FARMING OF THE GIANT AFRICAN SNAIL, *ACHATINA FULICA*

A MANUAL

Bull. no. 56

June – 1988

CENTRAL INLAND CAPTURE FISHERIES RESEARCH INSTITUTE
(Indian Council of Agricultural Research)
Barrackpore : West Bengal
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FOREWORD

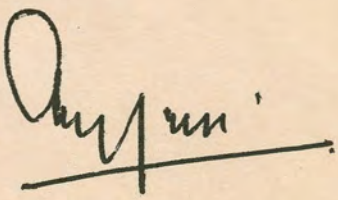
Search for protein food from unconventional sources has a special relevance to a developing country like ours. Snail farming is rather unknown to the animal husbandry profession, yet among the microlivestock they could occupy a pre-eminent position as massive meat producers.

Though eating snails is alien to Indian palate, it is a prized delicacy in the West, especially in countries like France, FRG, etc. where a tremendous market potential for the snails exists. With this export potential in view, the Central Inland Capture Fisheries Research Institute has been striving to develop a technology to culture the edible mollusc, *Achatina fulica* since 1984. I am glad to note that the untiring efforts of our scientists and technicians have culminated in success by 1987 and we could send a sample consignment of snail meat to the coveted ANUGA FAIR in Cologne in October 1987.

Apart from earning a sizeable foreign exchange, the snail farming also gives an opportunity to turn a species hitherto known as a pest in agri–horticultural farms into a much soughtafter proteinous food.

In this connection, I have great pleasure in placing on record our gratitude to the Marine Products Export Development Authority at whose instance the studies were initiated. They have been instrumental in motivating the overseas buyers and industries and entrepreneurs at home. Dr. N.V. Subba Rao of Zoological Survey of India has been a source of inspiration and guidance to our scientists.

Lastly I wish to commend the good work done by my scientists Mrs. G.K. Vinci, Dr. V.K. Unnithan and Shri V.V. Sugunan who have prepared this useful manual for the entrepreneurs and traders. This technology being new and unconventional, it offers much scope for further improvement and refinement. I am sure that the user group export traders will adopt the technology with the necessary modifications wherever required.



Arun G. Jhingran
Director

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EDIBLE SNAILS – AN INTRODUCTION

In India, even though a majority of the population is meat-eating by habit, the intake of protective food is markedly low. Protein consumption in India is estimated at 52 g per person per day of which the animal protein constitutes a meagre 6 g compared to 92 g and 65 g in USA and 92 g and 61 g in Australia. If the available projections of population growth are any guide, in addition to the conventional sources of animal protein, we will have to explore the unconventional areas of animal protein to ensure that the present deficit of protein intake is made up and adequate protective food is made available to our growing population at a reasonable price. Among the microlivestock and unconventional sources of animal proteins, molluscs as a group hold tremendous prospects, and amongst them the snails hold a very high promise.

Varieties of snails are available all over the world. Their habitats could be marine, freshwater or terrestrial. Their size ranges from a few mm to 20 cm or more. Well over 18,000 species of snails are reported to occur in nature. However, all of them are not considered to be edible. A few selected ones have been recognized as important sources of animal protein.

Snails – A new entrant in animal husbandry profession

In many parts of the world, molluscs, chiefly the snails and bivalves occupy a dominant position among the microlivestock that are farmed for food. 'Microlivestock' is a term coined by the National Research Council, USA to designate species smaller than standard breeds of sheep, goats and other conventional livestock.

Snail farming is little known to the animal husbandry profession, especially in Asia. These animals, however, form a part of the diet of select group of people in Asia, Africa and Latin America. It is a known delicacy to the elites of many European countries like France, Italy, FRG, USSR, Belgium and a host of East European countries.

Role in mitigating protein deficiency

Unlike the larger-sized livestock like cattle, sheep or goats, the raising of these tiny creatures demands lesser space and expense and hence plays a major role in mitigating the protein deficiency. Nevertheless, the importance of molluscs being reared as personal livestock raised on household wastes in enclosed garden space or backyard pond is being overlooked. These little farms could collectively become massive meat producers.

Scarcity of protein rich food still hits a good number of Asian and African countries. For people who have limited space and capital resources, farming of microlivestock like snails could help raising animal protein in their own dwellings. "The idea of eating such agreeable animals could seem repulsive. But they should reconsider. Small animals that are prolific, tractable and easy to feed, house and handle in indoors could be an important source of nutrition in societies that don't have same prejudices. The skills for rearing such small animals are less demanding and easier to learn, the economic risks minimal and the starting investment low . . . . . ". Such goes the argument put forward by the National Research Council in favour of snail farming . And we are tempted to agree.

Scope for overseas trade

Snails have been farmed for food in Europe since Roman times. The more recent records show that the Japanese troops raised them throughout South East Asia to provide fresh meat in jungle during World War II. Civilians in these countries lateron mastered the art and now apart from meeting a part of domestic demand for meat, countries like Taiwan earn a sizeable foreign exchange from these small animals. Snail farm output from Nigeria also ends up in paris where they fetch a more lucrative price for this delicacy.

The shortage of snails put at 1.8 billion (more than 20,000 t) per annum in France has tempted even the British to take on to snail farming. In the process, the British also have developed a taste for it. Roy Groves, the founder of the Snail Centre in Colwyn, North Wales believes that his favourite snail *Achatina fulica* would allure the local gourmets who are already paying US $ 48 for a mere 50 g jar of snail caviar.

Indian snails to hit European markets

India too is poised to hit the export market with its harvest of the giant land snail *Achatina fulica.* Recently with the help of Marine Products Export Development Authority of India (MPEDA) , a token consignment of 25 kg of live snails were processed at Triveni Food Products Ltd., a private firm in Calcutta and exhibited at the Anuga Food Fair (September, 1987) in Cologne, West Germany. The frozen snail meat from India was appreciated by many buyers in Europe and an order for 1,000 t of snail meat is already with MPEDA who arranged to exhibit the product in West Germany. The Indian seafood exporters have come up in a large way to make use of the opportunity.

CICFRI technology for snail farming

Achatina fulica which was introduced in India in 1847 from Mauritius

is reported to have established in 19 states of the country. Dense populations are available in Andaman and Nicobar Islands, West Bengal, Bihar, Orissa and the North Eastern Region. These slow moving snails with large shells are easy to locate and pick up from the wild. CICFRI's experience shows that natural populations are vulnerable to easy exploitation and unless resorted to farming, an uninterrupted supply cannot be guaranteed. With this objective in view, the Institute has developed a low cost technology to breed and raise the snails under captivity. The technology envisages a growth rate of more than 60 g in 150 days for the snails raised on kitchen refuse and an assortment of vegetables.

Edible snails other than the giant African snail

Though initially, hopes for beginning an export trade is planned on the giant snail *Achatina fulica* it is not the only snail which merits the attention of culturists. *Hemiplecta basileus, Ariophanta beddomei* and species of *Cryptozona,* etc also offer lucrative price ranges in markets abroad. These species are generally observed in Western Ghats and adjacent areas in the Country.

Several species of freshwater snails also are edible and already serve a domestic market. A recent survey conducted by the West Bengal Science and Technology Committee has identified the following 11 species of edible freshwater molluscs in North and North Eastern regions of the Country :

Sl. No.	Species	States in which used as food	Rate
1.	Pila globosa (Swainson)	Bihar, West Bengal	Re 1/- for 20 to 25 nos
2.	Bellamya bengalensis (Lamarck)	Bihar, West Bengal	Re 1/- to 2/- per kg.
3.	Brotia costula (Rafinesque)	North Bengal (W. Bengal) Arunachal Pradesh, Mizoram	Re 1/- per tin which include 15 to 20 average size specimens
4.	Paludomus conica Gray	Arunachal Pradesh, Mizoram	Re 2/- per tin which include 40 to 50 average size specimens
5.	Paludomus blanfordiana Nevill	– do –	– do –
*6.	Lamellidens marginalis (Lamarck)	Bihar, West Bengal	Re 1/- for 20 nos.
*7.	Lamellidens corrianus (Lea)	– do –	– do –
8.	Solenaia seleniformis (Benson)	Mizoram	Not observed in market
9.	Trapezoideus exolescens exolescens (Gould)	– do –	– do –
10.	Parreysia sikkimensis (Lea)	Arunachal Pradesh	– do –
11.	Parreysia caerulea (Lea)	– do –	– do –

* Species producing pearls.

Need for large–scale adoption of snail farming

Farming of snails whether terrestrial or aquatic are confined to various laboratories. Whatever little role they play in meeting the local demand, it comes from capture resources available in nature. Now with the development of a technology for farming of the giant snail, the scene is wide open. The culture technique has adequate scope for further refinement and if our entrepreneurs can take up the challenge of entering into snail trade exploring the vacuum in foreign snail market, not only India will earn a sizeable amount of foreign exchange every year but it will also provide higher income and job opportunities to our farmers and jobless thousands in rural areas. At the same time we are also solving a pest problem haunting the agri-horticultural farms in many parts of our country by converting it into a dependable source of protein.

ACHATINA FULICA

TAXONOMIC FEATURES AND DISTRIBUTION*

Systematic position

Phylum : Mollusca

Class : Gastropoda

Order : Stylommatophora

Family : Achatinidae

Achatina (Lissachatina) fulica fulica Bowdich

Diagnostic characters

The snail can be identified with its ovate-conoid shell having pale yellowish colour with brown transverse streaks. The streaks are irregularly decussated with fine spirals except on the last whorl. The shell have light convex whorls, the last one nearly equals to half the entire length of the shell. The aperture of the shell is elliptic ovate. Straight peritome, the margins connected by a callus or the parietal wall. Columella slightly concave and truncate.

Distribution

Eastern India

Assam : Common to abundant at Jhalukbari, Ulubari, Lachit Nagar, East Sarani and Panbazar of Guwahati town, Silonijan, Goalpara, Tejpur, Golaghat and Jorhat.

Bihar : The whole of North Bihar. i.e.,North part of river Ganga is heavily infested with *A. fulica.* Bhagalpur, Santal parganas, Dhanbad and Singhbhum districts of South Bihar and Chhotanagpur plateau also have populations of the giant snail.

Manipur : Imphal town

Meghalaya :	Gardens at Nongpoh region
Nagaland :	Heavy infestation in whole of the Dimapur sub-division.
Orissa :	Most common in Balasore, Mayurbhanj and Keonjar districts.
Tripura :	Kumarghat area of North Tripura region.
West Bengal :	Rich populations reported from 16 districts.
Southern India	
Karnataka :	Low density of population in and around Bangalore.
Kerala :	Palghat, Calicut, Malappuram and Trichur districts.
Tamil Nadu :	Reported from Snake park and Christian College campus in Madras, common in Pollachi of Coimbatore and Annamalai Nagar of South Arcot.
Northern India	
Uttar Pradesh :	Common around Moradabad, Dhampur and Bijnor.
Western India	
Maharastra :	Meagre populations in certain pockets of Marathawada of Aurangabad.
Central India	Not reported
Bay Islands	
Andaman and Car Nicobar Islands :	Common to abundant in the main island of South Andamans, Long island, Rangat, Mayabandar, Diglipur,Car Nicobar and Kamota.

* Source : Raut and Ghose, 1984. Pestiferous land snails of India. Monograph No. 112, Zoological Survey of India, Calcutta, pp. 5-27.

LIFE HABITS, COLLECTION AND TRANSPORT

The Giant African snail *Achatina fulica* is the largest among the land snails with its shell length reported upto 20 – 22 cm, and body lengh upto 30 cm. This snail found its way to India from its native place in Kenya (East Africa) through Mauritius as early as 1847 when a few specimens were introduced to Botanical Gardens, Calcutta by the conchologist W.H. Benson. In course of time, the snail proliferated, spread and established in as much as 19 states and union territories of the Republic. Soon the snail was noted as a menace to agro-horticultural economy especially of the Eastern India and neighbouring countries. Attention of research institutes and governments was hitherto drawn towards this species as a serious pest to the crops; and the scientific discussions and seminars centred around this species have been looking for its control. Of the seven species of land snails noted as pests of significance, the giant African snail tops the list for its capability of damaging the crops.

Behavioural studies were conducted on this species from the beginning of this century. The prominent behavioural features of almost all land snails including the giant snail is the dormancy during unfavourable climatic conditions and an enraged activity during the favourable season, mostly confined to monsoon months.

By nature, these snails are moisture-loving and the length of active period depends on the length of rainy season prevailing in the area. Therefore in the eastern region and Andaman & Nicobar islands, their activity extends for a longer period and this is reflected through their abundance in these areas. At Barrackpore it is observed that the snails come out of the hibernation during nor'westers in early April and the availability extends right upto the end of October. There can be a brief period of summer aestivation during May - June followed by the peak period of availability in July - September.

At the period of hibernation or aestivation, the snail retracts its foot upto the shell, seals it with an epiphragm (mucous) secretion except for a small hole left for exchange of gases. In this state they bury themselves in the soil or underneath the heap of dried and decaying leaves or twigs. The factors that induce dormancy in the snail have been identified as low, and high temperatures, low humidity, amount of body water and starvation. The period of dormancy may extend upto 8 months depending on the climate of the zone. Burrows in the wood/stems are also its favourite places for hibernation. Crevices in the walls, bricks, heaps of logs and dried grasses, etc. also form its preferred places for hiding. Some sort of schooling behaviour is seen during this period. As much as sixty snails were found hiding in a 3 feet long hollow stem of a papaya tree.

Once the season sets in, with a heavy downpour, large number of snails wake up from their long slumber, shed their mucous seal and set out to attack a variety of plants at night. They devour economic plants with a preference for leafy or fleshy vegetables. Their dislike is restricted only to a few items like bitter gourd, onion or chilli. No wonder, they cause enough distress to the farmers. Rout & Ghose (1984) also have given an account of the habitat and behaviour of these snails. Some of their observations are as follows:

"The snails always prefer damp and shady places and avoid direct sunlight. They occur mostly in and around villages, though quite a few are often found in open woodlands, parks, gardens, cemeteries, hedgerows, borders of marshes and similar habitats. Being nocturnal in habit they hide themselves in daytime in a retracted and quiescent state, under bricks, rocks, fallen logs, plant mats, holes in trees, decaying leaves and the like or partially buried in loose soil. *A. fulica* climb walls and tree trunks to a height of 400 cm and spend the day there. Interestingly, a some sort of advance signalling system in response to change in weather is present in *A. fulica,* since in the vast majority of the cases they move to protected sites prior to outbreak of a storm, and climb up some support quite ahead of heavy shower".

Generally, the giant African snails prefer a partner of same size group for mating, though exceptions are noticed quite often. A snail ready for mating can easily be identified by its conspicuous light coloured genital opening with a little protrusion of the area. Snail being hermaphrodite, mutual insertion of the penis is the general rule. Mating time varies from 2 to 8 hours as reported by various authors and also observed under the present investigations. If overcrowded, the copulating pairs are often disturbed by other snails, a possible attempt to snatch a partner. This may lead to the disengagement of the mating pairs. Hence overcrowding is to be avoided in the mating chambers.

Mating usually takes place immediately after the dusk or in the early morning. Mating also takes place in a cloudy environment following a shower. Copulation is more frequent after the rains at a temperature range of 22 - 32°C. Raut & Ghose (1984) report that no mating takes place below and above 18 - 32°C range and below 86% humidity.

Egg laying takes place within three weeks after the mating. eggs are in isolate mass after making a furrow to the sub-surface of loose soil. Egg mass is covered with sufficient amount of mucous to prevent dessication. Decomposing heaps of leaves and twigs, crevices, etc. protected from direct sunlight also form egg-laying places for the snail. The process takes about 2 - 8 hrs. They lay the eggs even in crowded conditions of culture.

Collection of snails

Collection of snail from wild can be initiated immediately after premonsoon rains. Though snails may be available throughout the night, cool humid evenings (after the dusk) following a heavy downpour and the wet early mornings are the most appropriate time for collection.

Base of large tree trunks, heaps of dried and decaying leaves and pits with dried grass may have aggregation of snails. The presence of one snail is the indication of more snails nearby. They can easily be hand-picked and collected in plastic trays, preferably with perforations.

Transportation

Snails by themselves having the tendency of aggregation, transportation can be done in trays at high densities. Since the snails collected remain more active than the resting ones, they tend to produce more heat when kept under high density. Hence container should have adequate ventilation. Feeding may be stopped 2 - 3 days prior to long distance transportion so that minimum excreta are accumulated in the trays. Direct heat and sunlight are to be avoided during transport. Two thousand snails can be put in one m^2 area for transportation for 2 - 3 days. However optimimum density under Indian conditions are still to be worked out.

BIOLOGY

Distinctive features of Gastropods

This class includes 40,000 living species. They are widely distributed in marine, freshwater and terrestrial habitat. They display a greater diversity in form and size - the smallest being 1/2 mm size and the lrgest one over 15 meter in length.

External Features

The body is divisible into 4 main parts - the visceral sac, th mantle, the head and the foot. The head and the foot are at one side. The greater part which is spirally coiled (visceral sac) is sheathed in the fleshy mantle. In the space between the head and the mantle lies the gills/lungs. The mantle secretes the shell. The shell appears in the embryo as a plate or cap like rudiment. The head is well developed and is connected to the rest of the body with a 'neck'. It is provided with sense organs, a snout and one or two pairs of tentacles. The foot is a powerful muscular organ. The animal is attached to the shell by the strong columellar muscle and by the contraction of which the animal can withdraw itself into the shell.

Internal features

The mouth is situated at anterior end of the head which leads to the buccal cavity. The buccal cavity is furnished with solid cuticular mandibles and a tongue like organ - the radula which is beset with numerous rows of teeth and is used for rasping food. On the either side of radula two salivary glands are there which secrete mucous. The oesophagus is long and tubular and its inner wall is thrown into numerous folds. The stomach has no digestive function. Digestion is effected by the liver only. It secretes a digestive ferment. It has absorptive and excretory functions.

Food

They prefer vegetables and other garden plants if available but in the wild they can survive on any tender plants. According to age and seasons there exists a sort of selective feeding. At the age of 6 days they start feeding mostly on tender leaves of lettuce, beans, etc. and juicy gourds. They start attacking coarser plants at the age of 1 month. They attack plants like gourds, cauliflower, beans, brinjal; tender parts of ladies finger, etc. voraciously. Carrot, cabbage, potato, spinach,

papaya etc. are also in the list of vegetables relished by the snails. Among garden plants, marigold is the most preferred food. Generally they avoid chilli, onion, bitter gourd etc. At dusk they start moving out in search of food.

In simulated envioronment there is no proper pattern followed in feeding time. They are not strictly nocturnal in simulated environment. Moreover, they feed on soaked bread, wheatflour dough, some aquatic weeds etc. in confinement. Powdered egg shell is also preferred by them either singly or mixed with other food materials.

Breeding

Starts laying eggs at a minimum length of 56 mm. Mating starts from June or after the 1st shower of monsoon. Generally the partners come from almost the same age group. Copulation extends for 2 -8 hrs. Optimum conditions for mating are :

Temperature	22 - 32°C
Humidity	> 86%
Rainfall	drizzling in cloudy days

The breeding season continues upto a maximum of October.

Fertilization

Sperms are collected in the spermatheca. The sperms are viable for more than one year. When the spermatozoa reach the talon ovulation starts. Fertilization continues for a fortnight.

Oviposition

After mating it will take 20-30 days for egg laying. Fecundity varies from 112 to 332 eggs per brood. There are records of a minimum of 46 eggs per brood. There are 2-3 broods per year. The number of eggs increased according to the age. Eggs are laid in nests prepared by digging the soil. Mucous is secreted over the eggs to keep the eggs moist and to keep them in a single mass. The colour of the eggs varies from yellow to white. More developed eggs are more yellowish in colour.

Hatching

Generally according to the developmental stage attained before laying, the eggs take 6-20 days for hatching. The most conducive condition is high moisture

content for which the mother snail provides a mucous covering the egg mass. The ideal condition is 78-95% humidity and 22-32°C temperature.

Growth

Since the larval stages are completed within the eggs the miniature of an adult snail is hatched out from the egg. During the active period only growth is recorded. During aestivation/hibernation growth is not recorded. However, under simulated conditioin the growth is not ceased but slowed down during inactive period, and with the attainment of sexual maturity.

On the average inactive period (3 months), the young snail developed 6 whorls and the shell size attained 36.25 x 21.0 mm and wt was 6.89 g. At about 160 days in nature they have grown to 55 mm in shell length.

DESIGN OF SNAIL HOUSE AND FARM

One has to have a first hand knowledge of the snail's life habits in nature before designing a house or plot for its farming. The tips given in chapter 3 will be of considerable help to those who venture into snail farming.

The design of the plot also depends on the magnitude of snail farming one wishes to undertake. A few hundred snails can be reared in a small plot in kitchen yard. The density can be as high as 100 – 150 nos/m^2 or even more. This can also be done in indoor terraria. A large farm may contain several plots supported by specially prepared snail houses meant for breeding and raising of young ones.

In any case, the following basic requirements are to be taken into consideration:

- the house/plot should have adequate shade;
- should retain enough moisture;
- should have hiding/sheltering facilities for the snails from excessive rains/predators/sunlight, etc.
- should have facilities for frequent watering; and
- should not be in water–logging areas.

Preparation of the terraria

Snails can be reared in indoor areas under controlled environment. As we call an aquarium for the fishes, for the snails it is designated as a *terrarium* . Terraria can be of any suitable size varying from 0.1 to a few square metres. An aquarium is converted into a terrarium in the following manner.

The base of the aquarium is filled with course gravel to about 3 inches in height, above which a layer of soil is spread to form a 3 – 4 inches thick bed. Another layer of clean dried leaves/grasses and twigs are spread over the soil to form a one inch thick mat and the terrarium is left undisturbed for about a fortnight. Water is then slowly added at one corner to the level just to immerse the gravel. Soil slowly absorbs water and remains moist. Water is further added so that the gravel layer always retains certain amount of water. The upper layer of leaves is kept always dry to minimise the growth of the moulds, etc. A substratum of glass sheet or asbestos sheet can be provided at one end for placing

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the feed. A porous hard cardboard sheet or a metallic sheet placed over the terrarium with a weight placed above can prevent snails escaping out.

Terrarium can be used as breeding chamber or for rearing the young ones or even raising the snails to marketable size. Young ones can be raised upto 5 – 10 g size in about 2 months at a stocking density of 2000 nos/m^2. With proper care, snails of about 60 g can be raised in about 150 days at a stocking density of 150 – 200 nos/m^2.

Construction of the snail house

Specially errected snail houses can effectively be used as breeding chambers. The principle of construction of a snail house essentially follows that of the terraria. However here the house got a cemented base and the sides and top are protected by wire meshes.

The experimental snail house errected at Barrackpore measures 5m x 2m x 0.6m (height) and has 10 small compartments each of 1m x 1m x 0.6m – arranged in two rows. Each compartment is supported by wooden stakes and covered on three sides and the top by 4mm G.I. wire mesh to prevent the snails from straying out and to keep away the predators. The floor of the house consists of monolithic cement concrete raft (1 : 2 : 4) laid over a single brick flat. The concrete raft is 12 cm thick at the middle and gently slopes to 10 cm on both sides to ensure easy drainage. Each compartment is fitted with a pair of 20mm diameter hard plastic outlet pipes. Approximetely, 0.1 cum of wood is required for building the complete structure (Fig.) which costs about Rs. 5,000/- and can accommodate 2,000 snails with a production rate of 120 kg in six months.

Bottom of the snail house is covered with 1 – 2 inches of gravel. Top soil is added with a thickness of 3 inches at one end. The thickness increases gradually to 6–7 inches at the other end making a sloping contour. Surface at the deeper half is covered with several layers of dry leaves, dry twigs etc. and allowed to dry for 2 – 3 weeks. When it is ready for use, the gravel is covered with water, pouring it at one corner as in case of the terrariuim. A small amount of water should be kept in the gravel at all times. The soil becomes moist and the snail house is ready for use. The moisture should remain throughout the culture period but a substantial part of the leaves should remain dry to minimise the growth of moulds.

About 15 to 20 snails can be kept in a chamber of one square metre at a time which will not be detrimental to the developing embryo. The spent snails can be

replaced by fresh snails. The hatched out young ones can be removed to the terraria of the chambers of the house itself specially meant for their raising.

A snail house of 5 x 2 x 0.6 m dimensions having 10 chambers can yield 0.1 million or more young ones in a season (calculated @ 300 young ones per snail and 30–40 snails in a season). Construction of a snail house of this dimension is estimated to cost about Rs. 5000/- and have a working life of five years.

Preparation of field plots

Open but protected field plots could also form ideal place for snail farming. The basic requirement is to prevent snails from escaping. Fencing large areas with small wire mesh have proved ineffective in two ways (i) The snails are capable of crossing over the sharp edges of the fence, (ii) the life of wire meshes exposed to soil, rain, etc. becomes reduced and the recurring expenditure tends to become prohibitive.

Achatina being air–breathing animals are incapable of crossing over areas submerged under water. Thus a drain (20 x 30 cm) around the plot filled with water helps confine the snails within the plot (Figure). Trees, shrubs, grasses, etc. need not be removed from the plot, rather they are advisable. Plantain gardens can be ideal habitats that can be converted to snail farms. Heaps of broken bricks or stones, hollow wooden trunks, stem of papaya tree, mats of decayed leaves or grass, etc. provided in the plot can be places of shelter during daytime. A larger plot can be subdivided by cross drains into smaller ones of 0.1 or 0.2 ha each for the convenience of management. Preparation of snail farm of one ha with subdivision into five plots may cost around Rs. 50,000/-. The farm with two breeding houses having a total of 20 chambers (one m^2 each) may cost around Rs. 60,000/-. In protected places, wire mesh fencing connected to low voltage current can keep away the snails from escaping.

Highly advanced snail culture practices in France and England follows the pattern of multilayered trays placed one above the other in an airconditioned environment. Trays placed one above the other with spacing in between can be adopted even in field conditions.

THE FARMING

Achatina being terrestrial, slow moving passive and handy in size, their farming has an added advantage over that of other livestock. The techniques are rather simple and do not require exceptional skills.

The culture expériments done at Central Inland Capture Fisheries Research Institute has led to a viable technology for breeding and raising of these wild snails under captivity. Like any other livestock farming, snail rearing also requires collection/procurement of brood stock, rearing them, breeding, hatching of the eggs and raising the hatchlings upto marketable size.

Collection of brood stock

In a situation where widespread culture of snails is not prevalent, the initial stock needs to be collected from nature. Since the giant African snail is distributed widely across the country, procurement of the brood stock may not pose as a constraint. Snails can be transported to long distances without mortality at a high density. However, care may be taken to avoid exposure to excessive heat during transport. Pre-monsoon shower period is the ideal time to collect brood stock since snails come out of hibernation and become quite active during the season. Moreover broods collected at this period may not have spawned and egg laying can be achieved at the early period and young ones can be provided a more growing period.

Breeding

Broodstock may be transferred to pre-prepared terraria or snail houses. Care should be taken to avoid overcrowding in breeding chambers so that the mating snails or the developing embryos are not disturbed by other snails. A density upto 15–20 nos/m^2 was found to be permissible in breeding chambers. The snails may be fed on ample feed and adequate amount of crushed and powdered egg shells to meet the calcium requirements during egg formation. A careful observation can distinguish a breeding snail with certain degree of certainty by the burrows they make. Snails which lay eggs can be transferred to isolation in pots or small terraria. The broods are not to be disturbed. Partially developed embryos are

embedded in mucous which prevent their dessication. Handling of eggs or eggs in isolation may tend to dry up the thin layer of mucous covering and die subsequently.

An atmospheric temperature ranging from 26 – 32°C was found to be ideal for breeding of the snail during the present investigation and earlier observations by other workers. Humidity level of 80% or more is required for its breeding.

The number of eggs obtained from some of the snails ot various sizes bred in the snail house were as follows:

Size / wt. (mm) / (g)	No. of eggs per brood	Av. wt. of eggs (mg)
56/30	112	42
62/36	126	43
62/45	228	42
65/37	170	46
72/37	161	45
74/57	187	44
80/63	218	46
82/72	280	45
83/95	336	46
85/110	330	44

Egg–laying lasted from 2–7 hrs. Eggs were released in spurts with 5 minutes to 2 hrs gap in between the spurts. Within a spurt, eggs were released with 5 – 15 seconds gap between two eggs. Snails disturbed during egg laying continued to breed irrespective of transferring from one place to another. Breeding occurred even in crowded plastic buckets, snail house or terrarium.

Hatching

Undisturbed egg mass in terraria or snail house kept in shade and having a soil moisture of about 80–85% hatch out in 6–20 days after laying. The hatching time depends on the stage of embryonic development at the time of laying. Deep yellow coloured eggs are almost sure to hatch out. Whitish eggs are at a more early stage of embryonic development. White opaque eggs are the ones which are

usually unfertilized. Usually 90–95% of eggs laid are fertilized and viable.

At the terminal stage of embryonic development, the young ones come out breaking the shells. With transparent and thin shells, the tiny ones move around. Feeding starts within 2 days after hatching. Young ones are observed to eat their own broken egg shells. The newly hatched out young ones measuring about 5 mm in length and 65 mg in weight are most vulnerable to mortality.

Feeding

The young snails require a proper environment in terms of temperature (15–35°C) and adequate moisture in the soil. Adequate privision of crushed egg shell powder is crucial to ensure survival of the young ones. Experiments have shown that mortality was upto 90% where egg shell powder was not provided, whereas cent per cent survival was obtained when egg shell powder @ 15–20% of the body weight of young ones was provided. Egg shell powder can be spread over the food or even broadcast in the terrarium or snail house.

The young snails prefer tender or fleshy leaves and fleshy vegetables. Ash gourd or bottle gourd can prove to be a good choice at this stage. At this voraciously eating stage, the feed can be given @ 20% of the body weight of the snails. Food spectrum can slowly be enlarged to a variety of plant materials, kitchen refuses, and leafy left-outs that are collected from the vegetable markets. Some of the feed items that are generally preferred by *Achatina* were worked out in the present investigations as well by earlier workers. The following list will give a broad idea about the feed preferences of this species.

1. Amaranth (*Amaranthus gangeticus, A. viridis*) – leaves, twigs and stem body and seedlings.
2. Antigonon (*Antigonon leptopus*) – only leaves
3. Ballabhianga (*Allangana lamarcana*) – leaves and twigs
4. Balsam (*Impatiens balsamina*) – leaves and flowers (*fallen leaves and flowers are preferred*)
5. Banana (*Musa sapientum*) – fruit only
6. *Basella rubra* – whole plant

7. Beans (*Dolichos* spp., *Glycine* spp.)	– leaves, twigs and fruits.
8. Boerhaavia (*Boerhaavia diffusa*)	– leaves, twigs, flowers and fruits.
9. Bougain villea (*Bougainvillea spectabilis*)	– leaves.
10. Cabbage (*Brassica oleracea* var. *capitata*)	– whole plant
11. Carum carvi (*Momordica cochinchinensis*)	– whole plant
12. Castor (*Ricinus communis*)	– leaves and seedlings
13. Cauliflower (*Brassica oleracea* var. *botrytis*)	– whole plant.
14. Chilly (*Capsicum* spp.)	– leaves and skin
15. China rose (*Hibiscus rosasinensis*)	– whole plant
16. Cosmos (*Cosmos* sp.)	– whole plant
17. Cotton (*Gossypium herbaceum*)	– leaves, flowers, floral buds and fruits
18. Cucumber (*Cucumis sativus*)	– leaves, flowers, floral buds, fruits and young plant
19. Drumstick (*Moringa olifera*)	– fallen leaves.
20. Ficus (*Ficus hispida*)	– leaves.
21. Gourd (*Cucurbita maxima, Lagenaria vulgaris*)	– whole plant.
22. Grass	- only in the absence of other food
23. Jute (*Corchorus* spp.)	– young plant leaves, flowers and

fruit

24. Ladies finger (*Hibiscus esculentus*) – flowers and fruits

25. Lettuce (*Lettuca sativa, L. indica*) – whole plant

26. Maize (*Zea mays*) – seedlings

27. Marigold (*Tagetes patula*) – whole plant

28. Ornamental garden plants – most of the plants are eaten

29. Papaya (*Carica papaya*) – leaves, floral buds, flowers, fruits, skin and seedlings

30. Sunflower (*Helianthus annus*) – floral buds and flowers

31. Zinnia (*Zinnia linearis*) – seedlings

32. Water hyacinth (*Eichhornia crassipes*) – tender leaves but no preference

Feed conversion

When fed on kitchen refuse, fruit peels, etc. the conversion ratio was worked out to be 6.1 : 1. When fed purely on ash gourd, the value was found to be 5.2 : 1.

A snail coming out of hibernation is found to consume feed as much as 60–70% of its body weight per day for the initial days. The rate of feeding comes down to 10–20% of its body weight in subsequent days.

A feed formulation of commercial viability will be the right answer to the feed requirements in large scale snail farming. A feed formulation is still to be made available in India. The investigation in this regard has been initiated and is under progress.

Stocking density

Experiments conducted in terraria at CICFRI have demonstrated that a stocking density upto 200 nos/m^2 can be adopted for raising to marketable size. If reared in open spaces, it is adviseable to raise the snails upto 3–5 g in enclosures and then released to the nature. At this level, the stocking density could be as

high as 2,000–2,500/m^2. In open areas too, if provided with enough shelter, plantations, etc. in the plot, the stocking density could be upto 150–200/m^2. A larger number of snails can be raised from limited area provided they are placed in trays placed one above the other supported by galvanised iron pipes.

Growth

Some of the researchers have worked out the growth rate of *Achatina fulica* in nature. under wild condition, they are reported to attain 55, 75, 90 and 100 mm in their 1st, 2nd, 3rd and 4th year respectively. Three sets of experiments conducted at CICFRI have given widely different growth–rate for various months.

Experiment	Stocking desnity (Nos./m^2)	Rate of feeding (% body weight)	Monthly record of growth (g)					
			1	2	3	4	5	6
			Months					
1*	200/m^2	15	2.5	9.7	18.2	24.0	61.6	62.0***
2**	180/m^2	12	2.9	8.5	22.5	28.5***		
3*	150/m2	10	2.0	6.8	17.6	31.5	57.0	

* Raised on kitchen refuse, market refuse, assortment of vegetables, fruitpeels, etc.

** Raised purely on ashgourd/bottle gourd

*** Further growth was arrested due to dormancy

Prevention of dormancy

Under laboratory conditions, the tendancy for dormancy was found to be reduced to certain extent. By frequent sprinkling of water, the snails could kept for longer period without dormancy.

Harvest

If stocking done sufficiently early, i.e., April–May, the snails get more time to grow before the commencement of winter season. However in areas where winter is not acute and frequent rains are available, year-round raising and

harvesting is possible. partial harvesting can be done from 4th month onwards by picking up grown-up snails and replacing them with young ones.

Parasites and diseases

Not much literature is yet available on pathological aspects of the snails. However, overcrowding of snails in terraria or snail houses seems to have some effect on the general well-being of the snails. A leucoderma type of disease is reported to occur in such cases leading to mortality upto 40% of the stock. This has not been noted during CICFRI experiments.

An unidentified bacterial type of disease was encountered twice in CICFRI experiments. A small stock of 400 snails were perished in May 1987 when the snails were kept in a crowded condition in a cement cistern. Snails were found to become inactive, operculum sealed and food consumption almost became nil. Once the symptoms set in – observed within 4–5 days of stocking – the snails did not recover even though they were transferred to conducive environment. Almost all the snails perished with in a week time. A similar incident took place again in May 1988 when a stock of about 1,500 snails were kept in the snail house at a stocking density of 150–300 nos./m^2. A few ailing snails were picked up and treated with 40–50 mg sulphadiazine/kg body weight mixed with food. A good number of them recovered, while the entire untreated snails perished. Since the cessation of feeding takes place with the advancement of disease, an early identification of the disease is necessary for treatment. A high day temperature with bright sunlight intermittent with heavy showers seems to encourage the disease occurrence. *Achatina* as vectors of parasites is yet to be ascertained.

Predators

A good number of predators of snails have been reported. They include –

Hermit crab	:	Feed upon the snails.
Ants	:	*Oecophyllus* sp. carries away eggs and the newly hatched.
Beetles	:	The most important arthropod predator – Glow-worm *Lamprophorus tenebrosus* feeds on this. They are nocturnal like *A. fulica* and the lympyrid larvae feed on this.

Millipedes	:	*Orthomorpha* sp. predates upon this in Andamans. It secretes hydro–cyanic acid and paralyses the prey before feeding.
Molluscs	:	The only Indian carnivorous snail *Gulella (Indoenna) bicolor* attacks on juveniles sometimes.
Birds	:	*Dendrocitta vagabunda* and *Centropus sinensis* predate on these. The former one pulls out the flesh with the help of beaks and the latter one breaks open the shell.
Mammals	:	Rat *Bandicota indica* is an effective predator. Pigs sometimes feed on it.

However, their impact in open snail farms has not been studied. Protective measures can be adopted, if necessary, depending upon the type of predators and the intensity of damage they cause to the stock.

The India Trade Centre at Brussels in its report (Source: Marine Products Export Development Authority, Cochin) says about the highly sofisticated approach followed in France in the farming of the giant african snail (also referred to as Chinese snail). In such cases automatic control panels are used to regulate the temperature and humidity and the culture is done in plastic trays (6 x 3') with supporting stands of galvanised iron pipes. Tubelights are used for 10 hrs out of 24 hrs in a day. A building with an area of 1,000 m^2 is required for a unit capable of producing 70 tonnes per year.

Once a firm market is established for Indian snails, such highly capital intensive technology also may not prove to be a taboo for the industry.

SNAIL FARMING – CERTAIN ECONOMIC CONSIDERATIONS

With the increase in population and income, demand for products of animal origin has been ever-expanding both in India and abroad. There has been a pronounced upsurge in the foreign trade of seafoods particularly shrimp export from India in the last decade. The patterns of overseas demand are generally governed by income, expenditure elasticity, consumer preferences and domestic availabilities. Generally, gap between domestic availabilities and requirements leaves hardly any option except importing the commodity at a competitive price. Heated international market both for seafoods and snail affords ample opportunities for exporters to have richer harvest of profits.

Possibilities of larger share in export trade become brighter only when our products are competitive. Therefore, issues relating to allocative and marketing efficiency arise necessitating an indepth analysis.

Production functions – Bio-economic relationship

Output from farming system is a function of variables and fixed inputs applied in production process. Unlike industrial or manufacturing process biological production systems are immutable to a great extent but the farming technology does make an endeavour to disturb decisively the relationship between input and output. It is possible to establish linkage between biological and economic considerations of producers. The relationship between input and output is commonly referred to as production function, and most of the text books on agricultural production economics are replete with methods of determining this physical input-output relationship and thereafter adding economic component, and interpreting producer's behaviour based on results.

Decision making environment – Risk and uncertainty management

Generally, conventional studies on economics of production are based on a number of assumptions such as perfect knowledge of the production function, constant prices, etc. But in real world things do not move in a linear fashion. Production relationships are not exact because the producer does not have a perfect control over environmental factors which influence crop and livestock yield. While some of the variations in yield may be attributable to differences in combination of inputs used, there is always a certain amount of variation due to uncontrolled factors. This residual variation may be viewed as chance variation; the result of good or bad luck. Scientific developments enable farmers to take effective control of the production process so as to impart stability to yield rates.

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Market risks

Although individuals by their own action may have no perceptible influence on market prices under pure competition, the combined decisions of large number of individuals may bring about sizeable price changes. Four types of price movement may be distinguished. First, there are long–term trends normally lasting over a period of several years or longer. These are caused by changes in population, income, tastes and techniques of production. Secondly, some prices move in cycles alternating rise and fall every few years (Great Depression, 1930). To some extent these cycles may be self–prepetuating. The third type of price movement is a seasonal fluctuation in prices which may be of inter–seasonal or intra–seasonal nature. Finally, there are irregular movements, many of which may be quite unpredictable. They may be caused by drought, outbreak of diseases or errection of tariff walls or protectionist barriers by importing countries.

From the farmer's point of view there is an important distinction between those changes which can be predicted and those which cannot. The farmer can allow for predictable changes in making his management decisions but unpredictable changes are caused for risk and uncertainty.

In the light of above conceptual framework farming of African snail (*Achatina fulica*) needs to be viewed. India is yet to register its presence in this export trade. Since uninterrupted supply may not be possible from natural collection alone, farming operations may place the enterprises on sure footing. Scientists of CICFRI have conducted successful production trials. The technical and financial viability of the technology have to be the subject matter of constant review. Based on CICFRI's work , the following details may merit attention.

Cost And Returns In Snail Farming
(in Rupees)

	Area 1 ha
Capital costs	3,07,000
Depreciation and interest	57,334
Variable costs	8,88,600
Annual operating costs	9,45,934

Returns

Size of the crop	120 tonnes
Turnover	12,00,000
Net receipts	2,54,066

Assuming five years project cycle important economic indicators are as under:
(at fifteen percent discount rate)

Discounted Benefits	**Discounted Costs**
40,22,856	31,70,008
Net Present Value (N.P.V.)	8,52,578
Benefit Cost Ratio	1.27
Incremental Internal Rate Of Return (IRR)	28.0 percent
Pay- off period	$1^1/_2$ years

The above analysis may, at best, be treated as tentative or indicative since technological developments as a result of subsequent production trials are likely to alter the costs. Since the commodity in question is intended to be produced for catering to international market, domestic market does not provide any cushion to absorb market risks. Therefore, it becomes essential to conduct comprehensive demand surveys in the importing countries. Further, export promotion strategy has to be an aggressive one based on standardisation and quality control. International trade emerges mainly due to differences in comparative costs and not absolute costs. The competitiveness of our products vis–a–vis other exporting nations need to be assessed by MPEDA for which they are well equipped.

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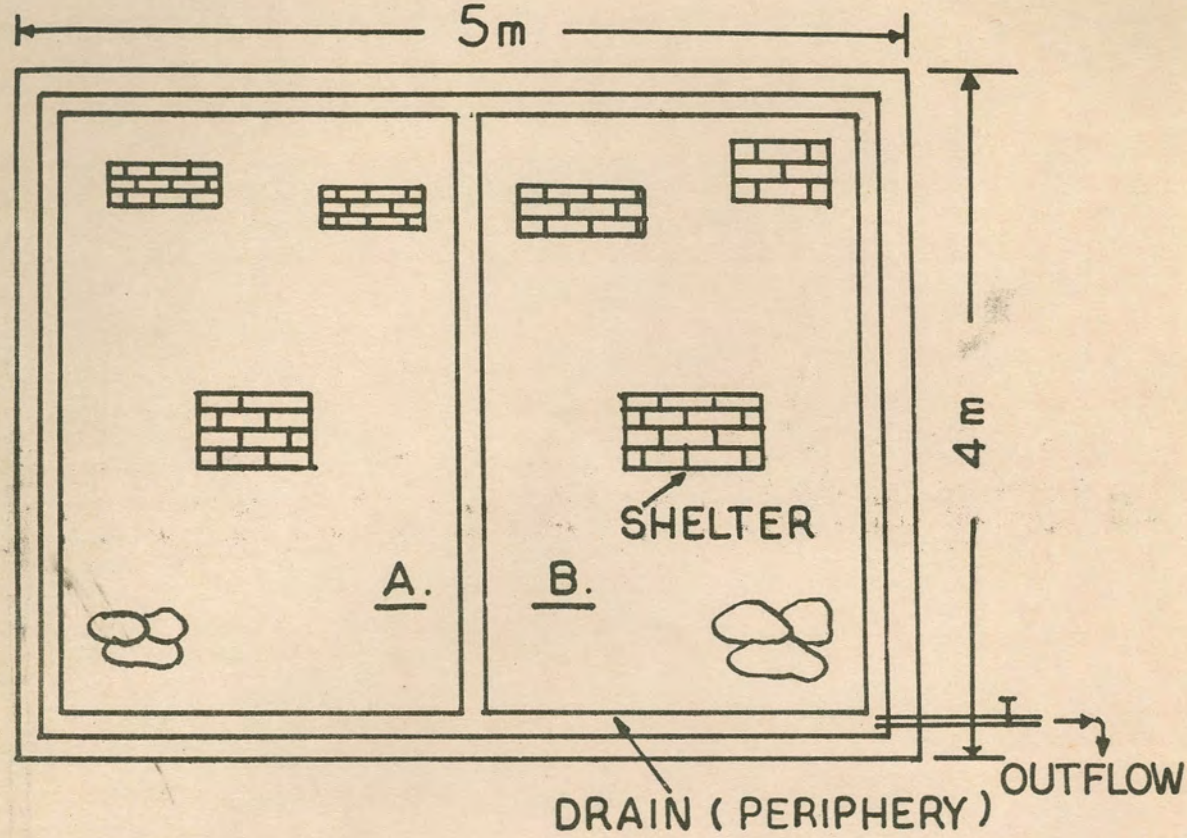
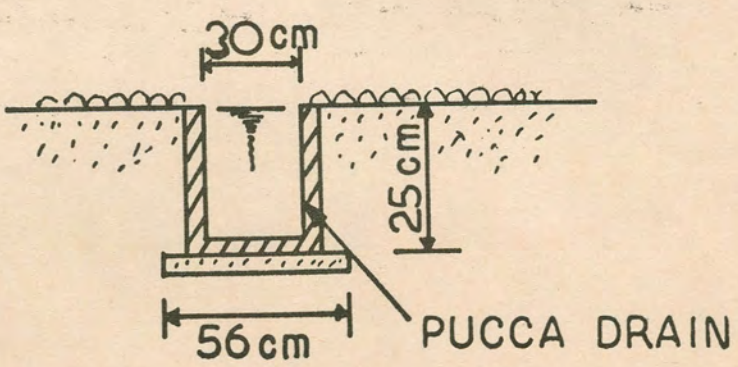


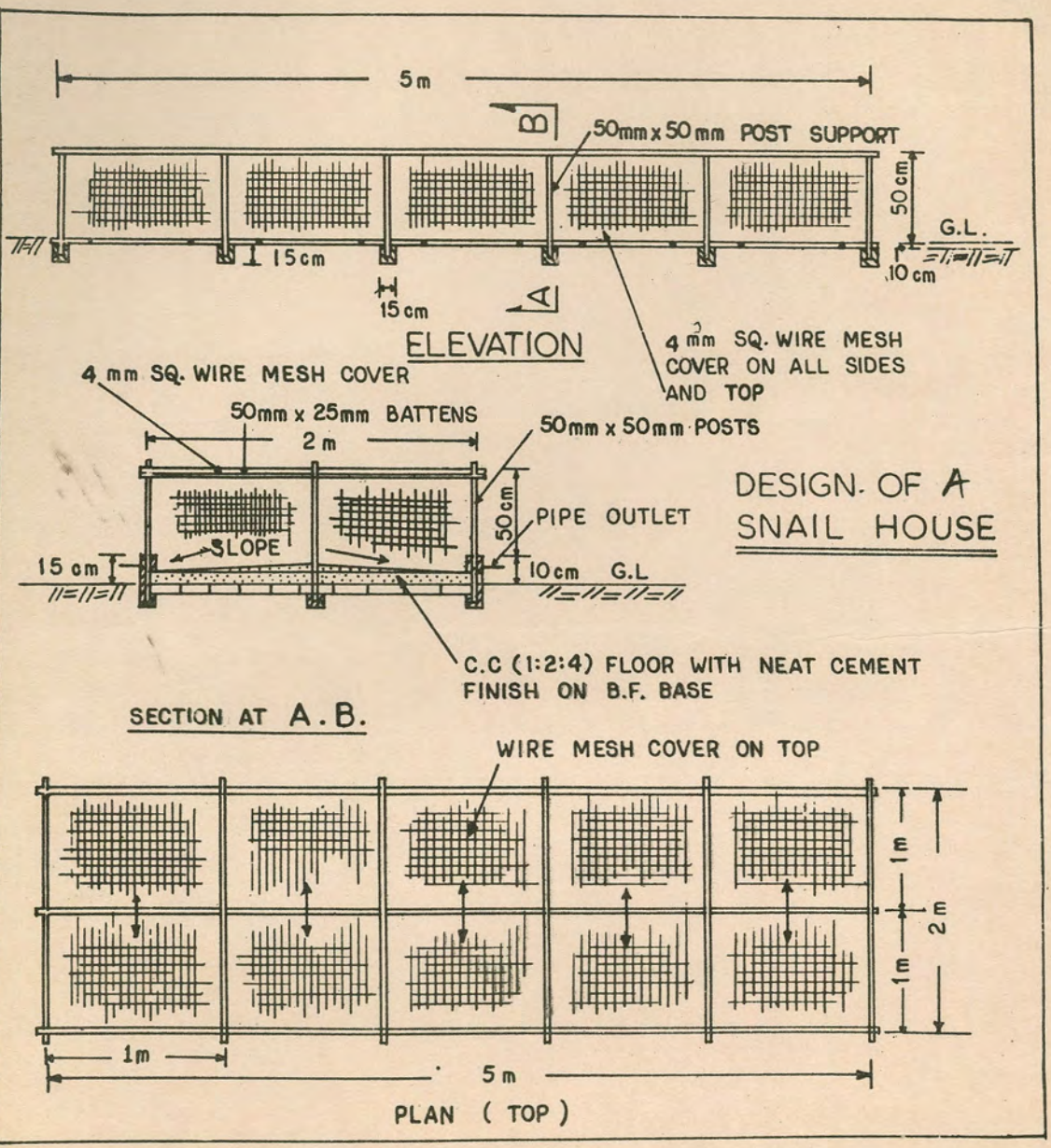
PLAN

LAND AREA – 5m X 4m



SECTION AT A. B.

Design of a field plot for snail farming


5m
B
50mm x 50mm POST SUPPORT
50 cm
G.L.
10 cm
15 cm
15 cm
A
ELEVATION
4 mm SQ. WIRE MESH COVER ON ALL SIDES AND TOP
4 mm SQ. WIRE MESH COVER
50mm x 25mm BATTENS
2 m
50mm x 50mm POSTS
50 cm
PIPE OUTLET
SLOPE
15 cm
10 cm G.L
C.C (1:2:4) FLOOR WITH NEAT CEMENT FINISH ON B.F. BASE
DESIGN OF A SNAIL HOUSE
SECTION AT A.B.
WIRE MESH COVER ON TOP
1 m
2 m
1 m
1m
5 m
PLAN (TOP)