ECOLOGY AND STATUS OF THE GIANT AFRICAN SNAILS

In

THE BIA BIOSPHERE RESERVE IN GHANA

By

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EXECUTIVE SUMMARY

The giant African snails are edible gastropods found within the dense forest floors and the forest environs in the humid tropical high forest zone of Ghana. Three species, namely *Achatina achatina, Archachatina degneri* and *Achatina fulica* occur within the Bia Biosphere Reserve (BBR) and its environs in Ghana. *Achatina fulica* is reported as being a recent immigrant in Ghana, and it is commonly found (within the humid zone) on farm clearings, along roadsides and footpaths, and also backyards in villages and towns. *Achatina achatina* and *Archachatina degneri* constitute the main species of giant African snails that are found within the BBR's forest floor.

The distribution pattern and abundance levels of the *Achatina achatina* and the *Archachatina degneri* have been reported to be on the decline over the years within the BBR. The *Achatina fulica* is rather reported to be on the increase, especially on degraded lands, along roadsides and within backyards of communities around the BBR. Presently no scientific database exists on the snail stock in the BBR and its environs, thus making it difficult to establish criteria for their sustainable exploitation and management.

This study was geared towards determining the present distribution pattern, abundance level, status and some ecological aspects of the giant African snails occurring within the Bia Biosphere Reserve. The ultimate objective is to suggest appropriate management strategies to ensure a viable and sustainable rural snail industry in the area.

The study was conducted into two phases. The first phase was a pre-survey (reconnaissance) exercise, whilst the second involved a field exercise with data collection from permanent sample plots (PSPs) within the BBR.

One major striking observation is the present non-existence of buffer zones around the BBR. The reserve is completely surrounded by villages and farmlands, thus existing currently as an 'ecological forest island'. Reasons for the loss of buffer zones is

attributed to clearing of previously adjoining unreserved forests, primarily for cocoa cultivation. This situation is seems to have contributed to present status of the different species of snails in the area.

There is a gradient in the abundance of *Achatina achatina* across the entire stretch of the reserve, becoming minimum or absent in the southern sector of the BBR (Resource Reserve) area and maximum at the northern sector (National Park area). Though they do not occur in the BBR itself, there is also a converse gradient with respect to the *Achatina fulica* in the localities around the BBR. They are abundant in the communities within the vicinities of the Resource Reserve but virtually absent at the National Park area. No such observation has been made with respect to the *Archachatina degneri* except that the are generally observed to be less common within the entire BBR.

From this study (short-term duration) the causes of the decline in the abundance of *Achatina achatina* may provisionally be attributed to the inter-playing roles of:

i. increased human population in the area and presently too many snail collectors (as compared to few people in the former days), thus leading to overexploitation of the snails,
ii. indiscriminate harvesting of any edible giant snail encountered, both immature and mature, during the harvesting seasons,
iii. clearing of the forests for cocoa cultivation,
iv. cultural practice of burning farms during land preparation for the planting season, and
v. the present non-observance of traditional customs and rituals concerning snail harvesting in the area

These factors are yet to be tested in a long-term study and determine real factors and their magnitude in affecting the snail's population dynamics within the BBR ecosystem.

There are two main snail-harvesting seasons in each year. The major harvesting season is in September and the minor one in May /June. These seasons coincide respectively with the major rainy season of May /June and the minor rainy season of September /October. On the converse, the snails seem to be less abundant during the major rainy season but more abundant during the minor rainy season.

Traditional customs governed snail harvesting from the BBR until the reserve was taken over by the Ghana Wildlife Department, and the department assumed total responsibility over the management of the reserve, largely to the exclusion of the traditional chiefs and people. The Wildlife Department currently operates a permit system for access into the reserve and collects tolls from snail harvesters at the onset of the major peak snail season. The permission is granted for a maximum of two weeks. The intention has been to solicit the local peoples' support in their biodiversity conservation efforts.

Issues of poverty resulting from low-income levels largely affect the local people, and the snail collection is a major supplementary income source for them. Options for sustainable use of the snail resources might first have to address rural poverty issues and sources of alternative income apart from the snail collection.

It may also be appropriate for the BBR management to consider initiating the formation of a "Management Committee" comprising of representatives from the traditional authorities, local government authorities, identifiable local associations and groups, and then the BBR management itself. The committee will then have to cooperate in the control of the snail collection exercise within the area. Complete denial of access into the reserve might not be a workable alternative and ignoring other social power structure in the local communities may be a major setback in the biodiversity conservation efforts.

1.0 INTRODUCTION

The giant African Snails are pulmonate, nocturnal, hermaphroditic gastropods of the family *Achatinidae*. They are indigenous to Africa and are distributed in sub-Saharan Africa, ranging from the Gambia in the West to the Lake Chad region in the East. Their distribution extends southwards to the Orange River in South Africa (Hodasi 1995).

The giant African Snails in Africa belong to two main genera namely *Achatina* (Lamarck) and *Archachatina* (Albers). The former occurs all over Africa whilst the latter is restricted to the West African sub-region. In Ghana, two species of the *Achatina* genus, namely *Achatina achatina* and *Achatina fulica*, and then two species of the *Archachatina* genus, i.e., *Archachatina degneri* and *Archachatina marginata* are known to occur (Monney, 1994). Both genera are known to be snails of the humid tropical environment. They are found within the dense forest floors in the forest zone of Ghana and also in the humid riparian forest floors. *Archachatina degneri* can also be found in secondary thickets and savanna woodlands (Hodasi, 1984). *Achatina fulica* is reported as being a recent immigrant in Ghana and it is commonly found (within the humid zones) on farm clearings, along roadsides and footpaths, and also backyards in villages and towns. It is reported as being a prolific breeder (Monney, 1994), attaining sexual maturity within 8 to 12 months, as compared to 21 to 24 months by the *Achatina achatina* (Hodasi 1979, Ghose 1959, Lange 1950). According to Hodasi (1979), studies of A. achatina under laboratory conditions indicate that the species breeds from April to July, which coincides with the major rainy season of the year. Reproduction is commonly by self-fertilization and oviposition occurs in the second and third years and sometimes up to five years after the first oviposition year. Clutch size range from 37 to 305, the eggs taking 10 to 31 days to develop. Hodasi (1982) again showed that natural photoperiodism favors maximum

egg production output in giant snails whilst snail maximum size is achieved under continuous light or reversed light and darkness situations.

Three species of *Achatinidae* are eaten in Ghana (Monney, 1994). *Achatina achatina* is specially a delicacy to the snail consuming Ghanaian populace, followed by *Archachatina marginata*, and then *Archachatina degneri* in descending order of delicacy. *Achatina fulica*, though nutritious and edible (Monney, 1994), is bluntly avoided by most snail eating Ghanaians, and with its very high turnover rate, it is appears to be a nuisance to some people.

The distribution pattern and abundance of the most preferred *Achatina achatina* and the less preferred *Archachatina marginata* and *Archachatina degneri* have been on the decline over the years in Ghana, as reported by rural dwellers in the humid forest regions of the country. Also their abundance in large market centers in the country during the snail peak seasons has declined dramatically over the years, according to a few selected snail dealers. Both reserved and unreserved forests have undergone drastic disturbance due to logging activities, coupled with decreased rainfall intensity and amounts over the years. Slash and burn system of farm clearing and then shifting cultivation systems of agriculture are still being practiced by the rural farmers. Both rural and urban populations have increased dramatically, leading to increased pressure on the wild snail stock for both local consumption and for sale, and currently for export (Monney, 1994).

The study site, BBR, until the recent past when immigrant farmers flocked into the area to cultivate cocoa (*Theobroma cacao*) was richly endowed with abundant snails, especially the most preferred *Achatina achatina*. Presently, the rural dwellers of the area

report of drastic decline in their abundance even during the snail peak seasons. Attempts are being made to encourage captive rearing of *Achatina achatina* within the rural communities in the area. However there are a few issues to be tackled in respect of this initiative. Some questions are:

- In what ways can the captive snail-rearing program simulate the wild habitat condition to ensure its success?
- Again are there options to manage the wild snail stock and maintain their exploitation levels within sustainable limits?
- Also how can the wild snail industry be promoted to serve the three basic functions under the UNESCO (MAB) Program concept, viz., conservation function, development function, and logistic function?

Prerequisite to answering these questions are the need for a thorough knowledge of their distribution, level of abundance of the individual species in the BBR itself and its environs. This study thus aimed at determining the present distribution pattern, abundance level, status and some ecological aspects of the various snail species occurring within the Bia Biosphere Reserve, and then suggest appropriate management strategies to ensure a viable and sustainable rural snail industry in the area.

2.0 BACKGROUND

UNESCO Biosphere Reserves Concept /MAB Program

By the UNESCO (MAB) Program definition, biosphere reserves are areas of terrestrial and coastal ecosystems that are internationally recognized within the framework of UNESCO's Man and the Biosphere (MAB) Program, and collectively constitute to a World Network. Biosphere Reserves are intended to fulfil three basic functions, and these include

i. a conservation function; that is to contribute to the conservation of landscapes, ecosystems, species and genetic diversity

ii. a development function; that is to foster economic and human development which is socio-culturally and ecologically sustainable

iii. a logistic function; that is to provide support for research, monitoring, education and information exchange related to local, national and global issues of conservation and development.

Each individual country has sovereign jurisdiction over its biosphere reserves and enacts legislation in respect of the establishment and conservation of the biosphere reserves, or re-designation of its other reserves as biosphere reserves under the framework of the UNESCO (MAB) Program's biosphere reserve concept. Each biosphere reserve consists of a core area, a buffer zone, and a transition area, with the core zone requiring absolute legal protection.

Ghana's Biosphere Reserve

Ghana currently has one wildlife-protected area that has been designated as a UNESCO (MAB) biosphere reserve. This is the Bia Biosphere Reserve (BBR) and it covers an area

of 355.62 km^2. It was designated as such in 1983 and constituted into the network of biosphere reserves. It comprises of a continuous block of two adjacent forest reserves, namely the Bia National Park (BNP) and the Bia Resource Reserve (BRR). The BNP was so declared in 1974 by Legislative Instrument 881 of the Wildlife Reserves Regulations of the Republic of Ghana, for the purpose of absolutely protecting both the rich flora and fauna, which had never been exploited for timber, nor farmed. The BRR was also declared as such by the Wildlife Reserves Regulations LI 1085 and LI 1105 of 1976 and 1977 respectively, to allow for controlled timber exploitation. Prior to their being constituted as BNP and BRR respectively, both reserves together used to be one block of forest reserve called the Bia Tributaries South Forest reserve. This reserve was selected for reservation in 1935, and demarcated between 1937 and 1939 for the purpose of reserving the rich timber resources. It was also meant to protect the watershed system between the main Bia River, and the Manzan river (a tributary of the Komoe river in the neighboring country La Cote d'Ivoire). At the time of reservation, the two reserves were adjoined by other blocks of forest reserves, namely the Sukusuku, Tawya, Krokosua Hills, and the Bia North forest reserves. These served as "buffer zones" under the biosphere reserves concept. BNP and BRR have respectively been under the management of the Wildlife Department of Ghana since 1974 and 1976, whilst the management of the "buffer zones" have long since been under the care of the Forestry Department of Ghana, and they still continue to be.

Biosphere Reserves for Biodiversity Conservation and Sustainable Development in Anglophone Africa (BRAAF) Project

In accordance with the network of biosphere reserves concept, and agenda 21 of the Convention on Biological Diversity, the Biosphere Reserves for Biodiversity

Conservation and Sustainable Development in Anglophone Africa (BRAAF) program has been initiated, under the spearheading role of the Ghana National UNESCO (MAB) Committee, to coordinate activities and exchange information of mutual concern to the UNESCO (MAB) Network within the sub-region. Under this project, baseline studies are being carried out within and around the BBR to compile a database of issues of biodiversity conservation and socio-economic concerns to the local people, and to promote environmental stability in and around the BBR. The present study on the giant African Snails in the BBR is of critical importance under the BRAAF project, since apart from the imminent threat of ecological disaster and the sharp decline in the snails' abundance over the years, they constitute a seasonal industry upon which some of the rural economies depend.

3.0 STUDY SITE

The Bia Biosphere Reserve is bounded within the geographical coordinates 6°32' N to 6°37' N and 3°02' W to 3°08' W. It is located within the northwestern part of the Western Region of Ghana. It is also located very close to the Ghana – Cote d' Ivoire border (Fig. 1), and covers a total area of 355.62km^2. The reserve comprises of two blocks of forest, i.e., the Bia National Park (177.7 km^2) and the Bia Resource Reserve (277.92 km^2). The Bia National Park lies within the Moist Semi-deciduous Vegetation Zone of the country whereas the Bia Resource reserve is within the Moist Evergreen Vegetation Zone (Hall and Swaine, 1981). It is on record of the forest maps of Ghana that there are four adjacent blocks of forest reserves, namely the Sukusuku, Tawya, Krokosua Hills and Bia north forest reserves, that potentially serve as buffer zones under the biosphere reserve concept. The Bia Resource Reserve has been exploited for timber in recent past whereas this activity has never been carried out in the Bia National Park.

The area is a forest island surrounded by farmlands of cocoa, and a feeder road network that links the surrounding villages (some of which are only seasonally inhabited). The major occupation in the area is farming with cocoa cultivation as the major activity. The area experiences a bimodal annual rainfall pattern with two seasonal peaks that occur in June and September. Rainfall pattern has changed in recent times and there have been two unusual peaks in March 1995 and March 1996 (see Fig. 4).

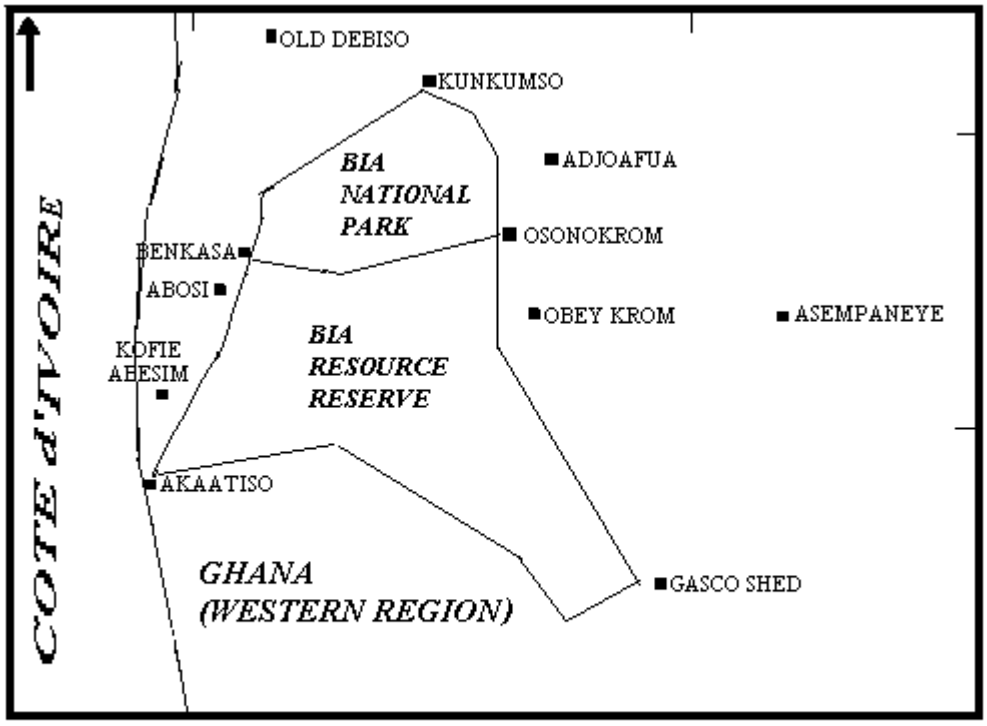
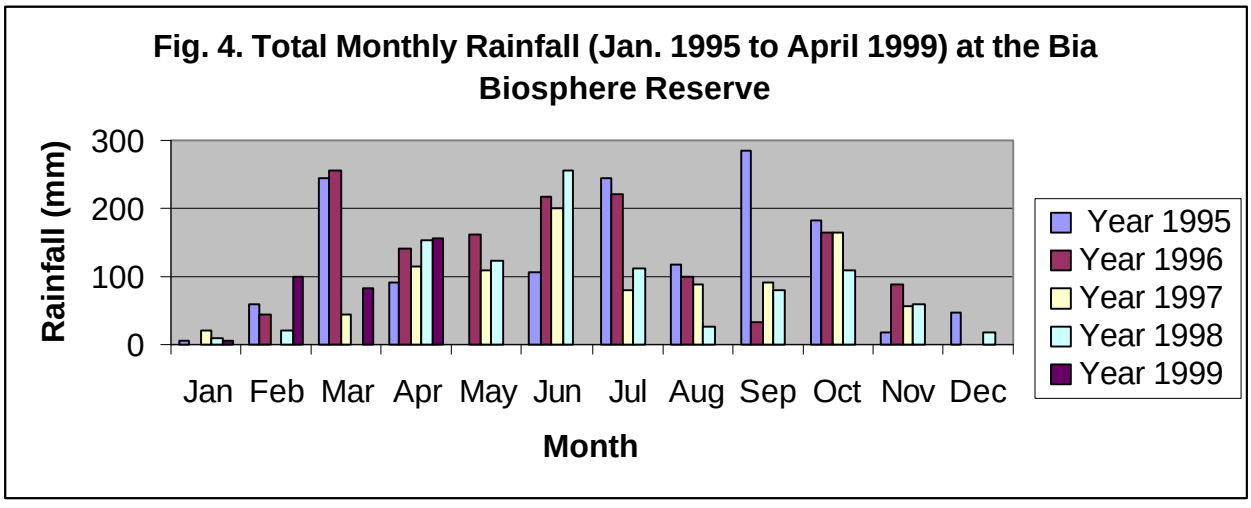


FIGURE 1: OUTLINED MAP OF THE BIA BIOSPHERE RESERVE SHOWING THE NATIONAL PARK, THE RESOURCE RESERVE, AND SOME SURROUNDING VILLAGE COMMUNITIES



4.0 STUDY METHODS

The study was divided into two phases. Phase I was a pre-survey (reconnaissance) exercise, whilst the second involved a field exercise with data collection from permanent sample plots (PSPs).

Methodology in Phase I (Pre-survey) Exercise

i. Interview

This involved interaction and interviews (formally & informally) with the Wildlife Officer-in-Charge, and then the staff in the Wildlife Protection Camps of the BBR. It was then followed by interaction and interviews with the traditional authorities, individual farmers and habitual snail harvesters in some of the communities around the reserve. This was done with the guidance and assistance of a staff of the Wildlife Department. A total of four village communities, together with the staff of five of the Wildlife Department's Protection camps around the BBR were both formally and informally interviewed. The formal interview involved the use of structured interview questionnaires. The informal interviews entailed more of courtesy calls on opinion leaders and socialization chats with individuals and households. A total of 52 persons were formally interviewed.

ii. Reconnaissance Survey

The reserve was also entered via three major entry points, i.e., through the Resource Reserve area, the National Park area, and then the dividing boundary between these two blocks of forest, to lay Permanent Sample Plots for the next phase of the study.

Methodology in Phase II (Field Survey) Exercise

More PSPs, in addition to the ones laid during the pre-survey exercise were laid at the onset of the phase II study. A total of 24 PSPs were used in the study. Four PSPs were laid at each of the 6 sampling locations within the BBR (fig. 2) and marked with flagging tapes. Each PSP had the dimensions of 25m X 25m. Every PSP was searched thoroughly for all snail species present during the minor rainy season of 1998 and major rainy season of 1999. The following records were taken from every PSP during each field visit:

i. identification and counts of various species of live giant African snails
ii. identification and counts of various species of newly dead giant African snails (record was taken only once)
iii. biometrics of individual snail species, notably total shell length (L), shell diameter (D) at widest part, weight (live snails) of shell and meat in-situ
iv. time of observation
v. snail activity at time of observation
vi. brief description of micro-habitat in which snail was found
vii. soil surface temperature, relative humidity and litter depth
viii. photographs, slides of the snails and habitat features (only strikingly observed features)
ix. any other striking feature such as evidence and activities of snail harvesters

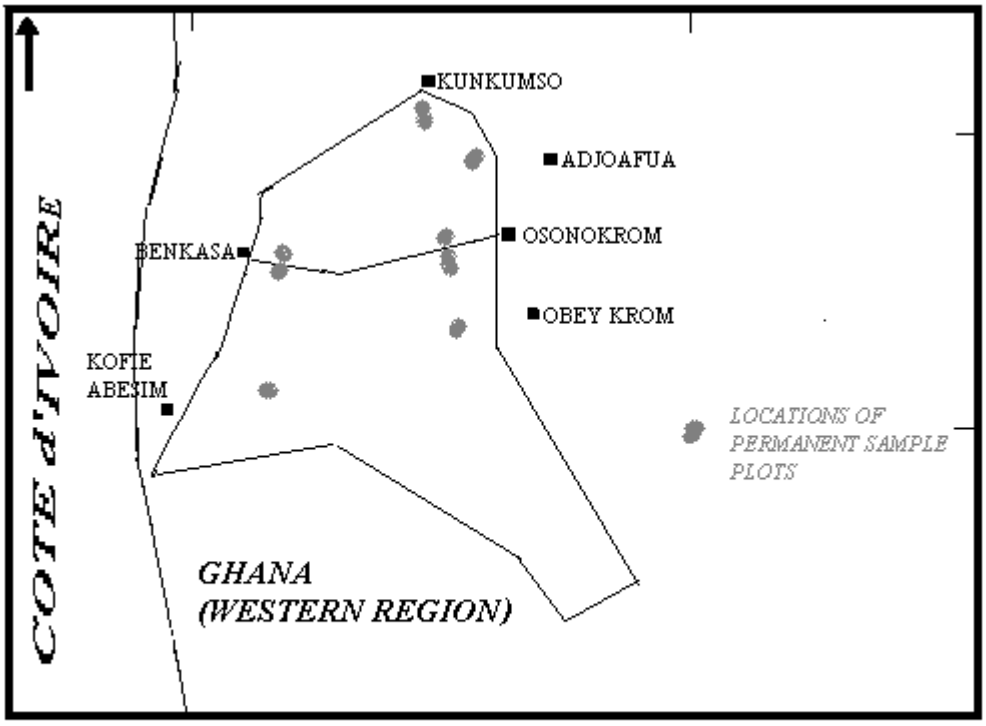


FIGURE 2: OUTLINED MAP OF THE BIA BIOSPHERE RESERVE SHOWING SAMPLING LOCATIONS

5.0 OBSERVATIONS FROM PHASE I STUDY

Demography of Interviewees

The interviewees comprised of local citizens and immigrants with different ethnic origins. The local indigenous people comprise of the Sefwi tribe in the Western Region of Ghana. Local Ghanaian immigrant farmers include the Asante, Fanti, Kussasi, Brong, Ewe, Krobo, Dagarti, Gomoa, Akwapim, etc. tribes who are in the area purposely for the cultivation of cocoa. Most of the immigrants go back to their hometowns at the end of the cocoa harvesting seasons, leaving their farms in the care of caretakers. Of the 52 people interviewed, about 75% were males and then 25% females. Females were generally wary and reluctant to avail themselves to be interviewed except their husbands or other familiar local folks were around. Approximately 70% of the interviewees had received formal education up to the primary level, and up to 10% had received secondary and/or tertiary education. The rest had no formal education. Adults of 21 years and above constituted 95% of the interviewees whilst the remaining 5% were between the ages of 10 and 20 years. About 90% of the males interviewed were married with mostly one wife, or less commonly two wives and an average number of four to five children.

Occupation

Farming constitutes the major occupation that is engaged in by almost everybody in the communities. Very few others have minor occupation such as petty trading and brewing of local alcoholic beverage. The crops engaged in are cocoa, cassava, plantain, maize, cocoyam, yam, rice, and banana. Average income per year from basically cocoa cultivation is ranged from US$ 1,000 to 2,500 (1US$ ≡ ¢2,000 - as at August 1998)

Loss of "buffer zone"

One major striking observation was the present non-existence of two of the adjacent forest reserves (buffer zones) namely the Sukusuku and the Tawya forest reserves. All these have been completely cleared for cocoa farming since the last two to three decades. The Krokosua Hills and Bia North forest reserves are the only closest blocks of forest to the BBR. They are however separated from each other, as well as from the Bia Biosphere Reserve itself, by villages and farmlands. The biosphere reserve currently exists as an 'ecological forest island' that is entirely surrounded by human settlements and farmlands. The local inhabitants attest to the fact that formerly there were lots of other undisturbed forest patches apart from the biosphere reserve itself, and the Sukusuku, Tawya, Krokosua Hills and Bia North forest reserves. Population density was very low in those days, but farmers started flogging into the areas over the last three decades, which resulted in increased clearing of the forests, primarily for cocoa cultivation.

Giant African Snail Species Present

According to the local residents, three species of giant African snails, namely *Achatina achatina, Achatina fulica* and *Archachatina degneri* occur in the area and the most common among these is the *Achatina achatina*. The newly invading species in the area is the *Achatina fulica*

Snail Harvesting

About 70% of the people indicated that they engage in snail collection and they do so for the purpose of:

i. obtaining their source of protein

ii. obtaining supplementary income from the sale of the snail, since their major source of income, which is from cocoa, is only seasonal.

The remaining 25% who did not partake in snail collection did so for the following reasons:

i. they were discouraged by their parents to do so with the explanation that snail collection makes a person lazy and reluctant to work on the farm

ii. they used to partake in it but presently they have less time to spare away from their farming activities to enable them engage in the snail collection

iii. it is a taboo to touch or eat sails in their tribes (i.e., Ewe and Krobo tribes)

iv. they lack good eyesight to locate the snails in their natural forest environment, especially during the night when most people go snail hunting

v. they do not necessarily go snail hunting but pick snails as and when they meet them, especially during their farm clearing operations

vi. snails are absent in their areas of residence around the park (i.e., in the environs of Akaatiso, Teacherkrom and Kofie Abesim)

Of the people who engaged in snail collection, almost all have engaged in this activity since their infancy and they collect snails during each of the snail seasons of the year. According to them, the snails are harvested indiscriminately, irrespective of their sizes or maturity, so long as they can be eaten. However, almost all the interviewees indicated that they preferred the snails most when they have attained their largest sizes. According to them, hardly can one find a snail that has attained its largest size in present times. The *Achatina achatina* species, according to them, was so abundant in former days that there was practically no need to put in too much searching effort before getting one head-load

(about 40 kg worth) of snails during a snail harvesting expedition. The snails could easily be harvested from anywhere, including backyards, farms, etc., for local consumption. One only went into the reserve to harvest snails for sale. During one (night) harvesting expedition in the reserve, a snail harvester was able to obtain at least two maxi-bags (i.e., about five head-loads) of mostly the *Achatina achatina*, together with just a few numbers, if any, of the *Archachatina degneri*. The situation is not so at present and the snail population has drastically declined over the years. Presently, hardly can one obtain even a maxi-bag load during a snail harvesting expedition, and above all, to be able to pick up *Achatina achatina* snail from outside the reserve is only a matter of chance. The only place where snails can be harvested in relative abundance is from within the biosphere reserve itself and occasionally, from farmland thickets during farm clearing exercise.

Knowledge about Current Status of Snails

The wild snail stock, according to 95% of the people, has been on a drastic decline over the years, whereas about 4% indicated no knowledge of the current status. Few people indicated that there is no change in snail abundance with the explanation that the snails lay large quantities of eggs during each season after which, if they are not harvested, they die naturally.

Abundance of Giant African Snails

It came to light from the interview that there is a gradient in the abundance of *Achatina achatina* across the entire stretch of the reserve, becoming minimum or absent in the Resource Reserve area (around Akaatiso) and maximum at the National Park area (around Kunkumso). Though they do not occur in the BBR itself, there is also a converse gradient with respect to the *Achatina fulica* in the localities around the BBR. They are

abundant in the communities within the vicinities of the Resource Reserve but virtually absent at the National Park area. No such observation has been made with respect to the *Archachatina degneri* except that the are generally observed to be less common within the entire biosphere reserve.

Options for Snail Farming

Majority of the local people showed concern about the sustainability of the giant snail resource since it is a major seasonal supplementary income and local protein resource. On the option of giant snail farming, the people indicated their preparedness to venture into it if only the technical know-how is available to them.

Causes of Decline in abundance of *Achatina achatina*

Achatina achatina, according to the local people, is the most palatable species among the three giant African snails and it is the most widely harvested species around the biosphere reserve area. It emerged from the interview that the causes of the decline in the abundance of giant African snails (*Achatina achatina and Archachatina degneri*) in the biosphere reserve area are;

vi. increased human population in the area and presently too many snail collectors (as compared to few people in the former days), thus leading to overexploitation of the snails,

vii. indiscriminate harvesting of any edible giant snail encountered, both immature and mature, during the harvesting seasons,

viii. clearing of the forests for cocoa cultivation,

ix. cultural practice of burning farms during land preparation for the planting season, and

x. the present non-observance of traditional customs and rituals concerning snail harvesting in the area.

Origin of *Achatina fulica* at BBR environs

The *Achatina fulica* is not specially a delicacy to the local people and according to them, it is only a recent invader from the adjacent Ivorian lands. It has been observed to be a prolific breeder and breeds at all times of the year, even when the other species of the giant African snails (*Achatina achatina and Archachatina degneri*) may be aestivating. *Achatina fulica* is thus a quick establisher when it colonizes a new habitat. The direction of invasion seems to be northeastwards from the Ivorian territory, hence their relative abundance at Akaatiso area and less so at Kunkumso area (see fig. 1). The origin of the species in the Ivorian territory is said to be from degraded forest lands and their invasion around the Bia Biosphere Reserve area is also onto degraded forest lands, farmlands, backyards and along feeder roads.

Snail Seasons of the Year

It was also realized that there are two main snail-harvesting seasons in each year. The major harvesting season is in September and the minor one in May /June. Incidentally the harvesting seasons coincide respectively with the major rainy season of May /June and the minor rainy season of September /October. However, on the converse, the snails are less abundant during the major rainy season but more abundant during the minor rainy season. It was also mentioned that, on the average, an edible giant snail picked by chance from a farmland and outside the reserve areas is bigger than one picked from the biosphere reserve itself. Again, those picked from the Bia North and Krokosua Hills forest reserves are, on the average bigger than those picked from the Bia Biosphere

Reserve itself. Furthermore, snails harvested in the former days were very abundant but of relatively smaller sizes as compared to those harvested in recent times, which are few but of relatively bigger sizes. The frequency of abundance of the giant African snail *Achatina achatina* was also stated to be on a cyclic pattern, as according to the local people, the snails become very abundant every three years. Also, the *Achatina achatina* died on or very close to the ovipository site soon after oviposition in the wild environment.

Traditional customs of wild snail harvesting

Ninety-five percent of the people indicated that in the former days, there were traditional customs that governed snail harvesting from the BBR. Customary ritual called 'Nwato' was performed by the traditional authorities to formally announce the commencement of the snail collection period. These rituals involved sacrilegious exercises for both men and women in the communities, and then a sacrifice to the gods of the land. Tolls were then collected from the local people to purchase the sacrificial lamb and fowls for the rituals. Afterwards, a 'gong-gong' was beaten to formally announce that permission had been granted for everyone willing to enter the reserve to harvest snails. This permission had a fixed duration of 2 – 3 weeks, after which no one was supposed to engage in the snail collection exercise within the BBR and surrounding forest reserves. The 'gong-gong' was beaten again to formally end the snail collection exercise. However, people were under permission to continue harvesting snails from only the farmlands and bushes. Any violator of this traditional custom was sanctioned before the local chief and made to pay a heavy fine. These traditional customs were in full force and strictly obeyed until the reserve was taken over by the Ghana Wildlife Department, and the department

assumed total responsibility over the management of the reserve, largely to the exclusion of the traditional chiefs and people.

Respondents from the southwestern parts of the reserve (Kofie Abesim and Akaatiso areas) indicated that the traditional customs were not operational in their area because there were no snails within their section of the reserve.

Wildlife Department's strategy for wild snail harvesting

According to the staff of the Wildlife Department, as well as the local people, there is presently complete denial of access into the Bia Biosphere Reserve for either snail collection or collection of any forest produce. In the early to mid 1990s, under the directive of the Chief Wildlife Officer of Ghana, a permit system for access into the reserve was introduced to allow the local people to harvest snails on a trial basis. This involved the collection of annual tolls of ¢5,000.00 (US$ 2.50) at the onset of the major peak snail season from the local snail collectors, and permission was granted them to harvest snails for a maximum of 2 weeks. The intention was to solicit the local peoples' support in the conservation and management of biological diversity of the biosphere reserve. It was soon discovered to be an inappropriate management measure because first, the level of abundance and status of the snail stock, coupled with their reproductive ecology and resilience capacity after a harvesting pressure were not scientifically known. Secondly, the local people abused the privilege of access to harvest only snails to include the harvest of other wild animals and forest produce. Consequently, the permit system was discontinued. However, the department is willing to collaborate with the local people in ensuring the sustainability of the snail resources, should there be an appropriate system to control the wild snail harvesting. As of late September 1998, the Management

of the Wildlife Department officially granted permission for a 2-week snail collection from the BBR. However, there were many incidences of illegal snail collection exercise at the expiration of this period of official permission.

6.0 OBSERVATIONS FROM PHASE II STUDY

Giant African Snail Species Present

Two species of giant African snails were identified from permanent sample plots set within the BBR. These were the *Achatina achatina* and *Archachatina degneri*. The third species, *Achatina fulica,* was observed to be absent from the BBR itself but rather on the outskirts within farmlands, along roadsides and footpaths. This observation thus confirmed the information received from the local people during the interview phase.

Distribution of Giant African Snails in the BBR

The distribution of *Achatina achatina* and *Archachatina degneri* in the BBR is reflected in their respective abundance per sampling location. Table 1 shows the numbers of both live and recently dead snails as recorded from the Permanent Sample Plots (PSPs) per sampling location during the study period. The general observation was that *Achatina achatina* is relatively more abundant around the transition between the BRR and the BNP (i.e., around the localities of Benkasa and Osonokrom), the BNP itself (around Kunkumso), and the eastern section of the BRR (around Obeykrom). Their numbers declined around the northeastern section (around Adjoefua) and virtually absent in the southernmost sectors (around Kofie Abesim). However, the occurrence of many dead and empty snail shells suggests that the snails until recently probably occurred within the Kofie Abesim area (Table 1). Secondly, the abundance of snails declined drastically in the sampling locations within a month after the major peak snail season of September 1998, and after two months of this peak season there were no records of snails in the sampling locations. The numbers of *Achatina achatina* as of the minor peak season of May 1999 was significantly small as compared to that of the major peak season of September 1998. The numbers of *Archachatina degneri,* according to table 1, is

negligibly small as compared to that of *Achatina achatina*, and that these records were only made at Kunkumso and Benkasa sampling locations during the first record taking period of September 1998. No record of this species was made in any sampling location during the succeeding record taking periods.

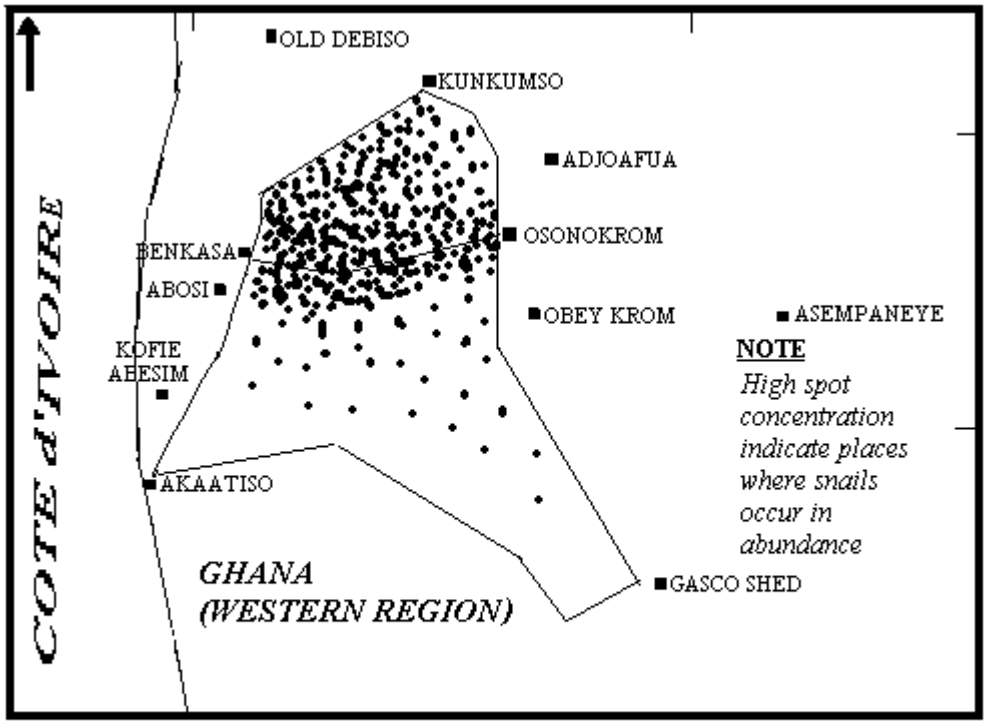


FIGURE 3: OUTLINED MAP OF THE BIA BIOSPHERE RESERVE SHOWING HOW SNAILS ARE DISTRIBUTED WITHIN THE RESERVE

The numbers of newly dead species of *Achatina achatina* per sampling location are also as presented in table 1. Most newly dead snails died soon after laying eggs, and some of these were found lying just over their oviposition spots or were within a few centimeters to metros from such spots.

- Table 1. Records of *Achatina achatina* (A) and *Archachatina degneri* (B) per Sampling Location

Location	Newly Dead Snails Sep 1998		Live Snails September 1998		Live Snails October 1998		Live Snails November 1998		Live Snails May 1999	
	A	B	A	B	A	B	A	B	A	B
Kofie Abesim	11	2	0	0	0	0	0	0	0	0
Benkasa	24	10	14	1	6	0	0	0	3	0
Kunkumso	11	1	14	2	3	0	0	0	0	0
Obeykrom	11	0	11	0	8	0	0	0	1	0
Osonokrom	17	1	20	0	4	0	0	0	0	0
Adjoefua	10	0	7	0	3	0	0	0	0	0
TOTAL	**74**	**14**	**66**	**3**	**24**	**0**	**0**	**0**	**4**	**0**

Numbers of Snails per Unit Area (Snail Density)

The mean records of live *Achatina achatina* per sampling plot per sampling location, and the estimated numbers per hectare are as presented in table 2. Relatively high numbers of live *Achatina achatina* per unit area (densities) were recorded in the Osonokrom, Benkasa and Kunkumso sampling locations for September 1998. Densities declined over subsequent record taking periods of October 1998 and virtually zero in November 1998. Strikingly sharp decline in densities were recorded in Kunkumso, Osonokrom and Adjoefua sampling locations during the succeeding months. During the minor peak season of 1999, *Achatina achatina* was recorded in only two of the sampling locations, i.e., Benkasa and Obeykrom. Newly dead *Achatina achatina* density was highest at Benkasa, but at the other sampling locations, they were of almost the same level.

Table 2. Average Numbers of *Achatina achatina* per Sampling Plot (25m X 25m), including estimates per Hectare

Location	Newly Dead Snails Sep'98		Live Snails Sep 1998		Live Snails October 1998		Live Snails November 1998		Live Snails May 1999	
	Nos. Per plot	Estimate Per Ha	Nos. Per plot	Estimate Per Ha	Nos. Per plot	Estimate Per Ha	Nos. Per plot	Estimate Per Ha	Nos. Per plot	Estimate Per Ha
Kofie Abesim	3	48	0	0	0	0	0	0	0	0
Benkasa	6	96	4	64	2	32	0	0	1	16
Kunkumso	3	48	4	64	1	16	0	0	0	0
Obeykrom	3	48	3	48	2	32	0	0	0.25	4
Osonokrom	4	64	5	80	1	16	0	0	0	0
Adjoefua	3	48	2	32	1	16	0	0	0	0

Encounter rates

Table 3 shows the encounter rates of *Achatina achatina* and *Archachatina degneri* per hour within sampling locations. Highest initial encounter rate (in September 1998) was computed for Osonokrom sampling location, and the lowest at Adjoefua and Obeykrom.

- Table 3. Encounter rates (per hour) per period of study within Sampling Locations

Location	*Achatina achatina*				*Archachatina degneri*			
	Sep. '98	Oct. '98	Nov. '98	May '99	Sep. '98	Oct. '98	Nov. '98	May '99
Kofie Abesim	0	0	0	0	0	0	0	0
Benkasa	6	3	0	2	2	0	0	0
Kunkumso	6	2	0	0	3	0	0	0
Obeykrom	5	4	0	1	0	0	0	0
Osonokrom	9	2	0	0	0	0	0	0
Adjoefua	5	3	0	0	0	0	0	0

Snail Biometrics

The average dimensions of *Achatina achatina* and *Archachatina degneri*, as recorded per sampling locations are as presented in tables 4a, 4b, and 4c. That for *Achatina fulica*, sampled along a footpath (for comparative reasons) are also as presented in table 4d. The general trend was an increase in length, diameter and weight of *Achatina achatina* within a one-month period during the major peak snail season of September 1998 to October 1998. Furthermore, the dimensions of *Achatina achatina* in the minor peak snail season were higher than those of the major peak snail season of September 1998. The dimensions (length and diameter) of newly dead snails recorded were lowest as compared to that of the live ones of both major and minor peak seasons.

- Table 4a. Shell Biometrics (Length – L, Diameter – D and Standard Deviation – S.D.) of *Achatina achatina* per Sampling Locations

Location	Newly Dead Snails Sep. 1998		Live Snails September 1998		Live Snails October 1998		Live Snails Nov. 1998		Live Snails May 1999	
	L ± S.D. (cm)	D ± S.D. (cm)	L ± S.D. (cm)	D ± S.D. (cm)	L ± S.D. (cm)	D ± S.D. (cm)	L ± S.D. (cm)	L ± S.D. (cm)	L ± S.D. (cm)	D ± S.D. (cm)
Kofie Abesim	11.9 ± 1.17	6.0 ± 0.5	-	-	-	-	-	-	-	-
Benkasa	7.2 ± 1.32	4.2 ± 0.76	9.5 ± 0.38	5.0 ± 0.21	10.2 ± 0.38	5.1 ± 0.06	-	-	11.2 ± 0.5	5.9 ± 0.44
Kunkumso	8.5 ± 1.68	4.3 ± 0.7	10.7 ± 0.39	5.4 ± 0.52	11.4 ± 0.55	5.7 ± 0.17	-	-	±	±
Obeykrom	9.7 ± 2.16	5.0 ± 1.11	10.7 ± 0.6	5.5 ± 0.25	11.7 ± 0.06	6.0 ± 0.21	-	-	11.5	6.0
Osonokrom	8.8 ± 1.24	4.3 ± 0.62	10.2 ± 0.99	5.1 ± 0.43	11.0 ± 0.21	5.6 ± 0.14	-	-	±	±
Adjoefua	7.5 ± 1.62	4.2 ± 0.84	9.6 ± 0.21	5.0 ± 0.27	10.7 ± 0.62	5.5 ± 0.21	-	-	±	±

- Table 4b. Shell Biometrics (Length – L, Diameter – D and Standard Deviation – S.D.) of *Archachatina degneri* per Sampling Locations

Location	Newly Dead Snails Sep. 1998		Live Snails September 1998		Live Snails October 1998		Live Snails Nov. 1998		Live Snails May 1999	
	L ± S.D. (cm)	D ± S.D. (cm)	L ± S.D. (cm)	D ± S.D. (cm)	L ± S.D. (cm)	D ± S.D. (cm)	L ± S.D. (cm)	D ± S.D. (cm)	L ± S.D. (cm)	D ± S.D. (cm)
Kofie Abesim	10.4 ± 2.2	6.0 ± 0.71	-	-	-	-	-	-	-	-
Benkasa	10.4 ± 0.55	6.2 ± 0.12	10.3	6.1	-	-	-	-	-	-
Kunkumso	10.0	5.7	10.9 ± 0.28	6.4 ± 0.06	-	-	-	-	-	-
Obeykrom	-	-	-	-	-	-	-	-	-	-
Osonokrom	-	-	-	-	-	-	-	-	-	-
Adjoefua	-	-	-	-	-	-	-	-	-	-

- Table 4c. Biometrics (Weights in grams) of *Achatina achatina* and *Archachatina degneri* per Sampling Locations

Location	Live Snails September 1998		Live Snails October 1998		Live Snails November 1998		Live Snails May 1999	
	A. achatina	*A. degneri*	*A. achatina*	*A. degneri*	*A. achatina*	*A. degneri*	*A. achatina*	*A. degneri*
Kofie Abesim	-	-	-	-	-	-	-	-
Benkasa	98 ± 10.32	135	103 ± 14.01	-	-	-	145 ± 26.46	-
Kunkumso	124 ± 16.31	144 ± 10.24	132 ± 12.58	-	-	-	-	-
Obeykrom	126 ± 13.72	-	166 ± 26.40	-	-	-	145	-
Osonokrom	120 ± 7.46	-	129 ± 19.31	-	-	-	-	-
Adjoefua	101 ± 14.66	-	132 ± 20.21	-	-	-	-	-

- Table 4d. Biometrics (Length & Weight) of fifteen randomly collected specimen of *Achatina fulica* along a roadside at the Bia Biosphere Reserve

Parameter	**Measurement**
Length (cm)	8.3 ± 1.3
Diameter (cm)	4.0 ± 0.59
Weight (g)	64.7 ± 27.44

7.0 INTERPRETION AND DISCUSSION OF OBSERVATIONS

Evident from the observations is the apparent loss of both reserved and unreserved forests, which ideally performed the roles of buffer zones around the BBR. As the loss of these forests are primarily due to clearing of the land for cocoa cultivation, it is imperative to note that increased human population, either from immigration sources or large family sizes have aggravated the problem. The present existence of the BBR as an "ecological island" is a critical issue of concern, as there is an imminent threat of instability of the BBR's ecosystem due to the decreased levels of biological diversity in alpha, beta and gamma perspectives. Of critical importance is the possible inbreeding among the "enclosed" faunal groups, especially the ungulate and predator populations which require appreciably large homeranges for optimum performance. However, the subject matter under study, i.e., the giant African Snails may not necessarily be affected by the ecological island syndrome because they do not require extensive home-ranges as the former categories. Thus under ideal climatic and edaphic conditions, coupled with good management systems, the remnant snail populations should be capable of producing viable progenies at their biotic potential levels, and thus occupy their essential niches in the BBR ecosystem.

The occurrence in greater abundance of *Achatina achatina*, relative to *Archachatina degneri* is an obvious observation from both phases of study. This situation seems to be a factor related to their respective genetic make-ups, as according to Hodasi (1979) *Achatina achatina* is more prolific and attains sexual maturity earlier (within 2 years in the wild environment) than *Archachatina degneri*.

The collection of snails has for a long time been part of the cultural and the economic livelihood of the local people around the BBR and from the cultural perspective, they had harvested snails on sustainable basis until the "taking over of the reserve" by the Wildlife Department. Presently, the snail stock has dramatically reduced and the question being asked is whether the decline is attributable to the 'change over of the management of the reserve'. Obviously not, because several factors have inter-playing roles and these could be summarized as:

i. increased human populations in the area in recent times and consequently large scale snail collection
ii. a general reduction and anomalies in rainfall regimes over the years
iii. general poverty syndrome associated with the current low and unreliable incomes from their agricultural activities
iv. a general reduction in the size of the habitable areas for the snails that have been lost to agriculture

The management strategies of the Wildlife Department would even provide enhanced conditions for high turnover rates of the snail stock. A setback is imposed by a high incidence of illegal snail collection that was clearly evident during the study period. The economics of the snail collection enterprise too is probably a crucial function causing the decline in the abundance of the snails. It is thus imperative to note that as rural poverty remains a crucial driving force, it might be difficult to absolutely enforce the Wildlife Department's declaration of a complete denial of access into the BBR to collect snails, even-though grievous penalties may be rewarded to trespassers.

The incidence of the snail harvesting seasons coincide with the 2 peaks of the rainy seasons characteristic of the eco-region, the major snail season coinciding with the minor peak rainy season and vice versa. The seasonal emergence of the snails in relation to the peak rains is explainable since breakage of the snails from periods of dormancy (aestivation) is directly related to high soil moisture regime at the forest floor (Cobbinah, 1997), which is also associated with the periods of the peak annual rains. The major snail season coincides with minor peak rains of September/October whilst the minor snail season also coincides with the major peak rains of June/July. This phenomenon could be a function of the complexity of the snails' reproductive ecology, growth characteristics and annual physiological rhythms. This however, will require more detailed and long-term investigation.

The observation that snails collected from the adjoining forest reserves and the farmland bushes, though relatively fewer in quantities, are on the average bigger that the ones collected from the BBR may be explained from deductive reasoning. Also the fact that the snails harvested in former days within the BBR itself were of smaller sizes as compared to those harvested in recent times may likewise be explained. There is the general notion that, "snails are abundant in the BBR" and so snail collectors, in order to obtain bumper harvest within minimal collection time and with little searching effort would do so in the BBR every snail season, and thus avoid the adjoining reserves and bushes. In this way the few snails in the 'avoided' areas have the opportunity to grow in size. Again, since the present snail population in the BBR has been on the decline, the snails are less available to be seen and picked. This situation has probably allowed the existing population to grow bigger in sizes as compared to those that were collected in former-days when there were 'too many' snails that were easily spotted and picked from

the reserve. Nevertheless, one cannot rule out the possibility of the remnant snail populations in present times evolving adaptive radiation to survive the current stress imposed by their overexploitation.

A fact in mentioning is the 3-year cyclic abundance pattern of snails in the BBR, which provides indication of their growth characteristics. According to Hodasi (1995), snails in the wild environment take about 2 to 3 years to attain sexual maturity, and then start to reproduce, and this period is halved if snails are raised under intensive feeding control in captive environment. The implication is that, a group of hatchlings in a particular year (season) grow together, and attain a peak oscillation in the third year, when they fall prey to snail harvester as bumper harvest. Another observation too is the fact that some snails in the wild environment died soon after oviposition. No such observation was ever made by Hodasi (1979) during his laboratory studies on *Achatina achatina*. This phenomenon, which requires detailed long-term study, could be a factor of excessive energy losses due to second and third year snails copulating and ovipositing without having probably accumulated enough energy reserves. (See tables 1a and 1b, shell length measurements of newly dead snails as compared to those of live snails as at September 1998). It is thus essential to note that such a phenomenon occurring within the BBR's ecosystem (where harvesting pressure does not allow snails to attain full maturity before reproducing, probably to offset the stress imposed by the harvesting pressure) is very unhealthy in ensuring the sustainability of a viable stock of breeding snail populations.

The distribution pattern of *Achatina achatina* and *Archachatina degneri* across the entire BBR presents interesting points for discussion. The snails tend to be more abundant in the northern section of the BBR, i.e., the BNP section than in the BRR section (southern section). The vegetation structure of Ghana places the BNP into the Moist Semi-

deciduous vegetation zone whereas the southern sector is within the Moist Evergreen vegetation zone, the main distinguishing character being the level of deciduousness of the standing vegetation. It may be worth noting that deciduousness could be crucial in determining the level of abundance of the giant African snails in a particular forest ecosystem. This phenomenon may be related to the abundance of litter (decaying organic matter) at the forest floor, which forms perfect substrates for detritivorous organisms such as the snails. Another probable point of concern is the fact that the BRR has been exploited for timber before whereas the activity has never been carried out in the BNP. Thus the probability of a depleted snail food source from fruits of certain timber species in the BRR could be very significant in determining their low levels of abundance (Osemeobo, 1992) within the BRR. This is more pronounced in the fact that the gradient of snail abundance declines and becomes virtually nil in the southernmost parts of the BRR where the level of degradation of the reserve due to logging is highest. It may be necessary to advocate for a long-term study to determine the effects of logging on the snail's distribution and abundance, upon which valid deductions can be made.

At the northeastern corner of the BNP, i.e., around Ajoefua village (Fig. 3) the snail density is low as compared to the Benkasa, Kunkumso and Ososokrom localities. The most probable factor is the level of overexploitation of snails, as the residents of Adjoefua and the nearby villages are typically noted for their massive engagement in snail collection exercise.

Benkasa and Osonokrom are transitional zones between the BNP and the BRR, as well as that of the Moist Semi-deciduous and the Moist Evergreen vegetation zones. This

transition zone probably presents optimum habitat for the snails, which is could be reflective of the high levels of snail numbers within the zone.

Marked increases in body sizes and weights of the snail samples were evident during the study period from September 1998 to May 1999 (see tables 4a, 4b and 4c). This presupposes that in the absence of external stress such as those resulting from harvesting pressure, unfavorable climate and habitat disturbance, the snails would grow significantly faster at levels that may be comparable to those raised under controlled feeding regimes in captive environments.

8.0 CONCLUSIONS AND RECOMMENDATIONS FOR SUSTAINABILITY

It appears that there is marked decline in the level of abundance of the giant African snails in the Bia Biosphere Reserve and several factors may have inter-playing roles in accounting for the situation. Among these are the issues of increased human population in the area and the attendant overexploitation of the snails, clearance of forests (the snail's habitats) for agriculture using cultural practices that result in the degradation of the BBR ecosystem. As no previous database exists against which the current figures of snail abundance could be tested to establish trends over the years, it may also be argued from another point that the presently too many snail collectors tend to reduce the harvest per head, thus making it seem as if snail numbers have declined over the years. Ascertaining the real facts of abundance levels over the years will require real long-term field data, of which the records from the present study will be a significant baseline. The period for the present study was not long enough to facilitate the establishment of abundance trends over the years.

Issues of poverty resulting from low-income levels, basically from arable agriculture that is climate dependent are also additional factors from economic perspective, which adversely affect the local people. Options for sustainable use of the snail resources might first have to address rural poverty issues and sources of alternative income.

Snails are not evenly distributed within the BBR and this is probably as a result of the BBR cutting across different vegetation zones, coupled with the effects of logging and also, high levels of snail exploitation in certain localized areas, i.e., around Adjoefua village section of the BBR.

Over the long-term, it is possible to restore snail populations to higher levels if some of the presumed causal factors, especially those from anthropogenic origin are brought under control.

Absolute ban on the exploitation giant African snails from the BBR in order to build up their numbers, in the face of the surrounding rural poverty, might not be an appropriate management measure in the long-term, though it may be expedient in the short-term. For the sake of sustaining the giant African snail enterprise within the framework of the biosphere reserve concept, the BBR management might have to consider the following suggestive measures:

i. Initiating the formation of a "Management Committee" comprising of representatives from the traditional authorities, local government authorities, identifiable local associations and groups, and the BBR management itself, with the task of together;

- discussing issues of concern to both BBR management and the local communities as far as the BBR and its resources are concerned
- mobilizing to educate the local people about the current status of the snails and the imminent threat to their availability and continued survival in the BBR, including the consequences on the local people themselves
- periodically reviewing snail harvesting operations and establish bye-laws that will protect the immature snails from exploitation
- encouraging the local people to embark on an "***Operation Snail Farming Exercise***", and coordinate technical assistance and micro-credit facilities for snail farming entrepreneurs within the communities
- instituting honors program for outstanding snail farming entrepreneurs

ii. The current system by which the Wildlife Department permits snail collection on a 3-year cyclic pattern needs to be encouraged and sustained, but this time with the involvement of the Management Committee in the exercise. The Management Committee should be made to cooperate with the Wildlife Department in the monitoring of harvests from the BBR whenever official permission is granted for snails to be collected from the reserve. A registration exercise for anyone wishing to engage in snail collection from the BBR might be necessary. Snail harvesters should be cautioned against picking under-aged snails. Specifically all snails less that 3 years old (i.e., shell length < 10 cm) should be confiscated and released back into the reserve. Offenders in this regard should be made to pay a fine, and these monies should be paid into local community development fund that should be set up.

iii. Educational campaign such as "***Operation Eat Achatina fulica***" may have to be established to promote the consumption of *Achatina fulica*, since studies have shown them to be nutritionally no different from *Achatina achatina*.

9.0 REFERENCES

Agyare A.K. (1996a) Report on Preliminary study of the socio-economic perspective of Bia Biosphere Reserve. Technical report submitted to the Ghana National UNESCO (MAB) Committee.

Agyare A.K. (1996b) Preliminary study of the socio-economic perspective of Bia Biosphere Reserve. Technical report submitted to the Ghana National UNESCO (MAB) Committee.

Cobbinah J.R. (1997) Aestivation responses of three populations of giant African snail, *Achatina achatina* Linne (Gastropoda: Achatinidae). Iberus, 15(2): 75 – 82.

Hall J.B. and M.D. Swaine (1981) Distribution and Ecology of vascular plants in a tropical rainforest. Forest vegetation in Ghana. W. Junk Publishers. The Hague. Netherlands 383pp.

Hodasi J.K.M (1975) Preliminary studies on the feeding and burrowing habits of Achatina achatina. Ghana Journal of Science 15: 193 – 199

Hodasi J. K. M. (1979) Life history studies of *Achatina (Achatina) achatina* (Linne). *Journal of Mulluscan Studies* 45: 328 – 339

Hodasi J.K.M (1982) The effects of different light regimes on the behavior and biology of *Achatina (achatina) achatina* (Linne). J. Moll. Stud. 48: 283 – 293

Hodasi J. K. M. (1995) Snails in the National Economy. *Inaugural lecture delivered at the University of Ghana on 9th May 1991*. Ghana Universities Press. Pp41.

Monney K.A. (1992) Observations on the food and feeding habits of *Archachatina (Calchatina) degneri* (Bequaert and Clench). Tropical Ecology 33(2): 148 – 156

Monney K.A. (1994) Notable notes on giant African snails. Snail Farming Research. Vol. V: 1 – 22 Associazione Nationale Elicicoltori (The Italian Snail Farmers Association)

Naada J.M. (1997) Conservation and Utilization of Biodiversity – The case of the African Giant Snail (*Achatina achatina*) in Bia National Park In: Amlalo D.S., L.D. Atsiatorme and C. Fiati (eds) (1998) Biodiversity conservation: Traditional Knowledge and Modern concepts; Proceedings of the 3rd UNESCO (MAB) Regional Seminar on Biosphere Reserves for Biodiversity Conservation and Sustainable Development in Anglophone Africa (BRAAF) 157pp

Osemeobo G.J. (1992) Effects of land use collection on the decline of African giant snails in Nigeria. Environmental Conservation 19(2).

Sam M.K. !1996) A preliminary survey of Bia National Park and the Bia Resource Reserve. Technical report submitted to the Ghana National UNESCO (MAB) Committee.