CONSERVATION OF SALAMANDERS IN NAMTHING POKHRI

Darjeeling district,West Bengal

Project carried out by-

NATURE ENVIRONMENT AND WILDLIFE SOCIETY
Kolkata

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FINAL REPORT

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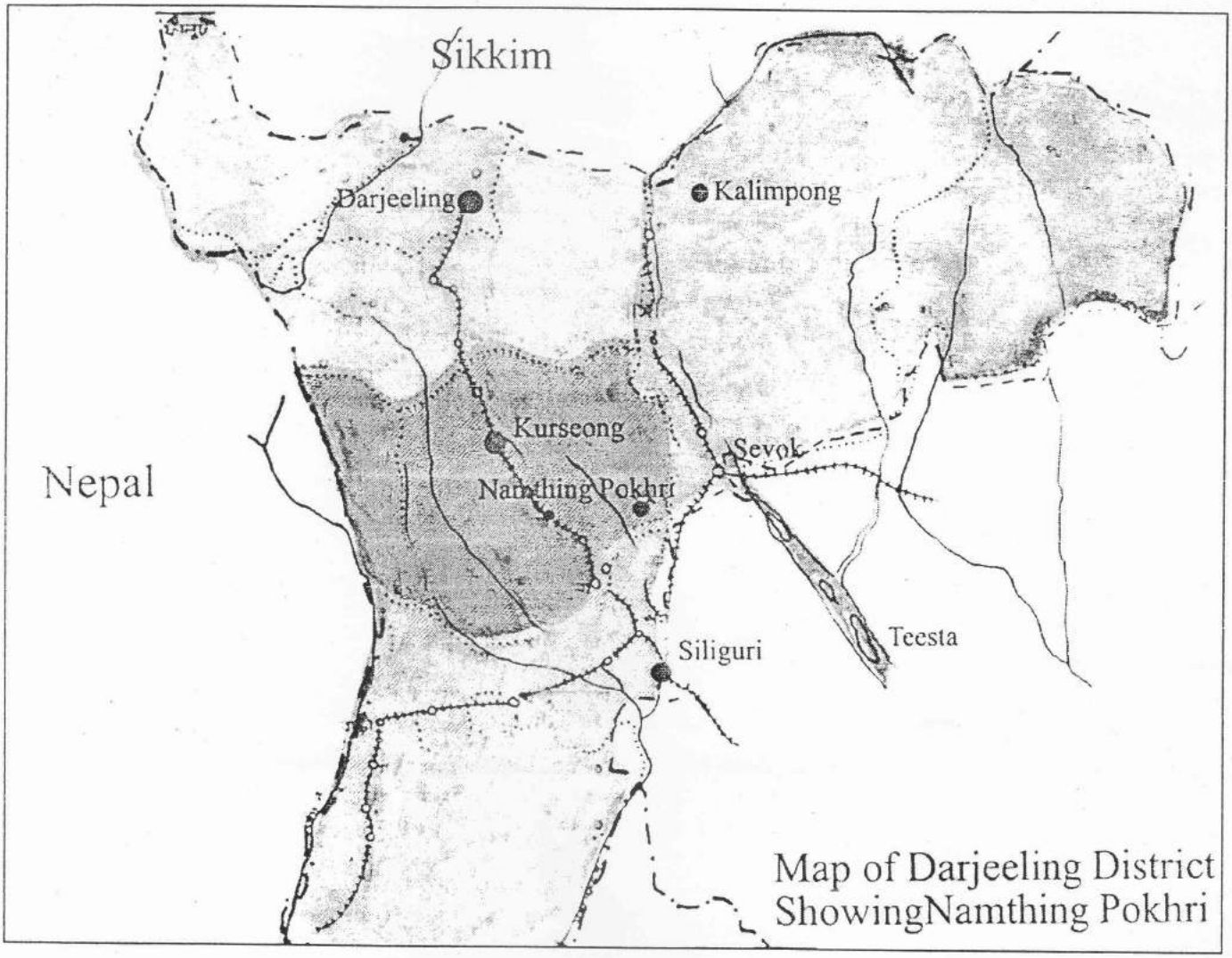
CONSERVATION OF HIMALAYAN SALMANDER, TYLOTOTRITON VERRUCOSUS ANDERSON (AMPHIBIA: SALALMANDRIDAE) IN WEST BENGAL

BACKGROUND

Owing to all round pressures, the wildlife of India has been under severe threat for the past few decades. The reason for this not to be documented here since these are now a common knowledge. In spite of many ill-conceived so-called development policies, there has been an awareness and conscious effort by Government towards the conservation of existing wildlife. The first step taken in this direction was the establishment of a network of Protected Areas along with conservation of threatened species in their habitats. However, be it wildlife conservation, management or research emphasis has been mainly paid on protected areas. Further, attention has been primarily given only to the megafauna or charismatic species. Not much endeavour has so far been initiated towards the management of habitats outside the protected areas and conservation of non-charismatic species living there. Presently, National Wildlife Action Plan (2002-2016) recognised that habitats outside the protected areas are also extremely valuable for wildlife conservation. It has recommended the urgent restoration of productivity potential of such areas and to provide incentives for promoting wildlife conservation on private lands. In reality, habitats like cropfields, grasslands, wastelands, rocks, marshes, wetlands and others are teeming with million of faunal species, each of which playing a crucial role in the respective ecosystem. Unfortunately, pressures of an enlarged and impoverished human population, industrial development, changes in agricultural practices, pollution and destruction of wetlands, combined with unplanned exploitation of biological resources have taken a heavy toll of faunal species particularly in unprotected areas. The Himalayan Salamander, *Tylototriton verrucosus* Anderson (Amphibia: Salamandridae) is one of such victims of anthropogenic pressures. Mainly due to loss or pollution of spawning and hibernation ground, it is becoming scarce day by day and now its status is considered as Endangered (Agrawal and Chandra 1994) in Indian situation.

Out of 209 amphibian species of India, the Himalayan Salamander is the only one in which the larval tail is retained throughout the life as its totally aquatic ancestors. Therefore, this tiny creature is regarded as a living fossil and may prove to be a missing link in understanding the process of evolution. Within the Indian territory it is confined to seasonal and perennial pools and neighbouring grassy slopes at an altitude between 1206-2220 m in certain pockets of Eastern Himalaya. Thus, the salamander may be taken as a indicator of a particular ecosystem. From the points of scientific, ecological, and academic interest, it deserves the fullest conservation for continued survival. Conservation need of this tiny but significant species of amphibia has been felt by a number of workers (Choudhury 1966, Shrestha 1984, Agrawal and Chanda 1994, Chanda 2002). The species was included in the Scheduled II of the Indian Wildlife (Protection) Act 1972. A small pool of about 0.04 sq. km. in Jorepokhri (Darjeeling) has been declared as Wildlife Sanctuary in 1985 for the purpose of conservation of the Himalayan Salamander. Regular monitoring is being made by State Forest Department to protect and rescue the Salamanders in and around its habitats in Sukia Pokhri, Mirik, Sonanda, and others. However, the desired result could be obtained so far.

During the course of the study of the project "Estimation of Population Trends of Endangered Wildlife of West Bengal" sponsored by the Ministry of Environment and Forests, New Delhi, investigating team of NEWS had found that populations of Himalayan Salamander has declined or even totally wiped out from many of its erstwhile habitat. Most of these habitats have totally been destroyed or are located near some urban areas or tourist spots. Local boys used to collect Salamanders and sell them to the tourists. Population of Jore Pokhri has also not spared from such local commercial activities. Singhal (1995) reported a population of salamanders in a seasonal water body, named Namthing Pokhri of Darjeeling District. NEWS team during their visits in 2002-2003 could also found a fairly good population of it in Namthing Pokhri area. The region is scarcely populated. Outsiders or tourists do not visit the area owing to isolated location as well as lack of infrastructural facilities such as accommodation, food, electricity, water etc. However, certain local threats could be identified which at certain point of time may prove to be fatal for the entire population of salamanders living there. Again, as the area



Map of Darjeeling District
ShowingNamthing Pokhri

is remote and almost free from activities of people travelling from outside, it appeared that a social fencing could be developed for the conservation of salamanders at Namthing Pokhri. As such keeping Namthing Pokhri as a Model site the present project was planned and initiated.

OBJECTIVES

1. To reveal the amphibian species composition in and around Namthing Pokhri.
2. To determine the preference of habitats and microhabitats.
3. Survey of neighbouring seasonal or perennial water bodies to locate further viable population of Himalayan Salamander.
4. Study of population dynamics and abundance of Himalayan Salamander in and around Namthing Pokhri
5. Study of physico-chemical parameters of the land and water.
6. Construction of a fencing encompassing Namthing Pokhri so that no one can intrude the pokhri without prior permission.
7. Establishment of a laboratory and herpetorium to study the behaviour and carry out captive breeding programme.
8. Organising awareness camps to generate consciousness regarding conservation of Himalayan Salamander. Also to develop a local NGO to look after the conservation programme after the project is over.

DURATION OF THE PROJECT

October, 2001 to November 2003

STUDY AREA

It has already been stated that a small seasonal water body named Namthing Pokhri and its adjacent area have been selected as model site to carry out the present project work. It lies at an altitude of about 1500 m of eastern Himalaya in Kurseong Division, Darjeeling district. It is connected with Kalijhora on one side and Dilaram on

the other by a fair weather 'kaccha' road. Both the places are about 22 km away from the site. The Pokhri is actually a deep, flat, elliptical depression spreading over 10,000 sq. m. amidist sloping hills. Surrounding slopes and hills are covered with dense growth of grasses, ferns, creepers, plantation of cinchona, Dhupi and some other conifers. Most part of the hills have moderate to thin layer of soil, but naked rocks or boulders are also not uncommon. In the plantation area thick leaf litter could also be seen. A small colony of tribals with few wooden huts mostly having commented floors has also developed on the flat lands adjacent to Pokhri. Locals carry out patchy cultivation of maize, tea and vegetables on the hill slopes. Farming of cattle, pigs and poultry are also being practised. There is also a small temple on one side of the Pokhri. The temple is managed by a local Temple Protection Committee. Daily 6 to 8 trekkers, few motor cycles and occasionally some matadors pass through the 'kachha' road, and they are the only means for travelling to the different parts of the hills.

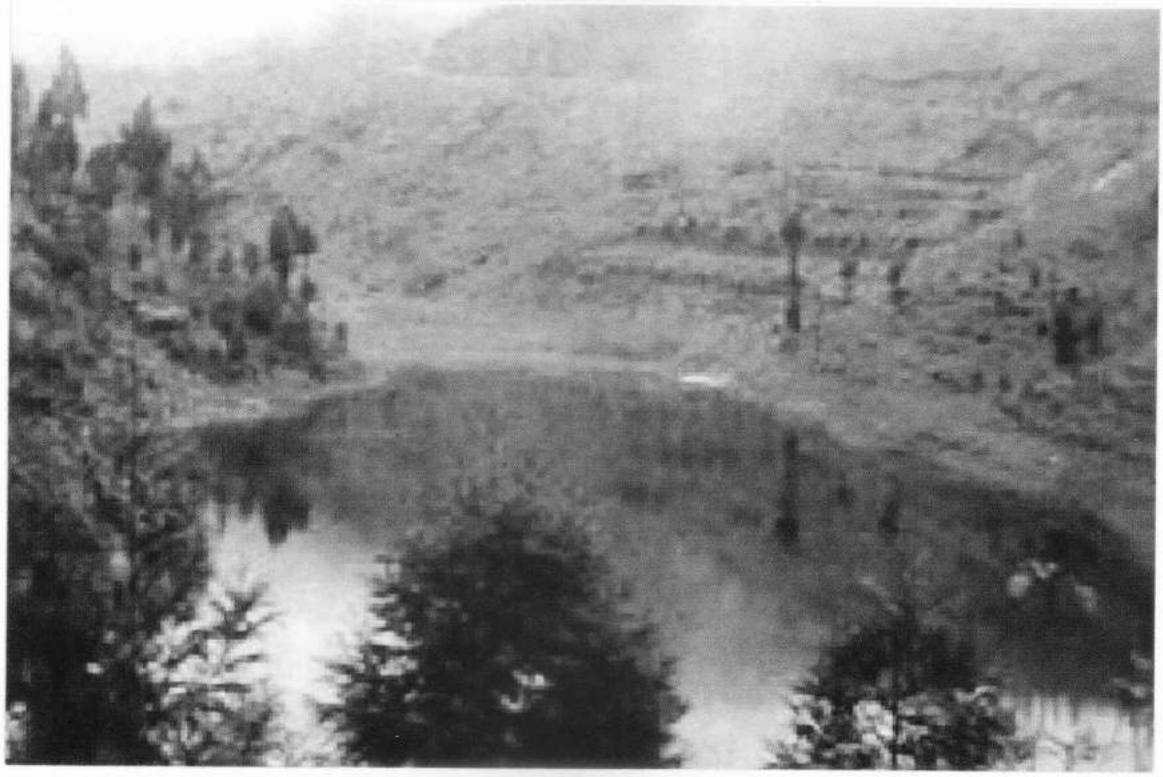
FIELD TRIPS

After the inception of the project, a total of 17 field trips of 5 to 16 days duration were conducted covering all the month during the period from October 2002 to November 2003. Main objectives of the field trips were to organise meetings for convincing the administrative as well as local people about the significance of the conservation of Pokhri and Salamander population; construction of a field laboratory and erect a fencing around Pokhri; survey of water bodies neighbouring Namthing Pokhri; ecological study along with population dynamics; captive breeding of Salamanders; holding awareness camps and formation of a local NGO to look after the future conservation.

METHODOLOGY

First of all a room was hired at Namthing Pokhri on monthly basis for accommodation of team members during field trips and setting up of an interim laboratory. Number of Group meetings were organised with various sections of local people to convince about the significance of conservation of Salamanders and ensure their participation in the project. Then discussions were made with the Forest Department

Namthing Pokhri in winter before fencing



Namthing Pokhri in rains before fencing

and local administrative authorities. After getting consent, plans for fencing around Pokhri and laboratory building were prepared.

During winter and dry months, Broad Quadrate Sampling (BQS) method was employed for estimating the abundance and microhabitat preference of Salamanders and other amphibian species. All the amphibians were identified in the field with the help of Handbook of Indian Amphibians (Chanda 2002). For each salamander specimen, weight and length have been noted. Further, as the Himalayan Salamander is included in Schedule II of IWPA (1972), sufficient care was taken not to injure any individuals and to replace them properly in the place of hibernation. Obviously it was not possible to determine the sex in hibernating stage. For BQS, plots of 8 × 8 M. sizes were selected at random ensuring adequate representation of all microhabitat types. Each plot was thoroughly searched as per Heyer et al. (1984).

Random collection of salamander from its aquatic habitat by netting is very difficult, as they mainly confined either at the bottom of the pool or within the aquatic weeds. However, adults often settle at the bottom in shallow water near the fringe. At this stage random collection was made by hand and data on sex and sizes were noted. Larvae of salamanders remain mainly confined in the center of the pokhri. As such they could be observed in nature only when water is almost dried up during end of September and beginning of October. At this stage random sample collection was made from Pokhri with the help of a large plankton net. Number and sizes of salamander larvae in each sample were noted and then released.

Monthly physico-chemical analysis of water samples of Pokhri was made. The surface temperature and depth of water at various points were taken with the help of a mercury thermometer and meter scale respectively. The pH was noted by using pH paper with marking of 1 to 10. For other chemical parameters such as dissolved oxygen, Chloride, Nitrate etc standard methods as recommended (APHA 1985) were applied. For captive breeding aquaria of 70 cm long × 30 cm deep × 35 cm tall sizes were used. Two-thirds of the aquarium was filled with water of the Pokhri along with some aquatic weeds. A wooden bar of 14×3×7 cm kept floating in the aquarium, to serve as an island so that

salamanders may emerge from the water as per their desire. Arrangement of daily draining the water of aquarium by siphon system and replenishing the same with pokhri water was made. Temperature and pH of aquarium water noted regularly.

During monsoon months, different perennial water bodies around Namthing Pokhri were surveyed in search of salamander populations.

Regular observation was made at nights with the help of a powerful torch light to record data on the pattern and time of de-hibernation, appearance in the Pokhri, dispersal from Pokhri, probable predators and related aspects.

Others details of methodology have been described as and when required along with the results.

NATIONAL AND INTERNATIONAL STATUS OF RESEARCH

First description of the Himalayan Salamander and subsequently accounts of breeding habits were given by Anderson (1871). Further information on its eggs and breeding were provided by Annandale (1907, 1908). Chandhuri (1966) discussed its habit, courtship and development in Darjeeling Himalaya. Description of its tadpole was available from Smith (1924). Daniel (1962), Sarkar et al. (1972), Agrawal and Chanda (1994), Chanda (2002) dealt with the taxonomy, distribution, habit, habitat and status of the species. Shrestha (1982, 1984) provided information on its distribution, habitat and threats in Nepal. Singhal (1995) focussed on the threats as well as management of the species. Sparreboom (1999) and Clare (2001) studied the husbandry and breeding aspects.

RESULTS

Information available at the start of the project:

Namthing Pokhri is a seasonal pool. With the on set of rain during April, water flowing through surrounding hills starts accumulating in Pokhri. In the year of good rain highest depth and extension of water go up to 3.5 m. and 10,000 sq.m. respectively

during August-September. Drying up starts immediately after the rainy season is over and no trace of water could be found from the end of October. It appears that, entire bed of Pokhri is very much porous, and major part of the water goes into the ground. Various species of semi aquatic grasses and other plants start growing in the fringe areas of Pokhri along with the accumulation of water. However, centre of the Pokhri remains almost free from any vegetative growth. These weeds become exposed during the dry period and they are collected by the local people to use mainly as fodder. During December-January, picnickers from far and nearby villages and tea gardens visit the area for picnicking in the dry Pokhri bed. Often the vehicles carrying picnickers go down along the slope and park in the flat bed. Picnickers make fire for cooking and throw various wastes including plastic packets here and there. Slopes are also not spared from hazardous activities. In other days, Pokhri bed is used for playing cricket, football etc.

When there is water in Pokhri, it is used by the local people to bathe, wash utensils/clothes and to clean the cattle. Often vehicles are driven along the slope to the water for servicing.

With the drying up of water, all the amphibians including Salamander of various sizes start leaving pokhri in search of hibernating places. They hibernate in pokhri bed, slopes, forest floor, crop fields and even in and around huts. Stacks of woods, decaying logs, leaf litter, rocks and boulders, loose and moist soil are used for hibernation. Sometimes they go as deep as 20 cm in the loose soil. From November onwards no Salamander could be seen in open areas till one shower in April.

Quite a number of threat factors as detailed below have been identified.

(1) Pollution of water by detergents, sepage of fossil fuel, plastic and other refuses of picnickers.

(2) Occasional clearing of patches of vegetative growth of pokhri slope for cultivation or other purposes.

(3) Fire hazard.

(4) Movement of vehicles along the slope destroying large number of hibernating individual.

(5) Soil erosion and siltation of Pokhri.

The Pokhri after fencing

An equipped laboratory has been set up beside the pokhri

(6) Accidental death or injury of hibernating individuals during ploughing.

Meetings :

It was felt that without the local support, no conservation programme could be developed at Namthing Pokhri. Therefore, during October, 2002, a meeting was arranged with the members of the Temple Protection Committee of Namthing Pokhri. Members were explained about the natural heritage of their area, existing threats and significance of conservation of Salamander habitat particularly Pokhri and surroundings. By the active support of the temple Protection Committee, a total of seven meetings were held with the people of the neighbouring villages, local administrative authorities and State Forest Department. After a long persuasion it was possible to make the villagers understand that there should be certain restriction in the use of Pokhri in wet as well as dry period for the conservation of Salamanders. It was agreed upon that with the financial support of the Project Authority, a complete fencing with birbed wire and iron angles will be done around Pokhri. On one side of the fencing there will be a get with lock and key provision. People will be allowed to carry water from the Pokhri for their household purposes. Washing of utensils/clothes, bathing, cleaning of cattles directly in Pokhri will be prohibited. No servicing of automobiles to be allowed. During dry period locals many collect the fodder grown in the Pokhri as per their tradition. It may also be used as play ground but with least disturbance of the slopes. However, no picnic can be arranged in the Pokhri or nearby areas. For erecting the fencing, labourer to be engaged from neighbouring villages by rotation. Two local persons will be appointed as guards. A joint committee comprising two members from NEWS and three from local villages was formed to supervise the entire construction work.

Construction :

It was decided that fencing will be done on the slopes around the Pokhri and nearly 5 m above the normal maximum stretch of water. All the construction material had to bought from Siliguri. Iron angles of 2.5 m height were fixed at 3.5 m intervals along the line of fencing. Each iron angle was placed in the foundation of cement concrete. These angles are joined with each other by eight parallel rows of birbed wire. Each birbed wire is separated from the next by a gap of nearly 20 cm. During construction work, necessary

training was given to all the labourers for taking utmost care to have least disturbance of the natural vegetation of the slopes. Whenever, a hibernating salamander is exposed, that was brought to the notice of the scientific team and subsequently placed in nearby suitable place. A grilled gate of about 3×2.5 m size was made for allowing entry to the Pokhri as and when required. Erection of fencing was started in November, 2002 and completed by the end of December, 2002. Along with fencing, a small laboratory cum captive breeding centre was erected on a piece of flat rocky land near Pokhri.

Inventory:

As already stated Broad Quadrate sampling (BQS) method was applied for revealing the amphibian species composition and estimating the frequency of their of occurrence in different habitats during hibernation. This study was conducted in each month from October, 2002 to March 2003 covering all the microhabitats of existing habitats within 500 m. around the Pokhri. It has been found that Salamanders hibernate on the surface of earth when there is a cover of boulder, log or leaf litter; in between stacks of woods or fodder; even under loose and moist soil as deep as 20 cm. Twelve number of plots of each microhabitats were searched for.

Apart from *Tylototriton verrucosus*, six more species of amphibians viz. *Bufo melanostictus, B. himalayana, Rana cyanophlyctis, R. limnocharis, R. leucomystax* and *Philautus annandalii* could be found during B.Q.S. Percentage frequency of occurrence of amphibian species in different habitats are given in Table 1. It appeared that highest number of amphibians hibernate in Pokhri slopes followed by human dwelling areas including crop fields.

Table 1. Percentage frequency of occurrence of amphibians in different habitats

Habitats	Frequency	Percentage
Plantation	29	9.73
Grass lands	35	11.74
Human dwellings including crop field	90	30.2
Rocky areas	18	6.04
Pokhri bed	14	4.69
Pokhri slopes	112	37.58

Microhabitats were broadly classified as grass, leaf litter, under boulder, under logs, under boulder, crop fields with crops, crop fields without crop, bush and cowsheds cum store rooms of fodder's. Preferred microhabitats of Salamanders were leaf litter (37.66%) followed by crop fields without crop (17.53). The result is presented in Table 2.

Table 2. Microhabitat preferences of *Tylototriton Verrucosus*

Microhabitats	No. of occurrence	Percentage of occurrence
Grass	13	8.44
Leaf litter	58	37.66
Under boulder	6	3.89
Under log	21	13.63
Crop field with crop	13	8.44
Crop field without crop	27	17.53
Bush	10	6.49
Cowshed cum store room of fodder	6	3.89

When distance from the possible highest margin of Pokhri water is considered, maximum number of hibernating Salamanders were found within 100 m. of the Pokhri. However, if only the number of adult hibernating animals (over 14 cm in total length) is taken, it is highest within 100 + to 200 m. of the Pokhri (Table 3).

Table 3. No. and percentage of occurrence of *Tylototriton verrucossus* at various distances from estimated highest margin of Pokhri.

Distance from Pokhri (m)	Total number of occurrences	Percentage of occurrence	No. of occurrence of adults (above 14 cm)	Percentage of occurrence of adult
0 to 100	58	37.66	16	23.88
100 to 200	40	25.97	21	31.34
200+ to 300	26	16.88	18	26.86
300+ to 400	19	12.33	7	10.44
400+ to500	11	7.14	5	7.46

Except for indoor plots vegetal cover of all the sampling plots are in the form of tree canopy, shrub cover and herb cover. The same occur either individually or in

combination. The percentage of vegetal cover of sampling plots were determined by using a graduated mirror 15×15 cm. size. In each plot, four observations were taken in a day at different hours by keeping the mirror at a fixed point. Percent number of square on the graduated mirror covered by vegetal cover were noted and average of four reading in a sample plot provided the percentage of vegetal cover. Except in the crop fields with crop where vegetal cover varied from 15 to 36%, in all other plots it was very low varying from 0 to 25%. No definite relation between number of hibernating animals and percentage of vegetal cover could be found as the occurrence was high both in 'O' vegetal cover and in 20 to 25% vegetal cover.

Great variation in the size and weight class could be found among the hibernating Salamanders. Total length (snout to tip of tail) of smallest and largest animal was 51 mm and 168 mm respectively, while minimum and maximum weight was 5.6 gm and 16.4 gm. respectively. Distribution of different size and weight classes are shown in Table 4 and 5. Sarkar et al (1992) considered individual with total length of 128 mm. as the *smallest adult. As per that yardstick about 56.49 percent of hibernating individuals are* juveniles or sub-adults. When weight were tallied with total lengths, it was found that individuals of up to 120 mm length were always below 11 gm, and those above 135 mm were of more than 13.5 gm. While those in the size of above 120 mm and below 135 mm had weight anything between 11 + and below 13.5 gm. Thus, it appears that in respect of weight there exists much overlapping among advanced sub-adults and young adults. Highest number of individuals was found in 11+ to 13 gm class, which in all probability included both advanced sub-adults as well as young adults.

Table 4. Distribution of size classes among the hibernating *Tylototriton verrucosus.*

Size class (mm)	No of Individual	Percent
50 – 70	3	1.94
71 – 90	18	11.69
91-110	31	20.13
111-127	35	22.72
128-150	52	33.76
151-170	15	9.74

Table 5. Distribution of weight classes among the hibernating *Tylototriton verrucosus*.

Weight class	No. of Individual	Percent
5-7	4	2.59
7+ to 9	16	10.38
9+ to 11	28	18.18
11+ to 13	53	34.41
13+ to 15	41	26.62
15+	12	7.79

Sex determination in hibernating stage was very difficult and any attempt to do that might injure the animal. As such distribution of sex in hibernating population was not done. Netting in pond did not yield any adult individuals. As such, during the period from June 2003 to August 2003, a total of 42 specimens of adult Salamander were collected by hand from Pokhri. Sexes of these individuals were determined as per characteristics provided by Clare (2001). However, a characteristic of male viz. a pale line around eye, as mentioned by Clare (2001) was not evident in Pokhri population. This random collection of handpicked specimens exhibited a very high ratio of female being 27 out 42. Total length of females varied from 132 to 158 mm (mean 140 mm), while in males 129 to 168 mm (mean 141 mm); while weight varied from 12 to 14 gm (mean 13 gm) in female and 11.5 to 15.5 gm (mean 13.2 gm) in male.

Out of these 42 hand-picked specimens, 2 males and 2 females collected during June were released in the aquarium of the laboratory for captive breeding.

Random collection from Pokhri with a large plankton net revealed huge number of tadpoles of species of amphibians other than Salamanders during April and May 2003. These tadpoles were mainly concentrated near the margin of the Pokhri. However, a good number of Salamanders of various sizes were found crawling or remain motionless on the bottom of Pokhri in fringe areas. They swim only when disturbed or come to the surface for breathing. They swim by the help of tail and limbs are kept motionless and parallel to the body. It appeared that tadpoles of Salamanders remain concentrated at the bottom of deep water in the center region of Pokhri. As such no tadpoles of them could be seen or collected by plankton net, till the Pokhri, almost dried up during October when there was knee deep water only at the center. At this stage large number of tadpole of various sizes

(25-56 mm) and developmental stages were found. It appeared that most of these tadpoles of smaller sizes could not complete their metamorphosis and suffered premature death as the Pokhri dried up completely by the end of October. Further, when water level was decreased, aquatic larva of an insect (species could not be identified) were found as predators of tadpoles. It was found that these larvae were feeding upon the dorsal and tail fin including the distal part of the tail of tadpoles.

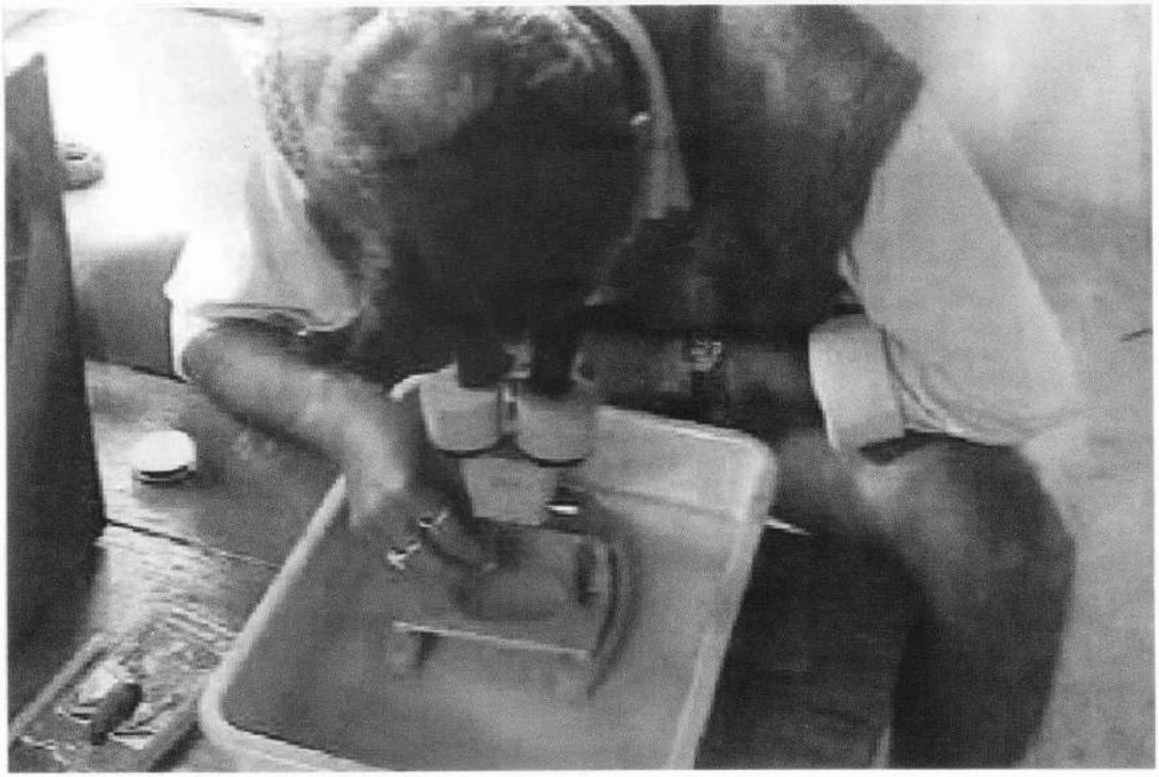
Night survey revealed that with the on set of first rain during April, Salamanders come out from their hibernation. At this stage, individual of various sizes could be seen in large number moving towards Pokhri. However, till there was certain accumulation of water of two to three rain, none of them could be noticed in the Pokhri. Terrestrial movement of this animal is very sluggish. Whenever, a vehicle passed through the road at night, a good number of them found smashed. From the mid-June, no terrestrial salamander could be observed till the month of October. It appeared that Salamanders spend a complete aquatic life so long there is water in the Pokhri.

Water quality effects the composition and abundance of aquatic fauna. Pohkri serve as an ideal habitat and spawning ground of Salamanders and few more amphibian species. As such it was thought worthwhile to study some of the parameters of Pokhri water right from the time of accumulation during April till it dried up in October. These data will provide guidelines to identify other suitable water bodies which may serve as spawning ground, if required.

Pokhri water was found to be acidic, pH value varied within a small range of 4 to 5. It was highest during August, when water level was highest.

Monthly as well as daily fluctuation of water temperature is very high. On average, minimum temperature (11°C) was attained in October and maximum temperature (26°C) in June. Overall average minimum and maximum temperature during the period of study were 14°C and 22°C. Highest daily fluctuation was recorded in June (Min. 14°C, Max. 26°C), and lowest fluctuation in August (Min. 12°C, Max. 20°C).

Acquariums were placed in the laboratory to carry out the experiments



Research works are in progress in the laboratory

Dissolved oxygen is a valuable tracer for water and sensitive indicator for biological and chemical processes occurring in it. The values of Dissolved Oxygen in Pokhri ranged from 7.8 to 9. It also attained the highest level in August.

Chloride content was very low and did not exhibit significant monthly variation. It ranged from 1.1 mg/l. Klein (1957) showed a direct relation between Chloride content and pollution level. More Chloride is considered as an indicator of more pollution. Least value of chloride indicate lesser pollution of water Pokhri water.

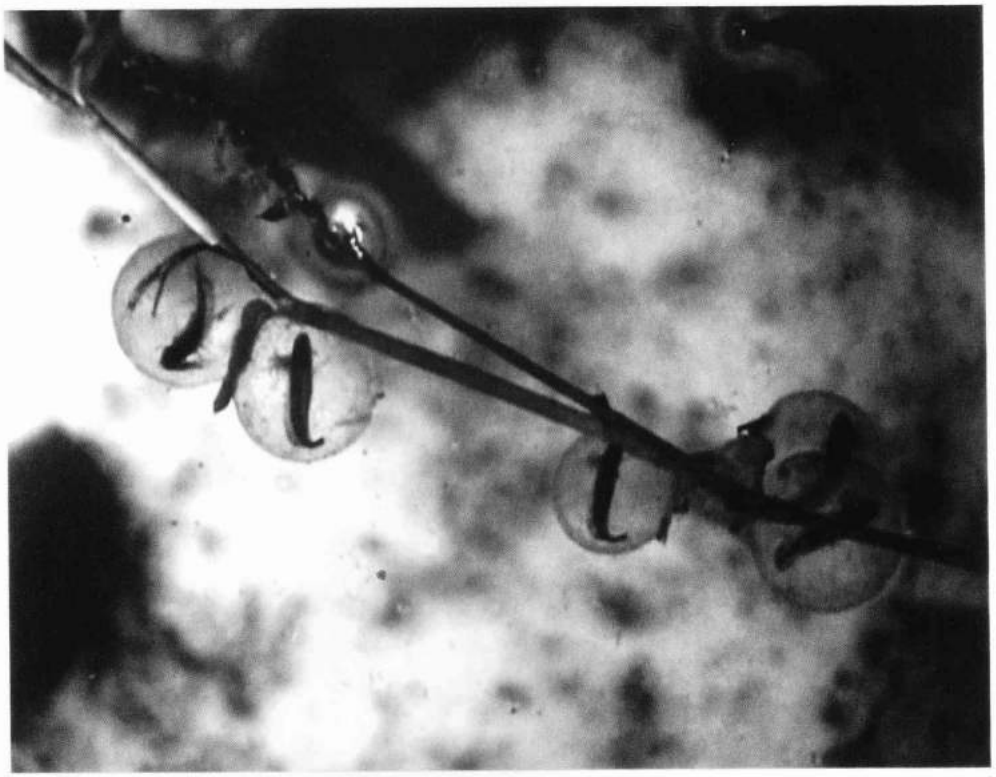
Concentration of nutrients, viz. Nitrogen and Phosphate are important as they are directly related to biological productivity. Nitrogen is one of the most important nutrients in plant, however, excess of this element in water may result eutrophication. Phosphate is another nutrient that limit the growth of Phytoplankton. Normal source of Phosphate and Nitrate in Pokhri is the rainwater that passes through the soil and agricultural land. As substantial part of the catchment area is rocky and there is little agricultural land, both Nitrate and Phosphate content of Pokhri were very low ranging from 0.03 to0.04 (mg/l) and 0.01 to 0.03 (mg/l) respectively. It is to be noted that, prior to the present study, use of detergents which may add Phosphate in water, has been stopped.

Sulpher is an essential element to all life forms and enters the biomass as Sulphate. Sulphate deficiency may inhabit algal population directly by hindering chlorophyll synthesis (Cole 1979). Concentration of Sulphate in Pokhri showed a definite seasonality. During initial accumulation of water during April-May sulphate content was less (4.02 ppm), and gradually increased reaching maximum at the end of September and beginning of October (6.01 ppm.)

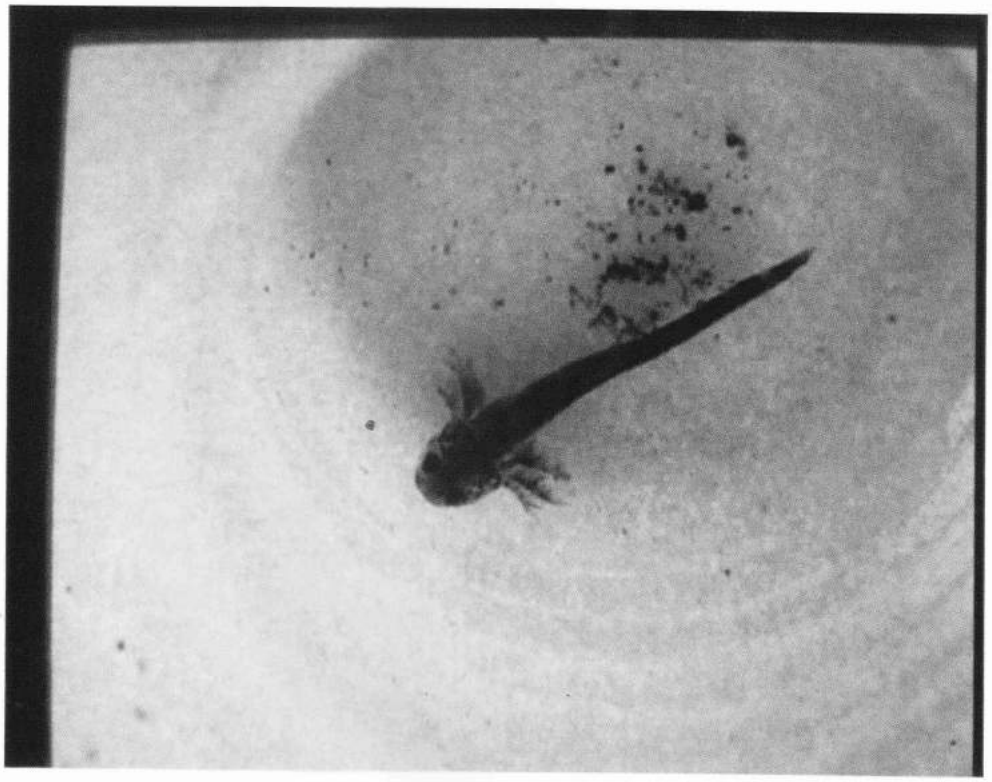
Studies in captivity :

To study the behaviour in captivity, and carryout captive breeding, as already stated, two adult males (total length 162 mm, 156 mm) and two adult females (total length 156 mm and 153 mm) collected from Pokhri were released in the aquarium of the laboratory on 16th June, 2003. Within few minutes of the release, all the four animals settled at the bottom of the aquarium. Then at an interval of 3 to 4 minutes, each animal came to the

Eggs are being laid within 48 hours after copulation

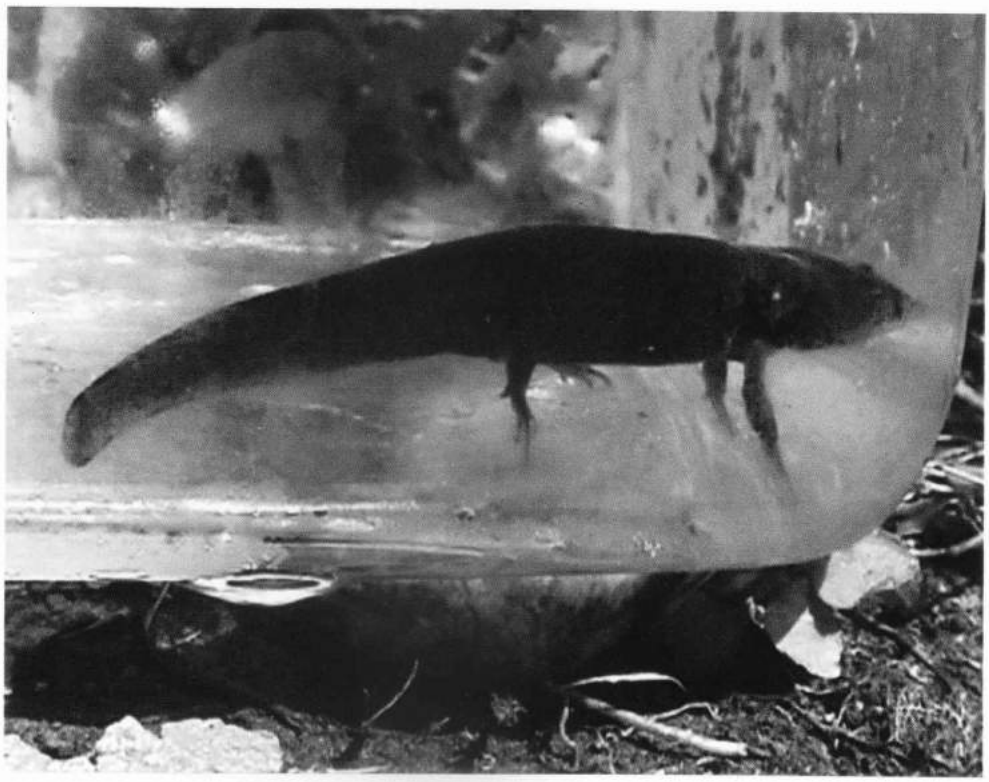


Larvae are formed inside eggs



First larva is born in the captivity

The larva is now about to shed its gills and the dorsal fin



Larva has been transformed to a complete salamander after 40 days

surface for oxygen and again going to the bottom. All the animals readily accepted various items of food provided. Fresh earthworm, bloodworm, tubifex worm, prawn, chicken liver were provided in pieces. Mating of a pair occurred on 22nd June at about 11-30 hrs. Prior to mating, the male performed elaborate courtship by chasing the female. It also occasionally fan the female with tail. After about an hour of courtship, the male entangled with the female from below and hold the mate by clasping his forelegs. At this stage, the pair moved throughout the aquarium with occasional rest of few seconds in floating condition. Pairing lasted for about an hour. After the mating was over, the other pair of male and female specimens were removed to a second aquarium. On 24th June, at about 09.00 hrs, the female started laying egg. The female pressed back its hindlimbs from time to time, the anal opening bulged out and in a few minutes after this action eggs came out very slowly. Egg remain attached to it for sometime. The animal then moved gently towards the submerged leaves of aquatic plants that already provided in the aquarium. It respired upon the leaves for a short while and then moved away sticking few eggs on the dorsal surface of the leaves with a sticky secretion. In this way, it laid a total of 61 eggs in three instalments within a span of an hour. Egg are round in shape and housed in bilayered, transparent jelly like substance. Eggs are about 5-6 mm in diameter. After 6 days of laying, embryo became visible in the egg. Between 15th to 17th July, hatching of eggs started. A total of 41 larvae were hatched and rest of the eggs were decayed. Newly hatched larvae were 8 to 13 mm in length. Within few minutes of hatching they started active swimming. At this stage both the parents were removed from the aquarium to avoid any short of cannibalism. Finely minced earthworm, tubifex worm and live daphnia were provided as food. The larvae were found to be voracious eater and accepted all types of food material with preference of minced earthworm. At the initial stage only fore legs and trace of gills were visible. By 5th of August, well-developed hind and forelegs, four pairs of feathery gills and dorsal fins were clearly visible and they attained the size 18 to 22 mm. However, by this time six of them died. At this stage, they remained completely aquatic and never came to the surface. Within next few days, gills and dorsal fins started obliterating and by the 3rd week of August they were scarcely visible indicating almost completion of metamorphosis. However, from 5th to end of August another eight larvae died. Further, growth of tadpoles were not satisfactory as

they reached only the length of 28 to 32 mm by the first week of September and another fine specimens died. At this stage, surviving tadpoles were released in the Pokhri.

Throughout the study in captivity, water temperature varied from 12°C to 21°C and pH from 4 to 5. Again aquarium was kept in the laboratory in such a way that it may have at least 11 hours of daylight.

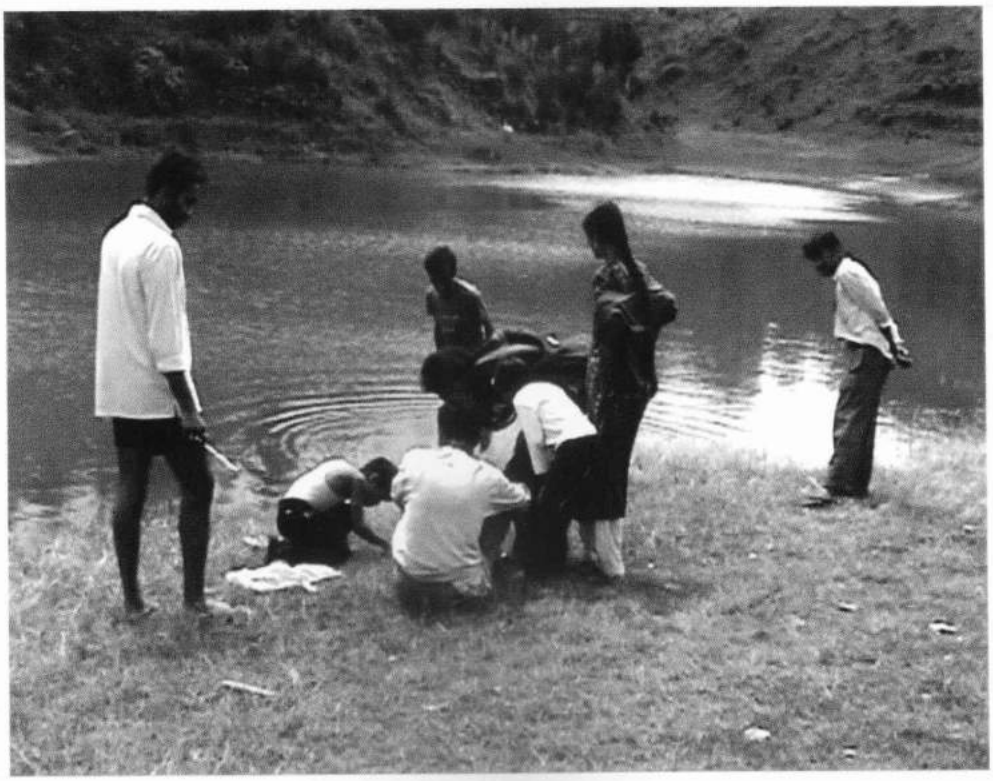
Survey of adjoining areas of Namthing Pokhri :

Survey was conducted on foot nearly 16 sq. km area surrounding Namthing Pokhri in search of perennial or permanent water bodies and population of Salamander. Except some small fountains no permanent water bodies could be found. In some small depressions within the hills water accumulates during rain, but within few days after the cessation of rain, water goes away from there. However, five small adjacent depressions (each about of 200 sq. m. area) locally known as Panch Pokhri were found at about 3 km away from Namthing Pokhri. Panch Pokhri is located at an altitude of nearly 1700 M. Rain water accumulates in these five depressions for a period of nearly four months from June to September. Not much growth of aquatic or semi-aquatic plants could be noticed there. Present team could find a small population of Salamander in Panch Pokhri. However, no detailed study could be made due to lack of time.

Awareness campaign and formation of local NGO :

It is obvious that without the support of the local people no conservation programme can reach the target. As such from the very beginning of the Project local, people including women and children were taken into the confidence. One of the project team member (Shri Ghose) is conversant with local language. As such, it was easy for us to explain them about significance of conservation, habit and habitat of salamanders, existing threats, what to do and what not do and others. Campaign was not restricted to the Namthing Pokhri, but also extended to nearby villages. A total of six regular camps were organised with the help of the local teachers and members of the Temple Protection Committee. Students and their parents were regularly taken to the laboratory to show the activity of Salamanders in captivity. Often large numbers of hibernating Salamanders are unintentionally killed during the process of ploughing. The people were trained to replace

Captive bred salamanders are being released in nature



An NGO has been formed involving local school students and villagers

the exposed Salamanders in suitable place or to hand over them to Project team member for subsequent rehabilitation.

A local NGO, named 'Save Salamander' was formed comprising members from the nearby villages. The NGO has good representation of students and women. Main objectives of the NGO are to protect the hibernating and spawing ground of the Salamanders and to arrange plantation in collaboration with the Forest Department to minimise soil erosion.

DISCUSSION

While population of Himalayan Salamanders, *Tylototriton verrucosus* wiped out or drastically declined in most of its erstwhile habitats, Namthing Pokhri presents a different picture. Hill slopes and flats serving as hibernating ground and Pokhri as a very good spawing ground.

Existence of a large number of juveniles and subadults in the hibernating population indicates viability of Salamanders in the area.

Feeding in nature could not be studied, but in captivity it readily accepts earth worms, tubifex worms, Daphnia, crustaceans etc. All these items are readily available in nature in and around Namthing Pokhri. Thus, it appears that there is sufficient food in nature to support the population of Salamanders existing there.

Number of other amphibian species occur in close association with Salamanders at Namthing. However, during breeding period, Salamanders keep themselves almost confined to aquatic condition, while other species regularly visit the land. Further, salamanders apparently breed little later as compared to others. Some territorial difference in the habitat utilisation could also marked as the larvae and tadpoles of Salamanders usually remain concentrated in deep water at the center of the Pokhri, while tadpoles of other toads and frogs could be seen in large number at the margin when Pokhri is full of water. This, in all probability, reduces the inter specific competition.

Slopes adjacent of Pokhri appeared as most suitable habitat for hibernation of amphibian species in general. Thus, any sort of disturbance or encroachment of Pokhri may effect the amphibian population most severely. Leaf litter is the most preferred microhabitat of Salamander. As such, extension of plantation programme in the nearby areas of Pokhri may act as a boon. When distance from Pokhri is considered, it became obvious that, Salamanders are relatively small ranging animals and do not move far from their spawing ground. This also suggests that immediate adjacent area of Pokhri should be kept free from anthropogenic pressures for the existence of viable Salamander population.

Occurrence of various sizes of tadpole during the month of October, suggests that it breeds throughout the period of rain. However, Pokhri dries up by the end of October. As such metamorphosis of most of the larvae can not be completed by that time and die in the process. In the absence of any apparent natural predators, this might be playing a role in maintaining the balance of population.

Salamanders can be maintained in captivity with least difficulty. It also breeds freely under captive condition. However, the rate of development and metamorphosis appeared to be very slow with certain amount of mortality. Further study, in this respect is necessary to develop ideal physico-chemical condition and balanced nutrition in captivity so that a healthy population may build up in captivity.

RECOMMENDATION

(1) Present arrangement for the protection of Pokhri to be maintained permanently.

(2) Calculated plantation programme should be developed around Pokhri to minimise soil erosion and also for regular accumulation of leaf litter.

(3) Arrangement of technical and financial support to the newly formed NGO to be made.

(4) Laboratory at Namthing Pokhri should be developed as an ideal captive breeding centre for Salamanders and maintaining a stock of captive breed population as a part of Ex-situ conservation.

(5) Salamanders have lost much of their earlier range in Darjeeling and Sikkim Himalayas. With aprropriate financial support, survey to be initiated at different areas of Sikkim and Darjeeling hills in search of seasonal or perinnial waterbodies and to carry out studies on the physio-chemical parameters as well as ecological situations of them. Bsaed on these studies, feasibility of introduction of salamander from captive stock at Namthing Pokhri should actively be considered. However, prior to any introduction all the criteria provided in the guidelines of IUCN to be strictly followed.

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