

Comparative Osteology of Japanese Frogs and Toads for Paleontological Studies (II): *Rhacophorus*

By

Hiroshi NOKARIYA*

Museo Nacional de Historia Natural, La Paz, Bolivia

(Communicated by Ikuwo OBATA)

Introduction

In the preceding paper, the author described skeletons of *Bufo*, *Hyla*, *Microhyla*, and *Bombina*. Here, I intend to describe skeletal elements of six Recent species of the genus *Rhacophorus* distributed in Japan.

It had been said that *Rhacophorus leucomystax* was introduced from Philippine to Okinawa islands after the end of World war II. From Minatogawa Quarry, Okinawa, however, a few postcranial fossil specimens similar to those of *Rha. leucomystax* was discovered (HASEGAWA *et al.*, m.s.), which indicate the natural distribution of the species in Okinawa.

The generic and specific characters are described following the classification of OKADA (1966) and NAKAMURA and UÉNO (1963). The osteological terminologies follow CHANTEL (1968), ECKER (1956), and NOKARIYA (1983). The following skeletal elements of examined species are deposited in the collection of National Science Museum: fronto-parietal, ethmoid, parasphenoid, maxilla, scapula, humerus, sacrum, ilium, and femur.

List of Species Examined

Order Salientia

Family Rhacophoridae

- Rhacophorus* TSCHUDI, 1838
- Rhacophorus arboreus* (Y. OKADA et KAWANO, 1924)
- Rhacophorus schlegelii* (GÜNTHER, 1858)
- Rhacophorus viridis* (HALLOWELL, 1860)
- Rhacophorus buergeri* (SCHLEGEL, 1838)
- Rhacophorus japonicus* (HALLOWELL, 1860)
- Rhacophorus leucomystax* (GRAVENHORST, 1829)

* Present address: 444-109 Kogane, Matsudo-shi, Chiba Prefecture 270, Japan.

Description

Family Rhacophoridae

Genus *Rhacophorus* TSCHUDI, 1838

Fronto-parietal (Fig. 1, 1-6): no occipital process; no dermal ornamentation nor ridge present except in *Rhacophorus leucomystax*.

Ethmoid (Fig. 1, 7-18): slightly longer than its width; anterior projection well developed; posterior dorsal edge strongly arches anteriorly; longitudinal striation present on surface.

Parasphenoid (Fig. 2, 1-6): blade almost equal to its width across alae; blade well developed; length of alae along body axis short comparing to width.

Maxilla (Fig. 2, 7-18): teeth present; dorsal process well developed; pterygoid process present; lingual shelf poorly developed.

Scapula (Fig. 3, 1-12): anterior margin of clavicular process convex; neck well developed; slenderer than in other Genera; length along body axis short comparing to width; ridge runs along long axis of dorsal surface of coracoid process.

Humerus (Fig. 3, 13-22): lateral flange present except in *Rhacophorus japonicus*; spina tuberculi medialis not or weakly present; width of anterior margin of ventral crest wider than that of base of ventral crest; long axis of olecranon ball external to that of shaft; from posterior view, outline of olecranon scar not clear; in male, size of medial flange larger than that in female (sexes are easily distinguishable by medial flange); in general, size of shaft in female far larger than that in male.

Sacrum (Fig. 3, 23-28): anterior surface of centrum concave in *Rhacophorus arboreus*, *Rha. schlegelii*, and *Rha. viridis*, but convex in *Rha. buergeri*, *Rha. japonicus*, and *Rha. leucomystax*; diapophysis rod in shape with expanded both ends; ridge thin.

Ilium (Fig. 4, 1-6): ilial crest slightly developed; no ilial crest in *Rha. buergeri*; dorsal protuberance slightly developed; antero-postero length of ventral acetabular expansion broad.

Femur (Fig. 3, 29): deltoid crest present.

Rhacophorus arboreus (OKADA et KAWANO, 1924)

Fronto-parietal (Fig. 1, 5): width slightly increases towards its proximal end; no occipital process nor canal; neck of medial posterior corner of orbital foramen developed; eaves as in lateral margin of body present; postorbital shelf scarcely developed; general shape of body resembles that of *Rha. schlegelii*.

Ethmoid (Fig. 1, 11-12): length equal to width; anterior projection scarcely developed; anterior margin arches anteriorly; processus lateralis projects antero-laterally; orbitonasal foramen faintly visible from below; flange weakly developed; posterior ventral edge wavy; posterior dorsal edge wavy; proximal end scarcely posterior to distal corners of both flanges.

Parasphenoid (Fig. 2, 5): blade scarcely shorter than its width across alae;

proximal end of blade pointed; neck of blade developed; alae almost perpendicular to blade or inclined at about 5° angle posteriad; distal end of posterior process slightly posterior to distal ends of alae.

Maxilla (Fig. 2, 7–8): teeth present; anterior end of pars facialis convex anteriorly; dorsal margin of pars facialis weakly arches ventrally; height of pars facialis low; dorsal process well developed and projects dorsally; pterygoid process not clearly visible lingual shelf weakly developed; height of body decreases towards its distal end.

Scapula (Fig. 3, 3–4): anterior margin of clavicular process convex; neck of body well developed; from dorsal view, anterior margin of coracoid process straight; ridge runs along center of coracoid process and continues to center of body parallel with posterior margin of body.

Humerus (Fig. 3, 13–14): distal end of medial epicondyle above that of olecranon ball; long axis of olecranon ball almost overlapped that of shaft; outline of olecranon scar not clear; general shape of shaft resembles that of *Rha. schlegelii*; in male, body size of this species larger than that of *Rha. schlegelii*; however, in smaller specimens of female it is hard to distinguish this species from *Rha. schlegelii*; lateral flange more developed than medial flange; sex easily distinguishable by size of medial flange.

Sacrum (Fig. 3, 27): anterior surface of centrum concave; diapophysis rod in shape with slight distal expansion; anterior margin of diapophysis slightly angular; ridge \cap shaped and runs to distal end of diapophysis; this ridge slightly bent anteriorly and its center does not contact anterior margin of neural arch.

Ilium (Fig. 4, 1): ilial crest weakly developed; condition of dorsal protuberance in Y type; antero-postero length of ventral acetabular expansion broad; ilial shaft angle at about 70°.

Remarks: large sized frog. This species resembles *Rha. schlegelii*, especially when small female is harder to identify these species. Three specimens are available for study. This species differs from other frogs and toads as follows: eaves as in lateral margin of fronto-parietal present; ridge on sacrum does not contact anterior margin of neural arch; ilial shaft angle of this species narrower than that of *Rha. schlegelii*.

Rhacophorus schlegelii (GÜNTHER, 1858)

Fronto-parietal (Fig. 1, 1): both lateral margins run parallel with each other; occipital process weak; occipital canal narrow and shallow; neck of medial posterior corner of orbital foramen not developed; no ridge present; postorbital shelf developed.

Ethmoid (Fig. 1, 15–16): length slightly longer than its width; anterior projection well developed; width narrow; processus lateralis projects latero-anteriorly; distance between both distal ends of processus lateralis almost equal to body length; orbitonasal foramen faintly seen from below; flange weakly developed; posterior ventral edge almost straight; posterior dorsal edge well arched anteriorly; its proximal end anterior to posterior corner of flange.

Parasphenoid (Fig. 2, 1): blade slightly shorter than its width across alae; proximal end of blade not pointed; alae inclined posteriad; antero-postero length of alae almost constant and narrow comparing to blade; neck of blade not pointed; distal end of posterior process extends a little posterior to distal end of alae.

Maxilla (Fig. 2, 9–10): teeth present; anterior end of pars facialis convex anteriorly; dorsal margin of pars facialis slightly arches dorsally; pars facialis very high; dorsal process well projects; height of posterior half of body very low; pterygoid process developed; anterior one third of lingual shelf developed; distal end of body pointed; general shape resembles that of *Rana (R.) limnocharis*.

Scapula (Fig. 3, 1–2): anterior margin of clavicular process convex; center of anterior margin of body does not concur with that of posterior one; from dorsal view, ridge runs along center of dorsal surface of coracoid process from its proximal end to center of body; no difference found between *Rha. schlegelii* and *Rha. arboreus* except by their size.

Humerus (Fig. 3, 17–18): shaft narrow comparing to those of other species of *Rhacophorus*; distal end of medial epicondyle at same level as that of olecranon ball; anterior margin of ventral crest arches anteriorly; long axis of olecranon ball external to that of shaft; outline of olecranon scar not clear; in male, lateral flange more developed than medial flange; sexually dimorphic.

Sacrum (Fig. 3, 26): anterior surface of centrum concave; diapophysis rod in shape with slight expansion; ridge lambda-shaped or \cap shaped and runs along dorsal surface of diapophysis to its distal end; this ridge stands upright and antero-postero length very thin; center of this ridge contacts anterior margin of neural arch.

Ilium (Fig. 4, 3): ilial crest present; dorsal margin of ilial crest almost straight; dorsal margin of dorsal acetabular expansion straight; angle between dorsal margin of it and posterior edge of dorsal protuberance wider than that of *Rha. arboreus*; condition of dorsal protuberance in X type; base of ilial shaft stands at antero-dorsal end of acetabular fossa; antero-postero length of ventral acetabular expansion broad; ilial shaft angle at about 90° .

Remarks: small sized frog. Size of male much smaller than that of female. This species resembles *Rha. arboreus*. It is difficult to separate *Rha. schlegelii* from *Rha. arboreus* except by their size. Ten specimens are available for study. This species differs from other frogs and toads as follows: shaft of humerus narrow comparing to those of other species of *Rhacophorus*; ridge on sacrum lambda-shaped and its center contacts anterior margin of neural arch; ilial shaft angle of ilium at almost 90° .

Rhacophorus viridis (HALLOWELL, 1860)

Fronto-parietal (Fig. 1, 4): width broad at proximal end; anterior margin of body inclined antero-medially; no occipital process nor occipital canal present; neck of medial posterior corner of orbital foramen not developed; parietal crest scarcely

developed; postorbital shelf weakly developed.

Ethmoid (Fig. 1, 9–10): length almost equal to width; anterior projection well developed; processus lateralis projects latero-anteriorly; distance between both distal ends of processus lateralis longer than its length; both flanges slightly developed; posterior ventral edge arched posteriad; posterior dorsal edge well arched anteriorly; its anterior end at same level as posterior corner of both flanges; in adult specimen, fused with vomer.

Parasphenoid (Fig. 2, 6): blade slightly longer than its width across alae; proximal end of blade not pointed; anterior margin of alae perpendicular to blade; posterior margin of alae strongly arches anteriorly; both distal ends of alae expanded; neck of blade slightly developed; distal end of posterior process extends beyond both posterior ends of alae.

Maxilla (Fig. 2, 11–12): teeth present; anterior margin of pars facialis convex anteriorly; dorsal margin of pars facialis almost straight; pars facialis slightly high; dorsal process projects dorso-anteriorly; pterygoid process developed; lingual shelf weakly developed; body decreases its height towards its distal end.

Scapula (Fig. 3, 5–6): anterior margin of clavicular process scarcely convex; neck of body well developed; in ventral view, anterior margin of articular fossa strongly arches anteriorly; in anterior view, coracoid process more curved dorsally than clavicular process; in dorsal view, ridge runs along center of coracoid process from proximal end to base and continues parallel with posterior margin of body.

Humerus (Fig. 3, 15–16): distal end of medial epicondyle at same level as that of olecranon ball; anterior margin of ventral crest almost straight; long axis of olecranon ball external to that of shaft; outline of olecranon scar indistinct; lateral and medial flanges well developed but thickness of both flanges very thin; in female, both flanges weakly developed; sex can be separated with flange; spina tuberculi medialis present in female.

Sacrum (Fig. 3, 25): anterior surface of centrum concave; diapophysis rod in shape with slight distal expansion; ridge \cap shaped and runs along dorsal surface of diapophysis to nearly distal end; this ridge well developed but thin and stands upright; center of this ridge contacts anterior margin of neural arch.

Ilium (Fig. 4, 2): ilial crest well developed; this medio-lateral width very thin; condition of dorsal protuberance in Y type; base of ilial shaft contacts anterior end of acetabular fossa; antero-postero length of ventral acetabular expansion broad; ilial shaft angle at about 75° .

Remarks: large sized frog. Two specimens are available for study. This species differs from other frogs and toads as follows. Anterior margin of fronto-parietal inclined antero-medially; parietal crest of fronto-parietal very weakly developed; posterior ventral edge of ethmoid arches anteriorly; anterior margin of clavicular process of scapula scarcely convex anteriorly; both flanges of humerus very thin in male; spina tuberculi medialis of humerus present in female; anterior surface of centrum of sacrum concave posteriad; ridge on sacrum \cap shaped and center of it

contacts anterior margin of neural arch; ilial crest of ilium very developed; base of ilial shaft of ilium contacts anterior end of acetabular fossa.

Rhacophorus buergeri (SCHLEGEL, 1838)

Fronto-parietal (Fig. 1, 3): width slightly increases towards its proximal end; width broad comparing to its length; no occipital process present; occipital canal present but shallow; neck of medial posterior corner of orbital foramen not developed; postorbital shelf scarcely developed.

Ethmoid (Fig. 1, 13–14): slightly longer than width; anterior projection well developed; processus lateralis projects latero-anteriorly; distance between both distal ends of processus lateralis almost equal to its body length; both flanges slightly developed; posterior ventral edge almost straight; posterior dorsal edge well arches anteriorly; its proximal end at same level as posterior corner of both flanges.

Parasphenoid (Fig. 2, 3): blade slightly longer than its width across alae; width of blade broad comparing to its length; proximal end of blade has several points; alae slightly inclined posteriorly; antero-postero length of alae almost constant; neck of blade not developed; distal end of posterior process at same level as posterior ends of both alae.

Maxilla (Fig. 2, 13–14): teeth present; anterior end of pars facialis convex anteriorly; dorsal margin of pars facialis almost straight and slightly inclined anteriorly; height of pars facialis low; dorsal process weakly projects dorsally; pterygoid process scarcely developed; lingual shelf scarcely developed; body decreases its height towards its distal end.

Scapula (Fig. 3, 9–10): anterior margin almost straight and neck weakly developed; from dorsal view, ridge on dorsal surface of coracoid process scarcely present; narrow foramen present between clavicular and coracoid processes.

Humerus (Fig. 3, 19–20): spina tuberculi medialis present; distal end of medial epicondyle above that of olecranon ball; anterior margin of ventral crest arches anteriorly; long axis of olecranon ball external to that of shaft; outline of olecranon scar indistinct; in male, medial flange well developed and projects medio-posteriorly; in female, lateral flange narrow but long; it can separate each sex with medial flange.

Sacrum (Fig. 3, 23): anterior surface of centrum convex; diapophysis in rod shape; anterior margin of diapophysis arches postero-medially; from dorsal view, general shape of this diapophysis in bow shape; ridge lambdoid and disappears on way to distal end of diapophysis.

Ilium (Fig. 4, 5): no ilial crest present; dorsal protuberance well developed; anterior end of acetabular fossa almost anterior by half length to dorsal protuberance; antero-postero length of ventral acetabular expansion broad; ilial shaft angle at about 80°.

Remarks: small sized frog. Six specimens are available for study. This species differs from other frogs and toads as follows: shallow occipital canal present on fronto-

parietal; several points present on proximal end of parasphenoid; ridge on dorsal surface of coracoid process of scapula indistinct; narrow foramen of scapula present between clavicular and coracoid processes; neck of scapula weakly developed; spina tuberculi medialis present on humerus; anterior surface of centrum of sacrum convex anteriad; ilial crest of ilium not present.

Rhacophorus japonicus (HALLOWELL, 1860)

Fronto-parietal (Fig. 1, 2): width decreases towards its proximal end; width slightly narrow compared to length; weak occipital process; no occipital canal present; neck of medial posterior corner of orbital foramen not developed; postorbital shelf scarcely developed.

Ethmoid (Fig. 1, 17–18): body rectangular, length slightly longer than its width; anterior projection weakly developed; processus lateralis projects latero-anteriorly; distance between both distal ends of processus lateralis almost equal to body length; both flanges weakly developed; posterior ventral edge arches anteriad; posterior dorsal edge well arches anteriad; its proximal end at same level as both posterior corner of flanges.

Parasphenoid (Fig. 2, 2): blade slightly longer than its width across alae; width of blade narrow compared to length; proximal end of blade pointed; anterior margin of alae about perpendicular to blade; antero-postero length of alae almost constant; neck of blade developed; distal end of posterior process posterior to both posterior ends of alae.

Maxilla (Fig. 2, 17–18): teeth present; anterior edge of pars facialis convex anteriad; dorsal margin of pars facialis almost straight and slightly inclined anteriad; height of pars facialis low; dorsal process projects dorsally; pterygoid process well developed; anterior one third of lingual shelf developed; distal end of body pointed; height of body decreases its height towards its distal end.

Scapula (Fig. 3, 11–12): neck of body well developed; from ventral view, anterior margin of articular fossa strongly arches anteriad; from dorsal view, ridge runs along center of coracoid process from its proximal end to nearly center of body; this ridge well developed.

Humerus (Fig. 3, 21): distal end of medial epicondyle above that of olecranon ball; base of medial margin of medial epicondyle angular; long axis of olecranon ball external to that of shaft; outline of olecranon scar not clear; both flanges not developed; it is difficult to separate each sex.

Sacrum (Fig. 3, 24): anterior surface of centrum convex; diapophyses rod in shape and extend to latero-postero-dorsally; weak ridge extends onto dorsal surface of diapophysis to both distal ends of it; this ridge ↑ or + in shape.

Ilium (Fig. 4, 4): ilial crest well developed; condition of dorsal protuberance in X type; antero-postero length of ventral acetabular expansion narrow; ilial shaft angle at about 50°.

Remarks: small sized frog. This species has many peculiar characters for *Rhacophorus*. Six specimens are available for study. This species differs from other frogs and toads as follows: width of fronto-parietal decreases its width towards proximal end; width of fronto-parietal narrow comparing to length; width of blade of parasphenoid narrow compared to length; anterior margin of articular fossa of scapula strongly arches anteriorly; both flanges of humerus lacking; anterior surface of centrum of sacrum convex anteriorly; antero-postero length of ventral acetabular expansion of ilium narrow.

Rhacophorus leucomystax (GRAVENHORST, 1829)

Fronto-parietal (Fig. 1, 6): dorsal surface well sculptured; width broad at middle; both fronto-parietals fused with each other at medial suture; fused with prootics; anterior margin of body concave posteriorly.

Ethmoid (Fig. 1, 7-8): length almost equal to its width; anterior projection developed; proximal end of dorsal surface of anterior projection concave posteriorly; processus lateralis projects latero-anteriorly; distance between both distal ends of processus lateralis longer than body length; orbitonasal foramen can be seen from below; both flanges developed; posterior ventral edge W-shaped; posterior dorsal edge wavy and its proximal end at same level as posterior corner of both flanges.

Parasphenoid (Fig. 2, 4): blade equal to its width across alae; proximal end of blade pointed; alae perpendicular to blade; posterior margin of alae arches anteriorly; both distal ends of alae pointed; shallow concavity present on both distal ends of ventral surface of alae; neck of blade developed; distal end of posterior process extends beyond both posterior ends of alae.

Maxilla (Fig. 2, 15-16): teeth present; anterior margin of pars facialis almost straight; dorsal margin of pars facialis almost straight and inclined slightly anteriorly; pars facialis slightly high; dorsal process projects dorsally; pterygoid process developed; lingual shelf weakly developed.

Scapula (Fig. 3, 7-8): neck of body weakly developed; anterior margin of clavicular process convex; from anterior view, coracoid process bent more dorsally than clavicular process; from dorsal view, ridge runs along center of coracoid process from proximal end of it to center of body; general shape of this species resembles that of *Rha. viridis*; ridge on coracoid process of this species weaker than that of *Rha. viridis*.

Humerus (Fig. 3, 22): spina tuberculi medialis weakly present; tip of medial epicondyle at same level as that of olecranon ball; long axis of olecranon ball external to that of shaft; length of ventral crest short comparing to that of shaft; shaft strongly arches anteriorly; outline of olecranon scar indistinct; in female, both flanges present and thin.

Sacrum (Fig. 3, 28): anterior surface of centrum convex; diapophyses rod in shape with slightly distal expansion; ridge + shaped and runs along long axis of diapophyses; this ridge does not contact both distal ends of diapophysis; anterior

end of centrum anterior to that of both prezygapophyses.

Ilium (Fig. 4, 6): ilial crest weakly present; dorsal margin of ilial crest slightly arches dorsally; condition of dorsal protuberance in X type; antero-postero length of ventral acetabular expansion broad; ilial shaft angle at about 80° ; general figure of this species resembles that of *Rha. viridis*.

Remarks: large sized frog, not naturally distributed in Japan. This species generally resembles *Rha. viridis*, especially in postcranial skeletons. Two specimens are available for study. This species differs from other frogs and toads as follows; dorsal surface of fronto-parietal heavily sculptured; both flanges of ethmoid well developed; shallow concavity present on each distal end of ventral surface of alae of parasphenoid; ridge on scapula weakly present; length of ventral crest of humerus short comparing to its shaft; ridge on sacrum + shaped; dorsal margin of ilial crest of ilium slightly arches dorsally.

Discussion and Conclusion

Osteologically, there are two groups in the genus *Rhacophorus*. One includes *Rhacophorus arboreus*, *Rha. schlegelii*, and *Rha. viridis*. The other includes *Rha. buergeri* and *Rha. japonicus*. The characters of the former group are as follows: width of fronto-parietal broad; length of ethmoid almost equal to width; lateral flange of humerus developed; anterior surface of centrum in sacrum concave posteriad; ilial crest of ilium present.

The characters of the latter group are as follows: width of fronto-parietal narrow; width of ethmoid shorter than length in *Rha. japonicus*; ridge of scapula weakly present (a foramen present in *Rha. buergeri*); no lateral flange of humerus present in *Rha. japonicus*; anterior surface of centrum in sacrum convex anteriad; ilial crest present on ilium in *Rha. buergeri* (antero-postero length of ventral acetabular expansion narrow in *Rha. japonicus*).

OKADA (1930) placed the latter group (*Rha. buergeri* and *Rha. japonicus*) in the genus *Polypedates*. There are differences in characters, however, between *Rha. buergeri* and *Rha. japonicus* (in scapula, humerus, and ilium). I did not have an opportunity to examine specimens which belong to the genus *Polypedates* (*Polypedates microtyimpanum*). So this time the author used *Rhacophorus* to include both groups.

According to NAKAMURA and UÉNO (1963), *Rhacophorus viridis* includes three subspecies: *Rhacophorus viridis amamiensis*, *Rha. v. viridis*, and *Rha. v. oustoni*. The characters that separate these subspecies are density of spots on the posterior surface of the thigh, length of the body, and their ranges. The subspecific characters, however, are difficult to be found on skeletons.

Osteologically, the genus *Rhacophorus* is well differentiated from other Japanese frogs. Diagnostic characters separating *Rhacophorus* from other frogs and toads are recognizable on the following skeletons.

Fronto-parietal (Fig. 1, 1-6): dermal ornamentation present (*Rhacophorus*

leucomystax); width broad comparing to length; no occipital process present.

Ethmoid (Fig. 1, 7–18): slightly longer than width; anterior projection developed; posterior dorsal edge well arches anteriorly.

Parasphenoid (Fig. 2, 1–6): blade almost equal to its width across alae; blade well developed.

Maxilla (Fig. 2, 7–18): no special difference present between *Rhacophorus* and *Rana*; teeth present; dorsal process well developed and projects dorsally; pterygoid process present; lingual shelf weakly developed.

Scapula (Fig. 3, 1–12): antero-postero length short comparing to its width; anterior margin of clavicular process convex; ridge runs along long axis of dorsal surface of coracoid process.

Humerus (Fig. 3, 13–22): lateral flange developed; width of shaft narrow comparing to that of genus *Rana*; long axis of olecranon scar indistinct.

Sacrum (Fig. 3, 23–28): anterior surface of centrum convex or concave; diapophyses in rod shape.

Ilium (Fig. 4, 1–6): ilial crest weakly developed; antero-postero length of ventral acetabular expansion broad.

Femur (Fig. 3, 29): deltoid crest present.

Digit: distal end of distal phalanx in Y shape.

References

- BRATTSTROM, M. B., 1957. The phylogeny of the Salientia based on skeletal morphology. *Syst. Zool.*, **6**: 70–74.
- CHANTEL, C. J., 1968a. The osteology of *Acris* and *Limnaeodes* (Amphibia: Hylidae). *Am. Midl. Nat.*, **79** (1): 169–182.
- , 1968b. The osteology of *Pseudoeacris* (Amphibia: Hylidae). *Am. Midl. Nat.*, **80** (2): 381–391.
- ECKER, A. *et al.*, 1956. The anatomy of the frog. i–xvi+1–449 pp. pls. I–II. Amsterdam, A Asher & co. n. n.
- GAUPP, E., 1896. Anatomie des Frosches. i–xiii+1–229 pp. Braunschweig, Friedrich Vieweg und Sohn.
- ICHIKAWA, M., 1951. Kaerugaku. i–v+1–239 pp. Tokyo, Shiyokabou. (in Japanese).
- NAKAMURA, K. & S. UENO, 1963. Japanese reptiles and amphibians in colour. i–ix+1–214 pp. Osaka, Hoikusha Publishing Co. Ltd. (in Japanese).
- NOKARIYA, H., 1983. Comparative osteology of Japanese frogs and toads for paleontological studies (I): *Bufo*, *Hyla*, *Microhyla*, and *Bombina*. *Bull. Natn. Sci. Mus., Tokyo*, Ser. C, **9** (1): 23–40.
- OKADA, Y., 1930. Monograph of Japanese tailless Batracus. (1)–(2)+1–234 pp. pls. 1–29. Tokyo, Iwanami-shiyoten. (in Japanese).
- , 1966. Fauna Japonica, Anura (Amphibia). xii+234 pp. Tokyo, Biogeographical Society of Japan.

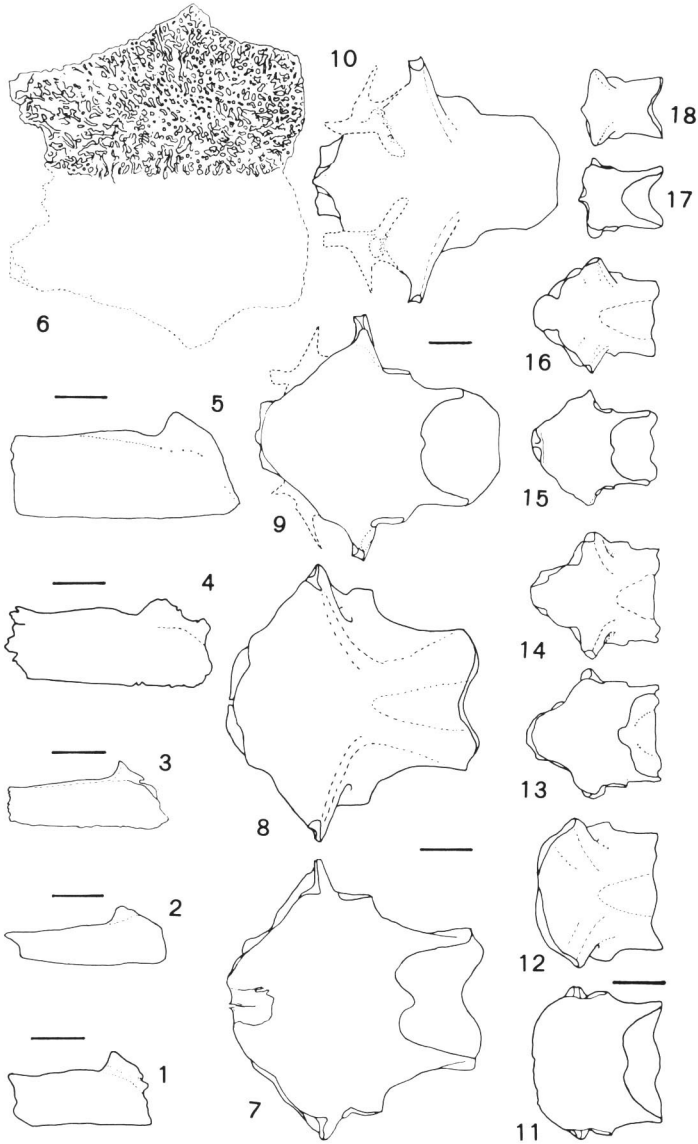


Fig. 1. Right fronto-parietal (Dorsal view). 1. *Rhacophorus schlegelii*, "Shuregeruaogaeru", 2. *Rhacophorus japonicus*, "Nihonkajikagaeru", 3. *Rhacophorus buergeri*, "Kajikagaeru", 4. *Rhacophorus viridis*, "Okinawaaogaeru", 5. *Rhacophorus arboreus*, "Moriaogaeru", 6. *Rhacophorus leucomystax*, "Shiroagogaeru". Ethmoid (Odd number: dorsal view, even number: ventral view). 7, 8. *Rhacophorus leucomystax*, "Shiroagogaeru", 9, 10. *Rhacophorus viridis*, "Okinawaaogaeru", 11, 12. *Rhacophorus arboreus*, "Moriaogaeru", 13, 14. *Rhacophorus buergeri*, "Kajikagaeru", 15, 16. *Rhacophorus schlegelii*, "Shuregeruaogaeru", 17, 18. *Rhacophorus japonicus*, "Nihonkajikagaeru". A scale indicates 1 mm. Scale between 11 and 12 applies for 11 through 18. For all figures, the anterior is to the left.

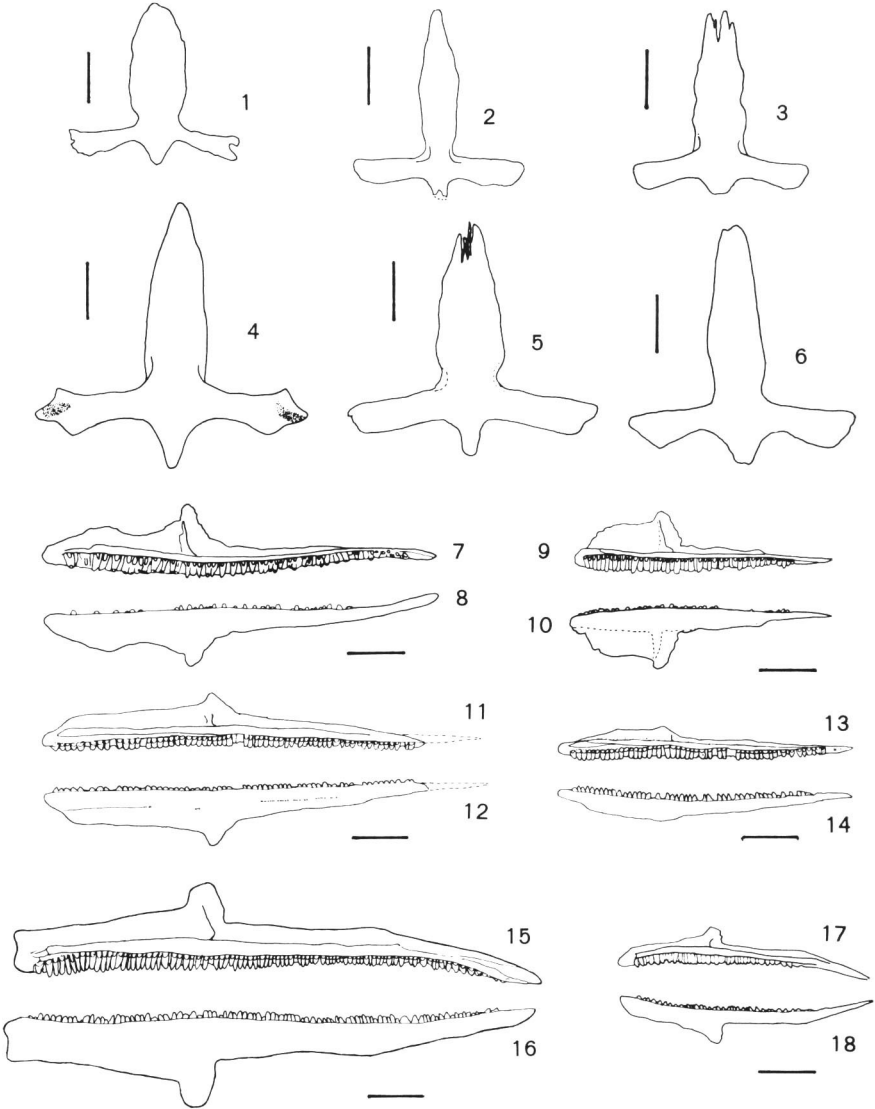


Fig. 2. Parasphenoid (Ventral view). 1. *Rhacophorus schlegelii*, "Shuregeruaogaeru", 2. *Rhacophorus japonicus*, "Nihonkajikagaeru", 3. *Rhacophorus buergeri*, "Kajikagaeru", 4. *Rhacophorus leucomystax*, "Shiroagogaeru", 5. *Rhacophorus arboreus*, "Moriaogaeru", 6. *Rhacophorus viridis*, "Okinawaaogaeru". A scale indicates 2 mm.

Right maxilla (Odd number: medial view, even number: lateral view). 7, 8. *Rhacophorus arboreus*, "Moriaogaeru", 9, 10. *Rhacophorus schlegelii*, "Shuregeruaogaeru", 11, 12. *Rhacophorus viridis*, "Okinawaaogaeru", 13, 14. *Rhacophorus buergeri*, "Kajikagaeru", 15, 16. *Rhacophorus leucomystax*, "Shiroagogaeru", 17, 18. *Rhacophorus japonicus*, "Nihonkajikagaeru". A scale indicates 2 mm.

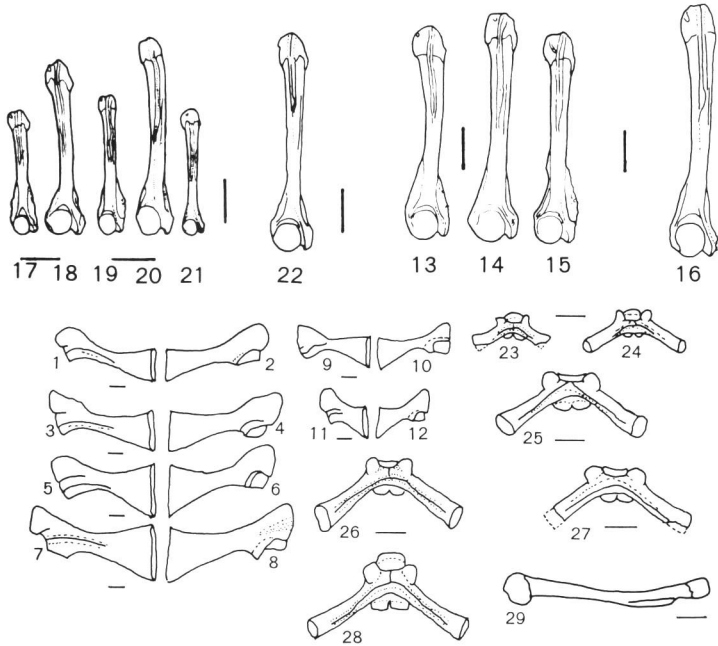


Fig. 3. Right scapula (Odd number: dorsal view, even number: ventral view). 1, 2. *Rhacophorus schlegelii*, "Shuregeruaogaeru", 3, 4. *Rhacophorus arboreus*, "Moriaogaeru", 5, 6. *Rhacophorus viridis*, "Okinawaaogaeru", 7, 8. *Rhacophorus leucomystax*, "Shiroagogaeru", 9, 10. *Rhacophorus buergeri*, "Kajikagaeru", 11, 12. *Rhacophorus japonicus*, "Nihonkajikagaeru". A scale indicates 1 mm.

Right humerus (Anterior view). 13. *Rhacophorus arboreus*, "Moriaogaeru", male, 14. ditto, female, 15. *Rhacophorus viridis*, "Okinawaaogaeru", male, 16. ditto, female, 17. *Rhacophorus schlegelii*, "Shuregeruaogaeru", male, 18. ditto, female, 19. *Rhacophorus buergeri*, "Kajikagaeru", male, 20. ditto, female, 21. *Rhacophorus japonicus*, "Nihonkajikagaeru", male, 22. *Rhacophorus leucomystax*, "Shiroagogaeru", female. A scale indicates 2 mm.

Sacrum (Dorsal view). 23. *Rhacophorus buergeri*, "Kajikagaeru", 24. *Rhacophorus japonicus*, "Nihonkajikagaeru", 25. *Rhacophorus viridis*, "Okinawaaogaeru", 26. *Rhacophorus schlegelii*, "Shuregeruaogaeru", 27. *Rhacophorus arboreus*, "Moriaogaeru", 28. *Rhacophorus leucomystax*, "Shiroagogaeru". A scale indicates 2 mm.

Right femur (Anterior view). 29. *Rhacophorus*, "Aogaeru". A scale indicates 2 mm.

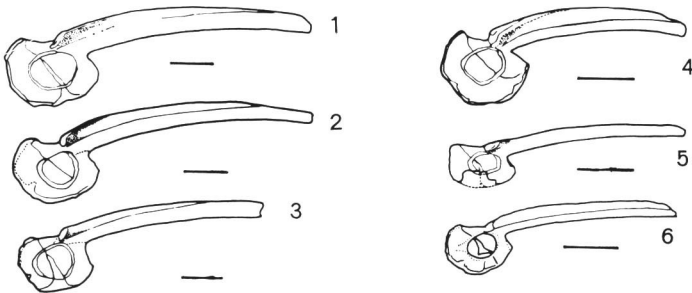


Fig. 4. Right ilium (Lateral view). 1. *Rhacophorus arboreus*, "Moriaogaeru", 2. *Rhacophorus viridis*, "Okinawaaogaeru", 3. *Rhacophorus schlegelii*, "Shuregeruaogaeru", 4. *Rhacophorus japonicus*, "Nihonkajikagaeru", 5. *Rhacophorus buergeri*, "Kajikagaeru", 6. *Rhacophorus leucomystax*, "Shiroagogaeru". A scale indicates 3 mm.

