First verified record of the genus *Landouria* Godwin-Austen, 1918 from Thailand (Gastropoda: Stylommatophora: Camaenidae) with description of a new species

Chanidaporn Tumpeesuwan 1 & Sakboworn Tumpeesuwan1,2*

**Abstract.** A new species of land snail is described from the Suan Hin Pha Ngam Limestone Area in Loei Province, northeastern Thailand. This species is placed in the genus *Landouria* Godwin-Austen, 1918 based on the presence of a slightly long club-shaped flagellum with variably sized tubercles, a gametolytic sac with swollen basal part, and absence of dart sacs and mucous glands. This is the first verified record of the genus *Landouria* in Thailand.

**Key words.** new species, *Landouria, Aegista, Thaitropis*, reproductive anatomy, Loei Province, Thailand

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**INTRODUCTION**

*Landouria* Godwin-Austen, 1918 was based on the type species *Helix huttoni* L. Pfeiffer, 1842 from the Himalayas of northern India, and was accompanied by four other species: *Landouria aborenensis* Godwin-Austen, 1918; *L. damsangensis* Godwin-Austen, 1918; *L. hengdanensis* Godwin-Austen, 1918; and *L. radleyi* (Joussseaume, 1894). Based on the documented localities, the genus is distributed over northern India and Sri Lanka. Zileh (1966) referred an additional six species from Indonesia to *Landouria*. Marwoto (2016) checklisted the land snails of Sumatra, which comprised six species of *Landouria*, then, Richardson (1985) recognised 8 species, which were distributed in northern India (Himalayas), Sri Lanka (Ceylon), Myanmar (Burma), China, Malaysia (Malaya), and the Philippines and 19 nominal species as synonyms (Table 1). Schileyko & Kuznetsov (1998) described the shell morphology and reproductive anatomy of six species of *Landouria* from Nepal: *L. huttoni* (L. Pfeiffer, 1842), *L. savadiensis* (Nevill, 1877), *L. aborenensis* Godwin-Austen, 1918, *L. dhaulagirica* Schileyko & Kuznetsov, 1998, *L. coeni* (Preston, 1914), and *L. rhododendronis* Schileyko & Kuznetsov, 1998; and one species from Sri Lanka, *L. radleyi* (Joussseaume, 1894) (Table 1). These authors also assigned the genus to the family Bradybaenidae (Aegistinae). The distinct characters of *Landouria* given in the original description of the genus were as follows: absence of the dart sac and accessory organs; the penis, epiphallus, flagellum, and vas deferens short; the gametolytic sac is swollen at the base, has a thin duct in the middle with globose sac at the distal end (Godwin-Austen, 1918). The recently described *L. omphalostoma* Páll-Gergely et al., 2013 from northern Yunnan, China, is the easternmost record of the genus. In Thailand, small conical-lenticular shells, with wide and deep umbilicis were previously identified as *Aegista*. Panha (1996) recorded six nominal species of *Aegista*, and subsequently Hemmen & Hemmen (2001) reported five nominal species (Table 2).

Only *Aegista goniochila* L. Pfeiffer, 1842 was revised on the basis of reproductive anatomy by Schileyko (2004), showing its genitalia to be similar to *Landouria dhaulagirica* Schileyko & Kuznetsov, 1998. Schileyko (2004) introduced a new genus *Thaitropis* for *A. goniochila* based mainly on the presence of the sharp narrowing between the epiphallus and penis. Therefore, it is entirely possible that the *Aegista* spp., which were previously reported from Thailand, belong to *Landouria* or *Thaitropis*. This hypothesis needs to be verified by anatomical study. In this paper, we describe a new species of the genus *Landouria* Godwin-Austen, 1918 from Suan Hin Pha Ngam, Loei Province, northeastern Thailand. The new species has peculiar flagellum features and very sharp peripheral keel on the last whorl.

**MATERIALS AND METHODS**

Living snails and empty shells were collected from the surface of the rock and under leaf litter in the rainy seasons in 2014 and 2018 at Suan Hin Pha Ngam, Nong Hin District, Loei Province (Fig. 1), at an elevation of about 350 m above mean sea level. Living snails were drowned in water for 24 hours, then fixed, and preserved in 70% ethanol to examine their genitalia and radula. Complete adult shells were measured for whorl number, shell height (SH), and shell width (SW) with digital vernier calipers (Electronic Digital Caliper S.H.).
Table 1. List of recognised species of *Landouria* and their synonyms. (References: 1 = Richardson (1985); 2 = Godwin-Austen (1918); 3 = Zilch (1966); 4 = Schileyko & Kuznetsov (1998); 5 = Marwoto (2016); and 6 = Páll-Gergely et al. (2013).

<table>
<thead>
<tr>
<th>S/N</th>
<th>Recognised species</th>
<th>Synonyms</th>
<th>References</th>
</tr>
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</table>
| 1   | *L. huttoni* (Pfeiffer, 1842) | *L. orbiculata* (Hutton & Benson, 1838) (non Orbigny, 1835)  
*L. radleyi* (Jousseaume, 1894)  
*L. savadiensis* (Nevill, 1877) | 1, 2, 3, 4 |
| 2   | *L. winteriana* (Pfeiffer, 1842) | *L. crassiuscula* (Smith, 1896)  
*L. intumescentes* (Martens, 1867)  
*L. scheppansi* (Möllendorff, 1897) | 1, 3, 5 |
| 3   | *L. rotatoria* (Busch in Pfeiffer, 1842) | *L. castanea* (Möllendorff, 1897)  
*L. conoidea* (Leschke, 1914)  
*L. kraepelini* (Leschke, 1914)  
*L. leucocynha* (Gude, 1905)  
*L. leucophala* (Möllendorff, 1897)  
*L. micromphala* Böttger  
*L. moussoniana* (Martens, 1867)  
*L. subfasciata* (Möllendorff, 1897)  
*L. sumatranana* (Martens, 1864)  
*L. trichotrochium* (Möllendorff, 1897) | 1, 3, 5 |
| 4   | *L. smimensis* (Mousson, 1849) | *L. tenggerica* (Schepman, 1912) | 1 |
| 5   | *L. ciliocincta* (Möllendorff, 1897) | *L. pedachro* Böttger | 1, 3, 5 |
| 6   | *L. epiplatia* (Möllendorff, 1897) | | 1, 3, 5 |
| 7   | *L. costulata* (Martens, 1892) | *L. politocostata* (Rensch, 1934) | 1 |
| 8   | *L. aborensis* Godwin-Austen, 1918 | | 2, 4 |
| 9   | *L. dampsangensis* Godwin-Austen, 1918 | | 2 |
| 10  | *L. hengdanensis* Godwin-Austen, 1918 | | 2 |
| 11  | *L. menticola* van Benthem Jutting, 1950 | | 1, 3, 5 |
| 12  | *L. dhaulagirica* Schileyko & Kuznetsov, 1998 | | 4 |
| 13  | *L. coeni* (Preston, 1914) | | 4 |
| 14  | *L. rhododendronis* Schileyko & Kuznetsov, 1998 | | 4 |
| 15  | *L. omphalostoma* Páll-Gergery et al., 2013 | | 6 |

Table 2. List of nominal species of *Aegista* (*Plectotropis*) spp. reported from Thailand.

<table>
<thead>
<tr>
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<tbody>
<tr>
<td><em>A. emensa</em> (Godwin-Austen)</td>
<td><em>A. emensa</em> (Godwin-Austen)</td>
<td>–</td>
</tr>
<tr>
<td><em>A. goniochila</em> Pfeiffer</td>
<td>–</td>
<td><em>Thaitropis goniochila</em> (L. Pfeiffer, 1842)</td>
</tr>
<tr>
<td><em>A. oldhami</em> Pfeiffer</td>
<td><em>A. oldhami</em> (Benson, 1859)</td>
<td>–</td>
</tr>
<tr>
<td><em>A. orthocheilis</em> Heude</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td><em>A. trichotropis</em> Pfeiffer</td>
<td><em>A. trichotropis</em> (L. Pfeiffer, 1850)</td>
<td>–</td>
</tr>
<tr>
<td><em>A. winteriana</em> Pfeiffer</td>
<td><em>A. winteriana</em> (L. Pfeiffer, 1842)</td>
<td>–</td>
</tr>
<tr>
<td><em>Ganesella diplogramme</em> Möllendorff</td>
<td><em>A. diplogramma</em> (Möllendorff, 1902)</td>
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</tbody>
</table>
Type specimens were deposited in the following institutions: Natural History Museum, Mahasarakham University, Maha Sarakham, Thailand (NHMSU); Zoological Reference Collection, Lee Kong Chian Natural History Museum, National University of Singapore (ZRC); and Thailand Natural History Museum (THNHM).

**SYSTEMATICS**

**Family Camaenidae**

Asian Camaenidae Pilsbry, 1895 were taxonomically separated from the family Bradybaenidae Pilsbry, 1939 on the basis of the absence of dart apparatus and mucus glands in the reproductive system (Páll-Gergely et al., 2013). Schileyko & Kuznetsov (1998) argued that the camaenid-like genitalia of *Landouria*, are the result of secondary reduction, and placed *Landouria* in the Bradybaenidae. However, the results from a study of the molecular phylogeny of the helicoid land snails indicated that AsianAustralasian camaenid and bradybaenid taxa intermingle in the same clade of the phylogenetic tree, which suggests that both taxa are confamilial (Wade et al., 2007). This opinion was followed by Gittenberger et al. (2012) and Páll-Gergely et al. (2013), who considered Bradybaenidae Pilsbry, 1939 as...
a junior synonym of Camaenidae Pilsbry 1895. We also agree with this opinion.

**Genus Landouria Godwin-Austen, 1918**

According to Schileyko & Kuznetsov (1998), this genus is distributed in north-eastern India, Nepal, Myanmar (Mandalay and Shan), and China (Yunnan). Only the Nepalese localities have been verified by reproductive anatomy. Thus, the specific and generic identities of shells from other areas remain questionable.

**Diagnosis.** The anatomical characters of some Nepalese species of *Landouria* were investigated by Schileyko & Kuznetsov (1998), comprising *Landouria savadiensis* (Nevill, 1877), *L. aborensis* Godwin-Austen, 1918, *L. dhualagirica* Schileyko & Kuznetsov, 1998 and *L. rhododendronis* Schileyko & Kuznetsov, 1998. However, the anatomy of the type species is unknown. The important characters of the genus as suggested by Pál-Gergely et al. (2013) are: depressed shell, last whorl descending in front, and umbilicus open and broad; flagellum possessing a series of distinct tubercles on its surface and internally with an axial canal from which the secondary smaller canals branch off, and ending in superficial tubercles; penis consisting of proximal and distal portions, verge minute. The vagina is long and possesses longitudinal folds on the inner wall. The gametolytic sac is very thin except for the swollen base, and a small globose sac at the distal end; dart apparatus and mucus glands absent.

**Remarks.** In the original description of the genus *Landouria*, Godwin-Austen, 1918 included five species from Sri Lanka and the Himalayas (northern and north-eastern India). Schileyko & Kuznetsov (1998) added four species from Nepal to the genus. Other species were described and reported from Indonesia and the Philippines, and have often been mentioned as *Landouria* (Rensch, 1931; Zilch, 1966; Marwoto, 2016). However, the systematic positions of these island taxa remain uncertain. By compiling distribution records, Schileyko & Kuznetsov (1998) concluded that the genus is restricted to northern India, Nepal, northern Burma, and Sri Lanka. According to Godwin-Austen (1918), the Sri Lankan *L. radleyi* showed a short and oval flagellum with an elongated distal end with no sign of tubercles, which are characteristic of other *Landouria* species. Therefore, *L. radleyi* probably needs to be reclassified in another possibly undescribed genus.

**Superfamily Helicoidea Rafinesque, 1815**

**Family Camaenidae Pilsbry, 1895**

**Genus Landouria Godwin-Austen, 1918**

**Type species.** Helix huttoni L. Pfeiffer, 1842.

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**Table 3. Shell dimensions of *Landouria strobiloides*, new species.**

<table>
<thead>
<tr>
<th>Specimen</th>
<th>Width</th>
<th>Height</th>
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<tr>
<td>Holotype</td>
<td>16.7 mm</td>
<td>9.1 mm</td>
</tr>
<tr>
<td>Paratypes (n=27)</td>
<td>Max. 16.6 mm</td>
<td>9.6 mm</td>
</tr>
<tr>
<td></td>
<td>Min. 13.4 mm</td>
<td>7.1 mm</td>
</tr>
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**Fig. 2. Living specimen of *Landouria strobiloides*, new species.** Photograph by: Benchawan Nahok.

**Landouria strobiloides, new species**

(Figs. 2–5; Table 2)


**Type material.** Holotype: NHMSU-0017 (Fig. 3). Suan Hin Pha Ngam Limestone at an elevation of about 350 m above mean sea level (Fig. 1) in Nong Hin District, Loei Province, northeastern Thailand, 17°3′7″N, 101°44′9″E; 28 June 2014.

Paratypes: NHMSU-00018 (27 shells): collected with holotype at type locality (genital structure in ethanol). ZRC. MOL.14241 (one shell), THNHM-Iv-18175 (one shell), same data as holotype.

**Etymology.** The specific epithet strobiloides derived from the strobilus, referring to the flagellum of the new species, which looks similar to the strobilus of non-flowering plants because it possesses many tubercles on its surface.

**Diagnosis.** Body whorl of shell with very sharp keeled, aperture slightly thickened and with a reflexed rim. Flagellum slightly long, club-shaped, with variably-sized tubercles. Base of gametolytic sac enlarged and swollen.
Description. Shell (Fig. 3, Table 3): Shell small, 13.4–16.7 mm in width, 7.1–9.6 mm in height, conical-lenticular, color pale brown at early whorls and gradually changing to dark brown on body whorl, with 5.25–5.50 slowly increasing whorls; protoconch consisting of about two whorls, sculpture irregular, very fine; suture rather shallow, last whorl with very sharp peripheral keel, keel with paler color than other parts of shell. Umbilicus very deep and moderately wide (about ¼ of the shell width), showing all whorls. Aperture irregularly ovate, moderately oblique, with little reflected thin margin; columellar margin more reflected.

Body (Fig. 2): Animal without shell lobes. Dark brown to black body and tentacles. Posterior part of foot very short, caudal foss and caudal horn absent.

Radula (Fig. 4): Elongated lanceolate, comprising 100 transverse rows of teeth, with 3–53 teeth in each row. Central teeth unicuspid, lanceolate, and smaller than flanking first lateral teeth. Latero-marginal teeth gradually changing from unicuspid, lanceolate shape to bicuspid, and oblique tricuspid.

Genital system (Fig. 5): Prostate gland very long. Uterus long and swollen. Vas deferens long and slender tube, entering the epiphallus apically. Epiphallus as long as penis, but shorter than flagellum. Flagellum resembling strobilus of non-flowering plant, with many variously sized tubercles. Penis divided into two portions, both are short and slightly stout. Gametolytic sac connected to free oviduct, comprising three parts, including, small ovate gland at distal end, very long slender tube at middle, and large swollen tube at base. Vagina is longer than penis and epiphallus taken together, of a long-cylindrical in shape. Free oviduct very short, cylindrical. Amatorial organ absent.

Remarks. The genitalia of the new species agree in general detail with the genital anatomy of congeneric species, but it has the longest tubercles on the flagellum within the genus. The anatomy of Landouria differs from Aegista by the absence of a well-developed dart sac, lateral accessory sacs, and mucous glands (Schileyko, 2004). In Thailand, the snails that have the last whorl slightly descending in front and large umbilicus were assigned to Aegista, but this needs to be confirmed by a study of their anatomical characters.
Fig. 4. Radula morphology of *Landouria strobiloides* new species, paratype (NHMSU-00018). A, whole radula; B, close up view of widest part of radula; C, close up view of central part of radula; D, close up view of central and first lateral teeth; E, close up view of left side of radula; F, close up view of right side of radula.
DISCUSSION

In pulmonate land snails, superfamily Helicoidea, the genital anatomy is more useful for taxonomy than shell morphology. The species described herein is the southeastern most verified species of *Landouria* and represents the first anatomically verified record of the genus from Thailand. According to Schileyko (2004), three bradybaenid genera have a tuberculate flagellum and no dart sac and mucous gland, comprising *Landouria* Godwin-Austen, 1918; *Neoaegista* Azuma, 1955; and *Thaitropis* Schileyko, 2004. Moreover, the base of the gametolytic sac of *Thaitropis* is not thickened, unlike in *Landouria*. The tuberculated flagellum is also present in *Trishoplita* Jacobi, 1898 and *Aegista* Albers, 1850, but these genera have well-developed dart sacs and mucous glands.

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Fig. 5. Genital anatomy of *Landouria strobiloides*, new species, paratype (NHMSU-00018). pro = prostate gland, ut = uterus, vd = vas deferens, ep = epiphallus, ef = flagellum, p = penis, gs = gametolytic sac, v = vagina, fo = free oviduct.