Classifications of snakes and reptiles

Reptiles are some of the oldest living creatures on the planet and made their first appearance some 300 million years ago. It is believed that the first species of snakes contained limbs which became more and more reduced through great periods of time, this phenomenon can be seen as a clear indicator just how evolution took place within a group of organisms. Today vestigial structures occur in certain serpent families such as Pythonidae and Boidae, and are remnants of structures they once possessed. Spurs which occur in the posterior position opposite the cloacae in Boas and Pythons is a clear example of vestigial structures that formed through time.

Snakes are carnivorous reptiles that belong to the order Squamata (Lepidosuaria), which is regarded the most important assemblage, as far as snakes are concerned. Squamates is a very diverse group of ectothermic (organisms that rely on their external environment to obtain the energy needed to facilitate metabolic and other processes crucial for life), amniote vertebrates which contain the distinct characteristic of being elongated and covered in overlapping scales. Squamata is subdivided into three distinct suborders: Ophidia or Serpentes, containing snakes, Sauria containing lizards and Amphisbaenia containing worm- lizards.

The suborder Ophidia contains 15 families which are subdivided into 456 genera that consist of more than 2900 species. Snakes have one of the widest distributional ranges in the animal kingdom, covering the whole planet except Antarctica (Figure 1. 1). In South Africa alone there occurs 166 species and subspecies of snakes, 101 of these species have enlarged fangs to deliver venom of which only 15 are regarded as very dangerous and potentially fatal to man. This means that of all our snake species only 8. 5%

are classified as dangerous, where administration of antivenin is deemed necessary. The remainder of venomous species is of no medical importance to man, in fact in some species the toxicity of their venom is less than that found in bees and wasps.

There are a few morphological characteristics of Ophidia which distinguishes them from the other two suborders e. g. the lack of eyelids, external ears, the lack of limbs and the occurrence of a single row of ventral scales, whereas lizards and amphisbaenas differ in the sense that they have various patterns of scales that do not occur in specific rows. Amphisbaenians scale formation is atypical in the sense that scales are arranged in rows around the body of the animal thus supposedly mimicking the resemblance of an earthworm. The skulls of Serpents are very unique in the sense that their upper jaw bones aren’t united/interconnected at snout of the animal, this enables the two jaw bones to act separate form one another and enables the snake to swallow large prey items. In contrary to popular belief snakes can however not dislocate or unhinge their jaws to swallow large prey items, the two upper jaws are simply connected to each other through connective tissue which is highly elastic and serves as the binding factor between the jaws.

Snakes fulfill a crucial role/function in nature and can be seen as an integral aspect of our environment both as key predators and as prey. They assist in regulating rodent numbers and are good indicators of the natural balance of the environment (bio-indicators). In addition to this, research and development is being done on the properties of venom in the medical field. Research is being conducted on the applications of venom in fields such as

high blood pressure, mental disorders and diseases of the central nervous system to mention but a few. Such is the complexity of venom that further studies, beneficial to man, are essential. It is there for imperative that we conserve our snakes not only for the preservation of our environment, but also for the wellbeing of mankind.

Evolution that took place within the Class Reptilia

Reptiles evolved from prehistoric amphibians called Labrynthodonts (Flank, 1997), and according to paleontologists made their first appearance in the Pennsylvanian era some 300 million years ago. They were also the first vertebrates to escape dependency on water. The earliest forms of reptiles suggested a mixture of both amphibian and reptilian characteristics, and diversified greatly over the next 200 million years. Reptiles were the dominant animal group on earth during the Mesozoic period, and were represented by 15 major groups. Only 4 of these orders survive today. Extinct are the fishlike Ichtyosaurus, sail-backed Pelycosaurs, flying Pterosaurs, Mosasaurs, plesiosaurs, well-known dinosaurs like Brachiosaurs and many others. The dinosaurs included the largest animals ever to walk on earth-the Sauropods, some of them reaching lengths of nearly 27 meters long. Many of the less familiar dinosaurs were no longer than chickens. (Carr, 1963)

Several basic advances made possible the rise and wide distribution of reptiles on land. Most important was the amniote egg, with its tough outer covering and protective membranes, and a cornified skin that protected the animals from drying out. The positioning of the limbs also made it possible

for reptiles to move more easily on land, and an improved circulatory system ensured that oxygen rich blood reached the animals.

In their Mesozoic heyday, Reptiles dominated the land, seas and air, and the reason for their dramatic decline during this period is still not clear, although there are some speculation by biologists that the decline was probably caused by a meteor shower which altered a dramatic change in climate and giving rise to the so called Ice Age. Warm blooded vertebrates (Birds and Mammals) began to expand by the end of the Mesozoic period. By the time the Cenozoic period arose only 4 orders of reptiles still existed, and these same four have persisted to this day. The order Rhynchocephalia is represented by only one species, the lizzardlike, granular scaled Tuatara (Sphenodon punctatus) confined to New Zealand where its survival is now threatened. The remaining 3 orders have representatives throughout the world. The order Testudines (turtles) is the most ancient, appearing about 250 million years ago and remaining virtually unchanged for the past 200 million years. The order Crocodylia (crocodilians) is slightly less ancient and is traceable to the Permian thecodonts. The order Squamata refers to scaled reptiles that include lizards, amphisbaenids and snakes. This is the most recent order and was not common until the late Cretaceous times about 65 million years ago.

In order to classify snakes or other organisms it is necessary to understand the origin and evolution of the species and place them into specific genera and families (Figure 1. 2)

Scientists believe that modern day snakes evolved from the family Varanidae, a group of lizards that belong to the genus Veranus. The fossils of Lapparentophis defrennei (Figure 1. 3) was found in North Africa as we know it today, and it represents the earliest member of the suborder Ophidia. This species however shows no direct link between earlier snake like reptiles, and its origin continues to boggle biologists. Lapparentophis defrennei appeared on the earth around 100 million years ago during the Cretaceous period and were around for about 35 million years, were after it got extinct by the end of the Cretaceous period. Boidae was one of the seven families of snakes that arose after the Cretaceous period and was at its peak of speciation during this time. Colubridae in modern day times is the family that contains the largest amount of different snake species, and first emerged some 36 million years ago during the late Eocene, and the beginning of the Oligocene period. During this time Colubrids started to diversify at an immense rate and eventually gave rise to more new species during the Miocene period. This diversification led to the disappearance of some of the more primitive lineages of snakes because they could no longer compete with the better adapted species that was starting to evolve. Viperidae (vipers, rattle snakes and adders) and Elapidae (front fixed fang snakes generally cobras and mambas and their relatives) originated during the Miocene period and belongs to the infraorder Alethinophidia. The family Viperidae is by far the most advanced evolved species of snake in the world and contains highly specialized structures that enable them to be a very successful hunters e. g. heat- sensitive pits that developed on the upper labial and a brightly colored tail tip that occur in Agkistrodon sp. This is just one example of how specialized this family of serpents is to survive.

Distinguising features of the suborder Ophidia

All snakes are elongated, lack eyelids, external ears and osteoderms.

Snakes poses a forked tongue which can be retracted into a sheath (Figure 2. 1)

All have along backbone. (Some have in excess of 400 vertebrae), with many articulated ribs used predominantly for locomotion and maintaining body shape.

The lower jaw is not fused, which allows the snake to engulf large items. They do however not dislocate their jaw.

Prey is subdued either by constriction or by the injection of venom. In the case of venomous snakes small prey items are bitten and held in the mouth until paralysis or death occurs, whereas large prey items are bitten and released to ensure that damage do not occur to the snake.

The majority of species have only the right lung but more primitive species such as Pythonidae and Boidae also contains a rudimentary left lung.

Unlike lizards the tail cannot be regenerated.

All snakes shed their skin.

All snakes hatch from eggs, some are Oviparous (eggs hatch outside the females body), and some are ovoviviparous (eggs hatch inside the mothers body thus giving birth to live young).

Classification of snakes

Kingdom: Animalia

Phylum: Chordata

Subphylum: Vertebrata

Class: Reptilia

Order: Squamata

Suborder: Ophidia (Serpentes)

Infraorders: -Alethinophidia

-Scolecophidia

The classification of snakes are based on different morphological structures

The general morphology of snakes is a crucial factor used in their Taxonomy. Factors such as the arrangement of bones in the skull and other parts of the skeleton, especially the presence or absence of a pelvic girdle are used to distinguish between separate and subspecies of snakes. The hypapohyses (vertebrae with downward pointing spike like projections), the coronoid bone (a small bone that occur in the lower jaw), structures of the hemipenes (Figure 2. 2, Jadin, 2000) and microscopic and biochemical material such as chromosome arrangement and protein analyses are also used in classification of snakes.

The presence or absence hypapohyses, especially in the lumbar region of the spine, is used as one of many diagnostic characters when classifying snakes. The hypapohyses is very prominent in the genus Dasypeltis which use them too saw trough egg shells. There occurs much variation in the shape and size of the coronoid bone. It is particularly large in primitive snakes such as Typhlopidae, Leptotyphlopidae and Anomalepididae. The coronoid bone is very small or absent altogether in advanced snake species. A hemipenis is the sex organ of male Squamates. Male snakes has two hemipenes probably for the reason that when one is damaged or injured, it still left with a spare one which can remain to work and carry out its normal function during copulation. This ensures that the male’s genes don’t get lost and can still be carried over through copulation with females. Hemipenes, under normal conditions are used in an alternating fashion when copulation occurs with female individuals. Sperm is carried through the sulcus spermaticus (which is the line running through the middle of a male’s hmipenis) to the female during copulation. By examining the tail of an individual we are able to distinguish its sex. Males usually have a long tail which contains prominent bulges of where the hemipenes are situated and females usually have very short tails without the occurrence of any prominent bulges. The shapes of hemipenes differ greatly from species to species and contain different cranial structures thus forming a very important method for taxonomists to classify snakes into different species and subspecies. Relationships that occur between different species of Squamates as a result of evolution is best explained through the examination hemipenal characteristics of the different species. The function of the spines and ridges that occurs on hemipenes of

different species of male snakes, serves as an adaption to ensure that copulation lasts long enough for egg fertilization to occur.

Biology

Hearing and Vision

Snakes cannot hear airborne sounds due to the fact that they do not posses external ears. Snakes do however have an auditory nerve enabling them to hear sounds travelling through a dense medium. They are extremely sensitive to vibrations and can thus detect someone or something approaching them. For this reason people seldom see snakes whilst walking in the bush, the snake senses the vibrations created by footsteps and beats a hasty retreat for cover. There is however snakes that do not retreat when approached and this is a direct result of the morphological attributes they contain. Bitis arietans, Bitis atropos and, Bitis gabonica, are species of snakes that rather rely on their camouflage to conceal them from potential predators and dangers than to move away, and it is not surprising to find out that Bitis arietans is responsible for 60% of all snake bites in Southern Africa. Contrary to popular believe snakes do have good vision. How else would they safely navigate through the bush except of course via smell? Their vision however is used mainly for detecting movement. Most snakes have monocular vision (unable to distinguish depth of field) whilst some snakes have binocular vision (able to distinguish depth of field) e. g. Thelotornis capensis and Dispholidus typus. Snakes do not have movable eyelids, instead they possess a fixed transparent shield which covers the eye and is shed during sloughing.

Sense of smell

For this function the snake uses its tongue. The tongue is flickered; picking up minute airborne particles which when retracted back into the mouth is deposited onto organs situated in the roof of the mouth. These organs are known as the organs of Jacobson. Studies have shown that snakes enjoys a similar sense of smell as we do, the epithelium of the organs of Jacobson works in exactly the same way as the olfactory epithelium we as humans possess. The tongue is forked so that the snake can detect the differences in strength of smell and thus enabling it to locate its prey very accurately. Snakes diet consists of quite a few prey items such as: rats, mice, small mammals, birds, frogs, toads, insects, lizards, fish, small antelope, eggs and other snakes, which is swallowed whole usually head first.

Shedding

Shedding of skin depends primarily on the growth rate. Juveniles for example shed their skin more often than adults for the simple reason that they are growing faster. Juveniles may shed their skin as often as twelve times a year whereas an adult may only shed its skin three to four times a year. During this process the entire skin is shed from the tip of the snout through to the tail including the eye shields. During this time the snakes eyes become opaque, restricting the snake’s vision and therefore making the snake not only more vulnerable, but also more aggressive. A snake may often go into hiding during this period. You may also find snakes basking for longer periods prior to shedding, the reason being higher temperature speeds up the development of new skin, thus reducing the vulnerability period.

Cold Blooded – (Ectothermic) and Hibernation

All members of the order Squamata are so called cold blooded (exothermic) organisms. This simply means that unlike mammals and birds which generate heat internally (endothermic), reptiles obtain their heat externally, usually from the sun. All reptiles will bask in the sun absorbing heat from their environment until their bodies reach the correct optimal temperature (± 30°C) which allows them to function at their maximum potential. The advantage of ectothermy is that it is fuel efficient. Mammals on the other hand convert 90% of what they eat into heat in order to maintain biochemical and muscle efficiency which allows mammals the opportunity to function at colder temperatures. This method demands a constant intake of food. Reptiles however become temporarily dormant at colder temperatures and thus waste no energy. A snake can survive and grow on ten to fifteen meals a year. Reptiles will go into hibernation when their optimal body temperature cannot be achieved from the environment. In areas where there is a significant fluctuation in temperature snakes will go into hibernation. The correct term used is topor. Areas such as the lowveld where there is no significant temperature variations will see reptiles not going into true hibernation but rather into a state of burmation. During hibernation snakes live off the body fat accumulated during the warm periods of the summer, and will exhibit very little signs of activity, thus becoming sluggish. A snake will use anything that will offer it protection against the elements and predation. Sites which are used by Squamates during the winter or cold times of the year for hibernation include deserted termite mounds, hollow logs and rock crevices.

Reproduction

Sexually active males will approach any snake they come across. The reaction of the approached snake will determine how the encounter develops. If the approached snake is a male and reacts aggressively it may give rise to a battle between the two parties. Battles vary according to species, Vipers and Elapids generally engage in a form of ritualistic wrestling, but refrain themselves from biting each other. Colubrids however react violently and bite each other severely. In some species of snakes several males group together amicably and follow a receptive female. Should there be no reaction from the approached snake the sexually active male uses its Vermonasal organ to chemically determine the species and sex of the snake it has approached. It does so with the use of its tongue interpreting the pheromones emitting from the other snake. Should it be of a different species, the male then seeks out a new mate.

All reptiles have internal fertilization. The male places his head on the back of the female and winds his tail around the females and attempts to join their cloacas together. This is seldom achieved at the first attempt. It sometimes takes hours, even days, for successful copulation to take place. The sexual organs of the male consist of two penises, referred to as the hemipenes. Each hemipene is equipped with flexible spines which inflate once penetration has occurred making it difficult for the male and female snakes to become dislodged. Sperm is transferred to the female via a single penis in Crocodilians and Chelonians, and paired penises in lizards and snakes (although only one penis is used at a time). Once mating has taken place the male will often stay with the female for a few days to mate again.

Fertilization of the ovule and spermatozoid takes place high in the oviduct, then the egg gradually moves down into the oviduct where the uterine glands secrete a substance which surrounds the egg. The length of the embryonic development depends on the species and also within the species depending on climate (temperature), and ranges from 2-5 months.

As stated before all snakes hatch from eggs. The method of incubation however does differ between some species. The majority of snakes lay eggs andleave them to be incubated externally (oviviparous) with no parental care whatsoever. Species such as Python natalensis coils around their eggs throughout incubation. This not only protects the eggs but also regulates the temperature to help assist with incubation. In other species such as Hemachatus haemachatus the female retains the eggs inside her body to produce fully developed live young (viviparous).

Between four to eight weeks after mating the female selects a suitable site to deposit her eggs. The site chosen is usually a suitably protected place in the form of rotting vegetation, hollow tree trunks or any other suitable location. The number of eggs deposited depends on a variety of circumstances for example, species, size of the female, habitat (availability of food), age and climate. Eggs laid vary between one and two to as many as 60, sometimes more, depending on factors mentioned above. Eggs usually have soft leathery shells which require a specific amount of heat and humidity in order to ensure that hatch. Once the eggs have been laid there is often no parental care with the exception of a few species. In South Africa the young of Python natalensis may stay with the female for several days

after hatching, leaving the burrow by day and returning to the female at night.

In most reptiles the sex of hatchlings is determined by temperature, for example outer eggs (cooler) will be female while the inner eggs (warmer) within the nest will be male. The eggs usually hatch between one to three months after the female has deposited them. In the case of some species of chameleons eggs might take up to a year to hatch. The young are equipped with an egg tooth consisting of a sharp ridge on the tip of the snout which allows the young to slit open the eggshell thus freeing itself. The young that emerges are exact replicas of the adults, and the hatchlings of venomous snakes are equipped with fully functional venom glands and fangs, and are thus venomous directly from birth.

Egg mortality is quite high. Reasons for egg mortality range from predation to unsuitable nest sites chosen. Giving birth to live young may be an evolutionary process to assure the success of a species, reducing the risk of egg mortality in particularly cold areas where the temperatures won’t be adequate enough for incubation.

Movement (Locomotion & Speed)

The ability to function at speed and endurance is directly related to the supply and amount of oxygenated blood to the body. Reptiles, unlike mammals and birds, do not receive as good supply of oxygenated blood. Directly translated, this means that reptiles tire more easily and are incapable of endurance. Based on these facts it is doubtful that the speed of a snake would exceed 20km/h which is much slower than the average

human. The two fastest snake species world occur in Southern Africa and belongs to the genus Psammophis and Dendroaspis.

There are four basic modes of locomotion in snakes:

- Sepentine – This is the more familiar method of locomotion that most snakes use e. g. the family Elapidae which makes use of this method. The body undulates from side to side while the hind part of the snake makes contact with the surface and the rest of the body is pushed in the direction the snake wishes to go.
- Caterpillar – These are usually heavy bodied snakes e. g. Bitis arietans. The snake progresses in a primarily straight line using its ventral scales to propel it forward.
- Concertina – This is when a part of the body is anchored whilst pushing forward. The snake may anchor its head and then drags the rest of the body towards the head. This is often seen in arboreal species when negotiating between smooth braches of trees. Snakes that make use of this type of locomotion usually contain the characteristic of keeled ventral scales, and include species of the genus Philothamnus.
- Sidewinding – This method is most seen in desert species. It is the most effective method of locomotion on loose unstable surfaces such as sand. Only one or two sections of the body are in contact with the surface at any given time. A section of the body is thrown sideways and is followed by the next section. This way of locomotion can be seen as a specific adaption for desert species e. g. Bitis peringueyi, to ensure that they don’t get burned by the hot desert sand when moving.

Scales

Most people refer to snakes as being wet or slimy, which is quite the contrary. In fact if you touch a snake you will notice that it is in fact dry. Scales are horny skin that originates from the snakes epidermis. The primary function of scales is to prevent rapid water loss, an evolutionary process which has allowed snakes to move onto land. Scales can be smooth or keeled. Some snakes use their scales as a warning mechanism. By rubbing them together this creates a rasping sound that serves as a warning to would be predators. Dasypeltis scabra is a species of snake that occur in Southern Africa and which use this specific defensive mechanism to ward of predators. The North American rattlesnakes rattle is also an example of modified scales that formed through evolution. Scales also help in the locomotion of snakes.

Scale counts remain one of the main methods in the identification and classification between different species of snakes. There are four methods which can be used to correctly identify a species via scale counts:

Head scales – This is done by counting the upper and lower labials on each side, taking note of which scales are in contact with the eye. Examine the nasal scales (single, semi-divided or fully divided). Count the number of preocular and postocular scales and check whether a loreal shield is present. There should also be taken note of the arrangements of scales that occur on the temples, and the presence of any fused scales. Observe the relative sizes of internasals, prefrontals, frontal and parietals, and also note the proportions and shape of the rostral scales at the front of the nose.

Dorsal scales – Note whether the scales are smooth or keeled. And one head length away from head and in front of the cloaca

Subcaudal scales – The first scale is the single or paired scale that meets the lateral scales on both sides. Count back along the tail towards the conical tip. Note whether scales or anal shields are single or divided as this forms a crucial part of the identification between different families of snakes.

Internal Anatomy of Snakes

A snakes' skull is specifically designed to suit their specialized feeding habits. Because a snake cannot chew its food and must swallow it whole it is important that the snake be able to open its mouth very wide. For this reason the fifty odd bones in the skull are not fused together, instead they are loosely connected to each other by ligaments which allows the snake to produce an enlarged gape allowing it to swallow prey much larger than its head. The concept is similar to an elastic band. Often after a snake has eaten it will seem to yawn, this is done simply to relax the ligaments and bones t their original shape. The structure of a snake's brain is very similar to that of a bird, but unlike birds and mammals snakes lack the enlarged cerebral hemispheres. In mammals (and birds) the cerebral is the part of the brain, which acts as the learning center of the organism. For this reason, although snakes are perfectly adapted to the environment, it is correct to say that snakes are not very intelligent. To allow snakes to engulf such large prey whole the stomach has to be very strong and elastic allowing it to expand greatly once prey is engulfed. Powerful digestive juices allow the snake to digest bone and teeth.

Because a snake is for the most part long and cylindrical, the shape of the lung must be somewhat different in order to fit inside the snakes' body. The right lung is usually the largest and extends for 1/3 of snakes body length. The left lung, in most cases is absent, or very small. Snakes have in effect only one lung. During feeding the snake is able to extend a muscular extension of its windpipe (epiglottis) from the bottom of its mouth allowing it to breathe while prey is being consumed.

Most reptiles have a primitive three chambered heart which is not as effective as the four chambered heart found in crocodiles (and mammals). In snakes oxygen depleted blood gets pumped into one of the top chambers while oxygenated blood gets pumped into the other top chamber, both chambers get emptied into the bottom chamber and then circulated through the body. This is the main reason why snakes tire easily. In proportion to their body size snakes have very large kidneys. The left kidney is situated behind the right kidney in the abdominal region. The function of the kidney is to filter the waste products from the bloodstream and pass them on to the cloaca for excretion. Unlike mammals which excrete nitrogen waste in the form of water soluble urea, snakes excrete these body wastes as crystals which forms a dry white paste which is excreted along with the feaces. This allows reptiles to be extremely efficient in their use of water. Mammals have a separate urinary, reproductive and anal opening. Snakes however do not. Instead they have a common chamber known as the cloaca which performs all these rudimentary functions. Waste material is stored in the cloaca until eliminated. The claoca opens to the outside through a transverse slit at the base of the tail. It is often possible to tell the difference in sexes between

species by looking at the length from the cloaca to the tip of the tail. The longer the distance between these points would signify the snake as being male whereas a short distance between these points would indicate the snake as being female. The reason behind this is that during reproduction, as mentioned earlier, the male wraps his tail around the females. Some snakes, like the Pythonidae family, have special glands which also empty into the cloaca, these glands contain a foul musky scent which can be ejected when a snake is threatened, frightened or stressed.

Venom

There is no easy describing venom. Simply put, snake venom is highly modified saliva which is produced by modified saliva glands. Venom is a combination of different enzymes, or proteins, that act on other chemicals and proteins thus altering them or simply breaking them down. Many of these proteins are harmless, but some are toxins. The makeup of these toxins varies widely from species to species. Snakes venom can therefore be best described as a cocktail of hundreds of different proteins and enzymes, this complexity alone accounts for widely differing effects of snakebite. In essence venom affects the protein and chemicals of the immune system and the blood, transported through the body via the lymphatic system. The venom glands are situated in the skull slightly behind the eyes.

In order for venom to be effective it has to be injected into the circulatory system. It is therefore quite safe for a normal healthy person to drink venom without any consequences. Venom cannot be compared to poison, and are totally different entities.

- Venom has to be injected (circulatory system)
- Poison has to be ingested (swallowed)

The functions of venom are numerous:

- Prevents the putrification of prey prior to ingestion.
- Immobilizes prey thus preventing the snake from being injured.
- Digestive properties within the venom begin the digestive process prior to ingestion.
- Snake venom is also antibacterial, antiviral, antifungal and antiprotozoal which protects the snake from microbial diseases which it may contract from prey.
- As a last resort, self defense when the snake is threatened.

There are three types of snake venom:

1. Neurotoxic – nerve acting venom (Elapidae).
2. Cytotoxic – cel destroying venom (Viperidae.)
3. Haemotoxic – blood acting venom (Colubridae).

Fangs (Dentition)

All snakes have teeth, but not all snakes have fangs. Most snakes have teeth on the upper and lower