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Short Note

First Record on Chiral Dimorphic Population of *Amphidromus inversus annamiticus* (Crosse and Fischer, 1863) from Thailand

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In nature, the vast majority of living gastropod species occur in either the dextral (clockwise shell coiling, >90%) or sinistral (counterclockwise shell coiling) form[1,2]. Although comparatively rare, sinistral species, populations or individuals appear in various occasions, such as mutant individuals within dextral species, related sinistral species within otherwise dextral genera, or as entirely sinistral genera or families[1-4]. However, over the dimorphic chirality of dextral and sinistral individuals occurring in the same population is extremely rare in gastropods[1-4]. The Southeast Asian endemic tree snail genus *Amphidromus* are exceptional and remarkable cases as they mostly exist as chirally polymorphic populations[5-8]. The genus is regarded as a good model in evolutionary studies, and many of the papers focused on the chirality of snails over the last decade have been based on members of this genus of snails[8-13].

Currently, the genus *Amphidromus* is comprised of about 90 nominal species of which the prominent character other than their colorful shell and arboreal habit is the presence of dimorphic shell coiling[5,6,14,15]. Since from more than 2,200 specimens from 16 localities of *A. inversus annamiticus* (Crosse and Fischer, 1863)[16] from Thailand only a dextral (clockwise) shell coiling was found, this subspecies has been assumed to be monomorphically dextral for shell coiling[6,17]. Although sinistral coiled shell specimens have been recorded in the literature, they are not unequivocal and have inaccurate locality records[14]. Here, the first precise record for over a hundred years on chirally dimorphic populations of *A. inversus annamiticus* is presented, along with additional notes on their reproductive biology and ecology.

In October 2010, a land snail survey in northeastern Thailand along the Thai-Cambodia border discovered a peculiar population of *A. inversus* from Nam Yuen district, Ubonratchathani Province in the lower Mekong basin. The species designnation was determined by comparison with the type specimen, and examination of genitalia, and these indicated the typical *A. inversus annamiticus*[5,6]. Voucher specimens (CUMZ 4921 – CUMZ 4925) are housed in Chulalongkorn University, Museum of Zoology, Bangkok.

The habitat of the *A. inversus annamiticus* population at Nam Yuen was a mixed deciduous forest along a nature trail (approximately 200 m long and 10 m wide) parallel with a cascade stream. Both juvenile and adult snails were found on tree trunks, branches or climbers of various tree species, such as *Mangifera indica* L. and *Artocarpus*

heterophyllus Lam., and so they appear not to be tree species-specific. Some snails were also found under the roof of a small cottage nearby to the stream.

Both empty shells (2 dextral and 2 sinistral) and living snails (21 dextral, 14 sinistral) were observed and collected (Fig. 1A, B). Measurement of the adult shells yielded a shell height range from 45 to 55 mm, and shell width range from 35 to 40 mm. The shell morphology was as in the typical *A. inversus annamiticus*, except they were slightly larger, with the presence of black varices, a dark brown streak, rose-pink colored spire with a black suprasutural band, and dark apex[5,6,14-16]. The living snails possessed a brown to brownish body and were usually covered with a light brown reticulated skin (Fig. 1C, D). The foot was greyish to brownish; head black; upper tentacles blackish with yellowish tips; lower tentacles, head and mouthpart were brown to light brown; and a pale cream mantle cavity. The male and female genital systems and radula morphology were exactly similar to that described in Sutcharit and Panha (2006)[6].

The known range of *A. inversus annamiticus* in Thailand is therefore not only the offshore islands in the Gulf of Thailand, but is extended to the northeastern mainland regions of high plateau (0 - 350 m amsl) and mountainous characteristics. The whole distribution range of the subspecies is then from northeastern Thailand to southern Laos, Cambodia and south of Vietnam, with the southernmost limit being at Koh Samui Islands, Suratthani, Thailand[5,6,14-17].

In Thailand, *A. inversus annamiticus* are mainly found inhabiting islands[5,6,17], perhaps since the suitable mainland habitats were mostly invaded by farmers for agricultural purposes, and, if so, then the species seems to be vulnerable. However, basic information on the biology and ecology of this subspecies are still largely unknown. Normally, members of *Amphidromus* are nocturnal animals being active at night time, but they also appear at day time in high humidity conditions, especially after heavy rain. Most behaviors are accordingly easily observed at night, and include their feeding, mating, egg laying and nesting.

Only five intrachiral copulating pairs (dextral x dextral) of *A. inversus annamiticus* were observed, where the snails displayed a face-to-face mating pattern[3,18] with their coiling axis almost at right angles to each other (Fig. 1C). This is slightly different from the interchiral matings (dextral x sinistral) of *A. inversus albulus* Sutcharit and Panha, 2006[19], in which the mating pairs are reported to perform at an acute angle of coiling axis[2,8,18]. The copulating process was prolonged, lasting more than 6 to 9 hours for complete exchange of spermatophores. With respect to egg laying, *A. inversus annamiticus* did not create an egg nest, as seen in *A. atricallosus atricallosus* (Gould, 1843), but rather they laid egg clusters (~60-120 eggs) under loose-bark or small holes in tree trunks or branches, similar to that reported for *A. inversus albulus*[8,18]. The details of egg development and post-hatched juveniles, as well as their growth and survival rates, in the local environment are still unavailable. Members of *Amphidromus,* including *A. inversus annamiticus*, are arboreal and spend their entire life on trees of up to more than 10 m height (Fig. 1E-G). Snails feed on microscopic flora on the tree trunks, branches or leaves, and leave distinctive grazing trails which are easily to identify as *Amphidromus*. These grazing trails can also be observed on artificial structures, such as concrete walls or electric poles (Fig. 1E).

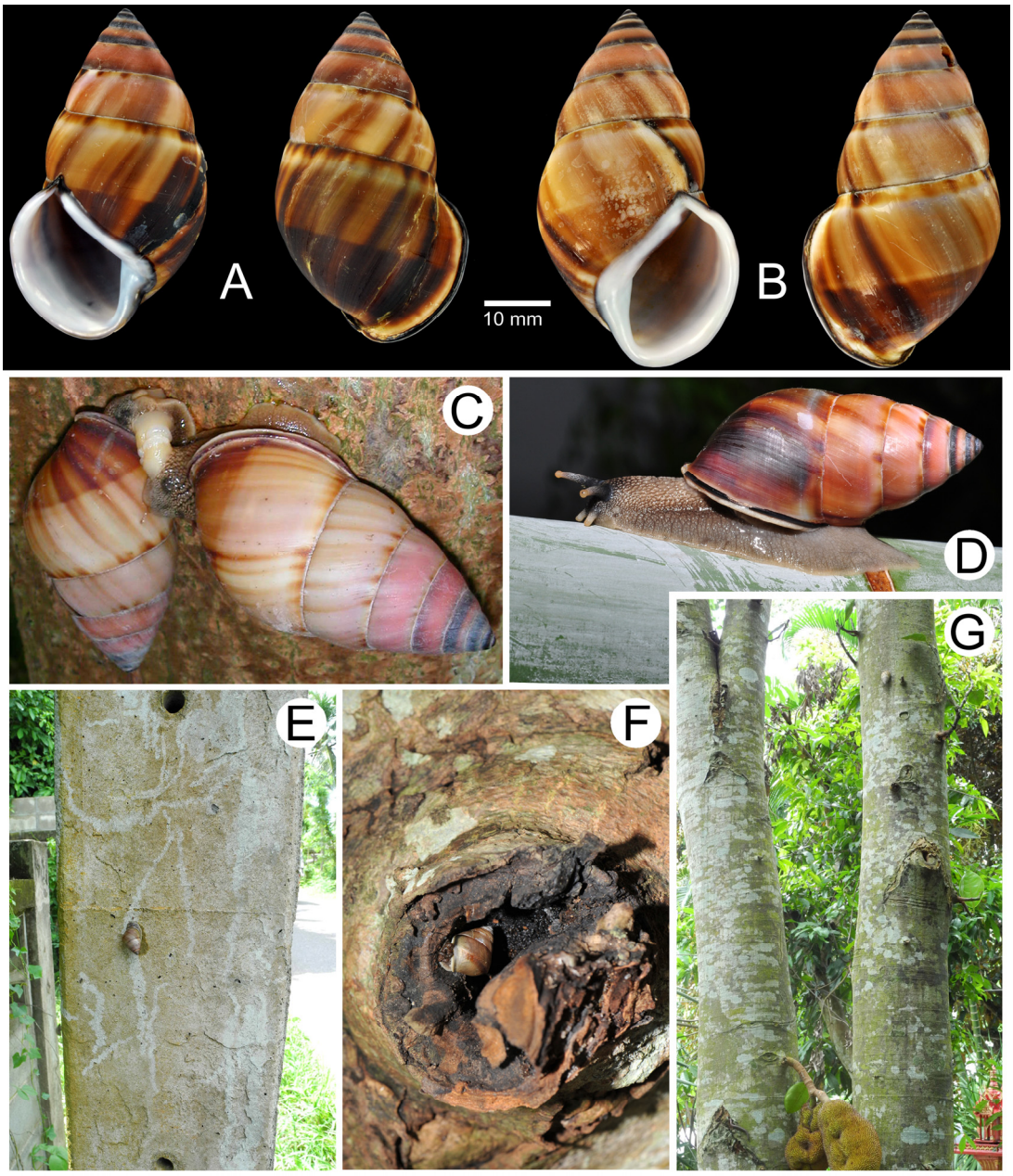

FIGURE 1. Shells and living snails of *A. inversus annamiticus*; (**A, B, D**) from Nam Yuen district, Ubonratchathani (June 2010), (**C**) from Samui Island, Suratthani (June 2007) and (**E-G**) from Chaiya district, Suratthani (May 2012). **A, B.** Dextral and sinistral shells (CUMZ 4922). **C.** Mating pair of D x D, photo taken from the field, 1-2 hours after rain. **D.** Living sinistral snail (shell height 48 mm). **E.** Juvenile snail grazing micro-flora on an electric pole (height about 1.5 m). **F.** Juvenile snail hiding in a small hole in a mango tree *Mangifera indica* L. **G.** Snail, on the top left, on the trunk of a Jackfruit tree (*Artocarpus heterophyllus* Lam.) at about 5 m height.

Snails, collected as eggs or juveniles, were reared and observed in captivity in terrarium conditions but they never reached adult size despite the provision of artificial diets and some vegetables[20]. However, collected adults were observed to form copulation pairs in captivity and egg-laying was observed. Eggs hatched within 10 to 15 days, and newborn snails were fed on the above artificial diet supplemented with cuttlebones. After hatching, the juvenile snails initially grew very well (shell height reach about 10 to 15 mm within three weeks), but thereafter the growth rate became quite slow and later the snails showed signs of abnormal development including shell deformation and subsequently died at a maximum shell height of 20-30 mm.

No information on the natural enemies of *A. inversus annamiticus* is currently available, with very little on members of *Amphidromus* in general. There have been some field observations of *A. inversus albulus* and *A. atricallosus temasek* Tan, Chan and Panha, 2011[21] in Singapore, where it was reported that the snails were predated upon by some rodent species[8,11,22]. From interviews with local people at Koh Samui Island and the broken shells we found, we suspect that squirrels and rats predate upon *A. inversus annamiticus*. Likewise, correspondence with bird specialists and examination of the dropped-food of hornbills, and the observation of shell remnants at the sacrificing stones of the blue whistling thrush, tend to suggest that land snails, including unidentified *Amphidromus* spp. are one of the major food sources of these birds (Panha, personal observation). In addition, local herpetologists have stated that a group of arboreal snail-eating snakes (*Pareas* spp.) are expected to be a significant predator of *Amphidromus* species. However, there is still no direct evidence to confirm these suggestions or their applicability to *A. inversus annamiticus* specifically.

It seems that the survival of *A. inversus annamiticus* is dependent to a fair degree on good habitat conditions, and that they may survive in a fragmented habitat as long as sufficient suitable trees remain as these snails can be found in anthopogenic habitat[5]. However, populations have been found to exhibit a low genetic diversity and likely inbreeding[23]. Habitat loss by deforestation and natural disasters will likely be the main causes of extinction of snails on those islands.

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