai and Singapore, are conspecific. None of the *A. atricallosus temasek* examined in this study has a twisted columella. Very rarely, the columella may appear slightly curved, but is never twisted or developed into a plate. Conversely, the columella is rather consistently twisted in the examined specimens from various Malaysian localities (see **Comparative material**). Fulton (1901) also noted that the extent of this character is variable, from rather inconspicuous to forming a plate-like projection or tooth in many, presumably mature, individuals. Nevertheless, even in specimens without a significant plait in the columella, the slight twist often forms a shallow groove at the parietal side which is not seen in *A. atricallosus temasek*. Thus even when the variables are considered, we concur with Fulton (1901) that this character is generally consistent for *A. atricallosus perakensis* (see Fig. 1).

The thin white subsutural line of *A. atricallosus temasek* is distinctive. Shells from Malaysian localities, with the exception of Pulau Tulai, have a broader white subsutural band that diffuses into the yellow part of the shell. The Pulau Tulai population is problematic because the subsutural band is barely discernible in most of the examined specimens

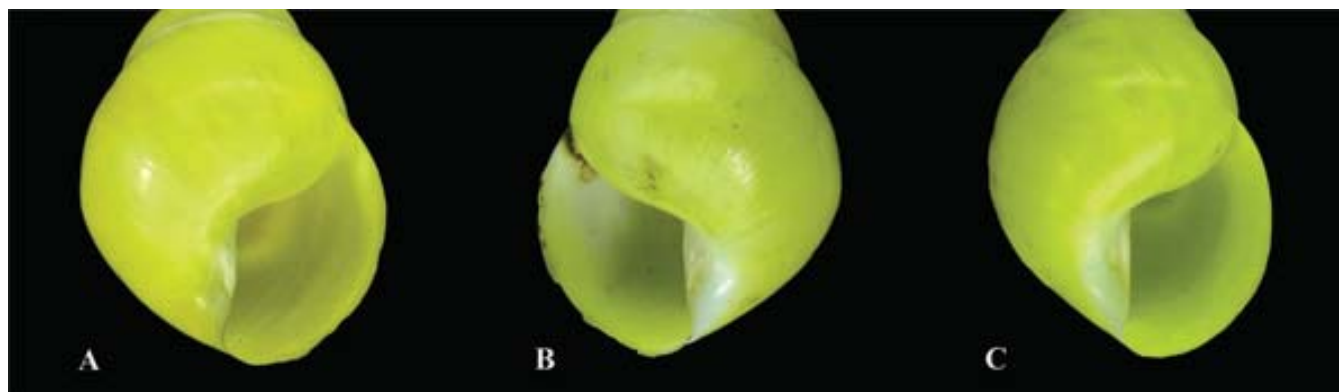


Fig. 2. A–C, Shells of juveniles: A, SH 31 x SD 19.7, juvenile shell of *Amphidromus atricallosus temasek*, new subspecies, showing the white columella; B–C, *Amphidromus atricallosus perakensis* (Fulton, 1901), juveniles, has a white zone bordering the columella: B, SH 33.9 x SD 22.4, Tapah Hill, Perak, West Malaysia; C, SH 34.7 x SD 25, Pulau Tulai, West Malaysia.

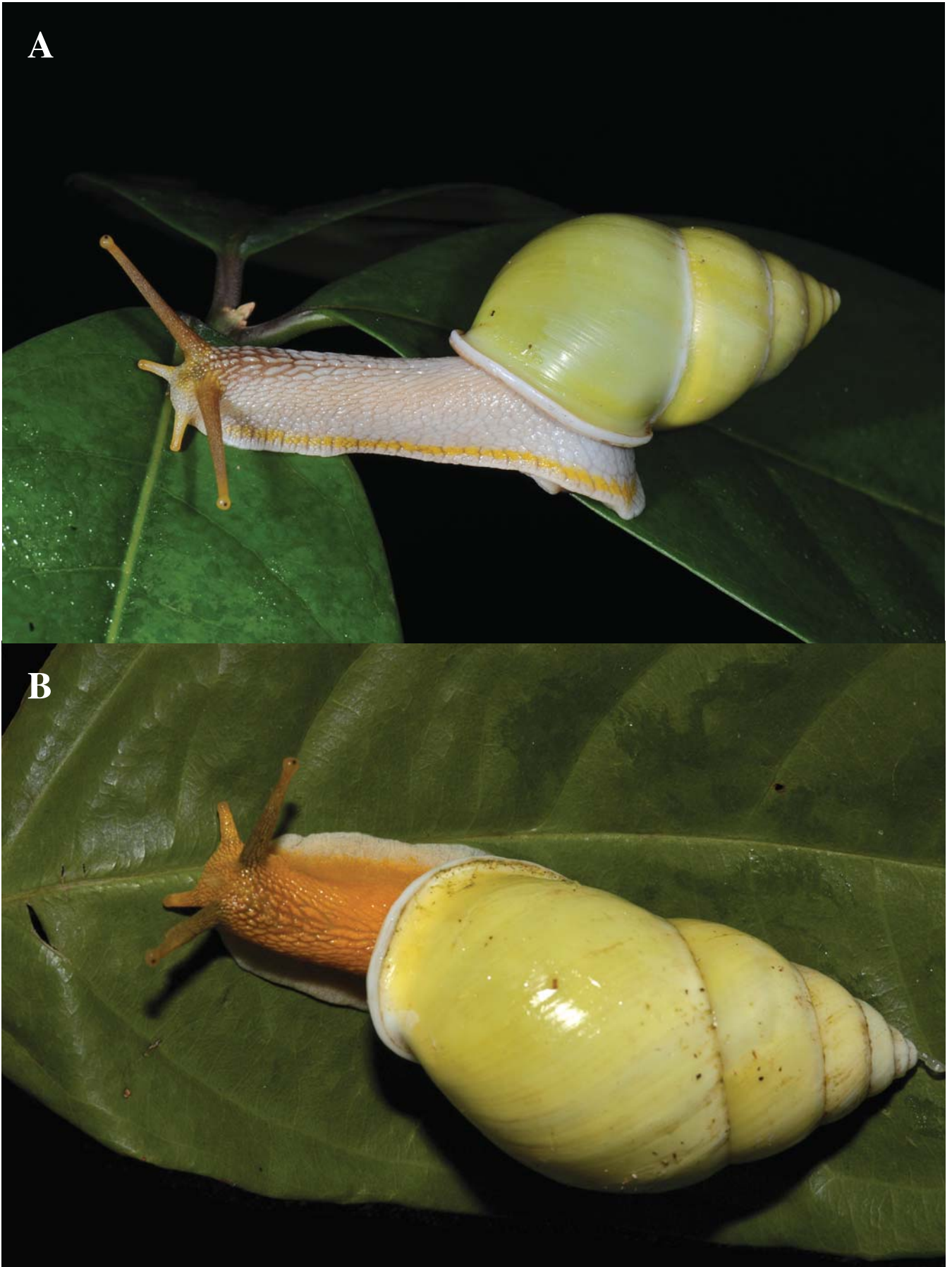


Fig. 3. **A–B**, Live animal colouration: **A**, *Amphidromus atricallosus temasek*, new subspecies, holotype (ZRC.MOL.3058); **B**, *Amphidromus atricallosus perakensis* (Fulton, 1901), Pulau Tulai, West Malaysia. (Photographs by Tan Heok Hui)

although it is broad where present and other characters suggest affinity with typical *A. atricallosus perakensis*. It is possible that we are dealing with a separate or incipient subspecies here. A number of specimens from the more northerly states of Peninsular Malaysia have a brown line at the suture on early whorls (e.g., Fig. 1. E), but this appears to have no taxonomic bearing as the character is inconstant. The white subsutural line of *A. atricallosus temasek* is however, of little use when examining eroded or weathered shells.

The shells of live *A. atricallosus temasek* appear green, and it is often known by the common name of green land snail or green tree snail in Singapore (Ng & Lim, 1992; Chou & Tan, 2008; Lok & Tan, 2008). In comparison, shells of *A. atricallosus perakensis* from Pahang, and Pulau Tulai, except for juveniles, do not appear as greenish while alive. And even though empty shells are invariably yellow, *A. atricallosus temasek* is by and large a deeper shade of yellow (very pale ochre yellow versus pale sulphur yellow of typical *A. atricallosus perakensis*). Differences in colour and tone of the shells on living snails and empty shells between *A. atricallosus temasek* and *A. atricallosus perakensis* are likely due to shells of the former being thinner. The soft body colouration also shows remarkable differences. The mantle edge of *A. atricallosus temasek* is cream coloured to brown, whilst it is orange in animals from Bukit Serdam and Pulau Tulai, Pahang. However, the body of the Pulau Tulai animals is almost entirely orange, while the Bukit Serdam animals have an orange head and stripe on either side of the foot, the other parts being milky white in colour. Photographs of animals from Perak showed a similarly patterned animal with much lighter colouration (light yellow instead of orange) and with very faint, almost non-existent, yellow longitudinal stripe, but otherwise similar to the Pahang animals. The implications and full extent of inter-population variations regarding soft body colouration is not understood, and at this stage inconclusive. Nevertheless, the typical colouration of the animals of *A. atricallosus temasek* is distinct from those of any Malaysian population that we have observed thus far.

Probably due to the lack of prominent or distinctive morphological features, the number of accepted subspecies in the genus *Amphidromus* is relatively high and the prevailing tendency is to apply subspecies conservatively in spite of consistent morphological differences and allopatric distribution. But despite the superficial similarities in shell form and colour, *A. atricallosus temasek* is ostensibly not closely affiliated with the other recognised *A. atricallosus* subspecies. Recent studies on molecular phylogeny and allozyme analyses suggest significant genetic discontinuity (see Sutcharit et al., 2007; Prasankok et al., 2007). The same studies also suggest that one or more of the presently recognised subspecies, including the population from Singapore (as *A. atricallosus perakensis*), might be valid full species, and the morphological differences mentioned in this study can probably be ascribed to allopatric speciation. Until in-depth phylogenetic revisions of the genus or family are conducted, *A. atricallosus temasek* is here conservatively regarded a subspecies since it has been unanimously regarded

as a member of the *A. atricallosus* group (Maassen, 2001; Sutcharit & Panha, 2006; Prasankok et al., 2007; Lok & Tan, 2008).

Comparative material. – *Amphidromus* (*Amphidromus*) *atricallosus perakensis* Fulton, 1901. 1 D (ZRC 1989.1108), SH 51.7 x SD 29.5, no data. **WEST MALAYSIA. Perlis:** 1 D (broken, not measured) (CSY 409.3.4.11), Bukit Keteri (Twin Peaks), near a cement factory, Chuping Mukim, dead collected at foot of limestone hill, coll. S. Y. Chan & L. Nguang, 27 Apr.1996; **Kedah:** 1 D SH 53.4 x SD 29.5, 1 S SH 50.5 x SD 30.9 (ZRC 1990.10272–10273), Pulau Langkawi, coll. 1968; **Perak:** 1 D SH 48.8 x SD 26.8 (ZRC 1975.4.2.10), Sungai Siput, Perak, coll. 1936; 3 D SH 47.2 x SD 23.8–SH 50.7 x SD 28 (ZRC 1975.4.2.14–16), Gapis; 18 D (all broken, not measured) (CSY 409.3.4.6), Sungei Kuala Lipang (Chinese cave temple, ‘Kwang Yin Tong’) about 9 km NNE of Kampar town, Sungei Siput Selatan, Kinta District, dead collected in limestone rock crevices and forest debris bordering foot of hill, coll. S. Y. Chan et al, 28 Dec.1995; 1 S SH 52.6 x SD 25.8, 1 D (juv.) (CSY 409.3.4.7), Gunung Terendum (Chinese cave temple, ‘Wan Shi Kong’), about 9 km SSE of Ipoh City, road to Kramat from Gopeng Town towards Pahang border, Kinta District, dead collected at base and slopes of the limestone hill, coll. S. Y. Chan et al, 22 Feb.1996; 4 D SH 50.5 x SD 27.9–SH 51.8 x SD 28.2, 11 S (2 juv.) SH 48.8 x SD 27.5–SH 51.4 x SD 28 (CBB), Tapah Hill, on tree trunks, coll. M. Yeh, 1998; 3 D SH 48.5 x SD 26.2, SH 53.0 x SD 28.3, SH 55.3 x SD 29.8, 1 S SH 47.7 x SD 24.7 (CSY 409.3.4.23), same data as previous; 8 D SH 47.1 x SD 26.8–SH 55.5 x SD 28.3, 7 S SH 45.5 x SD 24.5–SH 54.9 x SD 28.8 (CSY 409.3.4.32), Kuala Woh Recreation Park, Perak, on tree trunks, coll. M. Yeh, 1998; 3 S (2 juv.) SH 46 x SD 24, 3 D (fragments, not measured) (FJK CAM 0006), Gua Tempurung, Gunung Tempurung, Dead and scattered around base of a tree beside a limestone cliff, coll. J. K. Foon, 12 Aug.2005; 2 S (1 juv.) SH 50 x SD 28, 2 D (1 juv.) SH 47 x 26 (FJK CAM 0004), Kampung Ulu Geroh (Orang Asli village), Gopeng, on concrete lamp post early morning after rain, coll. J. K. Foon, Sep.2007; 1 S SH 46.4 x SD 24.2 (ZRC.MOL.3062 [ex CUMZ]), Gunung Genting, on tree near road from Ipoh town to Tanjung Rambutan, 27 Sep.2007; 1 S SH 49.7 x SD 24.5, 2 D SH 43.9 x SD 23–SH 48.4 x SD 26.5 (both with apex broken) (ZRC.MOL.3063 [ex CUMZ]), Gunung Genting, Ipoh, dead on ground and rock, 27 Sep.2007; **Kelantan:** 1 S SH 49.3 x SD 26.4 (ZRC 1975.4.2.8–9), Batu Tongkat, coll. M. W. F. Tweedie, 5 Sep.1939; 1 D (broken, not measured) (CSY 409.3.4.29), dead collected, coll. G. Davison, 1990; 1 S (apex broken, not measured) (FJK CAM 0025), Orang Asli Village, Kampung Jidim, Lojing Highlands, along an Orang Asli trail, coll. J. K. Foon, 24 Dec.2005; 1 D SD 23.3 (apex broken) (M.E.2009/0205), Gua Musang, dead in cave floor, coll. M. E. Marzuki, 19 May 2009; 1 S SH 50.05 x SD 23.3 (M.E.2010/0149), FELDA Ciku 4, dead on forest floor at foot of limestone hill, coll. M. E. Marzuki, 17 Feb.2010; **Pahang:** 1 S SH 54.3 x SD 26.1 (ZRC 1975.4.2.12), Bukit Chintamani, coll. 1935; 1 S SH 50.4 x SD 24.8 (ZRC 1975.4.2.11), Sungai Telom, Kuala Terla, coll. 1935; 1 D SH 51.2 x SD 29.2 (apex broken)

(ZRC), Kuala Tahan, coll. E. R. Alfred; 1 S (broken, not measured) (CSY 409.3.4.18), Bukit Chintamani, at foot of limestone hill, in banana plantation, coll. S. Y. Chan et al, 03 Jan.1997; 2 S SH 38.2 x SD 22.9, SH 35.9 x SD 23.0 (CSY 409.3.4.28), near Bera, on ground (dead) in the forest; 4 S SH 36.7 x SD 22.5–SH 40.8 x SD 23.9, 4 D SH 36.4 x 22.7–SH 41.8 x 22.5, same data as last; 1 S SH 46.9 x SD 24.1 (CSY 409.3.4.20), Bukit Serdam, dead on forest floor, coll. S. Y. Chan et al, 03 Jan.1997; 1 S (juv.) (CSY 409.3.4.33), Kota Gelanggi, dead on forest floor beside hill, coll. S. Y. Chan et al, 25 May 1997; 8 D SH 48.0 x SD 25.8 – SH 51.2 x SD 30.3, 7 S SH 46.7 x SD 27.4 – SH 52.7 x SD 27.5 (CSY 409.3.4.22), Bukit Serdam, Raub District, live collected, on trees next to limestone hill (Bukit Serdam), coll. S. Y. Chan et al, 06 May 2001; 1 D SH 51.8 x SD 30.7, 1 S SH 45 x SD 26.4 (TSK 11041), same data as last; 2 S SH 46.8 x SD 25.0, SH 48.0 x SD 24.7 (CSY 409.3.4.24), Cameron Highlands, coll. H. E. Ng, 28 Jan. 2003; 2 S (broken, not measured) (FKJ CAM 0005), Dusun Eco Resort (between Bukit Tinggi and Bentong, along the <E8> Karak Highway), Bentong, Pahang, long dead specimens collected on forest floor, coll. J. K. Foon, 14 Dec.2005; 1 S SH 48.0 x SD 25.7 (M.E.2009/0030), Gunung Jebak Puyuh, dead on forest floor, coll. M. E. Marzuki, 22 Mar. 2009; 1 D SH 48.1 x 24.9 (M.E.2010/0287), Bukit Mengabor, dead on forest floor at foot of limestone hill, coll. M. E. Marzuki, 21 Feb.2010; 1 S (broken, not measured) (M.E.2010/0035), Bukit Kilat, dead on forest floor at foot of limestone hill, coll. M. E. Marzuki, 16 Feb.2010; 1 D SH 50.3 x SD 26.4 (M.E.2010/0065), Bukit Keling, dead on forest floor at foot of limestone hill, coll. M. E. Marzuki, 16 Feb.2010; 5 S (2 S broken; 1 S juv.) SH 44 x SD 25–SH 46 x SD 26 (FJK CAM 0022), Kampung Salang, Pulau Tioman, long dead specimens collected in cleared coastal bushland, coll. J. K. Foon, 16 Mar.2009; 1 S, SH 47.2 x SD 27.6 (ZRC. MOL.3064), Pulau Tulai, off Pulau Tioman, coll. P. K. L. Ng, 23 Aug.2003; 3 D (1 juv.) SH 44.7 x SD 26–SH 47.5 x SD 27.1, 4 S SH 44.5 x SD 27.9–SH 47.2 x SD 27.6 (ZRC. MOL.86), Pulau Tulai, off Pulau Tioman, coll. P. K. L. Ng et al., 23 Aug.2003; **Negri Sembilan**: 1 D SH 49.4 x SD 28.1 (ZRC 1975.4.3.2.13), Bukit Tangga.

ACKNOWLEDGEMENTS

We would like to thank P. K. L. Ng for advice and important discussions, and also for suggesting the epithet. Ang W. F., B. Boo, B. Dharma, Foon, J. K., A. Lok, Lua H. K., M. E. Marzuki, B. Ng, Ng. P. X., Ng H. E., L. Nguang, Tan H. H., Teo S., M. Yeh, and Yeo C. K. are gratefully acknowledged for their generosity and help with information and specimens. We would also like to thank M. Low for help with literature, and Tan H. H. for photographs of the live snails. Comments and suggestions from the anonymous reviewers improved this article.

LITERATURE CITED

- Albers, J. C., 1850. *Die Heliceen, nach natürlicher Verwandtschaft systematisch geordnet*. Verlag Theodor Christian Friedrich Enslin, Berlin. 262 pp.
- Bartsch, P. F. & A. Solem, 1971. Notes on a collection of non-marine Mollusca from Pulau Aur, an island off the east coast of Malaya. *Federation Museums Journal*, **16**: 91–95.
- Bentham-Jutting, W. S. S. van, 1949. On a collection of non-marine Mollusca from Malaya in the Raffles Museum, Singapore, with an appendix on cave shells. *Bulletin of the Raffles Museum*, **19**: 50–77.
- Berry, A. J., 1963. An introduction to the non-marine Molluscs of Malaya. *Malayan Nature Journal*, **17**: 1–17.
- Chan, S. Y. & S. K. Tan, 2010. On two new species of *Amphidromus* (Gastropoda: Camaenidae) from the Lesser Sunda Islands, Indonesia. *Raffles Bulletin of Zoology*, **58**(2): 245–249.
- Chou, L. M., P. K. L. Ng & K. K. P. Lim, 1994. Animalia. In: Wee, Y. C. & P. K. L. Ng (eds.), *A First Look at the Biodiversity in Singapore*. National Council on the Environment, Singapore. Pp 70–106.
- Chou, L. M. & K. S. Tan, 2008. Fauna: invertebrates. Corals, worms and molluscs. In: Davison, G. W. H, P. K. L. Ng & H. C. Ho (eds.), *The Singapore Red Data Book: Threatened Plants and Animals of Singapore. 2nd Edition*. The Nature Society (Singapore), Singapore. Pp. 39–61.
- Collinge, W. E., 1903. Report on the non-operculate land Mollusca. *Fasciculi Malayenses, Zoology*, **2**: 205–218.
- Fulton, H., 1896. A list of the species of *Amphidromus*, Albers, with critical notes and descriptions of some hitherto undescribed species and varieties. *Annals and Magazine of Natural History*, Series 6, **17**: 66–93, Pls. V–VII.
- Fulton, H., 1901. Descriptions of new species of *Xesta*, *Amphidromus* and *Cyclostoma* from Madagascar and Perak. *Journal of Malacology*, **8**: 103–104, Pl. IX.
- Gould, A. A., 1843. [S]hells not long since announced as having been received from Rev. Francis Mason, missionary at Tavoy, in British Burmah. In: Regular meeting—Dr. C. T Jackson, Vice-President, in the Chair. September 6th, 1843. *Proceedings of the Boston Society of Natural History*, **1**: 139–141.
- Gould, A. A., 1844. Descriptions of land shells from the province of Tavoy, in British Burmah. *Proceedings of the Boston Society of Natural History*, **4**: 452–459.
- Hanitsch, R., 1908. *Guide to the Zoological Collections of the Raffles Museum, Singapore*. Straits Times Press, Limited, Singapore. 21 pls + 112 pp.
- Ho, W. H., 1995. A Review of the Land-snail Fauna of Singapore. *Raffles Bulletin of Zoology*, **43**(1): 91–113.
- Laidlaw, F. F., 1933. A list of the land and freshwater Mollusca of the Malay Peninsula. Part 2 (Land Mollusca, Pulmonata). *Journal of the Malayan Branch Royal Asiatic Society*, **11**(2): 211–234.
- Laidlaw, F. F. & A. Solem, 1961. The land snail Genus *Amphidromus*. A synoptic catalogue. *Fieldiana: Zoology*, **41**(4): 505–677.
- Lok, A. F. S. L. & S. K. Tan, 2008. A review of the Singapore status of the green tree snail, *Amphidromus atricallosus perakensis* Fulton, 1901 and its biology. *Nature in Singapore*, **1**: 225–230.
- Maassen, W. J. M., 2001. A preliminary checklist of the non-marine molluscs of West-Malaysia. “A handlist”. *De Kreukel*, Extra Editie **2001**: 1–155.
- Martens, E. von, 1864. Diagnosen neuer Heliceen aus dem ostasiatischen Archipel. *Monatsberichte der Königlichen Preussischen Akademien der Wissenschaften zu Berlin*, **1861**: 523–529.

- Ng, P. K. L. & K. K. P. Lim, 1992. The conservation of the Nee Soon freshwater swamp forest of Singapore. *Aquatic Conservation: Marine and Freshwater Ecosystems*, **2**(3): 255–266.
- Pilsbry, H. A. 1895. *Manual of Conchology*. Second Series: Pulmonata, Volume 9. Academy of Natural Sciences Philadelphia. i–xlviii + 366 pp, 71 pls.
- Pilsbry, H. A. 1900. *Manual of Conchology*. Second Series: Pulmonata, Volume 13. Academy of Natural Sciences Philadelphia. 253 pp., 72 pls.
- Prasankok, P., H. Ota, M. Toda & S. Panha, 2007. Allozyme variation in the Camaenid tree snails *Amphidromus atricallosus* (Gould, 1843) and *A. inversus* (Müller, 1774). *Zoological Science*, **24**: 189–197.
- Schilthuizen, M. & S. Looijestijn, 2009. The sexology of the chirally dimorphic snail species *Amphidromus inversus* (Gastropoda: Camaenidae). *Malacologia*, **51**(2): 379–387.
- Solem, A. 1965. Land snails of the Genus *Amphidromus* from Thailand (Mollusca: Pulmonata: Camaenidae). *Proceedings of the United States National Museum*, **117**(3519): 615–627.
- Sutcharit, C. & S. Panha, 2006. Taxonomic review of the tree snail *Amphidromus* Albers, 1850 (Pulmonata: Camaenidae) in Thailand and adjacent areas: Subgenus *Amphidromus*. *Journal of Molluscan Studies*, **72**: 1–30.
- Sutcharit, C., T. Asami & S. Panha, 2007. Evolution of whole-body enantiomorphy in the tree snail genus *Amphidromus*. *Journal of Evolutionary Biology*, **20**(2): 661–672.