Amphibian Diversity

UNIVERSITAS INDONESIA
Veritas, Probitas, Iustitia

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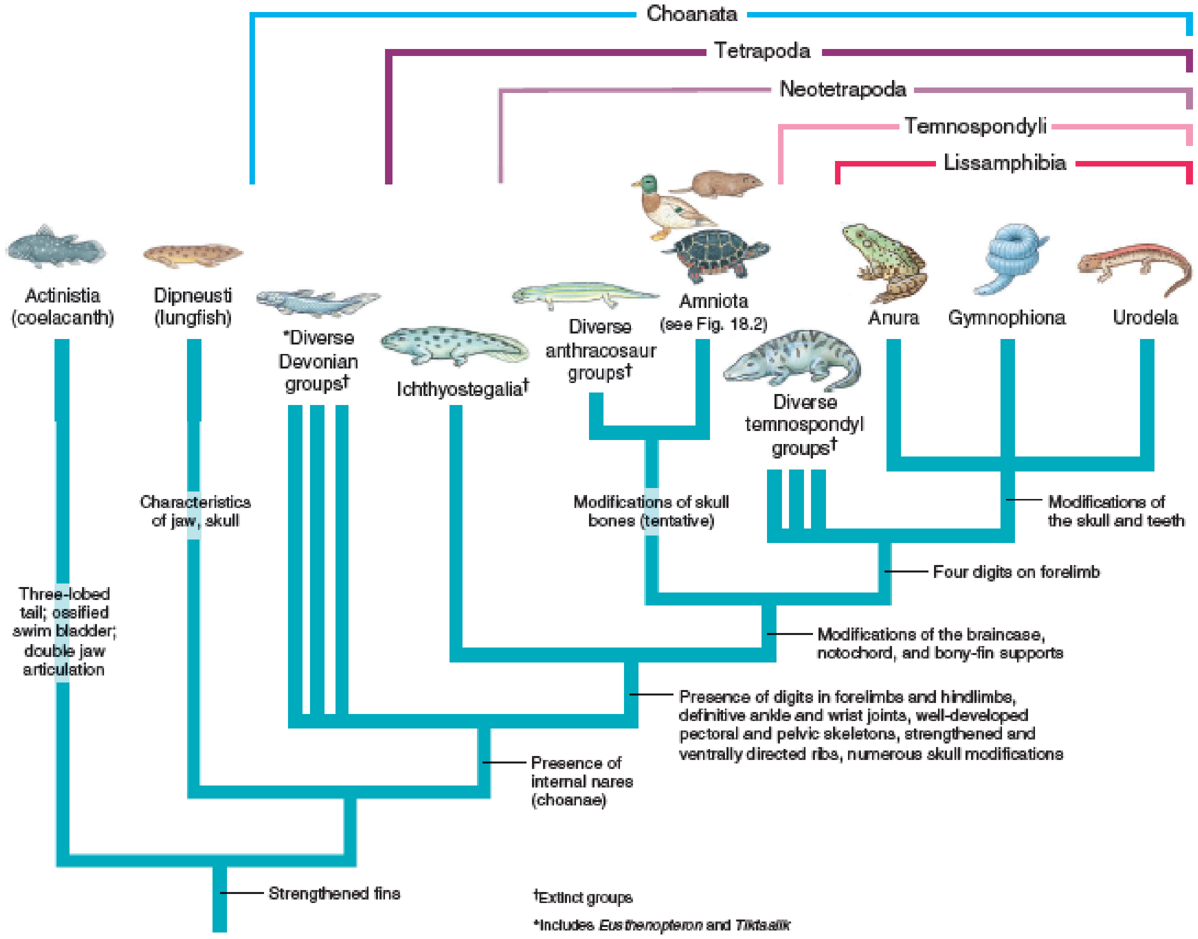
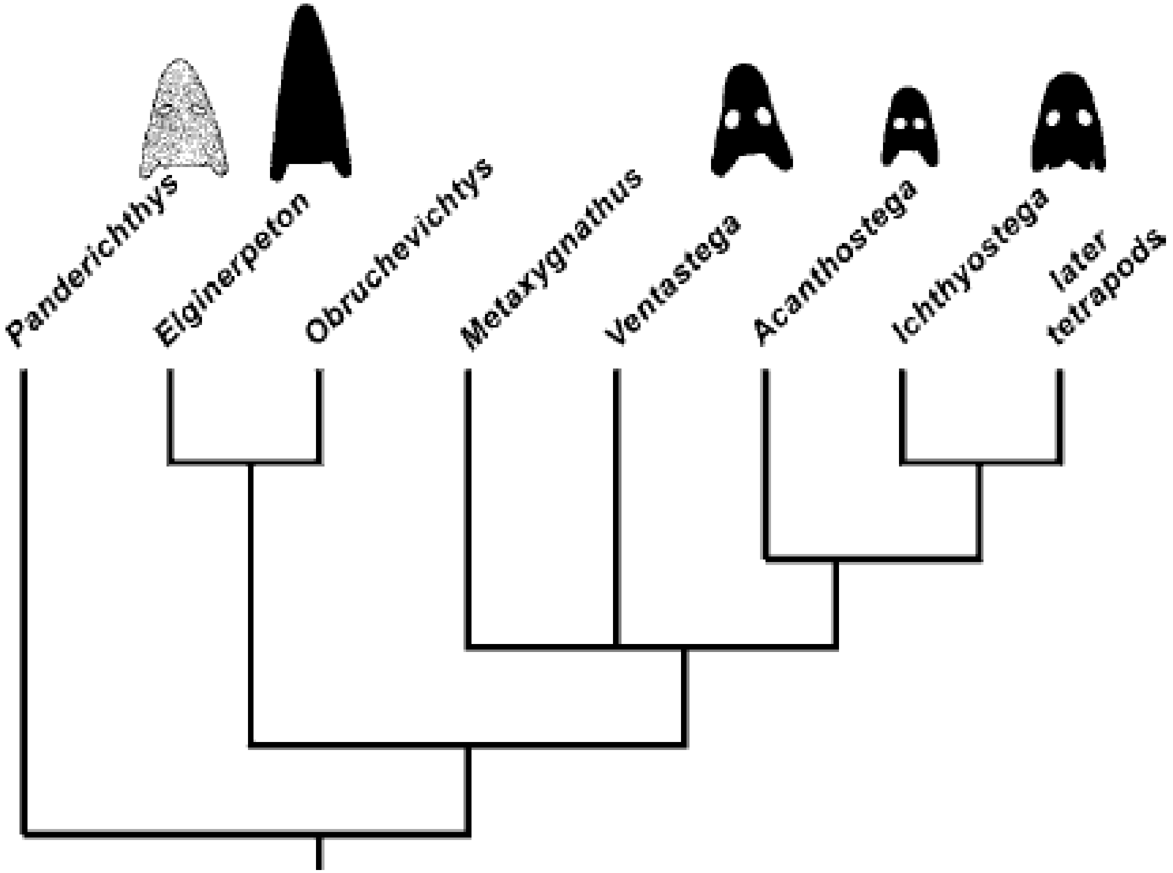
The Origin and Evolution of Amphibians

- The three living groups of amphibians are descended from a diverse group of tetrapods that first appeared in the **Devonian Period**, about 400 million years ago
- The ancient continents were uniting into a single large landmass, **Pangaea**, much of which was situated in **tropical** or **subtropical** latitudes.
- The climate is assumed to have been relatively warm and equable for terrestrial life. Land communities were characterized by assemblages of relatively primitive plants and arthropods.

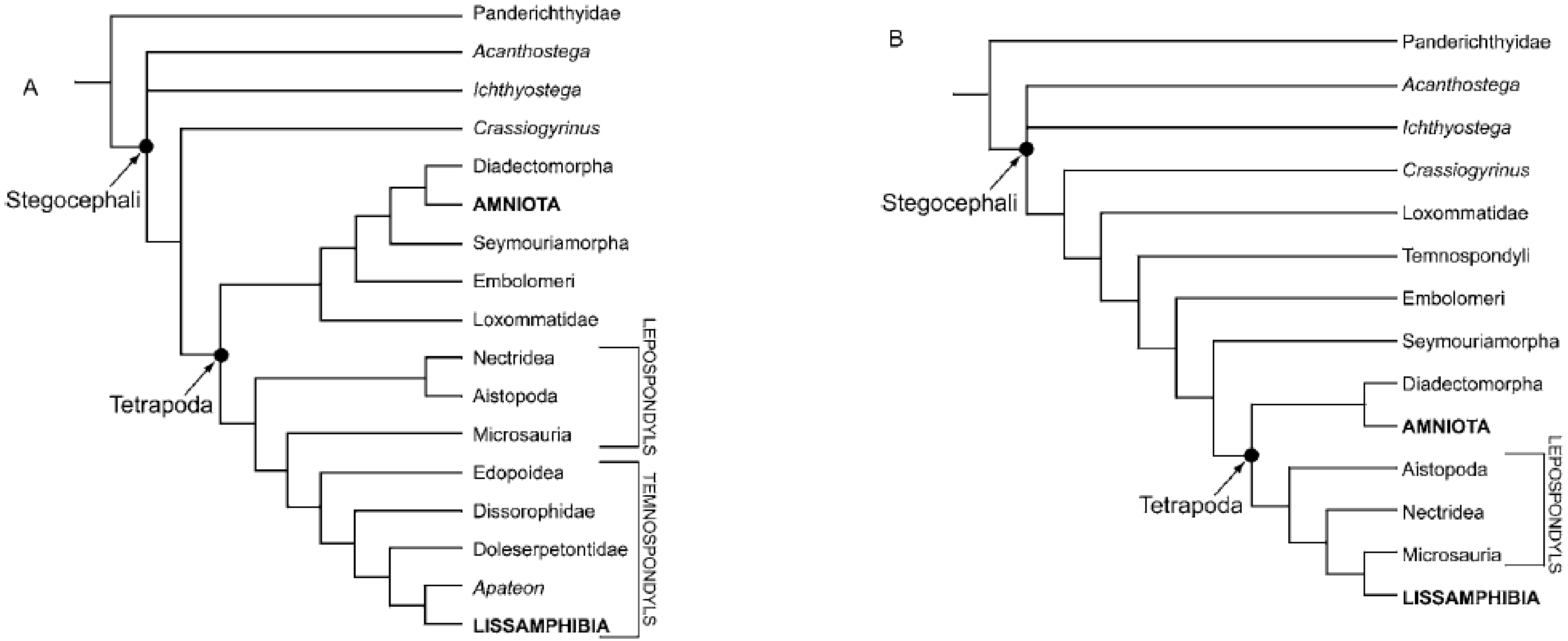


Phylogeny of Devonian tetrapods



Phylogeny of Devonian tetrapods, with diagrammatic representations of skull structure of major clades. *Ichthyostega* is considered the sister group to the later tetrapods.

The Origin of Modern Amphibians



Alternative phylogenetic hypotheses for the relationships of lissamphibians, amniotes, and early tetrapods.

(A) Traditional hypothesis showing lissamphibians related to temnospondyls.

(B) Hypothesis of Laurin and Reisz (1997), showing lissamphibians related to lepospondyls and to microsaurs in particular.

General Characteristics of Living Amphibians

- Three major groups of amphibians are very different :
  1. Frogs and toads (order Anura) :

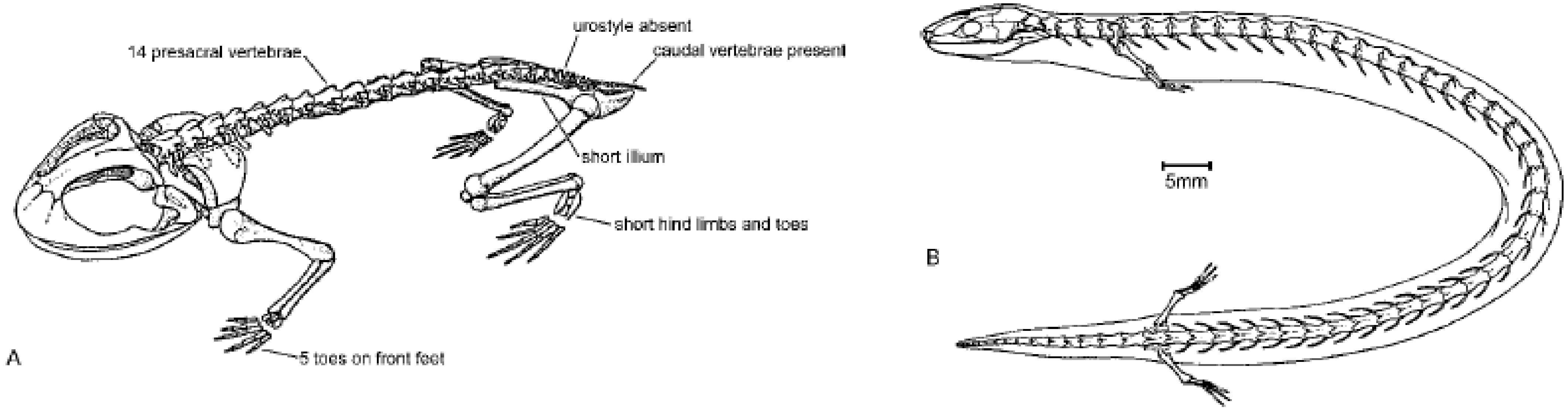
     specialized for jumping, with greatly enlarged hind legs, shortened bodies, no tail, and large heads and eyes.
  2. Salamanders and newts (order Urodela):

     more elongate, with front and back legs of approximately equal size and a long tail (this clade is called Caudata by some systematists, derived from the Latin rather than the Greek word for “tail”).
  3. Caecilians (order Gymnophiona) :

     specialized for life underground. They have elongated, snakelike bodies that lack legs, and they have greatly reduced eyes.

Representatives of the three major clades of living amphibians.
(A) *Agalychnis callidryas* (Anura, Hylidae).
(B) *Ambystoma annulatum* (Urodela, Ambystomatidae).
(C) *Siphonops annulatus* (Gymnophiona, Caeciliidae).

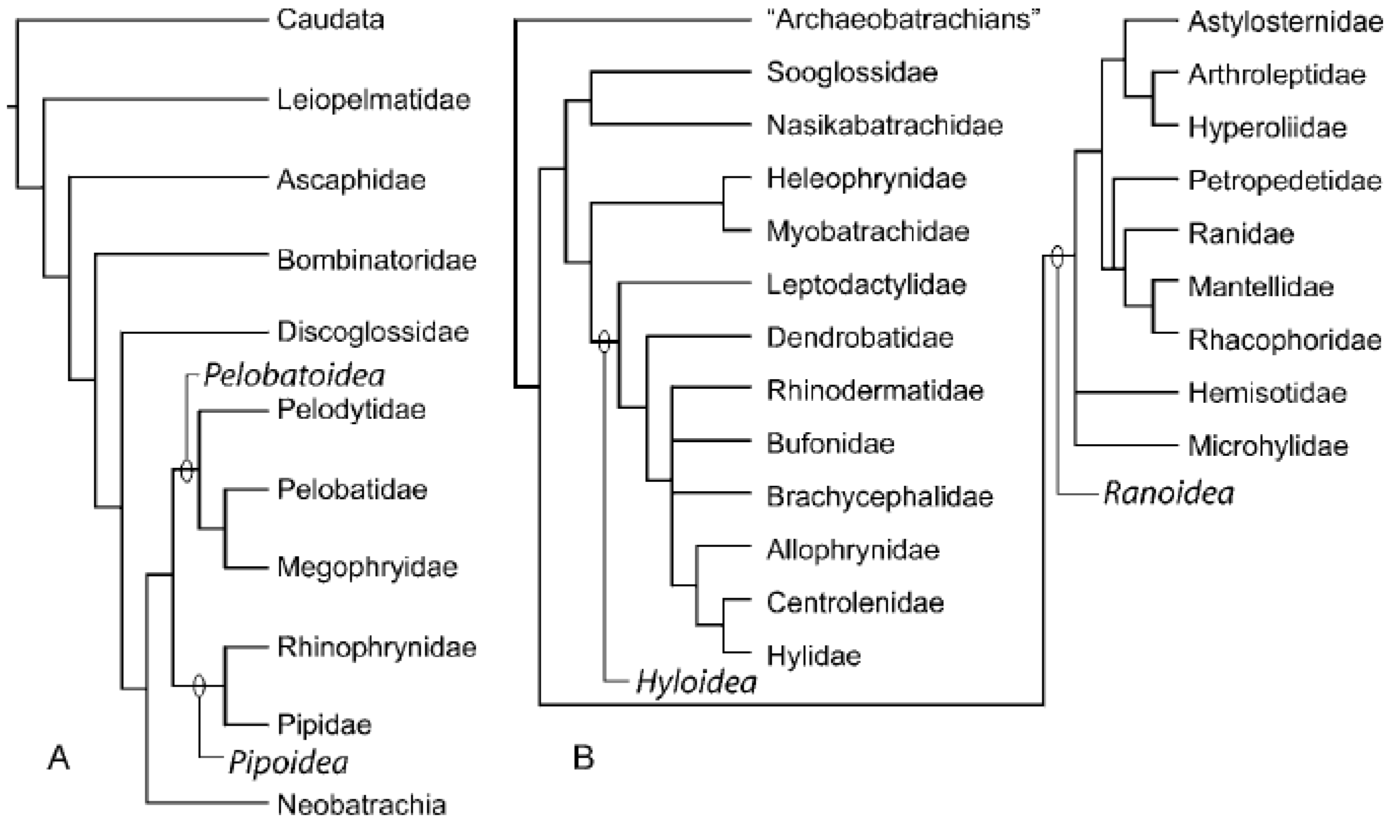
Reconstructions of The Earliest Anuran and Caecilian Fossils



(A) ***Triadobatrachus massinoti***, a froglike amphibian from an early Triassic deposit in Madagascar. This animal had 14 presacral vertebrae, compared to no more than nine for modern frogs. It also had a remnant of a tail and lacked the fused pelvic girdle, elongate illium, and urostyle of modern frogs. It also had five toes on the front feet, whereas modern frogs have four.

(B) ***Eocaecilia micropodia***, a caecilian with legs from a Jurassic deposit in Arizona. The skull and lower jaw resemble those of some modern caecilians, but no modern species has limbs.

Phylogeny and Classification of Anurans

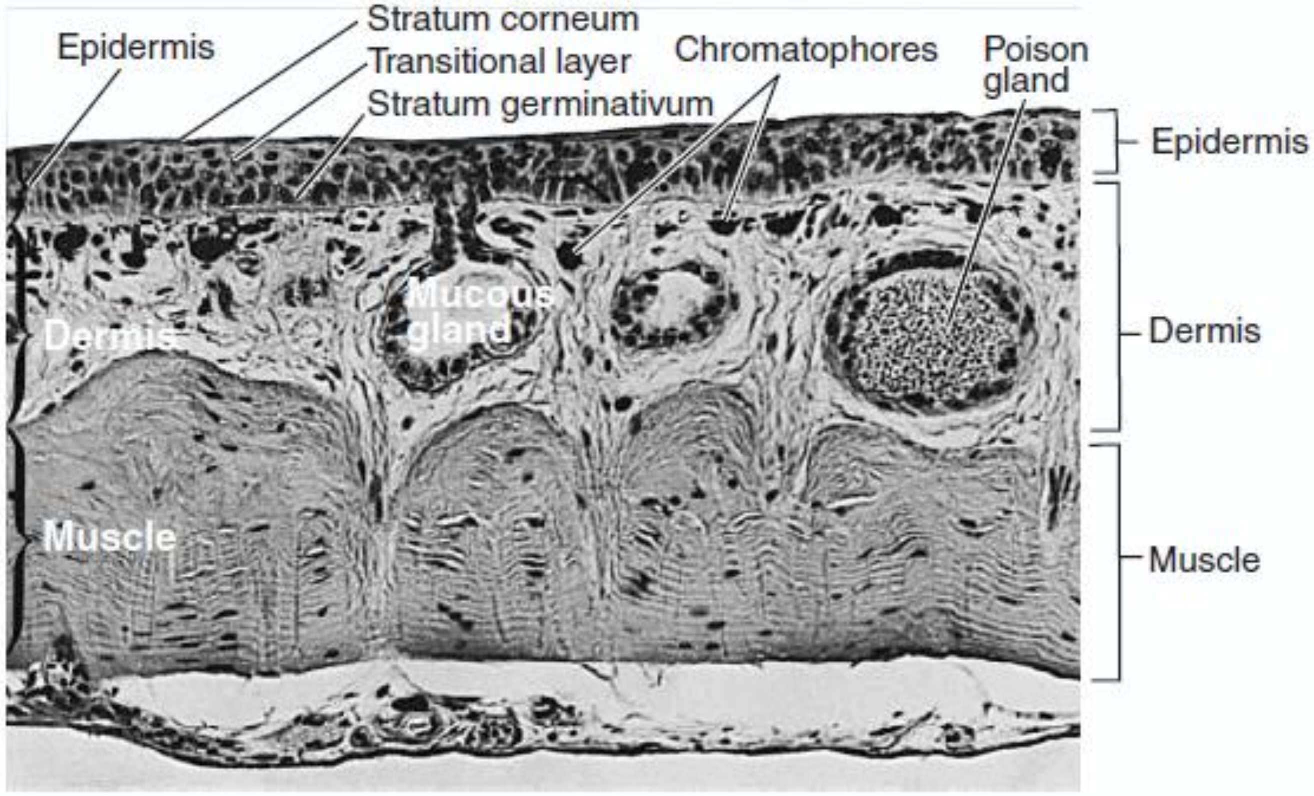


Phylogenetic relationships of the major clades of anurans.

(A) Relationships of the "archeobatrachian" anuran families, a nonmonophyletic group. Most phylogenetic analyses agree on the monophyly of the clades Pipoidea and Pelobatoidea, although there is some disagreement over relationships within the latter clade.

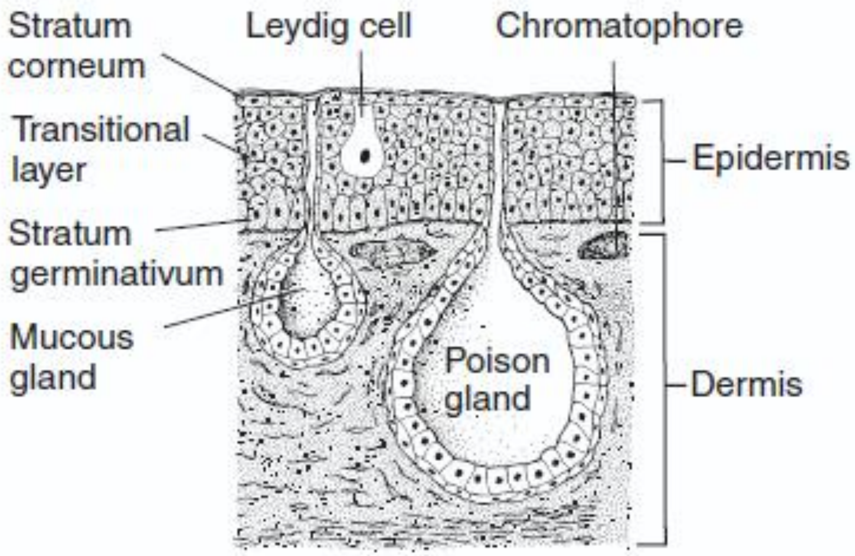
(B) One of several possible phylogenies for the monophyletic clade Neobatrachia. The monophyly of the clades Hyloidea and Ranoidea is well supported, but relationships of families within these clades are uncertain.

Frog Skin



Epidermis
Stratum corneum
Transitional layer
Stratum germinativum
Chromatophores
Poison gland
Mucous gland
Dermis
Muscle
Epidermis
Dermis
Muscle

(a)

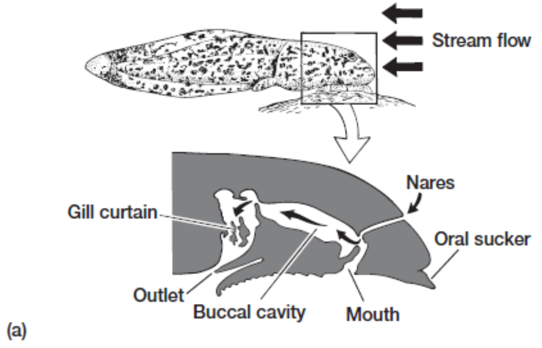


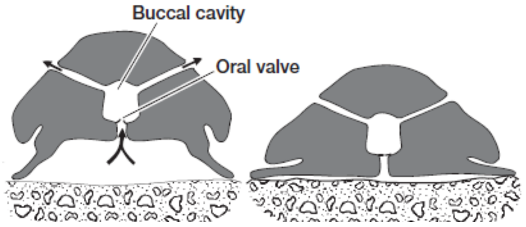
Stratum corneum
Leydig cell
Chromatophore
Transitional layer
Stratum germinativum
Mucous gland
Poison gland
Epidermis
Dermis

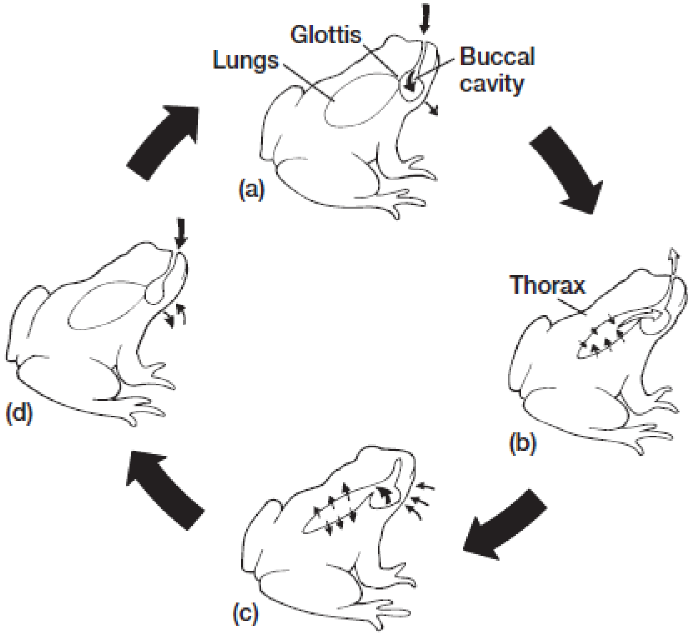
(b)

Respiratory System

- **Amphibian larvae**:
  1. Salamander → internal and external gills.
  2. Anuran → buccal and pharyngeal force
- **Amphibian adult** → cutaneous respiration continues to play an important role in meeting respiratory demands after metamorphosis, and lungs, if present, are ventilated by a buccal pump.
- **Four stages** of lung ventilation in frogs :
  1. the buccal cavity expands to draw fresh air in through the open nares
  2. the glottis opens rapidly, releasing spent air from the elastic lungs
  3. the nares close, and the floor of the buccal cavity rises, forcing the fresh air held in this cavity into the lung through the open glottis
  4. the glottis closes, retaining the air that has just filled the lungs, and the nares open again

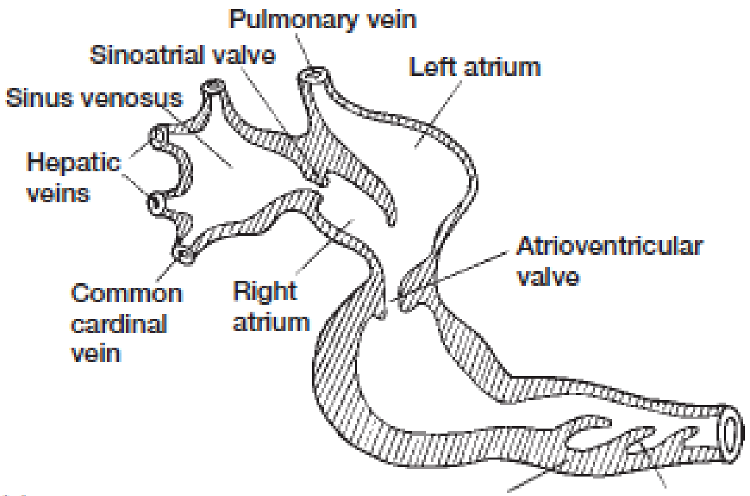




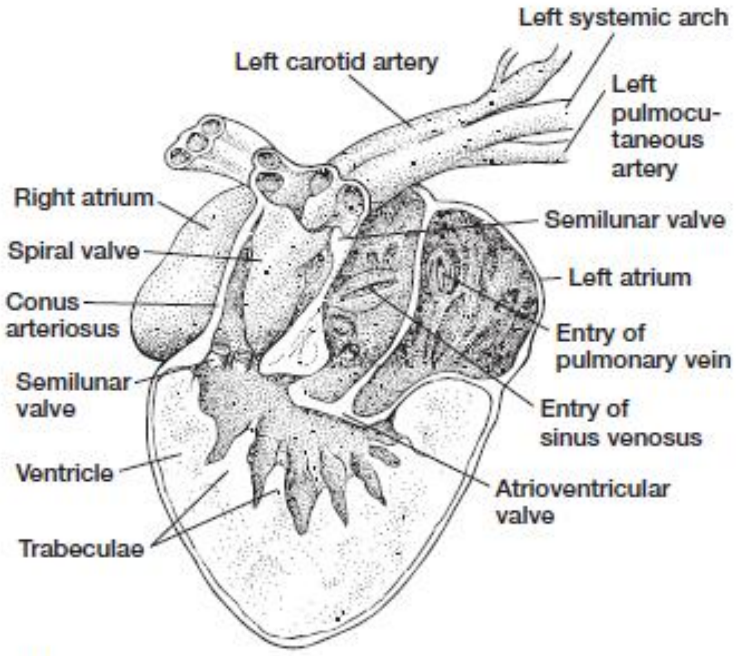


Cardiovascular System

- Amphibians rely on cutaneous gas exchange (plethodontid salamanders lack lungs entirely), on gills (many larval forms), on lungs (most toads and frogs), or on all three modes (most amphibians).
- Generally, in amphibians with functional lungs, the heart includes a sinus venosus, right and left atria divided by an anatomically complete interatrial septum, a ventricle lacking any internal subdivision, and a conus arteriosus with a spiral valve.
- Exception:
  1. *Siren* → have a partial interventricular septum
  2. lungless salamanders → reduced lung function, the interatrial septum and spiral valve may be much reduced or absent



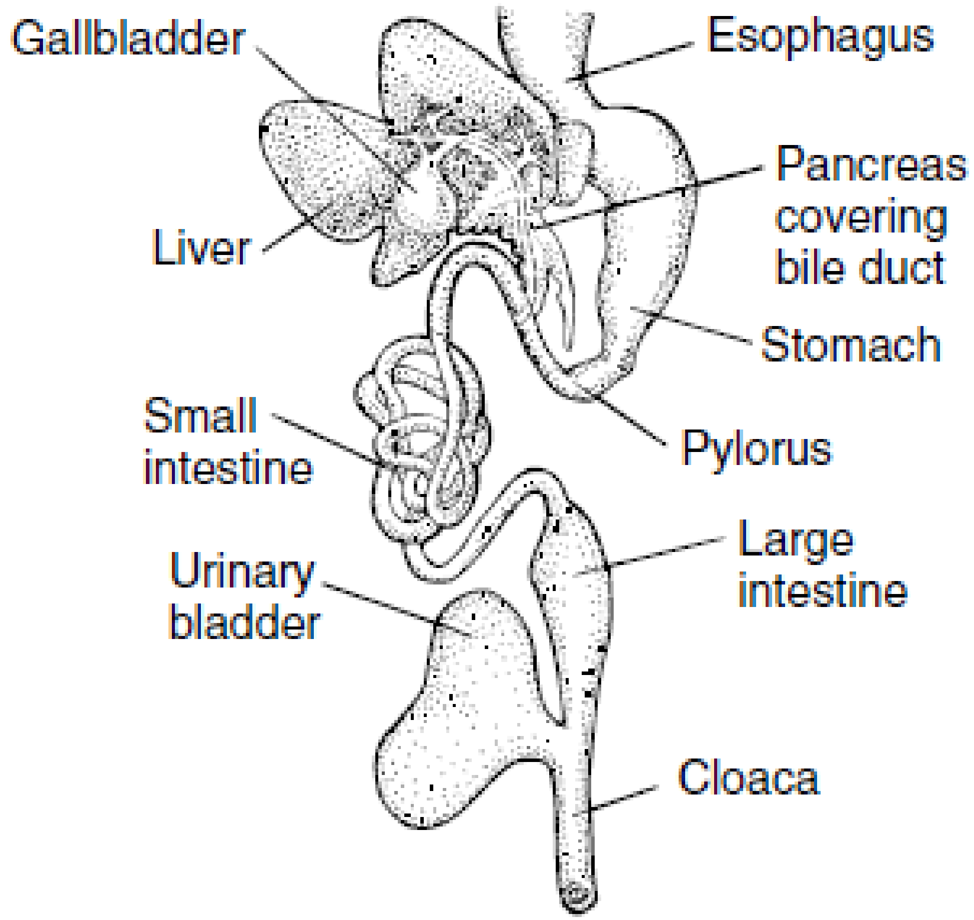
(a)



(b)

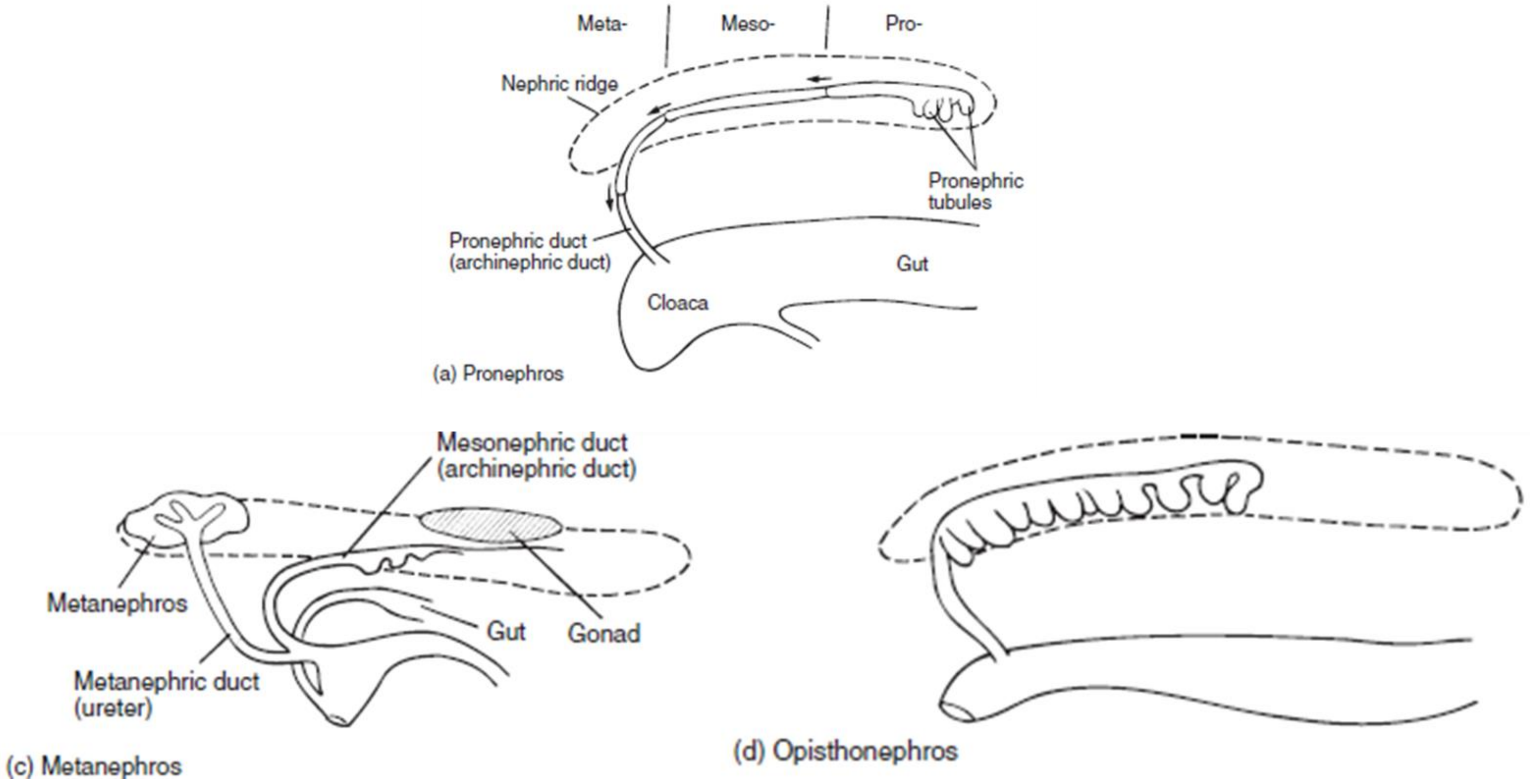
Digestive System

- Most species of amphibians possess a tongue in their oral cavity. The tongue is poorly developed in aquatic forms and is absent in pipid frogs (Pipidae).
- Most amphibians have small teeth that are shaped alike →**homodont dentition**, found on the palate as well as on the jaws.
- Feeding habits and digestive systems change drastically with metamorphosis. Larval forms with herbivorous diets have longer intestines than those with carnivorous diets in order to more efficiently break down the cellulose cell walls of plant cells.
- All amphibians have a cloaca that receives the contents of the digestive, urinary, and reproductive systems.



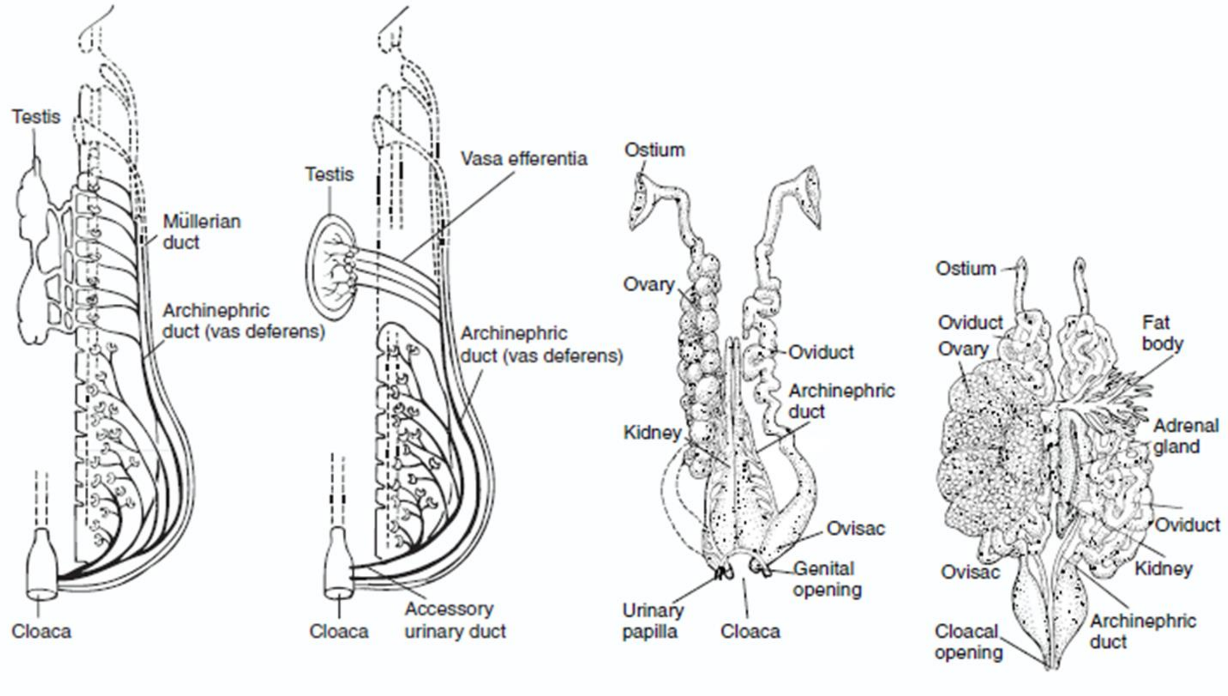
Urogenital System

- The pronephric kidney is functional during larval development, after which it is replaced by the opisthonephros, which serves as the functional kidney of most adult amphibians.



Reproduction System

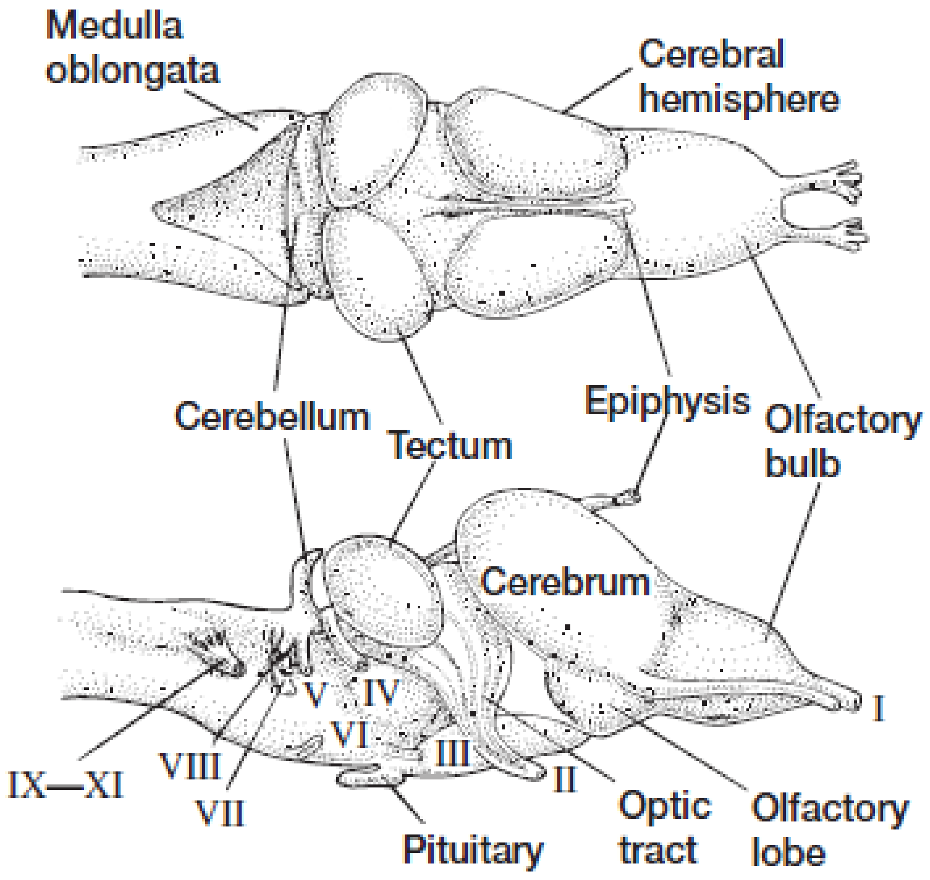
- Amphibian reproduction can be divided into three broad categories:
  1. *Aquatic development:* Eggs deposited in water; larvae develop in water.
  2. *Semiterrestrial development:* Eggs deposited out of water; larvae develop in water.
  3. *Terrestrial development:* Eggs and young completely independent of standing water.



(a) Most adult male salamanders and frogs (b) Some adult male salamanders and frogs (c) Female salamander (d) Female frog

Nervous System

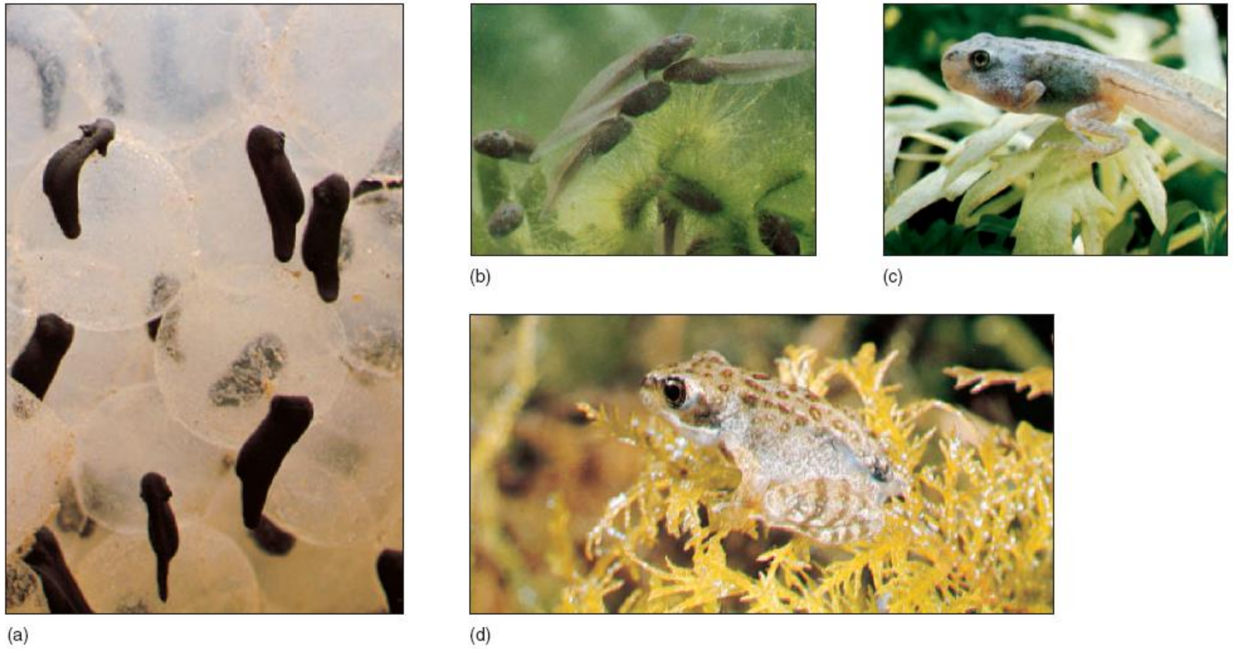
- Larval and adult aquatic amphibians possess **neuromast organs** in the form of lateral-line canals and cephalic canals.
- The anterior portion of the brain consists of a pair of olfactory lobes and a pair of cerebral hemispheres.
- A pineal organ is present and may serve as a photoreceptor, but only remnants of the parapineal organ are found in amphibians.
- Impulses from the **lateral-line system** are directed to the cerebellum, which coordinates and controls voluntary muscular activity. The cerebellum is very poorly developed in those amphibians with a reduced lateral-line system.
- In amphibians, the **forebrain** contains olfactory centers and regions that regulate color change and visceral functions. The midbrain contains a region called the optic tectum that assimilates sensory information and initiates motor responses. The midbrain also processes visual sensory information. The hindbrain functions in motor coordination and in regulating heart rate and the mechanics of respiration.



(d) Frog

Metamorphosis

- A series of abrupt structural, physiological, and behavioral changes that transform a larva into an adult. A variety of environmental conditions, including crowding and food availability, influence the time required for metamorphosis. Most directly, however, metamorphosis is under the control of neurosecretions of the hypothalamus, hormones of the anterior lobe of the pituitary gland (the adenohypophysis), and the thyroid gland.
- Morphological changes associated with the metamorphosis of caecilians and salamanders are relatively minor. Reproductive structures develop, gills are lost, and a caudal fin (when present) is lost. In the Anura, however, changes from the tadpole into the small frog are more dramatic. Limbs and lungs develop, the tail is reabsorbed, the skin thickens, and marked changes in the head and digestive tract (associated with a new mode of nutrition) occur.



Events of Metamorphosis in the Frog, *Rana temporaria*. *(a)* Before metamorphosis. Prolactin secretion, controlled by the hypothalamus and the adenohypophysis, promotes the growth of larval structures. *(b–d)* Metamorphosis. The median eminence of the hypothalamus develops and initiates the secretion of thyroid-stimulating hormone (TSH). TSH begins to inhibit prolactin release. TSH causes the release of large quantities of T_4 and T_3, which promote the growth of limbs, reabsorption of the tail, and other changes of metamorphosis, resulting eventually in a young, adult frog.

Synopsis of Families of Anura (1)

No	Family	Distribution	Content
1	Allophrynidae	Guianan region of northeastern South America, including parts of Surinam, Guyana, French Guiana, Venezuela, and Brazil	A single species, *Allophryne ruthveni*
2	Arthroleptidae	Tropical Africa	Three genera, about 50 species
3	Ascaphidae	Pacific Northwest region of North America	One genus, two species
4	Astylosternidae	Tropical Africa	Five genera, 29 species
5	Bombinatoridae	Europe and Asia	Two genera, *Bombina* (eight species) and *Barbourula* (two species)
6	Brachycephalidae	Humid coastal forests of southern Brazil	A single genus, *Brachycephalus* with eight species, including two species formerly placed in the genus *Psyllophryne*
7	Bufonidae	Worldwide, except for Madagascar, Australia, New Guinea, and oceanic islands	About 33 genera, 480 species
8	Centrolenidae	Wet tropical forests from southern Mexico through Central America to Argentina	Three genera, about 135 species
9	Dendrobatidae	Tropical South and Central America, some islands in West Indies	Nine to eleven genera, more than 240 species
10	Discoglossidae	Europe, the Middle East, and North Africa	Two genera, 12 species

Synopsis of Families of Anura (2)

No	Family	Distribution	Content
11	Heleophrynidae	Southern Africa	One genus, *Heleophryne*, with six species
12	Hemiphractinae	Panama and South America; one species in Trinidad and Tobago	Five genera, about 80 species
13	Hemisotidae	Tropical and subtropical sub-Saharan Africa	A single genus, *Hemisus*, with nine species
14	Hylidae	North, Central, and South America, West Indies, Europe, North Africa, Asia north of the Himalayas, Japan, Australia, New Guinea, Solomon Islands	About 42–45 genera, more than 800 species
15	Hyperoliidae	Sub-Saharan Africa, Madagascar, and the Seychelles Islands	About 19 genera, 260 species
16	Leiopelmatidae	New Zealand	One genus, *Leiopelma*, with four species
17	Leptodactylidae	Texas, Florida, Mexico, Central and South America, West Indies	About 50 genera, more than 1,100 species
18	Mantellidae	Madagascar and the Comoro Islands	Five genera, 157 species
19	Megophryidae	Northern Indian subcontinent to China, Southeast Asia, the Philippines, and islands of the Sunda Shelf	11 genera, about 130 species
20	Microhylidae	North, Central, and South America, sub-Saharan Africa, Madagascar, Asia, the Australo-Papuan region, Indonesia, Philippines	About 70 genera, 430 species

Synopsis of Families of Anura (3)

No	Family	Distribution	Content
21	Myobatrachidae	Australia and New Guinea	23 genera, about 120 species
22	Nasikabatrachidae	Western Ghats of India	One species, *Nasikabatrachus sahyadrensis*
23	Pelobatidae	North America, Europe, western Asia, North Africa	Three genera, 11 species
24	Pelodytidae	Western Europe and southwestern Asia	single genus, *Pelodytes*, with three species
25	Petropedetidae	Sub-Saharan Africa	13 genera, about 100 species
26	Pipidae	Tropical South America and Africa	Five genera, 30 species
27	Ranidae	Worldwide, except for southern South America, the West Indies, Australia, and most oceanic islands (ranids are found on islands such as Japan, the Philippines,New Guinea, Borneo, the Indonesian Archipelago, and the Solomon Islands).	About 38 genera, 650+ species
28	Rhacophoridae	Tropical Africa, China, Southeast Asia, Japan, Taiwan, Philippines, Greater Sunda Islands	Ten genera, about 270 species
29	Rhinodermatidae	Cool temperate forests in the Andes of southern Chile and Argentina	A single genus, *Rhinoderma*, with two species
30	Rhinophrynidae	Lowland areas from southern Texas through Mexico to Costa Rica	Only one living species, *Rhinophrynus dorsalis*, the Mexican burrowing frog
31	Sooglossidae	Seychelles Islands	Two genera, *Sooglossus* (three species) and *Nesomantis* (one species)

Diversity of anurans (Allophrynidae to Brachycephalidae).

(A) *Allophryne ruthveni* (Allophrynidae) from South America.

(B) *Schoutedenella xenodactyla* (Arthroleptidae) from West Africa.

(C) *Ascaphus truei* (Ascaphidae) male, showing copulatory organ, from Washington.

(D) *Trichobatrachus robustus* (Astylosternidae) from West Africa.

(E) *Bombina orientalis* (Bombinatoridae) from Asia.

(F) *Brachycephalus ephippium* (Brachycephalidae) from Brazil; male giving foot-waving display.

Diversity of anurans (Bufonidae).

(A) *Bufo bankorensis* from Taiwan.

(B) *Bufo lemur* from Puerto Rico.

(C) *Dendrophryniscus minutus* from South America; small male in amplexus with a very large female.

(D) *Atelopus varius* from Central America; male giving leg-waving display.

(E) *Nectophrynoides tornieri* from East Africa, a viviparous toad.

(F) *Schismaderma carens* from South Africa.

Diversity of anurans (Centrolenidae to Mantellidae).

(A) *Hyalinobatrachium fleischmanni* (Centrolenidae) from Panama; pair in amplexus.

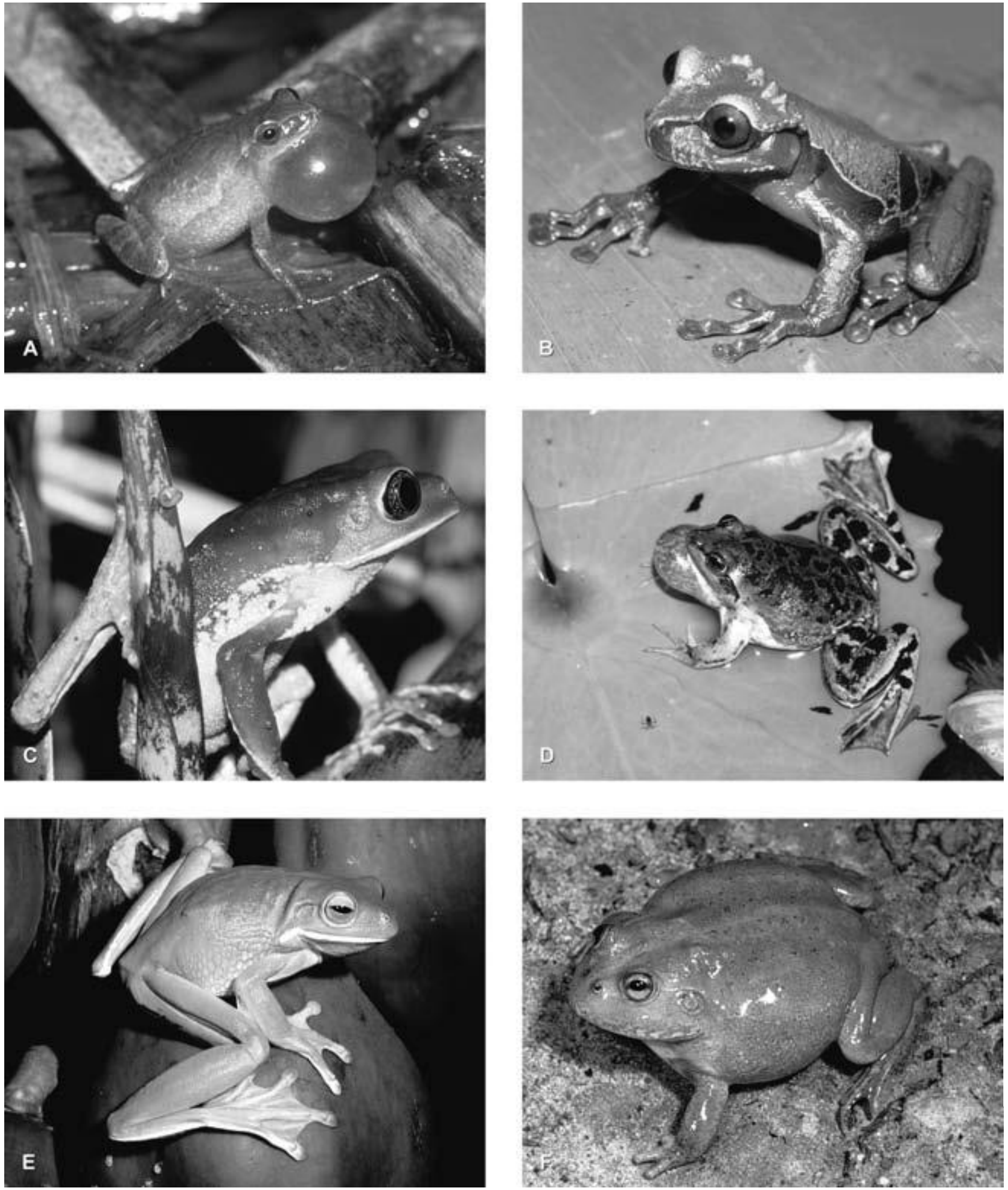
(B) *Dendrobates virolinensis* (Dendrobatidae) from Colombia.

(C) *Heleophryne purcelli* (Heleophrynidae) from South Africa.

(D) *Hemiphractus proboscieis* (Hemiphractinae) from Ecuador.

(E) *Leiopelma hamiltonii* (Leiopelmatidae) from New Zealand.

(F) *Mantella cowani* (Mantellidae) from Madagascar.



Diversity of anurans (Hylidae).

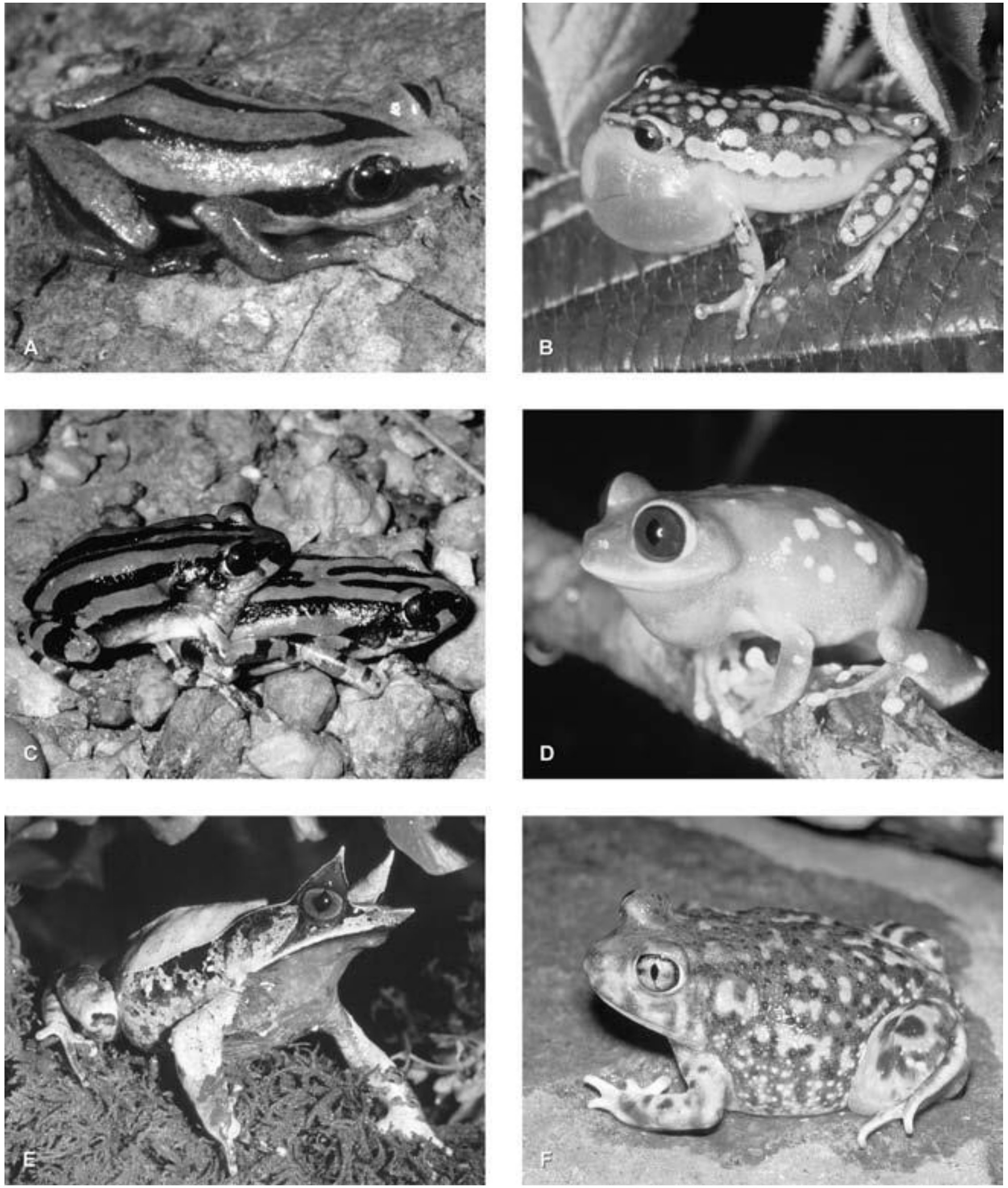
(A) *Pseudacris crucifer* from Connecticut.

(B) *Anotheca spinosa* from Central America.

(C) *Phyllomedusa trinitatis* from Trinidad. (D) *Pseudis paradoxa* from Trinidad.

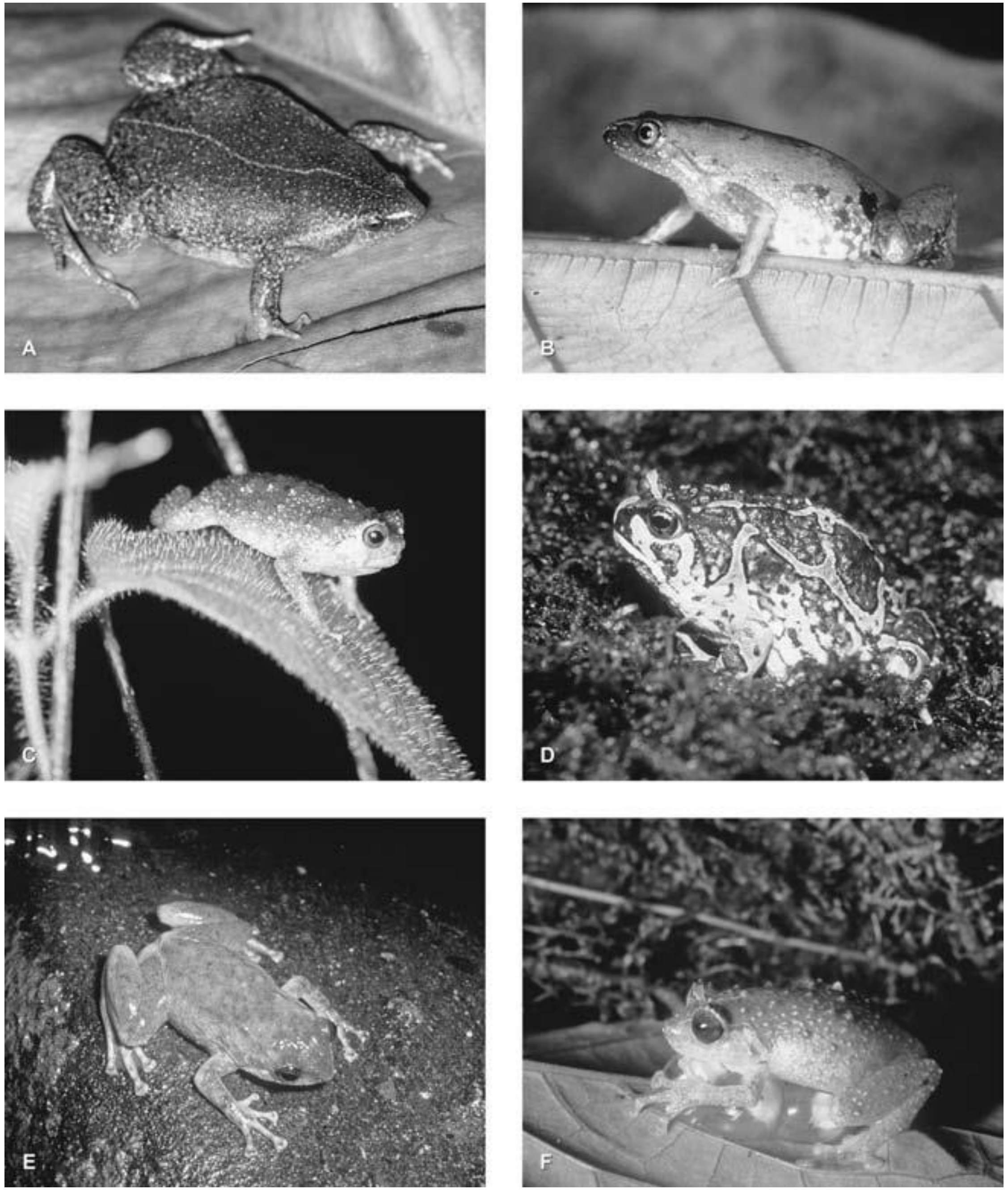
(E) *Litoria infrafrenata* from Australia.

(F) *Cyclorana platycephalus* from Australia.

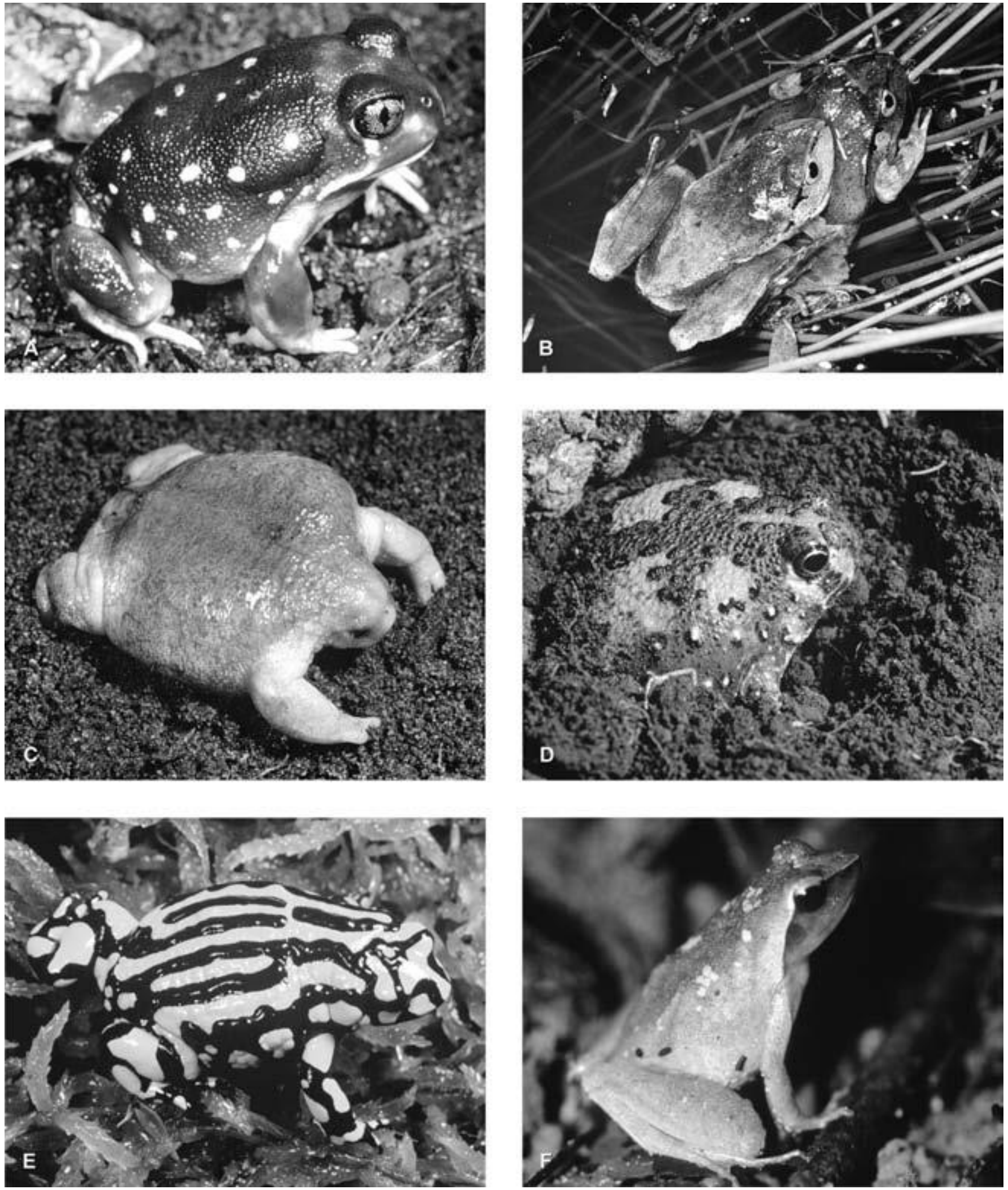


Diversity of anurans (Hyperoliidae to Pelobatidae).
(A) *Afrixalus wittei* (Hyperoliidae) from southern Africa.
(B) *Hyperolius puncticulatus* (Hyperoliidae) from East Africa.
(C) *Kassina cassinoides* from the Ivory Coast.
(D) *Leptopelis uluguruensis* (Hyperoliidae) from Tanzania.
(E) *Megophrys nasuta* (Megophryidae) from Southeast Asia.
(F) *Scaphiopus couchii* (Pelobatidae) from western North America.

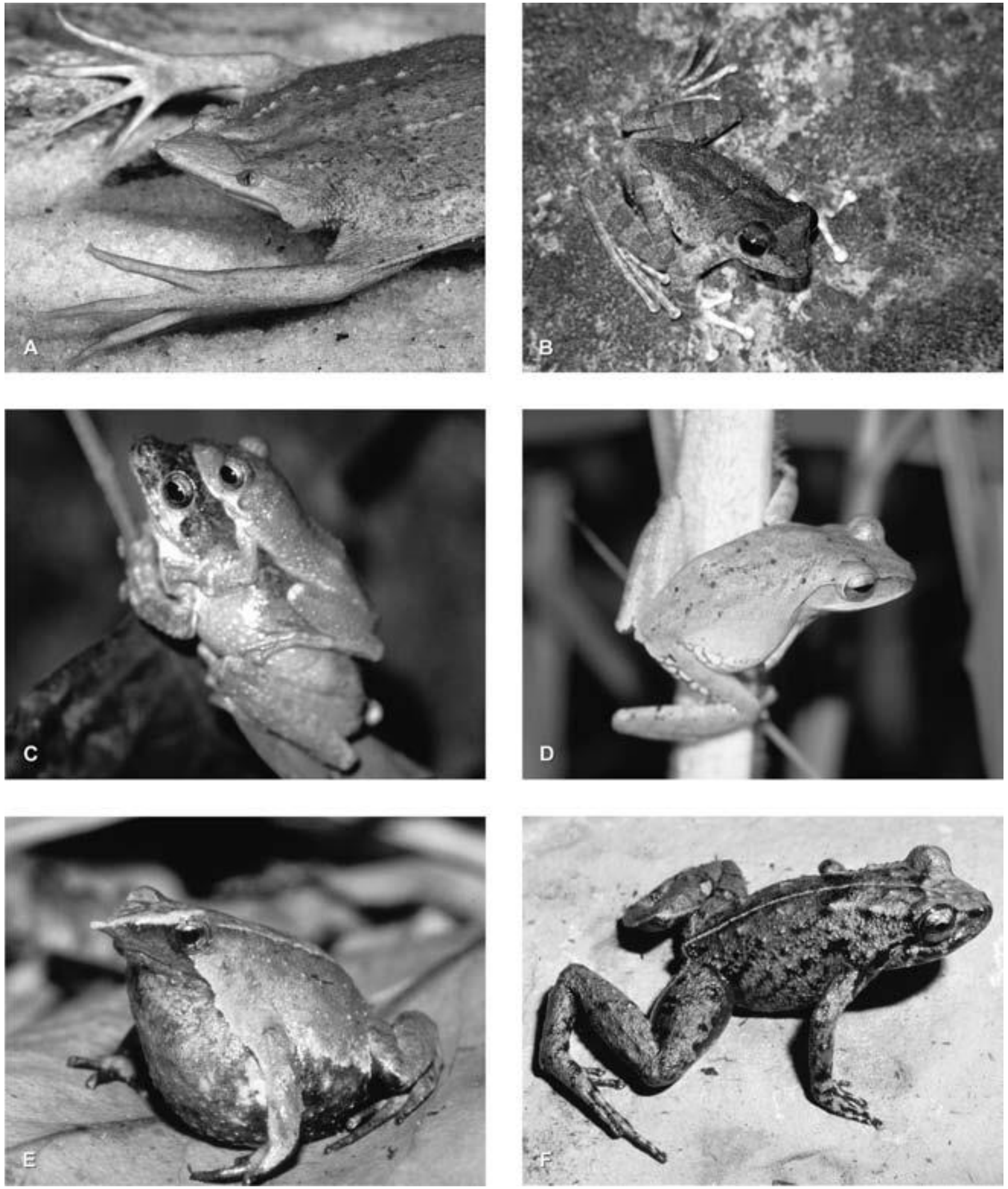
Diversity of anurans (Leptodactylidae).
(A) *Megaelosia massarti* from Brazil.
(B) *Hylodes sazimai* from Brazil.
(C) *Macrogenioglottus alipioi* from Brazil.
(D) *Ceratophrys aurita* from Brazil.
(E) *Pleurodema diplolistris* from South America.
(F) *Eleutherodactylus coqui* from Puerto Rico.



Diversity of anurans (Microhylidae).
(A) *Elachistocleis ovalis* from Trinidad.
(B) *Chiasmocles shudicarensis* from French Guiana.
(C) *Callulina kreffti* from Tanzania.
(D) *Scaphiophryne pustulosa* from Madagascar.
(E) *Austrochaperina palmipes* from New Guinea.
(F) *Oreophryne* sp. from New Guinea; male brooding eggs.

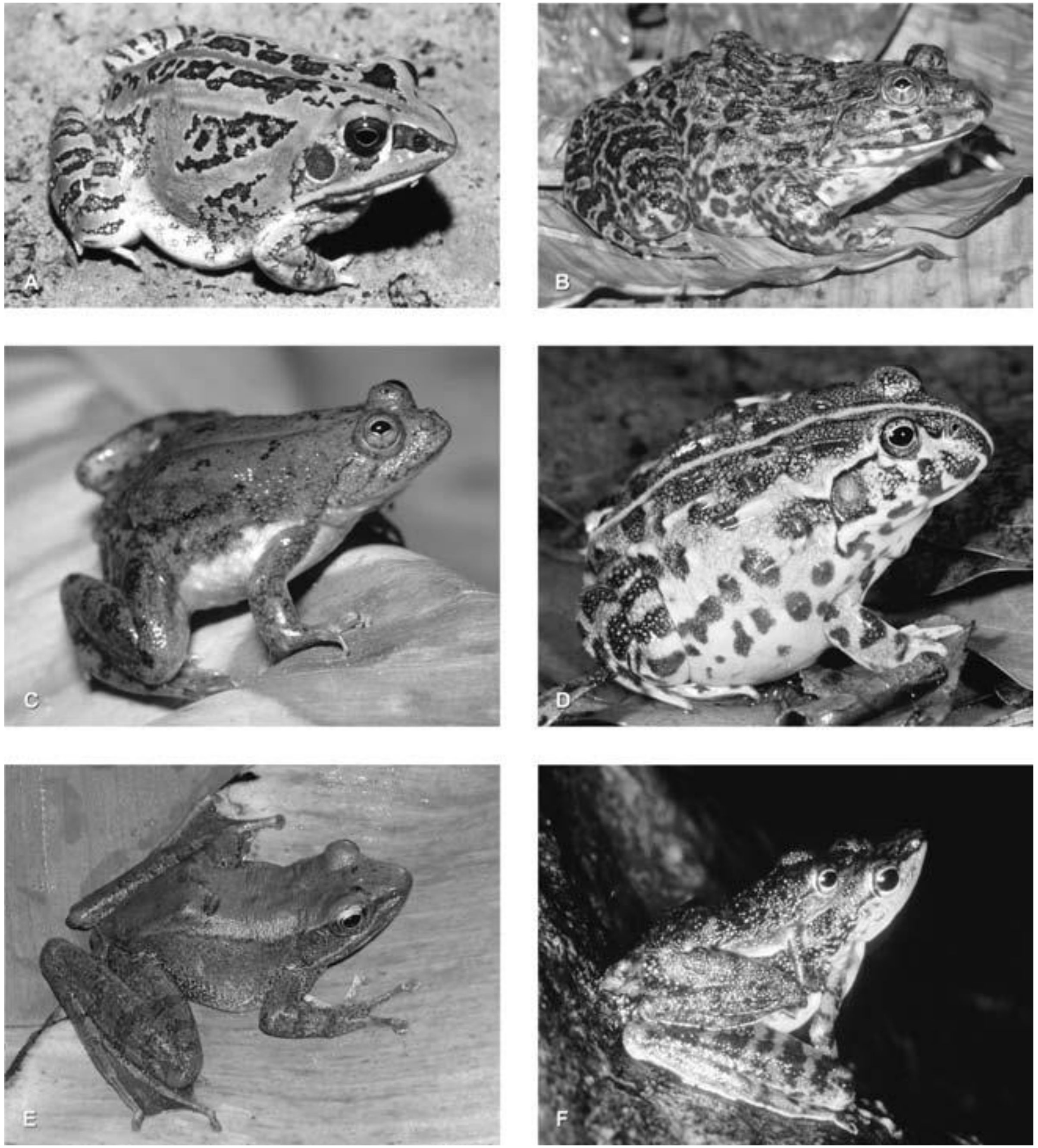


Diversity of anurans (Myobatrachidae and Petropedetidae).
(A) *Heleiporus albopunctatus* (Myobatrachidae) from Australia.
(B) *Lechriodus fletcheri* (Myobatrachidae) from Australia.
(C) *Myobatrachus gouldii* (Myobatrachidae) from Australia.
(D) *Notaden bennettii* (Myobatrachidae) from Australia.
(E) *Pseudophryne corroboree* (Myobatrachidae) from Australia.
(F) *Phrynobatrachus plicatus* (Petropedetidae) from West Africa.



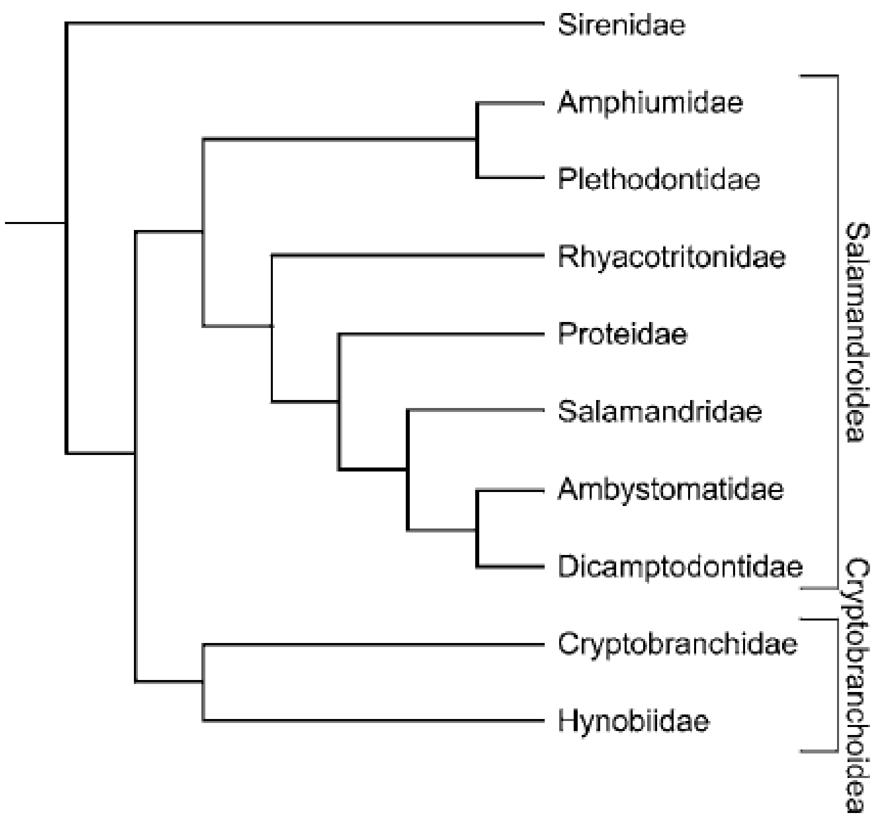
Diversity of anurans (Pipidae to Sooglossidae).

(A) *Pipa pipa* (Pipidae) from South America.
(B) *Buergeria robusta* (Rhacophoridae) from Taiwan.
(C) *Chiromantis rufescens* (Rhacophoridae) from West Africa.
(D) *Polypedates megacephalus* (Rhacophoridae) from Taiwan.
(E) *Rhinoderma darwinii* (Rhinodermatidae) from Chile; male carrying tadpoles in vocal sac.
(F) *Nesomantis thomasseti* (Sooglossidae) from the Seychelles Islands.



Diversity of anurans (Ranidae).
(A) *Hildebrandtia ornata* from South Africa.
(B) *Hoplobatrachus rugulosus* from Vietnam.
(C) *Occidozyga lima* from Vietnam.
(D) *Pyxicephalus adspersus* from southern Africa; juvenile.
(E) *Rana banaorum* from Vietnam.
(F) *Staurois natator* from Borneo; pair in amplexus.

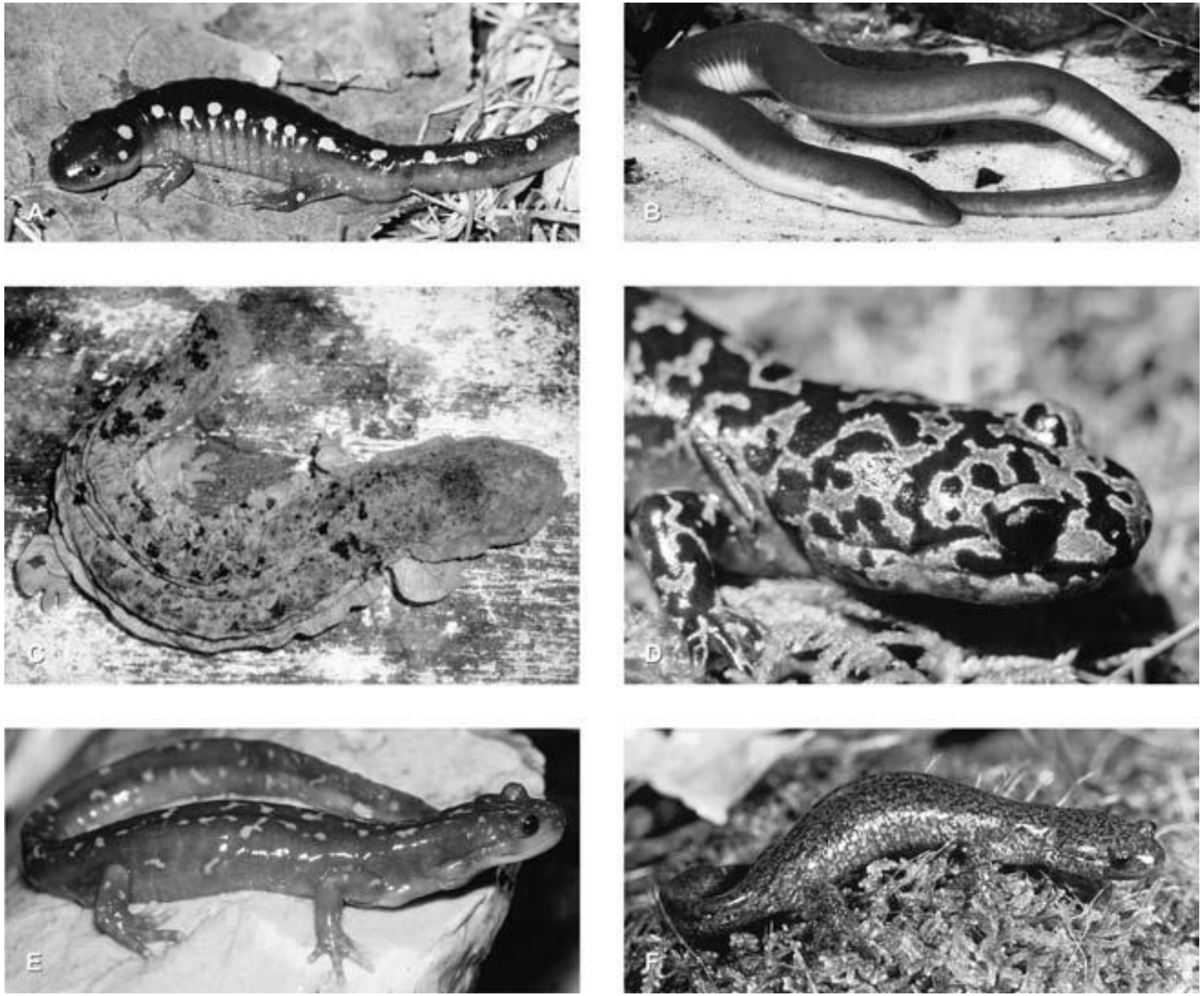
Phylogeny and Classification of the Urodela



Phylogenetic relationships of the urodeles, based on combined molecular and morphological data. Some other recent phylogenies differ in the placement of the family Sirenidae, which may or may not be basal to all other salamander families. There also is some debate over whether Salamandroidea is a monophyletic clade.

Synopsis of Families of Urodela

No	Family	Distribution	Content
1	Ambystomatidae	North America from Alaska to the eastern United States and the Mexican Plateau	One genus, *Ambystoma*, 31 species
2	Amphiumidae	Southeastern United States	A single genus, *Amphiuma*, with three species
3	Cryptobranchidae	Eastern Asia and eastern North America	Two genera, the Chinese and Japanese giant salamanders, *Andrias* (two species) and the North American hellbender, *Cryptobranchus alleganiensis*
4	Dicamptodontidae	Pacific Northwest region of the United States and adjacent Canada	A single genus, *Dicamptodon*, with four species
5	Hynobiidae	Eastern Asia, including Siberia, northern China, Korea, and Japan. Disjunct populations in Central Asia	Seven to nine genera, 49 species
6	Plethodontidae	North, Central, and South America, with one genus (*Hydromante*s) having a disjunct distribution in northwestern North America and southern Europe. A single species, *Karsenia koreana*, occurs in Korea, the only plethodontid known from Asia	27 genera, more than 375 species
7	Proteidae	Southern Europe and eastern North America	Two genera, *Necturus* from North America (five species) and *Proteus* from Europe (one species)
8	Rhyacotritonidae	Pacific Northwest region of the United States	One genus, *Rhyacotriton*, with four species
9	Salamandridae	Europe, Asia, extreme northern Africa, North America	15–20 genera, about 70 species
10	Sirenidae	Southeastern and central United States and northeastern Mexico	Two genera, *Siren* (two species) and *Pseudobranchus* (two species).



Diversity of urodeles (Ambystomatidae to Hynobiidae).

(A) *Ambystoma maculatum* (Ambystomatidae) from Connecticut.

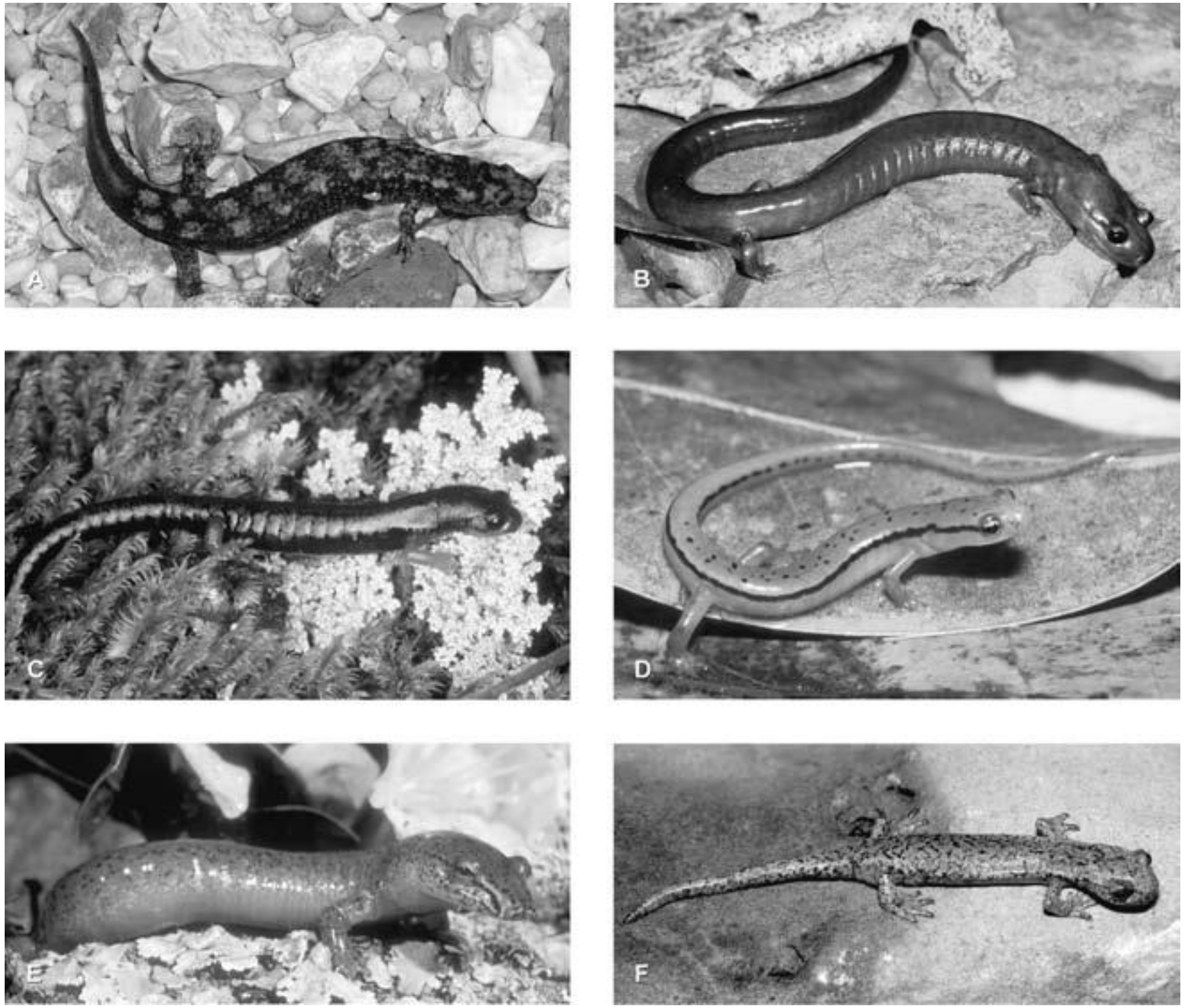
(B) *Amphiuma tridactylum* (Amphiumidae) from the southern United States.

(C) *Cryptobranchus alleganiensis* (Cryptobranchidae) from the Ozark Mountains.

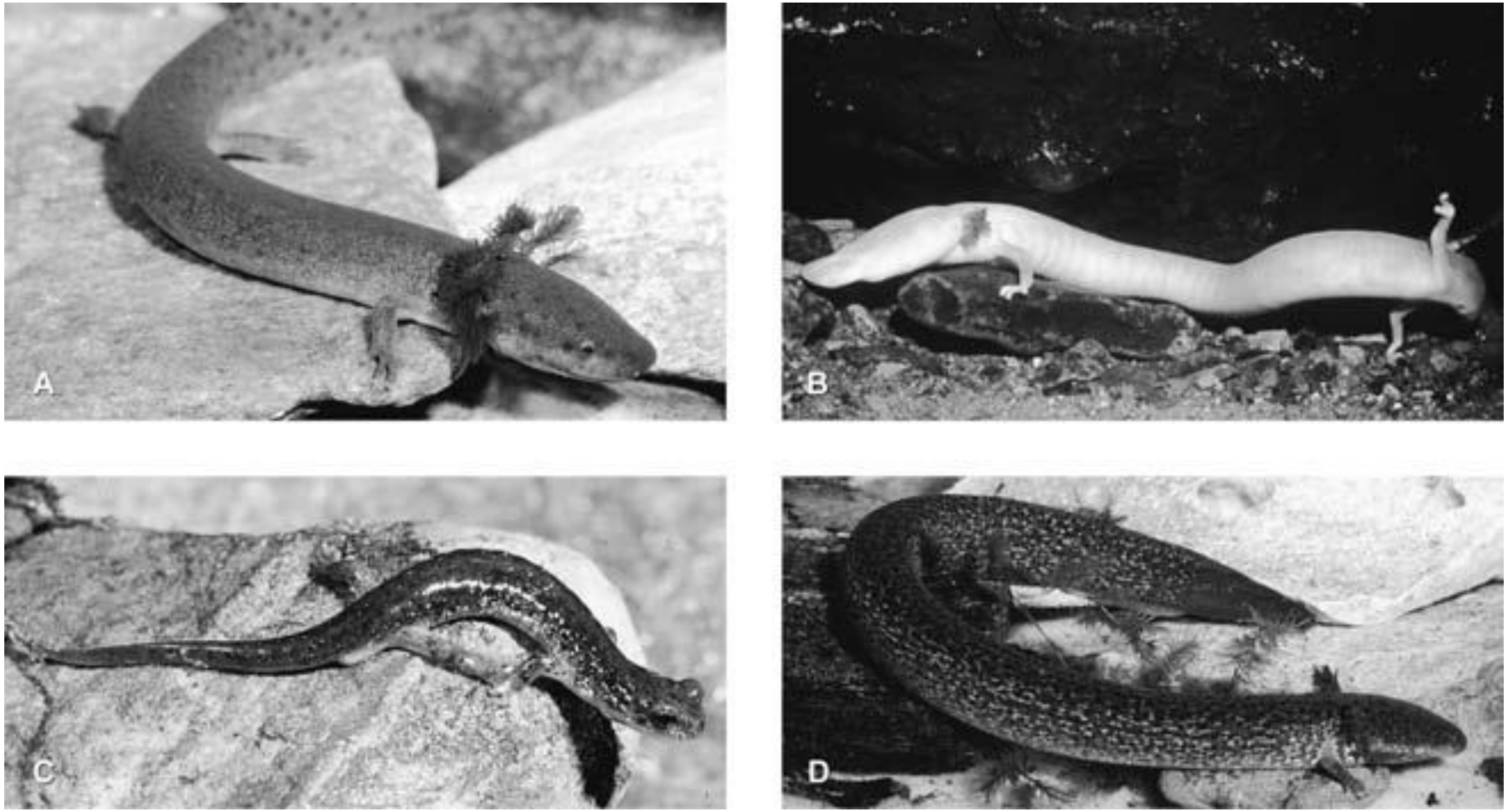
(D) *Dicamptodon ensatus* (Dicamptodontidae) from California.

(E) Batrachuperus persicus (Hynobiidae) from Iran.

(E) *Hynobius* sp. (Hynobiidae) from Asia.



Diversity of urodeles (Plethodontidae).
(A) *Desmognathus marmoratus* from North Carolina.
(B) *Phaeognathus hubrichti* from Alabama.
(C) *Bolitoglossa pesrubra* from Costa Rica.
(D) *Eurycea cirrigera* from North Carolina, with elongated cirri on the male's snout.
(E) *Gyrinophilus porphyriticus* from North Carolina.
(F) *Hydromantes platycephalus* from California.



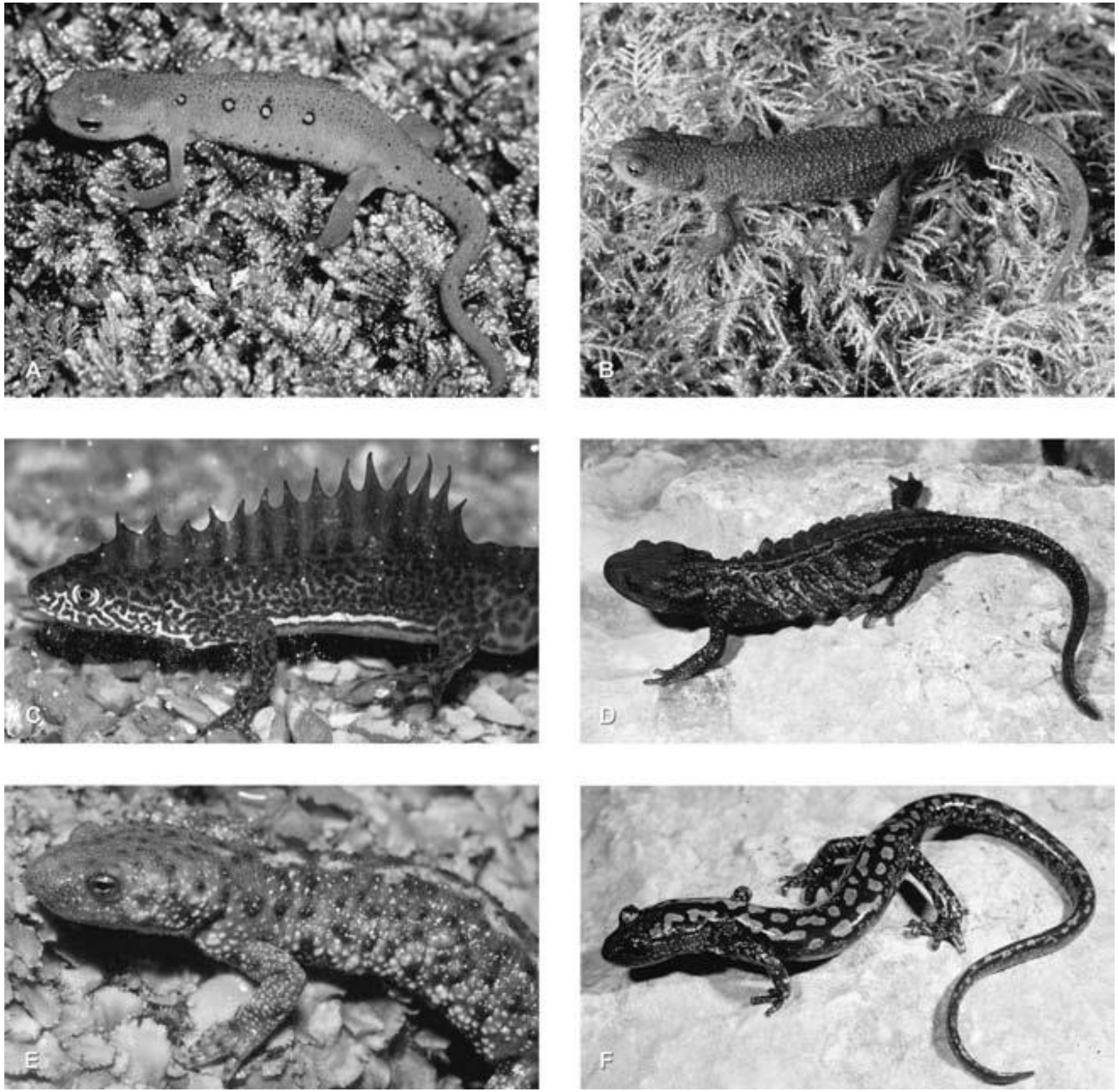
Diversity of urodeles (Proteidae to Sirenidae).

(A) *Necturus punctatus* (Proteidae) from the Coastal Plain of the southeastern United States.

(B) *Proteus anguinus* (Proteidae) from Europe.

(C) *Rhyacotriton cascadae* (Rhyacotritonidae) from Washington.

(D) *Siren lacertina* from the southeastern United States.



Diversity of urodeles (Salamandridae).

(A) Terrestrial red eft stage of *Notophthalmus viridescens* from Connecticut.

(B) *Taricha granulosa* from Washington.

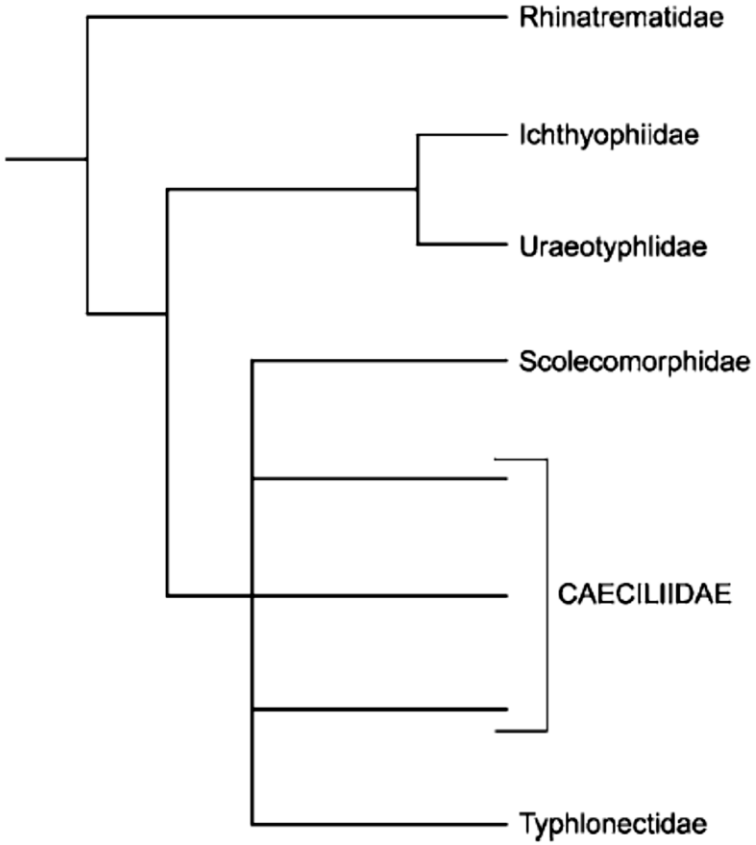
(C) *Triturus vittatus* from Asia Minor.

(D) *Echinotriton andersonii* from China.

(E) *Calotriton* (= *Euproctus*) *asper* from the Pyrenees Mountains of southwestern Europe.

(F) *Mertensiella caucasica* from northeastern Turkey and western Georgia in the Caucasus Mountains.

Phylogeny and Classification of the Gymnophiona

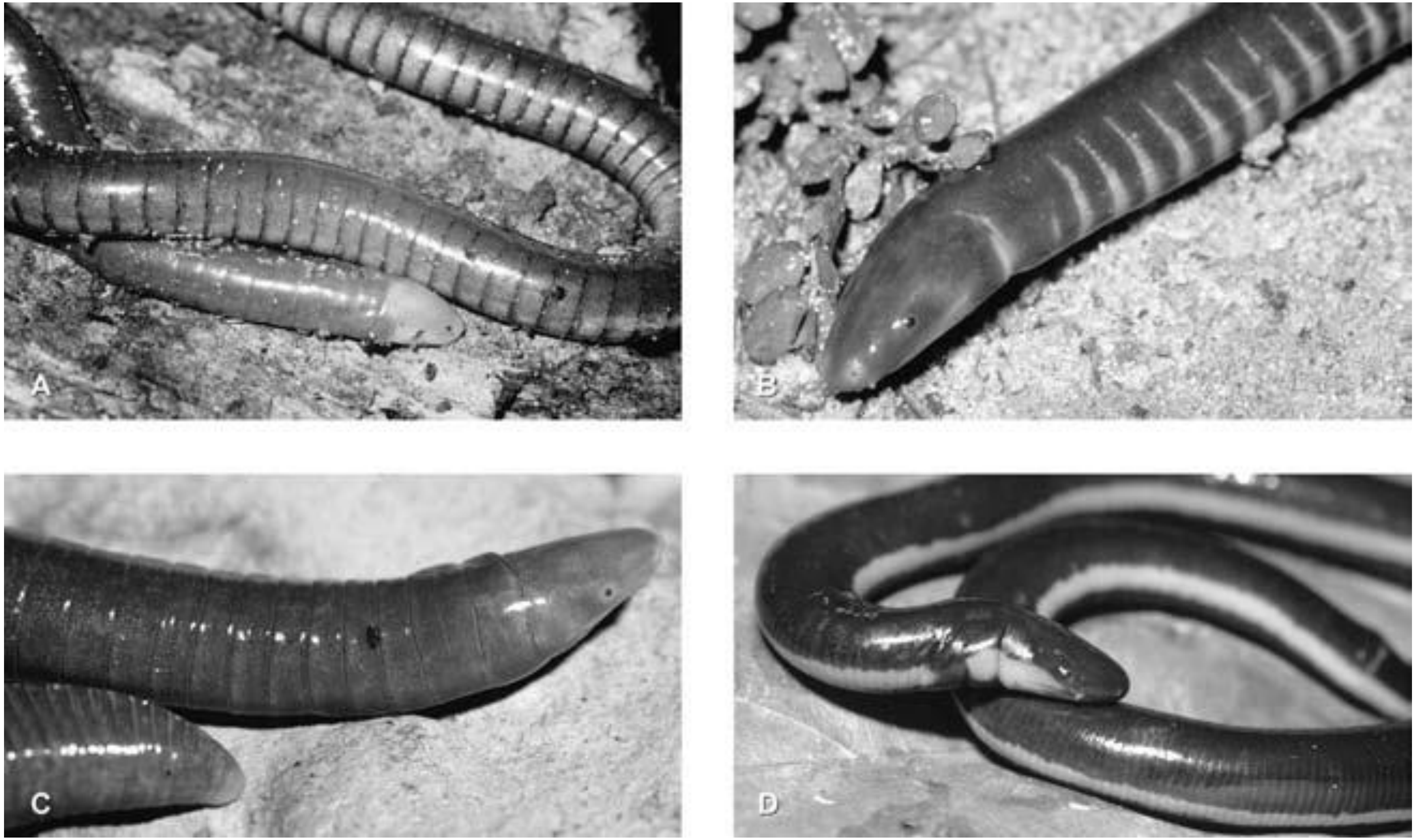


Phylogenetic relationships of caecilians, derived from a combination of morphological and molecular data.

- The family Caeciliidae probably is not a monophyletic group as currently constituted and is shown as several distinct lineages. Some classifications place the typhlonectids in the family Caeciliidae.

Synopsis of Families of Gymnophiona

No	Family	Distribution	Content
1	Caeciliidae	Tropical South and Central America, tropical Africa, the Seychelles Islands, the Indian subcontinent	21 genera, about 100 species
2	Ichthyophiidae	Southeast Asia, the Indian subcontinent, Sri Lanka, Borneo, Sumatra, the Philippines	Two genera, *Ichthyophis* (34 species) and *Caudacaecilia* (five species)
3	Rhinatrematidae	Tropical South America	Two genera, *Epicrionops* (eight species) and *Rhinatrema* (one species)
4	Scolecomorphidae	Disjunct distribution in tropical West and East Africa	Two genera, *Scolecomorphus* (three species) and *Crotaphatrema* (three species)
5	Typhlonectidae	Disjunct distribution in northern South America and southern Brazil and northern Argentina	Five genera, *Chthonerpeton* (eight species), *Typhlonectes* (two species), *Nectocaecilia* (one species), *Potomotyphylus* (one species), and *Atretochoana* (one species)
6	Uraeotyphlidae	Southern India	A single genus, *Uraeotyphlus* (five species)



Diversity of caecilians (Gymnophiona).

(A) *Oscaecilia ochrocephala* (Caeciliidae) from Panama.

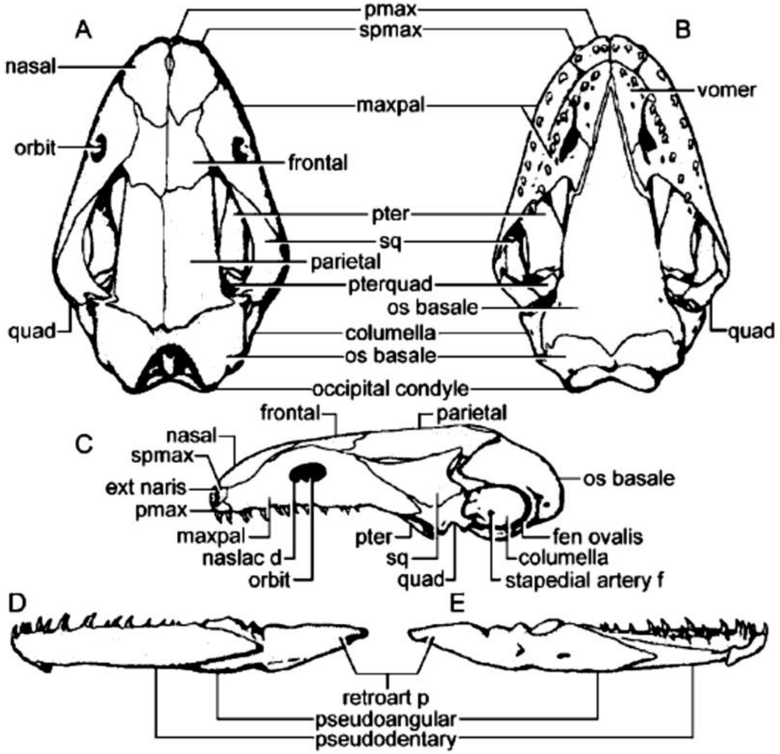
(B) *Geotrypetes seraphini* (Caeciliidae) from the Ivory Coast.

(C) *Grandisonia alternans* (Caeciliidae) from the Seychelles Islands.

(D) *Ichthyophis bannanicus* (Ichthyophiidae) from Vietnam. The tentacle, a sensory organ unique to caecilians, is clearly visible in B and D.

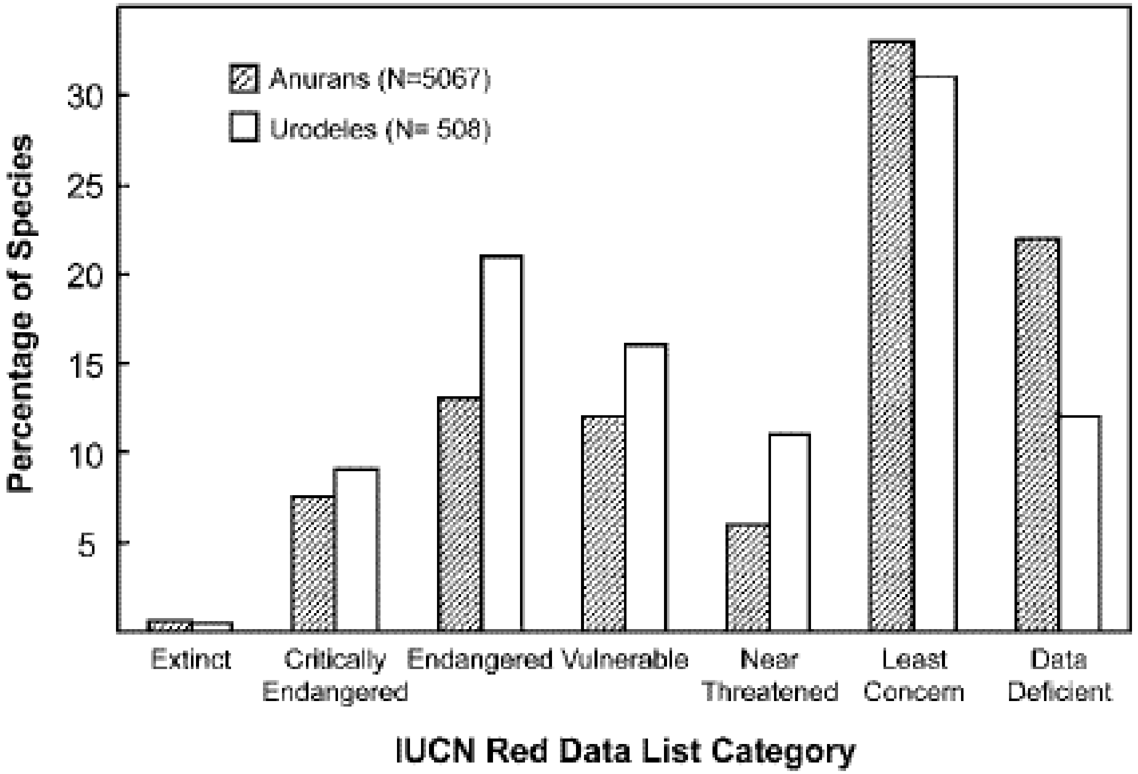
Morphological Evolution and Ecology of Caecilians

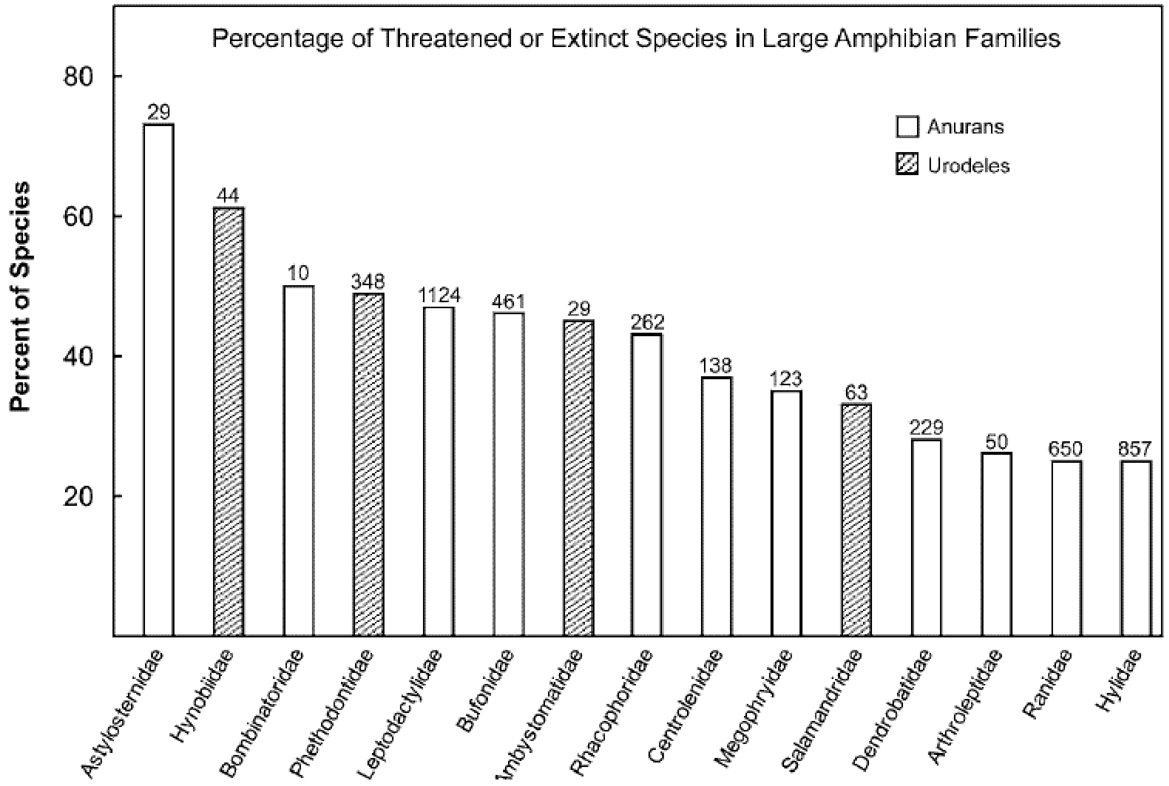
- All caecilians are elongate animals with large numbers of vertebrae (95–285). They lack any trace of limbs or pelvic and pectoral girdles, and in all but the basal groups, the tail is absent as well.
- This morphology presumably is a derived condition related to their fossorial habits. The discovery of well preserved fossil caecilians from the early Jurassic has shown that the ancestors of modern caecilians probably had well developed legs and tails.
- Caecilians burrow by inserting the snout into the ground at an angle, bracing the loosely curved body against the substrate, and elevating the head to push the soil aside. Once the burrow is started, it is enlarged by pushing and compacting the soil with the head, while pushing forward with contractions of the trunk and vertebral muscles.
- The skulls of caecilians are highly derived relative to ancestral amphibians, and very different in structure from those of anurans and urodeles. The head is flattened and wedge-shaped, with the mouth underneath a relatively pointed snout. In most species, the whole skull is heavily covered in dermal bone, and the snout region is strengthened



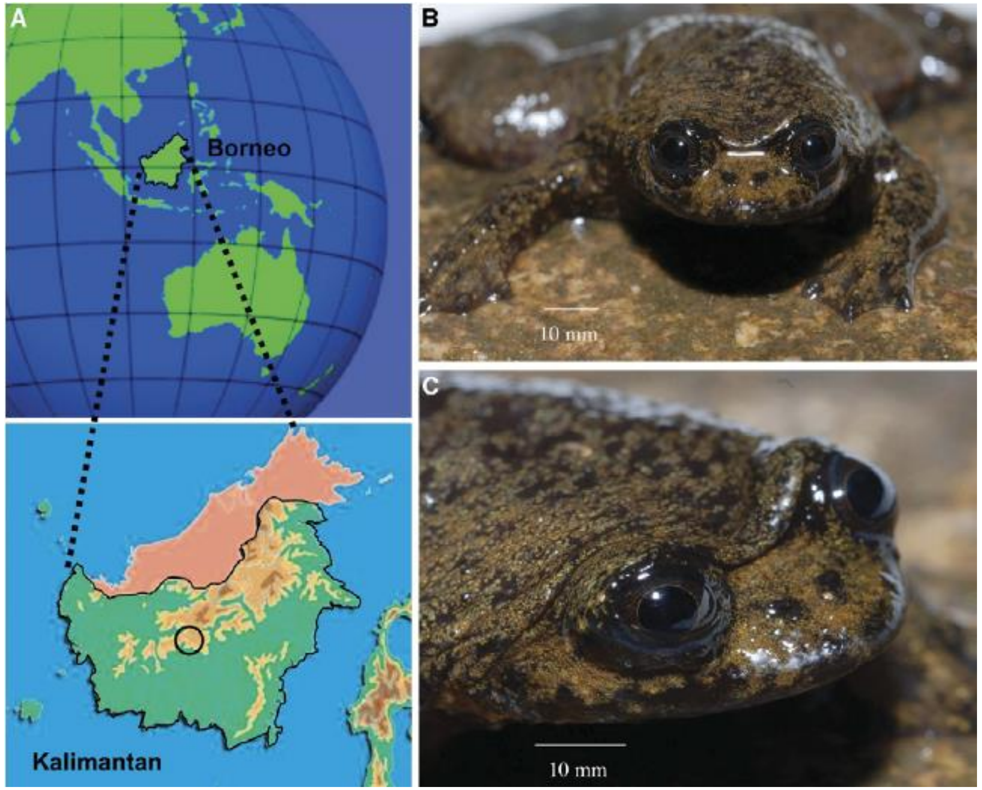
Skull of a primitive caecilian, *Epicrionops petersi* (Rhinatrematidae). (A) Dorsal view. (B) Ventral view. (C) Lateral view. (D) Lateral view of mandible. (E) Medial view of mandible. Heavy dermal bone covers the entire skull and snout region. Note the very small size of the orbit.

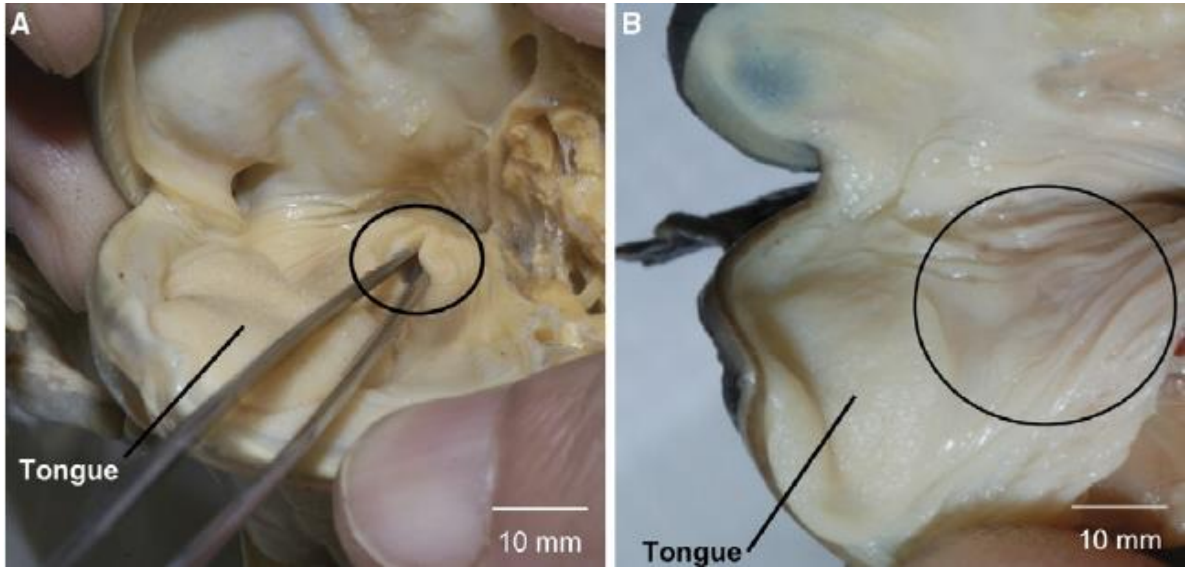
Conservation





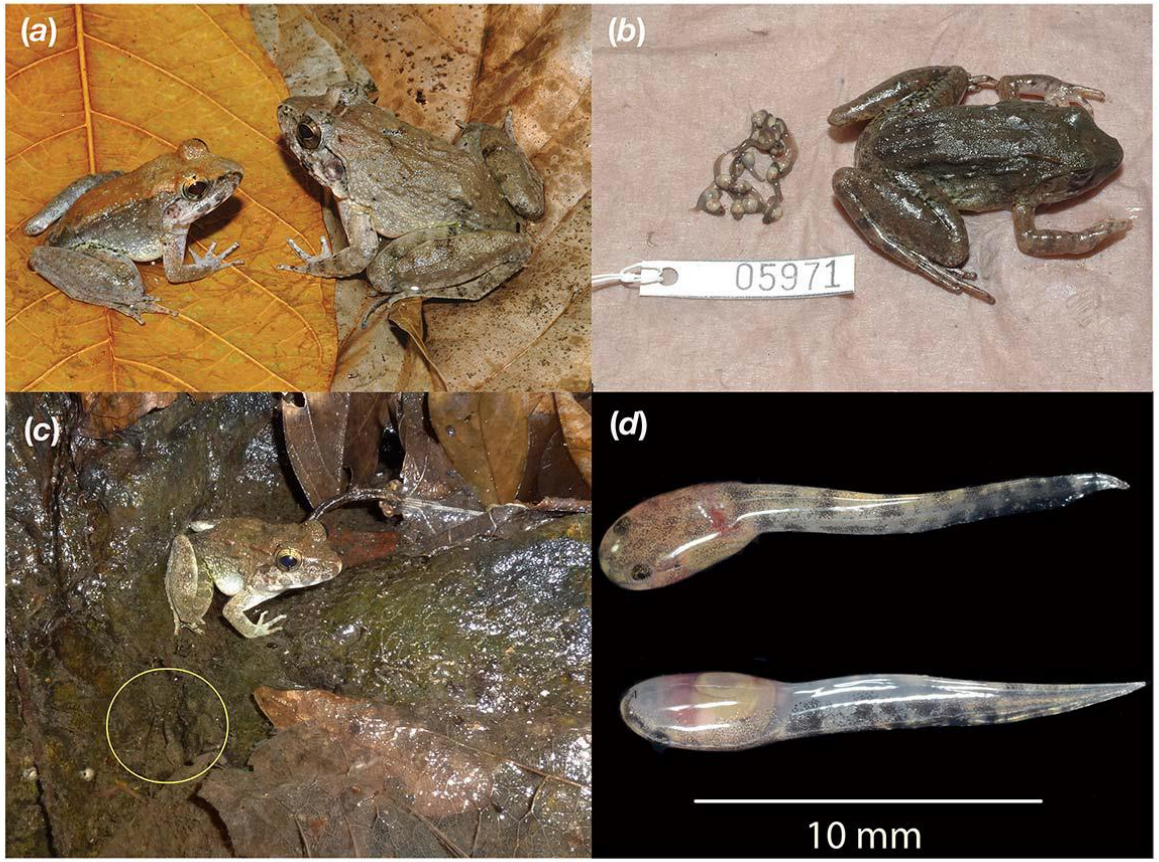
Barbourula kalimantanensis



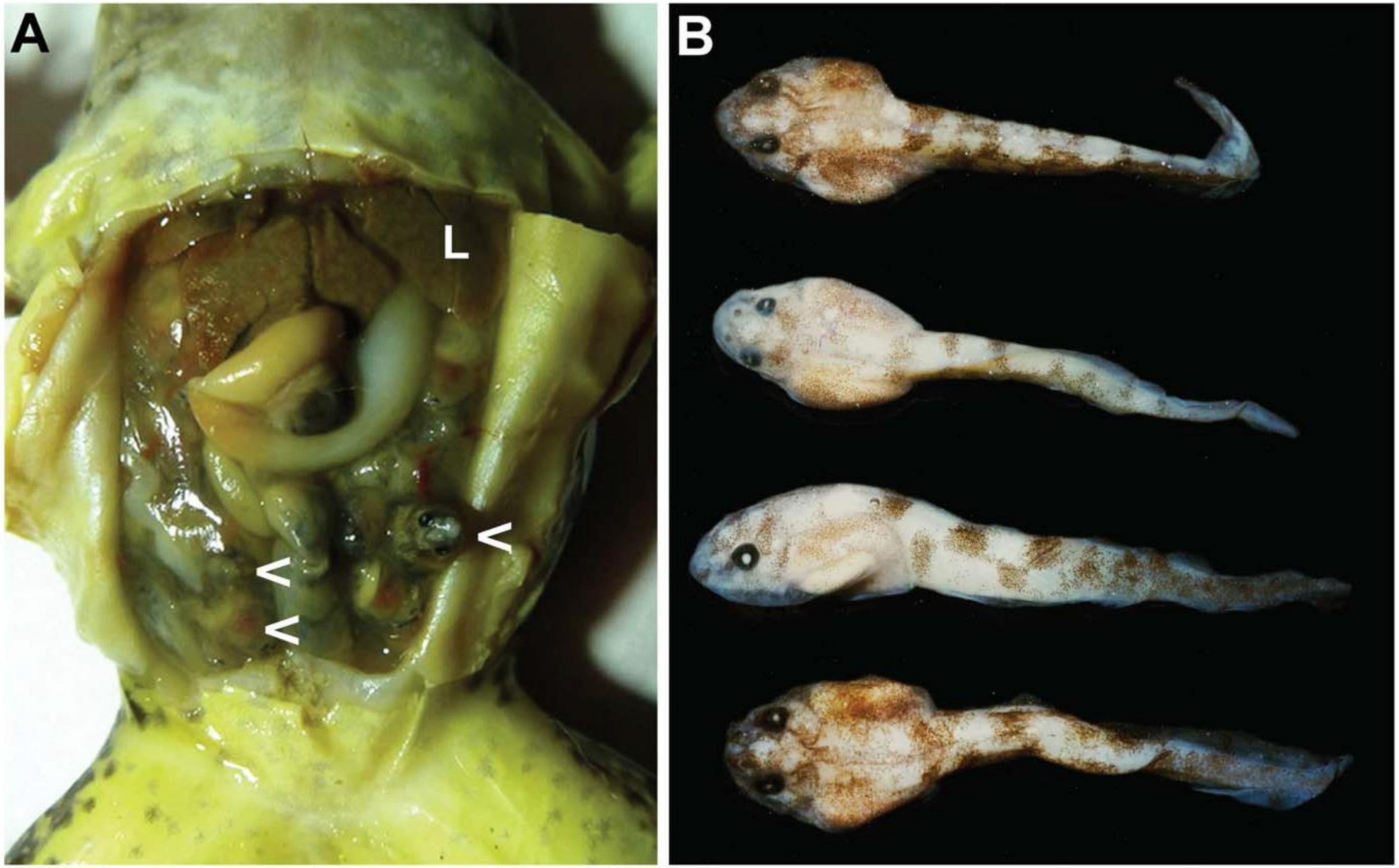


Anatomy of lunglessness. Comparison of (A) typical frog mouth and pharynx (*Rana catesbeiana*), showing glottis (circled), tongue, and esophageal opening, and (B) *B. kalimantanensis* showing tongue, no glottis (circled), and an enlarged esophageal opening leading directly to the stomach.

Limnonectes larvaepartus



(a) MVZ 268323 (male, left) and MVZ 268307 (female, right)
(b) Limnonectes larvaepartus female (MVZ 268426) with tadpoles removed from the oviduct. Note the large yolk reserves available to the tadpoles;
(c) An in situ adult male *L. larvaepartus* (JAM 14234) observed calling while perched on the edge of a small pool 2 m away from a 2 m wide stream; several *L. larvaepartus* tadpoles were present in the pool including the two visible within the yellow circle;
(d) Dorsal and ventral views of ,stage 25 *L. larvaepartus* tadpoles (JAM 14271) released by a pregnant female (JAM 14237) at the moment of capture.



(A) Intact viscera of gravid female (MZB Amp 22973; L5liver and arrows5several tadpoles
(B) Four f the preserved tadpoles removed from the oviducts of the same female.