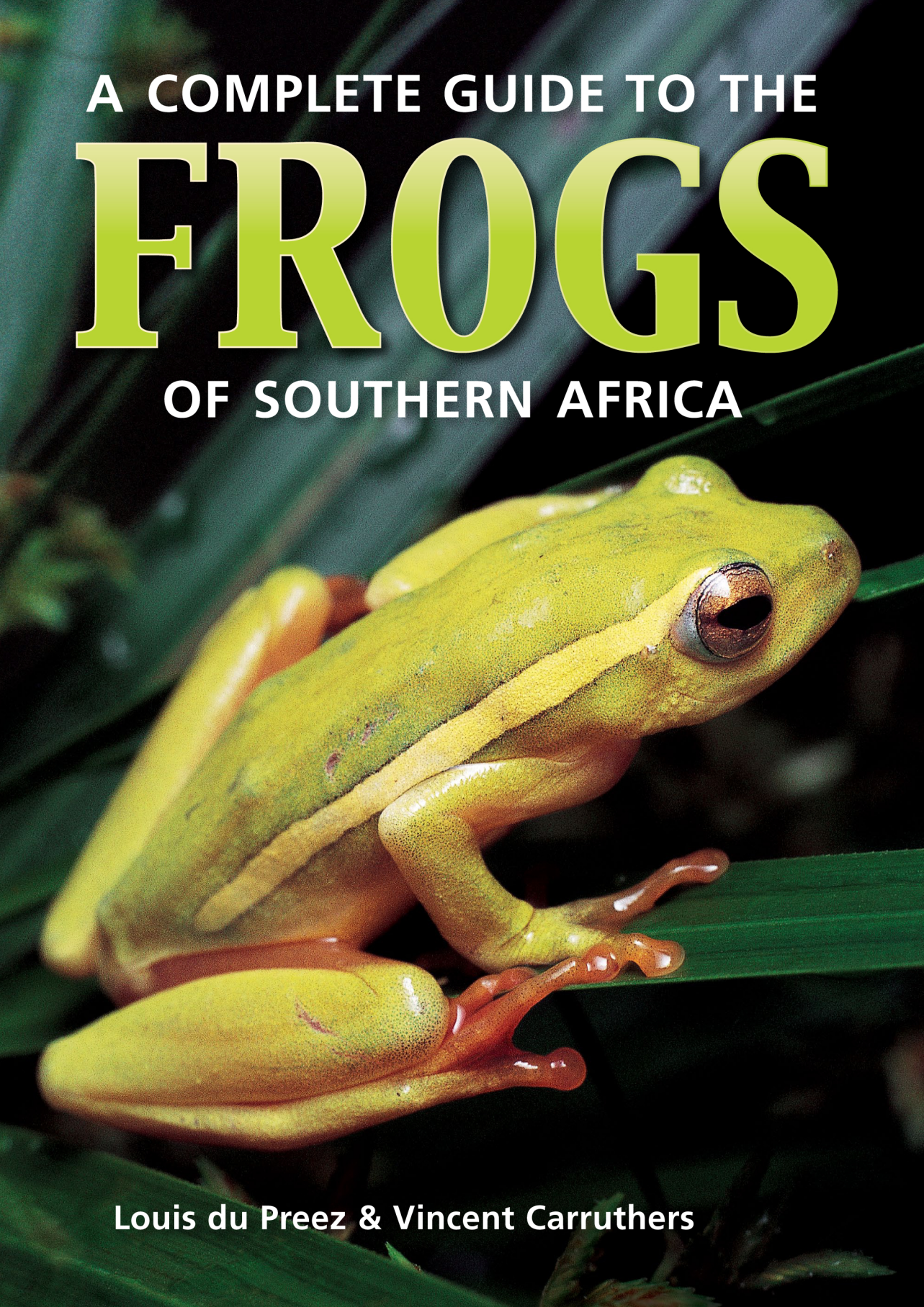
A COMPLETE GUIDE TO THE FROGS OF SOUTHERN AFRICA



Louis du Preez & Vincent Carruthers

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Front cover: Yellow-striped Reed Frog* Hyperolius semidiscus. *(Vincent Carruthers)
Right: Table Mountain Ghost Frog* Heleophryne rosei. *(Anton Pauw)

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INTRODUCTION

Identification, classification, taxonomy and evolution

'These foul and loathsome animals are abhorrent because of their cold body, pale colour, cartilaginous skeleton, filthy skin, fierce aspect, calculating eye, offensive smell, harsh voice, squalid habitation, and terrible venom; and so their Creator has not exerted his powers to make many of them.'

Carolus Linnaeus (father of modern taxonomy and one of the great naturalists of his time), referring to amphibians, 1758

Harmless, colourful, melodious and ecologically vital, frogs are the antithesis of Linnaeus's disdain. Some 6 000 species of amphibians are known worldwide and more are discovered every year. At the same time, the decline and extinction of species is occurring at a disturbingly high rate, indicating widespread environmental malaise.

This field guide describes the species found in southern Africa south of the Zambezi, Okavango and Cunene rivers and introduces the reader to their biological and conservation significance. All southern African species formally described before June 2009 are included, and subsequent discoveries or descriptions will be made available on the website **http://www.nwu.ac.za/p/z/frogbook.html** in the same page format as published in this book. The taxonomy and classification used here follows that of *The Amphibian Tree of Life* by Frost *et al.* 2006.

DISTINGUISHING CHARACTERS OF FROGS AND TADPOLES

Most people are familiar with the general appearance of frogs and tadpoles, but considerable variation exists between species. Frogs vary in size from the West African Goliath Frog, *Conraua goliath*, with feet as large as the palm of a human hand and weighing more than 3 kg, to the smallest species, a Cuban frog, *Eleutherodactylus iberia* which is only 8.5 mm long. In southern Africa the largest species is the Giant Bullfrog, *Pyxicephalus adspersus* (page 420) and the smallest is the Northern Moss Frog, *Arthroleptella subvoce* (page 360). Substantial variation may occur even within members of a single species. Colour and pattern, in particular, may differ from one frog to another within a species while, conversely, two different species are sometimes so similar in colour that they are indistinguishable on the basis of appearance alone.

Often the most dependable method of distinguishing between similar species or identifying unknown tadpoles is laboratory analysis of DNA. However, this technique falls outside the

scope of this book, the main purpose of which is to enable identification of living frogs in their natural habitats. Reliable identification of frogs in the field depends on a combination of different characters. These are illustrated diagrammatically on the following two pages. All of these characters should be considered in order to reach a confident decision when identifying a specimen. Where possible, more than one specimen from a population should be examined to establish the degree of variation that might occur. On p.10, a step-by-step process is described and this should be followed when identifying a frog or tadpole.

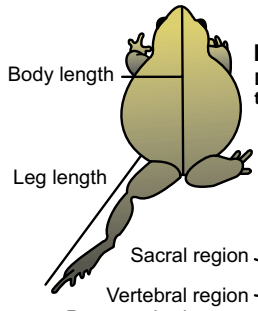
Ansel Fong

Smallest known frog species: Eleutherodactylus iberia *from Cuba.*

Renaud Fulconis

Largest known frog species: Conraua goliath *from Gabon.*

CHARACTERS FOR IDENTIFYING ADULT FROGS

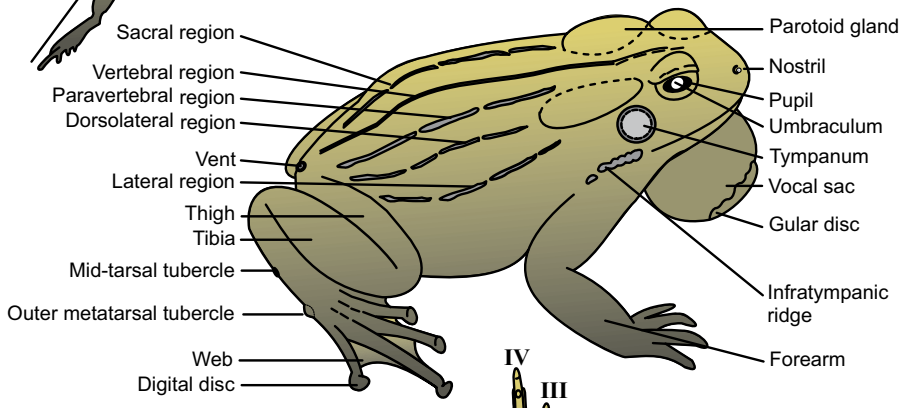


LIMB LENGTH

Determined relative to body length.

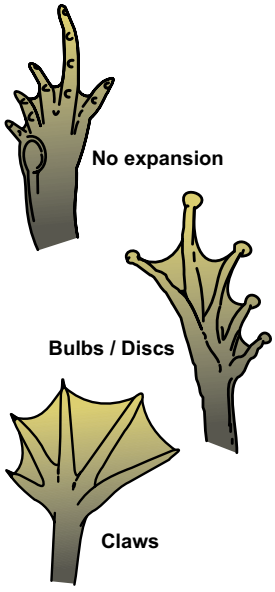
COLOUR

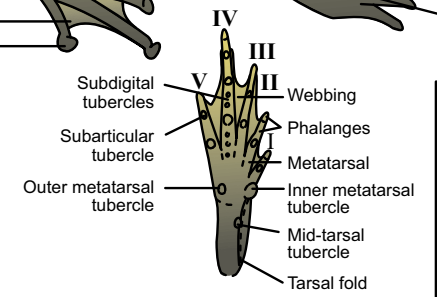
Colour pattern is often variable and is described for each species.

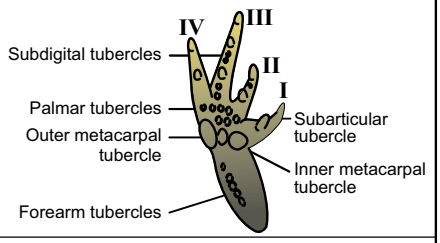


FEET

Webbing varies from absent to full. Toes may have terminal bulb or disks.







HANDS

Fingers may vary in length and have terminal bulbs or disks.

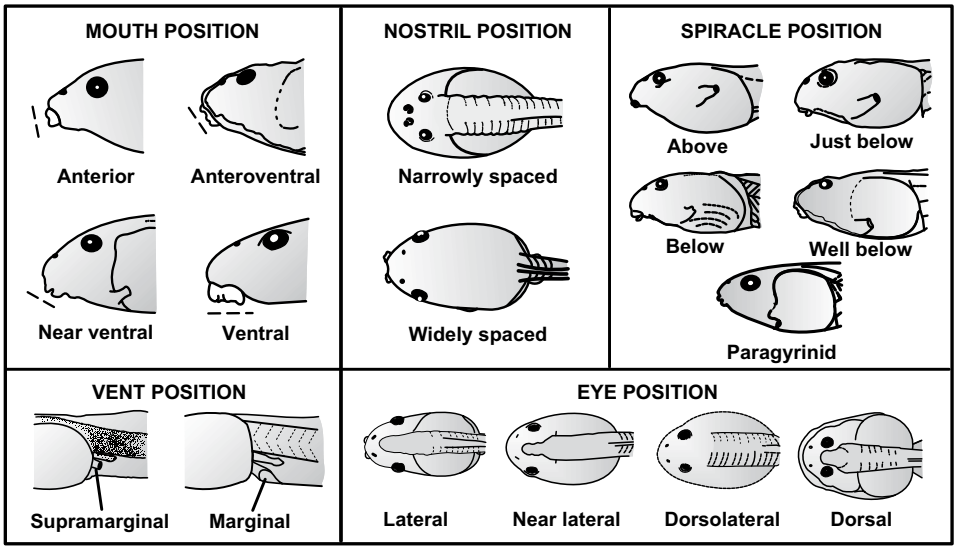
EYE PUPIL

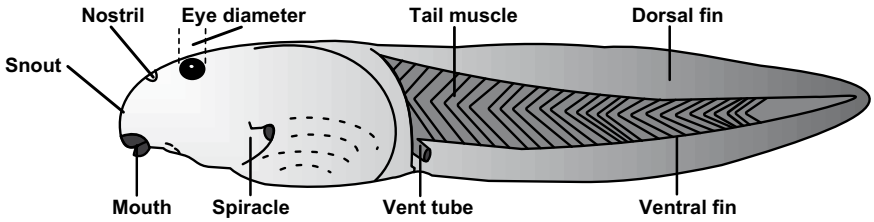
Vertical

Circular

Horizontal

CHARACTERS FOR IDENTIFYING TADPOLES



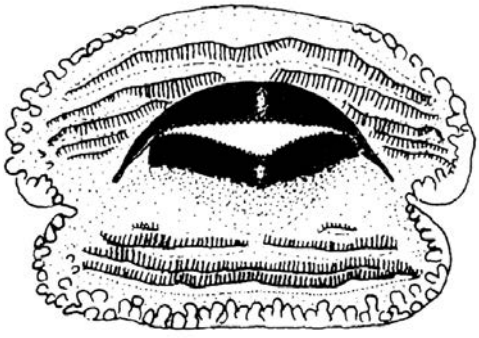


LABIAL TOOTH ROW FORMULA (LTRF)

LTRF: 3(2-3)/3

LTRF: 0/1

LTRF: 4/10(1)



The LTRF formula here is: 5(2-5)/4(1-2), indicating that there are five rows in the upper jaw, of which rows 2-5 are divided, and 4 rows in the lower jaw, of which rows 1 and 2 are divided.

Modified from Anstis, M. (2002) *Tadpoles of South-eastern Australia a guide with keys*. New Holland Publishers, Sydney, Australia.

JAW SHEATHS

Delicate

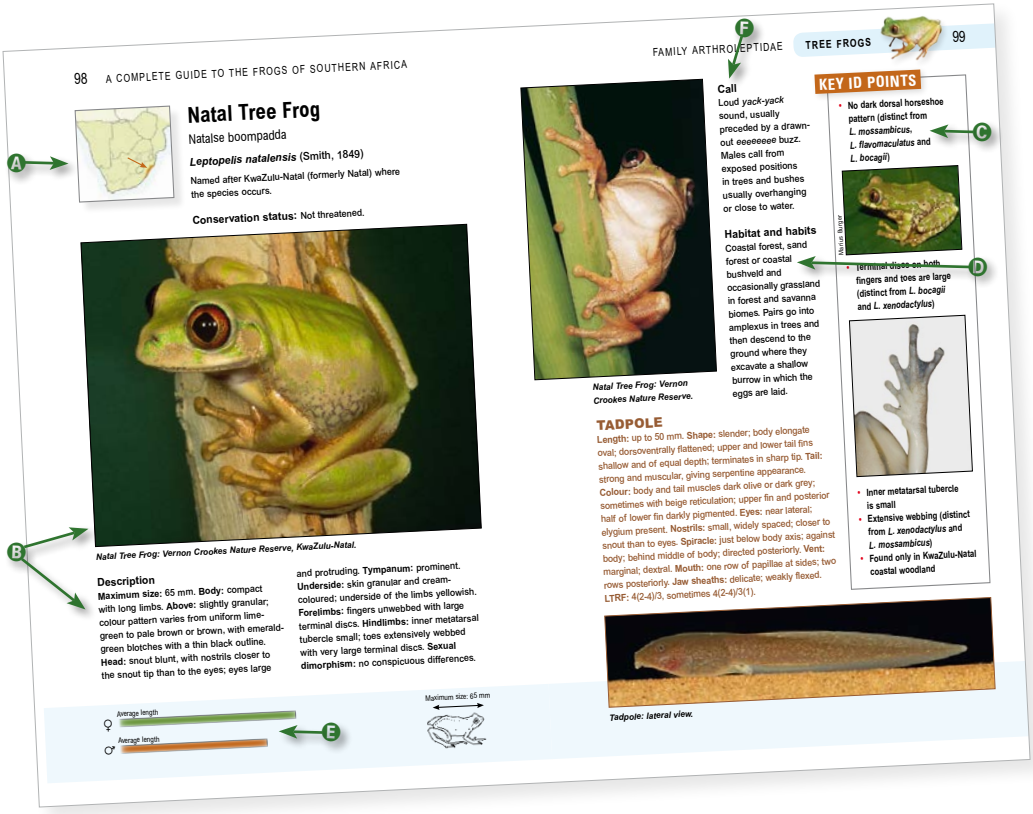
Moderate

Massive

HOW TO USE THIS BOOK

Every southern African species of frog (and most of their tadpoles) is individually described and illustrated in this book. Descriptions are grouped by genus and each genus is introduced on facing, tinted pages, which include a key to the species in that genus. Where a genus comprises only one species, the genus and species descriptions are combined. Reliable identification of specimens can best be achieved by following this step-by step process:

1 Work through the FIELD KEY TO THE GENERA OF ADULT FROGS (pages 68–74) to determine the genus to which the specimen belongs.
2 Turn to the relevant genus description page and check whether the specimen conforms to the points listed in the DISTINCTIVE CHARACTERS box. If not, retrace the selections made in the key process.
3 Work through the KEY TO SPECIES on the genus page to identify the species.
4 Turn to the relevant species description page and ensure that the following questions are answered positively:
A Was the specimen found within the distribution range indicated in the **map**?
B Is the general appearance similar to the photographs and **description**, remembering that colour and patterns can vary considerably?
C Does the specimen conform to all of the points in the **KEY ID POINTS** box?
D Was it found in or near the type of **habitat** described?
E Is it approximately the same length as the **average length** bar? **Note:** smaller than average juveniles are often encountered.
F If the frog was heard calling, does the call heard match the **call description** given for each species, as well as the **sound spectrogram** (pages 470–488)? Guidance on the interpretation of spectrograms is given.
5 Tadpole identification follows a similar series of steps, starting with the FIELD KEY TO THE FAMILIES AND GENERA OF TADPOLES (pages 75–79).
6 Information about the **biology** and **ecology** of amphibians is given on pages 30–66 and contributes to a better understanding of the complexity, fascination and importance of amphibian life in southern Africa.
7 The GLOSSARY (pages 466–469) will assist with unfamiliar terms.



CLASSIFICATION AND TAXONOMY

Classification is the process by which organisms are grouped systematically. Species in which there are indicators of a common evolutionary ancestor are grouped as genera. Genera sharing a common ancestor are assembled as families, families similarly as orders, orders as classes, and classes as phyla. Taxonomy is the science of assigning organisms to their positions within this classification system and naming them according to tightly prescribed principles developed originally in the 18th century by Carolus Linnaeus.

CLASSIFICATION OF FROGS WITHIN THE ANIMAL KINGDOM	
PHYLUM	The animal kingdom is divided into 25 phyla. Frogs belong in the phylum Chordata – animals with a notachord and a hollow dorsal nerve cord. Most familiar animals belong to the sub-phylum Vertebrata (vertebrates).
CLASS	There are 9 classes of vertebrates. Frogs belong to the class Amphibia. (Other classes are Reptiles, Birds, Mammals and 5 classes of Fish.)
ORDER	Amphibians are divided into 3 orders comprising about 6 000 species: Anura (frogs), Urodela (salamanders and newts) and Apoda (caecilians). Only 1 of these, the Anura, occurs in southern Africa.
FAMILY	There are 32 families of frogs in the world, 13 of which are represented in southern Africa.
GENUS	About 270 genera of frogs exist worldwide; 33 occur in southern Africa.
SPECIES	Worldwide, there are about 5 200 described species of frogs and 157 of these are found in southern Africa.

The phylum Chordata (LATIN *chorda* = rope or cord)

Chordate animals have an axial notachord. The phylum includes certain worm-like and primitive aquatic animals, but the most familiar Chordata are the vertebrates which, in addition to amphibians, include fish, reptiles, birds and mammals.

The class Amphibia (GREEK *amphi* = double; bios = life)

Amphibians are a group of vertebrate animals characterised by having two distinct phases in their lives. Although there are many exceptions, the two phases generally comprise an aquatic, larval stage – the tadpole – and a terrestrial, reproductive adult stage. Different species use a variety of strategies to protect themselves from desiccation and exposure to a harsh environment. They lay eggs without shells and these are fertilised externally as they are being laid.

Amphibians are the evolutionary ancestors of all terrestrial vertebrates – reptiles, birds, mammals and modern amphibians. In prehistoric times they were more prolific and diverse, but today only three orders remain. No marine amphibians are known.

The order Anura (GREEK *an* = absent; *oura* = tail)

These are the frogs with which most people in southern Africa are familiar. The order Anura is the only amphibian order that occurs in southern Africa. The adult form is a squat tetrapod that loses its tail when it metamorphoses from the larval tadpole. Many of the common species have well-developed hindlegs, giving rise to the alternative name for this order, **Salienta** (LATIN *saliens* = leaping).

Anura is the largest order of amphibians, with more than 5 200 species known worldwide. The order has adapted to almost every habitat type, from rain forest to desert, and occurs on every continent and large island except Antarctica.

Unlike the other orders, the Anura have the ability to vocalise and this is an important aspect of their reproductive biology (see pages 40 and 43–45).

The order Urodela (GREEK *ouros* = tail; *delos* = evident)

The order includes the salamanders and newts. They retain a tail throughout the larval and adult stages, and the alternative Latin name, **Caudata**, means 'with a tail'. There are about 550 species, all of which occur in the northern hemisphere. Most are about 150 mm in length but the Japanese and Chinese giant salamanders may exceed 1.5 m. Unlike frogs, the front and hindlegs are of equal size and positioned at right angles to the elongated body. In some species the limbs may be rudimentary or absent altogether. The Urodela are voiceless.

Marbled Newt, Triturus marmoratus*: an example of the Urodela.*

The order Apoda (GREEK *a* = without; *poda* = feet)

Caecilians are naked, legless, tail-less amphibians. To date, only 173 species have been described. They occur in the tropical forests of South America, Africa and South East Asia and the biggest species may reach a length of 1.5 m. Almost all species are burrowers. Their eyes are rudimentary or absent and they have a pair of small sensory tentacles on the head to help them navigate underground where they prey on small invertebrates in the soil. The alternative name for the order is **Gymnophiona** (GREEK *gymnos* = naked; *phiona* = snake-like) but they differ from snakes and lizards by having no tail and having a terminal anus. Unlike other amphibians, fertilisation occurs internally. Eggs are usually laid in moist soil near water and, while some larvae are aquatic, most complete their entire development inside the egg. Some species guard their eggs by curling up around them.

Marius Burger

Marius Burger

Sao Tome Caecilian Schistometopum thomense*: an example of the Apoda. Eyes are rudimentary or absent.*

Anuran families

The Anura are divided into 32 families worldwide, of which 13 are represented in southern Africa. In the past, taxonomists used skeletal and external morphological characters to classify frogs, and species were assembled into families because they appeared to be anatomically similar. Modern classification, however, relies extensively on mitochondrial DNA analysis to determine the genetic associations that make up families. In 2006 a group of international taxonomists led by Darrel Frost presented a major taxonomic revision of the world's amphibians based on modern genetics. This work, *The Amphibian Tree of Life*, demonstrates that species that look similar are not necessarily closely related, and that many of the old assumptions that defined certain families were incorrect. The new classification by Frost *et al*. is a working hypothesis, and may require changes in the future as new information becomes available.

After consultation with several prominent herpetologists around the globe, the authors of this field guide chose to follow Frost *et al*. because their work contributes significantly to scientific understanding of amphibian evolution and genetic relationships. For the fieldworker, however, the new classification of families may compound the difficulties of identification because several families include genera that are so diverse in appearance that they cannot easily be recognised as a single family. As an aid to the reader, therefore, pictures of typical representatives of each genus appear at the top corner of each species description.

Genera

The 13 families of southern African frogs are divided into 34 genera, each of which has a common ancestry indicated by its DNA. Although families are not always identifiable by external appearance, genera exhibit certain morphological or ecological characteristics that allow them to be identified in the field.

AN EXPLANATION OF THE TERMS 'FROGS' AND 'TOADS'

For many centuries the name 'toad' was applied to the European species of the genus *Bufo* while 'frog' was the common term for other Anura, mostly of the genus *Rana*. The two are easily distinguishable in Europe and were originally regarded as two types of reptile, like lizards or snakes. As scientific taxonomy progressed in the 18th and 19th centuries, frogs and toads were reclassified as two families of amphibians, a separate class from reptiles. In southern Africa there are 13 amphibian families (see pages 19–29). Toads are one of the frog families, along with the Rain Frog family, Ghost Frogs, Reed Frogs and others. It is therefore incorrect to separate frogs from toads; one is a family (toads) within an order (frogs).

Mascarene Grass Frog: a typical frog.

Guttural Toad: toads are one of the many frog families.

Species

The basic building block of the classification system is the species. In southern Africa 160 species of frogs have been described and new ones are discovered regularly as new habitats are explored and techniques for identifying species are improved.

In amphibians and other sexually reproducing animals, a species is defined as a population of animals capable of producing viable offspring by breeding among themselves but not with other species. Speciation usually occurs when a group of animals is genetically separated from other members of its species as a result of geographical, ecological or climatic change. Thus isolated, the group evolves independently inherited characteristics and becomes a separate allopatric species.

In some circumstances, groups within a species may become isolated. In time, each segregated group may show slight morphological differences yet still retain the ability to interbreed if reconnected. Such groups are considered to be **subspecies**.

In other instances, for example Painted Reed Frogs, the species is widely distributed and groups of frogs in different parts of the range show different local colour patterns. Some taxonomists accord subspecific status to the different geographically located colour forms, but there are no clear-cut boundaries between each form and breeding is continuous throughout the range. Such situations are better referred to as **clines** or **clinal population groups** than as subspecies.

SCIENTIFIC NOMENCLATURE

One of the most important aspects of taxonomy is the description and naming of species. A description is based on a **type specimen** – that is, a single specimen or small collection, usually preserved and lodged in a museum or recognised repository where scientists may have access to it in order to study it.

The scientific name of each species follows the binomial system first introduced by Carolus Linnaeus in 1735. It comprises two Latinised words, the first of which is used for all members of the genus, and the other identifies the species. The same specific name may be used in different genera (for example, *Pyxicephalus adspersus* and *Breviceps adspersus*) but in combination with a generic name, each is unique. A third Latinised name may be added to denote a subspecies. Generic, specific and subspecific names are customarily italicised, and the generic name is spelt with an initial capital letter. Family, order and class names are not italicised.

The full scientific name also includes the name of the person who first described the species for science and the date of the description. If the species is reassigned to another genus after its original description, the first describer's name appears in brackets. For example, the correct scientific name of the Painted Reed Frog is *Hyperolius marmoratus* Rapp, 1842, and the Clicking Stream Frog is named *Strongylopus grayii* (Smith, 1849). In the second example, 'Smith, 1849' is bracketed because Smith originally named the species *Rana grayii*. When the name of a genus is given without reference to any particular species, the name of the person who described the genus is given, as well as the date of description.

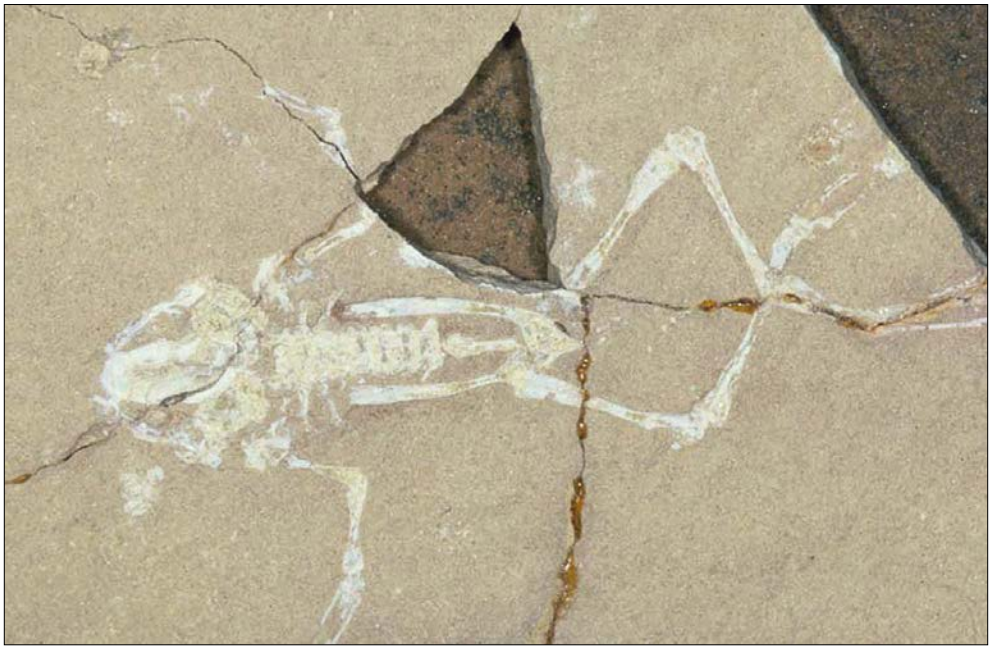
Strict principles apply to the naming of species and this is supervised by the International Code of Zoological Nomenclature. Once accepted in the scientific literature, a name is used universally in all countries irrespective of local language, as shown below:

GENUS	SPECIES	SUBSPECIES	DESCRIBER	DESCRIPTION DATE
Hildebrandtia	*ornata*	*ornata*	(Peters)	1878

EVOLUTION OF AMPHIBIANS

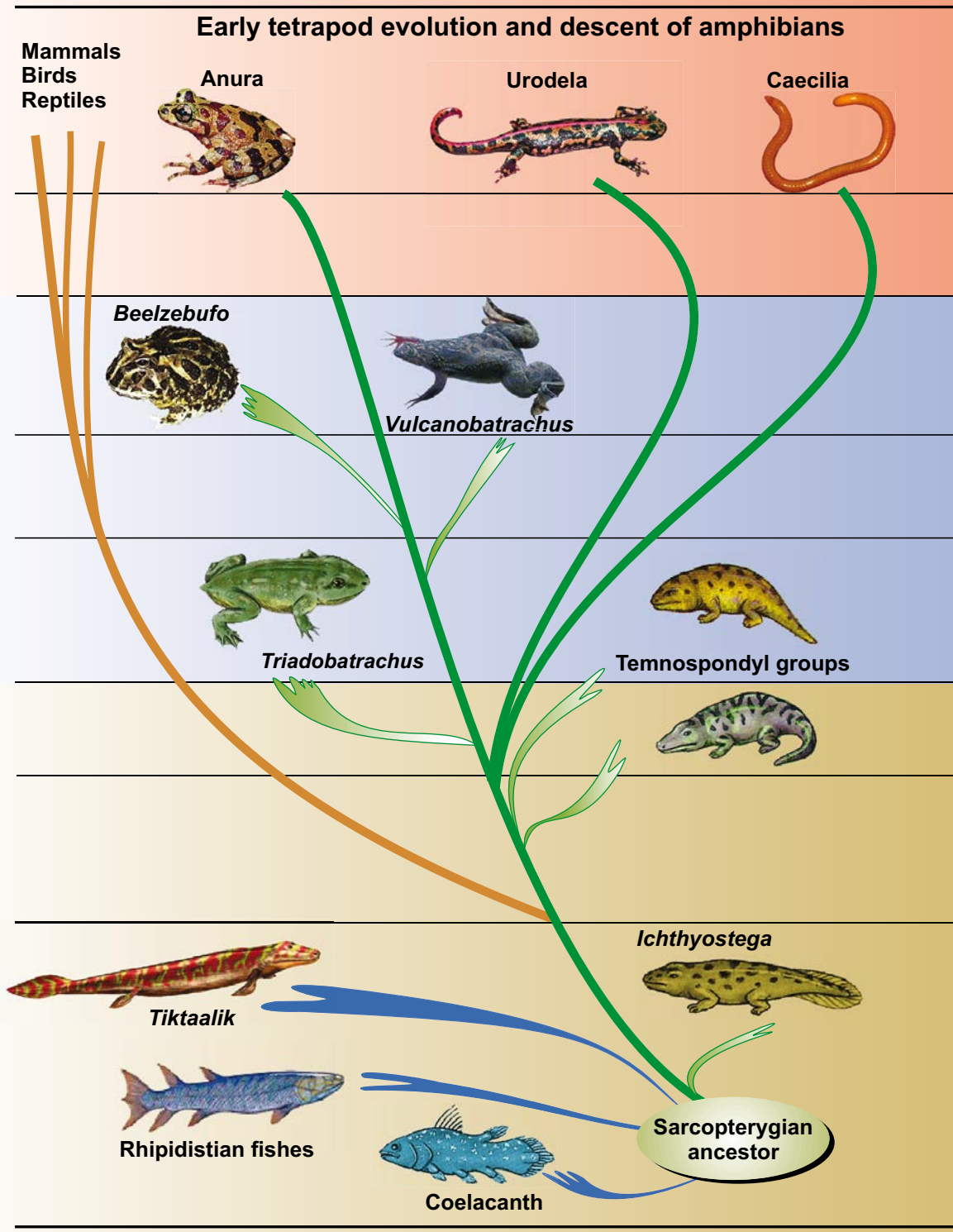
Amphibians were the first vertebrates to emerge from the water and exploit the terrestrial landscape more than 350 million years ago. The process entailed substantial physiological changes including the development of a skeleton capable of supporting the weight of the body in air, and the evolution of lungs that could inhale and absorb free oxygen from the atmosphere. These early amphibians were the common ancestors of all terrestrial vertebrates – mammals, birds, reptiles and modern amphibians.

The fossil record of frog evolution is imperfect, but tail-less anurans appear to have emerged during the Triassic prior to the dinosaurs. Southern African anurans can be traced to this period. *Vulcanobatrachus mandelae*, a frog not unlike the modern Platanna, existed in the part of Gondwana that is now southern Africa 120 million years ago. The main developments in the evolution of southern African amphibians are shown on the next two pages.



Fossil frog Vulcanobatrachus mandelai *from the Cretaceous deposits in the Marydale District, Northern Cape, about 120 million years ago.*

Fossil tadpole from Europe: the soft body parts of tadpoles rarely fossilise and our knowledge of tadpole evolution is therefore limited.


Early tetrapod evolution and descent of amphibians
Mammals
Birds
Reptiles
Anura
Urodela
Caecilia
Beelzebufo
Vulcanobatrachus
Triadobatrachus
Temnospondyl groups
Ichthyostega
Tiktaalik
Rhipidistian fishes
Coelacanth
Sarcopterygian ancestor

ERA	PERIOD	MYA*	CONDITIONS	AMPHIBIAN EVOLUTION
CENOZOIC	NEOGENE (QUATERNARY)	0	Human evolution; possible start of *sixth mass extinction* of living species.	*Xenopus* changes little physically, but colonises diverse aquatic habitats; other southern African species radiate; frog populations decline globally.
	PALAEOGENE (TERTIARY)	23	Modern reptiles and mammals evolve; global cooling.	Emergence in Namibia of *Xenopus stromeri* (similar to the modern platanna *Xenopus laevis).*
MESOZOIC	CRETACEOUS	65	Breakup of Gondwana (65 mya); massive asteroid impact contributes to the *fifth mass extinction* of living species, and demise of dinosaurs; primitive birds emerge.	Xenopoides-like *Vulcanobatrachus* (primitive antecedents of genus *Xenopus*) dated to about 120 mya; fossil *Beelzebufo*, discovered in Madagascar, indicates that the island may have been connected to South America as late as 60 mya (after separating from Africa about 80 mya).
	JURASSIC	145	Large dinosaurs emerge; reptiles proliferate throughout Africa.	True Anurans begin to radiate throughout the world.
	TRIASSIC	200	*Fourth mass extinction* of living species (probably caused by asteroid impact); global warming; demise of mammal-like reptiles.	Tail-less Gondwana amphibian, *Triadobatrachus* (fossil found in Madagascar) pre-dates break-up of Gondwana (65 mya) and has more vertebrae than true Anurans – indicating possible ancestor of today's southern hemisphere frogs.
PALAEOZOIC	PERMIAN	251	Reptiles become dominant species; *third mass extinction* of living species (caused by seismic activity).	Gondwana fossils (such as the Temnospondyl groups found in fossil record of Australia and southern Africa) diversify further – identifiable as ancestors of modern amphibians.
	CARBONIFEROUS	299	Northern hemisphere warm and wet (mosses and ferns flourish), southern hemisphere arid; global cooling.	Amphibians dominate the landscape, some resembling crocodiles several metres long; adapt to terrestrial conditions with greater agility and extensive webbing on the feet; skin develops as a respiratory organ; at least 15 amphibian orders known from this period, but unclear which evolve to become today's three orders.
	DEVONIAN	359	Mild global temperature; fluctuating wet and dry periods; *second mass extinction* of living species (caused by multiple asteroid impacts followed by rapid radiation); all vertebrates aquatic – confined to swamps and shallow seas and thus vulnerable to desiccation in low water levels.	Terrestrial vertebrates descend from a Sarcopterygian ancestor (lobed fin fish); fossilised fins of Rhipidistian fishes similar to the limbs of early amphibians, and indicate probable ability to inhabit terrestrial environments. *Tiktaalik* has neck and possibly primitive lungs – develops ability to support itself on robust weight-bearing, articulated fins (375 mya); earliest amphibian in fossil record is *Ichthyostega*, a 1.5 m long monitor-like creature, dating from about 367 mya, which can 'walk' in swamps – this adaptation probably leads to ability to inhabit terrestrial environments.
		416		

* million years ago

SYSTEMATIC LIST OF SOUTHERN AFRICAN FROGS

Scientific and common names of species

The following tables list the 13 families, 33 genera and 157 species of frogs that occur in Namibia, Botswana, South Africa, Zimbabwe, Swaziland, Lesotho and Mozambique south of the Zambezi River. Family headings are colour-coded to correspond with the coloured tabs that appear at the top, right-hand corner of the descriptive pages. A small illustration of a typical member of the family or genus is included in the tab and a page reference to the descriptive page is given.

The scientific name appears in the first column of the table. This is followed in the next two columns by the standard common English and Afrikaans names. Unlike birds or mammals, few frogs have widely known common names. In the past, authors often used names of their own or local popular names, which frequently led to duplication or confusion. In 1979, after wide discussion and research, *South African Frogs* (Passmore and Carruthers) assigned standard English names to all South African species. These, together with standard Afrikaans names, were reviewed and formalised in the *Atlas and Red Data Book of the Frogs of South Africa, Lesotho and Swaziland* (Minter *et al.* 2004) and those names have been retained here. Where species have not been included in the *Atlas*, English names have been taken from 'Amphibian Species of the World' **http://research.amnh.org/herpetology/amphibia/index.php** and Afrikaans names have had to be created.

The final column in the table lists the common names that have been used in earlier publications so that they can be cross-referenced to the modern literature.

Image provided by Iziko Museums of Cape Town

PIONEER OF SOUTHERN AFRICAN FROGS

The first scientific work on southern African frogs was published in 1849 by Dr Andrew Smith in his monumental multi-volume *The Zoology of South Africa,* illustrated by George Henry Ford. It contained detailed descriptions and paintings of the 26 species of South African frogs then known, 14 of which Smith had discovered himself.

Andrew Smith was a Scottish military doctor who resided at the Cape from 1821 to 1839. Under the patronage of the governor Lord Charles Somerset he founded the South African Museum. He was also an explorer and diplomat for the colonial government and took an expedition north of the Vaal River to meet African leaders including Mzilikazi.

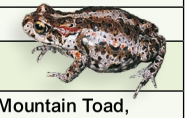
Scientific name	Standard English name	Standard Afrikaans name	Other published names
FAMILY ARTHROLEPTIDAE **Squeakers and Tree Frogs** (pp.80–101)			
Genus *Arthroleptis*	**Squeakers**	***Kikkers***	
Arthroleptis stenodactylus	Shovel-footed Squeaker	*Graafpootkikker*	Common Squeaker, Dune Squeaker, Kihengo Screeching Frog, Narrow-footed Humus Frog, Savanna Squeaking Frog, Shovel-footed Bush Squeaker, *Duinkikker, Duinekikker*
Arthroleptis troglodytes	Cave Squeaker	*Grotkikker*	Poynton's Humus Frog, Rock Humus Frog, South Rhodesia Screeching Frog, Troglodyte Humus Frog, Troglodyte Squeaker
Arthroleptis xenodactyloides	Dwarf Squeaker	*Dwergkikker*	Chirinda Cricket Frog, Chirinda Screeching Frog, Dwarf Squeaker, Hewitt's Bush Squeaker, Hewitt's Humus Frog, Nyika Squeaker
Arthroleptis wahlbergii	Bush Squeaker	*Boskikker*	Wahlberg's Forest Frog, Wahlberg's Frog, Wahlberg's Humus Frog
Genus *Leptopelis*	**Tree Frogs**	***Boompaddas***	
Leptopelis bocagii	Bocage's Tree Frog	*Bocage se boompadda*	Bocage's Burrowing Frog, Bocage's Burrowing Leaf Frog, Bocage's Frog, Horseshoe Forest Treefrog
Leptopelis broadleyi	Broadley's Tree Frog	*Broadley se boompadda*	Bagamoyo Forest Treefrog, Broadley's Tree Frog, Triad Tree Frog
Leptopelis flavomaculatus	Yellow-spotted Tree Frog	*Geelspikkelboompadda*	Brown Forest Treefrog, Brown-backed Tree Frog, Johnston's Treefrog
Leptopelis mossambicus	Brown-backed Tree Frog	*Bruinrugboompadda*	Mozambique Tree Frog, Mossambique Forest Treefrog
Leptopelis natalensis	Natal Tree Frog	*Natalse boompadda*	Forest Tree Frog, Natal Forest Treefrog, Raucous Tree Frog, *Woudboompadda*
Leptopelis xenodactylus	Long-toed Tree Frog	*Langtoonboompadda*	Natal Tree Frog, Weza Forest Treefrog
FAMILY BREVICIPITIDAE **Rain Frogs** (pp.102–137)			
Genus *Breviceps*	**Rain Frogs**	***Reënpaddas***	
Breviceps acutirostris	Strawberry Rain Frog	*Aarbeireënpadda*	Cape Short-headed Frog, *Pienkreënpadda, Aarbei-blaasoppadda*
Breviceps adspersus	Bushveld Rain Frog	*Bosveldreënpadda*	Bushveld Rain Frog, Common Rain Frog, Common Rain Frog, Common Short-headed Frog, Peters' Rain Frog, South African Short-head, Transvaal Rain Frog, Transvaal Short-headed Frog, *Blaasop, Transvaal blaasop*
Breviceps bagginsi	Bilbo's Rain Frog	*Bilbo se reënpadda*	*Bilbo se blaasoppadda*

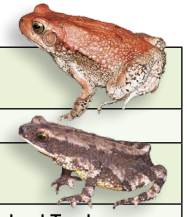
Breviceps branchi	Branch's Rain Frog	*Branch se reënpadda*	
Breviceps fuscus	Plain Rain Frog	*Swartreënpadda*	Black Rain Frog, Brown Short-headed Frog, *Gewone Janblom, Blaasoppadda, Knysnablaasop*
Breviceps gibbosus	Cape Rain Frog	*Kaapse reënpadda*	Cape Short-head, South African Short-headed Frog, Giant Rain Frog, Headless Frog, Hunched Toad, Linnaeus' Rainfrog, Cape Rain Frog, Linnaeus' Short-headed Frog, Rain Frog, Short-headed Frog, South African Rain Frog, Verruculose Rainfrog, Verruculose Short-headed Frog, *blaasop, Jan Blom, Kaapse Janblom, Kaapse blaasoppadda, Aartappelpadda*
Breviceps macrops	Desert Rain Frog	*Woestynreënpadda*	Boulenger's Short-headed Frog, Web-footed Rain Frog, *Melkpadda, Woestynblaasoppadda*
Breviceps montanus	Cape Mountain Rain Frog	*Kaapse bergreënpadda*	Mountain Blaasop, Mountain Rain Frog, Mountain Short-headed Frog, *Kaapse bergblaasoppadda*
Breviceps mossambicus	Mozambique Rain Frog	*Mosambiekse reënpadda*	Flat-faced Frog, Flat-faced Rain Frog, Moçambique Rain Frog, Mozambique Rain Frog, Mozambique Short-headed Frog, *Mosambiek blaasop*
Breviceps namaquensis	Namaqua Rain Frog	*Namakwareënpadda*	Namaqua Short-headed Frog, *Namakwa blaasoppadda, Blaasoppadda*
Breviceps poweri	Power's Rain Frog	*Power se reënpadda*	Power's Short-headed Frog
Breviceps rosei	Sand Rain Frog	*Rose se reënpadda*	Rose's Rain Frog, Rose's Rainfrog, Rose's Short-headed Frog, Sand Rain Frog, *Rose se blaasoppadda, Rose's blaasop, Sandblaasoppadda, Sandreënpadda*
Breviceps sopranus	Whistling Rain Frog	*Fluitreënpadda*	*Fluitende blaasoppadda*
Breviceps sylvestris	Northern Forest Rain Frog	*Transvaal woudreënpadda*	Forest Rain Frog, Forest Short-headed Frog, Transvaal Forest Rain Fog, *Transvaal woudblaasoppadda*
Breviceps verrucosus	Plaintive Rain Frog	*Klareënpadda*	Natal Short-headed Frog, *Fluitblaasoppadda, Klaende reënpadda, Klaende blaasoppadda*
Genus *Probreviceps*	**Forest Rain Frogs**	***Woudreënpaddas***	***Primitive Rain Frogs***
Probreviceps rhodesianus	Highland Forest Rain Frog	*Hoëveldse woudreënpadda*	Highland Primitive Rain Frog, Zimbabwe Big-fingered Frog

FAMILY BUFONIDAE
Toads (pp.138–197)

Genus *Amietophrynus*	**Typical Toads**	***Gewone-skurwepaddas***	
Amietophrynus garmani	Eastern Olive Toad	*Olyfskurwepadda*	Garman's Toad, Olive Toad, Northern Mottled Toad, Light-nosed Toad, Garman's Square-marked Toad, Garman's Square-backed Toad, Eastern Olive Toad
Amietophrynus gutturalis	Guttural Toad	*Gorrelskurwepadda*	Common African Toad, Flat-backed Toad, Greater Cross-marked Toad, Guttural Toad, Leopard Toad, Lobatsi Toad, Marbled Toad, Common Toad, Square-marked Toad

Amietophrynus lemairii	Lemaire's Toad	*Lemaire se skurwepadda*	Lemaire's Toad, Pweto Toad, Yellow Swamp Toad
Amietophrynus maculatus	Flat-backed Toad	*Gestreepte skurwepadda*	Flat-backed Toad, Hallowell's Toad, Lesser Cross-marked Toad, Lesser Square-marked Toad, Merten's Striped Toad, Striped Toad
Amietophrynus pantherinus	Western Leopard Toad	*Westelike luiperdskurwepadda*	August Frog, Cape Toad, Leopard Toad, Panther Toad, Southern Panther Toad
Amietophrynus pardalis	Eastern Leopard Toad	*Oostelike luiperdskurwepadda*	August Toad, Gleniffer Toad, Leopard Toad, Snoring Toad
Amietophrynus poweri	Western Olive Toad	*Power se skurwepadda*	Common Lowveld Toad, Power's Toad, Kimberley Toad
Amietophrynus rangeri	Raucous Toad	*Lawaaiskurwepadda*	Kei Road Toad, Ranger's Toad, *Lawaaipadda*
Genus *Poyntonophrynus*	**Pygmy Toads**	***Dwergskurwepaddas***	
Poyntonophrynus beiranus	Beira Pygmy Toad	*Beira-dwergskurwepadda*	Beira's Toad, Beira Toad
Poyntonophrynus damaranus	Damaraland Pygmy Toad	*Damara-dwergskurwepadda*	
Poyntonophrynus dombensis	Dombe Pygmy Toad	*Dombe-dwergskurwepadda*	Dombe Toad
Poyntonophrynus fenoulheti	Northern Pygmy Toad	*Noordelike dwergskurwepadda*	Fenoulheti's Pygmy Toad, Fenoulhet's Toad, Grindley's Pygmy Toad, Newington Toad, Transvaal Dwarf Toad, Transvaal Pygmy Toad
Poyntonophrynus hoeschi	Hoesch's Pygmy Toad	*Hoesch se dwergskurwepadda*	Okahandja Toad, Hoesch's Toad
Poyntonophrynus kavangensis	Kavango Pygmy Toad	*Kavango-dwergskurwepadda*	Kavanga Toad, Kavango Toad, Khwai River Toad
Poyntonophrynus vertebralis	Southern Pygmy Toad	*Suidelike dwergskurwepadda*	African Dwarf Toad, Flat Toad, Pygmy Toad
Genus *Vandijkophrynus*	**Van Dijk's Toads**	***Van Dijk skurwepaddas***	
Vandijkophrynus amatolicus	Amatola Toad	*Amatola-skurwepadda*	
Vandijkophrynus angusticeps	Cape Sand Toad	*Sandskurwepadda*	Sand Toad, Common Cape Toad, Narrow-headed Toad
Vandijkophrynus gariepensis	Karoo Toad	*Karooskurwepadda*	*Pispadda*
Vandijkophrynus inyangae	Inyanga Toad	*Inyanga-skurwepadda*	Inyangani Toad
Vandijkophrynus robinsoni	Paradise Toad	*Paradyskloof-skurwepadda*	
Genus *Capensibufo*	**Mountain Toadlets**	***Bergskurwepaddas***	
Capensibufo rosei	Rose's Mountain Toadlet	*Rose se bergskurwepadda*	Cape Mountain Toad, Muizenberg Cape Toad, Rose's Mountain Toad, Rose's Toad, Striped Mountain Toad, *Rose se skurwepaddatjie*
Capensibufo tradouwi	Tradouw Mountain Toadlet	*Tradouw-bergskurwepadda*	Cape Mountain Toad, Swellendam Cape Toad, Tradouw Mountain Toad, Tradouw's Toad





Genus *Schismaderma*	**Red Toad**	***Rooiskurwepadda***	
Schismaderma carens	Red Toad	*Rooiskurwepadda*	
Genus *Mertensophryne*	**Forest Toads**	***Woudskurwepaddas***	
Mertensophryne anotis	Chirinda Toad	*Chirinda-woudskurwepadda*	Chirinda Forest Toad, Boulenger's Earless Toad, Mashonaland Toad

FAMILY HELEOPHRYNIDAE
Ghost Frogs (pp.198–215)

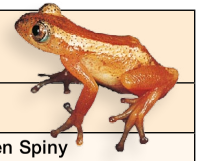
Genus *Hadromophryne*	**Cascade Frog**	***Snelstroompadda***	
Hadromophryne natalensis	Natal Cascade Frog	*Natalse snelstroompadda*	Natal Ghost Frog, Heleo Frog, Natal Torrent Frog, Southeastern Ghost Frog, Southeastern Torrent Frog
Genus *Heleophryne*	**Ghost Frogs**	***Spookpaddas***	
Heleophryne depressa	Cederberg Ghost Frog	*Sederbergspookpadda*	
Heleophryne hewitti	Hewitt's Ghost Frog	*Hewitt se spookpadda*	Hewitt's African Ghost Frog, *Elandsberg-spookpadda*
Heleophryne orientalis	Eastern Ghost Frog	*Oostelike spookpadda*	East Cape Ghost Frog, East Cape Torrent Frog
Heleophryne purcelli	Cape Ghost Frog	*Kaapse spookpadda*	
Heleophryne regis	Southern Ghost Frog	*Suidelike spookpadda*	Rex's Ghost Frog, Rex's Torrent Frog, Royal Ghost Frog, Southern Ghost Frog
Heleophryne rosei	Table Mountain Ghost Frog	*Tafelberg-spookpadda*	Ghost Frog, Rose's Ghost Frog, Rose's Torrent Frog, Skeleton Gorge Ghost Frog, Thumbed Ghost Frog

FAMILY HEMISOTIDAE
Shovel-nosed Frogs (pp.216–223)

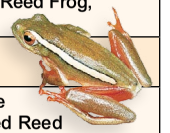
Genus *Hemisus*	**Shovel-nosed Frogs**	***Graafneuspaddas***	
Hemisus guineensis	Guinea Shovel-nosed Frog	*Guinee-graafneuspadda*	Broadleys Shovel-nosed Frog, Guinea Shovelsnout Frog, Guinea Shovel-snouted Frog, Pig-nosed Frog
Hemisus guttatus	Spotted Shovel-nosed Frog	*Gespikkelde graafneuspadda*	Spotted Burrowing Frog, Spotted Pig-nosed Frog, Spotted Shovelnose Frog, Spotted Shovel-snouted Frog, Spotted Snout-burrower, *Gespikkelde spitsbekpadda*

Hemisus marmoratus	Mottled Shovel-nosed Frog	*Marmergraafneuspadda*	Marbled Pig-nosed Frog, Marbled Shovelnose Frog, Marbled Shovel-snouted Frog, Marbled Snout-burrower, Mottled Burrowing Frog, Mottled Shovel-nosed Frog, Pig-nosed Frog, Shovel-nosed Burrowing Frog, *Gemarmerde graafneuspadda*

FAMILY HYPEROLIIDAE
Reed Frogs (pp.224–282)



Genus *Afrixalus*	**Leaf-folding Frogs**	***Blaarvoupaddas***	
Afrixalus aureus	Golden Leaf-folding Frog	*Goueblaarvoupadda*	Golden Dwarf Reed Frog, Golden Banana Frog, Golden Spiny Reed Frog, Golden Dwarf Leaf-folding Frog
Afrixalus crotalus	Snoring Leaf-folding Frog	*Snorkblaarvoupadda*	*Blaarnespadda*
Afrixalus delicatus	Delicate Leaf-folding Frog	*Delikate blaarvoupadda*	Pickersgill's Banana Frog, Delicate Spiny Reed Frog, *Sierlike blaarnespadda*
Afrixalus fornasinii	Greater Leaf-folding Frog	*Grootblaarvoupadda*	Brown and White Spiny Reed Frog, Brown-striped Spiny Reed Frog, Fornasini's Banana Frog, Fornasini's Frog, Fornasini's Spiny Reed Frog, Mozambique Banana Frog, Silver-banded Banana Frog, Spiny Reed Frog, Zaire Banana Frog, *Grootblaarpadda*
Afrixalus knysnae	Knysna Leaf-folding Frog	*Knysna-blaarvoupadda*	Knysna Banana Frog, Knysna Spiny Reed Frog, *Knysna-blaarpadda*
Afrixalus spinifrons	Natal Leaf-folding Frog	*Natalse blaarvoupadda*	Golden Spiny Reed Frog, Natal Banana Frog, Natal Spiny Reed Frog, *Natalse blaarnespadda*, Intermediate Spiny Reed Frog
Genus *Hyperolius*	**Reed Frogs**	***Rietpaddas***	
Hyperolius argus	Argus Reed Frog	*Argus-rietpadda*	Argus Sedge Frog, Argus-eyed Frog, Argus-spotted Sedge Frog,Boror Reed Frog, Golden Sedge Frog, Golden Spotted Reed Frog, Yellow Spotted Reed Frog, *Argusrietpaddatjie*
Hyperolius benguellensis	Bocage's Sharp-nosed Reed Frog	*Bocage se skerpneusrietpadda*	Benguella Reed Frog
Hyperolius horstockii	Arum Lily Frog	*Aronskelkrietpadda*	Arum Frog, Horstock's Arum Frog, Horstock's Reed Frog, Yellow-striped Reed Frog, *Varkblompadda*
Hyperolius marginatus	Marginated Reed Frog	*Rooiflankrietpadda*	Silver-striped Sedge Frog, Margined Sedge Frog
Hyperolius marmoratus	Painted Reed Frog	*Skilderbontrietpadda*	Ahl's African Reed Frog, Aposematic Reed Frog, Black and White Striped Reed Frog, Marbled Reed Frog, Marbled Rush Frog, Sangeve Reed Frog, Spotted Tree Frog, Striped Reed Frog, Striped Rush Frog, Variegated Rush Frog, White-lipped Reed Frog, *Gestreepte rietpaddatjie, Geverfde rietpadda*
Hyperolius mitchelli	Mitchell's Reed Frog	*Mitchell se rietpadda*	
Hyperolius nasutus	Long Reed Frog	*Langneusrietpadda*	Longnose Reed Frog, Long-nosed Reed Frog, Sharp-nosed Reed Frog, Sharp-and-blunt-snouted Sedge Frog
Hyperolius parallelus	Angolan Reed Frog	*Angolese rietpadda*	

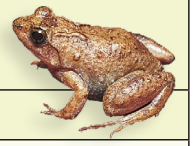


Hyperolius parkeri	Parker's Reed Frog	*Parker se rietpadda*	Brown Sedge Frog, Green Sedge Frog
Hyperolius pickersgilli	Pickersgill's Reed Frog	*Pickersgill se rietpadda*	Avoca Reed Frog
Hyperolius poweri	Power's Sharp-nosed Reed Frog	*Power se skerpneusrietpadda*	Brown Long Reed Frog, Green Long Reed Frog, Günther's Sharp-nosed Reed Frog, Long Reed Frog, Sharp-nosed Reed Frog
Hyperolius pusillus	Water Lily Frog	*Waterleliepadda*	Dwarf Reed Frog, Lily Pad Frog, Translucent Tree Frog, Transparent Pygmy Sedge Frog, Water Lily Reed Frog, Water Lily Reed Frog
Hyperolius rhodesianus	Laurent's Reed Frog	*Laurent se rietpadda*	
Hyperolius semidiscus	Yellow-striped Reed Frog	*Geelstreeprietpadda*	
Hyperolius swynnertoni	Swynnerton's Reed Frog	*Swynnerton se rietpadda*	Broadley's Forest Treefrog, Broadley's Tree Frog
Hyperolius tuberilinguis	Tinker Reed Frog	*Groenrietpadda*	Green Reed Frog, Smith's Reed Frog, Straw Sedge Frog, Green Sedge Frog, Yellow-green Reed Frog
Genus *Kassina*	**Kassinas**	***Vleipaddas***	
Kassina maculata	Red-legged Kassina	*Rooibeenvleipadda*	Brown-spotted Tree Frog, Red-legged Pan Frog, Spotted Hylambates, Spotted Kassina, Spotted Kassin's Frog, Spotted Running Frog, Vlei Frog
Kassina senegalensis	Bubbling Kassina	*Borrelvleipadda*	Burbling Kassina, Running Frog, Senegal Frog, Senegal Kassina, Senegal Kassin's Frog, Senegal Land Frog, Senegal Running Frog
Genus *Semnodactylus*	**Rattling Frog**	***Ratelpadda***	
Semnodactylus wealii	Rattling Frog	*Ratelpadda*	Long-toed Running Frog, Rattling Kassina, Weale's Frog, Weale's Kassina, Weale's Kassin's Frog, Weal's Frog, Weal's Running Frog

FAMILY MICROHYLIDAE
Rubber Frogs (pp.283–291)

Genus *Phrynomantis*	**Rubber Frogs**	***Rubberpaddas***	
Phrynomantis affinis	Spotted Rubber Frog	*Gespikkelde rubberpadda*	Northern Red-spotted Frog, Pweto Snake-necked Frog, Red-spotted Frog, *Spikkelrubberpadda*
Phrynomantis annectens	Marbled Rubber Frog	*Marmerrubberpadda*	Red-spotted Namibia Frog, Red Marbled Frog, Cape Snake-necked Frog, Red-spotted Frog, *Marmerpadda*
Phrynomantis bifasciatus	Banded Rubber Frog	*Gebande rubberpadda*	Red-banded Frog, Red-banded Rubber Frog, South African Snake-necked Frog, Two-banded Frog, Two-striped Frog

FAMILY PHRYNOBATRACHIDAE
Puddle Frogs (pp.292–301)



Genus *Phrynobatrachus*	Puddle Frogs	*Modderpaddas*	
Phrynobatrachus acridoides	East African Puddle Frog	*Oostelike modderpadda*	Cope's Toad Frog, Eastern Puddle Frog, Mababe Toad-frog, Small Puddle Frog, Zanzibar Puddle Frog, Zanzibar River Frog
Phrynobatrachus mababiensis	Dwarf Puddle Frog	*Dwergmodderpadda*	Chitiala Frog, Common Cricket Frog, Mababe Puddle Frog, Mababe River Frog, Mababi Puddle Frog
Phrynobatrachus natalensis	Snoring Puddle Frog	*Snorkmodderpadda*	Auata River Frog, Typical toad Frog, Murle River Frog, Natal Frog, Natal Puddle Frog, Natal River Frog, Puddle Frog, Scortecci's River Frog, Smith's Frog, Toad Frog
Phrynobatrachus parvulus	Small Puddle Frog	*Kleinmodderpadda*	Dwarf Puddle Frog, Loanda River Frog

FAMILY PTYCHADENIDAE
Grass Frogs (pp.302–329)

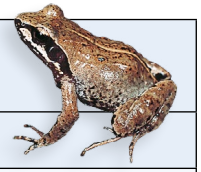
Genus *Hildebrandtia*	Ornate Frogs	*Skilderbontpaddas*	
Hildebrandtia ornata	Ornate Frog	*Skilderbontpadda*	African Ornate Frog, Black-throated Pyxie, Budgett's Burrowing Frog, Common Ornate Frog, Moeru Frog, Ornate Burrowing Frog, Ornate Pyxie, Southern Ornate Frog
Genus *Ptychadena*	**Grass Frogs**	***Graspaddas***	
Ptychadena anchietae	Plain Grass Frog	*Rooiruggraspadda*	Anchieta's Frog, Anchieta's Ridged Frog, Benguella Grassland Frog, Long-legged Grass Frog, Northern Rana, Savanna Ridged Frog
Ptychadena guibei	Guibe's Grass Frog	*Guibé se graspadda*	Guibe's Yellow Bellied Grass Frog, Guibe's Grassland Frog, Guibe's Ridged Frog
Ptychadena mapacha	Mapacha Grass Frog	*Mapacha-graspadda*	Mapacha Ridged Frog
Ptychadena mascareniensis	Mascarene Grass Frog	*Maskareense graspadda*	Broad-banded Rana, Broad-banded Ridged Frog, Mascarene Frog, Mascarene Grassland Frog, Mascarene Ridged Frog, Mascarene Rocket Frog
Ptychadena mossambica	Broad-banded Grass Frog	*Breëbandgraspadda*	Broad-banded Grass Frog, Moçambique Ridged Frog, Mozambique Grass Frog, Mozambique Grassland Frog, Mozambique Ridged Frog, Single-striped Grass Frog
Ptychadena oxyrhynchus	Sharp-nosed Grass Frog	*Skerpneusgraspadda*	*Gevlekte graspadda*

Ptychadena porosissima	Striped Grass Frog	*Gestreepte graspadda*	Ethiopia Grassland Frog, Grassland Ridged Frog, Steindachner's Frog, Three-striped Grass Frog, Three-striped Rana
Ptychadena schillukorum	Schilluk Grass Frog	*Schilluk-graspadda*	Sudan Grassland Frog, Schilluk Ridged Frog
Ptychadena subpunctata	Speckled-bellied Grass Frog	*Spikkelpens-graspadda*	African Spotted Frog, Bocage's Grass Frog, Bocage's Grassland Frog, Spotted Grass Frog, Spot-bellied Ridged Frog, Spotted Ridged Frog
Ptychadena taenioscelis	Dwarf Grass Frog	*Kleingraspadda*	Dwarf Rana, Lukula Grassland Frog, Small Ridged Frog, Spotted Throated Ridged Frog, Stripe-legged Frog
Ptychadena uzungwensis	Udzungwa Grass Frog	*Udzungwa-graspadda*	Udzungwa Ridged Frog, Uzungwe Grass Frog, Uzungwe Grassland Frog, Uzungwe Ridged Frog

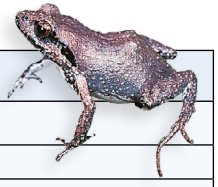
FAMILY PIPIDAE
Platannas (pp.330–339)

Genus ***Xenopus***	**Platannas**	***Platannas***	
Xenopus gilli	Cape Platanna	*Kaapse platanna*	Cape Clawed Frog, Gill's Clawed Frog, Gill's Clawed Toad, Gill's Frog, Gill's Platanna
Xenopus laevis	Common Platanna	*Gewone platanna*	African Clawed Frog, African Clawed Toad, Clawed Frog, Clawed Toad, Common Clawed Frog, Common Clawed Frog, Common Clawed Toad, Platanna, Smooth Clawed Frog, Upland Clawed Frog, Upland Clawed Frog
Xenopus muelleri	Müller's Platanna	*Geelpensplatanna*	Muller's Clawed Frog, Müller's Clawed Frog, Müller's Clawed Toad, Muller's Smooth Clawed Frog, Northern Platanna, Sago-bellied Clawed Frog, Sago-bellied Clawed Toad, Sago-bellied Platanna, Savanna Clawed Frog, Tropical Platanna, Yellow-bellied Platanna, *Tropiese platanna*
Xenopus petersii	Peters's Platanna	*Peters se platanna*	Peters' Clawed Frog

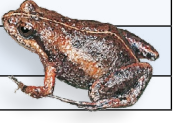
FAMILY PYXICEPHALIDAE
African Common Frogs (pp.340–455)

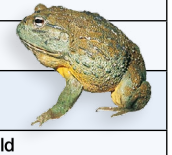


Genus ***Anhydrophryne***	**Chirping Frogs**	***Kwetterpaddas***	
Anhydrophryne hewitti	Natal Chirping Frog	*Natalse kwetterpadda*	Hewitt's Frog, Yellow Bandit Frog, Hewitt's Moss Frog, Natal Moss Frog
Anhydrophryne ngongoniensis	Mistbelt Chirping Frog	*Misbeltkwetterpadda*	Natal Bandit Frog, Ngongoni Moss Frog, Mistbelt Moss Frog
Anhydrophryne rattrayi	Hogsback Chirping Frog	*Hogsback-kwetterpadda*	Hogsback Frog, Rattray's Forest Frog, Rattray's Frog



Genus *Arthroleptella*	**Moss Frogs**	***Mospaddas***	
Arthroleptella bicolor	Bainskloof Moss Frog	*Bainskloof-mospadda*	Bainskloof Chirping Frog
Arthroleptella drewesii	Drewes's Moss Frog	*Drewes se mospadda*	Drewes' Chirping Frog
Arthroleptella landdrosia	Landdroskop Moss Frog	*Landdroskop-mospadda*	Landdros Moss Frog, Landdroskop Chirping Frog
Arthroleptella lightfooti	Cape Peninsula Moss Frog	*Skiereilandmospadda*	Brown Bandit Frog, Cape Chirping Frog, Cape Peninsula Chirping Frog, Chirping Frog, Cricket Frog, Lightfoot's Frog, Lightfoot's Moss Frog, Tiny Chirping Frog, *Skiereiland mospaddatjie*
Arthroleptella rugosa	Rough Moss Frog	*Skurwe-mospadda*	
Arthroleptella subvoce	Northern Moss Frog	*Noordelike mospadda*	
Arthroleptella villiersi	De Villiers's Moss Frog	*De Villiers se mospadda*	De Villiers' Chirping Frog
Genus *Cacosternum*	**Cacos**	***Blikslanertjies***	
Cacosternum aggestum	Klipheuwel Caco	*Klipheuwel blikslanertjie*	Klipheuwel Dainty Frog
Cacosternum australis	Southern Caco	*Suidelike blikslanertjie*	Southern Dainty Frog
Cacosternum boettgeri	Boettger's Caco	*Gewone blikslanertjie*	Boettger's Caco, Boettger's Dainty Frog, Boettger's Frog, Boettger's Froglet, Boettger's Metal Frog, Common Caco, Common Dainty Frog, Dainty Frog
Cacosternum capense	Cape Caco	*Kaapse blikslanertjie*	Cape Caco, Cape Dainty Frog, Cape Froglet, Cape Metal Frog, Cross-marked Frog, Dainty Frog
Cacosternum karooicum	Karoo Caco	*Karooblikslanertjie*	Karoo Dainty Frog
Cacosternum namaquense	Namaqua Caco	*Namakwa-blikslanertjie*	
Cacosternum nanogularum	KwaZulu Caco	*KwaZulublikslanertjie*	Small-throated Dainty Frog
Cacosternum nanum	Bronze Caco	*Bronsblikslanertjie*	
Cacosternum parvum	Mountain Caco	*Bergblikslanertjie*	
Cacosternum platys	Flat Caco	*Platblikslanertjie*	Smooth Dainty Frog
Cacosternum rhythmum	Rhythmic Caco	*Ritmiese blikslanertjie*	Rythmic Dainty Frog
Cacosternum striatum	Striped Caco	*Gestreepte blikslanertjie*	Striped Metal Frog
Cacosternum thorini	Hogsback Caco	*Hogsback blikslanertjie*	Hogsback Dainty Frog
Genus *Microbatrachella*	**Micro Frog**	***Mikropadda***	
Microbatrachella capensis	Micro Frog	*Mikropadda*	Cape Flats Frog





Genus *Natalobatrachus*	**Kloof Frog**	***Kloofpadda***	
Natalobatrachus bonebergi	Kloof Frog	*Kloofpadda*	Boneberg's Frog, Gloomy Kloof Frog, Natal Diving Frog, Natal Frog
Genus *Poyntonia*	**Marsh Frog**	***Moeraspadda***	
Poyntonia paludicola	Montane Marsh Frog	*Bergmoeraspadda*	Kogelberg Reserve Frog
Genus *Amietia*	**River Frogs**	***Rivierpaddas***	
Amietia fuscigula	Cape River Frog	*Kaapse rivierpadda*	Dark-throated River Frog, Dusky-throated River Frog, Dark-throated Frog, Cape Rana, Brown-throated Frog
Amietia hymenopus	Phofung River Frog	*Phofung rivierpadda*	Berg Stream Frog, Drakensberg Frog, Drakensberg Rana, Drakensberg Stream Frog, Natal Drakensberg Frog
Amietia inyangae	Inyanga River Frog	*Inyanga-rivierpadda*	
Amietia poyntoni	Poynton's River Frog	*Poynton se rivierpadda*	
Amietia quecketti	Common River Frog	*Gewone rivierpadda*	Common Rana, Angola River Frog, Dusky-throated Frog, Angola Frog, Northern Rana, Nutt's Frog, Chapin's Frog
Amietia vandijki	Van Dijk's River Frog	*Van Dijk se rivierpadda*	
Amietia vertebralis	Maluti River Frog	*Maluti rivierpadda*	Water Rana, Water Frog, Ice Frog, Umbraculate Frog, Umzimkulu River Leopard Frog, *Grootbek rivierpadda*
Genus *Pyxicephalus*	**Bullfrogs**	***Brulpaddas***	
Pyxicephalus adspersus	Giant Bullfrog	*Grootbrulpadda*	African Bullfrog, Bullfrog, Giant Pyxie, Giant Pyxie, Highveld Bullfrog, South African Speckled Frog, Tschudi's African Bullfrog
Pyxicephalus edulis	African Bullfrog	*Kleinbrulpadda*	Lesser Bull-frog, Peter's Bullfrog, Edible Frog, Edible Bullfrog
Genus *Strongylopus*	**Stream Frogs**	***Langtoonpaddas***	
Strongylopus bonaespei	Banded Stream Frog	*Gebande langtoonpadda*	Banded Sand Frog, Mountain Frog, Jonkersberg Frog
Strongylopus fasciatus	Striped Stream Frog	*Gestreepte langtoonpadda*	Long-toed Frog, Long-toed Grass Frog, Striped Frog, Striped Grass Frog, Striped Long-toed Frog, Striped Rana, Tanganyika Striped Grass Frog
Strongylopus grayii	Clicking Stream Frog	*Kliklangtoonpadda*	Gray's Frog, Gray's Grass Frog, Gray's Spotted Frog, Gray's Stream Frog, Spotted Rana
Strongylopus rhodesianus	Chimanimani Stream Frog	*Chimanimani-langtoonpadda*	Hewitt's Long-toed Frog
Strongylopus springbokensis	Namaqua Stream Frog	*Namakwa-langtoonpadda*	Springbok Frog

Strongylopus wageri	Plain Stream Frog	*Wager se langtoonpadda*	Plain Rana, Natal Upland Frog, Wager's Stream Frog
Genus *Tomopterna*	**Sand Frogs**	***Sandpaddas***	
Tomopterna cryptotis	Tremelo Sand Frog	*Trillersandpadda*	Catequero Bullfrog, Common Burrowing Frog, Cryptic Sand Frog, Striped Burrowing Frog, Striped Pyxie, Striped Sand Frog
Tomopterna damarensis	Damaraland Sand Frog	*Damara-sandpadda*	
Tomopterna delalandii	Cape Sand Frog	*Gestreepte sandpadda*	African Bullfrog, Cape Burrowing Frog, Delalande's Burrowing Bullfrog, Delalande's Burrowing Frog, Delalande's Dwarf Bullfrog, Delalande's Frog, Delalande's Pyxie, Pyxie, Striped Pyxie
Tomopterna krugerensis	Knocking Sand Frog	*Sandveld-sandpadda*	Kruger Bullfrog, Kruger Burrowing Frog, Sandveld Pyxie
Tomopterna marmorata	Russet-backed Sand Frog	*Rooirugsandpadda*	Blunt-nosed Burrowing Frog, Blunt-nosed Pyxie, Marbled Bullfrog, Marmorate Pyxie, Moçambique Burrowing Frog, Mozambique Burrowing Frog, Mozambique Dwarf Bullfrog, Mozambique Pyxie, Striped Pyxie
Tomopterna natalensis	Natal Sand Frog	*Natalse sandpadda*	Natal Burrowing Frog, Natal Pyxie, Natal Bullfrog
Tomopterna tandyi	Tandy's Sand Frog	*Tandy se sandpadda*	
Tomopterna tuberculosa	Beaded Sand Frog	*Skurwesandpadda*	Angola Bullfrog, Beaded Burrowing Frog, Beaded Dwarf Bullfrog, Beaded Pyxie, Bearded Pyxie, Rough Sand Frog, Tuberculate Sand Frog, Warty Frog, *Gekraalde sandpadda*

FAMILY RANIDAE
European Common Frogs (pp.456–461)

Genus *Hylarana*	**Golden-backed Frogs**	***Gouerugpaddas***	
Hylarana darlingi	Darling's Golden-backed Frog	*Darling se gouerugpadda*	Darling's Frog, Darling's White-lipped Frog, Golden-backed Frog
Hylarana galamensis	Galam Golden-backed Frog	*Galam-gouerugpadda*	Galam White-lipped Frog, Golden-backed Frog, Lake Galam Frog, Marble-legged Frog, Yellow-striped Frog

FAMILY RHACOPHORIDAE
Foam Nest Frogs (pp.462–465)

Genus *Chiromantis*	**Foam Nest Frogs**	***Skuimnespadda***	
Chiromantis xerampelina	Southern Foam Nest Frog	*Grootgrysskuimnespadda*	African Gray Treefrog, Foam Nest Frog, Foam Nest Tree Frog, Foam Nest Treefrog, Great African Grey Tree Frog, Grey Foam-nest Frog, Grey Tree Frog, Grey Treefrog, Large Grey Tree Frog, Southern Foam Nest Tree Frog

MORPHOLOGY AND PHYSIOLOGY

Structure and function

The evolution of amphibians from an aquatic to a terrestrial environment and the subsequent exploitation of widely divergent habitats have been achieved through a variety of remarkable physical and functional adaptations.

SKIN

The amphibian skin is a complex organ providing a number of essential functions. It aids in respiration, protects the animal against pathogens, assists with thermoregulation and water balance, provides a cocoon during hibernation and other states of inactivity, changes colour to camouflage the animal and secretes toxic or distasteful fluids to deter predators.

The skin is loosely attached to the body and consists of two layers: the inner dermis and the outer epidermis. The outer surface of the epidermis consists of a layer of cornified keratin cells, the *stratum corneum,* which is replaced by a new layer at intervals of between four and eleven days. On the days prior to moulting, the skin becomes opaque, obscuring colour and pattern. During moulting, some species (especially the toad family) hunch and contort the body to loosen and remove the dead *stratum corneum*, which is then eaten. Other species simply allow fragments of moulting skin to fall away.

There are three types of glands in the inner surface of the epidermis at the interface with the underlying dermal tissue: mucous glands which keep the skin moist, poison glands which exude toxins to deter predators and, in species living in semi-arid environments, wax glands which secrete impermeable fluids that are wiped over the skin to reduce water loss.

Cross section through frog skin.

A Mucous gland
B Poison gland
C Epidermis
D Dermis

(Wax glands are not present in this cross section.)

Respiration

An extensive network of blood capillaries runs close to the surface of the skin allowing carbon dioxide to be released through the skin and, to a lesser extent, oxygen to be absorbed. For this to take place the skin must remain moist so that these gases are exchanged in their dissolved state.

Thermoregulation

Amphibians are ectothermic – their body temperature is determined by the temperature of the external environment. Southern African frogs are most active when the surrounding temperature is 20–30°C. Unlike other vertebrates, amphibians are not insulated by a covering of hair, feathers or scales, so at temperatures above 40° and below 3°C they need special mechanisms in order to survive. Most species burrow or withdraw to damp retreats to stabilise body temperature and avoid dehydration during the heat of the day, but in some species, such as the Southern Foam Nest Frog *Chiromantis xerampelina* and some Reed Frogs, the skin becomes almost white in temperatures above 30°C and fluids are secreted to cool the body. These fluids sometimes attract sweat flies.

Water balance

Frogs do not drink water. To regulate moisture levels in their bodies they absorb water by osmosis through their semi-permeable skin when they are submerged in water or sitting on wet surfaces. They release water via the kidneys. Tadpoles and aquatic species, such as the Common Platanna *Xenopus laevis,* constantly need to excrete water and waste in the form of ammonia to compensate for the intake via osmosis. Conversely, terrestrial species reduce their loss of water by excreting waste as urea. The Southern Foam Nest Frog excretes waste as uric acid, a white paste requiring almost no water to carry it out of the body. It also uses its limbs to spread a waxy glandular secretion over the body to reduce loss of moisture through the skin.

Marius Burger

Foam Nest Frog with feet concealed to reduce water loss.

Most water is lost through the ventral surface of the frog's body where the skin is most permeable. For this reason Tree Frogs and Reed Frogs tuck their feet tightly under their bodies to prevent water loss. Highly terrestrial species such as Sand Frogs and Toads retain water reserves in the bladder and lymph sacs. A sudden discharge of this fluid onto surprised would-be predators serves as a secondary defence mechanism.

When hibernating, some fossorial (burrowing) species retain several layers of the outer epidermis instead of moulting them. This forms an impermeable keratin cocoon that, except for small nostril apertures, completely seals the frog while it remains buried. In this state, metabolism slows, water loss is greatly reduced and hibernation can be sustained throughout the dry winter months – or even for years if the seasons are unsuitable for breeding.

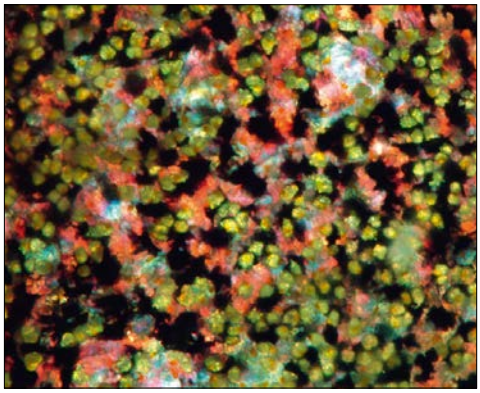
Colour

Many frogs adjust their colour to camouflage themselves or to regulate body temperature. Skin colour is produced by pigments known as chromatophores that are located in branched

cells within the dermis. Chromatophores can be withdrawn into a small zone of the cell so that barely any pigment is evident, or they can be distributed throughout the cell to make the colour conspicuous. Controlling the extent of chromatophore dispersal in the cells enables the frog to change colour in response to stimuli such as background colour, temperature, light intensity and even to reflect the emotional state of the animal.

Most amphibians have three types of pigments. Melanophores contain black or brown melanin and are the most deeply imbedded in the skin. Iridiophores contain a silvery light-reflecting pigment and are the next deepest. Uppermost in the skin are xantophores with yellow, orange or red pigments. Light penetrating the skin is reflected back by the iridiophores through the xantophores to produce the bright, conspicuous colours commonly found in tropical frogs.

Brightly coloured chromatophores in the eye and skin.



Micrograph of chromatophores in frog skin.

Painted Reed Frog with colour visible (left) and with colour hidden (right).

Camouflage

Polymorphism in two frogs of the same species, Boettger's Caco: polymorphism diminishes vulnerability to predators. Pale specimens are less conspicuous in winter grassland, while striped ones blend in better in summer grassland.

Masked and banded Plain Stream Frog: eye masks and transverse banding on the legs break the outline of the frog.

Striped camouflage in the Rattling Frog: light and dark stripes match the contrasting light patterns in long grass.

Mottled specimen of the Tremelo Sand Frog: mottling and coarse texture replicates the gravel substrate.

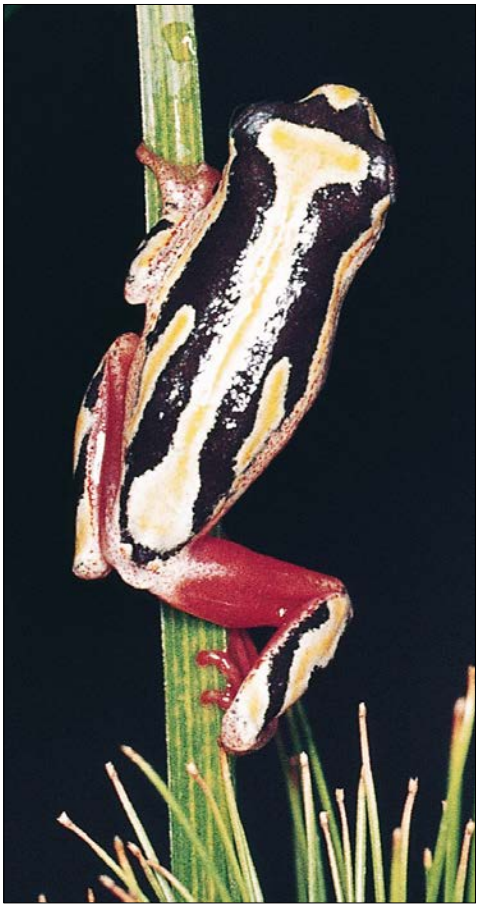
Aposematic colours

Red, orange, yellow, white and black often signify toxicity in nature. Predators learn to associate these colours with distasteful or dangerous species and avoid preying on them.

Right: The highly toxic skin secretion of the black and red Banded Rubber Frog is signalled by its colours, and its elevated stance enhances the size of the animal to discourage a predator further.

Flash colours

Some frogs have brightly coloured patches that are concealed when the frog is at rest, but vividly displayed when it moves. It is believed that the striking colours confuse predators as they are visible only intermittently.

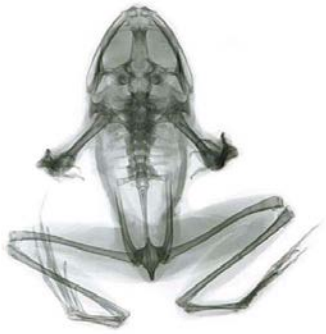


Painted Reed Frog at rest (left) and exposing flash colours (right).

SKELETON AND LIMBS

During metamorphosis the boneless tadpole develops a complex skeleton of bone and cartilage comprising spinal column, skull, rib cage and limbs. This gives structure to the body, protects the nervous system and provides attachment points for muscles which allow for effective movement. The evolution of a skeleton strong enough to support the body without the buoyancy of water was a key development that enabled amphibians to develop from their aquatic ancestors.

Adaptation of the limbs reflects the behaviour patterns of different species and is often a useful diagnostic feature. The toes of Tree and Reed Frogs bear adhesive discs for climbing. The more aquatic species have extensive webbing between their toes. Grass Frogs and River Frogs have long and powerful hindlegs with which to leap away from danger. By contrast, the burrowing frogs have short stubby legs with hard, calloused tubercles on their feet which are used to thrust aside soil as they dig.



Eddie van Dijk

X-ray of a River Frog showing skeletal adaptation for leaping.

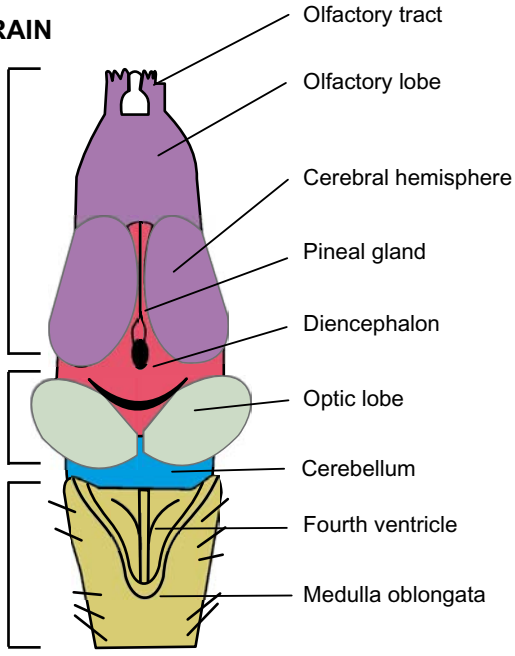
Eddie van Dijk

X-ray of a Rain Frog showing skeletal adaptation for burrowing.

BRAIN AND NERVOUS SYSTEM

The frog brain is divided into three parts: the forebrain contains the olfactory centre which is responsible for the highly sensitive sense of smell; the midbrain controls complex integrative activities and includes the optic lobes responsible for sight; and the hindbrain is well developed and plays an important role in maintaining equilibrium and movement.

FROG BRAIN



Dorsal view

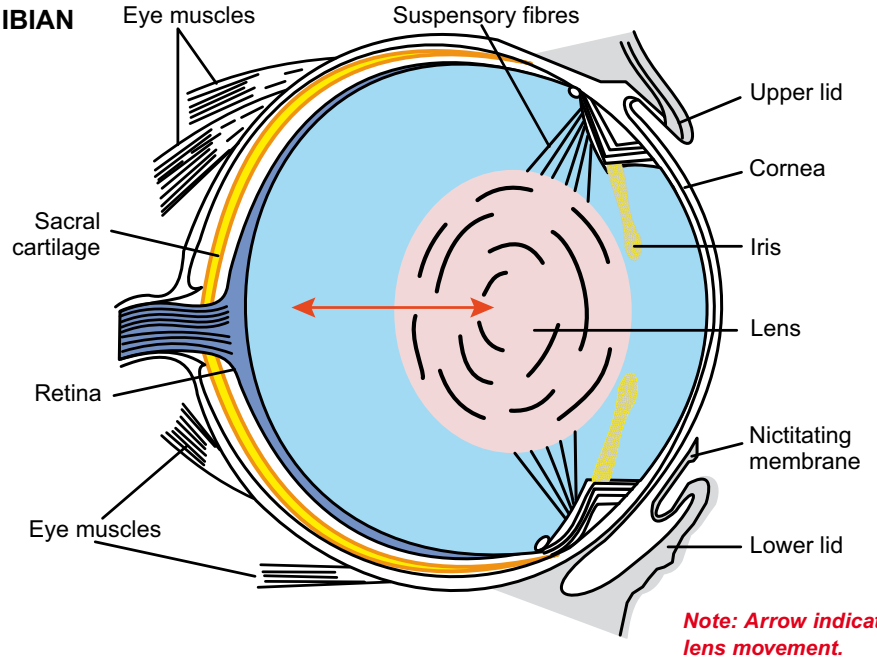
EYES AND SIGHT

In frogs, vision is critically important for feeding and detecting danger. Except for Platannas, which are largely confined to aquatic habitats, the eyes of frogs need to function on land and under water. They have retractable eyelids and lachrymal glands to lubricate eyes in dry air, and transparent nictitating membranes to protect them under water. Unlike mammals, frogs focus by moving the lens within the eye rather than changing lens shape and focal length. At rest, the eye is focused on a point in the distance. To look at closer objects, the lens moves backwards into the eye.

Species that hunt fast-moving prey after dark have evolved large bulbous eyes with irises that can dilate from narrow slits in daylight to full circles for night vision. Frog eyes are equipped with both rods and cones in the retina and can thus see colours – at least in good light. Because of their large size, eyes can be withdrawn into the skull for protection. A retractable nectitating membrane protects the eye underwater. Prey is usually detected only when it moves.

The shape of the iris in bright light – vertical or horizontal – is a useful diagnostic tool for identification.

AMPHIBIAN EYE



Note: Arrow indicates lens movement.

VOICE

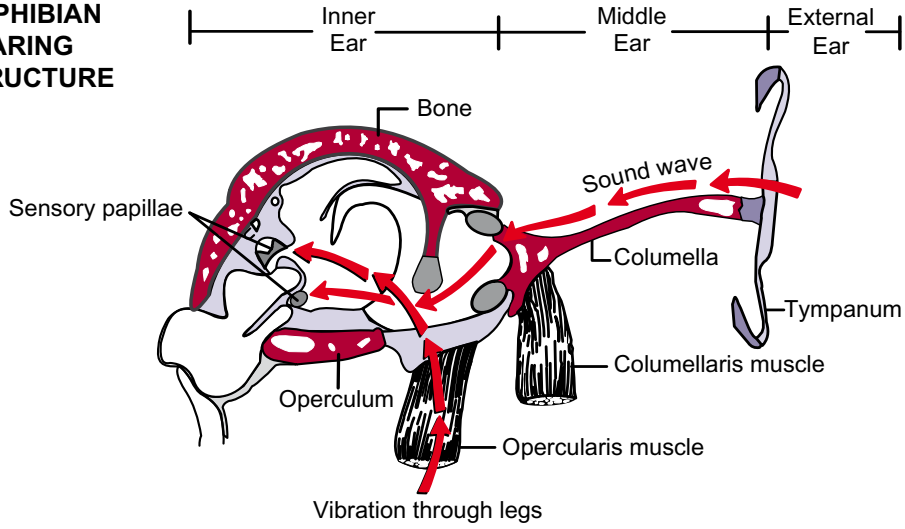
Frogs and toads appear to have been the first creatures to develop advanced vocalisation, and the importance of calls and communication is discussed on pages 43–45.

Relative to the size of a frog, the energy and volume of sound produced is prodigious. Calls are produced by inflating the lungs beyond the volume needed for normal breathing. Surplus air is passed rhythmically via the larynx to the buccal or mouth cavity, vibrating the vocal chords as it does so. Unlike most other vocal animals, the mouth is kept closed while calling and sound is amplified by resonance in a thin-walled vocal sac that expands from the base or sides of the buccal cavity.

EARS AND HEARING

The eardrum or tympanum is exposed and visible in most species and is a flat, circular membrane located close to the eye. Behind the tympanum lies the middle ear and a strip of tissue (columella) that transmits sound vibrations from the tympanum to sound sensory organs in the inner ear. A small muscle (opercularis) connects the ear to the shoulder so that the frog can detect ground vibrations via its forelimbs. A blocking mechanism controlled by the columellaris muscle protects the inner ear from particularly loud sounds.

AMPHIBIAN HEARING STRUCTURE



FEEDING, SWALLOWING AND DIGESTION

With the exception of Platannas, southern African species feed on land. Arthropods make up the diet of most frogs, but larger River Frogs and Bullfrogs may take rodents, fledgling birds and other frogs. Cannibalism is a common occurrence, practised especially by newly metamorphosed juveniles which eat one another.

Movement of a prey item generally triggers a feeding response and a frog usually takes whatever appears edible by snapping at it or catching it on its adhesive tongue. Most southern African species have a tongue fastened at the front of the mouth which can be flipped out readily to capture prey. After dirt or indigestible parts, such as wings, have been scraped away with

Giant Bullfrog eating a Red Toad.

Platanna tadpoles in characteristic head-down position.

Les Minter

*Yoke-filled eggs of a Rain Frog (*Breviceps*), a genus that lacks a tadpole stage and develops directly into a small frog.*

Common River Frog tadpole feeding near the bottom of a pond.

the forelimbs, prey is swallowed whole. If it proves distasteful, the prey is immediately expelled from the mouth. Large prey is sometimes crushed or suffocated before being swallowed. Most species have small recurved teeth to assist with grasping and swallowing. In some species these are restricted to the upper jaw, while in others they may be located in the roof of the mouth (vomerine teeth). After a few gulps, swallowing large items can be assisted by retracting the eyeballs into the buccal cavity so that the food is pressed down the gullet.

Platannas scavenge for detritus (fine debris) underwater. They hover a few centimetres below the surface, waiting for edible fragments to drift their way, and then shovel them into their mouths with their forelimbs. They have neither teeth nor tongue and sometimes rake large food items into manageable pieces with their clawed feet.

Digestive enzymes are secreted in the oesophagus and digestion takes place in the stomach and intestine. Undigested waste is passed through the rectum and out via the cloaca.

Whereas adult frogs are carnivorous, tadpoles are semi-herbivorous, feeding largely on algae and bacteria. Most have sets of keratinised beaks or jaw sheaths (rostrodonts) and scrapers or labial teeth (keratodonts), and these are used to rasp off plant material or bacteria growing on plant material. Food particles are trapped in a filter mechanism when water is pumped into the mouth and out via one or two spiracles at the side of the head. Sticky cells transport the food to the opening of the oesophagus.

Tadpoles of Platannas are filter-feeders. Small shoals hang in a characteristic head-down position in the water while the tip of the tail beats constantly, drawing a flow of water towards the mouth. Microscopic food particles in the water are trapped in filters and ingested in the same manner as other tadpoles.

A number of southern African frogs have no free-living tadpoles. Their eggs are laid in humus or underground and contain sufficient yoke to nourish the developing tadpole until metamorphosis is complete.

HEART AND CIRCULATION

Amphibians have three-chambered hearts with two atria and one ventricle (the muscular pump). Blood from the body enters the right atrium via a receiving chamber known as the *sinus venosus*. From here blood enters the ventricle and is pumped to the lungs where it absorbs oxygen. Oxygenated blood returns to the left atrium from where it is pumped via the ventricle back into the circulatory system of the body. Oxygenated and deoxygenated blood is prevented from mixing in the ventricle by a spiral valve that keeps the blood from the lungs separate.

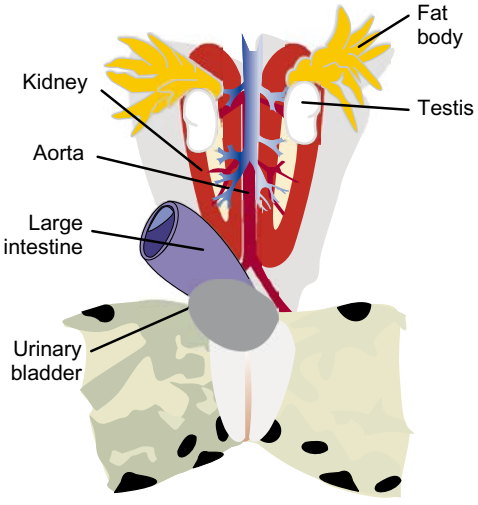
UROGENITAL ORGANS

The excretory and reproductive systems are closely associated. Primitive kidneys (known as mesonephros) are elongated and situated towards the back, on either side of the aorta. In males, two pale-coloured testes are attached to the kidneys. During the reproductive season they increase in size and sperm gathers in collecting ducts and is transported to the cloaca.

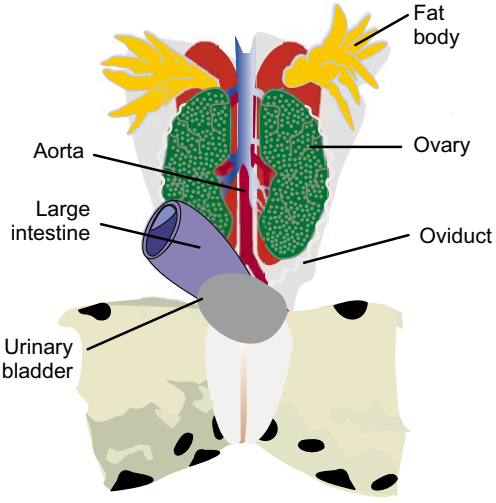
In females, paired ovaries are attached to the kidneys. Each ovary consists of a thin sheet of connective tissue, the ovisac, which encloses the developing ovarian follicles. At the onset of the breeding season the follicles ripen, increase in size, and then pass through coiled oviducts where they are coated with a jelly secretion before reaching the cloaca of a gravid female.

The urinary bladder consists of a smooth epithelium and muscle layers that allow considerable distension of the bladder when filled with urine.

MALE UROGENITAL SYSTEM



FEMALE UROGENITAL SYSTEM

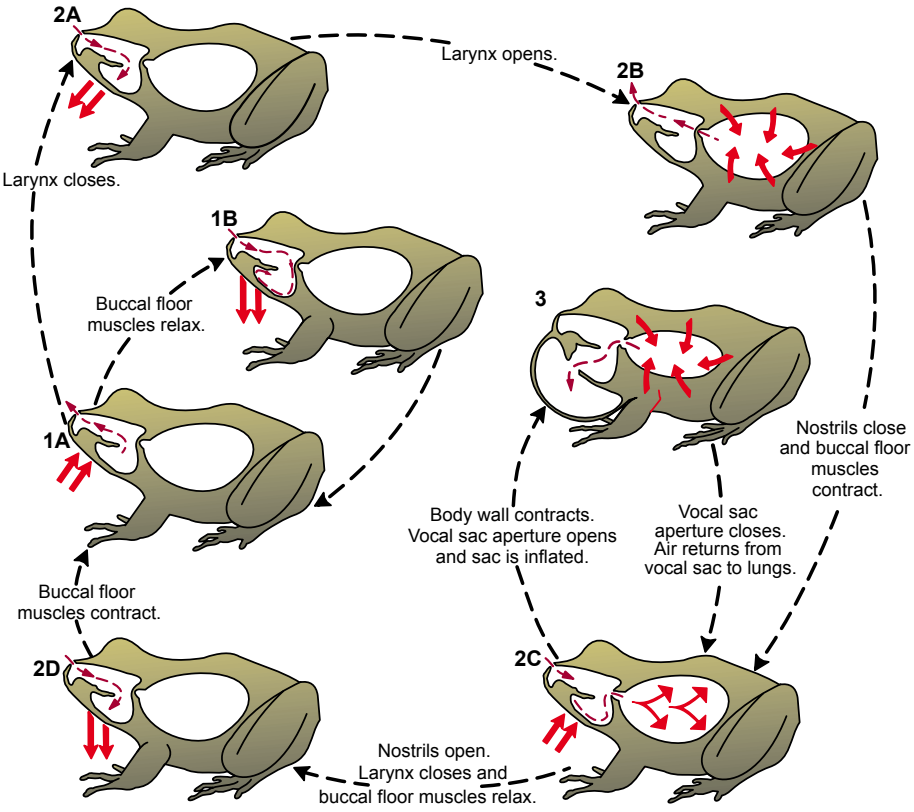


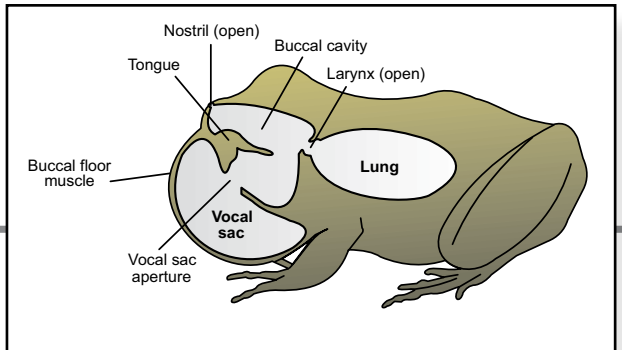
RESPIRATION AND VOCALISATION

1: Respiration through buccal cavity and rapid throat oscillation.
1A: Buccal floor muscles (under throat) contract, expelling used air in buccal cavity through nostrils.
1B: Buccal floor muscles relax. Air drawn in through nostrils. Oxygen absorbed through buccal wall.

2: Respiration through lungs.
2A: Larynx closed to prevent air from entering lungs. Buccal floor muscles relax to draw in fresh air.
2B: Larynx opens. Body wall muscles deflate lungs. Used air expelled through open nostrils.
2C: Nostrils closed. Larynx open. Contraction of buccal floor muscles pumps fresh air into lungs.
2D: Nostrils open. Larynx closed. Buccal floor muscles relax drawing fresh air into buccal cavity to be pumped into lungs (2C) or used in buccal cavity and expelled through nostrils (1A).

3: Vocalisation.
Nostrils closed. Body wall muscles deflate lungs, forcing air over vocal chords into extended vocal sac to amplify sound.





Adapted from Gans (1973b)

RESPIRATION

Oxygen intake is mainly through the lungs, while carbon dioxide is lost primarily through the skin. Mammals inhale air by contracting the diaphragm. In frogs, however, air is pumped into the lungs by raising and lowering the floor of the mouth. Lowering the mouth floor sucks air through the nostrils into the expanded buccal cavity. The nostrils are then closed and when the floor of the mouth is raised, air is pushed through a valve into the lungs. To expel stale air, the nostrils are closed, air is drawn from the lungs back into the mouth and then expelled through re-opened nostrils. Frogs draw and expel air rapidly in and out of the mouth. After several inhalations they pump air through to the lungs. Oxygen and carbon dioxide are exchanged through the lungs and through the walls of the buccal cavity. The rapid pumping action under the jaw can usually be seen when observing a frog at rest.

Frog lungs are ovoid elastic sacs and the inner surfaces are divided into a network of septa or dividing walls. These are in turn subdivided into smaller compartments, each ending in a blind chamber covered with vascular respiratory surfaces known as alveoli.

Tadpoles have gills for respiration but they also make use of the skin as a respiratory surface. For the first day or so after hatching, tadpoles have external gills but these are soon covered by a membrane so that water can be pumped into the mouth, over the gills and then out through the spiracle. The majority of species have a single spiracle but Platannas have two.

SMELL AND CHEMORECEPTION

Amphibians detect scents in the environment through the olfactory epithelium (cellular tissue) and the epithelium of the Jacobson's organ which is located in the roof of the mouth near the nostrils. It is believed that amphibians use smell for homing orientation and for recognising breeding sites.

ENDOCRINE SYSTEM

Behaviour is to a large extent determined by hormones secreted by ductless glands situated in various parts of the body, most importantly, in the thyroid and pituitary glands.

The main function of the *thyroid gland* is to control metamorphosis in tadpoles through the hormone thyroxin. Production of this hormone is influenced to some extent by water temperature: cold water inhibits thyroid activity, while warm water enhances it. This plays a role in survival in cases where frogs breed in non-permanent water. If the water level drops, a frog's temperature increases, stimulating the thyroid to speed up metamorphosis before the water dries up completely. Conversely, in temperate regions, tadpoles are prevented from metamorphosing as winter approaches so that juveniles are spared the probability of freezing to death.

The *pituitary gland* is situated at the base of the brain and secretes a variety of hormones that control breeding, colour change and water balance in the animal.

AGE, GROWTH AND LONGEVITY

In nature, little is known about the longevity of amphibians. Larger amphibians have the potential to live longer, and records exist of toads living for up to 40 years in captivity. Confirmed ages that have been reported for southern African frogs in captivity are:

30 years for a Common Platanna *Xenopus laevis*
18 years for a Cape Sand Frog *Tomopterna delalandii*
23 years for a Red-legged Kassina *Kassina maculata*
35 years for a Giant Bullfrog *Pyxicephalus adspersus*

REPRODUCTION AND VOCALISATION

Breeding biology and survival

Frog calls are a positive sign of the advent of spring. They are a critical component of the annual reproductive cycle which, although familiar in its simplistic form, is a remarkably complex process linking the aquatic and terrestrial components of the lives of amphibians. Complexity is compounded because different species have adapted the cycle to suit their particular environmental niches.

1. ***Adult bullfrog ready to breed.***

2. ***Males gather at specific breeding sites and produce calls unique to their species.***

3. ***Females are attracted to the calls, and pairs mate.***

4. ***While mating, females extrude eggs which the males fertilise externally.***

5. ***Eggs scattered in shallow water.***

6. ***Eggs develop into tadpoles.***

7. ***Tadpoles metamorphose from aquatic to terrestrial form.***

8. ***Juvenile frogs disperse and mature.***

BREEDING CYCLE

Giant Bullfrog

MATING SEASONS

Although many species have developed ways of reducing their dependence on water, all frogs require some form of moisture in order to breed. In winter rainfall areas of the Western Cape, most species breed at the end of winter when ponds and streams are full and the landscape is saturated. In the interior summer-rainfall areas, breeding usually takes place after the first thunderstorms. Within these broad parameters species will select different mating seasons, stimulated by a combination of day-length, temperature and rainfall.

The duration of a mating season may vary considerably and in warmer and wetter climates, calling and breeding continues for periods of up to nine months of the year. Under these circumstances a female may lay eggs two or more times in a season. In species that breed in cool, permanent water, metamorphosis may take several months.

In regions with erratic rainfall, frogs need to exploit opportunities as they arise and the species that do so are referred to as 'explosive breeders'. Often using temporary water bodies that accumulate after suitable rains, they emerge in large numbers to call, mate and lay eggs in a short period, sometimes in only a single day, although this may be repeated if conditions are favourable. Explosive breeding is typified by vigorous fighting between males competing for females at the breeding site. In particularly dry years these frogs may not breed at all. Metamorphosis is accelerated in temporary water and may take less than four weeks in the warm waters of shallow pools so that tadpoles avoid desiccation as ponds start to dry up (see Endocrine system, page 41). At least one species, the Giant Bullfrog (pages 420–421), shows parental care in protecting tadpoles in these circumstances.

SECONDARY SEX CHARACTERISTICS

As the breeding season approaches the internal reproductive organs in both males and females undergo significant changes. Externally, males develop vocal sacs and nuptial pads. The structure of the vocal sac varies between species, and four broad categories can be identified.

Nuptial pads are rough-surfaced swellings on the fingers and forelimbs that allow the male to clasp the female securely during amplexus. In species that inhabit fast-flowing streams, the nuptial pads may take the form of sharp spines which allow for a more secure grip. Some burrowing species develop adhesive glands that produce substances that glue the pair together during amplexis in order to prevent separation as they dig into the soil.

VOCALISATION

Frogs are more often heard than seen, and calling is a critically important aspect of their survival. Calls serve four purposes and different sounds are produced for each: to attract females to a breeding site, to ensure males keep separated from one another, to signal release from amplexus, and to alarm and discourage predators.

Advertisement calls

The type of call most commonly heard is produced by males to attract females. Males congregate at suitable breeding sites from the start of the breeding season and produce an advertisement call that is unique to each species. Calls are amplified by an expanded vocal sac. The hearing of a female is attuned so that she is responsive only to the sound of a conspecific mate and she homes in on him by cocking her head from side to side to confirm her direction as she approaches. Neither vision nor smell is involved in this approach.

Subgular sac: the elastic membrane expands and resonates as the call is made (Guttural Toad).

Subgular sac with covering disc: the membranous sac is protected by a thick skin when at rest (Painted Reed Frog).

Paired subgular sac: the twin lobes expand only at the instant of the short call (Water Lily Frog).

Les Minter

Paired lateral sac: twin membranous sacs emerge from slits on either side of the jaw (Ornate Frog).

The unique character of the call of each species is known as the 'specific mate recognition system' (SMRS) and it is the principal means by which frogs recognise and mate with conspecific partners and thereby perpetuate the species. Calls can readily be identified by the human ear and they are the most reliable method of identifying species in the field. The spectrograms (pages 470-488) are important identification tools.

In species that have extended breeding seasons, females approach the calling males and select one with which to mate. Factors influencing a female's selection may be the volume or frequency of the call or the choice of call site. Occasionally a silent male, referred to as a 'satellite', stations himself close to a robust caller and intercepts the female as she approaches.

In explosive breeders, however, competitiveness at the breeding site and the need to mate urgently drive males to mount approaching females as soon as they are detected. Often other males, frogs of other species and even bits of flotsam on the water are mistaken for females and assaulted.

Males may establish choruses of considerable size, and the sound is orchestrated to enhance their effectiveness. Individuals close to each other tend to call antiphonally – that is, one calls in the brief space between the calls of neighbours so that while their combined and continuous sound is heard from a distance, they still retain their individuality in attracting a mate. Disturbances usually cause the whole group to fall silent simultaneously, after which individuals slowly stimulate reparticipation so that the chorus soon swells again to maximum volume.

Choruses consisting of ten or more different species at one site are not uncommon and the ability of females to negotiate this cacophony and locate the correct mate is assisted by several factors: the zone of the call site is usually consistent within species – for example, certain species prefer emergent vegetation while others call at water level; and some call from mudbanks, while others call from trees. Species also separate themselves with regard to the time of calling – some call only in the early evening while others begin to call only towards midnight.

Spacing and aggressive calls

The selection of a call site by a male determines his ability to attract females. Individuals are known to return constantly to the same site each night and they will defend their positions vigorously. If approached too closely by a potential competitor, the male emits a particular sound to warn the intruder to keep his distance. This spacing call is quite different from the advertisement call. Some species, such as the River Frogs and certain Reed Frogs, produce a dual advertisement and spacing call constantly; the two components – a rattle and a croak in the case of River Frogs – are easily distinguishable. But in most species the spacing call is used only when required and is to be heard more frequently in the early evening while males are establishing their call sites.

If the spacing call fails to deter a challenger, antagonists may resort to punching at each other with distended vocal sacs, kicking or biting one another until one individual is driven off.

Release calls

Females produce short grunting sounds combined with vibrations of the flanks to terminate amplexus once their eggs have been laid. Males give a similar call if inadvertently grasped by other males in the frenzy of the breeding site. Amplexus is quickly terminated in these circumstances – the release call appears to be effective even between different species when accidental mounting occurs.

Distress calls

In some species, such as Rain Frogs, both sexes can give a distress call if molested by potential predators. The call is emitted with the mouth wide open and its purpose is to startle a potential predator into releasing its victim. It has also been suggested that the distress call serves to alert other frogs to danger.

MATING

Fertilisation takes place externally. The male, which in all cases (except Bullfrogs) is smaller than the female, clasps the female from the back with his forelegs and exudes sperm onto the eggs at the moment that she expels them from her cloaca. The system is not always efficient in that sperm and – especially – underwater eggs can be separated before fertilisation takes place. Mating methods that different genera use to improve fertilisation rates are discussed in each generic description.

EGG DEVELOPMENT

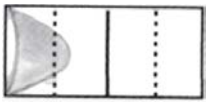
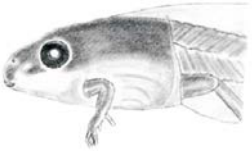
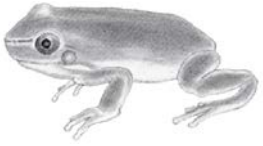
The time taken for the development of egg to free-swimming tadpole varies considerably between species and in response to temperature. It can be completed in as little as a day (e.g. African Common Frogs Pyxicephalidae) or it can last several days. The average times given below are for the Guttural Toad *Amietophrynus gutturalis*. Gosner stage refers to the embryological developmental phase of the tadpole.

	Hours	Illustration
Ovum **Outer jelly-like material** • Animal pole. Contains the cells that will divide and give rise to the embryo. Faces upwards to absorb sunlight and is pigmented to shield ultra-violet radiation. Often pigmented to absorb warmth. • Vegetal pole contains yoke as nourishment for the developing tadpole.	**0–1**	**Gosner stage 1** 
• Ovum starts as a single-cell structure. • Undergoes a series of divisions (known as cleavage) into 2, 4, 8, 16, 32, etc., stages. • Multi-celled stage: the zygote grows around the yolk, which is slowly absorbed as the tadpole develops.	**2–3**	**Gosner stages 2, 4, 8** 
• A process known as gastrulation leads to the development of the Gastrula stadium with 3 layers of cells, the ecto-, meso- and endoderm from which organs develop during organogenesis. • Ectodermal cells fold in through neurilation to become the brain and nerves. • Mesoderm gives rise to musculature and skeletal elements and vascular system. • Endoderm gives rise to internal organs and inner ear.	**3–4**	**Gosner stages 11, 15, 17** 

Drawings modified from Anstis, M. (2002) *Tadpoles of South-eastern Australia: a guide with keys*. New Holland Publishers, Sydney, Australia

TADPOLE DEVELOPMENT AND METAMORPHOSIS

Although the time it takes for tadpoles to develop and metamorphose into juvenile frogs varies from about 3 weeks to more than 2 years (depending on the species), the stages of development are similar for all species.

	Days	Illustration
• External gills develop and start to function. • Tail develops. • Tadpole frees itself from the capsule. • At first, tadpoles adhere to the substrate by means of an oral adhesive structure, but after 1–2 days they swim freely and begin feeding.	1	**Gosner stage 20** 
• External gills are replaced by internal gills. • Keratonised mouthparts develop. • Eyes appear. • Spiracle starts as a slit on the left side.	3	**Gosner stage 24** 
• Hindlegs start growing from a bud. • Tubercles develop on feet. • Forelegs develop inside the gill chamber.	10–14	**Gosner stages 26, 38**  
• Alimentary and other internal organs develop. • Forelimbs break through skin. • Keratinised mouthparts recede and mouth widens for terrestrial feeding.	35–40	**Gosner stage 42** 
• Tail is fully absorbed.	42–70	**Gosner stage 46** 

Drawings modified from Anstis, M. (2002) *Tadpoles of South-eastern Australia: a guide with keys*. New Holland Publishers, Sydney, Australia

SURVIVAL ADAPTATIONS FOR EGGS AND TADPOLES

Shell-less eggs and tadpoles are constantly vulnerable to disease, aquatic predators such as fish and dragonfly larva, deoxygenated water and desiccation. Many species have evolved special adaptive behaviour to lessen these threats. Jelly surrounds the eggs as protective cushioning against shock and damage, and also to ward off bacterial or fungal attack.

Family and genus	Survival adaptation
ARTHROLEPTIDAE (pp.80–101)	
Arthroleptis Squeakers	Eggs are laid in damp soil or leaf litter away from open water. Tadpoles develop terrestrially from egg to metamorphosis.
Leptopelis Tree Frogs	Eggs are laid in damp soil. Tadpoles are able to survive out of water while they make their way to water to develop.
BREVICIPITIDAE (pp.102–137)	
Breviceps Rain Frogs	Eggs are laid in underground chambers. Tadpoles develop and metamorphose in the chamber, nourished only by the large egg yolk and without contact with open water, so that they are not exposed to aquatic predators or other hazards.
Probreviceps Primitive Rain Frogs	Egg and tadpole development is similar to that of Rain Frogs.
BUFONIDAE (pp.138–197)	
Amietophrynus Typical Toads	Large numbers of eggs (up to 20 000) are laid with the statistical probability that some will survive. Eggs are laid in strings of jelly, making it difficult for predators to take 1 at a time. Tadpoles may be distasteful to predators.
Poyntonophrynus Pygmy Toads	Eggs are laid in strings of jelly making it difficult for predators to take 1 at a time. Tadpoles may be distasteful to predators.
Vandijkophrynus Van Dijk's Toads	Eggs are laid in strings of jelly making it difficult for predators to take 1 at a time. Tadpoles may be distasteful to predators.
Capensibufo Mountain Toadlets	Eggs are laid in strings of jelly making it difficult for predators to take 1 at a time. Tadpoles may be distasteful to predators.
Schismaderma Red Toad	Eggs are laid in strings of jelly around underwater vegetation. Tadpoles form dense swarms that may deter predators. Tadpoles have a specialised respiration flap on the head.
Mertensophryne Forest Toads	Eggs are laid in pools of water trapped in buttressed roots where there are few predators. Tadpoles have a specialised respiration system to survive in stagnant water.
HELEOPHRYNIDAE (pp.198–215)	
Hadromophryne Cascade Frog	Breed in fast-flowing streams. Eggs are laid in shallow water or on damp soil next to water. Tadpoles are strong swimmers and have wide mouths adapted to cling to slippery rocks in strong currents while simultaneously feeding on algal growth.
Heleophryne Ghost Frog	Breed in fast-flowing streams. Eggs are laid in shallow water or on damp soil next to water. Tadpoles are strong swimmers and have wide mouths adapted to cling to slippery rocks in strong currents while simultaneously feeding on algal growth.
HEMISOTIDAE (pp.216–223)	
Hemisus Shovel-nosed Frogs	Eggs are laid in underground nests near water. Adults transport tadpoles to water where they develop further.
HYPEROLIIDAE (pp.224–282)	
Afrixalus Leaf-folding Frogs	Eggs are laid in folded leaf envelopes. Tadpoles dissolve the adhesive binding of the envelope and develop in open water.
Hyperolius Reed Frogs	Eggs are laid by different species in a variety of situations: some sandwich eggs between overlapping leaves, others deposit egg clusters on vegetation or attach them to underwater vegetation.
Kassina Kassinas	Eggs are attached individually to underwater vegetation. Tadpoles are narrow-bodied with deep fins to allow them to swim among thick protective aquatic vegetation. Tadpoles develop bright red tail fins in clear water to scare off predators.