

## A REVIEW OF THE SINGAPORE STATUS OF THE GREEN TREE SNAIL, *AMPHIDROMUS ATRICALLOSUS PERAKENSIS* FULTON, 1901 AND ITS BIOLOGY

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### INTRODUCTION

The genus *Amphidromus* belongs to the phylum Mollusca, order Stylommatophora and family Camaenidae (Sutcharit et. al., 2007), although it was inexplicably placed in the family Amphidromidae by Chou et. al. (1994). *Amphidromus* is a genus of arboreal (tree-dwelling) snails that occurs from the Garo and Khasi Hills in India, Myanmar, Peninsular Malaysia, Thailand, Laos, Cambodia, Vietnam, Indonesia as far east as the Celebes, Banda Islands, Timor and the Tanimbar Islands but not on Ceram, Buru, Halmahera, Batjan Island, the Obi Islands, the Aru and Kei Islands and in the southern Philippine Islands of Mindanao and the Balabac-Palawan chain (Laidlaw & Solem, 1961). As in most arboreal snails, the shells are strongly coloured yellow, red, orange, green with elegant patterns of bands or “flames” in contrasting colours (Lim, 1970) and are relatively large, from 25–75 mm high (Laidlaw and Solem, 1961). Over 300 nominal species and subspecies have been proposed, but only 85 remain, and these still require close scrutiny using biological and molecule approaches (Sutcharit et. al., 2007).

The genus is currently divided into two subgenera, *Amphidromus* (*Amphidromus*) and *Amphidromus* (*Syndromus*), which are distinct in shell size, colour pattern and genital morphology (Sutcharit et. al., 2007). The subgenus *Amphidromus* has a larger shell (35–75 mm high and 20–40 mm wide) and has a long epiphallic caecum, whereas the subgenus *Syndromus* has a smaller shell (20–40mm high and 10–25mm wide) and has a short epiphallic caecum (Sutcharit et. al., 2007).

Enantiomorphy (left to right polarity development) is a condition that is absent in most snail populations but seem to be especially persistent in many species of *Amphidromus* (Sutcharit et. al., 2007). In fact the name *Amphidromus* bears witness to the curious circumstance that many of its species have individuals in a population, which are either dextral (clockwise spiraling of the shell from the apex to the aperture) (Fig. 1) or sinistral (anti-clockwise spiraling of the shell from the apex to the aperture) (Figs. 2–5) (Pilsbry, 1900). This is unusual because enantiomorphy is seldom found within populations of snails, because copulation between sinistral and dextral individuals is physically difficult, as the genital openings are on different sides of the shell and further away from each other (Sutcharit et. al., 2007). The subgenus *Amphidromus* contains 32 species that are predominantly dimorphic for chirality with the exception of four dextral taxa (*Amphidromus givenchy*, *Amphidromus protania*, *schomburgki dextrochlorus* and *Amphidromus inversus annamiticus*) and one sinistral taxon (*Amphidromus atricallosus classiaris*), whereas the subgenus *Syndromus* includes all 44 sinistral species with one enantiomorphic species, *Amphidromus glaucolarynx* (Sutcharit et. al., 2007) and one dextral species *Amphidromus kuehni* (Laidlaw & Solem, 1961).

Five species and subspecies of the subgenus *Amphidromus* were reported from Singapore and they are *Amphidromus atricallosus perakensis*, *Amphidromus comes*, *Amphidromus inversus inversus*, *Amphidromus mundus*, *Amphidromus perversus melanoma* (Pilsbry, 1900; Laidlaw & Solem, 1961; Maasen, 2001). *Amphidromus* (*Syndromus*) *laevus* was also reported from Singapore (Laidlaw & Solem, 1961), but this is probably erroneous as the species is currently known only from the islands of the Maluku region in Indonesia. The taxon highlighted in this paper is *Amphidromus atricallosus perakensis* which is found only in Singapore and Peninsular Malaysia (Sutcharit & Panha, 2006) and was previously listed as nationally critically endangered, and is supposedly reported only from Nee Soon Swamp Forest (Ng & Lim, 1992; Chou et. al., 1994), but its status has since been revised to nationally endangered (Chou & Tan, 2008b). Threats to *Amphidromus atricallosus perakensis* include forest clearance and indiscriminate collecting by shell collectors (Chou & Tan, 2008a). In this article, we will look at the biology of other tree snail species, in an attempt to better understand the biology of *Amphidromus atricallosus perakensis*, of which very little is known. We will also look at the current known distribution of *Amphidromus atricallosus perakensis* in Singapore, and draw conclusions as to whether this taxon should really still be considered endangered or if it is just an elusive taxon that is more abundant than what was previously thought.

## SPECIMEN DETAILS

*Amphidromus atricallosus* is divided into four subspecies; *Amphidromus atricallosus atricallosus*, *Amphidromus atricallosus classiarus*, *Amphidromus atricallosus leucoxanthus* and *Amphidromus atricallosus perakensis*. The differences between the subspecies are highlighted in Table 1.

*Amphidromus atricallosus perakensis* are enantiomorphic with dextral and sinistral shells, that are high conical with a pointed but not sharp apex (Figs. 2 & 3). The shell is also polished light yellow sometimes mixed with patches of white although living specimens appear light mint green owing to the colour of the animal's body darkening the shell. The shell also has shallow sutures and a white subsutural zone (Fig. 2) lacking darkened callus. The aperture is oblique with a thick, reflected lip (Figs. 2 & 3). The juveniles are also differentiated from the adults in that they have more angular shells with a sharp and thin outer lip without thickening (Figs. 4 & 5).

Table 1. The distribution and differences between *Amphidromus atricallosus* subspecies (after Laidlaw & Solem, 1961; Sutcharit & Panha, 2006).

Subspecies	Distribution	Diagnostic features
<i>Amphidromus atricallosus atricallosus</i>	Myanmar, Cambodia, Thailand, Peninsular Malaysia	Shell colour yellow or white, similar to <i>Amphidromus atricallosus perakensis</i> , but having broader subsutural bands and distinct black to brown parietal calluses. Body whorl or earlier whorls usually interrupted by dark varices. Some juveniles have a reddish-brown spiral band at the periphery of their shells.
<i>Amphidromus atricallosus classiarus</i>	Known only from Koh Tachai, Andaman Sea (off Phangnga province)	Shells invariably sinistral, whorls relatively convex, suture depressed, and smaller compared to the other three subspecies. Similarly coloured to <i>Amphidromus atricallosus perakensis</i> but differs in having a straight columella and dark axial varices.
<i>Amphidromus atricallosus leucoxanthus</i>	Eastern Thailand, Cambodia	Shells variably yellow, white, or with crowded brown streaks (form <i>laidlawi</i> ), with yellow being most common followed by white and lastly brown. Parietal callus white as in <i>Amphidromus atricallosus perakensis</i> , and dark varices are present as in <i>Amphidromus atricallosus atricallosus</i> .
<i>Amphidromus atricallosus perakensis</i>	Peninsular Malaysia, Singapore	Shell usually yellow with a white narrow subsutural band, but white shells are known to occur. Parietal callus white or transparent, lacking axial bands (varices) on the whorls that are present in the other three subspecies.

Information concerning the ecology of *Amphidromus atricallosus perakensis* is almost non-existent. We do know that they are arboreal snails that spend much of their time in shrubs or trees. In Singapore, they are reported to occur only in the Nee Soon Swamp Forest (Ng & Lim, 1992) and can sometimes be seen grazing on concrete structures (Fig. 1).

This initial report by Ng & Lim (1992) of *Amphidromus atricallosus perakensis* as being restricted to the Nee Soon Swamp Forest is outdated and has since been found on numerous occasions at many other localities (Table 2) in our nature reserves where there is older or less disturbed forest and on Pulau Tekong. This suggests that *Amphidromus atricallosus perakensis* has a wider distribution in Singapore than previously thought, but because they are found in trees, usually escape detection.

Table 2. Localities of *Amphidromus atricallosus perakensis* in Singapore.

Observer	Location	Population Chirality	Date
Chan Sow Yan	Dairy Farm, Bukit Timah Nature Reserve	Sinistral	18 Apr.1993
Chan Sow Yan	Pulau Tekong	Dextral and sinistral	25 Dec.1993
Tan Siong Kiat	Mandai Road (near arboreal on fishtail palm)	dextral	4 Apr.1999
Tan Siong Kiat	Nee Soon Swamp Forest, on pipeline	Dextral and sinistral	29 May 1999
Tan Siong Kiat	Nee Soon Swamp Forest, on tree trunk along unnamed trail about 100 m from pipeline	Dextral and sinistral	15 Oct.2000
Tan Siong Kiat	Nee Soon Swamp Forest, on pipeline	Dextral and sinistral	02 Jan.2006
Norman Lim T-Lon and Kelvin Lim Kok Peng	Pulau Tekong	Dextral and sinistral	1 Aug.2006
Tan Siong Kiat	Dairy Farm, Bukit Timah Nature Reserve	Sinistral	28 Sep.2008



Fig. 1. *Amphidromus atricallosus perakensis* found in a crevice on a concrete structure in the Central Catchment Nature Reserve (Photograph by: Tan Heok Hui).



Fig. 2. Dorsal view of an adult Scale bar = 1 cm.



Fig. 3. Ventral view of an adult Scale bar = 1 cm.



Fig. 4. Adult showing a rounded shell. Scale bar = 1 cm.



Fig. 5. Juvenile showing a more angular shell. Scale bar = 5 mm.

Feeding information for *Amphidromus atricallosus perakensis* is not available but we speculate that their diet is similar to other genera of tree snails. The genus *Achatinella*, which is found on Oahu Island (Hawaii), feeds on fungi growing on leaves (Nelson et. al., 2004), the genus *Partula*, found on many South Pacific islands, feeds on microscopic algae found on the larger plants (Dollinger & Gesser, 2008) while the genus *Papustyla*, from Manus Island (Papuan New Guinea), feeds mainly on lichens and fungi growing on trees (Miller et. al., 1999). In Singapore *Amphidromus atricallosus perakensis* is often seen grazing on the concrete structures and on forest tree leaves, leading us to believe that these snails feed on microscopic flora such as fungal mats, lichens, or algal epiphylls.

The natural enemies of *Amphidromus atricallosus perakensis* are poorly characterised, except for a report by Wee (2006) of a *Megalaima rafflesii* (red-crowned barbet) seen at Upper Peirce Reservoir forest feeding on an *Amphidromus* sp. (identified by Leong Tzi Ming). Other possible predators of *Amphidromus* species include rodents, and *Amphidromus inversus* shell remains have been found in a rat mitten in Kapas Island, Malaysia (Schilthuizen et. al., 2007). Numerous shell fragments of *Amphidromus atricallosus perakensis* have been found at the Diary Farm area in the Bukit Timah Nature Reserve (BTNR), scattered at defined localities on the forest floor (S. Y. Chan, pers. comm.; S. K. Tan, pers. obs.). We are not sure what are preying upon these snails but it is possible that they were eaten by birds.

Information on reproduction for *Amphidromus atricallosus perakensis* is also not available although the breeding of a few other *Amphidromus* species are available. There are two mating orientations in *Amphidromus* species depending on their subgenus and chiral morphism. Members of the subgenus *Amphidromus*, which *Amphidromus atricallosus perakensis* belongs to, generally have a longer epiphallic caecum, which allows mating between enantiomorphs (Sutcharit et. al., 2007). In the subgenus *Amphidromus*, copulation between enantiomorphs occurs with the sinistral snail to the left of the dextral snail, with both individual facing up the tree (Sutcharit et. al., 2007). This type of mating has been observed in both *Amphidromus atricallosus* and *Amphidromus inversus albulus* (Sutcharit et. al., 2007). In the subgenus *Syndromus*, where populations are chirally monomorphic, copulation occurs with the two individual tightly together (Sutcharit et. al., 2007).

To date, the egg laying habits of *Amphidromus atricallosus perakensis* have not been observed, although egg-laying accounts of other species have been made. *Amphidromus palaceus* var. *pura* was observed at Palimanan, Java, Indonesia to have made a nest by folding the exterior leaves of a young bamboo shoot and gumming them together into

a pointed cornet. The shoot hung vertically with the narrow end pointing upward and the wide opening below. The upper part of the sack was filled with eggs when collected. The snail was observed descending slowly, rotating around its longitudinal axis, and deposited eggs until the entire cavity was filled. If a crack in the basket exposed eggs to the air, they quickly dried up. Two days after capture, egg-laying was finished and the snail closed the opening by folding over more leaves. The total egg-laying process probably took four days since the cavity was half-filled at the start of the observations. The second nest was similarly folded, except that it was constructed of *Mangifera* species leaves and contained 234 eggs. The volume of eggs in each case greatly exceeded the size of the snail, indicating that the eggs must have only been encapsulated before deposition. The capsules were very thin and dried quickly upon exposure to the air. The breeding period of this species was reported to be in Oct., and marked the start of the rainy season. The coincidence with the rainy season probably allowed for greater clutch viability, preventing the eggs from drying out (Paravicini, 1921 in Laidlaw & Solem, 1961). In another incident, eggs of *Amphidromus porcellanus* were reported to hatch only 10 days after being laid (van Benthem Jutting, 1950 in Laidlaw & Solem, 1961).

## CONCLUSIONS

From the data collected so far on *Amphidromus atricallosus perakensis*, it appears that this species is not as uncommon as what was previously believed, as it has since been found in other parts of Singapore's Nature Reserves and Pulau Tekong. However this species does seem to be very dependent on the presence of healthy forest habitats, and has only been found in primary forest and old secondary forest in Singapore. The loss of these forest habitats would therefore almost certainly spell disaster to this beautiful tree snail.

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## LITERATURE CITED

- Chou, L. M., D. H. Murphy & P. K. L. Ng, 1994. Corals, molluscs and other invertebrates. In: Ng, P. K. L. & Y. C. Wee (eds.), *The Singapore Red Data Book: Threatened Plants and Animals of Singapore*. The Nature Society (Singapore), Singapore. Pp. 314–318.
- Chou, L. M. & K. S. Tan, 2008a. 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. 2<sup>nd</sup> Edition*. The Nature Society (Singapore), Singapore. Pp. 39–61.
- Chou, L. M. & K. S. Tan, 2008b. Checklist of threatened species: 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. 2<sup>nd</sup> Edition*. The Nature Society (Singapore), Singapore. Pp. 245–247.
- Dollinger, P. & S. Geser, 2008. *Pacific Tree Snails*. <http://www.waza.org/virtualzoo/factsheet.php?id=800-000-000-000&view=Molluscs>. (Accessed 4 Nov.2008).
- Laidlaw, F. S & A. Solem, 1961. The land snails genus *Amphidromus*: a synoptic catalogue. *Fieldiana: Zoology* **41**(4): 507–677.
- Lim, R., unpublished. The terrestrial molluscs of Singapore. B. Sc. Thesis.
- Maassen, W. J. M., 2001. A preliminary checklist of the non-marine molluscs of West-Malaysia. "A handlist". *De Kreukel*, Extra Editie: 1–155.
- Miller, S., E. Hyslop, G. Kula & I. Burrows, 1999. Status of biodiversity in Papuan New Guinea. [http://www.geocities.com/RainForest/9468/papua\\_ng.htm](http://www.geocities.com/RainForest/9468/papua_ng.htm). (Accessed 4 Nov.2008).
- Nelson, R., J. Strenstrom, H. Audel & J. Coleman, 2004. Important Hawaiian invertebrates. <http://www.explorebiodiversity.com/Hawaii/BiodiversityForgotten/Wildlife/Inverts/Tree%20Snails.htm>. (Accessed 4 Nov.2008).
- 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. 1900. *Manual of Conchology. Second Series : Pulmonata. Volume 13. Structural and Systematic with Illustrations of the Species. Australasian Bulimulidae : Bothriembryon, Placostylus, Helicidae : Amphidromus*. Academy of Natural Sciences Philadelphia. 253 pp.
- Sutcharit, C. & S. Panha, 2006. Taxonomic review of the tree snail *Amphidromus* Albers, 1850 (Pulmonata: Caneanidae) in Thailand and adjacent areas: subgenus *Amphidromus*. *J. Molluscan Studies*, **72**: 1–30.
- Sutcharit, C., T. Asami & S. Panha, 2007. Evolution of the whole-body enantiomorphy in the tree snail genus *Amphidromus*. *Journal of Evolutionary Biology*, **20**(2): 661–672.

- Schilthuizen, M., P. G. Craze, A. S. Cabanban, A. Davison, J. Stone, E. Gittenberger & B. J. Scott, 2007. Sexual selection maintains whole-body chiral dimorphism in snails. *Journal of Evolutionary Biology*, **20**(5): 1941–1949.
- Wee, J. 2006. Red-crowned barbet feeding on snail. <http://besgroup.talfrynature.com/2006/06/01/red-crowned-barbet-feeding-on-a-snail/>. (Accessed 4 Nov.2008).