Original Article

Two fossils ranids from the Late Tertiary Kabutoiwa Formation, Gunma Prefecture, Central Japan

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Abstract

In 1980, two almost complete fossil frog skeletons were discovered from the Kabutoiwa area, about 3 kilometers north—westnorth of the Hoshio Pass, Kanra—gun, Gunma Prefecture.

From osteological features, two species can be differentiated. One specimen can be assigned to *Rana* sp. and the second to *Rana* aff. architemporaria.

They can be assigned to the genus *Rana* based on the following diagnostic characters in width of the fronto—parietal is narrower than that of the genus *Rhacophorus*; scapula ridge runs along the anterior margin of the coracoid process; an outline of the olecranon scar of the humerus is present; the ilial crest is well developed; the vertebrae are proceedous; no deltoid crest present on femur.

Key words: Rana, Amphibia, Late Tertiary, Kabutoiwa Formation, Gunma

Introduction

In 1934, Makiyama and Kimizuka collected two specimen of the genus *Rana* in the Kabutoiwa area, at Usuda—machi, Minamisaku—gun, Nagano Prefecture (36°11′20″N, 138°37′20″E), the famous locality of fossil plants and insects. Those specimen were described as *Rana architemporaria* by Okada in 1937.

On the basis of the paleobotanical evidence (Suzuki et al., 1970) and data from the regional geology (Motojuku collaborative Research group, 1970), the frog and plant—bearing sediments were dated from the upper part of the Funakawa stage, Late Miocene. The area in this region once believed to be Upper Miocene in age are now placed in the Pliocene as a result of studies of Ozaki (1991). The authors agree with him.

Described here are two new specimens belonging to *Rana*. These fossil frogs were found by Okabe and Ibaraki from a different locality in the Kabutoiwa area, near Hoshio Pass, Nanmoku—mura, kanra—gun, Gunma Prefecture. This locality is the same horizon where *Rana architemporaria* was found (Motojuku collaborative Research group, 1970).

Another fossil *Rana* specimen from Japan is *Rana* siobarensis Shikama, 1955 from Shiranzawa, Nakashiobara Tochigi Pref. It resembles *Rana architemporaria* in the shortness of limbs and cranium (Shikama, 1955).

The oldest known ranid fossil was found in Niger from the lower Senonian (De Broin, Vergnaud—Grazzini et al., 1974). Ranids probably migrated from western Eurasia to eastern Asia during the middle Tertiary and introduced to tropical Asia during the Oligocene—Miocene (Savage, 1972).

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Nomenclature follows Ecker and Haslan (1971), Martin (1972), Chantell (1968), and Nokariya (1983 a,b).

Class Amphibia LINNAEUS, 1758
Order Salientia LAURENTI, 1768
Family Ranidae BONAPARTE, 1831
Genus Rana LINNAEUS, 1758
Rana sp.

Generic diagnosis: width of fronto—parietal narrow compared with its length; scapula ridge running along anterior margin of coracoid process; outline of olecranon scar of humerus present; procoelous vertebrae; ilial crest well developed; no deltoid crest on femur.

Locality and horizon: Kabutoiwa, about 3 kilometers north westnorth of the Hoshio Pass, Nanmoku-mura, Kanra-gun, Gunma Prefecture, Upper Motojuku Formation, Pliocene.

Material: Fig. 1, Pl. I-2a, 2b. Almost complete specimen except for some cranial elements. Dorsal view. outer mould.

Description: almost complete skeleton except parts of skull, right pes, and left leg missing; soft part preservation and colour bands on leg present; fronto—parietal and both distal parts of maxillae present.

Fronto—parietal: ornamentation present on dorsal surface; left and right ridges separate with complete sagittal suture present; width decrease proximally; width narrow compared with length; lateral margins not running parallel to each other; neck of medial posterior corner of orbital foramen not developed;

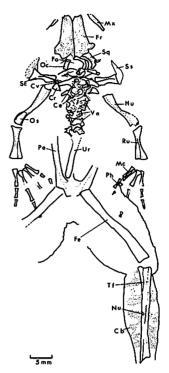


Fig 1. Rana sp. dorsal view

medial anterior margin of left and right sides do not contact each other; neither ridge nor occipital canal present; occipital process weakly developed.

Squamosal: left posterior arm present; anterior arm present but narrow.

Exoccipital: both exoccipitals present but details not clear.

Maxilla: teeth not seen; distal half of both maxillae present; ornamentation present on labial surface.

Mandible: missing.

Scapula: both present; ridge running along anterior margin of coracoid process to centre of body but does not contact anterior margin; anterior margin of clavicular process almost straight.

Coracoid: distal halves of both coracoids present; contacts scapula in normal position.

Clavicular: left distal half of body present.

Suprascapula: both present.

Humerus: both present; deltoid crest poorly developed; right olecranon scar present; olecranon scar high and width narrow; medial flange may be present; this specimen is therefore male.

Radio—ulna: both present; olecranon process only slightly developed; neck of body well developed; articulates with humerus in normal position.

Metacarpus: both missing.

Manus: right four fingers present; second and fifth right metacarpi longest among series; in right

manus, two phalanges in second finger, a single phalanx in third finger, two phalanges in fourth, and two phalanges in fifth finger present; left fourth metacarpus longest and second metacarpus shortest among series; in left manus, one phalanx in second finger, two phalanges in third finger, two phalanges in fourth finger present; tips of third and fourth fingers slightly expanded.

Vertebrae: eight procoelous vertebrae and urostyle present; first three vertebrae seen clearly and transverse process present; neural foramen of second vertebra small compared with centrum; neural arch thick; transverse process of vertebrae rod shaped; centra of third and fourth vertebrae small; outline of body from fifth to sacral vertebrae not seen clearly; diapophysis of sacrum may be rod shaped; both epiphyses of urostyle missing.

Pelvis: both distal ends of ilium missing; ilial crest present.

Femur: both present; distal end of right femur missing; outline "S" shaped; no deltoid crest present; length shorter than that of tibio—fibula; articulate

with ilium in normal position.

Tibio-fibula: only left present; distal end of left tibio-fibula missing; nutrial foramen present in middle of left tibio-fibula; femur articulates with tibio-fibula in normal position.

Tarsus: both missing.

Pes: missing.

Soft part: outline of both legs present; five or six colour bands present on left lower leg.

Comparison and remarks

The total body length of the specimen is shorter than that of Rana sickenbergi, R. yueshensis, R. architemporaria. However, it is longer than that of R. basaltica. The width of the fronto-parietal of Rana architemporaria remains roughly almost constant along its length. That of this specimen decrease distally. The direction of the ridge of the scapula of Rana ornativentris is similar to that of the present specimen. The anterior margin of the clavicular process is almost straight in Rana sp. In Rana

Measurement of Rana sp. (mm)		
Length of fronto-parietal	6.5	
Width of fronto-parietal	4.5	
Width of foramen magnum	2.5	
Length of maxillae	L. 2.9+	R. 2.0+
Length of scapulae	L. 3.4	R. 3.6
Length of coracoids	L. 1.6+	R. 1.6+
Length of suprascapulae	L. 2.1	R. 1.9
Length of humeri	L. 7.0+	R. 6.7+
Length of radio-ulnae	L. 4.8	R. 4.7
Length of metacarpals 2	L. 1.7+	R. 2.0
MC. 3	L. 2.1	R. 1.7+
MC. 4	L. 2.6	R. 2.0+
MC. 5	L. 2.2	R. 2.1
Length of pelvis	9.1+	
Length of femora	L.13.4	R. 7.7+
Length of tibio-fibula	L.14.1+	
Length of vertebrae from atlas to urostyle	15.4+	
Length of urostyle	6.5+	
Total length of body	30.3+	

architemporaria and other ranids, the anterior margin of the clavicular process is concave posteriorly. Although the distal end of the tibio—fibula is missing, it is of similar length to the femur, a complete tibio—fibula must therefore be longer than that of the femur in this specimen.

The dorsal surface of the fronto-parietal shows cranial ornamentation in this specimen. This differentiates Rana sp. from the other Rana genera in Japan and adjacent countries. In recent Japanese frogs and toads, the cranial ornamentation is present in Bufo b. japonicus, B. b. gargarizans, B. melanostictus, and Rhacophorus leucomystax (Nokariya, 1983 a, b). There is the cranial ornamentation in Rana (Aubria) subsigillata and Rana (Pyxicephalus) adspersa. The latter, however, is known only from tropical Africa. According to Procter (1919), these two species are closely related. This specimen is distinguished from Rana subsigillata and R. adspersa by the following characters; 1) sagittal ridge present in R. subsigillata. 2) notch present on lateral margin of fronto-parietal in R. adspersa. 3) sagittal suture does not persist beyond a third of its length in Rana subsigillata and R. adspersa.

Dermal ornamentation was widespread in primitive Amphibia ... to strengthen the skull and aid in the prevention of desication (Trueb,1973). According to Ozaki (1983), the fossil locality belonged to a temperate forest. Okabe *et al.* (1980) reported that this area correlated with the flora of central Japan which is mainly temperate deciduous broad leaved forests and shallow marshes. Therefore, arid conditions would not be prevalent in this area at that time. Cranial ornamentation might therefore have been to strengthen the skull. Anyway, this should be left to further study.

The soft part of Rana siobarensis Shikama is missing. The presence of colour bands on the legs of R. siobarensis is unknown. The cranial ornamentation was also not present in R. siobarensis. Neither colour bands nor cranial ornamentation are present in R. architemporaria, R. yueshensis, or R. basaltica. Five colour bands are present on the dorsal part of the thighs and four are present on the lower legs in Rana strausi from the Pliocene of Europe. According to Okada (1930), of living Rana that have the colour bands on the legs (there are 14 species and four subspecies) in Japan, Korea, and Formosa. In

Western China, eight species of *Rana* have colour bands on their legs (Liu,1950). Also, Taylor (1966) and Inger (1954) recognized 18 species of *Rana* that have colour bands on the legs in the Philippine Islands.

The presence of colour bands is important to identify species. However, there are variations in the numbers of colour bands between individuals.

This species agrees with that of the genus Rana as below; The width of the fronto-parietal is narrower than that of the genus Rhacophorus. There are maxillary teeth present in the genera Rana and The teeth on the maxilla might be Rhacophorus. present in this specimen, because teeth might be present in the counter part. The ridge of the scapula runs along the anterior margin of the coracoid process. In the genus Rhacophorus, that ridge runs along the centre of the coracoid process. The outline of the olecranon scar of the humerus is present in the genera Rana and Bombina. The ilial crest of the ilium is developed in the genera Rana and Rhacophorus. The vertebrae are procoelous in the genera Rana and Rhacophorus. There is not deltoid crest on the femur of Rana and Microhyla.

There are many generic characters of genus *Rana* in the present specimen. It is therefore not necessary to create a new genus.

Because of mentioned above characters, this specimen may be a new species. But it should be left to further study.

> Family Ranidae BONAPARTE, 1831 Genus *Rana* LINNAEUS, 1758 *Rana* aff. architemporaria

Generic diagnosis: width of fronto—parietal narrow compared with its length; ridge of scapula running along anterior margin of coracoid process; anterior margin of clavicular process of scapula concave posteriorly; ilial crest of ilium developed; rod like sacral diapophysis; no deltoid crest on femur.

Locality and horizon: Kabutoiwa about 3 kilometers north—westnorth of the Hoshio Pass, Nanmoku—mura, Kanra—gun, Gunma Prefecture, Upper Motojuku Formation, Pliocene.

Material: Figs. 2, 3 and Pl. I-1. Almost complete specimen. Dorsal view, outer mould.

Description: left manus and pes missing; soft body part and colour bands on back and legs present.

Fronto—parietal: left and right sides separated and sagittal suture completely present; width of body decreases towards its proximal end; width of body narrow compared with its length; medial posterior corner of orbital foramen not concave; neither ridge nor occipital canal present; occipital process weakly present; posterior end of occipital process at same level as that of body.

Squamosal: general shape like a "T"; striations present on lateral surface of posterior arm; length of anterior arm shorter than that of middle one.

Palatine: does not run straight; distal width of body wider than that of posterior one; body does not contact anterior arm of pterygoid.

Nasal: banana shaped; body narrow; nasals do not contact at medial line; only right side present.

Pterygoid: both present; anterior arm does not contact palatine; neither middle nor posterior arms seen.

Quadrate jugale: both present; proximal end pointed; they disarticulate with maxillae.

Maxilla: teeth not seen; both maxillae present; lingual shelf present on anterior two thirds; outline of pars facialis not clear; nasal margin (margo nasalis) not clear.

Premaxilla: teeth not seen; both present; outline not clear; they do not contact each other.

Columella: both present; rod like bar.

Mandible: both present except by both ends.

Scapula: both present; anterior margin of clavicular process concave posteriorly; ridge running along anterior margin of coracoid process lies central; body narrow and long.

Clavicular: missing.

Coracoid: both distal ends present.

Suprascapula: missing.

Humenus: both present; deltoid crest poorly developed; about half the length of tibio—fibula; articulates with radio—ulna in normal position.

Radio-ulna: both present; olecranon process slightly developed; neck well developed; shorter than that of tarsus.

Manus: third, fourth, and fifth fingers of right—manus present; only one left finger present; fourth metacarpus longest its series; three phalanges in fourth, three phalanges in fifth finger present; outline of digits expanded at each end.

Vertebrae: ten vertebrae present; transverse process

of second vertebra projecting latero—anteriorly; those of third and fourth vertebrae projecting latero—posteriorly; length of transverse process (from fifth to eight vertebrae) almost same length; they project latero—posteriorly; sacral diapophyses present and rod shaped; it projects postero—dorsally; sacral ridge running along long axis of diapophysis, but does not reach its distal end; total length of vertebrae (from atlas to sacrum) longer than that of urostyle.

Pelvis: both ilial shafts present; ilial crest present, but details not clear; distal ends of sacral diapophysis articulate with ilial shafts.

Femur: both present; outline "S" shaped; no deltoid crest present; shorter than that of tibio—fibula; they articulate with ilium in normal position.

Tibio-fibula: both present; almost straight; nutrial foramen present on middle of left tibio-fibula; femur articulates with tibio-fibula in normal position.

Tarsus: both present; half the length of tibio—fibula; articulates with tibio—fibula in normal position.

Pes: three right and four left metatarsi present; two phalanges in second finger, three in fourth finger present.

Soft part: outline of body clearly present except for the left manus and pes; three colour bands present on left soft part of thigh; four colour bands on right thigh; five colour bands on right lower leg; one colour band present on left lower leg; two colour bands present on right soft part of tarsus; three colour bands present on left soft part of tarsus; some longitudinal colour bands running parallel to each other on its back; pigments present in both orbital area that might represent eyes.

Comparison and remarks

One specimen is examined. The total body length of this specimen is shorter than that of Rana yueshensis and Rana architemporaria, but larger than that of R. basaltica, R. sickenbergi, and Rana sp.

The shape of the fronto-parietal of this specimen is similar to that of Rana basaltica, R. okinavana, and R. japonica. In Rana architemporaria, the width of the fronto-parietal is almost constant. The width of the fronto-parietal decreases towards its proximal end in Rana okinavana and this specimen. The length of fronto-parietal of this specimen is longer



Fig 2. Dorsal view of the Rana aff. architemporaria.

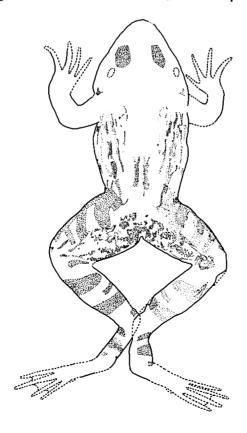


Fig. 3 Reconstruction of the body patterns of Rana aff. architemporaria, dorsal view.

Measurement of Rana aff. architemporaria (mm)		
Length of skull	14.6		
Width of skull	15.5		
Length of fronto-parietal	7.8		
Width of fronto-parietal	4.5	4.5	
Length of nasal	4.0	4.0	
Width of nasal	0.8	0.8	
Length of maxillae	L. 9.6+	R.10.2+	
Width of premaxilla	3.2	3.2	
Length of columellae	L. 1.3+	R. 0.8+	
Length of orbits	L. 5.5	R. 5.5	
Width of orbits	L. 2.2	R. 3.2	
Length of squamosals	L. 3.8	R. 3.9	
Length of palatines	L. 3.0+	R. 3.3+	
Length of mandibles	L. 9.4+	R.11.3+	
Length of scapulae	L. 4.4	R. 4.1	
Length of coracoid		R. 2.3+	
Length of humeri	L. 8.3	R. 9.6	
Length of radio-ulnae	L. 5.9+	R. 6.1	
Length of metacarpal 3		R. 2.5	
MC. 4		R. 3.1	
MC. 5		R. 2.8	
Length of pelvis	14.4	14.4	
Length of femora	L.16.0	R.15.8	
Length of tibio-fibulae	L.18.6	R.18.4	
Length of tarsi	L. 7.5	R. 8.1	
Length of vertebrae from atlas to uros	tyle 21.2	21.2	
Length of urostyle	10.0	10.0	
Total body length	40.1	40.1	

than that of R. architemporaria. The width of the nasal of this specimen is narrower than that of Rana architemporaria and R. temporaria. In Rana adenopleura, the medial posterior corner of orbital foramen is concave. But in this specimen, however, it is not concave. Rana sp, this specimen, R. okinavana, R. architemporaria, and R. japonica do not have the occipital canal. In Rana plancyi and R. limnocharis, the parietal crest is present on the dorsal surface of the fronto-parietal. Because of the lack of the posterior part of the cranium of this specimen, it is unknown whether the parietal crest is present or not. The occipital process of Rana japonica and R. ornativentris is well developed. Those of R. okinavana and this specimen are poorly developed. In Rana plancyi, the length of the anterior arm of the squamosal

is longer than that of this specimen. In Rana tigrina, the anterior arm of the pterygoid contacts the palatine. That of this specimen does not contact the palatine. Cranial ornamentation is not present in this specimen as in other ranids. In Rana ornativentris, the direction of the ridge of the scapula is similar to that of this specimen and Rana sp. Rana architemporaria does not have colour bands on the legs (Okada, 1937). Only Rana strausi, R. sp, and this specimen show colour bands on the legs in fossil Rana. Moreover, this specimen has longitudinal colour bands on its back.

The general impression of the skeletal elements of this specimen is similar to that of R. architemporaria except by having colour bands on legs and back.

Anyway it should be left to further study.

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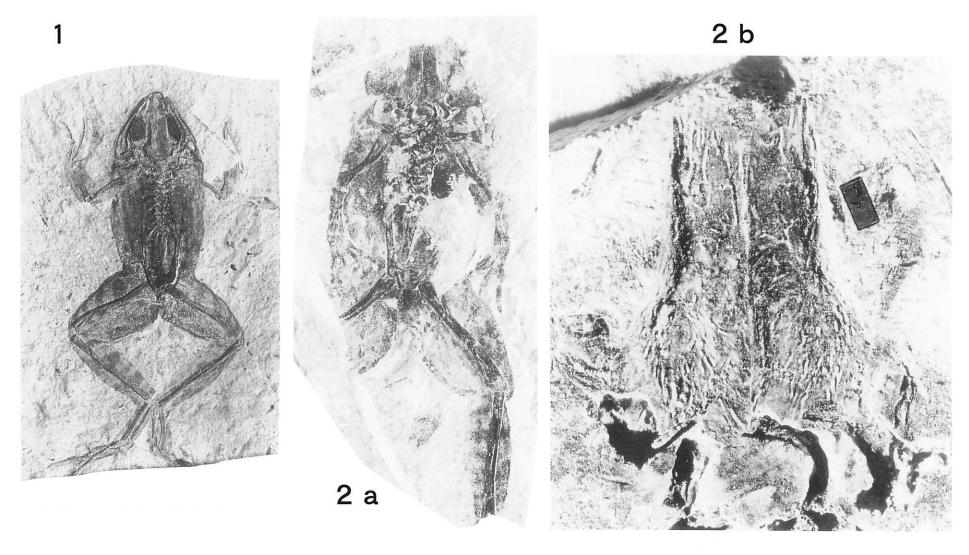
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Pl. I Two Late Tentiary ranids. 1. Dorsal view of Rana aff. architemporaria. ×1/2 2a. Dorsal view of Rana sp. ×1/2 2b. Enlarged shull part of the 2a, ×13

要旨

第三系兜岩層産アカガエル化石

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群馬県甘楽郡南牧村星尾の北北西約3kmにある上部本宿 層(兜岩層)から産出した2種類のアカガエル属化石を記 載した。

Rana aff. architemporariaは軟質部の印象が残っているばかりでなく、大腿部には体表のカラーパターンが鮮明に

みえる、極めて保存の良い標本である。Rana sp.は同様に、体表のカラーパターンが薄くみえる。この個体は特に前額頭頂骨および上顎骨の背面に彫刻がみられることから、前者とは異なる種である。新種の可能性がある。

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