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Research article

Larval description of Salween Frog *Hoplobatrachus salween* (Anura: Dicroglossidae) from Northwestern Thailand

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Abstract

Importance of the work: Existing knowledge lacks description of tadpoles of *Hoplobatrachus salween*. The current study filled this knowledge gap by providing a detailed description of external and buccal anatomy.

Objectives: To describe the external morphology and buccal anatomy of the tadpoles of *H. salween*.

Materials & Methods: Tadpoles were described based on six specimens (THNHM 26833.1–6) collected in Salawin National Park, Mae Sariang, Mae Hong Son province, northwestern Thailand. Identification was based on Thongproh et al. (2022). External morphological description was based on THNHM 26833.2. Buccal description was based on images from scanning electron micrographs of THNHM 26833.2.

Results: The tadpoles were large-sized (total length 48.1–63.2 mm, stages 37–39), body ovate, tail musculature moderate, oral disc moderate-sized. Keratodont row formula = 2:2+2/3+3:2 (stage 37) and 2:3+3/3+3:2 (stage 39–40), biserial rows at 1st upper labial teeth row and 2nd–5th lower labial teeth rows), single row at 2nd–5th upper labial teeth rows, three rows at 1st lower labial tooth row. The prenarial arena was wide with a large medial keratinized conical knob.

Main finding: The results have provided the first description of the external morphology and buccal anatomy of tadpoles of *H. salween*. This work has added knowledge on buccal anatomy, which is insufficient in members of *Hoplobatrachus* spp.

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Introduction

Hoplobatrachus is a genus of frog in the family Dicroglossidae which is wildly distributed from Sub-Saharan Africa south to Angola to northeastern Zambia and Tanzania, Peninsular India, Sri Lanka, Peninsular Malaysia, Myanmar, Thailand, Laos, Cambodia, Vietnam and southern China, as having been introduced to Borneo and Madagascar (Frost, 2023). Members of *Hoplobatrachus* contain six species: *H. chinensis* (Osbeck, 1765), *H. crassus* (Jerdon, 1853), *H. litoralis* Hasan, Kuramoto, Islam, Alam, Khan, and Sumida, 2012, *H. occipitalis* (Günther, 1858), *H. salween* Thongproh, Chunskul, Sringurngam, Waiprom, Makchai, Cota, Duengkae, Duangjai, Hasan, Chuaynkern, and Chuaynkern, 2022, and *H. tigerinus* (Daudin, 1802). *Hoplobatrachus* spp. are eaten by humans in many parts of the world and thus at least three species (*H. crassus*, *H. chinensis* and *H. litoralis*) have been facing population decline (International Union for Conservation of Nature and Natural Resources, 2023). Two *Hoplobatrachus* species have been reported in Thailand (Frost, 2023): *H. chinensis* (as *H. rugulosus*) and *H. salween*. *Hoplobatrachus chinensis* distributes throughout the country (Chuaynkern and Chuauynkern, 2012) while *H. salween* is restricted to only its type locality (Thongproh et al., 2022).

Information of anuran tadpoles is important for understanding their development and natural history. A more complete description of tadpole morphology is necessary to further general understanding of this species' identity, biology, ecology and evolution. Although such information in the form of descriptions of the external morphology and buccopharyngeal anatomy has been published worldwide, there is still much to be learned (Leong, 2002; Das and Haas, 2005). Presently, three species of *Hoplobatrachus* have been described in publications based on their external morphology and buccopharyngeal anatomy. Specifically, Grosjean et al. (2004) and Kaewtongkum (2016) provide information of *H. occipitalis*, *H. chinensis* and *H. tigerinus*. Therefore, the present work aimed to provide the first description of the buccal anatomy of *H. salween* via scanning electron microscopy (SEM) and to compare tadpoles of this species with previously known tadpoles.

Materials and Methods

Six tadpole specimens (THNHM 26833.1–6) from the collection of the Thailand Natural History Museum (THNHM) were used to describe details of the external and buccal morphology. These tadpoles were caught in a rice field in the breeding season from the type locality (Salawin National Park, Mae Hong Son Province, western Thailand) of the species *H. salween* with permission from the Department of National Parks, Wildlife and Plant Conservation (permission number: 0907.4/25571) and the Institutional Animal Care and Use Committee of Khon Kaen University, based on the Ethics of Animal Experimentation of the National Research Council of Thailand (reference no. 660201.2.11/235[44]). At the collection site, the males were calling at night. Forests surrounding the collection site included dry evergreen, mixed deciduous and dry dipterocarp forests. Identification followed Thongproh et al. (2022) who assigned these tadpoles to *H. salween* based on their morphological details, similar to tadpoles of genus *Hoplobatrachus* and only *H. salween* was found in the type locality. The developmental stage was assigned according to Gosner (1960). The morphological terminology followed Altig and McDiarmid (1999), the oral disk terminology followed Altig (1970), the buccal anatomy terminology followed Wassersug (1976) and the keratodont row formula (KRF) followed Dubois (1995).

Measurements recorded followed Grosjean (2005) and were taken using a digital caliper, except for some characters < 1 mm, which were obtained using an ocular micrometer attached to a stereomicroscope. In total, 22 measurements were used in this work: SS, distance from tip of snout-insertion to spiracle opening; body height (BH); body length (BL); maximum body width (BW); maximum eye diameter (ED); maximum lower fin height (LF); maximum tail height (MTH; nostril diameter (ND); internarial distance (ID); nanopillar distance (NP); interpupillary distance (PP); rostro-narial distance (RN); SD, spiracle diameter (SD); distance from tip of snout-insertion to upper tail fin (SU); tail length (TAL); total length (TL); maximum tail muscle height (TMH); tail muscle width at end of body (TMW); maximum upper fin height (UF); anterior labium (AL); posterior labium (PL); and oral disc width (ODW).

The mouthparts of selected tadpoles were cut into two pieces (roof and floor) using surgical scissors for inspection using SEM at the Faculty of Science, Khon Kaen University, Khon Kaen Province, northeastern Thailand. The roof and floor were wrapped with straining cloth for preparation for SEM consisting of dehydration, critical point drying and gold sputtering surface coating. Dehydration was performed by passage through a series of 70%, 90% and 100% ethanol solutions (24 hr for each concentration). Later, these materials were soaked 20 min)

in a solution with equal parts ethanol and amyl acetate followed by soaking for 20 min in amyl acetate. Then, they were dried in a critical point drier (Quorum K850; Quorum Technologies; Laughton, UK) before being attached to an SEM stub and coated with heavy metals for SEM photography (DMS 950 scanning electron microscope; Zeiss; Oberkochen, Germany) at 10 kV. The resulting images were improved using Adobe® Photoshop CS6 (Adobe Systems Inc.; San Jose, CA, USA).

Results

Larval description

Larval description was based on specimen number THNHM 26833.2 (field no. 1103.3) Gosner stage 39, as shown in Fig. 1. Measurement data are provided in Table 1. Body in dorsal

Table 1 Measurements (measured in millimeters; mean ± SD) of tadpoles of *Hoplobatrachus salween*

Character-istic	THNHM 26833.1	THNHM 26833.2	THNHM 26833.3	THNHM 26833.4	THNHM 26833.5	Summary [mean ± SD (range)]	THNHM 26833.6
Stage	37	39	39	39	39		40
SS	11.5	13.5	11.4	14.2	14.4	13.4±1.38 (11.4–14.4)	14.6
SU	8.4	10.1	8.6	9.9	10.3	9.7±0.77 (8.6–10.3)	10.3
BL	16.8	20.6	16.7	20.6	21.2	19.8±2.06 (16.7–21.2)	20.5
TAL	34.4	41.9	29.5	–	41.2	37.6±6.99 (29.5–41.9)	43.4
TL	48.8	60.0	48.1	–	63.2	57.1±7.92 (48.1–63.2)	65.1
UF	1.9	3.5	1.6	2.8	2.5	2.6±0.81 (1.6–3.5)	4.0
LF	1.5	2.0	1.3	2.3	1.8	1.8±0.45 (1.3–2.3)	2.2
MHT	4.5	4.6	3.3	4.5	4.7	4.3±0.66 (3.3–4.7)	4.0
BH	6.0	8.0	6.8	9.6	8.7	8.3±1.17 (6.8–9.6)	8.6
BW	7.2	9.3	7.9	10.4	10.6	9.6±1.24 (7.9–10.6)	11.1
TMH	3.5	5.3	3.6	5.4	5.3	4.9±0.84 (3.6–5.4)	5.3
TMW	3.7	5.1	4.3	5.5	5.7	5.1±0.63 (4.3–5.7)	5.4
PP	3.6	4.6	4.2	4.5	5.0	4.6±0.35 (4.2–5.0)	4.7
NN	1.8	2.4	1.5	2.0	2.3	2.1±0.42 (1.5–2.4)	2.4
RN	3.1	3.8	2.6	3.7	3.3	3.3±0.55 (2.6–3.8)	3.6
NP	2.6	3.5	2.3	2.7	2.9	2.8±0.49 (2.3–3.5)	3.1
ED	2.4	2.4	2.2	2.7	2.6	2.5±0.25 (2.2–2.7)	2.6
ND	0.5	0.8	0.5	0.8	1.0	0.8±0.2 (0.5–1.0)	0.8
SD	1.2	1.3	1.2	1.9	1.4	1.4±0.29 (1.2–1.9)	1.0
AL	1.0	0.6	0.9	1.3	1.6	1.1±0.45 (0.6–1.6)	0.8
PL	0.9	0.8	0.8	0.9	0.9	0.8±0.08 (0.8–0.9)	0.7
ODW	3.3	4.5	3.7	4.4	4.9	4.4±0.48 (3.7–4.9)	4.2

BH = body height; BL = body length; BW = maximum body width; ED = maximum eye diameter; LF = maximum lower fin height; MTH = maximum tail height; ND = nostril diameter; ID = internarial distance; NP = nanopillar distance; PP = interpupillary distance; RN = rostro-narial distance; SD = spiracle diameter; SU = distance from tip of snout-insertion to upper tail fin; TAL = tail length; TL = total length; TMH = maximum tail muscle height; TMW = tail muscle width at the end of the body; UF = maximum upper fin height; AL = anterior labium; PL = posterior labium; ODW = oral disc width; The summary were calculated from the tadpoles in stage 39.

and ventral view ovate, body in lateral view ovate, slightly depressed (BL 20.6 mm, BW 9.3 mm, BH 8.0 mm); snout rounded; eyes of moderate size (ED 2.4 mm), bulging but not visible in ventral view, in dorsolateral position, dorsolateral directed, located at about 1/3 of body length; nares opening ovate, small size (ND 0.8 mm), lacking bulging rim and flap, in anterolateral position, anterolaterally directed, closer to eye than snout (NP 3.5 mm, RN 3.8 mm); single spiracle, sinistral, tubular, long, attached to body wall except margin, located at midpoint of body length, visible in lateral view; spiracle opening with rounded shape, positioned above the body axis, in dorsoposterior direction (SS 13.5 mm). Tail musculature moderate (TMH 5.3 mm, TMW 5.1 mm), reaching to tail tip, gradually tapering; tail fins of moderate size (UF 3.5 mm, LF 2.0 mm), upper fin extending onto the body (SU 10.1 mm), lower fin not extending onto body, reaching its maximum height at the middle of the tail; tail tip pointed; vent tube of large size, rectangular in shape, linked to ventral tail fin, vent tube opening directed to medial side of the lower fin. KRF = 2:2+2/3+3:2 (stage 37) and 2:3+3/3+3:2 (stages 39–40), biserial rows at 1st upper labial teeth row and 2nd–5th lower labial teeth rows), single row at 2nd–5th upper labial teeth rows, three rows at 1st lower labial tooth row.

Oral disc (Fig. 1) moderate size (ODW 4.5 mm, AL 0.6 mm, PL 0.8 mm) of semicircular shape, in anteroventral direction, emarginated laterally; anterior labium without marginal papillae; posterior labium with marginal papillae in a continuous single row, crenate, tip of papillae rounded; submarginal papillae absent; denticulate papillae absent; upper jaw sheath black, broad, marginal fine serrated, strong medial projection; lower jaw sheath black, broad, medial concaved (V-shape), marginal fine serrated, with drawing under upper jaw sheath; labial teeth black, conical, alternate arrangement; 1st upper labial teeth continuous alternate two rows at middle, lateral continuous single row; 2nd upper labial teeth continuous single row; 3rd, 4th, and 5th upper labial teeth with gap, single row; 1st lower labial teeth grouped, alternated three tooth rows at middle, 1–2 rows at lateral; 2nd lower labial teeth continuous alternate two rows at middle, lateral continuous single row; 3rd, 4th, and 5th lower labial teeth with gap, alternate two rows, more alternating on side of lower jaw sheath, 5th lower labial teeth sometime grouped two or more rows.

Neither pineal ocellus nor lateral line present. In preservative, body greyish brown in dorsal and lateral view, cream in ventral view; muscle tail and hind limb light brown, muscle tail with irregular small black dots; tail fin translucent cream with irregular small black dots; intestinal coil indistinct in ventral view.

Buccal description

Buccophryngeal description was based on specimen number THNHM 26833.2 (field no. 1103.3), Gosner stage 39.

Buccal roof (Figs. 2–5) narrow triangular in shape with round angle; prenarial arena wide with a large medial keratinized conical knob, triangle-shaped with rounded angles in top view, cone shape in lateral view; prenarial projection present; narial wall present, undulate edge, short and wide, increasing around choanae, tuberculate at base, smooth surface at middle and end; narial wall projection, increasing on lateral part of anterior narial wall; choanae elliptic, oblique. Postnarial papillae long, lanceolate shaped, undulated margin, sponge-like surface, directed anteromedially. Postnarial arena with tubercles; medial ridge present, trapezoid, reticulate surface; lateral ridge with tubercle on upper side. Buccal roof arena much longer than wide, with tubercles, reticulate surface; buccal roof arena papillae absent; lateral roof papillae absent; lateral side skin of buccal roof arena streaked.

Fig. 1 Photographs of *H. salween* tadpole (THNHM 26833.2; stage 39) in preservative: (A) lateral view; (B) dorsal view: (C) ventral view

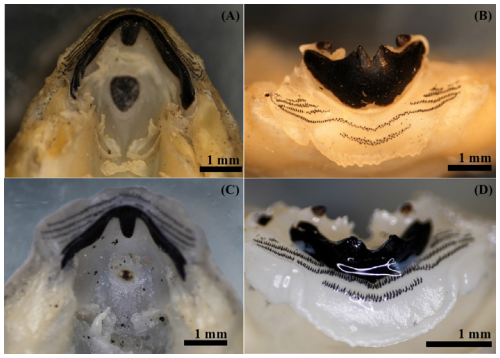

Fig. 2 Photographs of tadpoles of *H. salween* (THNHM 26833.2; stage 39) and *H. chinensis* from Maha Sarakham province showing oral disc under stereo microscopy: (A–B) upper and lower labia, respectively, of *H. salween*; (C–D) upper and lower labia, respectively, of *H. chinensis*.

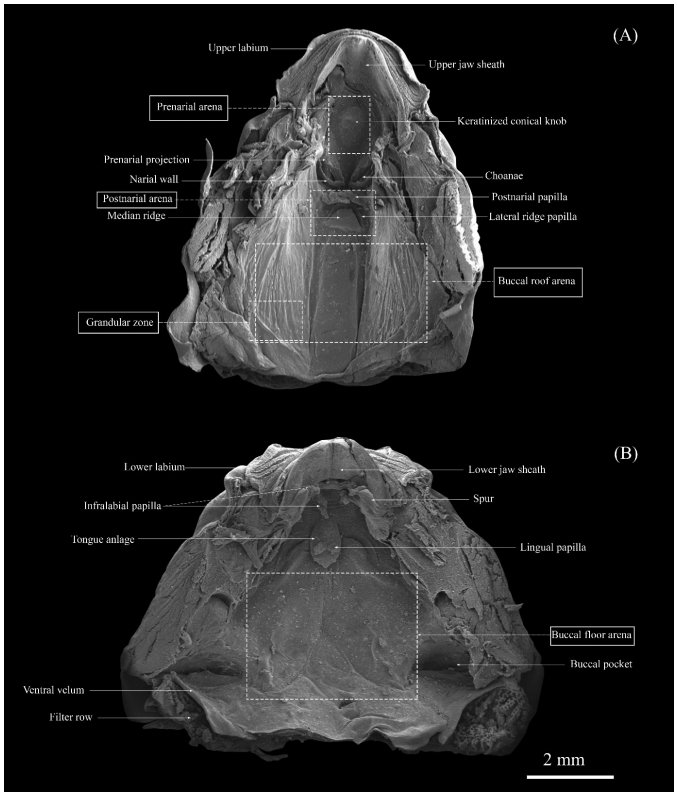

Fig. 3 Scanning electron microscopy (SEM) photographs of *H. salween* tadpole (THNHM 26833.2; stage 39) showing the buccal morphology: (A) buccal roof; (B) buccal floor

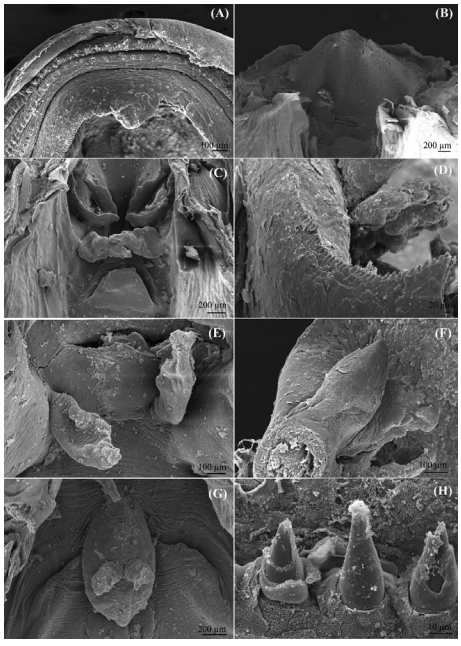

Fig. 4 Scanning electron microscopy images of *H. salween* tadpole (THNHM 26833.2; stage 39) showing buccal contents: (A) upper beak; (B) conical knob in lateral view; (C) narial wall, prenarial projection, postnarial papillae and median ridge; (D) serrated edge of the lower beak; (E) infralabial papillae; (F) keratinized spur; (G) tongue anlage and lingual papilla; (H) and labial teeth

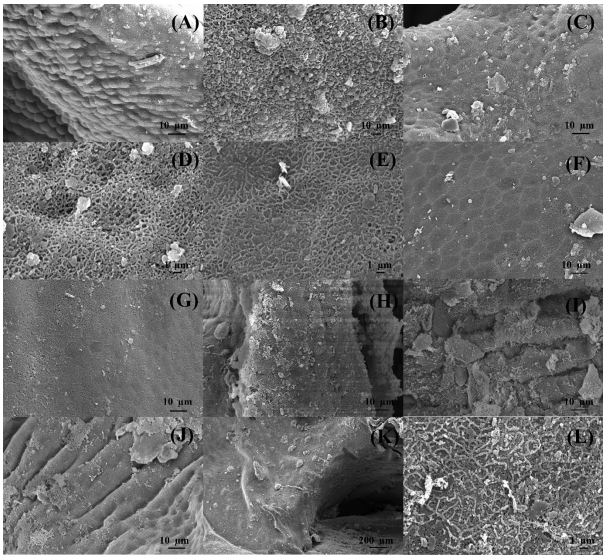

Fig. 5 Scanning electron microscopy images of *H. salween* tadpole (THNHM 26833.2; stage 39) showing the surface of the buccal skin: (A–B) surface of the narial wall at base of the narial wall surface; (C–D) postnarial papilla surface; (E–F) median ridge surface; (G) buccal roof arena surface; (H) infralabial papilla surface; (I) tongue anlage surface; (J) lingual papilla surface; (K) buccal pocket and pre–pocket papillae; (L) middle buccal floor arena surface

Buccal floor (Figs. 3–5) obtuse triangular shaped with round angle; prelingual arena triangular shaped; two pair of infralabial papillae, edge gnarled, first pair raising at the base of both sides of beak, in front of the spur, linked to the base of the spur; second pair long, skin wrinkled with reticulate surface, edge gnarled, positioned medially, below the plane of first pair and spur. A pair of large spurs at the base of the lower beak, tip of spur black, basal spur cream, cuticles covered. Tongue anlage elliptic, depressed swelling, sponge-like surface; two large lingual papillae on tongue anlage, positioned medially, edge gnarled, skin wrinkled with sponge-like surface. Interior of arena dwelled by a long groove, across from the posterior end of tongue anlage to halfway, elongation of this groove making a triangle at posterior part of the arena; buccal pockets narrow elliptic, transverse, curved slightly backward, closer to medial end of ventral velum than to tongue anlage; Buccal floor arena triangular with irregular small tubercles, not very dense, defined by papillae posteriorly on each side, reticulate surface; about 3–4 prepocket papillae; ventral velum continuous, margin smooth, without papillae; branchial baskets bulging, oblique, much wider than long, ornaments gathered frill filters, filter rows present on each side.

Discussion

Tadpoles of *H. salween* are distinguished from tadpoles of *H. chinensis* (based on specimens from Maha Sarakham and Sakon Nakhon provinces, northeastern Thailand) by having a large keratinized conical knob on the prenarial arena of the buccal roof, which is small in specimens from eastern Thailand (Fig. 2). The specimen differs from *H. chinensis* of Grosjean et al. (2004; as *H. chinensis*) and Kaewtongkum (2016) by having a posterior labium, a continuous single crenated row of papillae with rounded tips, which were indistinct in Grosjean et al. (2004) and not emarginated in Kaewtongkum (2016). *Hoplobatrachus salween* tadpoles differ from *H. tigerinus* described by Grosjean et al. (2004), Khan and Mufti (1994), and Khan (1996) by having: V-shaped lower beak concavity; postnarial papillae long, ovate-shaped, flat, undulated margin, directed transverse into body axis; posterior labium with continuous single crenated row papillae, tip of papillae rounded. The tadpole is distinguished from *H. occipitalis* by having more rows of labial teeth (Table 2).

The current six tadpole specimens collected at the same location as *H. salween* adult paratypes were assigned as tadpoles of *H. salween*. The six tadpoles showed substantial morphological similarities to tadpoles of the genus *Hoplobatrachus*; the most prominent character of *Hoplobatrachus* larvae is the presence of keratinized spurs in the anterior part of the buccal floor (Annandale, 1917; Noble, 1927; Okada, 1931; Lamotte and Zuber-Vogeli, 1954; Khan, 1982; Chou and Lin, 1997) and the double labial tooth rows (Noble, 1927; Pope, 1931; Bourret, 1942; Lamotte and Zuber-Vogeli, 1954; Liu and Hu, 1961; Khan, 1982; Chou and Lin, 1997; Grosjean et al., 2004). The current specimens showed keratinized spurs behind the lower beak and 1st pair of infralabial papillae. The base of the spur was linked to the base of the 1st pair of infralabial papillae.

Table 2 Morphological comparison of *Hoplobatrachus* tadpoles with average measured characteristics

Species	Gosner stage	TL (mm)	BL (mm)	KRF	Body	Tail	Mouth
H. crassus	No data	No data	No data	No data	No data	No data	No data
H. litoralis	No data	No data	No data	No data	No data	No data	No data
H. occipitalis (n = 2)	36–37	46.5	20.0	2^2:2^2+2^2/2^2+2^2:2^2) to 2^2:1^2+1^2/2^2+2^2:2^2 (stage 28–40)	Body ovoid, elongate, snout semicircular, rounded	Point of maximum height of tail at first quarter of tail length. Tail tip bluntly pointed	Oral disk bordered by a more pronounced continuous row of marginal papillae than *H. tigerinus*. Labial teeth stronger than *H. tigerinus*
H. chinensis (n = 1 in Grosjean et al., 2004; n = 11 in Kaewtongkum, 2016; n = 4 in current study)	36	36.0	12.1	2^2:2^2+2^2/4^2+4^2:1^2 (provided in description). 2^2:3^2+3^2/3^2+3^2:2^2 (provided in Fig. 3B in Grosjean et al. (2004); specimen number 1999.425 stage 40)	Body obovate in dorsal view, snout rounded	Tail musculature moderate, gradually tapering. Tail tip fine and pointed	Continuous row of blunt and almost indistinct marginal papillae (upper and lower)
H. salween (n = 6)	37–40	57.0	19.4	2:2+2/3+3:2 (stage 37), 2:3+3/3+3:2 (stage 39–40) (biserial rows at 1st upper labial teeth row and 2nd–5th lower labial teeth rows, single row at 2nd–5th upper labial teeth rows, three rows at 1st lower labial tooth row)	Body ovate in dorsal view, elongate, snout rounded	Tail musculature moderate, gradually tapering in the proximal half, reaching tail tip. Tail tip pointed	Anterior labium without marginal papillae, posterior labium with continuous single crenated row papillae, tip of papillae rounded
H. tigerinus (n = 4)	36	43.8	17.3	2^2:3^2+3^2/4^2+4^2:2^2 (stage 36) 2^2:2^2+2^2/3^2+2^2:2^2 (stage 29) 2^2:4^2+4^2/4^2+4^2:2^2 (stage 38)	Body pear–shaped, widest in posterior part, constricted at the level of gill, snout rounded	Tail musculature moderate to moderately weak, gradually tapering or parallel in the proximal half, reaching tail tip. Tail tip fine and pointed to lanceolate	Continuous row of small, flat and very blunt marginal papillae. Almost indistinct on upper labium

Table 2 Continued

Species	Shape of labial teeth	Prenarial papillae at buccal roof	First pair of infralabial papilla	Keratinized conical knob	Postnarial papilla shape and direction	Lower beak edge	Shape of lower beak concavity	Anal tube	Sources
H. crassus	No data	No data	No data	No data	No data	No data	No data	No data	–
H. litoralis	No data	No data	No data	No data	No data	No data	No data	No data	–
H. occipitalis	Needle-like	Triangular and pustulose	Bifid, each part multilobes	No data	No data	No data	V-shape	Long, tubular, not linked to ventral tail fin	Grosjean et al. (2004)
H. chinensis	Needle-like	Long triangular and pustulose	Sharply indented, cleft less sharply marked	Small	Long, lanceolate–shaped, undulated margin, directed transverse into body axis	Serrated	V-shape	Moderate, tubular, rectangular, attached to ventral tail fin, opening at ventral of lower fin	Grosjean et al. (2004); Kaewtongkum (2016); Current study
H. salween	Conical to Needle-like	Long triangular and pustulose	Cleft, two palps, gnarled ends.	Large	Long, lanceolate-shaped, undulated margin, spong-like surface, directed anteromedially	Serrated	V-shape	Large, short, rectangular, attached to ventral tail fin, opening at ventral of lower fin	Current study
H. tigerinus	Needle-like	Short and wide. No data of texture.	Edge indented with a deep cleft midway (creating the impression of two palps)	Present but no data of size	Long conical-shaped, gradually tapering to tip, directed anteriorly	Serrated	U–shape	Short, medial, tubular or bulb–shape, direct posteriorly, linked to ventral tail fin, opening medial	Grosjean et al. (2004)

TL = tail length; BL = body length; KRF = Keratodont row formula

Other *Hoplobatrachus* tadpoles, including those of *H. chinensis*, *H. tigerinus*, and *H. occipitalis*, show needle-like teeth arranged in double rows (Grosjean et al., 2004). The shape of the labial teeth in the current specimens was similar to other *Hoplobatrachus* tadpoles described previously. In the current specimens, the 1st row of lower labial teeth showed three alternating rows of teeth in the middle and 1–2 rows on the lateral sides. The presence of a labial tooth row consisting of triple rows in each row had been documented by Khan (1996), but this was later suggested to be incorrect (Grosjean et al., 2004). Although the current specimen showed triple rows in the 1st lower labial tooth row, other rows (both upper and lower labial tooth rows) showed only a single or double row. Furthermore, in the current specimen, the alternation of tooth rows was not typically arranged throughout the teeth rows; it usually occurred in the middle of the rows and sometimes increased on the inner side near the beak. Due to the presence of spurs, conical teeth, needle-like teeth and conical keratinized knobs, the current specimens were referred to as *Hoplobatrachus*. Furthermore, the tadpoles from the current sampling site could only be identified as *Hoplobatrachus*, with no other *Hoplobatrachus* species occurred at this site. Therefore, all tadpole specimens were assigned to *H. salween*.

According to Dubois (1992), needle-like labial teeth and their double row arrangement seem to be unique to anuran tadpoles. Grosjean et al. (2004) suggested that this unique character is a synapomorphy of *Hoplobatrachus* and probably not homologous to the multiserial rows in *Ascaphus truei* and Discoglossidae. The current SEM results showed fractures of labial teeth, which was similar to Altig et al. (2009), who reported broken teeth with five successive teeth in a stack from the outermost at the top to the innermost at the bottom. Those authors explained that tooth replacement in *Hoplobatrachus* occurs by initial damage to the outer tooth and then larger pieces break off to reveal the next tooth inside. The keratinized conical knob at the center of the prenarial arena was prominent in the current specimens. These characters of *H. chinensis* and *H. occipitalis* have not been reported previously (Grosjean et al., 2004). However, the current work showed that the

keratinized knob of *H. chinensis* was smaller than that of *H. salween*. Presumably, tadpoles of *H. occipitalis* also have the conical knob because the description of Grosjean et al. (2004) was abbreviated, mainly mentioning differences compared to *H. tigerinus*. However, the current comparison entered "No data" for this character because no more details of this character were available. Khan (1996) reported that extra keratinized oral elements in *H. tigerinus* help to manage large food items. This knob is also present in the cannibalistic species *Scaphiopus bombifrons* (Grosjean et al., 2004).

Conflict of Interest

The authors declare that there are no conflicts of interest.

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