THE VARIED ROLES OF SNAILS (GASTROPOD MOLLUSCS) IN THE DYNAMICS OF HUMAN EXISTENCE

BY

PROF. FABIAN C. OKAFOR

Mr. Vice Chancellor Sir,
Distinguished Colleagues
Ladies and Gentlemen,
Lions and Lionesses.

1. INTRODUCTION:

1.1 PREAMBLE.

It gives me tremendous pleasure to stand before you to make this presentation today. I give God all the glory for this his marvelous act. In the eyes of man, this would have been impossible, but the Creator of the Universe in His mercies has given me this opportunity.

My family and I are very grateful. I would like to thank the Vice Chancellor for rushing to my aid when I was in very deep health problem. He stood by me with his lieutenants in a manner that left me dumbfounded and today I celebrate the outcome of their Kindness by being part of this glorious event- the University of Nigeria Inaugural Lecture.

I am proud to be a Professor of Zoology, serving in this University and I have thoroughly enjoyed this my chosen area of competence that has opened wide the divine chest of knowledge to me, as I go about conducting research in areas as wide apart as diagnostics, physiology, environmental toxicology, parasitic infections, epidemiology and other branches of applied Biology. By specialization I am a Parasitologist a field as wide as Biology in itself. So for me to choose a topic for the inaugural lecture is a very difficult one. However in course of my studies I noticed that snail always recur in my work and I also know, they are eaten in some areas and some control it, either because they are known intermediate hosts of human disease parasites, or they devastate crops and so are important pests in agriculture. I settled to deal with these organisms that my friend Dr Obi Udengwu always refer to as "Mpioro" Today, together we are going to look at the roles of the snails in the dynamics of human life. At the end we will judge whether the Gastropods are friends or foes; and whether they have any thing to offer to humans as we march on in our quest for survival.

1.2 DYNAMICS OF HUMAN LIFE

The dynamics of human life involves overcoming population pressures and the degradation of the planet Earth. It also revolves around nutrition, health, industrial development and other responsible activities that lead to the stable socio-economic development and aesthetics of life. Dating back to several million years ago, the population of the world was very low, and then later it grew very slowly. In the beginning, the number might have been three to ten million people on earth. In the first millennium after Christ, there might have been about two hundred and fifty million. Five hundred million was the population reached around 1650, one thousand million in

1820 and twice that in 1930 (Martins, 1983). There are now more than six Billion people. This population growth is not without setbacks such as childhood mortalities due to diseases and malnutrition, fertility problems and many other demographic transitions. Despite these, population growth today is still rapid and exponential. Survival became linked to social, agricultural, technical and economic development. These result in the environment being bedeviled with such problems as deforestation, overgrazing, erosion, desertification, urban expansions, population changes, climatic changes and global warming. Features that have produced individuals faced with several harmful side effects like, high population density, high consumptions, excessive use of non-renewable resources, the accumulation of wastes, pollution and the deterioration or destruction of the natural environment. As the years progress, stagnation of socio-economic development stirs man in the face. This situation, in conjunction with the increase in population, make it clear that man is heading for catastrophe even faster than expected, unless he starts to deal with these problems by not further destroying the ecological support systems but rather enhancing their responsible exploitation, renewal and protection.

The problems with the dynamics of human life lie in the following two processes:

(a) the initial productive potential of the earth accommodated population growth but the demands of the population exceeded the potential sustainable harvest, so that biological and ecological reserves are increasingly exhausted;

(b) the consumption in the system is reduced when the ecosystem collapses with disastrous consequences such as malnutrition, morbidity and mortality.

Complex and big changes occur in the ways man pursued his life, his methods of production and exploitation of his resources. For instance, the universal demand for food, clothing, shelter and other comforts of life, prompted the creation of many new things including new ways of using biodiversity around. Gastropods (i.e. snails) are one of the organisms that have co-existed with man which over the years have found itself playing several roles to meet the needs of man in a variety of ways. Scientists observed that everyday life throws more than a million opportunities in a man's way but he tries to make the most of each one that may be accessible. In the case with snails, every opportunity to be useful to man is being harnessed and consummated.

1.3. MAN – SNAIL INTERACTIONS IN NATURE

Man and Snails have associated intimately in nature from antiquity. The interactions between them have been recognized from the earliest times. These interactions became very prominent during the height of the Roman Empire when it was a common practice to eat Snails in the courts of the Emperor where they are used as aphrodisiac (Taylor, 1900). The high nutritive value of snail meat was later publicized by Leger in 1925 and Moretti in 1934. The true nature of snail meat was discussed in a Symposium paper where it was stressed that "snails were neither fish nor flesh; and that their consumption was permitted on meatless days in Europe (especially during lent), whereas they are avidly consumed in the rural tropical areas". The contributions of snails to human existence have been a subject of several debates and research evaluations. As far back as 1890 studies such as those of Locard in 1890, Rust in 1915, Boisseau and Lonorville in 1931, Arnould in 1933, Kaibo in 1935, Ri in 1935, Maubert in 1943, Pardo in 1943, Metteo in 1946, Jutting in 1952 and Cadart in 1955, attracted great attention to the snails and their benefits. The matter is still a topic being discussed in several rural development and poverty alleviation forums today. The scientists all agree that snails and man live together and have some dependence that exerts fundamental influences on the survival of both groups.

Gastropods, as snails are known, belong to the biological Taxon called Mollusca. These belong to the animal kingdom. They are conspicuous invertebrates that have their soft bodies covered with calcareous shells and are very successful in nature. They live in a wide range of ecosystems from swamps, ditches, ponds, rivers, lakes, forests, gardens to farm lands. Not every member of this group has similar preferences, structure or behaviour.

1.4. DOMESTICATION OF WILD SPECIES

As far back as 12,000 years ago, man started the journey into utilizing domesticated wild species of animals including snails. The process of looking to the wild in the quest for animals to be used for either medicine or food, was then guided by certain fundamental demands of human societies, especially, the need to obliterate hunger, to solve transportation problems and to do haulage work. In meeting these needs, man resorted to using wild animals and their products in a variety of ways that suited his existence (Afolayan, 1980). Several hundreds of thousands of wild animals were evaluated over time till we arrived at the present few that are intricately woven into human ecology and food security.

Man categorized wild animals into:

(a) Conventional mainframe species such as cattle, sheep and goats, which are too large, requiring too much expense and space;

and

(b) Mini-frame species such as rodents, grasshoppers, termites, maggots, earthworms, and snails that are increasingly playing important roles in human nutrition and other activities.

The latter are tiny, user friendly “species and are becoming more attractive now as potential farm animals. They lend themselves to economic niches that are not easily filled by large main-frame livestock. Much of their potential is for subsistence production, for the benefit of peasants and the poorest people in rural communities that have found themselves outside the cash economy (Asibey and Child, 1990). These resources have indirect contributions to human food security as follows:

a). income generation, e.g. in tourism and recreation; in hunting; in bush meat trade; in sales of trophies, skins, and hides.

b). in live animal trade, in spiritual health, in physical and mental health and in forestry/agriculture.

Wild life production falls into three categories:

a.) Production from the wild (wild catching of animals.).
b.) Wild ranching
c.) Wild farming and domestication.
d.) Production from the wild (wild catching of animals.).
e.) Wild ranching
f) Wild farming and domestication

Domestication of wild animals is encouraged for meat production to improve protein supply (Martin 1983; Muir, 1989; and Ajayi, 1979). Works on snails have been carried out in West Africa for a long time.. Among these, snail farming has been projected to have the potential for playing an important role in the life of man, especially when developed into commercially viable and sustained industry, using simple technical know – how and cheap methods of production (Ajayi and Tewe,1983; Asibey).

2. General Features of Molluscs:

All molluscs must have: food, oxygen and moisture to be alive. Most molluscs live in the ocean or, if on land, in moist places such as under leaves or in soil, some need a sandy, ocean environment. All molluscs require moisture to stay alive. The desert dwelling snails are no exception as they maintain their own moisture inside their shell by means of a trap doors and or a mucus plug.
Many molluscs eat: plants (herbivores) or plant cell materials in the water. Terrestrial snails like to eat fresh leaves and decomposing materials. This can be beneficial because they break down decomposable materials, but

snails can also become pests when they turn their attention to garden crops and vegetables. Many water molluscs eat mosses, algae and such other microscopic plants.
Some molluscs are carnivores (eating such things as fish and other molluscs) and some are even parasites (living within another living host)
Most aquatic molluscs filter oxygen from the water to “breathe” by means of gills. Terrestrial and some pond snails breathe using lungs (Pulmonary sacs). Some pond snails have both gills and modified lungs. Deep ocean trenches have molluscs that are anaerobic.
Polluted waters lack oxygen and food for molluscs to eat and “breathe”. This makes them sick and they die and the eggs fail to hatch or the juveniles would not live long. .
Most molluscs can be eaten by man. Some of our favorites are scallops, oysters, clams and “escargot” (land snails - Helix , Achatina, Archachatina.)
Many people collect shells for their beauty and interesting shapes. People who study the shells are called Conchologists. Those scientists that study the molluscan animal are called Malacologists
Shells have long been used by man as tools, and buttons, jewelry (pearls and cameos), etc.
Dyes can be produced from shells for use in colouring cloth. This is not so important today as we have much cheaper synthetic dyes..
Molluscs can be found in gardens, in ponds, deserts and oceans. Some live in the tops of trees and others high in the mountains.

Gastropods I: Terrestrial or Garden Snails:

Fig .1 Achitina achatina (African Land Snail)

Terrestrial gastropods often have a shell to protect their soft body. Some like slugs have no shells.

The body of the snail is usually moist and often slimy.

Snails have tentacles with eyes on the ends. They have a very developed sense of smell, but do not feel much sensation/touch-wise. They do not hear or taste food like we do and their behavior is instinctive.

The eye is on the tip of the tentacles. The snail has two pairs of tentacles on its head. One pair is longer than the other pair. The eyes are on the longer pair. The shorter pair is used for smelling and feeling its way around. The tentacles are very important to a snail.

Many gastropods are autonomous, meaning they can re - grow lost body parts.

When the snail is disturbed, it simply withdraws or pulls its body back into its shell. The snail then seals the entrance with a mucus plug or a trap door, called an operculum. Many snails also use this trap door, to hold in valuable moisture during dry spells. This door is located on the top of their foot and when danger is around or they are required to maintain moisture, this operculum closes them into their shell.

When land snails are threatened and want to hide, they go beneath leaves, stones or logs.

The majority of snails are most active at night and on cloudy days. It does not like the sunshine very much.

Snails do not like hot and dry conditions. They like it moist or humid and not too bright.

During very cold weather or winter, it hibernates in the ground. During dry periods (droughts) molluscs also pull into their shells or create a mucus cocoon to keep in valuable moisture. This kind of hibernation is called aestivation.

Snails have different shaped shells. It can be a single shell that is rounded or a pointed spiral or flat. They are often brightly coloured or some even have spines and ridges as well.

A snail has fingernail file like tongue called a radula in its mouth for scraping food particles off. This radula is like a rough tongue-like ribbon, something like a file with rows of tiny teeth, which it uses to scrape off bits of leaves and flowers to eat.

Snails eat mostly living plants as well as decaying plants. They also chew on fruits and young succulent plant barks.

The snail moves by creeping or gliding along on a flat “foot” underneath its body. The band of muscles in the foot contracts and expands and this creates a kind of rippling movement that pushes the snail forward. The “foot” has a special gland that produces slimy mucus to make a slippery track. You can often see these silvery tracks in the garden. The slime comes out from the front and hardens when it comes into contact with air. The snail is able to move on very sharp pointed needles, knife, razors and vines without being injured because the mucus-like secretion helps to protect its body.

The garden snail travels about 70 cm every 3 minutes-that’s 1 km every three and a half days.

Many snails are both male and female. Therefore, it can produce sperms and eggs at the same time! However, to fertilize the eggs, the snails need to exchange sperms with each other. An animal that is both a male and a female is called a hermaphrodite. This method of reproduction comes in very handy as these snails are very slow moving and don’t like moving around too much. If they had to go looking for a boyfriend or girlfriend, it could take them a very, very long time to have babies.

The brown garden snail lays about 80 spherical shaped white or yellowish coloured eggs at a time into the topsoil of the ground. It can lay eggs up to six times a year. Snails take about 2 years to become adults.

Snails have many natural enemies. They include ground beetles, snakes, toads, turtles, and birds, including chickens, ducks and geese.

The largest known land snail is the Giant African Land Snail. It can weight up to 2lb (900g) and measure up to 15.5 inches (39.3cm) from snout to tail.

Many land snails are very strong: they can lift 10 times their own weight, even moving up the side of something-like a tree.
Snails can live up to 10 years depending on which species you look at. Some have been known to live up to 15 years or longer.
Many people get upset and farmers get angry when snails eat up their plants and crops. Snails can cause serious damage to crops.
Many types of terrestrial snails such as the helicidae or escargot snails are actually farmed today. This farming method is called Heliciculture.

Gastropods II: Aquatic (Pond or other Freshwater) snails:

Fig. 2 :*Pomacea bridgesi* (Golden apple snail)

The pond snail is, in many ways, like the garden snail.
Pond snails are usually tan or dark brown in colour.
Some pond snails have gills to breathe in water. Those with gills will live at the bottom of the pond. Those that do not have gills will come up to the surface to breathe and have pulmonary sacs which act like our lungs. These snails will

live on the surface so that they can come up to breathe easily.

You can often buy pond snails from a pet or aquarium stores. One common pond snail often sold is called “Apple” snail or golden snail.

The pond snail feeds mainly on plants like algae and microscopic creatures that are found on the surface of waterweeds. They eat by scraping bits off with their rough, sandpaper-like tongue, just like the garden snails.

When pond snails are threatened and want to hide, they bury in the sand, or hide beneath rocks or logs on the bottom of the pond. In the ocean, snails will hide in caves, or on rock ledges.

Some snails have pointy spines on their shells to keep their enemies from eating them; some have very heavy shells that discourage their prey. Some snails have a body that comes over their shells to camouflage them from those that would eat them, and some are poisonous to fend off prey.

Most pond snails reproduce just like the garden snail. It is a hermaphrodite. The only difference is that, unlike the garden snail, the pond snail carries its fertilized eggs with it or sticks them onto or under foliage or stones. If carried around on their mother’s shell, the baby snails will only leave their mother when they are hatched.

Some pond snails can swim and others can bury themselves in the sand very quickly.

Gastropods III: Marine Gastropods:

These are the conchs (Strombidae), whelks (Buccinidae), limpets (Lotiidae), periwinkles (Littorinidae), cones (Conidae), volutes (Volutidae), and cowries (Cypraeidae) that live in the seas.


Fig. 3 : *Cypraea moneta* (Money cowrie)

Most seashells that people recognize and pick up along our beaches fit into this group of molluscs
Most have a coiled shell. Their soft bodies have a head complete with two eyes located on the tops of two tentacles
They have a big flat foot, which they use for locomotion and on the back end of this foot is a structure called an operculum, which acts as a trap door
Most breathe through gills; however, some absorb oxygen from the water directly through a specialized membrane (something like the thin skin lining the insides of your cheeks) lining their mantle cavity.
Many of these molluscs have very colorful bodies. Some members in this class only have a very small, fragile shell and it is often contained right inside their soft bodies or they may not have a shell at all. We know some of the Opisthobranchs as: sea hares, sea butterflies (Thecostoma), sea slugs (saccoglossans and nudibranchs), and canoe (Scaphandridae) and bubble shells (several families).
All cone shells possess a poisonous dart (a modified radula) with which they harpoon, inject venom and thus kill their prey. Some cone shell possess venom is so toxic that if stung, it can severely harm or even be fatal to man.

Many members of the Carrier shell family collect seashells. These shells scientists call Xenophoridae attach other shells or stones to their own shell for protection and camouflage. Sometimes they even use man-made objects such as glass and bottle caps!

The largest snail (univalve) known attained a length of 78 cm (two and one half feet) with a girth of nearly forty inches. This trumpet conch, Syrinx aruanus (Linneus, 1758), weighed in at nearly forty pounds.

The smallest known snail shell is the Ammonicera rota and measures only 0.02 inches in diameter. Fifty of them laid end to end would measure one inch!

“Pelagic” gastropods live their entire life without ever touching bottom or shore! They float and travel on the ocean’s currents. The violet snail, the Janthina, can travel hundreds of miles in its lifetime as it floats around on the ocean’s currents. Its delicate shell only touches land when it gets washed up onto beaches during storms.

Money cowries were the first item used by man for trade and a monetary system. Other examples of this are the wampum trade beads used by the North American Indian.

Bivalves or Lamellibranchs :

Fig. 4 : The Giant clam

Covering their soft body is a thin membrane called the mantle (like a thick piece of skin). The mantle takes lime and calcium out of the water and turns it into a two piece shell

Bivalves all have this two-part shell which is hinged together. These two shell parts are called valves. They open and close these valves by using strong adductor muscles and ligaments much like you bend your elbow or knee.

They have a siphon (like a short, fat drinking straw that feels like rubber) which they use to pull in water and tiny animals that live in the water. They extract both oxygen and their nutrients from this inflow of water through gills which can filter out the tiny food particles from the water and pass them on to their stomach where they are digested.

If a foreign object such as a piece of sand gets into their soft mantle, it hurts, so they take the same smooth shelly material that we put on the inside of their shell and cover the offending object up and make a pearl.

Most bivalves reproduce by laying millions of eggs into the water surrounding us. The male bivalves then release their sperm into the same water. If the eggs and sperm meet, a new baby bivalve is born. However, some species hold their eggs in a space called the mantle cavity in their body. The males still spurt their sperm into the water and when she pulls this water in through her siphon, the eggs are fertilized. These are then brooded inside her body until she knows they are big enough to live in the water. She then releases them into the water. All juvenile bivalves start life as tiny specks, (larval stage) swimming in the water. When these larvae become big enough, they start to settle in their new homes. When they are still young, and settled, they are called "spat".
Some molluscs, such as the oysters, change sex. Some like oysters even alternate their gender. Male one year, female the next year,

Some bivalves like to live attached to hard objects such as rocks or manmade objects. Some live all their lives buried beneath the sandy or muddy ocean, lake or stream bottoms. Some actually live inside wood. These bivalves (known as ship worms) have caused man a lot of trouble when he sails in wooden ships. for example the Barnacles make holes on the ship body. They also attack wharves and other wooden man made structures causing a lot of damages. Some of the other species are parasites, meaning that they live inside a living host.

2. WHAT ARE ACTUALLY THE SNAILS?

The scientific classification of snails shows that they belong to the Phylum Mollusca and Class Gastropoda (Curvier, 1795). The word snail is a common name that can be used for almost all members of this class. They are mainly characterized by having coiled shells in the adult stage (those snails which do not have a shell or only a very small shell are usually called slugs) Snails are second only to the insects in terms of total number of species. With more than 62,000 described living species, they comprise about 80% of living molluscs. Estimates of total extant species range from 40,000 to over 100,000, but there may be as many as 150,000 species. There are about 13,000 named genera.

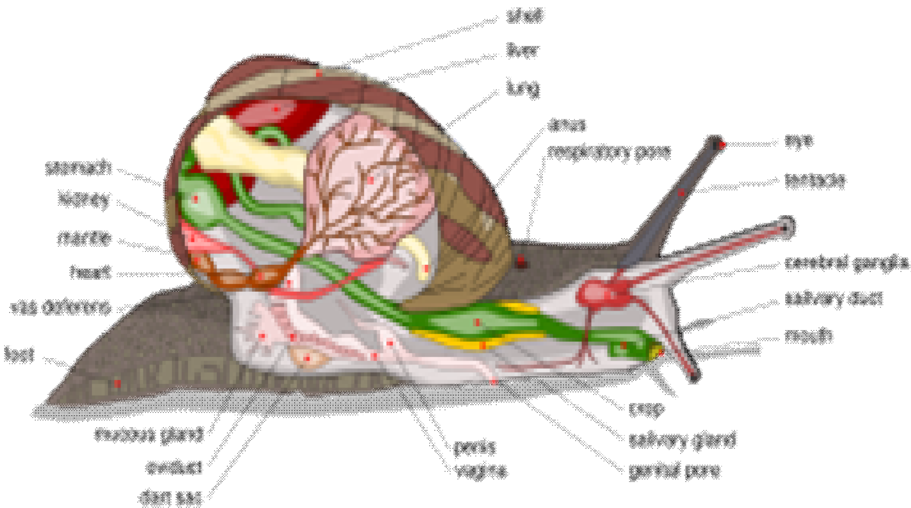


Fig 4 : Anatomy of a Gastropod snail

Apart from having extraordinarily diverse types of habitats, they vary extensively in form, habit, behaviour and anatomy. It has since been noted that among the snails, what is true of one species may not be at all true of another. They are found in the deserts, ditches and the abyssal depths of the sea. The great majority of snail species are marine, many are terrestrial and numerous can be found in the fresh water, and brackish water biomes. Many snails are herbivorous, though a few land species and many marine species are omnivores or predatory carnivores others are grazers, browsers, suspension feeders, scavengers, detritivores and there are suctorial forms.

Snails are among the animal groups that everybody knows a little about. After rains, snails can be seen crawling around in bushes, trees, walls and roads at a proverbially slow pace and mainly at nights. Besides the characters typical for molluscs, there can also be found characters typical for all snails, whatever they may look like from outside.

These common features include:

(a) **Foot:** Most snails have got a noticeable muscular crawling foot with a flat sole. The animal uses it to move slowly but visibly. Besides this crawling motion, seen mostly among land, living snails, there are many alternative methods of locomotion. So many snails also are able to use their foot for digging. Among sea snails, there are species that can swim in the free water. In ponds and lakes there are arboreal snails that climb up and down trees, shrubs and herbs within the bodies of water

(Azugo, 2009) and pulmonate forms swimming about in open water.

(b) **Head:** At the end of the foot in the front end, a snail has its head. This head carries eyes and a variable number of tentacles. Most terrestrial snails are equipped with four tentacles; the remaining snail species only have two tentacles at their dispositions that may look like threads or look like ears. The eyes are attached on the tips or at the base of the tentacles. These positions are diagnostic

(c) **Operculum:** At their foot's rear end many water living snails (and few terrestrial species) carry a calcareous lid (operculum) that closes the shell aperture, when the snail withdraws. Using their "saber-shaped" conches, the snails are able not only to, defend themselves, but also to move in jumps by pushing their operculum into the ground and jerking themselves forwards.

(d) **Radula:** Like other molluscs, snails feed with their rasp, tongue (radula). From the composition of their radula and the shape of their teeth, different snail groups may be distinguished, such as the primeval docoglossan beam tongue (limpets) or the carnivorous toxoglossan (meaning venom tongue of cone shells). The main function of the radula, whatever its appearance, based on the same principle, is a rasping tongue with tiny chitin teeth used for food provision. The number and shape of teeth is dependent on the type of nutrition, as it is among mammals (fig. 2). Herbivorous snails usually have many similarly shaped broad toothlets, that are connected to a venom gland and are used toinject the venom into its prey's body as a snake.

In grastropods, the jaw, radula and the reproductive tracts are useful in identification and systematic. The radula is a rasping structure consisting of a chitinous belt and rows of posteriorly curved teeth. This tongue like structure is supported by a cartilaginous odontophore and is situated on the floor of the buccal cavity. It lies on top of the odontophore. When the radula is projected out of the mouth, the teeth become erect. When the radula is retracted by muscles, the teeth scrape in algae. The radula teeth are worn with use.

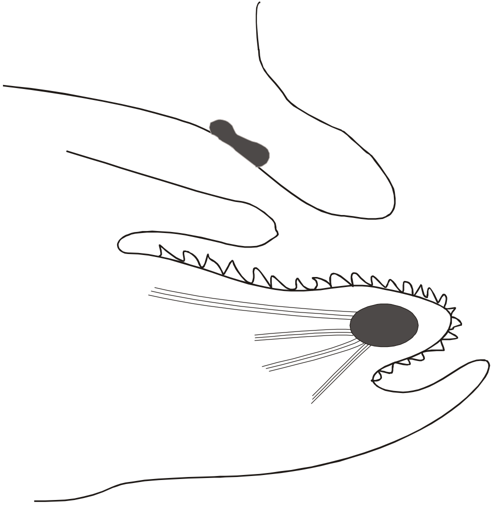


Fig.
5: Radulae in the jaw of a snail
(After Yoloye, 1988)

(e) **Shell:** Snail's shells mainly protect the snails backside (i.e. the visceral mass), but also several internal organs that are assembled in the dorsal visceral hump. The shell is produced by cells of the mantle, the tissue coat protecting the snail's visceral hump and back. Originally snail shells differ noticeably from other mollusc shells, such as those of Nautilus, as they are asymmetrically coiled to one side of the body.

Shell sculpture is a habitat dependent feature. Open surfaces (e.g. rocky plains swelling gastropods may be more exposed to shell crushing, predation particulary by fishes and rodents than sand dwelling species). This was part of the observation of Vermeil's in 1978, that while the "most profound inter oceanic variations in architecture occur in open rocky surfaces", changes in sand dwelling species are considerably less pronounced. Consequently sculptural defenses against crushing may be of greater importance to open surface dwelling species compared to sand dweller.

For the lovers of beauty, shells of gastropods (fig. 6) have always offered a wide variety of opportunities for artistic ingenuity, producing many gift items. Some gastropods have striking colour patterns showing a good deal of contrasts. They may occur in the shell, foot, mantle or eys. Some are understandably camouflage and warning features and are distinctive for each species of one genus. Thus they are often used for species recognition. Most pulmonate gastropods have dull coloured shells without patterns. They have constellations in addition to their species specific micro-sculptures.

Using molecular biological studies, it was found that the controls of colour patterns are located in several gene loci. It has been suggested that shell patterns are caused by deposition of shell pigments in the primitive molluscs. These pigments are believed to be derived from waste metabolic products removed from living tissues by incorporating them into shells. The fact that the substances are laid down in bands, spots, strips and other intricate patterns of constant nature indicates that the disposal of these wastes may definitely be under genetic control and so have adaptive value.

Gastropod shells have three major layers – the inner or Ostracum, the middle which is relatively thick is the Calcareous while the outer or Periostracum is thin and transparent. The Periostracum is made of chitin like protein material called Concholin. This protein is secreted by the mantle. The Ostracum is also known as the nacreous layer and is formed from thin sheets of calzium carbonate alternating with organic matter. This nacreous layer is secreted by cells along the entire epithelial border of the mantle. Secretion of the nacreous causes the shell to grow in thickness. This thick shell helps in protecting the soft tissues of the gastropods.

The snail shells have many shapes. The fundamental shape is globose while some are conical tubes; some are spirally coiled around a central axis – the columella. The separate coils of the spiral are called the whorls. Each whorl is partially covered by its successor. The line occurring where two whorls meet is called the suture. The last whorl is called the body whorl, and it is around the opening known as the aperture.

Fig. 6: Shells of different freshwater snail species
(After Thomas Kristensen, 2005)

(f) **Torsion:** The Principal diagnostic criterion for the members of the class gastropoda is torsion. The process of torsion was thought to be due to two different gradual adaptive processes:

(a) To regulate stabilization of the larval equilibrium.

(b) To regulate balancing posture in the plantigrade stage. The process of torsion therefore regulates differential growth processes e.g. shifting the mantle cavity into the anterior position. The mantle or shell sinus already existing appears to be a prerequisite for the survival of such torted animals in not shedding their waste products towards the inhalant currents. The regulative growth also includes the development of the right pallial organs and the right dorsoventral retractor muscle.

.

The process of torsion and its consequences may be summarized thus:

(a) The pretorsional presence of a planispirally coiled visceral hump with a mid posterior shell sinus or slit.

(b) Regulative shifting of the leavy visceral mass of the larvae towards an arrangement of equilibrium for their balancing posture in the pelagic environment and the adaptive dominant development of the right larval dorsoventral retractor muscle.

(c) Positively selective genetic stabilization of the precociously accelerated development of threat right larval retractor i.e. establishment of the first phase of torsion (90%).

(d) The predominant development of the pretorsional right (or the retarded development of the pretorsional left), pallial organs due to respiratory currents.

(e) Regulation of the divergent axial and balanced conditions between the visceral hump and the head foot respective of plantigrade movement which is by differential growth processes in metamorphosing animals. That is the second phase of torsion of approximately another 90^o.

(f) This regulation includes and is combined with the development of the second (post torsional right) set of pallial organs including the retractor muscle, the mantle or shell sinus or slit enabling the new paired inhalant respiratory current to be directed symmetrically from the latero-frontal areas towards the anterior-medio-dorsal area.

In the larval stages of gastropods the internal organs undergo twisting as the animal develops. For example, the digestive tract is simply U-shaped but during torsion it completes a 150^o twist that brings the anus up over the mouth. This twist causes other organs on one side of the body to be compressed and fail to develop while the nervous system contorts to a figure eight.

Among other groups after the torsion there is a counter clockwise detorsion, moving the pallial cavity to a position on the right side of the body, behind the heart. This situation can be found among the opisthobranchia (hind gill snails) and pulmonata (lung snails). In primeval snail groups the two main neural pathway run straight and parallel from front to back. After the torsion, in the prosobranch stage, those nerves are crossed, a situation referred to as chiastoneury. Those snail groups are also known as Streptoneura (crossed nerve snails). In contrary to that, after detorsion the nerves lie straight, and parallel again, which is why Opisthobranch and Pulmonate snails are grouped as euthyneura (straight nerve snails).

(g) Systematics:

There is controversy about the phylogenetic position of some gastropod groups. The relationship between the groups with each other remains unclear. The respiratory and neural systems of gastropods are used in the systematic arrangements of snail groups. Gastropoda is divided into:

(a) Prosobranchia
(b) Opisthotoranchia
(c) Pulmonata

Starting from the torsion process, two different adaptive phases in many orders of gastropods evolved. Recent gastropods appear to belong to different lines having achieved pallial symmetry independently thus:

(i) The most conservative stock – also with respect to shell structure, possesses paired pallial organs and paired dorso ventral rectractor bundles in the adults. A common example is *Haliotis*.

(ii) The predominance of the post torsional right rectractor muscle and helicoids coiling result in the loss of the left rectractor muscle.

(iii) The hypertrophy of the right retractor muscle and helicoids coiling which leads to the suppression of the left retractor as well as to the right set of pallial organs e.g. *Trochacea.*

(iv) The reason for the change in water currents and the abandonment of the right set of the pallial organs remains enigmatic.

(v) The hypertrophy of the post torsional right excretory – genital duct causes the pronounced asymmetry with the loss of the right set of pallial organs e.g. *Neritacea.*

(vi) The asymmetry of the pallial organs is due to a paedomorphous retention of the larval asymmetry prior to the regulation in the plantigrade stage. Owing to a long lasting planktotrophic larval life, the development of the right pallial organs as well as of the right retractor muscle was more and more retarded.

The snail groups within the class gastropoda thus include snails, limpets, slugs, whelks, conchs, periwinkles, sea slugs, sea hares, sea butter flies, etc. These animal goups are basically bilaterally symmetrical.

All the gastropods have common features i.e. the head, tentacles, and at some stage of their development they show torsion.

(a) Prosobranchia (Milne-Edwards, 1848) are gastropods in which the adult shows torsion, the visceral loop is in figure 8 the gills are anterior to the heart. Common examples are *Haliotis, Patella, Buccinium*, etc.

(b) Opisthobranchia are gastropods in which the adults show detorsion by a process of untwisting e.g. *Aplysia*, *Doris*, etc.

(c) Pulmonata are gastropods in which the adult nervous system becomes symmetrically developed following torsion by a process of shortening of the abdominal commissures e.g. *Achatina*, *Lymnaea* *Bulinus*, *Biomphalaria*, etc. (see table 1)

Table 1 : Comparative Study of the Morphology of the 3 Sub-Classes

S/n	Characters	Prosobrachia	Opisthobranchia	Pul
1.	Torsion	The visceral mass exhibits torsion to a maximum degree	Undergoes detorsion with Gut straight	Cor Gut
2.	Ctenidia	Primitive forms have two gills. Advanced forms have one i.e. monopectinate	One or more or none secondary anal gills may be present	Ctn
3.	Mantle Cavity	The mantle cavity is anterior and hence the name Prosobranch. The opening is wide.	When present cavity opens on the right side by a wide aperture	The ante is r pne roo and bei lung
4.	Auricles/Kidne	Two auricles and	One auricle and one	One

	ys	two kidneys present	kidney present	kidı
5.	Operculum	Operculum present	No operculum	No
6.	Nerves	Figure 8 due to torsion	Straight due to detorsion	Stra brai
7.	Reproduction	Sexes are separate free living veliger larvae is present	Hermaphrodite veliger larvae present	Her larg Dev dire

h. THE CLASSIFICATION OF GASTROPODA

Phylum **Mollusca**

Class **Gastropoda (Cavier, 1745)**

Sub class: Prosobranchia (Milne-Edwards, 1848)
Order I: Archeogastropoda (Thiele, 1925)
Sub order: Vetigastropoda nor
Sub order: Decoglossa (Troschei, 1866)

Sub order: Neritopsina (Cox, 1960)

Order II: Caenogastropoda (Cox, 1960)
Sub order: Mesogastropoda (Thiele, 1925)
Sub order: Neogastropoda (Thiele, 1929)

Sub class: Pulmonata (Cavier, 1817)
Order: Archaeopulmonata (Morton, 1955)
Order: Basommatophora (keterstein, 1864)
Order: Stylommatophora (Schmidt, 1855)

Sub class: Gymnomorpha (Slvini-Plawen, 1970)
Order: Onchidiida (Rafinesque, 1815)
Order: Soleolifera (Simrota, 1908)
Order: Verohicellida (Gray, 1840)
Order: Rhodopida (Fischer, 1883)

Sub class: Opisthobranchia (Milne-Edwards, 1848)
Order: Pyramidellimorpha (Freter, 1979)
Order: Cephalaspidea (Fischer, 1883)
Order: Anaspidea (Fischer, 1883)
Order: Saccoglossa (Thering, 1876)
Order: Ascoglossa (Bergh, 1879)
Order: Notaspidea (Fischer, 1883)
Order: Nudibranchia (Ducrotay-Blainerille, 1814)
Order: Anthobranchia (Ferussac, 1819)

Difficulties exist when one wants to differentiate among gastropod species. Brown (1966) compared the copulatory organs of some species and found significant differences in the dimensions of the preputium and penis sheaths. Wright and Rollinson (1979) examined the possibility of using iso-electric focusing techniques in differentiating snail species and they found no clear enzyme type for certain characters. However these studies made enough in road to allow them suggest that biochemical taxonomic methods could be used to effectively differentiate the species. Jelnes (1979) using electrophoresis came to similar conclusions. Other methods that show promise are distribution of micro-sculpture on the shell, presence or absence of aperture bands, number of whorls, and characters of the radula.

Biometric multivariate analyses of phenotypic characters; stepwise discriminant analysis of morphological characters of the shell and pairwise discriminant analyses are statistical tools that have been used in snail taxonomical studies. In these analyses, shape of shell, length of shell diagonal, width of shell at the level of the last suture, length of body whorl above the aperture and width of the shell are the factors that could be used to load the characters important in separating the Genera and species.

i. ECOLOGY OF GASTROPODS

Gastropods live in every conceivable habitat on earth. They are found in virtually all habitats ranging from high mountains to deserts, and to the rain forests. They are also found from the tropics to high altitudes. Many snails are benthic and mainly epifaunal, but some are planktonic. There are many microspecies of gastropods too numerous to count.

It has also been found that the relationship between snails and plants are often mutualistic deriving a lot of benefits both ways. The chemicals produced by plants often attract snails while the snails themselves develop strategies for locating and exploiting the plant species. It is now known that plants derive two major benefits from the snails eating them (especially dead plant materials) namely:

(a) Removal of the dead tissues minimizes the risks of living tissues becoming invaded by pathogens.
(b) The consumption of this material by snails increases the turnover rate of potentially growth limiting inorganic and organic nutrients for the plants.

In further understanding the ecology of snails, the quantitative parameters which determine the interactions between the snails and the non living components of their environment are important to be known. These interactions determine the number of species available in the given habitat at any given time.

Each species of snail in each habitat is known to be distributed according to the resource patterns in the environment. Thus each habitat has a theoretical maximum number of individuals that it can support a phenomenon referred to earlier as the carrying capacity of the habitat.

The development and growth of gastropods are influenced by the environment in which they live. Various environmental cues, endocrine and neuroendocrine reponse mechanisms regulate the growth and reproduction in snails. These are known to be useful in snail farming where the goal is to optimize the production of edible snail species.

a) Fe**eding:** All snails are from one trophic level- primary consumers that play important roles in the functioning of the ecosystems. Quantitative studies have shown that some activities of the snails are imperative for the ecosystem dynamics to operate smoothly (Mason, 1970). The food choices of snails are influenced by the qualitative composition of the foods, the qualitative availability and the nutritional needs of the snails (Calow, 1971). There is a positive correlation between food availability and its proportion in the diet (Okafor, 1990; Speiser, 2001). Diet itself has been found to vary seasonally and is shown to be specific to age (Baur, 1992). Snails feed on an assortment of plant and animal species including algae, bacteria, and fungi. They feed on whole plants and infusions as well as animal remains, food remains, while some are carnivorous, feeding on other animal species including other snails or their eggs. Snails are not everything selective and eat almost available in their environment. In general, they prefer soft and digestible vegetable. Tough plants and algae are consumed as long as they are able to grasp their pieces as food with their radula. They consume litters on the forest floors where they act as bioconverters that help recycle nutrients Studies show that the apple snails are mainly herbivorous but some exhibit cannibalistic behaviour e.g. *Marisa conuarietis*

. Most snails are opportunistic feeders eating even fish, frogs, crustaceans and insects. They also cause deforestation in collection of food, this when superimposed on long pre reproductive periods, leads to low fecundity in gastropods (Egonmwan, 2004).

a. DISTRIBUTION

A major factor that affects the distribution of gastropods is the presence of calcium carbonate which the snails use to build their shells (Dennis, 1985), and for muscular movement. Most of the gastropods live on land, many live in the seas, others live in the freshwater and estuarine habitats. All are secretive in habit and hide under leaves, aquatic macrophytes and litters. They are active mainly during the night time and voraciously feed at this time.

In many tropical parts of the world, many snails feed on lichens e.g. *Bulimulus*, some live on trees e.g. *Orthalicus*, and generally gastropods show a wide form of ubiquitous ness. Freshwater forms prefer to live in quiet water and among weeds and other aquatic macrophytes. Many prefer inhabiting swift flowing water and others enjoy living on stones and pebbles. The marine forms live in a wide assortment of microhabitats. Most are found hiding under rocks, in and around coral reef or on sandy substratum. A few of the marine snails live in the open sea. Wilbur (1933) showed that gastropods thrive mainly in the coastal zone of the marine habitat. Tropical waters have the richest diversity of gastropod species and in the warn waters, the most colourful species are found. Colder waters have fewer species. Most Marine snails are plant feeders, feeding on live vegetable matters and decaying plant tissues. A few are carnivorous and feed on other mollusks.

The effects of some ecological factors on snail growth and distribution are difficult to assess as they may be both of a direct and an indirect nature. Studies show that snails have distributional patterns in nature which strongly correlate with the distribution of specific aquatic macrophytes for freshwater species (Pimentel and white, 1959; Sturrock, 1974). It has also been found that the relationship between snails and plants are often mutualistic deriving a lot of benefits both ways. The chemicals produced by plants often attract snails while the snails themselves develop strategies for locating and exploiting the plant species. It is now known that plants derive two major benefits from being eaten by the snails (especially dead plant materials) namely:

(i) Removal of the dead tissues minimizes the risks of living tissues becoming invaded by pathogens and damaged by toxins.
(ii) The consumption of the material by snails increases the turnover rate of potentially growth limiting inorganic and organic nutrients for the plants.

In further understanding the ecology of snails, the quantitative parameters which determine the interactions between the snails and the non living components of their environment are important to be known. These interactions determine the number of species available in the given habitat at any given time.

Each species of snail in each habitat is known to be distributed according to the resource patterns in the environment. Thus each habitat has a theoretical maximum number of individuals that it can support a phenomenon referred to earlier as the carrying capacity of the habitat.

b. REPRODUCTION:

Most gastropod molluscs have separate sexes, but some groups are hermaphroditic. Most hermaphroditic forms do not normally engage in self-fertilization. Basal gastropods release their gametes into the water. Derived gastropods use a penis to copulate or exchange spermatophores and produce eggs. The egg matures and hatches into a trochophore larva that transforms into a veliger which later settles and undergoes metamorphosis to form a juvenile snail.

The development and growth of gastropods are influenced by the environment in which they live. Various environmental cues, endocrine and neuroendocrine response mechanisms, regulate the growth and reproduction in snails. These are known to be useful in snail farming where the goal is to optimize the production of edible snail species. Some of the factors that affect growth and reproduction are light, photoperiod, and temperature. Photoperiod specifically affects egg- laying. It is observed that snails receiving 9h of light per day, do not lay eggs while reproductively active snails continue to lay eggs when transferred from the field to controlled long-day environment (L:D 18:6). Exposure of similar snails to short- day period regime (8 h / day) caused a depression in spermatogenesis. Changes in temperature have similar effects on gametogenesis.

The role of endocrine secretions has been well elucidated. Distinct neurosecretory cell types, found in the nerve ganglia acting with steroids in the ovotestis help to metabolize androsteredione and synthesize steroid hormones like ecdysteroids that accelerate the production of spermatozoa in males or stimulate oogenesis in the females.. Self fertilization is a common mode of reproduction and mating is often absent while ovposition results from the transfer of stimulatory substances with origin in the reproductive tract during mating. Snails are hermaphrodites. Although they have both male and female reproductive organs, they must mate with another snail of the same species before they lay eggs. Some snails may act as males one season and as females the next. Other snails play both roles at once and fertilize each other simultaneously. When the snail is large enough and matures enough, which may take several years, mating occurs in the late spring or early summer after several hours of courtship. Sometimes there is a second mating in summer. In tropical climates, mating may occur several times a year. In some climates, snails mate around October and may mate a second time 2 weeks later. After mating, the snails can store sperm received for up to a year, but it usually lays eggs within a few weeks. Snails are sometimes uninterested in mating with another snail of the same species that originated from a considerably distant place. For example, some *H. aspersa* from southern France may reject *H. aspersa* from northern France.

Snails need soil at least 2 inches deep in which to lay their eggs. For H. ***pomatia***, the soil should be at least 3 inches deep. Keep out pests such as ants, earwigs, millipedes, etc. Dry soil is not suitable for the preparation of a nest, nor is soil that is too heavy. In clay soil that becomes hard, reproduction rates may decrease because the snails are unable to bury their eggs and the hatchlings have difficulty emerging from the nest. Hatchability of eggs depends on soil temperature, soil humidity, soil composition, etc. Soil consisting of 20% to 40% organic material is good. Maintaining the soil moisture at 80% is optimal. Researchers remove eggs immediately after they are deposited, for counting, then keep them on moist cotton until the eggs hatch and the young start to eat. Snails lose substantial weight by laying eggs. Some do not recover. About one-third of the snails will die after the breeding season.

Snail eggs measure from about 3 - 5mm in diameter and have a calcareous shell with high yolk content. The eggs are laid in holes dug out in the ground. (Data varies widely on how long after mating snails lay eggs.) The snail puts its head into the hole or may crawl in until only the top of the shell is visible; then it deposits eggs from the genital opening just behind the head. It takes the snail 1 to 2 days to lay 30 to 50 eggs. Occasionally, the snail will lay about a dozen more a few weeks later. The snail covers the hole with a mixture of the slime it excretes and dirt. The slime, which the snail excretes is to help it crawl and to help preserve the moisture in its soft body. It is a glycoprotein similar to egg white.

Fully-developed juvenile snails hatch about 3 to 4 weeks after the eggs are laid, depending on temperature and humidity. Birds, insects, mice, toads and other predators take a heavy toll on the young snails. The snails eat and grow until the weather turns cold. They then dig a deep hole, sometimes as deep as 1 foot, and seal themselves inside their shell and hibernate for the winter. This is a response to both decreasing temperature and shorter hours of daylight. When the ground warms up in spring, the snail emerges and goes on a binge of replacing lost moisture and eating.

H. aspersa* egg is** white, spherical, about 3mm in diameter and is laid 5 days to 3 weeks after mating. (Data varies widely due to differences in climate and regional variations in the snails' habitats.) ***H. aspersa lays an average of 85 eggs in a nest that is 1- to 1 ½-inches deep. Data varies from 30 to over 120 eggs, but high figures may be from when more than one snail lays eggs in the same nest.

In warm, damp climates, these snails lay eggs as often as, once a month from February through October. This depends on the weather. Mating and egg-laying begin when there are at least 8 hours of daylight and continue until days begin to get shorter. In the United States, longer hours of sunlight that occur when temperatures are still too cold will affect this schedule, but increasing hours of daylight still stimulate egg laying. If warm enough, the eggs hatch in about 2 weeks, or in 4 weeks if cooler. It takes the baby snails several more days to break out of the sealed nest and climb to the surface. ***Snails*** mature in about 2 years. In central Italy, ***H. aspersa*** hatches and emerges from the soil almost exclusively in the autumn. If well fed, and not overcrowded, those snails that hatch at the start of the season will reach adult size. They form a lip at the edge of their shell by the following June. If you manipulate the environment to get more early hatchlings, the size and number of snails that mature the following year will increase. In South Africa, some ***H. aspersa*** mature in 10 months, and under ideal conditions in a laboratory, some have matured in 6 to 8 months. Most of ***H. aspersa's*** reproductive activity takes place in the second year of its life.

By contrast, one giant African snail**, *Achatina achatina***, lays 100 to 400 elliptical eggs that each measure about 5mm long. Each snail may lay several batches of eggs each year, usually in the wet season. They may lay eggs in holes in the ground like ***H. pomatia***, or lay eggs on the surface of a rocky soil, in organic matter, or at the base of plants. In 10 to 30 days, the eggs hatch releasing snails about 4mm long. These snails grow up to 10mm per month. After 6 months, the ***Achatina achatina*** is about 35mm long and may already be sexually mature. Sexual maturity takes 6 to 16 months, depending on weather and the availability of calcium. This snail lives 5 or 6 years, sometimes as many as 9 years.

Some of the factors that affect growth and reproduction are light, photoperiod, and temperature. Photoperiod specifically affects egg laying. It is observed that snails receiving 9h of light per day, do not lay eggs while reproductively active snails continue to lay eggs when transferred from the field to controlled long-day environment (L:D 18:6). Exposure of similar snails to short- day period regime (8 h / day) caused a depression in spermatogenesis. Changes in temperature have similar effects on gametogenesis.

The role of endocrine secretions has been well elucidated. Distinct neurosecretory cell types, found in the nerve ganglia acting with steroids in the ovotestis help to metabolize androsteredione and synthesize steroid hormones like ecdysteroids that accelerate the production of spermatozoa in males or stimulate oogenesis in the females.. Self fertilization is a common mode of reproduction and mating is often absent while oviposition results from the transfer of stimulatory substances with origin in the reproductive tract during mating.

c. VARIOUS FACTORS AFFECTING SNAIL DISTRIBUTION

Factors affecting the distribution of gastropods include the nature of the substratum, certain physical, chemical and biological factors. Other factors include: mortality, diversity, turnover, disturbance, and productivity. It has been observed that the snails' responses to these factors are species specific and each species is able to maintain their populations within certain limits of tolerance.

A habitat can sustain a certain maximum number of individuals (the carrying capacity) which is determined by the availability of resources e.g. food quality, as well as space. The density of species living in a relatively stable environment fluctuates around the unstable environments and may never approach the carrying capacity, they fluctuate severely. In unstable environment there is regular high mortality caused by the periodic unfavourable conditions.

The effects of some ecological factors on snail growth and distribution are difficult to assess as they may be both of a direct and an indirect nature. Studies show that snails have distributional patterns in nature which strongly correlate with the distribution of specific aquatic macrophytes for freshwater species (Pimentel and white, 1959; Sturrock, 1974). It has also been found that the relationship between snails and plants are often mutualistic deriving a lot of benefits both ways. The chemicals produced by plants often attract snails while the snails themselves develop strategies for locating and exploiting the plant species. It is now known that plants derive two major benefits from the snails eating them (especially dead plant materials) namely:

(a) Removal of the dead tissues minimizes the risks of living tissues becoming invaded by pathogens.

(b) The consumption of this material by snails increases the turnover rate of potentially growth limiting inorganic and organic nutrients for the plants.

In further understanding the ecology of snails, the quantitative parameters which determine the interactions between the snails and the non living components of their environment are important to be known. These interactions determine the number of species available in the given habitat at any given time.

Each species of snail in each habitat is known to be distributed according to the resource patterns in the environment. Thus each habitat has a theoretical maximum number of individuals that it can support a phenomenon referred to earlier as the carrying capacity of the habitat.

d. LIFE CYCLE & LIFE BUDGET SUDIES:

Other important things involved in the ecology of snails include growth rates, key factor analyses, capacity for increase, net reproductive rate that constitute Life Budget studies. Iheagwam and Okafor (1984) collected long term data on the numerical and production changes in *Bulinus globosus* and *Lymnaea natalensis* (gastropods). They followed the population dynamics and production of many consecutive cohorts of the snails and found roles for density and habitat quality in controlling reproductive rates in the gastropods. They concluded that horizontal (cohort) life tables were statistically acceptable in such studies and encouraged its use in the study of other species of gaqstropods.

To calculate cohort production, the life cycles are often divided into time intervals while for production in the snails it will be subdivided into age intervals. Such life tables are prepared by following the survival of consecutive cohorts of snails over their life span. Egg production estimates are used to calculate the net reproductive rates (R_O). From such life tables information on age specific survivorship rates (L_X), age specific fecundity rates (M_X) and mortality rates(qx) are also obtained for each species. Analysis of the brood years performances usually show a positive linear correlation. The degree of linearity of the data collected often suggests how the carrying capacity of the habitat is declining.

Survivorship data suggest the type of regulation of the brood size which in itself narrows the number of survivors at maturity. The survival pattern when integrated with the reproductive rates often assesses the success or failure of each brood in replacing its initial numbers during its reproductive span in a given population.

Various studies on the ecology of gastropods threw up the conclusion that snails in nature suffer heavy mortality during production even though that the R_{Os} suggest tremendous production potentials. The mean generation time (T) calculated as T = å $\frac{LxMx}{Ro}$ shows how long the snails are expected to live while the age specific mortality rate (q_x) can also be derived using the data.

Okafor (1990a) showed that seasonal fluctuations occur in snail density and this correlates positively with the rhythm of rainfall. Further, Anya and Okafor (1990a) added that topographical water types affected snail ecology tremendously. Another fact revealed was that conditions prevailing during the early dry seasons are more favourable to the snails than those prevailing during the late rainy season.

In other similar studies, Anya and Okafor (1990b) suggested that snail abundance depended on such environmental factors as temperature, altitude, current speed, turbidity, shading and nature of the substratum. Okafor in 1984 had suggested that there was high positive correlation between P^H, Calcium ions, Magnesium ions, and snail abundance. Anya and Okafor (1991) showed a negative correlation between humic acid and snail abundance, distribution and density. From all those later studies we gather that the snails have a wide tolerance range for many of the factors and that the interactions of these factors also result in definite community structuring for the snails. Thus most of the snail communities were competitively loosely packed. With this form of distribution, the relative abundance follows the distribution of resources, with each species occupying its fundamental niche. In real life, within species rich communities, the average niche width and niche overlap declines.

The snails are mostly hermaphroditic in nature, this allows for self fertilization and parthenogenesis, Aphallic species often occur from African species. Snails also survive in the environment because of the nature of their shells.

5. IMPORTANT ROLES OF SNAILS IN HUMAN AFFAIRS

(a) EFFECTS OF SNAILS ON THE ECOSYSTEM:

(h) **Feeding:** All snails are from one trophic level-primary consumers that play important roles in the functioning of the ecosystems. Quantitative studies have shown that some activities of the snails are imperative for the ecosystem dynamics to operate smoothly (Mason, 1970). The food choices of snails are influenced by the qualitative composition of the foods, the qualitative availability and the nutritional needs of the snails (Callow, 1971). There is a positive correlation between food availability and its proportion in the diet (Okafor, 1990). Diet itself has been found to vary seasonally and is shown to be specific to age (Baur, 1992). Snails feed on an assortment of plant and animal species including algae, bacteria, and fungi. They feed on whole plants and infusions as well as animal remains, food remains, while some are carnivorous, feeding on other animal species including other snails or their eggs. Snails are not selective and eat almost everything available in their environment. In general, they prefer soft and digestible vegetable. Tough plants and algae are consumed as long as they are able to grasp their pieces as food with their radula. They consume litters on the forest floors where they act as bioconverters that help recycle nutrients Studies show that the apple snails are mainly herbivorous but some exhibit cannibalistic behaviour e.g. Marisa conuarietis

Two techniques are used to devour other snails: attacking the prey by introducing the proboscis into the aperture of the victim and eating the flesh or by gnawing holes into the victim's shell in several stages with the radula and eating the exposed tissues. Most snails are opportunistic feeding on even fish, frogs, crustaceans and insects. Deforestation and collection for food, superimposed on long pre reproductive periods lead to low fecundity (Egonmwan, 2004).

Snails therefore feed on an assortment of plant and animal species including algae, bacteria, and fungi. They feed on whole plants and infusions as well as animal remains, food remains, while some are carnivorous, feeding on other animal species including other snails or their eggs. Snails are not selective and eat almost everything available in their environment. In general, they prefer soft and digestible vegetable. Tough plants and algae are consumed as long as they are able to grasp their pieces as food with their radula. They consume litters on the forest floors. Carnivory in some Taxa involve grazing on colonial animals. Some others engage in hunting their preys.

Two techniques used in devouring other snails include attacking the prey by introducing the proboscis into the aperture of the victim and eating the flesh; or by gnawing holes into the victim's shell in several stages with the radula and eating the exposed tissues. Most snails are opportunistic, feeding on even fish, frogs, crustaceans and insects.

(i) **Predators:** Snails are a popular food source for various animals like birds, turtles, tortoise, fishes, insects, crocodiles, snakes, snail kites, and lizards. Mammals including man also prey upon snails. Table 2 gives a list of some groups identified as predators of snails.

TABLE 2: LIST OF SNAIL PREDATORS

Names of the predators of their types	
Insects	- Sciomyzidae

	□ *Odonata* □ Water bugs □ Lampyridae (fire flies) □ Hydiophillidae □ *Solenopsis* sp □ Ground beetles □ Leeches □ Decollate snails □ Predatory caterpillars(*Hyposmosoma malluscivora)*, *Eciton*, etc □ *Ochromusca* sp
Fishes	□ H
Amphibians	□ *Rana pipiens* □ Various salamanders
Crocodilians	□ Alligator □ *Crocodylus* □ *Paleosuchus sp* □ *Caimau* sp
Reptilia	□ Snakes □ lizards
Flat Worm	□ *Leucochloridium paradoxum*
Crayfishes	□ *Procambarus* sp □ Crustaceans
Mammals	□ Rice rats □ Water rats □ House rats □ Other mammals

Birds	☐ Various ducks ☐ Storks ☐ Kites ☐ Other birds.

(iii) Nutrient recycling

From this stand point, snails play important roles in the recycling of materials from the producers to the consumers' levels of the food chain in an ecosystem. Due to their litter feeding habits they recycle minerals from plant tissues to the soil thus improving soil fertility.

Snails are endowed with a lot of enzymes including cellulases which allows them to play a major role in primary decomposition of plant materials. The mucoproteins in snail faeces and slime are useful in binding soil particles thus according to Newell (1967) they help in the development of crumb structure of the soils.

The burrowing activities of snails like those of annelids permit easy air movement inside the soil. Malek (1982) stated that the presence of food increases the biotic potential of snails in that more eggs are laid whole maturity attainment is rapid with a gross enhancement of growth. He also showed that snails help pollute their habitats by dumping waste materials, by the accumulation of large quantities of organic materials of vegetables or animal origin. They also dump industrial wastes into the habitats. It has been reported that cases of helicine snail poisoning have been found in man when noxious content of the snail alimentary tracts were not removed before the snails are cooked. Such wastes contain large granules of oil, acids, mineral contents, and poisonous wastes all of which also reduce the snail populations when their levels exceed the tolerance limit.

(iv) Factors affecting snail populations

Four environmental factors affect snail populations viz

Water levels.
Current speed
Temperature/shades
Elevation.

(b) Snails as Biological Indicators of Pollution and age of the environment:

Palaeoecologists have since noted the presence of gastropod remains in geological sediments and included these in the interpretation of geological age of past environment and perturbations (Crisman, 1978). The shells of gastropods are preserved well and are located in calcareous sediments. These fossils provide information regarding water and soil chemistry, lake trophic state, variations in oxygen distribution and concentrations over time, and the changes in water levels following geological times.

Studies show that molluscs generally do not inhabit strong acidic waters and their shells are rarely preserved in weakly acidic environments. In freshwaters Okafor (1990) traced the relationship between humic acids and snail distribution and abundance and found a highly negative correlation. In that study, it was observed that when mineral ions form chelate complexes with humic acids, snails begin to establish in such habitats. Studies with sedimentary core sampling for molluscan analysis have been used to identify areas that were the lower limits of littoral zones in the past geologic times. The value of snails in applied palaeoecology has been further demonstrated by using carbon dating technologies. The pulmonate snails which breathe atmospheric oxygen were found to be completely replaced by clams and prosobranch snails as a result of eutrophication of their aquatic environment. This was the first indication of the possibility of using snails as valuable palaeoindicators of human impacts on aquatic systems.

Soils normally contain at least trace quantities of the heavy metals e.g. copper, lead, zinc, Nickels, Cadmium and mercury. In some areas, levels of these metals have been substantially increased from mining waste tips from industrial fallouts e.g. from smelting industries or by lead derived from car exhausts and by the use of non biodegradable pesticides (i.e. insecticides, herbicides and molluscicides). Snails are often used to monitor the concentrations of these metals because when they reach certain levels in the environment they become toxic to plants and animals including snails. Cavalloro and Ravora (1966) suggested that the gastropods are good biological indicators of manganese contamination in terrestrial environments. A study of the concentration of nine metals in the tissues of A. ater from locations close to, or far away from highways in Canada by Rophazard D'auria (1980) made them to suggest that these molluscs, might be useful as bio monitors for assessing environmental quality. These gastropods were particularly suitable as they are widely distributed in rural and urban environments. They tend to have specific home ranges and habitat preferences

The distribution of metals in the tissues of these slugs collected from relatively unpolluted sites and those collected from sites near disused lead and zinc mines where manganese levels are so high were compared (Irland, 1979). The comparison showed that all metals, except manganese were higher in tissue concentrations in the slugs found in the polluted areas when the concentrations in the mollusks where compared with situation in other invertebrates, it was found that molluscs accumulated higher concentrations of mental ions than other groups of invertebrates. Marigomez et al; (1986) however observed that the higher concentrations of these metals in the tissues did not translate to higher mortalities thus making the molluscs potential bioindicator tools for the environmental pollutions with metals Greville and Morgan (1990) reached similar conclusion and stated that the intrinsic variability in metal levels increase the likelihood of using gastropods as biological monitors of metal contamination in terrestrial environment.

Hydrogen sulphide and methage are produced during anaerobic bacterial decomposition and when these substances come into contact with the upper oxygenated layers, they produce deleterious effects on snail. Similarly, high concentrations of zinc, copper, cadmium or lead ions, are highly toxic to snails at levels above 1.0ppm. At intermediate levels (0.05 – 1.0ppm), they produce stress. Thus snail distribution and abundance should indicate the presence or absence of these pollutants in the environment. Having this knowledge helps in protecting human health since most of the environmental pollutants constitute serious public health hazards.

(b) SNAILS AS HUMAN FOOD:

Domestication of wild species has been particularly popular in the West African sub-region where "bushmeat" is a most important dietary item. The giant African land snails have been variously studied, especially in Ghana and Nigeria as they are avidly consumed. Studies on the various aspects of biology and ecology as well as capture rearing of the snails have been going on in the Department of Zoology of the University of Ghana for over 25 years (Hodasi, 1973). These snails have been found to provide alternative sources of animal protein complementing that from other foods.

The edible giant snails in Africa belong to two genera: Achatina (Lamarch) and Archachatina (Albers). Species of both genera are common south of the Sahara. Achatina achatina is the most common species in West Africa whereas Archachatina marginata occurs more in Southern Nigeria and in the Congo basin (Hodasi, 1984). The snails are collected in large numbers by rural people and are marketed fresh or smoke dried. During the rainy season, the snails are cheap and abundant.

In 1961, Mead reported from the 1919 paper of one Scientist called Lang that the snails were avidly consumed in. Belgian Congo and that Japanese roasted their snails and consumed them with Soya sauce. This is in addition to several reports of the use of snails as food in Europe, South America and other parts of Africa. Our bodies require a constant supply of energy and raw materials to maintain vital functions and to rebuild tissues worn out in the day to day processes of living. Snails may not be an energy giving food item but it is surely a mineral and protein giving food supplement. It is common knowledge that in addition to calories, we need specific nutrients in our diet, such as proteins, vitamins, and minerals. People in richer countries often eat two much meat, salt and fat and too little fibre, vitamins, trace minerals and other components lost from highly processed foods. In poorer countries, people often lack specific nutrients because they cannot afford more expensive foods such as meat, fruits, and vegetables that would provide a balanced diet. It is in these latter situations that snail consumption plays very important roles in mineral and protein supplementation.

The nutrient composition of raw snails (per 100 grams of edible portion), according to information from the proximate analyses of snail meat is:

Energy	(kcal):	80.5
Water	(g):	79

Protein	(g):	16
Availablecarbohydrates(g):		2
Fibres	(g):	0
Fat	(g):	1
Magnesium	(mg):	250
Calcium	(mg):	170
Iron	(mg):	3.5

Vitamin C (mg): 0

Improved nutrition and food sufficiency are two of the main priorities in providing food and nutritious products. Several studies have shown that the protein content of snail meat is higher than in livestock and guly slightly less than in poultry and giant rats. The fat content of snail meat is much lower than in Mammalian or poultry flesh. Snail meat is rich in calcium with an exceptionally high content of iron (measuring up to 12.2mg/100g). The energy content of snail meat is about 80k/cal/100g. it also contains high levels of phosphorus while being low in sodium and cholesterol.

In France, it has been suggested that snails be used instead of precious beef in animal feeds and in preparing bacteriological culture plates. As far back as 1944, a nutritionist known as Aguayo asked people to return to the consumption of snails. In the United States of America, records show that *Helix pisana* (Theba) were being sent from Sicily for consumption and a report from the U.S. Bureau of Entomology and plant Quarantine revealed that about 721 cases and 24, 969 baskets of living snails were once imported into New York between May, 1947 and April, 1948 (Mead, 1951).

Further reports suggested that for a number of years, almost exactly one million pounds of snails were imported annually into the U.S.A. just from Morocco (Heifer, 1949). With approximately fifty snails to the pound the total number of snails would be close to 50 million or in linear measurement, close to a thousand miles of snails placed head to tail.

Who would have guessed that such an appetite for snails existed just in U.S.A. Human use of land snails as food ranges from Native Americans consumption of *Oreohelix* sp in the Western States to fine dining escargots (*Helix* spp) in urban areas. For France (another country where snails are avidly consumed) the amount of snails eaten surpass the U.S. figures by about fifteen times or greater.

In West Africa, especially in Ghana, various species of snails especially the Tiger snails are eaten. There the snails actually form the largest single item of animal protein in the diet of the common people. It was in that country that people can eat snails after boiling in water or on hot coals, removing the shell, freed of the soft visceral mass, chopped, and combined with starchy dishes such as cassava or cocoyam, and palm oil or pea nut oil to form their standard meal of fufu.

In Nigeria, snails are eaten as food especially in the rain forest belt. The nutritive value of one species of snails eaten in Nigeria (*Achatina*) was found to correlate with what was already known for snail meat. For example, Wilson et al, (1975) showed that protein is a major component of snail body, exceeded only by water thus snail meat was advocated for use in Kwashiokor cases. Due to the iron contents, snail meat is often recommended in cases of anaemia. Quantitative measurements put protein in snail meat at $57.08 \pm 5.99\%$ per g dry wt. Russel – Hunter (1968) while analyzing the meat from either *Achatina* or *Helix* put the protein value at 85.5%. He found that there is an abundance of fat soluble vitamins (Vit. A, D, E and K). Also found are Linoleic acid, Linolenic acid and Arachidonic acid all essential fatty acids (Ajayi, et al., 1974). Snails are also found to contain a lot of Lecithins. Probably because of these nutritive facts, snails are eaten in large numbers in Italy, South America, Malaya, Thailand, Japan, Africa and China.

From the foregoing it seems that many agree that snail is rich in nourishment, good as a tonic and will give excellent dishes in vinegar mixtures, sesame bean mash, bean mash mixture, broiled with soy, coquille or stew.

EDIBLE SNAILS

My work had exposed me to many aquatic and terrestrial snails and edible species can be found in both environments. Such snails are widely distributed among the various genera and in many parts of the world. Snails are noted to be in the wild and are gathered by the very poor (especially women and children) from eating, and also for sale to urban dwellers. The afrotropical region of the world (housing the sub-Saharan Africa) harbours the largest number of land snails that are consumed by man and also the biggest known carnivores among the land snails (*Watelina cafra, Rhytididae*). *Archachatina marginata* is the largest land snails in the world and is a widely sought after species due to the size, distinct makings and lack of availability. They are more difficult to breed than other African snails.

They are found in the dense forest floors in the forest zones of West Africa. They are believed to have a 3 year breeding cycle which is longer than other snails. This fact, coupled with deforestation and snail picking for consumption has caused the numbers to dramatically fall over the last 20 years. Unfortunately, they are considered to be the most prized snail for eating followed by *Achatina achatina* and *Achatina fulica*.

This region (Afrotropical) has also the richest and most diverse terrestrial malacofauna. Some species of land snails were already known as early as 1758 as Linnaeus in his basic work validly described *Achatina achatina S.n., Bulla achatina* (an East American species). The knowledge of land snails of the African continent was first summarized for South Africa. Latter those of Angola were reported with those of East Africa by Beurguinat by 1889 and Von Martens in 1897 for N.E. Africa by Jickeli in 1874. In Central Africa, specifically in Camerouns the reports of Aclly in 1896 other sin the 20th century include Kobelt for N.E. Africa in 1909; in South West Africa, Connolly in

1925, 1931, at Angola and Namibia; Connolly and Degner, in 1934, worked in West Africa on Edible Land Snail. In Nigeria, Ajayi et al (1974); Akinnusi (1998), Hodasi (1973, 1982), Imevbore and Ajayi (1988), Okafor (1990, 2001) did intensive work on the biology, ecology and production of both land and freshwater snails.

The total number of land snails in Africa is estimated to be about 6000 and these were found to belong to about 34 families. Of these about 189 genera are fully identified; 80% of these are recognized as endemic to the continent. However, it is known that of all these only 3 families dominate and have their endemic genera all over Africa. These include, Subulinidae, Achatinidae and Urocyclidae.

The Achatinidae have about 23 genera of which 9 or 39% are endemic to West Africa. For the other 2 families, Subulinidae contains 21 genera with 6 or 18% are endemic to Africa. The zoogeographical analysis of land snails species isolated four areas of endemism in Africa namely;

(a) Southern Africa
(b) Northeast Africa
(c) Eastern Africa
(d) Central and West Africa (See table below).

The central and West African zone represents the largest continuous forest refugium in Sub-Saharan Africa. This area has the greatest numbers recorded in Cameroun and Gabon. These two countries still represent the single most important area in Africa in terms of diversity of land mollusks. There are other three minor forest refugia namely:

(a) Niger Delta (in Nigeria)
(b) In Ghana and Ivory Coast

(c) In Liberia and other parts of the tropical rainforest, and the Guinea Savannah, forest mosaic in Nigeria.

The population of edible land snails is high in the wild and because the people of Africa are beset with acute protein shortages many people tend to eat a lot of snails to assuage the acute shortage. The known nutritive value of the snails makes it unthinkable not to harness it for human benefits in view of the acute shortages. In most areas, the land snails and some aquatic forms (e.g. the prosobranchs) are collected indiscriminately by the rural people for their family consumption on a daily basis. However some collect them to sell in the local markets from where they find their way to the urban markets. Our studies show that edible snails are also consumed in Europe and North America.

In these places the snails are sold in shops and restaurants. The traditional European species of what they call "Escargots" is relatively small and slow at growing, so the demand for snail meat which has tremendously grown over the years has been partially satisfied by importation of the fleshy giant African land snails, "Escargot achatine".

The commercial success of farm ranching Escargot achatine may be appreciated by the observation that as far back as 1977, over 1,500 tons of canned snail meat, worth US $3 million was shipped into Europe from Taiwan alone. The giant African substitutes are said to be slightly inferior in quality to the European edible snails because it is "rubbery" and too often have "swampy-tastes". This quality disadvantage is usually addressed by flavouring the meat with garlic. British species are also well accepted as meat in most countries.

It is now known that edible snails can be farmed using different pen systems, Cages and Tanks. The snails have high biotic potentials and large net reproductive rates (Ro) and so have the capacity to thrive well in captivity. The can feed on a large variety of readily available plant food materials. It has been proven that rearing the snails in captivity helps in sustainable supply of snail meat to meet the increasing demand for snail meat and in conserving these animals. The adult grow up to 200mm and weigh about 250g.

THE KNOWN EDIBLE SNAIL SPECIES

In Africa and Europe, the following are edible snails. Besides the species listed there are many more species in many countries of the world.

Table: 3: List of Land Snail Families from Africa

S/No	Families	Genera in Africa	Endemic Genera
1.	Maizaniidae	3	3
2.	Cyclophoridae	4	3
3.	Pomatiasidae	2	2
4.	Hydrocenidae	1	-
5.	Veronicellidae	3	2
6.	Orculidae	2	2
7.	Chondrinidae	1	-
8.	Pupillidae	4	-
9.	Valloniidae	2	-

10.	Enidae	11	4
11.	Succineidae	3	-
12.	Puncidae	2	-
13.	Charopidae	25	25
14.	Arionidae	3	3
15.	Thyrophorellidae	1	1
16.	Vitrinidae	1	1
17.	Euconulidae	1	1
18.	Helicarionidae	1	-
19.	Ariophantidae	1	-
20.	Gymnarionidae	2	2
21.	Urocyclidae	50	50
22.	Aiilyidae	1	1
23.	Prestonellidae	1	1
24.	Ferussaciidae	2	1
25.	Subulinidae	21	14
26.	Achatinidae	13	13
27.	Ampuulariidae	10	8

(Afer Zilch, 1959-60)

Table 4: List of Fresh Water Snail Families from Africa

S/N		**Families**
	Subclass:	Prosobranchia: Contains about 30,000 species. They are mostly marine and possess gills.
1.		Neritinidae
2.		Patellidae
3.		Trochidae

4.		Helicinidae
5.		Fissurellidae
6.		Littorinidae
7.		Viviparidae
8.		Tympanotonidae
9.		Crepidulidae, etc.
	Subclass:	Pulmonata:
1.		Lymnaeidae
2.		Planorbidae
3.		Ancylidae
4.		Physidae
5.		Orthalicidae
6.		Bulimulidae
7.		Dryomaelidae, etc
	Subclass:	Opisthobranchia: Contains about 1,100 species and all are exclusively marine.
1.		Hydatina
2.		Philene
3.		Runcina
4.		Aplysia
5.		Doris and
6.		Eolis.

African fresh water systems have rich and abundant malacofauna. Most prosobranchs are edible and in addition to the terrestrial pulmonates, freshwater pilids, ampullarids and neritids are avidly eaten. In addition, the common edible snail species include:

- *Helix aspera*

- *Helix lucorum*
- *Helix pomatia*
- *Burtoa nilotica*
- *Caracolus marginella*
- *Cepaea horteusis*
- *Cepaea nemoralis*
- *Cernuella virgata*
- *Euglandina rosea*
- *Ligus intertinctus*
- *Megalobulimus oblongus*
- *Metachatina kraussi*
- *Oxychilus cellarius*
- *Theba pisana*
- *Veronicella sloanei*
- *Zachysia provisoria*
- *Limicolaria flammea*
- *Limicolria chlemys*
- *Limicolaria martenois*
- *Otala vermiculata*
- *Otala lacteal*
- *Cornus aspersa*
- *Limicolariopsis*
- *Perideriopsis*
- *Pseudoachatina*
- *Columna columna*
- *Columna leai*
- *Helix adanensis*
- *Helix anotostoma*
- *Helix melanonixia*
- *Helix thiessiana*

- *Helix nucuea*
- *Helix aperta*
- *Arianta arbustorium*
- *Perforatella incarnate*
- *Achatina achatina*
- *Achatina achatina albopicta*
- *Achatina achatina albopicta*
- *Achatina achatina allisa*
- *Achatina achatina balteata*
- *Achatina achatina craveni*
- *Achatina achatina dammarensis*
- *Achatina achatina fulgurate*
- *Achatina achatina monochromatica*
- *Achatina achatina togoensis*
- *Achatina achatina bayoli*
- *Achatina fulica*
- *Achatina glutinosa*
- *Achatina immaculate*
- *Achatina iostoma*
- *Achatina iredaleri*
- *Achatina mulanjensis*
- *Achatina murrea*
- *Achatina nyikaensis*
- *Achatina panthera*
- *Achatina passagei*
- *Achatina reticulate*
- *Achatina schinziana*
- *Achatina schweinfurthi*
- *Achatina semisculpta*
- *Achatinaslyvatica*

- *Achatina smithii*
- *Achatina stuhlmanni*
- *Achatina tincta*
- *Achatina tracheia*
- *Achatina varicose*
- *Achatina variegate*
- *Achatina vignoniana*
- *Achatina weynesi*
- *Achatina zebra*
- *Achatina bequaerti*
- *Achatina tavarensiana*
- *Achatina elegans*
- *Achatina depravata*
- *Achatina roseolabiata*
- *Achatina bicarinata*
- *Achatina buylaerti*
- *Achatina camerunensis*
- *Achatina churchilliana*
- *Achatina cinamomae*
- *Achatina crawfordi*
- *Achatina degneri*
- *Achatina dimidiate*
- *Achatina drakensbergensis*
- *Achatina gabonensis*
- *Achatina granulate*
- *Achatina knorri*
- *Achatina limitanea*
- *Achatina machachensis*
- *Archachatina calachatina marginata*
- *Archachatina calachatina marginata ovum*

- *Archachatina calachatina marinae*
- *Archachatina calachatina montistempli*
- *Archachatina calachatina omissa*
- *Archachatina calachatina papyracea*
- *Archachatina calachatina parthenia*
- *Archachatina calachatina purpurea*
- *Archachatina puylaepti*
- *Archachatina semidecussata*
- *Archachatina semigranosa*
- *Archachatina simplex*
- *Archachatina ustulata*
- *Archachatina ventricosa*
- *Archachatina vestita*
- *Archachatina marginata suturalis*

All these snails can be eaten and are actually consumed in many parts of the world. For example, in West Africa (Ghana and Nigeria) snails are served as a delicacy in taverns, hotels and restaurants and are also eaten domestically in individual homes. Some of the West African species are the largest snails in the world. The freshwater prosobranchs are also widely eaten.

Generally snails are delicacies in French cuisine, where the name escargot evokes culinary delight. In the English language menu, escargot is generally reserved for snails prepared with traditional French recipes (served in the shell with a garlic and parsley butter). Snails are also popular in Portuguese cuisine where they are called in Portuguese "cavacois" and serve in stewed (with different mixtures of white wine, garlic, piri piri, oregano, coriander or parsley, and sometimes chourico). Bigger varieties called "caracoletas", are generally grilled and served with a butter sauce, but other dishes also exist such as "feijoada de caracois". Overall Portugal consumes about 4000 tonnes of snails each year.

Traditional Spanish cuisine also uses snails ("caracoles"), consuming several species such as *Helix aspersa, Helix punctata, Helix pisana* or *Helix alonensis* among other small to medium sized varieties are usually cooked in several spicy sauces or even in soups, while the bigger ones may be reserved for other dishes such as the (a paella-style rice with snails and rabbit meat dish) "arroz con cotio & caracoles" or "carecols". In fact the Catalonians have a snail celebration they call "Aolec del cargol". Here snails are called cargols or caragols. The gill the snails inside their shells and eat it after dipping in garlic mayonnaise or a la gormanda, boiled in tomato and onion.

In Greece snails are popular in the Island of Crete but are also eaten in other parts of the country and can even be found in supermarkets, some times pleaced alive near partly refrigerated vegetables. In this case, snails are one of the few live organisms sold at super markets as food. They are eaten either boiled with vinegar added or sometimes cooked in a casserole with tomatoes and squashes. Another cooking method is the "Koali Bourbouristi" traditional Cretan dish, which consists of fried snails in olive oil with lemon. In sicily snails are known as babbaluciiad and widely eaten.

In a nutshell, snails are eaten in several countries in the world even as far back as thousands of years beginning in the Pleistocene. They are especially abundant in Caspian sites in North Africa but are also eaten throughout the Mediterranean region, where their fossil remains are found in archaeological site dating between 12,000 and 6,000 years ago. However it should be noted that wild caught land snails that are undercooked can harbour a parasite that may cause a rare kind of meningitis but this does not stop specialized snail caviar growing in popularity in cuisines around the world.

(d) SNAILS AND HUMAN **HEALTH**

Due to its slowness, snails have traditionally been seen as a symbol of laziness. In Judeo – Christian culture, they have often been viewed as manifestations of the deadly sin of sloth. Psalm 58 vs 8 implies that slimy track of a snail is a sign that is will eventually wear itself away. Snails were also widely noted and used in divination. The Greek Poet Hesiod was noted to have said that snails signified the time to harvest by climbing the stalks, while the Aztec moon god “Teccizteatl” bore shell on his back. This symbolized rebirth. The snail’s penchant for appearing and disappearing was analogized with the moon. Despite all these folk tales, snails actually constitute a serious health problem for man. For example, the giant African snails are carriers of the rat parasite, *Angiostrongylus cantonensis*. This parasite can be contracted by man (zoonosis) by ingesting improperly cooked snail meat or by handling live snails and transferring some of the mucus (slime) to the human mucus membranes such as those in the eyes, nose and mouth. They develop in man to cause a form of meningitis.

Perhaps the greatest disease problems of man traceable to snails have been linked to trematode parasites using the snails as intermediate hosts for their larval stages. Snail borne diseases have been counted as one of the most important public Health problems second only to mosquito-borne diseases. In the past there was a stable ecological relationship between man, snail and parasites. The human population was low, thus with a low level of diseases. Currently the explosive growth in human population with its attendant poor sanitary conditions and increased mobility of infected people, more and more people get in contact with infective stages of the parasites in the snails. Thus an excellent condition is presented for parasite transmission making snail borne diseases serious public health problems today.

Some of these snail borne diseases include:

(a) **Schistosomiasis**:

Schistosomiasis or bilharsiasis is the commonest parasitic zoonoses first recorded in Egypt about 4000 years ago. The parasite was isolated in 1851 by a doctor known as Theodore Bilharz in the mesenteric veins of an Egyptian. It was named Bilharzia and later changed to Schistosomiasis of the unique appearance of the body of the male parasite which looks as if it is split longitudinally to produce a canal in which the female positions herself.

This parasite is a trematode that belongs to the subclass Digenea; the order prosostomata and the suborder strigiata. Their super family is schistosomatiodea. Sixteen species are known to infect man or animals. The five principal species that infect man fall into one of the three groups that are characterized by the type of egg produced as follows:

(a) Eggs with lateral spine (S. mansoni)
(b) Eggs with terminal spine (S. haematobium) (S. intercalatum)
(c) Eggs that are round and minutely spined (tubercle) (S. japonicum; S. mekongi)

The disease is endemic in 74 countries of the world. It is estimated that around 200 million people are infected and that between 500 and 600 million persons are at risk. Infections persist because of ignorance, poverty, poor housing, substandard hygiene practices and the availability of few if any, sanitary facilities.

All schistomas species share the same basic life cycle. The eggs are passed in either urine (*S. haematobium*) or faeces (*S. japonicum, S. mansoni, S. bovis, S. rodhaini, S. bovis, S. curassoni and S. intercalatum).* Each egg contains a fully formed miracidium. On immersion in fresh water, particularly under condition of warmth and light they hatch almost immediately. The miracidium larvae which emerge swim actively by means of cilia with which they are covered and penetrate into the freshwater snail that is compatible to its species. The miracidia die in 16 – 32 hrs if they do not succeed in reaching a suitable snail intermediate host. The schistosoma is extremely host specific with regards to the snails in which they develop.

The species of snails used depends on the geographical region but generally *S. haematobium* and *S. intercalatum* develop in snails of the genus Bulinus (Planorbidae). *S. mansoni* develop in *Biomphalaria* where as develop in *Oucomelania*.

Through a series of asexual multiplicative division in the snail, a single miracidium will give rise to thousands of cercariae all of the same sex.

When man enters the water the cercariae penetrate the skin, often between the hair follicles and after between 4 – 12 weeks depending on the species, eggs start appearing in either urine or faeces.

Persons with Schistosomiasis may be asymptomatic or may manifest a spectrum of disease conditions. Acute schistosomiasis or Katayama fever occurs after the initial exposure and infection in *S. mansoni* or *S. japonicum*. This febrile condition results as a result of hypersensitivity reaction to schistosomal antigens. The patients complain of flu like illness with fatigue, headache and might sweat without the snail intermediate host the infection of man or animals is impossible.

Schistosomiasis is endemic in Nigeria and studies show that infection is focal and aggravated by developmental and agricultural projects. Several studies in Nigeria show that children within the age group 10 – 14 bear the most burden of the disease which depends on the human water contact patterns due to domestic, recreational and agricultural imperatives, and also follows the socio economic status of people in the endemic areas. Studies such as those of Cowper (1973), Iheagwam and Okafor (1984), Adekolu-John and Abolarin (1986), Anya and Okafor (1986), Okafor (1989, 1990, and 1992), Ozumba et al., (1989), Betterton and Fryer (1982), Fryer (1986), Emejulu et al; (1994), Anosike et al; (1992), Adewunmi et al.,(1990), to mention important few, are good for further reading to understand the epidemiology of the disease and the role of different snail species in its transmission.

The studies further present check lists of freshwater snails in the various ecoological zones of Nigeria. Roles of the snails in the aquatic food chains and the prominent roles they play as intermediate hosts of trematode parasites of wild animals are pointed out.

Table 5: Principal Freshwater Intermediate Host Snails

Snail genera	**Snail Species**	**Diseases Transmitted**
Lymnaea	*L. truncatula* *L. pellagra* *L. natalensis*	*Fasciola hepatica* *Fasciola gigantica*
Neritina	*N. glabarata* *N. adamsoniana* *N. afra* *N. oweniana* *N. rubricate* *N. cristata* *N. nasalensis*	Fish and Bird flukes
Bulinus *Bellamya*	*B.Bulimus fachsianus* *B. unicolor*	*Clonorchis sp*
Lanistes	*L. Ovum*	

	L. libycus *L. varicus*	
Pila	*P. luzonica* *P. ovata* *P. atricana* *P. wernei*	Bird flukes
Alocinma	*Alocinma longicornis*	*Clonorchis sp*
Gabiella	*G. humerosa* *G. purvipila* *G. verdicourti*	
Semisulcospira	*S. libertine* *S. amaurensis*	*Lung flukes*
Potadoma	*P. buttikoteri* *P. bicarinata* *P. liberensis* *P. freethi dykei* *P. moerchii*	*Paragonimus (Lung flukes)*
Melanoides	*M. tuberculata* *M.. Manguensis* *M. voltae*	
Cleopatra	*C. bulimoides*	
Pachymelania	*P. fusca* *P. aurita* *P. byronensis* *P. freethi dykei* *P. moerchii*	
Melanoides	*M. tuberculata* *M. manguensis* *M. voltae*	
Cleopatra	*C. bulimoides*	
Pachymelania	*P. fusca*	

	P. aurita *P. byronensis*	
Gyraulus	*G. costulatus*	
Indoplanorbis	*I. exutus*	*S. indicum* *S. spindale*
Biomphalaria	*B. pfeifferi* *B. rhodesiensis* *B. salinarum* *B. choanomphala* *B. smithi* *B. stanleyi* *B. Alexandrian* *B. angulosa* *B. sudanica* *B. camereunensis* *B. glabrata*	 *S. lhistosoma* *S. rodhaini* *S. mansoni*
Robertisiella	*R. obertsiella*	Malaysiam *Schistosoma*
Thiara	*T. granifera*	*Paragonimus*
Bulinus	*B. africanus* *B. abyssinicus* *B. globosus* *B. jouseaumei* *B. nasutus* *B. productus* *B. umblicatus* *B. ugandae* *B. forskalii* *B. scalaris* *B. camerunensis* *B. senegalensis* *B. truncatus*	 *Schistosoma* *heamatobium* Avian *Schistosoma* *S. boris* *S. curassoni* *S. maygrebowiei* *S. mattheei* *S. intercalatum*

	B. tropicus *B. reticulatus*	
Oxyloma	*O. elegans*	
Bithynia	*B. tentaculata*	
Para fossarulus	*P. manchouricus*	
Ferrisia	*F. ebunensis*	
Succinea	*S. putris*	
Cerithidea	*Cerithidea sp*	
Segmentina	*S. angustus*	
Physa	*P. waterloti*	
Pironella	*Pironella sp*	
Oncomelania	*O. anadrasi* *O. hupensis* *O. nosophora* *o. lindoensis* *O. formosana* *O. chiui*	
Tricula	*T. aperta*	*S. mekongi*

The intra-molluscan schistosome larvae are of no direct clinical importance, certain features are of interest. As the miracidium penetrates the snail, the tegumental plates, and cilia are shed and the rest of the body reorganizes into a sac of reproductive cells which absorbs nutrients from the snail tissues known as the mother sporocyst. The daughter sporocysts have even greater nutritional requirements which are best met in the digestive glands and gonads of the snail to which they migrate before beginning full development. The most important aspect of infection in the snail is the massive asexual multiplication which allows one miracidium the potential of producing many thousand cercariae which, when released from the secondary sporocysts, migrate through the tissues into the blood sinuses and escape from the snail through the walls of the superficial blood vessels of the mantle, gill or pseudobrach. The net result of prolonged production of cercariae increases the chance that one cercaria will eventually infect man or other suitable hosts.

It is important to note that the snails do not accept infection entirely passively (Loker et al., 1984). Amoebocytic cells originating from the heart epithelium attack invading foreign bodies, possibly in conjunction with soluble factors which themselves are derived from the amoebocytes. This reaction helps to destroy many primary sporocysts within a few days of penetration. In many snail species, the young snails are susceptible, but progressive changes in the composition of the haemolymph result in increasing resistance with age (Michelson, 1986). It is further important to note that some cercariae migrating through the snail tissues are trapped and destroyed in granulomatous reactions.

These infection processes of the snail borne trematodes can be broadly divided into oral and(or) transdermal routes of the worms' larval stages which have been previously released from the infected snails. During development within the human body clinical cymptoms appear.

These symptoms include uticaria, fever, ascites, haematemesis, carcinoma and hepatosplenomegaly. After maturation and depending upon the species of infection, the resultant adult worms reside within the blood vasculature system or internal body cavities of the human hosts. Unlike other parasitic infections the snail borne worms do not directly replicate inside the body but rather produce copious amounts of eggs. It is these eggs, which depending on the species of worms that are voided into the environment through sputum, urine or faeces, facilitating the life cycles of the parasites.

The eggs that fail to exit the body often become trapped in host tissues and organs and ultimately trigger the immunopathology associated with the disease.

(b) Fascioliasis

Another name for this disease is liver fluke disease. This disease is caused by the infection with the trematode Fasciola (F. hepatica and F. gigantica). The source of infection is ingestion of raw aquatic vegetation contaminated with encysted metacercariae such as lettuce and green salad, grasses and water crests.

Fasciola passes its life cycle in two different hosts: sheap, goat and cattle are the definitive hosts which snails of the genus Lymnaea are the intermediate hosts. The undifferentiated ovum develops into a miracidium under moist conditions in 9 – 15 days at 22 – 25^{o}C. The miracidiae which hatch out of the eggs lives for only eight hours and can move in a film of moisture on damp pastures. Further development takes place after free living miracidium penetrates an amphibious snail. More than 20 species of *Lymnaea* have been incriminated as capable of acting as intermediate host for *Fasciola*.

In the snail the miracidium metamorphoses into a sporocyst, rediae, daughter rediae and cercariae. The cercariae emerge from the snail and eneyst on water cress, grass, barks or soil. When ingested by a definitive host the metacercariae exyst in the duodenum. The disease runs an acute and chronic phases. The chronic phase occurs when the mature fluke enters the bile duct and symptoms pertaining to obstruction of the bile duct or inflammation of the duct occurs.

(c) **Fasciolopsiasis** (Ginger worms)

This disease is caused by the parasite *Fasciolopsis buski* which was earlier called *Distoma buski*. The parasite is also known as the Giant intestinal fluke of man. Its definitive hosts are man, pig or dog.

The molluscan hosts are of the genus *Segmentina.* The eggs are passed in the faeces of the definitive hosts. These eggs hatch in 3 to 7 weeks in water having a temperature of between 80 and 90^{o}F to give rise to the ciliated miracidia. These penetrate the suitable snail hosts and develp into sporocysts, then into rediae, daughter rediae (or rediae II) and cercariae. The cercariae emerge from the snails and get converted into metacercariae on the outer covering of water chestnuts.

Human beings get infected by eating contaminated raw water plants especially when peeling off the outer layers with their teeth.

The disease is confined to Southeast Asia. Countries affected include: China, Taiwan, Thailand, Vietnam, Bangladesh, and India (Assam and Bengal). About 10 million people were estimated to be infected worldwide by 1947 and must have surpassed 15 million giving the fact that its incidence varies between 5 – 50% in endemic areas.

(d) **Paragonimiasis** (Lung fluke disease)

This is a chronic infection of the lungs caused by the trematodes of the genus *Paragonimus. Paragonimus westermani*: is the commonest species but in Southeastern Nigeria the common species is *Paragonimus uterobilateralis* found Prof. Nwokolo and his colleagues around Okigwe, Ezinachi and Umuguma. It is a common human parasite in the Far East (Japan, Korea, Manchuria, China, Southeast Asia and Papua New Guinea). In the Indian sub continent it occurs in Bengal, Tamilnadu and Mumbai.

Man gets infected by eating raw or poorly cooked crab or crayfish which has been contaminated with metacercariae of the parasite. The parasite passes its life cycle in 3 hosts: one definitive and two intermediate hosts.

The definitive hosts are mammals, domestic animals, tigers and leopards. The intermediate hosts include a first host which is a freshwater snail of the genus *Melania* in Southeast Asia.

While *Potadoma* and *Semisulcospira* serve as hosts in West Africa. The second host is either a freshwater crayfish or crabs (*Potamon* or *Sudanonautes*).

The golden brown operculate eggs reach the bronchioles from where they are coughed up and excreted in sputum or swallowed and passed out in faeces. On reaching water the miracidia hatch out and penetrate into fresh water snails (e.g. *Semisulcospira libertina, S. amaurensis, Thiara, Potadoma, Melania).*

Table 6: Classification of Trematodes Infecting Man

S/N	Group	Location & Examples
A.	Dioecious blood flukes	They live inside veins in various locations. E.g.: (i) In the vesical and pelvic venousplexuses - *Schistosoma haematobium* *(ii)* In the inferior mesenteric vein – *S. mansoni* (iii) In the superior mesenteric vein – *S. japonicum*
.	Hermaphroditic flukes	They live in the lumen of various tracts: *(i)* Biliary tract – *Clonorchis sinensis* – *Fasciola spp* – *Opisthorchis* spp (ii) Gastrointestinal tract

		(a) Small intestine – *Fasciopsis buski* – *Heterophyes heterophyes* – *Metagonimus yokogawai* – *Watsonius watsoni* (b) Large intestine – *Gastrodiscoides hominis* (iii) Respiratory tract – *Paragonimus* spp.

In the snails the miracidia develop into sporocysts followed by two generations of rediae and later (3 months after) give rise to very short tailed cecariae (micro- cercous Xiphidio-cercariae). These emerge from the snail and swim in water and can survive for 24-48 hours. If they find freshwater crabs they enter.

The crab species include *Potamon, Sesarma, Eiocheir* and *Sudanonautes* or freshwater crayfish – *Astacus.* They penetrate and encyst in the gills or muscles as metacercariae. The Freshwater crustaceans can probably become infected by ingesting unencysted cercariae in the water or even inside infested snail.

The disease is insidious beginning with a non-specific cough that becomes chronic and is productive of blood tinged sputum known as endemic haemoptysis. Patients also experience pleural pain and dyspnoea. Depending upon secondary bacterial infection there may be pneumothorax and pleural adhesion. Lesions in the brain can lead to seizures.

(e) **Clonorchiasis**

Clonorchiasis is caused by *Clonorchis sinesis*. The species was earlier known as *Opisthorchis sinensis.* Infection due to this parasite is largely confined to Vietnam to Japan (Including Korea, Taiwan, China). It affects about 10 million persons.

Humans are the principal definitive hosts, but dogs and other fish eating canines act as reservoir hosts. Two intermediate hosts are required to complete its life cycle, the first being snails and the second is fish.

The eggs passed in faeces contain the ciliated miracidia. They do not hatch in water, but only when ingested by suitable species of operculate snails such as *Parafoassarulu, Bulimus, Alocinma*. The cercariae escape from these snails and swim about in water, waiting to get attached to the second intermediate host, suitable freshwater fish of the carp family. They then shed their tails and encyst under the scales or in the flesh of the fish to become in about 3 weeks the meta cercariae which are the infective stage.

Human infection occurs when such a fish is eaten raw or improperly processed. Frozen, dried or pickled fish may act as source of infection. Infection may also occur through fingers or cooking utensils contaminated with the meta cercariae during preparation of fish for cooking

(f) **Other Trematodes of Medical Importance**

(i) Dicrocoeliasis: Disease caused by the trematode parasite *Dicrocoelium dendriticum* (known as the lancet fluke). This fluke is a very common biliary parasite of sheep and other herbivores and accidentally infects Man in Japan and China, Europe, N. Africa far East and Northern Asia.

Eggs passed in faeces are ingested by land snails *Limicolaria* Cercariae appear in slime balls secreted by the snails and are eaten by ants of the genus *Formica* in which the metacercariae develop.

Infection occurs when the hosts accidentally eat the ants while feeding. Spurious infections have occurred in persons who ate infected sheep liver and can pass eggs in faeces for about a week or several days.

(ii) *Eurytrema pancreaticum*, is a related fluke and is commonly present in the pancreas, is a related fluke and is commonly present in the pancreatic duct of cattle, sheep and monkeys. Occasional human infection has been noticed in China and Japan.

(iii) **Intestinal Flukes**:

A number of fluke parasites parasitize the human intestine. These include *Heterophyes, Metagonimus*, *Wastonium* and *Echinostoma.* Only one fluke *Gastrodiscoides hominis* parasitizes the human large intestine.

The snail intermediate hosts for these are presented in table 7.

Table 7: Showing a list of trematode parasites, their intermediate hosts and reservoir hosts.

S/N	Trematode Parasite	Snail Intermediate Hosts	Other Hosts
1.	Heterophyes	Pironella Cerithidea	Cats, dogs foxes and otherfish eating mammala
2.	Metagonimus	Pironella	2nd host Trout, Reservior dogs, cats, pigs, pelican and other fish eating birds.
3.	Metorchis	Freshwater snails	Sled dogs and freshwater fish (white sucker)
4.	Watsonium	not known	Primates in Africa Asia.
5.	Gastrodiscoides	Freshwater snails	Pigs, monkeys, mouse and deers.
6.	Echino stoma	Snails and Fresh water snails	Man
7.	Alaria	Achatina	Man, foxes and

			other canids.
8.	Gymnophalloides	Marine oysters freshwater snails	Shore birds and man
9.	Nanophyetus	Freshwater snails	Dogs, foxes, and wolves.
10.	Mesocoelium	Achatina Archaehatina	Sailmonial fish, fish eating birds, man and other animals.

Beyond these trematode infections that must undergo multiplicative development in snails, there is other roles snail play in human health. The land H*elix* or snail has been used in medicine since antiquity and are used to prepare many formulations. Scientific knowledge recorded that Hippocrates proposed the use of snail mucus against protoceler and that snails increased the speed of delivery. It was also noted that in folk medicines, snails are used to prepare the "sovereign remedy to treat pain, abscesses and other wounds. Snails had been part of the various preparations recommended in the past for external uses and internally for symptoms associated with tuberculosis and nephritis. The 19th century saw a renewed interest in the pharmaceutical and medical use of snails. This interest in snail did not start now, for example, an entire paragraph was to snails indicating that usage of snails had begun by 1945. The America FDA showed a substance ziconotide (SN xii), a synthetic peptide coming from snails venom in 1999. Pre clinical and clinical studies of this new drug are promising and show reduction of pain intensity by 53% even in patients insensitive to morphine.

Snails from Africa are the best but they must be prepared in an uneven numbers. Anaemia patients feel much better if they drink snails. Eating snails was prescribed for cases like vertigo, fainting fits, and fits of madness. The snails should be crushed in wine. It was recommended at the time that snails could be used against hydrops foetalis. Snails have also been recommended against anthrax, and can cure hernias. Other ancient uses of snails are as astringents, first and second degrees, acute and chronic chest ailments, intestinal irritations, chapping, and efflorescence of sores. Transparent yellow oil extracted from *Helix pomatia* can cure marasmus. Snails have also been used with success against inflammations especially against cough and cold, bronchitis, catarrhs, asthma, haemoptysis, tonsillitis, pharyngitis, hoarseness, sore throat, influenza, croup, nervous cough of children, lung diseases, such as pneumonia, and stomach or intestinal cramps, gastritis, gastero-enteralgia, headaches coming from disorders of the stomach, cough that follows or comes with inflammatory skin disorders, measles, scarlet fever, small pox, erysipelas, etc. singers find them to be very active aids against several alterations of the voice.

Formulations made from *Helix pomatia* are now confirmed to cure whooping cough and chronic bronchitis. The fluids from snails are touted to have autiseptic, fluidizing properties. As much as 30 enzymes have been isolated from the digestive nucus, pancreostomach, the muscle and lymph fluid. Mucolytic and bacteriolytic properties of snails are noted as well as the antispasmodic activities, musculotropic effects and sedative properties.

In 1999 Pons and associates demonstrated that the broncho-relaxant effect of helicide was due to release of E_2 prostaglandins and that this was inhibited by pre-treatment with indomethacine. Scientists have also isolated a lectin called *Helix pomatia* agglutinin used as a prognostic indicator for some carriers such as those of the breast, storage and fixation of histological preparation of these tissues. This latter activity is attributed to the actions against an HPA associated glycoproteins that are linked to metastasis of cancer.

Investigators have also shown that in populations eating snails, that the life expectancy was high (about 7 countries studied), there was less number of deaths due to cardio vascular events than non snail eating populations. This was suggested to arise from the rich fatty acid content of their diet and the natural herbs that they eat. Snail meat is said to be rich in a-linolenic acid that has been reported to have a protective effect against cardiovascular disease.

In 2000 a substance called Conotoxin (TVIIA) was extracted from *Conus tulipa* a fish eating sea snail by Scientists in University of Utah, USA and another peptide called Contryphan-Vn was also extracted from the venom of sea snails. Recently it has been found that snails are helping scientists at the University of Sussex to explore ways of treating memory loss in humans by Drug manufacturers looking for ways to create a “Viagra” for the brain (that could alleviate memory loss). It is well known that one of the distressing symptoms of Alzheimer’s disease is memory loss. It is also known that people with memory loss have a devastating consequence of long term impaired memory and it occurs in millions of people. Using materials from snails, scientists are putting together information that will help in understanding and ultimately preventing and treating memory disorders. They are looking for brain molecules that are crucial for the building up and maintenance of long term memory and learning. People are now attempting to enhance, by chemical activation or inhibit those functions in the common pond snails.

Snails are ideal for this kind of study because humans and pond snails actually share some important characteristics unchanged by evolutions. These include the basic molecular mechanisms that control long term memory and learning. These processes involve the activation or suppression of a protein CREB which is a key to the formation of long term memory and are found in species ranging from molluscs, flies, rats to man. These responses can be tested by classical Pavlovian experiments that bring about a conditioned response. It has been reported that a snail exposed to the smell of pear drops and other foods will respond weeks later to the smell of pear drops by rhythmically moving its mouth parts in anticipation of food, even when none is provided. This shows that the snail now has a memory associating the smell of pear drops with the arrival of food – a learned and remembered response. This “flash bulb” response as it is called, created by just one response to a stimulus is complemented by another test where the snail is exposed to a tickling stimulus before food is introduced. It takes very long for the snail to associate this tickling with the arrival of food. Snail have large neurones which are easily identified, manipulated and observed under a microscope thus making them a vital tool to be explored in studies on learning and memory processes.

To the Japanese the giant African snails are presumed to have great medicinal properties. The possible curative power of snails in getting rid of tuberculosis was canvassed. It is also believed that slugs put in coconut milk cures asthma. A curative substance that is extracted from the snail known as “Ishinoto negligin” now known to be orthocalcium phosphate is believed to be the medicinal substance. This chemical is claimed to cure some kidney diseases, anaemia, diabetes, uticaria, circulatory disorders etc, to improve constipation, hemorrhoids and to prevent influenza. It is claimed to improve virility and vitality; to perpetuate beauty and clear the skin. In the past, those who sing always are advised to eat snails.

In a keynote address by Tazwa in 1934 he said “buying meat and fish for your table is unnecessary when you eat snails, and there will be no sickly person in the house, doctors and kept away and it brings smiles to the home”. In addition he urged the cultivation of Achatines and he made numerous recommendations for increasing production and simplifying the task for raising the snails. A species known as “Shirafuji” in Japan was being promoted in the early thirties as a new industry with high profit making potentials.

In the United States, it has been shown that some edible snails also play an important role in American folk medicine. In addition to the nutritional value of snail meat. Baratou (1988) in California showed that the glandular substances from edible snails cause agglutination of some bacteria. This bacteriostatic activity is of value against a variety of ailments, including whooping cough.

In Ghana the bluish liquid obtained from the shell of the tiger snail when the meat has been removed is believed to be good for infants' development. The high iron and vitamin contents are considered important in the treatment of anaemia. At the imperial courts of Rome it was reported that snail meat has aphrodisiac property and was often saved to visiting dignitaries in late evenings.

(d) **SNAILS AND AGRICULTURE**

In aquaculture (controlled raising of animals in water) the primary goal is to produce more foods. This type of agriculture, improves the quality of the organisms and their productivity. The main animals used in aquaculture are fish, crustaceans and molluscs. Among the molluscs the viable forms are mussels, oysters, clams and prosobranchs (e.g. Pilidae, Ampullaridae and Neritidae).

Available data suggest that over 12 million tonnes of meat are derived from aquaculture every year and 17.0% of these are molluscs. The rest comprise of sea weeds, algae, crustacean and fish. The most likely species of snails that will benefit from increased deployment in aquaculture are *Pila wernei (Philippi), Lanistes varicus, Ampullarium sp, Lanistes ovum, Pila ovata* and other groups are locally classified in Igbo land as ”akpakolo”. These are all freshwater Prosobranchs. About 34 developing countries and all developed economies have the potentials and infact, have started deploying aquaculture for increased animal and aquatic plants production. The need for finding employment of the teeming populations of youths world wide has served to renew interests in practices like oyster cultures, mussel farms and aquatic snail farms , shrimp and crayfish farms. Ways will be found for reducing the impacts of increasing costs of feeds, shortage of fertilizers that are required for improved aquaculture production as well as combating aquatic pollution due to uncontrolled application of pesticides, and herbicides.

A number of technological advances have occurred in aquaculture since it was developed about 4000 years ago mainly in South east Asia and China. A good example of such advances is the catfish farming in USA, prawn and shrimp farming in Canada and elsewhere in the world. These modern technologies can be adapted for snails to keep up with the requirements of rapid expansion of productions.

In regions where intense crop farming is extensive lime is always in serious demand. In such places it is common for the local farmers to use *Achatina* or other snails’ shells which they reduce in “Lime Kilns” as a by product in the preparation of snail meals. The shell of *Melania* and *Corbiculaare* are being used in this manner in Malaysia .

In areas where the soil is excessively acidic, as is the case in humus soils of forests, the alkalizing effect of adding crushed shells would be desirable as far as most crops are concerned. But on the other hand, in coralline soils which are already excessively basic and should not have more calcareous materials added to them. This suggests that if snail shells are ever used in formulating fertilizers, two different kinds should be made available:

(a) one with shell fragments and
(b) one without shell fragments.

The thin, quickly leached soils of tropical areas need enriching of some sort if they must be used for much more than two or three years. Besides the shells, the meat of the snails can be used as fertilizers. Primitive peoples in Asia were known to use disintegrating animal flesh to replenish the soil as plant growth promoting constituents in depleted soils. These use snails by putting them in metal oil drums and allowing them to stand in the hot sun until the snails died. They were allowed to reach a high degree of putrefaction. These rotting, maggot infested snails were then scooped out of the shells. Then the putrid slimy, odoriferous mess was then added as a fertilizer in farms. It had been found that crops that benefited from snail fertilizers had generally better quality. The use of this process introduced two disadvantages:

1. The inadequately covered oil drums permitted the escape of fly maggots as a threat to public health. However modern aquaculture practices suggest that these maggots could be harvested and used to feed fish in aquaculture pens thus reducing giving them positive value.
2. Addition of this and the crushed shells to the soil moved the soil P^H even more strongly in a basic direction.

This latter disadvantage has been eliminated as it is now known that when only “liquid” fractions were used by drawing off and diluting with ten parts of water before being added to the soil (Peterson, 1957), it becomes enriched.

Snail meat can also serve as salt water fish baits. In the U.S. the raw flesh of the Philippine pond snail *Pila luzonica* is used as a bait for line fishing.

Snails can be used for poultry feed. Small living snails were experimentally given to chickens with no success. They would occasionally pick at them. But Van Weel (1948) found that chickens would not reject well crushed snails but that they would not take to them as avidly as ducks invariably do. Other studies insist that chicken ate snails raw, boiled or roasted, but seem to prefer them crushed and boiled. In the Dominican islands, the freshly killed endemic snails are pounded with corn meal before they are fed to the chicken. The general consensus is that chicken and ducks accept snails when crushed and boiled. Another method which showed increased acceptability is that a portion of the snail shells were ground up and combined with snail meal as an added source of calcium carbonate. In the proper proportion, it would obviate the necessity of using oyster shell or other sources of bone meal.

Snails are also used in feeding livestock and they are incorporated in the daily rations of pigs. Experiments show that pigs eat snails live, boiled or chopped. The general agreement is to boil and de-shell the snails before feeding the pigs with them.

Snail meals can be produced and used as fertilizers or as supplemental feeds. In both cases it would be desirable to dehydrate the snails and reduce them to a powder or meal. In this form, it could be stored and used when needed either as a fertilizer or as feed supplement. The value of snail meal is in the high percentages of phosphates and lysine.

Snails are also pests of crops wherever they exist in the wild. Further information can be obtained in the publication slugs and snails in world agriculture edited by Henderson (1989). The snails ravage crops, vegetables and flower in gardens and farm lands especially during the rainy seasons. Its activities had to the restriction and quarantine of the snails especially the giant African land snails into many developed countries most especially in U.S. This has led to the US Department of Agriculture issuing warnings and placing embargo on importation of live snails. The snails are voracious plant feeders and can be very destructive to landscape and homes. They are known to eat at least 500 different types of plants including pea nuts, beans, peas, cucumbers and melons.

SNAIL FARMING

Snail farming is the keeping of snails in a confined environment under human control and management. Attempts at snail domestication have been documented from Roman times (Elmslie,1982). In Africa, the feasibility of farming snails has been demonstrated by a number of researchers (eg.Ajayi,1971; Plummer,1975; Ajayi et al.,1978; Hodasi, 1979; Okafor, 2000). The types of snails slated for cultivation are Achatina, Archachatina, Helix, Limicolaria, etc. Snail farming: is an activity that involves production, management, harvest and sales of snails as well as a means of supplementing household income and protein supply. Snails are marketed fresh or smoke-dried, but their supply is seasonal. Three discernible attitudes are known concerning snail consumption i.e. in one group snails are avidly consumed in large numbers; in another group, consumption of snails is a taboo; while another group do not ordinarily consume snails ,they prefer other sources of protein but would take the snail in seasons 0f abundance when snails are cheap.

The usefulness and importance of snail farming include:

1. It is an alternative activity to bushmeat hunting and trading
2. Provides a source of food/meat for protein supplementation
3. It generates income
4. It is a source of medicine (e.g. waist pain and anaemia)
5. It provides employment
6. It contributes to biodiversity conservation
7. It does not use large expanse of land or agricultural inputs as other agricultural activities
8. It makes use of organic materials.
9. The activities are environmentally friendly.

Many species of snails (helicidae and escargot) can be farmed. The following are the steps taken in farming snails:

(a) Selection of a suitable site that is preferably flat surface.
(b) Selection of initial stock of snails.
(c) Construction of pens
(d) Fencing of the site
(e) Installation of equipment

and

(f) The management of the snail farm.

HOUSING

Snails can be housed in many types of containers, but all must be able to withstand the warm humid conditions that are necessary. The common ones include old tyres, old basins / clay water pots, wooden or bamboo boxes and dug holes. An aquarium tank or plastic pet cage would make a suitable home. One sized 40cm x 25cm would house an adult snail or several smaller specimens. An escape proof top is necessary and preferably one that allows for some ventilation. A glass or Perspex, slightly raised on plasticine will often suffice. A layer of soil should be provided for the snail to burrow into. A light misting is necessary, as high humidity may be an essential requirement. Snails should be able to approach water, usually provided in a water dish. This they may drink. The environment should also contain other surfaces over which the snails can move. They need softish irregular surfaces. Hollows of tyres can be used as convenient hides. A lump of chalk or limestone is an essential furnishing of the pens. Snails have a huge requirement for calcium to build up this mineral requirement.

Large scale farming involves the use of large cages and fenced pens, Polyethylene tubes and wide expanse of lands. Most snail farms may require mild climate, with high humidity and a wide range of temperatures.

METHODS

There are several different methods used to farm snails. The factors that determine the choice of method are the scale of the enterprise, the stage of development of the snails and the habit of the snail.

Intensive method: This is practiced by large scale commercial farmers requiring high capital.

Semi Intensive method: In this method the cost outlay in low and is recommend for beginners and poor investors. Examples include the mini paddock pens, the trench pens, the moveable pens,

Free range: This is a good method as it allows the snails free movement. The disadvantage in this method is that it is difficult to locate eggs, young snails and to keep out predators.

PRECAUTIONS

Before installation of snail farm facilities:

(a) a good breeding foundation stock must be selected.
(b) Active snails with no damages and weighing between 200 – 300g should be selected.
(c) Ways of exposure to stress should be minimized.

FOOD AND FEEDING

Snails can be kept in groups of similar eat a huge variety of foods. In the wild they eat fresh or rotten leafy vegetations, an assortment of fruits like pawpaw, mangoes, banana. They also eat bread, cooked meat, chicken feeds, corn flakes or maize chaffs and mostly glabrous vegetables (e.g. Okra leaves, yam leaves and cassava leaves). The foods should remain in the cage for a reasonable length of time without rotting or casing smell. Rabbit pullets and layer mash are excellent foods. Foods should be abundant and available water should be copiously supplied. Locally snails can be fed with ripe fruits (paw paw, pears, banana etc) soft leaves (waterleaf, cabbage, green, paw paw leaves). They also can be fed scrape food like corn fufu, rice, cocoyams. Providing the snails a mixture of foods rather than one or two items, will enhance growth.

Snails do not need salt and so the foods supplied then should be without salt. It is advisable to feed snails every day and to remove old foods.

FARM MANAGEMENT

The following are some of the daily activities in snail pens.

Cleaning of feeders and drinkers
Keeping pens clean
Picking up and throwing away dead
Picking of eggs
Picking out snails with cracked shells
Keeping records
Checking the pens for any holes.

Periodic Activities:

Snails should be well mulched using dry leaves
Snails should be regularly repaired
Pens should be regularly repaired
In due time snails should harvested and sold
Pest should be controlled.

Reproductive Facts:

Snails are hermaphrodites (i.e. two sex organs per snail)
Snails of the same size mate for 3 hours.
Eggs are laid in batches.
Eggs hatch after 14-21 days.
Hatched snails mature after 3 months
Snails of the same size are kept in one cage or box
Snails can live up to 10 - 15 years depending on species
All eggs picked are kept in hatching chambers
Stocking density was expected to be 100 snails/m^2; 1000 eggs/m^2, 300 juvenile/m^2.

PEST MANAGEMENT

No major diseases have been identified except the infection with Aeromonas. The major pests in snail farming are ground beetles, birds, birds including chirkon and ducks, black ants, millipedes, centipedes, light flies, frogs, snakes, lizards, human being and muscoid flies. The most important preventive measure is applying a mixture of engine oil, water and constructing cages with raised floors. The adult snails sometimes feed on young ones, so it is important that they are separated in predesignated chambers and to keep the entrance to the cages locked up.

Keeping Records:

Keeping records is an important aspect in snail farming to give an idea about the functioning of the farm at any one moment. It is important to keep record on number of eggs picked, number of installed, number of young ones, number of dead; quantity sold, feed purchased and material/inputs.

Preparation of Snails:

Snails are widely eaten as a delicacy particularly in West and Central Africa. They can be dressed with the shells, eaten as snail meat (fried); snail pepper soup, snail soya or vegetable/soup/stew.

The heavy mucus secretion can be problematic but use of lime, Vinegar or Alum remove them very easily that after washing snails with these they can be cooked. The snails should be well cooked to avoid the toxicity noticed when improperly cooked snails are eaten.

COST BENEFIT ANALYSIS OF SNAIL FARMING

1 bucket of 400 snails costs= 20,000

1 snail lays 15 eggs (Archachatina) therefore 400 snails will lay 400 x 15 = 6000 snails.

Total number of snails will be 6000 + 400 mother snails = 6400 snails.

Number of buckets of snail = $\frac{6400}{400}$ = 16 buckets selling at N20,000 a bucket means that 16 buckets will sell at 16 x 20,000 = 320,000.00.

Profit = 320,000 – 20,000 = ₦300,000.00.

From the above analysis, it shows that snail farming is a very profitable venture.

This analysis was one with the low reproducing species *Archachatina marginata.* If it was done with a fast and high reproducing species *Achatina Achatina* that lays 100 eggs a year the profit margin will be higher e.g.

when you start with a bucket containing 600 snails but at ₦50.00 each

= bucket will cost ₦30,000.00.

At the egg production rate of 100egg/individual = 60,000 eggs = 60,000 young.

Total number of snails = 60,000 + 600 snails = 60,600

Number of buckets = $\frac{60600}{600}$ = 60 buckets selling at ₦30,000.00 per bucket means that the 60 buckets will sell at 30,000 x 60 = ₦1,800.000.00.

The profit = 1, 800,000 – 30,000 = ₦1,770,000.00 after one reproductive cycle. However in this species one expects a 15% mortality rate.

In the quest for poverty alleviation, I propose that people of Nigeria should embrace snail farming as a means of achieving food security and economic empowerment especially for the rural poor in our world.

Snails are slow growing, so farming them is not a way of making money quickly but with patience/good management and care it brings in substantial rewards in the long term.

One of the advantages of snail farming is that feeding of snails is easy and relatively cheap as all the edible snails have a voracious appetite and can eat all manner of plants and plant parts. Captive snails have been fed on wild lettuce *(Lactuca taraxacifolia*) and a wide range of other leaves and ripe fruits including paw paw (Ajayi et al., (1978) listed 28 species of dicotyledonous plants and six species of monocotyledons eaten by *A. marginata* and Okafor (1990) reported that *A. achatina* preferred rough surfaced, hairy leaves e.g. Okro, paw paw and yam leaves.

The Romans farmed snails for so many decades before the present civilization (Elmslie, 1982). Here in Africa, the feasibility of farming snails have been confirmed by the early 1970s (e.g. Ajayi, 1971; Plummer, 1975; Ajayi et al., 1978; Hodasi, 1979 and Okafor, 1990). Currently in Ghana there is a major campaign to promote snail farming both as a back yard activity to supplement household income and protein supply. It is also a large scale commercial activity.

The industry is growing rapidly and with adequate support both financial and technical, the industry has a high potential to change the life of both the rural and urban households.

(e) OTHER ECONOMIC USES OF SNAILS

(i) In Fashion Industries

: The colour and luster of snail shells are exploited in decoration and for making jewelries. The operculum of prosobranchs is cut to make buttons. Cameos are produced using snail shells and a lot of artistic designs for home decorations are created using shells of gastropods especially marine gastropods. Pearls are iridescent because of the nacreous substance they are made from. The pearls can be black, pink, orange, gold or white. Black pearl are the most valuable of all pearls. Shape of pearls confers great value to them. For example round pearls are used to produce bangles, earring and necklaces. Those with irregular shapes are called “baraques” and are used in the fashion industries a lot.

(ii) Aesthetics

The shapes, colour and luster of shells are exploited by interior decorators and artists to produce amazing crafts, create designs and ornamental pins. Conchs and other larger and exotic shells can be polished for use as lamp busses or paper weights craftsmen fasten many kinds of snail shells together in the shape of dolls and animals in various types of designs that are very attractive and a sold exorbitantly. According to Eke (1998) many of the beautiful are collected, arranged and displayed in attractive manner for home and office decorations.

Many people find shell collecting a fascinating hobby. They spend leisure times hunting and cleaning shells as well as mounting them in attractive displays. Today the collection and study of snail shells is a scientific discipline known as conchology.

(iii) In Games

In many African countries, the shells of Limicolaria spp are used for recreation e.g. locally called "Koso". This game is played by two to four people in which people play in turns using the cylindrical shells cut at the end to make a cap on the ground. After making a successful gap, the player is entitled to use the shell to knock the others backside of the hand as a compensation for his skill. This game is played mainly by male children.

(iv) Use as Money

In the very old days before the modern civilization, shells of the Marine gastropods (*Cypracea argus*) where used as money. They are called cowries. No cowrie demonstrates the miracle of pattern production more than the well known, 4-inch long eyed cowries of the Southwest Pacific whose fleshy mantle produce a uniquely characteristic colouration and pattern. The shells of the young cowries are thin, without shelly teeth and without distinctive colour patterns. These are used as money. When they age they develop shell teeth, the shells become larger and thicker.

There is also the Golden cowrie (*cypraea auranitium*) which has been greatly sought after by collectors for many centuries. Its popularity is due to its relative rarity, its beautiful glistering orange colouration, and because of its historical use as a symbol of chieftainship in the Fiji Islands, South of Japan; through out the Philippines and Solomons to Fiji.

(v) Other Scientific and economic Uses

The Phoenicians and Romans made a purple dye from some sea snails (e.g. Murex). The believed that cloth coloured with this dye was more valuable than gold.

Wampum, which consisted of beads made from shells, was used by the Indians to decorate garments and also to keep records. Most wampums were made into necklaces or belts. In ancient days, Indian wampum were used as currency.

Scientists use snail shells in their researches. For examples, Atomic energy researchers expose shells to atomic rays to test the effects of radiation.

Oil prospectors search for certain kinds of fossil shells in the deserts. These shells show that the area was an ocean bed many years before now. Large oil pools were found in many of these ocean beds as it is today in the Middle East areas of the world.

Man often release the snails into the environment to act as predators of other snail e.g. *Marisa* *cornuarietis* or of flatworms as biological control agents.

The snails have a voracious appetite. Some people introduce the snails in their rice and maize farms to eat up the weeds in their farms. The dangers in this however, are that the introduced snails can in a short time, reach such enormous numbers and become serious conservation problem, or eat up native plant species modifying the habitat and they out compete native snails.

Finally the snails can be used as pets, can be used to teach about native fauna, and for other educational purposes on a state by state basis, as nature facilities in teaching biodiversity and for physiological and drug research.

6. CONTROL OF SNAILS

Snails are an important part of many ecosystems constituting a major portion of the total animal biomass. They are food for other animals but some snails are predators themselves, many consume dead and dying plant material and therefore they are important in the cycling of nutrients through the ecosystems. Other species of snails carry diseases such as schistosomiasis, angiostrongyliasis, dicrocoeliasis, etc that infect man while some species have become crop pests. They are also incriminated in habitat destruction and modification.

Against this background, efforts have been made over the years to control or even eradicate snail population both on land and in the freshwater habitats.

The snails often thrive in forest edges, in modified forests and plantations as well as natural forest and freshwater ecosystems. Wherever they occur, they keep to the hot humid areas. The snails are killed by sunshine. They remain active at a temperature range of 9^0C to 25^0C by hibernation and 30^0C by aestivation. In agriculture the Africa land snail is regarded as one of the worst snail pests as they consume large volumes of native plants prompting the introduction of predatory species e.g. *Bufo mannus* (the invasive toad) in Japan or some species of red crabs or even some predacious snails like *Euglandina* prey on underwater snail species. There is even a more voracious and indiscriminate predator used called P*latydemus* sp.

The most important reason for snail control is hinged on the fact that snails serve as vectors for several pathogens, and parasites. Most especially important for land snails are that they transmit the worm *Angiostrongylus catonensis* responsible for eosinophilic meningo – encephalistis in man as well as the bacterium *Aeromonas hydrophila*. It was noted in the turn of the 20th Century that the parasites carried by the snails are usually transmitted to man through the consumption of raw or improperly cooked snails. Such disease as Eosinophilic radiculomyeloencephalitis can be contracted by this route. This resulted in many countries instituting quarantine measures to intercept snails.

In few location of the world, snails have been successfully eradicated e.g. U.S.A. and Queensland (Australia). In these areas the control costs can range from US$60,000 for a 7-month procedure to over US$700,000 for the eradication for a long period. Hand collection plays a major role in eradication; this is usually followed subsequent destruction. The most pragmatic approach to control of land snails is the use of pesticides (mo,lluscicides) such as metaldehyde, methiocarb (mesurol), iron phosphate, coconut oil soap, copper sulphate slurry, Bordeaux mixture, metallic copper strips or foil.

In freshwater snail control, chemical or physical measures have been found to be effective in reducing or eliminating snail populations, thus affecting parasite transmission and so snail control has been found to play a significant role in morbidity control programmes. Blanket mollusciciding has been suggested to be cost effective in irrigation schemes. In such diseases like schistosomiasis whose transmission is focal & seasonal, focal mollusciciding at easily identified transmission sites is the method of choice.

Environmental snail control measure include filling or draining of the marginal areas, concrete living of all the integration of chemical control and removal of vegetation are advocated. Bayluscide is the current molluscicide of choice.

7 CONCLUSION

I have in this lecture, tried to give an overview of the intricate relationships between man and snails. I started with the systematics and biology of the snails to the various snail products that man has learnt to use to his benefits. I tried to show the various roles snails and snail products play in the dynamics of human life especially the various ways man has benefited and the ways he must develop to get more out of the relationship with the snails. It is important to note that while this effort does not pretend to present a comprehensive treatment of snails, it tried to present the facts that man and snails are inextricably related in certain aspects of human endeavours and also tried to show that the snails make up a high proportion of species and biomass in the human environment that can be exploited especially in the tropics. It tried to bring out the great diversity of the snails and their ecological adaptations ranging from morphological traits, special physiological and metabolic reactions coupled with their variability and ecological relevance. In all, I tried to present the various ways man had processed snails and the many ways snails warmed their ways into the dynamics of human existence. Furthermore I tried to give a comprehensive taxonomic treatment of the edible snails at the generic levels which will be of immense help to researchers interested in their studies.

In treating snails as food I tried briefly to introduce the emerging interdisciplinary field of snail farming which is production. People involved in developing sustainable ways of rearing snails as a commodity, that could be managed and conserved, to improve human food security (especially for protein and mineral supplementation) will find this little effort interesting.

I highlighted the fact that many people are upset with snails and that farmers get angry when snails eat their plants and crops. This shows snails as pests & that they cause serious damages to crops. So, they must be eradicated or at best be controlled.

In all, I managed to give the good, the bad and the ugly of man-snail relationships that should be of great interest to people with varied backgrounds with the mind to search for the micro and macro perspectives, linking the welfare criteria of man with issues of technical progress, enhancing social security in areas of limited resources and policy implications for families and communities' income generation in the tropics Unfortunately, in these areas, endemic diseases, malnutrition and poverty are acute human problems.

It is my humble submission that more facts and experiences should be accumulated to help us in better understanding more the roles of the snails in education, training, research and product development for the use and for the benefits of man.

Thank you.

ACKNOWLEDGEMENT

The vice chancellor Sir, I crave your indulgence at this point to acknowledge in Public that God the Alpha and Omega had been my support up till now in such a palpable manner that all that know me ascribe to Him the glory for my life, my education and all that concerns me. I am also indebted to the Vice Chancellor for this golden opportunity given me to give the lecture and for other innumerable favours and confidences.

I thank my friend Prof O. U. Njodu. and his committee members for granting me this opportunity to give this lecture with a lot of support and understanding. I am

greatly indebted to my wife Lady Uche Okafor for her devotion and tremendous support. I appreciate the contributions of my children Nchekwube, Chijindu, Chinazam, Nkiruka, and Chiamaka to the successful conclusion of the writing that culminated to this lecture.

As I started this journey in academics, it was my father late Mr Eleazar Udeze Okafor who bore all the pains of my sustenance and so I salute his courage. My mother Emily Enuzo Okafor was always there to feed and nourish me; and to provide all domestic needs of mine. My late uncles, Ernest, Wilson, Cyprain, Benson, Samuel and Christopher I never forget. They believed so much that I was a star and they never let any. opportunity to pass by with out giving monetary and advisory supports. I am sincerely grateful to them.

At the University, I am happy and will continue to show gratitude to Prof. A. B. C Nwosu who was always there to lead me on the right parts and infused the right energy into me. I will always remember his contribution to my growth. The same goes for uncle Joe Ezigbo,they were so helpful. My post Graduate supervisor is one in a million. When I look back at his ever towering figure, I continue to thank God that he brought this man to mentor and teach me. I am talking about Prof. Anya Oko Anya. I will eternally be grateful to him and his wife our mummy Inyang.

Finally I am grateful to all my colleagues and friends, who are always there in my times of need, I mean people like OK, Dyke ,Carl, CIA, VCE, JEE, NSO and Others I plead for God's blessing on you all. I will not forget my in-laws for their concern and support.

REFERENCES

1. Adekoju-John, E. O. and Abolarin, M. O (1986). Status of human schistosomiasis on the eastern side of Kainji lakeof Nigeria. *East African Medical Journal, 63,* 469-470.

2. Adeola, M. O. (1992). Importance of wild animals and their parts in the culture, religious festivals and traditional medicine of Nigeria.
   Environmental conservation, 19, 125-134.

3. Adeola, M. O and Decker, E. (1982). *Wild life utilization in rural Nigeria*. In clers, B. D. (ed) proc. of the international symposium and conference on wild life management in sub sharan African, 6-13 October, 1987, Harare, Zimbabwe, pp512-21.

4. Adewunmi, C. O., Furu, P., Christensen, N. O., Marquis, B.B and Fagbola, M. (1990) Endemicity and seasonality of transmission of human schistosomiasis in 11e ife South weatern Nigeria.
   Tropical medicine and parasitology, 41, 443-445.

5. Afolayan, T. A. (1980). A synopsis of wild life conservation in Nigeria.
   Environmental conservation, 7,207-217.

6. Afolayan, T. A. and Ajayi S.S.(1983). Fifty years of Nigerian wild life resources.

The Nigerian Field, 44 (4), 130-144.

7. Ajayi S.S. (1971). Wild life as a source of protein in Nigeria some priorities for development.
The Nigerian field, 36,(3), 115-127.

8. Ajayi S.S (1973). Wild life management in the national economy.
Nigerian Journal of Forestry, 3 (1), 26-30.

9. Ajayi, S.S., Jewett O. O., Moriarty C. and Awesu, M. O. (1978). Observations on the biology and nutritive value of the giant African land snails *Archachatina Marginata*
African Journal of Ecology, 16, 85-95.

10. Anadu P. A. (1987). Progress in the conservation of Nigeria's wild life.
Biological conservation, 41, 237-251.

11. Akinnusi, O. A. (1998). Practical approach to backyard snail farming. *Nig.J. Anim. Prod., 25, (1-2),* 193-197.

12. Anosike J. C., Okafor, F. C., and Onwuliri C. E. O. (1992). The prevalence of Urinary schistosomiasis in Toro L. G. A. of Buachi State Nigeria.

Helmithologia, *29,*177-199.

13. ANON (1986). Molluscs in Medicine. Carefel Plulip (ed) *Shell News, 8* (2), p.9.

14. Anstey, S. (1991).*Wildlife utilization in Liberia*, Report of a survey undertaken for the world wide fund for Nature. Gland, Switzerland. Unpubl.

15. Anya, A. O. and Okafor F. C. (1986). Prevalence of urinary schistosomiasis in anambra State Nigeria. *Bull. de L'IFAN, 46,* 321-32.

16. Anya, A. O. ed Okafor, F. C. (1991a). The factors affecting the abundance of *Bulinus globosus* in freshwater systems of Anambra State, Nigeria. *Proceeding of the Nig. Academy of Sciences, 9,* 11-22.

17. Anya, A. O. and Okafor, F. C. (1991b). Field age structure, developmental biology and reproduction of *Bulinus globosus* and factors affecting its growth and reproduction. *Tropical Ecology, 32 (1*), 69-85.

18. Asibey, E. O. A (1986). *Wildlife and Food security*. FAO Forestry Department Report, Rome.

19. Asibey, E. O. A. and child, G. (1990). Wildlife management for rural development in sub-Saharan African
Unasylva, *41*, 3-10.

20. Avagnina, G. (1982). New methods for rearing edible snails
Informative Zootecnics, 29 (18), p.85

21. Azugo, W. I. (2008). *Ecology of gastropod molluscs in Obutu lake, Anambra State Nigeria.*
PhD. Thesis, University of Nigeria Nsukka, 297pp.

22. Baratou, B. (1988*). Raising snails for food*.
Calistagu, Califormia Illumination press, pp 38-40.

23. Baur, B. (1992). *Cannibalism in gastropods*. In Cannibalism, Ecology and Evolution among diverse Taxa (eds M. A. Elgar and crespi, B. J.) Oxford University press, Oxford pp 102-127.

24. Baur, B. and Baur, A. (1992) Effects of courtship and repeated copulation on egg production in the simultaneously reared hermaphroditic land snails. *Arianta arbustorum.*
Invert. Reprocuction and Development, 23 (1), 201-206.

25. Betterton C. and fryer, J. E. (1982). *Schistosoma haematobium* in Northern Nigeria a complex of snails hosts and parasitic strains. *Parasitology, 85 (2),* supplxx11.

26. Bequaert, J. C. (1950). Studies in Achatininae, a group of African land snails.
Bull. Mus. Comp. Zool., Harares, 105, 1-216.

27. Calow, P. (1970). Studies on the natural diet of *Lymnaea pereger Obtusa* (kobelt) and its possible ecological implications. *Proc. Malacol. Soc. Lond., 39,* 203-215

28. Cavallo passerini M. G. (1998). Practical studies and application on open air treeding to completes life cycle of *Helix pomatia*
Elicicoltura, April, 1998, P.12.

29. Cavallaro, R. and Ravera, O. (1966). Biological indicator of Manganese-54 contamination in terrestrial environments.
*Nature (loud), 209,*259.

30. Chen, M. G. and Feng, Z. (1999). Schistosomiasis control in the people's Republic of china.
Parasitol. Int., 48, 11-19.

31. Cowper, S G. (1973). Schistosomiasis in Nigeria.
Ann. Trop. Med. Parasite., 57, 307-322.

32. Dei, G. J. S. (1989). Hunting and gathering in a Ghanaian rain forest community *Ecology of Food and Nutrition*, *25*, 29-49.

33. de vanfleury, A. G., and Borgo, R. (2001).Invertebrate reproduction and development., 40 (2-3), 217-226.

34. de-Grisse, A. and Mededelingen van (1990). Oviposition and egg incubation in artificial conditions by *Helix aspersa* Mullor *Fac. Landbouw. Rijksuniv. Gent, 65*, 35-46.

35. Dimitriadis, V. K. (2001*). Structure and function of the digestive system in stylommatophora.* In: The Biology of Terrestrial molluser (ed G. M. Barker), C A B Informational, walling ford , pp 237-257.

36. Davis P. R., van schagen, J. J., Widmer, M. A., craven, T. J. (1996). *Slug and snails pasts in Agiculture*. Proc. Of a symposium held at University of Kent, Canterbury, U. K; 24- 26 sept.,1996.

37. Ebomoyi E. S. (1988) Nutritional beliefs among rural Nigerian mothers. *Ecology of Food and Nutrition*, *22*, 43-52.

38.Egonwan, R. I. (1992). Food selection in the land snails *Limicolaria Flammea* (muller) (pulmonata: Achatinildae)

J. Molluscan Studies, 58, 49-55.

39. Egonwan, R.I. (2004). Maturation timing in the Afric land snail *Archeehatina marginata ovum* (pfeifferi) and *Limixolaria Flammea* (muller)(pulmonata: Achatinidae)
Invert Reprod. And Dev., 461, 159-172.

40. Egonmwan, R. I. (2007). Food utilization in a laboratory colony of the giant African land snail Archachatina marginata
Turk. J. of zoology, 37, 265-270.

41. Elmslie, L.J. (1982). Snails and snail farming .
World Animal Review, 41, 20-26

42. Eltringham, S. K., (1984). *Wildlife resources and economic development*. John wiley and sons New York, U.S.A, 325pp.

43. FAO (1986*). Natural resources and the human environment for food and agriculture.* F A O, Rome.

44. Gomot, A. (1998). Biochemical composition of Helix snails: Influence of genetic and physiological factors.

J. moll. Studies, 64 (2), 173-181.

45. Grisse, A., de Defloor, J., Vercanteren, F., King . J. M. and Heath, B. R. (1975). Game domestication for animal production in African *world animal Rev., 16,* 23-30.

Mededelingen F., (1996). Influence of mixing different soil types (chalk, sand, leaf moued, peat) with feed on the growth of the edible snail *Helix aspersa maxima, landbouw. Toeg. Biologische Weternsc, Univ Gent., 61 (1),* 129-139.

45b. Grisse A. (1994). *Snail breeding, from hobby to profession*. De source Geat. (Belgium), 234pp.

46. Hodasi J. K. M. (1995). *Effect of different types of foods on the growth of Achatina achatina.* In Abstract of the 12th Malacological congress, Vigo, 488-489.

47. Hodasi, J. K. M. (1984). Some observation on the edible giant land snails of West Africa. *World Animal Review, 52,* 24-28.

48. Hodasi J. k. M. (1989). The potential for snail farming in West Africa. *Slugs, and snails in world Agriculture, 41,* 27-31.

49. Hopocraft D. and Arman, P. (1971). *Preliminary records on comparative productivity of wild and domestic animals*. Appendix 11. Ntional Report on the human enviroment in Kenya, 102 pp.
50. Iheagwam, E. U.and Okafor, F. C. (1984). The biology, life tables and intrinsic rate of natural increase of *Bulinus (physopsis) globosus* (mowlet) and *hymnaes ntalensis* (known Gastropoda, pumonata) snail informodiatehosts of schiztosoma haematobium and fysciolagigaatica respectively in southerstern Nigeria Bietr. *Trop. Land wist vetrinanod. 22 (A).*429-434.

51. Imevbove E. A. and Ajayi, S. S (1992). Food preferences of the giant African land snails (*Archalhatina margiata*) in captivity. *African J. of Ecology, 31 (3)* 265-267.

52. Ireland, M. P. (1970). Distribution of essential and toxic metals in the terrestrial gastropod, *Arionater. Environmental Pollution, 20*, 271-378.

53. Jardin C. (1970*). Lists of foods used in African.* Nutritional Information Document, series 2, FAO, Rome

55. Liu, Y. (1983). Progress on the study of medical mollscs during the past 32 years in New china. *Trans. China Soc. Malacol., 1*, 197-207.

56. Lux moore, R. (1985). Game farming in South African as a force in conservation. *Oryx, 19*, 225-231.

57. Makombe, K. E. (1993). *Sharing the land wildlife, people and development in Africa.* IUCN Regional office for southern Africa, 36 pp.

58. Malak, E. A. (1982) Snail transmitted parasite diseases. *Med. Journal, 6 (4),* 153-163.

59. Marigimez, J. A., Angulo, E., and saez, Y. (1986). Feeding and growth responses to copper, zinc, mercury, a lead in Environmental gastropod *Arion ater* (linne) *Journal of Molluscan Studies, 52*, 68-78.

60. Martin, G. H. G. (1985). Bushmeat in Nigeria as a natural resource with environmental implications. *Environmental Conservation, 10*, 125-132.

61. Martin, G. H. G. (1985). West Africa: Carcass composition and palatability of some wild animals commonly used as food. *World Anim. Rev; 53*, 40- 44.

62. Mason, C. F. (1970). Food, feeding rates and assimilation in woodland snails. *Oecologia*, *4*, 358-373.

63. Mead, A. R. (1957). *Achatina fudica* enters the economy. (A. Burges and F. Raw eds) Academic press, London. Pp413-433.

64. Muir, K. (1989). The potential role of indigenous resources in the oconomic development of and environments in sub-saharan Africa the case of wildlife utilization in Zimbabwe. *Seciety and Natural Resources, 2*, 307-318.

65. Newell, P. F. (1967). *Mollusca in soil Biology* (A. Burges and F. Raw eds). Academic press lands pp413-433.

66. Nisbet, R. H. (1974). The life of Achatinidae in London. *Pro. Soc Mollusc. Studie. London*, 41, 171-183.

67. Odo, S. (1995). *Epidemiology of urinary schistosomiasis in Benue State, Nigeria.* PhD. Thesis, University of Nigeria, Nsukka, 280pp.

68. Okafor, F. C. (2001). *Edible land sail: A manual of breeding management of Achatima achatina*. Simarch Publizahas, Lagos 72pp.

69. Okafor, F. C. (1989). Consumption and assimilation of food in *Achatina A. achatina* (L). *Tropical Ecology, 20(1*), 52-57.

70. Okafor, F. C. (1989b). Distribution of Fresh water gastropods in the River Niger and Cross River basins of southeastern Nigeria with reference to their trematode infections.
Bietr Trop landwirt. Veterinamed., 28, 207-212.

71. Okafor F. C. (1990a). On the effects of Ivermectin on snails of Medical and Veterinary importance
Angwe. Parasitol., 31, 65-68.

72. Okafor F. C. (1990b). *Schistosoma haematobium* cercarriage transmission patterns in freshwater systems of Anambra State, Nigeria.
Angwe. Parasitol., 31, 159-166.

73. Okafor, F. C. (1991). The effects of temperature on embryogenic development and reproduction of the freshwater snails *Bulinus globosus* (Morelet) and L*ymnaea natalensis* (Kraus).(Gastropoda: Pulmonata).
Nig. J. Aquatic Sci., 6, 7-11.

74. Okafor, F. C. (1991). Host spectrum in the transmission of *Schistosoma haematobium* in southeastern Nigeria.
Rivista Parasit., 2, 337-344.

75. Okafor, F. C. and Obiezue RNN (2004). Malacological survey of the Anambra River basin in Anambra State, Nigeria.
J. Bioresources and Biotechnology, 2(1), 29-28.

76. Ngang I and Okafor F. C. (2004). Effect of permethrin on survival and reproduction of *Buliniis globosus* (morelet,1868) and *Bulinus truncatus* (Audoin, 1872)
Anim. Res. Int., 1(2), 110-112.

77. Okafor F. C and Ngang (2004). Freshwater snails of Nkalagu Eastern Nigeria: Observations on some demographic aspects of the schistosome transmitting buliniids.
Anim. Res. Int., 1(2), 120-124.

78. Osemeabo, G. J. (1992). Effects of land use and collection on the decline of African giant snails in Nigeria.
Environmental conservation, 19, 153-159.

79. Olufokunbi, B., Phillips, E. O., Omidiji, J. O, Ogbonna, U. O., Makinde, H. T. and Apansile, O. j. (1989*). The economics of commercial domestication of the African giant land snail Archachatina (calachatina) marginata (swainson) in Nigeria*. In the series analytic, “slug and snails in Agriculture”.

Proc. Symposium organized by the British crop protection council, April 10-12, 1989. University of Surray, Guild ford, England series No. 41, 41- 88.

Thorton Heath, England.

80. Ozumba, N. A., Christensen, N. Nwosu, A. B. C and Nwaorgu, O. C. (1989). Endemicity, focacity of transmission of human schistosomiasis in Aruagunze Village, eastern Nigeria.
Journal of Helminthology, 63, 206-212.

81. Owen, D. F. (1975). A remarkable example of polymorphism in an African land snail.
Bull. De L'IFAN, 37, 771-774.

82. Plummer, J. M. (1975). Observations on the reproduction, growth and longevity of a laboratory colony of *Archachatina (calachatina) marginata* (Swainson) subspecies *Ovum. Proc. Malacol. Soc. London, 41,* 395-403.

83. Russel-Hunter, W. D., Meadows R. T., Appley, N. I. And Brukey, A. J. (1968). On the use of a wet oxidation method for estimating total organic carbon in molluse growth studies.
Proc. Malacol. Soc., London., 40. 407-12.

84. Sanz-Sample layo, M. R., Fonolla, J. and Extremera, F. G. (1991). Factors affecting food intake, growth and protein utilization in the *Helix aspersa* snails: Protein content of diet and animal age. *Laboratory Animals, 25(4),* 291-300.

85. Sheldon, C. (1988). *Raising snails: special reference briefs*. National Agricultural library SRB88-*04*. Beltsville, Maryland. USDA, pp212-230.

86. Solem, A. (1974). *The shell makers*: Introducing mollusce. 2nd Edition. Blackwell scientific publications, London, pp 210-230.

87. Taylor, T. W. (1900*). Monograph of the land and fresh water molluscs of the British 1sles: I. Structural and General.* Leeds, Taylor and Bros. 454 pp.

88. Tucker, R. A. (1976). *Sea Shells*. Transworld Publishers Ltd, Verona, London. 95 pp.

89. Wilbury, K. M. (1983). *The Mollusca* Vol. I. Academic press, New York, London, pp 180-210.

90. Webbe G. (1987). *The use of molluscicides in the control of human trematode infections.* In “The Toxicology of molluscicides intervention”. Encyclopedia of pharmacology and Therapentics, Section D125. pergamon press, oxford. Pp1-11.

91. Well, P. B. (1948). Some notes on the African giant snails *Achatina fulica:* on its economic significance.

*Chronicle Nautilus Batavia, 104,*278-285.

APPENDIX 1:

DESCRIPTION OF SOME OF THE GASTROPODA (AFTER, Yuri Yashin,2001)

Achatina balteata *Reeve,1849*

Shell olive-yellow, yellowish-brown, chestnut with or without blotches or streaks.

Length 100-148 mm and width 52-73 mm.

The shell has been used as money in Angola(cut into disks)and the Congo(cut length-wise).

In Upper-Guinea, Cameroon to Central Angola, Sierra Leone and Gambia.

Achatina fulica*Bowdich,1822*

Shell size is very variable, depending on locality, from 72-171 mm in length to 37.5-81

mm in width,dark brown with lighter vertical bands.

This species is both a favourite pet and serious pest.

Originally in East-Africa,but imported in India and the Pacific.

According to Bequaert(1950)there are five subspecies:

- Achatina fulica fulica
- Achatina fulica hamillei: larger, pale olive-gold yellow with chestnut streaks.
- Achatina fulica coloba: yellowish-red brown, & streaked.

- Achatina fulica rodatzi:olive-yellow with dark yellow streaks, pale body
- Achatina fulica castanea: above the periphery dark buff,below light brown.

Another subspecies is A.f. umbilicata, this has a very convex body whorl.

Achatina iostoma *Pfeiffer,1852*

About 13cm,light brownish with a granular surface.

In Cameroon.

Achatina immaculata *Lamarck,1822*

Shell:Thick and large,shape very variable,columella and inside of lip pink.

Apex smooth.

Color is whitish,buff or light brown,with darker brown axial stripes which are relatively straight compared to other Achatina species.

Achatina panthera Ferussac, 1832 is now to be believed As a narrow variety of A. immaculata.

Habitat: Coastal lowlands, dune forests, gardens, valley thickets and savanna

woodlands.

Distribution:East-Africa.

Achatina iredalei *Preston, 1910*

Shell thin, semi-transparent, lemon yellow, about 70-100 mm.

This species is one of two (the other one being Cochlitoma zebra) Achatinids to give birth to live young.

Achatina reticulata *Pfeiffer,1845*

Shell yellowish white to reddish brown with vertical markings,on the body whorl are

spiral lines and vertical welts.The periostracum is very thin and usually lost in

adult specimens.

The head and tentacles are dark brown,with a dark brown band running down the center towards the shell.

The eyes and tips of the tentacles and rest of the body are pale

yellowish brown.

Length 160 mm and width 75 mm with 8-10 whorls.

In Zanzibar.

Achatina stuhlmanni *von Martens,1892*

About 10cm.

In Uganda.

Achatina schweinfurthi *von Martens,1873*

About 14cm,light brownish with lightning darker stripes.

In East-Africa.

Metachatina kraussi *Pfeiffer,1846*

Shell:Large and thick, lip thickened, columella not truncated as in other Achatinids. However young snails do have a truncated columella.

Color whitish with brown streaks on the apex,columella and inside of the lip dark brown to purplish brown.

Length up to 160 mm.

The animal has a dark grey head and tentacles with a broad band running towards the shell,the sides are paler while the foot is whitish grey.

Habitat: Dune, coastal lowland forest,valley thicket,savanna woodland.

Distribution: Eastern South-Africa; KwaZulu Natal north to Mozambique,inland towards

Ithala,the Lebombo Mountains,Kranskop,Glencoe,the Vryheid region,south to Ifafa.

Genus Columna

Columna columna(Müller,1774): São Tomé and Principe

Columna leai(Tryon, 1866) : São Tomé and Principe

a b

a. Columna leai *Tryon,1866* .

b. Columna columna *Müller,1774*

APPENDIX II

SHELLS OF NIGERIAN SNAILS (After Okafor F.C., 2009)

Shells of *Potadoma Spp*.

Shells of *Lanistes ovum*

Shells of *Gyraulus costulatus*

Adults of *Achatina achatina*

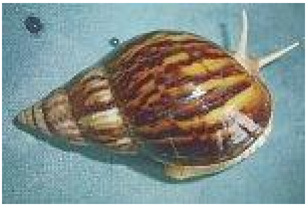
Shells of *Biomphalaria pfeifferi*

Shells of Lanistes varicus and operculum

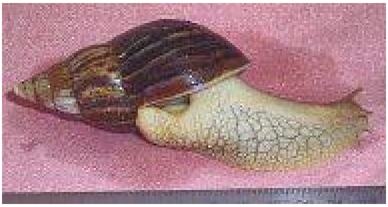
Adults of *Achatina balteata*

A mixture of *Buliniid* shells

Achatina panthera



Courtesy of
Yurii Yashin

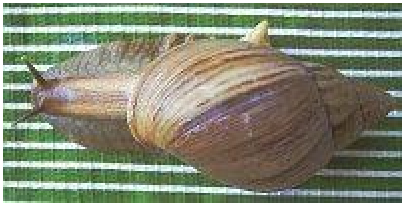


Courtesy of
Yurii Yashin

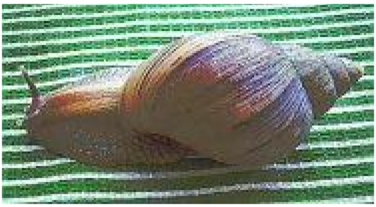
Courtesy of
Yurii Yashin

Courtesy of
Yurii Yashin

Courtesy of
Yurii Yashin



Courtesy of
Yurii Yashin



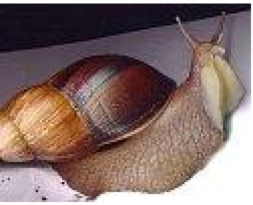
Courtesy of
Yurii Yashin

Achatina iredalei

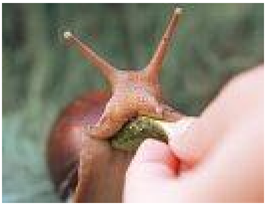
Courtesy of
Yurii Yashin

Courtesy of
Yurii Yashin

Achatina glutinosa



Courtesy of
Yurii Yashin

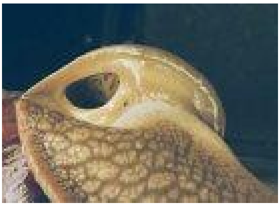


Courtesy of
Yurii Yashin

Courtesy of
Yurii Yashin

Courtesy of
Yurii Yashin

Courtesy of



Courtesy of

Courtesy of

Courtesy

Yurii Yashin Yurii Yashin Yurii Yashin Yurii Yash

Courtesy of
Yurii Yashin

Courtesy of
Yurii Yashin

Achatina immaculata

Courtesy of
Beth

Courtesy of
Daniel Israelsson

Courtesy of
Daniel Israelsson

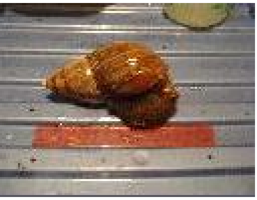
Courtesy of
Emmanuelle
Bresci

Courtesy of

Courtesy of

Emmanuelle Bresci *Emmanuelle Bresci*

Achatina fulica



Courtesy of *Sarah Houghton*

Courtesy of *Sarah Houghton*

Courtesy of *Sarah Houghton*

Courtesy of *Sarah Houghton*

Courtesy of *Sarah Houghton*

Courtesy of *Sarah Houghton*

Courtesy of *Sarah Houghton*

Courtesy of