The granitic Seychelles Is. lie in the western Indian Ocean between 4° and 5° S latitude and 55° and 56° E longitude, about 1600 km east of Africa (Mombasa), 926 km northeast of Madagascar (Antsiranana), and 2900 km southwest of India (Mumbai). These islands have fascinated biogeographers and geologists since the late 19th century when Darwin (1859) and Wallace (1880) pointed out that they are continental in character in spite of their great distance from large continental blocks.

Among the unusual features of the Seychelles is the presence of endemic amphibians. Wallace (1880) recognized amphibians as a group with very limited means of transoceanic dispersal, and their presence in the Seychelles was an important factor that prompted him to classify the Seychelles as “continental” as opposed to “oceanic” islands. However, the means by which amphibians and other sedentary groups may have populated the granitic Seychelles remained mysterious until the late 20th century when continental drift gained respectability, and the formation of the western Indian Ocean through the breakup of Gondwanaland began to be understood.

The amphibian fauna of the Seychelles consists of 13 species (6 caecilians and 7 frogs), 12 of which are endemic. The single non-endemic species, the ranid frog, *Ptychadena mascareniensis*, may have been introduced to the Seychelles by humans (Mertens 1934, Vences et al. 2004, but see Nussbaum 1984).

The frog family Sooglossidae is endemic to the Seychelles in the Indian Ocean, and consists of 2 genera and 4 species, the monotypic *Nesomantis* and *Sooglossus* (3 species). Many previous studies have suggested that *Sooglossus sechellensis* is more similar to *Nesomantis thomasseti* than to its congener, *S. gardineri*. Based on an extensive dataset of 188 morphological characters, we concluded that *Nesomantis* and *S. sechellensis* form a monophyletic group with the exclusion of *S. gardineri* (and *S. pipilodryas*). We therefore have established a new genus, *Sechellophryne*, to accommodate the latter 2 species.


**Key words:** *Nesomantis thomasseti, Sooglossus gardineri, Sooglossus pipilodryas, Sooglossus sechellensis, Sechellophryne gen. nov.*

Ronald A. Nussbaum and Sheng-Hai Wu (2007) Morphological assessments and phylogenetic relationships of the Seychellean frogs of the family Sooglossidae (Amphibia: Anura). *Zoological Studies* 46(3): 322-335. The frog family Sooglossidae is endemic to the Seychelles Is. in the Indian Ocean, and consists of 2 genera and 4 species, the monotypic *Nesomantis* and *Sooglossus* (3 species). Many previous studies have suggested that *Sooglossus sechellensis* is more similar to *Nesomantis thomasseti* than to its congener, *S. gardineri*. Based on an extensive dataset of 188 morphological characters, we concluded that *Nesomantis* and *S. sechellensis* form a monophyletic group with the exclusion of *S. gardineri* (and *S. pipilodryas*). We therefore have established a new genus, *Sechellophryne*, to accommodate the latter 2 species.


**Key words:** *Nesomantis thomasseti, Sooglossus gardineri, Sooglossus pipilodryas, Sooglossus sechellensis, Sechellophryne gen. nov.*

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The purposes of this paper were to (1) use a cladistic methodology applied to a broad morphological database to confirm or refute the monophyletic status of the sooglossids; and (2) determine the cladistic relationships within the family.

**Taxonomic history**

Boettger (1896) described the first sooglossid as *Arthroleptis sechellensis*, thereby assigning the species to a group of African ranids. Boulenger (1906) transferred *Arthroleptis sechellensis* to a new genus, *Sooglossus*, on the basis of tongue morphology (entire and elliptical), but retained the species among the ranids. Boulenger (1909) described *Nesomantis thomasseti* as a new frog genus and species from Mahé I., Seychelles. He wrote that *Nesomantis* is allied to *Sooglossus*, but unlike the latter genus, *Nesomantis* has vomerine teeth and lacks a claw-like, dermal tip to the digits. Boulenger viewed *S. sechellensis* as a dwarf *Nesomantis*. He did not comment on its relationships to other frogs, although he apparently assumed it was a ranid close to *Arthroleptis* and other African ranoids. Shortly afterwards, Boulenger (1911) described a 3rd Seychellen frog as *Nectophryne gardineri*, believing it to belong to an African bufoind genus, because of webbing at the base of the toes.

Noble (1926) noted pelobatid characteristics in all three of these Seychellen frogs, and consequently, he (1931) established a new pelobatid subfamily, the Sooglossinae, to accommodate all 3 species.

Noble (1926) stated that the differences between *S. sechellensis* and *Nesomantis* “are very trivial”, but that it is “well to utilize these generic names until the anatomy of *N. thomasseti* and *S. sechellensis* is better known.” He indicated that a separate genus might be justified for *Nec. gardineri*, but instead he opted for expanding the definition of *Sooglossus* and placing it in the latter genus as *So. gardineri*.

The recently described Nasikabatrachidae from the Western Ghats of India is considered to be the sister group of Sooglossidae based on molecular evidence (Biju and Bossuyt 2003). However, based on the limited morphological evidence from their description, it is more like the African Hemisotidae in the unique pectoral girdle architecture, external morphology, and life history (Scott 2005). However, Frost et al. (2006) found further support for a sooglossid-nasikabatrachid relationship and considered Nasikabatrachidae to
be a junior synonym of the Sooglossidae.

Gerlach and Willi (2002) described Soo. pipilodryas from the island of Silhouette as a new cryptic species closely related to S. gardineri. If Soo. pipilodryas proves to be a valid species (distinct from S. gardineri), then it is clearly the sister species of S. gardineri, and its existence will not affect the phylogenetic analysis that follows.

**MATERIALS AND METHODS**

We recorded morphological characters from 36 frog species representing 12 families (Appendix 1). The data set include 188 characters and is part of a larger project on the phylogeny of advanced frog families (Wu 1994). Characters and character states are listed in appendix 2. The data matrix can be obtained from the corresponding author upon request.

Cladistic analyses were performed using PAUP for Mclntosh, vers. 4.0b 10 (Swofford 2002). All 33 non-sooglossid taxa were used as outgroups. All characters were treated as unordered. Phylogenetic trees were obtained using maximum parsimony (MP) methods with heuristic search options. The following settings were used in the analyses: collapsing 0 length branches; starting trees obtained by stepwise addition and only minimal trees being swapped; and swapping options including the TBR (tree-bisection reconnection) algorithm, MULPARS, and steepest descent. Two hundred random additions were performed, and the 50% consensus cladogram was used in the results.

Branch supports were evaluated using bootstrapping methods with 1000 replicates and 10 random additions. The same search options used in the MP analysis were used in the procedure.

Character optimization was based on both the ACCTRAN (accelerated transformation) and DELTRAN (delayed transformation) methods. Only synapotypies obtained in both optimizing methods were listed as synapotypies in the final diagnoses of the clades. This is a more-conservative estimate of the synapotypies because there is no a priori reason to assume whether convergences or reversals are more-common processes in evolution.

**RESULTS**

The majority rule (50%) consensus tree from 1119 equally parsimonious cladograms had a consistency index of 0.243. Sooglossidae monophyly was supported by parsimony and bootstrapping (Fig. 1).

Twenty-four synapotypies diagnose the family, and bootstrap support for the clade was strong. Nesomantis thomasseti and Soo. sechellensis share 7 synapotypies, and bootstrap support for the grouping was moderately strong, thus supporting the monophyly of the 2 species with the exclusion of Soo. gardineri.

The family Sooglossidae is grouped with the Dendrobatidae and Leptodactylidae, but the bootstrapping support was low. Firmsternal families (Arthroleptidae, Microhylidae, and Petropedetidae) were highly supported by the MP and bootstrapping methods.

**DISCUSSION**

The cladistic results strongly support the conclusions of all students of the sooglossids beginning with Noble (1926) that this group is monophyletic. Noble’s (1926 1931) attempt to assign the sooglossids to the Pelobatidae was based on too-few characters and too-few taxa. Griffith’s (1959 1963) assignment of sooglossids broadly to ranoids resulted from errors in recording morphology, and subsequent workers who also argued for a ranoid association, (e.g., Savage 1973, Duellman and Trueb 1986, Blommers-Schlösser 1993) were misled by Griffith's erroneous morphological data. The discovery of some relatively plesiotypic character states for sooglossids also led various authors (Lynch 1973, Nussbaum 1980, Ford and Cannatella 1993) to hypothesize a myobatrachid affiliation for sooglossids.

DNA sequence data from the mitochondrial 12S ribosomal RNA gene suggested a closer relationship between myobatrachids and sooglossids than between bufonids and sooglossids (Hedges and Maxson 1993), as did a combined dataset using both mitochondrial 12S and 16S rRNA gene sequences (Hay et al. 1995). Both analyses indicated that sooglossids are more basal than myobatrachids and bufonids and closer to the former. With current knowledge, it is not possible to resolve the discrepancies between the cladograms based on morphology and rRNA gene sequencing.

Our results are consistent with earlier data on karyology (Nussbaum 1979), vocalization (Nussbaum et al. 1982), and allozymes (Green et al. 1988) which indicate that Nes. thomasseti and
Soo. *sechellensis* are closer cladistically than are *Soo. sechellensis* and *Soo. gardineri*. Additionally, the color patterns of *Nes. thomasseti* and *Soo. sechellensis* are similar and differ from the pattern of *Soo. gardineri*. The former 2 species have a generalized, camouflage color pattern consisting of a brownish ground color with scattered, small, dark markings; whereas *Soo. gardineri* has a more-specialized color pattern with a highly variable dorsal coloration and a bold black lateral band on the head and body. The color pattern of *Soo. pipilodryas* is nearly identical to that of *Soo. gardineri* (Gerlach and Willi 2002). Clearly a new taxonomic arrangement is needed, which includes 3 possible solutions. All 4 species could be placed in a single genus with the genus name *Sooglossus* having

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**Fig. 1.** Majority rule (50%) consensus cladogram of 937 steps (CI = 0.2467) with 161 informative morphological characters. Numbers above the branches indicate the percent support from 1119 equally parsimonious trees, while the numbers below the branches are bootstrap support for the clades. Only values > 50% are shown.
priority, or all 3 could be placed in monotypic genera, or Soo. gardineri and Soo. pipilodryas could be placed in a new genus and Nes. thomasseti placed in Sooglossus along with Soo. sechellensis. The latter option more reasonably reflects the cladistic relationships and acknowledges the great differences among the species, and is the solution we propose.

While sooglossids are undoubtedly monophyletic, the differences among the 4 species are great, which suggests long isolation in association with Seychellea. Our results do not resolve the issue of ex-Seychellean biogeographic relationships of the sooglossids. Bufonids occur in Africa and India, but are conspicuously absent from Madagascar, the continental land mass currently closest to Seychellea. Similarly, while caecilians occur in the granitic Seychelles, Africa, and India, none occurs in Madagascar. However, differences between sooglossids and bufonids, and between sooglossids and other possible sister groups (including Nasikabatrachus), are great; and it seems increasingly unlikely that a definite solution to the biogeographic origins of the sooglossids will be found.

For the moment, we do not include the Nasikabatrachidae within the Sooglossidae as suggested by Frost et al. (2006). This is because we lack comparative morphological data and because we suspect that Nasikabatrachus may prove to be a hemisotid or at least a microhyloid.

**SYNOPSIS**

**Sooglossidae Noble**

Sooglossinae Noble 1931: 494.

**Diagnosis:** Phaneroglossal anuran with modified arciferal pectoral girdles with small epicroacoid horns that are free posteriorly and with small musculus (m.) epicroacodeii; inguinal amplexus; 26 haploid chromosomes, the smaller of which are telocentric.

Twenty-four synapotypies diagnose the family based on our phylogenetic results. Even though none of the synapotypies is uniquely derived on a global scale, the combination of these character states is sufficient for diagnosing the family among advanced frog families. The character states are (numbers refer to characters listed in appendix 2): (20) 3rd toe shorter than 5th; (36) left and right m. sternohyoideus dorsalis inserting on each other rather than on hyoid plate; (38) a cutaneous slip of m. pectoralis present; (39) m. rectus abdominis pars anterorectifica present; (40) a type I iliosacral articulation; (41) m. iliolumbaris insertion on 1 or 2 transverse processes; (48) insertion of m. sartoriosemidentinosus dorsal to m. gracilis minor; (50) accessory ligament of m. gluteus magnus present; (66) tympanic ring absent; (67) stapes present; (91) choanal portion of prevomer wider than choanal diameter; (101-104) mentomeckelian bone absent; (119) cricoid ring with a mid-ventral gap; (123) bronchial process of cricoid absent; (141) monocondylar articulation between sacrum and coccyx; (145) transverse processes on coccyx present; (152) clavicle curved; (154) procoracoid curved; (177) tips of fingers pointed; (179) sesamoid bone at tibio-metatarsal joint present; and (187) tips of toes pointed.

**Content:** Two genera, Sooglossus (2 species), and a new genus (Sechellophryne) described below.

**Distribution:** Two islands, Mahé and Silhouette, of the granitic Seychelles, western Indian Ocean.

**Sechellophryne gen. nov.**

Type species: *Nectophyrne gardineri*
Boulenger 1911: 377.

**Diagnosis:** Sooglossid anuran with slightly webbed toes. A black lateral stripe from eye region to hindlimbs. Ten synapotypies: (19) webbing between toes at base; (53) posterolateral process of nasal absent; (64) braincase component of sphenethmoid contacting anterior border of optic foramen; (65) sphenethmoid forming anterior and medial border of orbit; (95, 96) palatine absent; (99) length of cultriform process of parasphenoid short, not reaching anterior border of optic foramen; (112) alary process of hyoid narrow base with lateral expansion; (166) dorsal protuberance of ilium absent; and (184) sesamoid on ventrolateral surface of tarsometatarsal joint present.

**Content:** Two species.

**Distribution:** As for the family.

**Etymology:** The generic name is derived from "Sechelles" (French) and "phryne" (Greek, feminine, toad), meaning the "Seychelles toad".
Sooglossus pipilodryas (Gerlach and Willi) comb. nov.
(Fig. 2)


Identification: Characters of genus. Small sooglossid, slightly larger than Sec. gardineri, females averaging 14.3 mm in snout-vent length with a maximum of 15.8 mm; males 10.0-12.6 mm. Compared to Sec. gardineri, Sec. pipilodryas with larger eyes, shorter tibia, and shorter fingers I and II. Coloration of upper surfaces variable, all with a mid-dorsal hastate mark running from a point halfway between eyes and forelimbs to vent. Vocalization, high-pitched squeak, similar to Sec. gardineri, but with more repetitions.

Distribution: Silhouette I. (Mon Plaisir, Jardin Marron).

Etymology: Refers to the calls, from pipilo (Latin, meaning a chirp), and dryas (Latin, for a forest spirit).

Sooglossus Boulenger


Diagnosis: Sooglossid frogs lacking webbing at base of toes. Diagnostic characters: (44) origin of m. coccygeosacralis on urostyle along its full length; (51) nasals with median contact; (54) posterior margin of nasal touching frontoparietal; (61) anterior margin of frontoparietal straight; (70) pre-maxilla and maxilla in contact and overlapping; (133) spinal processes on vertebrae II to IV present; and (164) posterior plate of xiphisternum slightly expanded.

Content: Two species, Sooglossus sechellensis (Boettger) and Soo. thomasseti (Boulenger).

Distribution: As for the family.

Etymology: Refers to the shape of the tongue, which is entire (no posterior notch).

Sooglossus sechellensis (Boettger) comb. nov.
(Fig. 3)


Identification: A small Sooglossus. Females averaging about 20 mm in snout-vent length (maximum about 25 mm); males averaging about 15 mm (19 mm maximum). Golden-brown dorsolateral ground color with bands and spots of black on back, sides, and upper surfaces of legs; no dark band on sides of head and body as in Sec. gardineri; large, often triangular, black spot on top of head just behind eyes, not present in Sec. gardineri; venter white, but chin and chest with light-brown spots. Most similar in coloration to young of...

Eight uniquely derived characteristics are found in this species: (6) supratympanic fold oblique; (96) lateral margin of palatine not in contact with maxilla; (100) posterior projection of parasphenoid entering foramen magnum; (106) pseudo-teeth on dentary present; (127) orientation of posterior margin of transverse process II horizontal; (130) transverse process VI posteriorly directed; (143) sacral diapophysis expanded; and (188) ventral surface of terminal phalanges with knob-like projection.

**Distribution:** As for family and genus.

**Etymology:** The specific name “*sechellensis*” (French spelling) refers to the group of islands where the species is found.

**Remarks:** *Sooglossus sechellensis* exhibits female parental care of embryos in terrestrial nests and has direct development with non-feeding larvae transported on the dorsum of the female parent. They call night and day and more frequently during wet weather. During dry weather, they seem to call more frequently during the day than at night.

*Sooglossus thomasseti* (Boulenger) 
**comb. nov.**

(Fig. 4)

*Nesomantis thomasseti* Boulenger 1909: 293. Holotype: BM 1907.10.15.111, collected in 1905 by H. P. Thomasset. Type locality: “Cascade, Mahé, at an altitude of 1500 feet.”

**Identification:** Thomasset’s frog the largest of the 3 sooglossid species and the rarest frog in the Seychelles. Full-grown females larger (about 55 mm in snout-vent length) than adult males (45 mm). Upper surfaces golden to reddish-brown with scattered black markings. Some few individuals with a broad, brown middorsal stripe. With black bars across tops of toes and legs. Many with a thin white or yellow line down middle of back and across backs of thighs. Most with a white line behind each eye which extends backwards to a point on back just above front legs. With a double row of 2-6 small, light-colored bumps down back, beginning behind each eye. Large eyes golden except for black pupils. Undersurfaces brown with some light mottling. Tips of toes slightly expanded, apparently for increased friction useful in climbing. Thomasset’s frog a rock climber, and found most often at night sitting on rocks and large boulders. Rarely found climbing on low branches of trees and shrubs. Call similar to that of Seychelles...
frog, but notes produced at a slower rate, call is longer, and 1st guttural note repeated 3 or 4 times rather than once. Entire song sounds like "rraack-rraack-toc-toc-toc-toc-toc-toc." 

Fifteen uniquely derived character states were found in this species:(11) tips of fingers expanded into discs; (15) fleshy tips of toes expanded into discs; (45) origin of m. tensor fasciae latae on ilium on posterior 1/3 of ilium; (59) crest on posterior 1/2 of frontoparietal present; (80) angle between horizontal process of squamosal and prootic greater than 45°; (81) squamosal bending posteroventrally; (92) dentary process of prevomer posterior to choana; (93) dentary processes of prevomer not in contact medially; (94) prevomerine teeth present; (97) palatine and prevomer fused; (111) hyoglossal sinus of hyoid deep; (113) posterolateral process of hyoid bifurcated; (128) length of transverse process IV longer than III; (156) lateral edge of procoracoid reduced; and (160) omosternum with distal expansion.

Distribution: As for family and genus.

Etymology: Named for Mr. H. P. Thomasset, who collected the holotype.

Remarks: The mode of development and the presence or absence of parental care is unknown for Soo. thomasseti comb. nov. However, this species is likely to have direct terrestrial development with female egg-guarding. This is based on the observation (RAN) that females have large yolky eggs (typical of direct development) in their ovaries, and that no unidentified larvae which might be young of Soo. thomasseti comb. nov. have been found in streams or small ponds in the Seychelles. The prediction of female egg-guarding is based on the observations (RAN) that females of Soo. sechellensis and Sec. gardineri comb. nov. guard their eggs.

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REFERENCES


APPENDIX I. Specimens examined

ARTHROLEPTIDAE: Arthroleptis stenodactylus, UMMZ 190671. BUFONIDAE: Atelopus varius, UMMZ 167396; Bufo bankorensis, UMMZ 199143, 199144; Dendrophryniscus brevipillicatus, UMMZ 127926; Melanophryniscus stelzneri, UMMZ 166797; Nectophrynoides viviparus, UMMZ 70290; Oreophrynella quelchii, UMMZ 85141. DENDROBATIDAE: Dendrobates auratus, UMMZ 184022, 184021; Mannophryne herinae, UMMZ 113914(2). LEPTODACTYLIDAE: Eleutherodactylus antillensis, UMMZ 80669; E. atkinsi, UMMZ 63981; E. augustidigitorum, UMMZ 112799; E. bakeri, UMMZ 123080; E. erythropleurus, UMMZ 121457; E. guentheri, UMMZ 204763; E. heminota, UMMZ 136452; E. karlschmidtii, UMMZ 73433; E. limbatus, UMMZ 65032; E. parvus, UMMZ 127919; E. ronaldi, UMMZ 80910; E. varleyi, UMMZ 63978; Telmatobius marmoratus, UMMZ 68179. LIMNODYNASTIDAE: Mixophyes schevilli, UMMZ 132692; Notaden nichollsi, UMMZ 124498. MEGOPHYRIIDAE: Megophrys sp., no tag. MICROHYLIDAE: Dyscophus antongilii, UMMZ 191162, 191167; Scaphiophryne calcaratum, UMMZ 191138. MYOBATRACHIDAE: Taudactylus diurnus, UMMZ 132731. PETROPEDETIDAE: Arthroleptella lightfooti, UMMZ 190668; Cacosternum bottgeri, UMMZ 190653. RHINODERMATIDAE: Rhinoderma darwini, UMMZ 123886. SCAPHIOPODIDAE: Scaphiopus couchii, UMMZ 200821, 200822. SOOGLOSSIDAE: Nesomantis thomasseti, UMMZ 144476, 177110, 177111, 179597; Sooglossus gardineri, UMMZ 183079, 183080; Soo. sechellensis, UMMZ 179624, 183077, 183078.
APPENDIX II. Characters and character states

**External morphology**


**Myology**

22. Aponeurosis on midline of m. intermandibularis. 0: absent; 1: present. 23. Lateral slip of m. intermandibularis. 0: absent; 1: lateral slip; 2: 2 lateral slips. 24. Origin of lateral slip of m. intermandibularis. 0: from jaw angle; 1: midway on mandible; 2: absent. 25. Orientation of anterior fibers of m. intermandibularis. 0: anteromedio-posterolaterally; 1: posteromedio-antrolaterally. 26. Position of cranial nerve V relative to m. adductor mandibulae longus. 0: muscle absent; 1: muscle medial to nerve; 2: muscle lateral to nerve; 3: muscle penetrated by nerve. 27. Position of cranial nerve V relative to m. adductor mandibulae internus. 0: nerve anterior to muscle; 1: nerve posterior to muscle; 2: nerve penetrating muscle. 28. Insertion of m. adductor mandibulae internus. 0: by muscle fiber; 1: by ligament. 29. M. adductor mandibulae externus superficialis. 0: muscle absent; 1: cranial nerve V medial to muscle; 2: cranial nerve V lateral to muscle. 30. Origin of m. depressor mandibulae. 0: on dorsal fascia and skull; 1: on skull only; 2: on dorsal fascia only. 31. Insertion of m. petrohyoideus posterior III. 0: on posteromedial process of hyoid; 1: on postero medial process and on cricohyoid membrane. 32. Origin of m. cucularis relative to that of m. petrohyoideus posterior III. 0: dorsal and lateral; 1: ventral. 33. Insertion of m. constrictor laryngis anterior. 0: on medial margin of postermedial process; 1: on ventral hyoid plate. 34. Number of slips of m. petrohyoideus posterior. 0: 2; 1: 3. 35. M. omohyoideus. 0: present; 1: absent. 36. M. sternohyoideus dorsalis. 0: originating on lateral hyoid. 1: fibers connecting to each other. 37. Insertion of m. pectoralis and m. deltoideus. 0: insertion converge; 1: pectoralis dorsal and medial to deltoideus; 2: insertion separated by deltoi d crest of humerus; 3: pectoralis inserting on axillary spine. 38. Cutaneous slip of m. pectoralis. 0: absent; 1: present. 39. M. rectus abdominis pars anteroreflexa. 0: absent; 1: present. 40. Lliosacral articulation. 0: type I; 1: type II. 41. M. iliolumbaris insertion on transverse process. 0: on 1 or 2 transverse processes; 1: on 3 or more transverse processes. 42. Origin of m. coccygeoliacus on urostyle. 0: on posterior tip; 1: on posterior 1/2 of urostyle. 43. Origin of m. iliacus externus. 0: covering the dorsal surface of ilium; 1: ilium exposed. 44. Origin of m. coccygeosacrals on urostyle. 0: on anterior 1/2 of urostyle; 1: along full length of urostyle. 45. Origin of m. tensor fascia latae on ilium. 0: on posterior 1/3 length of ilium; 1: on anterior 1/2 length of ilium; 2: muscle absent. 46. Anterior insertion of m. iliacus externus. 0: on margin of diapophysis; 1: not to diapophysis. 47. M. adductor longus. 0: absent; 1: present. 48.
Insertion of m. sartorio-semitendinosus relative to m. gracilis minor. 0: ventral; 1: penetrating; 2: dorsal. 49. Cutaneous slip of m. gracilis minor. 0: absent; 1: present. 50. Accessory ligament of m. gluteus magnus. 0: absent; 1: present.

Osteology of the head

51. Median contact of nasals. 0: in contact; 1: separate. 52. Nasal shape. 0: club-shaped; 1: wide, triangular; 2: square, rhomboidal, or rectangular. 53. Posterioral process of nasal. 0: absent; 1: present. 54. Posterior margin of nasal. 0: touching frontoparietal; 1: separated from frontoparietal. 55. Posteralateral process of frontoparietal. 0: absent; 1: present. 56. Ossification of frontoparietal. 0: well-osfified, separate; 1: well-osfified, in contact with each other; 2: poorly osfified, frontal fontanelle exposed. 57. Posterior margin of frontoparietal. 0: forming dorsal border of foramen magnum; 1: exposing exoccipital; 2: frontoparietal on lateral side, not to midline. 58. Frontoparietal posterior process. 0: straight; 1: with process; 2: frontoparietal restricted on lateral side, not to midline. 59. Crest on posterior 1/2 of frontoparietal. 0: absent; 1: present. 60. Frontoparietal ossification center. 0: 2; 1: 1. 61. Anterior margin of frontoparietal. 0: medial side extending beyond lateral side; 1: anterior margin straight; 2: lateral part extending beyond medial part. 62. Cranial exostosis. 0: absent; 1: present. 63. Fusion of sphenethmoid on mid-ventral portion. 0: separate; 1: fused. 64. Braincase component of sphenethmoid. 0: contacting anterior border of optic foramen; 1: not in contact. 65. Sphenethmoid. 0: on medial margin of orbit; 1: forming anterior and medial border of orbit. 66. Ear, tympanic ring. 0: present; 1: absent. 67. Ear, stapes. 0: absent; 1: present, proximal end simple; 2: present, proximal end enlarged. 68. Premaxilla, alary process. 0: projecting forward; 1: vertical; 2: backward. 69. Height of premaxillary alary process. 0: > width of pars dentalis; 1: ≤ width of pars dentalis. 70. Premaxilla and maxilla. 0: contacting and overlapping; 1: not in contact. 71. Premaxilla, pars palatina. 0: with a recess in middle; 1: with a straight edge; 2: absent. 72. Premaxilla, angle between alary process and horizontal process. 0: perpendicular; 1: inclined laterally away from midline. 73. Premaxilla, pars dentalis width of lateral and medial flanges. 0: lateral wider or equal to medial flange; 1: medial wider than lateral. 74. Maxilla, anterior border. 0: separate; 1: fused anteriorly. 75. Maxilla, articulation with quadratojugal. 0: in contact; 1: not in contact; 2: quadratojugal absent. 76. Pars facialis of maxilla. 0: pars absent; 1: pars triangular; 2: pars square. 77. Maxilla, articulation with zygomatic ramus of squamosal. 0: not in contact; 1: in contact. 78. Quadratojugal. 0: present; 1: absent. 79. Quadratojugal articulation with zygomatic ramus of squamosal. 0: not in contact; 1: in contact. 80. Alignment of horizontal process of squamosal with prootic. 0: parallel; 1: < 45°; 2: > 45°. 81. Squamosal shape. 0: straight; 1: bending posterovertrally; 2: bending posterosdorsally. 82. Squamosal, angle between ventral ramus and mandible. 0: nearly perpendicular; 1: > 45°, < 90°; 2: about 45°. 83. Squamosal, articulation with quadratojugal. 0: fused or abutting each other; 1: separate; 2: quadratojugal absent. 84. Zygomatic ramus of squamosal. 0: absent; 1: present. 85. Otic ramus of squamosal. 0: absent; 1: present. 86. Pterygoid, anterior ramus. 0: in contact or fused with maxilla; 1: separated by cartilage. 87. Pterygoid medial ramus. 0: absent; 1: separated from otic capsule by cartilage; 2: in contact with otic capsule. 88. Prevoer, odontoïd. 0: absent; 1: present. 89. Prevoer, anterior process. 0: absent; 1: present. 90. Size of precoanal process of prevoer relative to choanal diameter. 0: smaller than 1/2 choanal diameter; 1: larger than 1/2 choanal diameter. 91. Width of choanal portion of prevoer relative to choanal diameter. 0: wider; 1: narrower. 92. Dental process of prevoer. 0: posterior to choana; 1: medial to choana; 2: absent. 93. Dentary process of prevoer median contact. 0: separate; 1: meeting at midline; 2: process absent. 94. Prevoerine teeth. 0: present; 1: absent. 95. Medial margin of palatine. 0: meeting at midline; 1: not in contact at midline; 2: palatine absent. 96. Lateral margin of palatine. 0: not in contact with maxilla; 1: in contact; 2: palatine absent. 97. Palatine and prevoer. 0: separate; 1: fused; 2: palatine or prevoer absent. 98. Anterior margin of cultriform process of parasphenoid. 0: serrated; 1: rounded or square; 2: forked. 99. Length of cultriform process of parasphenoid. 0: reaching level of palatine or sphenethmoid; 1:

Osteology of the hyoid and larynx


Osteology of the vertebral column


Osteology of the pectoral and pelvic girdles

146. Medial coracoid. 0: straight; 1: bifurcated. 147. Coracoid, posterior margin. 0: curved; 1:

Osteology of the appendicular skeletons