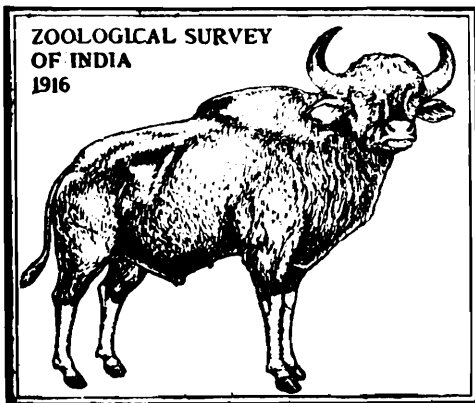


# ZOOLOGIANA

NUMBER 4

1981



ZOOLOGICAL SURVEY OF INDIA, CALCUTTA

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**Number 4**

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## THE ROLE OF WORLD FISHERIES IN HUMAN NUTRITION : A NEW APPRAISAL \*

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Spokesmen for fisheries point with justified pride to the fact that in the post-war period, in contrast to agriculture, fisheries has managed not only to keep up with world population growth but to supercede this on a global scale. On the other hand many exaggerated statements swirl around about the potential of the oceans and their future role.

The discussion of the role of world fisheries in human nutrition needs to be placed into a broader perspective. I will bring you as far back as the days of Christ, almost two millenia ago. There is ample evidence that in those days the oceans were teeming with living creatures. Whales existed in abundance in almost all major oceans, including the Mediterranean and the Black Sea, through which they moved in major annual forays. The biggest whaling in those days was that of the China "Seas." The first Europeans who ventured out to sea to catch whales were presumably the Basques, who inhabited the Atlantic shores of the northern part of the Iberian peninsula from where they also pioneered long distance fishing and hit upon Newfoundland and its rich fishing waters. The Basques, furthermore, hunted whales as far north as the Scandinavian peninsula. But with the growth of world population, the whales gradually diminished, culminating in the huge Arctic and Antarctic onslaught.

Whales are mostly conceived as plankton eaters but as you well know several species as, e. g., the killer whale are carnivorous—with fish included as their feed. With the gradual disappearance of the whales, excess herring among others swarmed in overwhelming numbers into the coastal areas of northern Japan. During the heydays of this fishery in the

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\*Lecture given to the Zoological Survey of India, Calcutta on the 19th December, 1979.

medieval period salted herring became the prime source of animal protein far inland and even to European farmers. This was prior to the full development of dairying, meat and poultry production. The herring schools became so enormous that much fish stranded in the tidal zones of the Scandinavian and European waters and were carted away to be used as fertilizer. There are famous Dutch, Scandinavian, and Hokkaido paintings that eternalized these dramatic events.

### **Food technology preceded agriculture**

My interest in these matters stems from my involvement with food science and technology. Food technology actually came on the human scene prior to the neolithic revolution shaping agriculture, maybe even prior to the development of fisheries. Ways had to be found to utilize these immense, but perishable aquatic resources. Earlier man had to feed on what could be eaten directly without any kind of preparation. It is evident from the thousands of mounds existing almost in all continents that molluscan shellfish and gastropods, first from freshwaters and later from marine sources may well have constituted man's first food. Molluscs did not run away as fish do. They could be picked and eaten without further ado. Various catching devices were created and man's feeding only gradually evolved into its next step. Hundreds of years later as methods of preparation developed, and fish were gradually made less perishable and thus became storable food commodities, primarily through salting and drying as the initial phases.

There is ample evidence of this historical sequence in all continents. In 1978 an important discovery was made by the US National Academy of Science lending further strong support for this sequence. All along the mid-Atlantic coastline of Brazil at 600 to 700 feet depth, 25,000 year-old shellfish-based settlements were discovered. At that time this was the coastal plain. Since then the ocean level has risen that much. These were early primitive settlements dating that far back. Unquestionably they existed prior to the neolithic revolution. The initial phases of man's conquest of the Middle East region started with coastal settlements, as, e. g., close to Beirut, and only one to two thousand years later did they actually move inland towards the mountains and different forms of agriculture took shape in the piedmont regions.

Man's striving for aquatic food resources presumably followed similar patterns around the globe. When visiting Japan some years ago I found old

paintings which carried many traits similar to those of the European herring runs of the 15th and 16th centuries in the NE Atlantic—as, e. g. those from the southern part of my native Sweden, showing farmers walking out to fork up stranded herring onto their wagons and thus cart away this fish to be used as fertilizers.

### **Post World War II expansion**

The period since World War II is unquestionable the most glorious in the history of world fisheries both in terms of technological advances and catch volumes. The catches have grown four to five times more rapidly than the population, leaving agriculture far behind in that regard. Nonetheless, it is about time we stop talking about fisheries as a form of hunting. Thanks to all the new technical devices that evolved, there has never been a more organized and technically sophisticated hunt either at sea or on land.

This whole postwar explosion in fishing was dominated by three, possibly four driving forces. Number one was the massive spread by the well-to-do world into almost all oceans. The big land grab by the Western World 1850-1950 epitomized by the White Man moving into all empty lands of the globe primarily North and Latin America but also Siberia and the highlands of Africa—got an unexpected sequel in the huge ocean grab after WW II. This drive was spearheaded by USSR, Japan, and Europe, both East and West. Japan rapidly took the lead in catch volume, but in a neck to neck race with USSR, which gradually emerged as a formidable contender creating a new highly modern, diversified fishing fleet, currently holding more than half the world's catching vessels. Having been aboard some of their units, I can vouch to that. The Soviets have floating "cities" fishing in practically all oceans, each fleet comprising besides coastal catching vessels, hundreds of long distance trawlers, sometimes equipped for processing operations, but mostly supplemented with specialized factory ships covering the entire processing range of freezing, canning, salting even drying, and meal production, etc., etc. In addition special supply ships have been built. These conglomerates constitute veritable floating cities not uncommonly counting crews of totally 20, 30 to 40 thousand people. A major part of this fishing fleet has been built on Soviet shipyards often with a streamlined regular launching. These yards are located in the Baltic, the Black Sea, and the Far Pacific regions. Numerous shipyards of Western and Eastern Europe ( Polish, East German, Scandinavian, French, Dutch, West and East German and others ) have filled many Soviet orders since the end

of the 1940ies. But the Europeans themselves soon joined this big race for the ocean riches. Belatedly towards the end of the 50ies, Western Europe, led by France and Spain, started this building up of a third big fishing force. Eastern Europe rapidly followed suite with East Germany, Poland, and later Roumania. Even Bulgaria became an ocean-fishing nation.

Consequently these are the three major powers in this huge ocean drive: Japan, USSR, and Europe (both East and West). The fourth major power was my own country, the United States, not so much by building new modern fleets other than marginally, in particular for tuna and shrimp fishing, but by becoming the leading purchasing power on the world seafood market, to the tune of more than two billion dollars a year. We will later on see the consequences of this happening.

Now this is the situation we are in. But it does not give you a full picture of what is happening, nor does it touch upon the grave crisis phenomena immediately ahead. In order to put these into their appropriate context the whole issue of world fishing needs to be placed into a biological focus, I would like to preface also this part of my review by bringing in a historical backdrop and doing this by describing to you a parallel happening which in many ways was far more basic and which partly explains what really did happen and why?

### **Why the ocean drive ?**

Why did USSR venture out into the oceans ? Why did Japan invest so heavily in fisheries ; to the degree of becoming the most important fishing nation even in the North Atlantic ? Why did Europe a little later enter into global fisheries ? In all three cases the driving forces were the same, namely pollution of domestic fishing waters coastal as well as lakes and rivers. But this came to a head at different points in time, starting in Europe with the water-destructive abuses created by the industrialization of the 18th and 19th centuries affecting to an increasing degree the Thames, the Danube, the Rhine and other main river arteries, as well as key lakes. But mch earlier, already in the 15th century, thus before Columbus reached America, the Portugese fisheries bought licenses from their king and ventured out all the way to the Newfoundland banks, the richest fishing waters in the x world. Japan early moved out to equally rich fishing grounds where south moving cold streams (Kuroshio) meet with north-going warm currents (Oyo-shio)—and later along the coasts of mainland Asia, in particular China, ending up in the 18th and 19th centuries in the Far East of Russia, over into the eastern parts of the Arctic Ocean.

In this connection I would like to remind you that a major site has been selected—maybe already decided upon for oil drilling in the North American waters off Newfoundland and New England. It is my contention that presumably this could well become some of the richest oil-fields in the world as this has been the site of high level organic production through many centuries—in the cross flow of major ocean currents.

But why did the Europeans have to go so far out at sea to fish? They were forced to find supplementary protein. Agriculture was poorly developed, dairying hardly at all. Salted herring gradually in medieval days became the prime animal protein food. Dried pike was in those times so invaluable that it was used as money which shows its fundamental significance.

As the population increased, the cities grew. When industrialization and urbanization converged it gradually almost rendered a death blow to freshwater fisheries in continental Europe. In 1650 the central core-land had sixty lakes. Today there are only two left, Lake Geneva and Lake Constance, both rapidly vanishing as sources of fish due to extensive pollution. In addition, both Berlin and Paris are eyeing these lakes for future potable water, a development which would require large investments, and heavily tax these sparse remaining waters.

For the Europeans the oceans was the only recourse and they developed such fisheries with great success. But it did not suffice. By the mid-1850s Europe stood for the greatest migration in human history and lifted off one-fourth of its population to North and South America, to Africa, Australia, New Zealand, and Siberia. (They also came to India but found it overpopulated already at that time.) They got hold of all these largely empty areas in the biggest land grab of history but also got as booty some of the richest agricultural lands of the world, in particular the prairies and the pampas. This is one of the great mysteries of history, militarily as well as diplomatically, that this could happen without any serious challenges, other than skirmishes.

I assume you know as much as I do about the fresh water fisheries of the North American continent with the Great Lakes and numerous big rivers, the Hudson, the mighty Mississippi and numerous others both on the Atlantic as well as Pacific. But in less than sixty years and certainly within less than a hundred years the North American inland fisheries were dwindling, this counted from the white man's formal takeover of the continent. The Great Lakes nowadays do not even yield enough fish to

supply the city of Detroit in Michigan, far less Chicago of Illinois. Most of the rivers are so polluted that they cannot be used to provide water for industry without previous chemical treatment, much less be a source of potable water. Attending a big conference in New York about North America's water resources I listened to Cousteau describe the change in water quality in the New York Bight by showing underwater films he had taken twenty years ago in this region then teeming with life but now almost a dead area. All you could see were waste products floating around or spread over the sea-bottom. There was not a single living fish. The Hudson is for sure not the only river in US-East that is basically destroyed for regular fishing—this is equally true for the Delaware and the Potomac and several others.

So US had to resort to off-shore fisheries which has been well developed on the rich banks of the NE, along parts off the Carolina and Florida coasts as well as along the Mexican Gulf, but especially in Alaska and the north-western states of Oregon and Washington.

### **U. S. tuna fisheries**

But may I just briefly review what happened to the US tuna fisheries. They started after the Spanish-American War in 1898 on one of the Caribbean islands and this saved some of the poor soldiers of the times from starvation. Around the turn of the century, southern California developed as a center of tuna fishing, but the industry had trouble selling the fish. Then the famous slogan "Chicken-of-the-Sea" was invented and that did it. Tuna became one of the key military provisions of the United States. The first labor strike among US fishermen took place in southern California. Why? Newly started canneries soon discovered that tuna sold so well that in order to satisfy the demand it was necessary to buy additional raw material from Japan, the biggest tuna catcher at the turn of the century. This saved the industry. But the fishermen were convinced that this arrangement would deprive them of their livelihood and it took a couple of years to settle this strike. This was prior to World War I.

In order to fill the growing demands, US tuna fisheries were nonetheless forced to expand southwards along the Pacific coast of South America in order to fill US demands. At the outbreak of World War II United States had established its tuna empire all along the coast, as far down as Chile. After World War II tuna plants were added in the South Pacific islands. To fill the yet growing US demands catching had to be moved into the Atlantic in particular as the coastal states of the western Pacific developed

their own fisheries and canneries. US-built tuna canneries were built in Puerto Rico, and finally in the Boston region to accommodate for these Atlantic catches. This shows what a rich powerful nation can do, while poor countries often could not afford the big investments required for such expansions of their fisheries. We will return to this crucial matter.

### **Main factors behind Soviet drive**

Before doing so, let us ask the intriguing question : why did USSR go out to all oceans in search of fish ? Some of militarily minded friends like to think that this presumably was part of a major venture and that grand strategy was behind this endeavor. I am in no way refuting this notion—it is possibly true. But I can assure you from my visits on board some of these ships that they are all equipped for fishing and used for fishing, a fact global fisheries statistics also bear out. Why did USSR get so profoundly involved. They needed to establish a more dependable source of animal protein than what the hazardous climate of their croplands could guarantee. That land area is no less than 1/6 of the globe but the adversity of the climate highly affects both agriculture and fisheries. Their road toward accomplishing this was to develop fisheries but on a global scale. Despite gales, bad weather, and other obstacles ocean fisheries contributed a reliable protein source, in particular when supported by highly efficient modern fishing vessels in turn provided with processing facilities or special ships for this purpose—in addition service and supply ships—with hospital and entertainment facilities — some even with airship service.

USSR needed to do this for two reasons. Firstly, the hazards of their climate cause substantial fluctuations in Soviet agriculture, not the least in animal production. This is the very same factor that made USSR into a major feed buyer on the world markets to uphold their animal production through agriculture. Fisheries were, however, transformed into the first safety valve to secure protein in daily food.

The second reasons for their huge fishery endeavor was the same that forced Europe and North America out to the wide ocean expanses, i. e., the industrial pollution — in particular of rivers, flowing east, south, and west, emptying into warm waters. As a rule, their water flow is only 1/3-1/5 of that of European rivers. The rapid and large scale industrialization of the Soviet Union therefore created a pollution, more precipitous and devastating to their inland fisheries than to those of European lands to the west. USSR was simply forced to resort to the oceans more hastily than

ever Europe and North America in their early forays to the oceans, although gradually all three took recourse to this alternative for securing added animal protein and of high nutritional quality.

But the Soviet invasion of the ocean fisheries could not, like the Japanese, rely on a net of regional bases negotiated around the globe. For all practical purposes most of the central Atlantic Islands are Japanese, as the many fishing boats going in and out there predominantly are of that nationality. Due to political circumstances, USSR was forced to choose an alternative way in building up what has become the world's largest fishing fleet. A fundamental difference prevails in this regard between the two fishing nations. USSR created self-contained floating fishing cities—now and then moving back home or into port primarily for resupplying.

### The true global role of fisheries

So much for the background. Let us now take a look at some other specifics of basic significance. Mankind is currently divided up into two worlds with one-fourth (27%) constituting the Satisfied World (SW) and three-fourths (73%) the Hungry World (HW). The former consists of North America, USSR, Europe, Japan, Australia, and New Zealand. These latter two hardly count in human numbers. Australia, larger in land than the United States, holds less people than the city of Tokyo. Asia (Japan excluded), Africa and Latin America make up the Hungry World. In terms of intake of plant protein, i. e., what is coming directly from cereals, grains, pulses, fruits, vegetables, plant products on the whole—the difference between these two major but highly unequal portions of the world population is in this particular regard minor. But in terms of the *animal protein* intake the gap is *enormous*: 55 grams per person and day in the SW as against 12 grams in HW. The role fisheries is performing in bridging the gap is as a rule only vaguely understood.

I will therefore chisel out in these specific terms the true global role of fisheries as well as its permanent but surely neglected significance to the feeding of the developing world. This has been one of the most seriously misinterpreted or neglected aspects of the glorious postwar expansion of world fisheries.

It is in the perspective of man's history almost unbelievable that the big Western Land Grab 1850-1950—despite its unique features did get an immediate follow up and almost a repeat in an equally dramatic grab of the world's oceans. It has already been described, but I intentionally left

the deeper analysis of this happening to the end of my discussion. Do we realize that more than two-thirds (around 70%) of the ocean catches are either eaten as food by Satisfied World (27% of mankind) or used by them as feed ? As to the disposition of the freshwater catches the situation is reversed, as 80% of this catch belongs and stays with the developing world.

	Final Disposal		
	mmt	SW	HW
Ocean catches	63.85	44.52	19.33
	%	70	30
Freshwater catches	7.45	1.48	5.97
	%	17	83
Total aquatic catch	71.3	46.0	24.30
	%	65	35

Norway and Denmark are converting no less than 4.5 mmt of their catches into fish meal, consisting of fish that in other parts of the world as, e.g., Japan constitutes prime human food—species such as herring, mackerel, sand eel, and capelin. This Scandinavian scoop going into fish meal is not well understood as to its true dimensions. It is 2.8 times more than what in these countries goes into human food from aquatic sources. This can, however, best be elucidated by comparing it with the total catch of North America (US, Canada, and Mexico) which it equals in tonnage. More telling is the fact that it also equals the combined aquatic catch of Thailand, Indonesia, Philippines, Malaysia, and Burma (5.1 mmt or twice that of India!) crucial to the feeding of more than 1/4 of a billion (280 million). Finally this is not very far from the amount of aquatic food which are extracted from the globe's freshwaters.

Africa is often referred to as one outstanding example of how since the 1950ies catches of this continent have more than 3.5-folded allegedly to the benefit of its inhabitants. Up to 1965 the dominant feature was the catch of South Africa, Namibia, and Angola—accounting for as much as half the landings of this continent. No less than 35-40% thereof was, however, converted into fish meal and largely placed on the world market. In later years most of South Africa's fish meal has been used within that country or sold to Zimbabwe. All this should be evaluated against the back-ground that since 1950 the African continent has added 260 million people—an increase of no less than 130%.

### **Development Programs—Goals and Trends**

In recent years fishing journals around the world have been deluged with feature articles and reports on fisheries development programs in a number of poor countries. The impression is given that a large scale effort is underway to aid the hungry world in mobilizing their fisheries resources and this in order to improve and expand domestic consumption. Any scrutiny of these programs, either as they are formulated on paper or carried out, shows that in an overwhelming number of cases they primarily hinge upon satisfying exportation. Though as a rule this is placed far down on the list of goals, it commonly holds the priority and remains a prime goal of consideration.

Europe and the United States were up to 1977 the chief net recipients of world trade in fish and fish products, some 95 per cent, since then Japan has joined as a third partner in order to uphold its high level of intake. Shrimp and tuna very much dominate in the food category. US holds the world record in consumption of tuna or 3 lbs. per person and year, thus accounting for some 60 per cent of the global catch of the tuna species used in US, or at any rate more than half of all tuna captured worldwide.

India is the prime source of shrimp to the world and hold the overwhelming lead in global catches, but with several of the catch areas faltering as in many other parts of the world. The biggest tuna cannery in the world appears to be located at Abidjan (Ivory Coast), a joint consortium with West German and French capital, but almost its entire production is sold to US, Japan, and Europe.

### **The Shrimp Fair**

US is importing shrimp from more than 60 countries of which some 40 can be labelled protein-short, hungry countries. Some of this shrimp is flown in by air as, e.g., from India. Miami can be likened with a huge siphon suctioning off most of the shrimp harvests along the entire coastline—from far down along the Atlantic coast of Brazil and the entire northern coast of South America, as well as the Gulf coasts of Central America and Mexico. By truck, ships and by air most passes through Miami primarily to the restaurants of New York, Chicago, Washington, and other cities. Cuba in a corresponding manner sells its shrimp catches to France. Most of this Mexican Gulf shrimping is coupled with disproportionate waste. For each ton of shrimp 7-10 tons of fish is thrown overboard. It does not pay to put

the lowly fish into the freezing holds. In addition much small-sized shrimp is harvested. This wasted catch amounts to more than two million tons.

Japan entered as a major shrimp buyer with India and Indonesia as chief providers in the mid-70ies, then procuring equally much as US. She also buys shrimp from Taiwan, Thailand, and Mexico.

These shrimp sales are claimed to earn foreign exchange, but through tax-free status and other arrangements the national coffers receive only modest contributions. The result is unquestionably some direct employment but at a marginal level. More important, however, is the fact that the resources to be developed within these programs in many cases already have been fished to the limit in the previous free-for-all operations. We are very far from the goal of making the resources of the ocean the joint property of all mankind, and we are seemingly not able to guarantee that the catches from the waters of the developing nations will be consumed by their peoples or put into their nutritional programs.

Also in 1978, USSR placed on order in Spanish shipyards 12 new shrimpers in a new series of ships, planned to reach more than one hundred. The USSR only had one such shrimper previously, built in 1975. The Soviet Fishing Ministry created in 1971, a joint Spanish-Soviet company ( Sovhispan ). Norway did in 1978, launch their first large shrimp catcher ( 850 BRT ). When the shrimp season is over these units will reportedly concentrate on capelin.

### **Tuna forays**

A strong consumer market for canned tuna and reportedly newly discovered yellowfin and skipjack stocks in the western Pacific and in the waters of New Zealand, Australia, and Africa have prompted a surge in worldwide superseiner construction. No less than twenty US designed and owned seiners are reportedly under construction in Denmark and Mexico. USSR did in a major way enter this tuna race building large catchers in considerable numbers on Polish and its own shipyards.

USSR early in the 60ies did make plans to emulate US as a tuna power but seemingly recognized the limitations of the oceans confronted by the huge assault by US and its supporting fleets of Taiwan and South Korea and others. Their dreams appeared squelched, in particular as France and more recently Spain entered in a growing scale the competition for these coveted pelagic, meaty species. Then suddenly, in 1978, Polish

shipyards launched a supermodern big tuna catcher ordered by USSR. So USSR has in a determined manner entered this race.

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### **New orientation of market forces**

Until recently the only untapped major fishing ground was the Falkland Shelf. USSR together with Eastern European partners first started the exploitation of these waters in the 60ies, but when licences within the 200-mile limit were introduced in the 70ies, they vanished. Argentina then entered into a major development program arranging for the settlement along the Patagonian coast of 300 to 400 Japanese and South Korean families ( altogether 2,000 people ).

This among other happenings forced Italy to sell part of its long distance fishing fleet. African countries have been reluctant to grant fishing licences. In 1977, Italy was as a consequence importing fish and fish products from close to fifty countries. Some fifty vessels equipped for long distance oceanic fishing were idled ( staying for cost reasons in foreign ports). Two thousand fishermen, largely from southern ports, lost their jobs.

Also Spain fears it will be compelled to buy its fish abroad and see its fisheries, the glory of centuries, terminated. Joint companies with Latin American countries and bilateral agreements with third world countries are elements of a restructuring. Ireland is sounded out. A Spanish-Mexican company signed in 1978 an agreement with US for the catch of a modest 85 tons of fish and squid in US waters. This year forty more catching vessels are being added. Most of the catch will be exported to Spain.

These are only given as a few examples to demonstrate the exceptional market forces that are building up in the wake of anticipated changes due to the UNCLOS decision as to territorial limits and the 200-mile zone. This is having its effect on some fishing nations with old traditions. Their dependence on the oceans is thereby coming into clear perspective and partly also explains why fisheries development in HW is becoming so strongly geared toward exportation.

## The Antarctic

Much attention has been directed to the huge untapped waters around the Antarctic continent. So far fish stocks have turned out to be rather small. Besides, they are also predominantly living at great depths, difficult to reach with traditional gear. Soviet fishing vessels introduced large scale fishing to these regions, in particular off the surrounding islands. Antarctic cod (*Notothenia rossi*) was the leading catch, 400 tmt in 1970, never attained again, which might indicate the biological fragility of these stocks, presumably due to slow and irregular growth.

Soviet, Japanese, West German, Chilean and other fleets have been and are involved in probing and marshalling the Antarctic krill resources. This species is now more abundant than ever due to the annihilation or at any rate heavy reduction of their chief predators, various whales. It is no surprise that it is technically feasible to process the krill into good human food. Some krill products, frozen like shrimp and various types of paste, have reached the Soviet and Japanese retail markets. Popular writings have glowingly described the immense potential of this protein source as the "globe's largest remaining food reserve" Catch prospects in the range of 50 to 1,200 million tons a year are anticipated from a total stock variously estimated at 1 to 5 billion tons. I need not tell you that these waters are some of the most rugged on earth. But far more important is the fact that they are very distant from any concentrations of humans. Krill is costly to catch, to process, and to distribute. But it is quite typical that it is persistently looked upon as a future bonanza for the well-to-do world ; the only section of the human family that could possibly afford to pay such expenses. The many billions that live much closer to this source and might demand their share are entirely forgotten. Krill will be priced out of their reach. It is therefore quite telling as well as understandable that krill more and more frequently is described as an invaluable feed concentrate for the livestock of the affluent world.

## The Energy Crunch

Many seem to get satisfaction from the mounting prices of seafood, frequently compensating for dropping catches. Yet subsidies have become a main feature of ocean fisheries in most Western countries. The key factor pushing costs upwards is energy, peaking in long distance fishing. Each ton of gutted fish brought into port in the UK requires one ton of oil. One ton of shrimp climbs to 10 to 12 tons of oil. This is easy

to grasp when it is reported that the *average* distance ocean fish travels to reach the daily food plate of a Soviet citizen is given as in excess of 5,000 km. In the drive to "economize" the amount of discarded catches has climbed. An additional factor is the growth in the sweeping range of the persistently larger trawlers. It is therefore not uncommon that nine-tenths of a catch is thrown overboard in the name of efficiency—in turn affecting the ultimate price.

One category of long distance fishing is the pursuit of pelagic species as, e.g., the tuna. Another quite different category are the forays to distant fishing grounds such as the rich waters of the NE of North America, the Bay of Guinea, off West Africa along SE Africa as well as the waters of the Northern Pacific Arch and now in its new phase of eyeing the vast expanses around the myriads of Pacific islands.

## POLLUTION OF INLAND WATERS

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Zoological Survey of India, Calcutta

Man has altered the natural environment of streams, rivers and lakes since time immemorial either directly by throwing his refuse or indirectly by clearing the forests, burning and cultivating which ultimately lead to the alteration of Inland waters. The problem was not severe as long as the population was primitive and small and needs were limited as natural purification of streams took place without causing any significant effect on fauna and flora. However, the problem become noticeable after civilization, increase in population and diversification of human activities. The coming of industrial and technological revolution resulting in the demand of luxuries and concentration in urban centres have added up greatly to the problem. Increased use of rivers and lakes has been made for the disposal of wastes from industries and urban centres. This resulted in the pollution of inland waters in the acute form in which it exists today in many parts of the world. Fig. 1 shows how the problem of aquatic pollution of inland waters came into existence.

India has its own specific problems. To meet the pressure of the population increase, more and more industries have to be established, more food has to be produced with the help of fertilizers and pesticides. Further, the population pressure is more on urban centres where it increased by 65 millions between 1941 and 1971. The concentration of economic activities and population in some large cities have resulted in further agglomeration of these centres. Calcutta and Bombay alone contribute about 40% of the large industries.

### Uses of Water

The fundamental importance of water for life on earth needs little justification. Indeed modern industrial development and public amenities would scarcely be possible without an adequate supply of water of right degree of purity ( Klein, 1962 ). The water is used for the drinking, washing and other domestic uses, in industries, for agriculture, navigation, fisheries, recreational purposes and indeed for the disposal of wastewaters. Fox (1951) has estimated that the average consumption of water taken over the whole

world for drinking, washing and other domestic purposes is about 10-15 gallons per person per day which varies from 100 g/p/d in some industrial cities of U. S. A. to 5 g/p/d in places where water carriage system and sanitation are non-existent. Choudhury (1977) stated that out of  $1900 \times 10^9$  cubic meters of water available in India,  $1092 \times 10^9$  cubic meters are utilized. The bulk (78.5%) is used by agricultural sector which at present causes not much pollution due to low fertilizer and pesticide input as compared to advanced countries. The important consumers of water which cause

**HOW THE PROBLEM OF AQUATIC POLLUTION  
CAME INTO EXISTENCE**

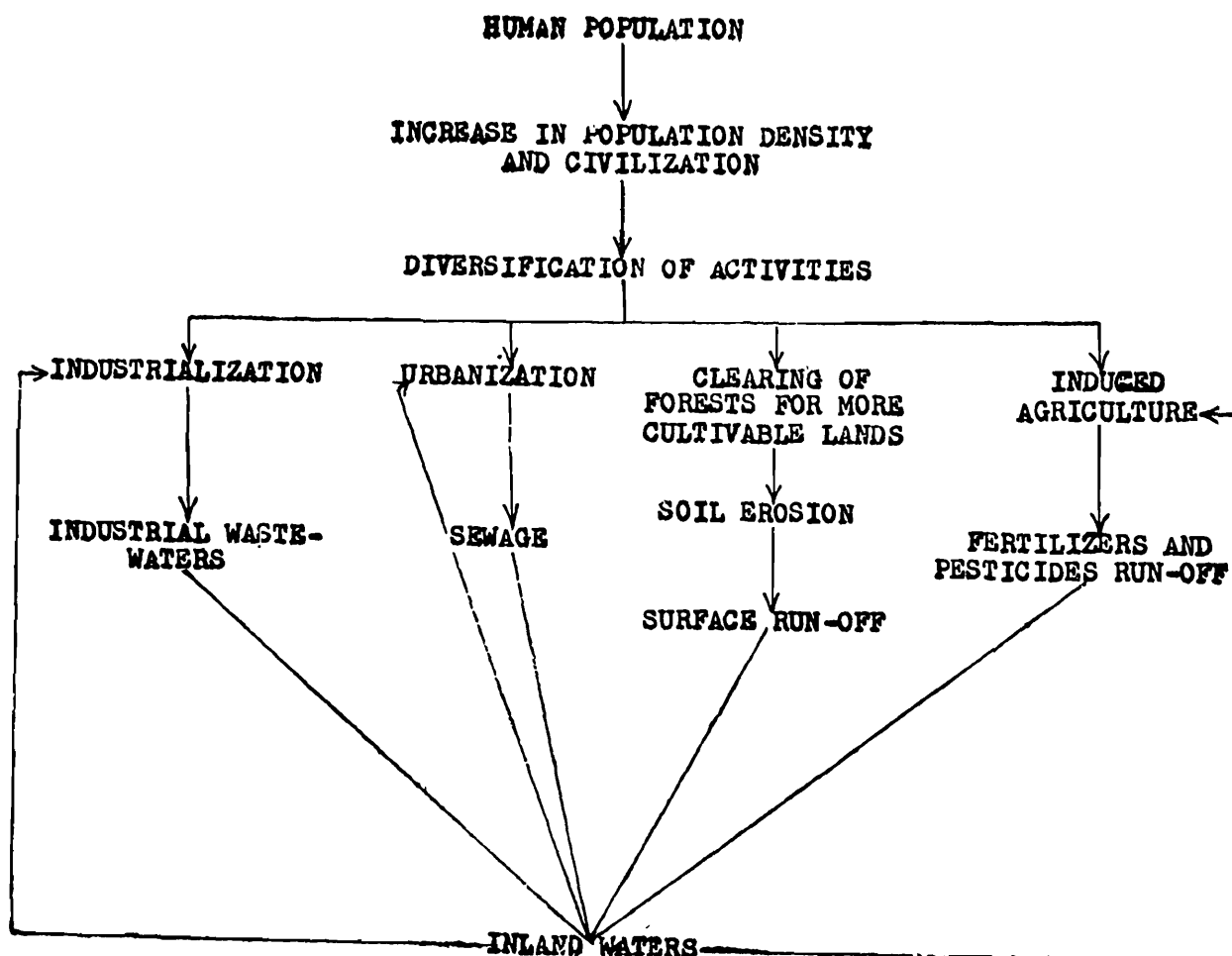


Fig. 1.

pollution of inland waters are thermal power plants (14.8%), industrial (3.2%) and domestic (3.5%) sectors, which use very little of the water drawn and discharge a large amount alongwith all their wastes' into the inland water system. For example industries which draw  $35 \times 10^9$  cubic meters of water, consumes  $10 \times 10^9$  cubic meters and discharge  $25 \times 10^9$  cubic meters as a highly polluted water. Similarly, power plants which discharge  $145 \times 10^9$  cubic meters of hot water out of  $150 \times 10^9$  cubic meters drawn and domestic sector which discharges  $30 \times 10^9$  cubic meters out of

$38 \times 10^9$  cubic meters drawn cause pollution of the inland waters in which they are discharged. An idea of the water required by various industries to produce their goods can be had from the following figures.

<b>Industries</b>	<b>Water requirements</b>
Paper and pulp	50,00-100,000 gal/ton of product
Tannaries	1800 gal/ton of hide
Rayon	220,000 gal/ton of yarn
Cotton dyeing	30,000 gal/ton of goods
Distillaries	10-15 gal/lit of alcohol
Sugar	2,000 gal/ton of sugar
Steel	50,000 gal/ton
Coke	3,000 gal/ton
Coal washery	100 gal/ton
Thermal power plants	888 million gal/MW of electricity

Water used by various sectors requires a certain degree of purity. For example, there is a WHO as well as Indian Standard for drinking water which must be of high degree of purity, free from toxic substance and pathogenic bacteria, low in suspended solids, salt contents and coliform counts with unobjectionable taste and odour. The water for agriculture should be low in salt contents, oil and grease and almost free from pathogenic bacteria and protozoa, ammonia, phenol, cyanides and other toxic substances and of moderate pH (5.5-9.0) as per IS : 3307. Ellis (1937) has worked out a quality standard of water for maintaining good fisheries which should be low in toxic substances, specially salts of heavy metals, pesticides, ammonia, phenol, cyanides and free carbon-di-oxide and of moderate pH (6.7-8.6) and dissolved oxygen ( 5 ppm ). Various industries require water of varying nature and varying degree of purity but generally low in turbidity, iron and manganese and free from undesirable colour and of moderate pH.

### **Causes of Pollution**

The aquatic pollution which has been defined as the act of making water physically or chemically impure, foul or filthy injurious to aquatic biota, livestock, wild life and public health, may be caused by human being either directly or indirectly. There are some natural factors also causing certain degree of pollution. Among direct causes, the discharge of crude or partially treated sewage into inland waters produces the commonest type of pollution. Choudhary (1977) stated that there are 142 class I cities in India and except few of them, which have partial treatment plants, most of the cities, including some big cities ( Surber, 1967 ), discharge crude

wastes directly into the rivers. Sunderesan (1977) has estimated that out of some 3000 urban centres discharging their wastes, 9 big centres alone having population more than one million, discharge major portion of total wastewaters. Based on his data, it has been estimated that about 14422.7 million liter per day are generated by these 3000 centers, out of which 3670 mld are generated by these 9 centres alone. This gives an idea of the extent of pollution of the rivers passing these regions. In Hooghly near Calcutta alone 177 million gallons (805.3 mld) of domestic wastes are discharged daily (Ray and Ghosh, 1976).

Industrial wastes also cause acute pollution in some of the rivers passing through heavily industrialized belts. The most important industrial polluters are, paper and pulp mills, textile and synthetic fibre mills of all types, tannaries, sugar mills and distillaries, Rubber, chemical, fertilizer and pesticide factories and mining, metallurgical and quarrying operations, specially coal washeries etc. There are about 115 paper mills in the country, producing 850,000 tons of paper per annum (Anon 1976), which cause maximum pollution. In Hooghly alone 6 paper and pulp mills discharge 39.29 million gallons of wastes per day which is more than 50% of the total industrial discharge (77.35 mgd). (Ray & Ghosh 1976). There are 276 sugar mills crushing 0.25 million tones of cane per day and 105 distillaries producing 500-600 millions liters of alcohol per day (Anon 1977). These mills cause severe organic pollution of some of the rivers of U. P., Bihar, West Bengal, Maharashtra, Tamil Nadu and Andhra. A large number of Industries, specially those of chemicals, rayon and pesticides, pollute river Kalu near Bombay up to the extent that pH of the river is about 2 which has caused havoc to all forms of life. In Damodar valley, particularly near Sindri and Durgapur, a large number of mining and metallurgical industries, specially coal washeries and a fertilizer factory, cause serious pollution of the river Damodar. In Delhi, a pesticide factory discharge has caused serious fish mortality in Yamuna river. Other important polluted rivers of the country are, Kulti near Calcutta, Son near Dehri-on-Son, Ganga at Barauni and Kanpur, Gomti at Lucknow, Kali near Bulandshahar, Mahi near Baroda, Cavery near Mettur dam, Godavari at Rajmundri, Bhadra at Bhadravati, Chaliar near Calicut etc. Some lakes and reservoirs like Hussain sager in Hyderabad, Mani Ram Tal in Gorakhpur and a part of Rehand reservoir are also polluted due to Industrial wastes. The large amount of hot water discharged by thermal power plants also causes considerable degree of thermal pollution in several rivers. They also discharge a large amount of fly ash. Waste waters from mining tips also contribute significantly.

A recent survey conducted by the author, in order to assess the effects on fauna and flora, revealed that river Damodar near Sindri, where on of the biggest fertilizer factory of the country discharges its wastes, is heavily polluted by toxic substances. No animal could survive up to 2 Km. below the outfall and even after that the recovery was nominal. Important fishes are almost absent even after 15 Km. In another stretch, near Chasnala Coal Washery, the suspended solid load was as high as 10,000 ppm with almost nil dissolved oxygen. Here also, in heavily affected zone, no animal were found. River Son, near Dehri-on-Son, where Rohtas Industries Ltd. discharges a variety of effluents resulting from paper and pulp, chemicals, vanaspati, cement and iron etc, is another example of serious aquatic pollution. The factory discharges its wastes through a nullah in the form of a fast running stream of effluents with huge quantity of foam. 20 Km stretch below the outfall was surveyed and not much faunal recovery was noted. The stretch has created a barrier in the river for the migration and breeding of fishes. Kanpur has excelled in defacing sacred Ganga. The river near this heavily industrialized and populated city is so organically polluted by crude sewage and tannary wastes that, at places, water is actually rotting and stinking. In a portion of Rehand reservoir in Mirzapur, where Kanoria Chemicals discharge their effluents, fish mortality has been noticed.

Among indirect causes of pollution are pesticide and fertilizer run-off from agricultural fields, which goes both, to running as well as stagnant water bodies, and pesticide drainage from urban centres, where they are used by sanitary authorities to control vectors of pathogen. Natural calamities like drought and flood also exaggerate the severity of pollution. Drought brings less amount of water for dilution while flood brings some not to be discharged wastes into the system. Deforestation, unplanned land management and construction on rivers result in undesirable soil erosion and silting of the bottom.

### **Nature of Pollution**

The extremely common type of pollution is organic, which is due to the presence of protein, fats, carbohydrates, soaps, resins, coal, oil and toxic organic substances like phenol, tar, cyanides, pesticides and detergents. The inorganic pollution is due mainly to corrosive substances like alkalis, acids, toxic salts of heavy metal, free chlorine and ammonia etc. Suspended solids from a number of sources and hot water from thermal plants cause important type of physical pollution. The physiological and microbiological nature, which is simply a manifestation of organic or inorganic nature, may

affect the taste and odour and may increase the bacterial content and pathogenicity of water.

### Effects of Pollution

Pollution affects in many ways. It alters the natural quality of the water in which effluents are discharged, bringing drastic changes which in turn affect the biota like plants, plankton, bottom fauna and fishes. It also affects the wildlife and livestock and after all public health.

For the purpose of the study of the effects of pollution, various pollutants have tentatively been divided into four main categories following Hynes (1960). Poisons, suspended solids, organic matters and hot water. One principal, seems to be common for all type of pollution, is that, the load decreases steadily as the river flows downstream away from the point of origin, because of the processes of neutralization, precipitation, absorption, oxidation or simple dilution. Poisons drastically alter the pH by increasing or decreasing acidity or alkalinity or contaminate the water with poisons. Suspended solids increase the turbidity and cause silting of the bed. Fermentable organic matters decomposed by bacterial action, use all oxygen and cause deoxygenation. This results in high biochemical oxygen demand load in heavily polluted zones and production of ammonia and hydrogen sulphide following anaerobic conditions. The organic matters cause a series of environmental changes which succeed one another in a complex manner as one proceeds downstream because of gradual increase in oxygen uptake (Hynes, 1960).

The effects of organic matter on lakes, ponds and reservoirs are also important as they cause eutrophication of these water bodies. Though eutrophication is a natural phenomenon, it is greatly enhanced by pollution. The addition of extra nutrient salts, released by the breakdown of organic matters, increases the fertility which results in high primary productivity and dense algal and some zooplankton growth making water unsuitable for important fishes and other uses. As lakes proceed towards eutrophication from oligotrophic condition, there is a gradual change in fish fauna. Due to considerable decay, the lake is filled up and ultimately the basin turns into plain land.

Heat greatly enhances the pollution results of other sources, increases the toxicity of the poisons, increases the rate of oxidation of organic matters and deepens the oxygen sag. Further it decreases the oxygen uptake capacity of the water.

### **Effects on Plankton and Bottom Fauna**

The smaller aquatic organisms, specially phytoplankton, zooplankton and bottom fauna are considerably affected by all types of pollution and individuals of each species can tolerate certain degree of pollution and if more is administered they die. The limit of the degree of pollution of any type, which any species can tolerate, is known as its tolerance limit and it varies greatly from species to species and from one type of pollution to other. Different kind of communities with different numerical abundance are present in various zones of pollution. As the river flows downstream, away from the source and gets gradually purified, more and more species of the normal ecosystem appear and finally when the water gets its natural quality, normal biota of the stream reestablish. Toxic substances either completely eliminate or drastically reduce the number of species near the outfall. Suspended matters reduce the penetration of light and primary productivity leading to impoverishment of fauna. When settled on the bed, they fill the interstitial space and smoothen all algae and rooted vegetation depriving cryptic and attached fauna. Surviving species are those building and borrowing ones like chironomids and oligochaetes. In case of organic matters, normal biotic communities are replaced by specialized pollution biota in heavily affected zone. Bacteria and sewage fungi flourish in affected zone, algae appear in abundance in slightly recovered zone and clean water fauna appear gradually further downstream. While intense heat may be lethal to many organisms, moderate heat increases the biological activity.

On the basis of varied responses of organisms to different kind of pollution the following main biological effects emerged. (Hynes, 1960).

1. Simple elimination of some species accompanied by a corresponding increase of those who remain due to abundant food supply and lack of competition.
2. Replacement of normal aquatic community by an other which is adopted to the peculiar ecological conditions.

### *Effects on fishes*

Fishes are the most sensitive inhabitants of inland waters. They are affected by pollution both, directly and indirectly. The direct effect is either lethal or chronic. Many pollutants kill the fishes either by impairing their ability to obtain oxygen (Salts of lead, zinc, mercury etc. and alkalies and acids) or by entering into the body and affecting the tissue specially blood and nervous system (Cyanides, ammonia, hydrogen sulphide and insecticides etc.) or by reducing the oxygen supply of the environment

(deoxygenation) and causing asphyxiation (sewage, organic substances, temperature etc.) (Jones, 1964). The chronic effects or long term disorders resulting from pollution include decrease in food consumption, growth rate, fecundity and hatching and survival rates. Indirect effects include the depletion of food material like plankton and bottom fauna and destruction of breeding ground due to deposition of solid pollutants on the river bed. Many polluted stretches of rivers are reported to prevent migratory fishes to pass from polluted areas, thus hampering the normal biology of fishes.

#### *Effects on wildlife and livestock*

Pesticides like DDT, Endrin, Aldrin, Dieldrin etc which come into natural waters from agricultural field drainages, have been reported to affect the wildlife specially the fish eating birds. The decline in the population of some important bird species have been related to this factor. These pesticides have more significant effects due to their quality of accumulation in the fatty tissues of the body and transmitting to young ones either through yolk or milk. The thinning of egg shells, poor hatchability, increased embryonic death, behavioural abnormalities and feather loss in some birds have been attributed to pesticides by various workers (Catibog, 1977). The effects on livestock are some-what of similar nature.

#### *Effects on human beings*

Many serious disease causing viruses, like that of jaundice and poliomyelitis; bacteria like that of cholera, typhoid, food poisoning and bacillary dysentery; protozoa like *Entamoeba histolytica* and many disease causing nematodes, flourish in polluted waters and transmitted directly from such waters to human beings.

#### **Assesments of Water Pollution**

Various methods have been evolved to monitor the type and intensity of pollution in rivers. Parameters for physicochemical methods are suspended solids, chemical oxygen demand, dissolved oxygen, pH and determination of the amount of toxic substances present in the water which is a tedious procedure and can not be easily applied. Most of the chemical methods only give the condition at the time of sampling (Cook, 1976) and detection of actual factor causing effects on river fauna and flora may not be obtained by routine analysis.

The physiological method or biochemical oxygen demand test, which has been in practice since long time is a reliable indicator of water quality,

specially in case of pollution caused by organic matters. This test depends upon the fact that when organic matters are added to rivers, they are immediately attacked by the bacteria which break these down to simple substances and in doing so they consume oxygen, lowering the concentration and increasing the demand.

### **Biological Assesments**

The changes in the composition of stream fauna and flora resulting from the effects of pollution, as already discussed, have been used as a guide in assessing the degree and the type of pollution of the streams. Here tolerance limits of various species have been given consideration as their absence, presence or density can indicate the load and nature of pollution. These organisms have been termed as biological indicators of water pollution. Kolkwitz and Marson (1908, 1909) evolved a procedure of biological assessment of pollution based on these organisms. In spite of much criticisms and modifications, the method which is known as saprobic system still hold good. They postulated that when a river receives heavy load of pollution, the normal process of self purification would result in a series of zones of decreasing severity. They divided the river into Polysaprobic (heavily polluted.), a-Mesosaprobic (moderately polluted), b-Mesosaprobic (polluted) and oligosaprobic (clean water) zones. They listed a large number of animals and plants said to be the characteristics of each zone, which has been modified by many later workers. Quantitative approach has also been made to assess the pollution where the structure of the community and abundance of various organisms have been given due consideration. The concept of community diversity index has been applied. It is based on the theory that natural communities are composed of relatively few species which are common and many more which are rare, while in case of altered (polluted) environment, species diversity is low.

The other test is based on the lethal effects of various pollutants to animals and plants of the stream, known as bioassay test, carried out in laboratory by exposing test animals to varying concentration of pollutants and either lethal concentration at which all animals die or  $LC_{50}$  or  $TL_m$  (mean tolerance limit, the concentration of substances tested at which 50% of the test organisms die) over a given period of time are worked out.

### *Microbiological assessment*

The load of organic pollution can also be monitored by the density of coliform bacteria in water which is expressed as most probable number

(MPN) per 100 ml. The density can give the comparative strength of organic pollution at various places. The pathogenic bacteria have also been taken as indicator of pollution.

### **Treatment of Wastewaters**

Various types of wastewaters can be treated so as to reduce the pollution effects. Both, physicochemical and biological methods of treatment have been evolved. The physicochemical methods are chiefly based on principles of physics and chemistry e. g. settling and screening of suspended solids, mechanical removal of oil by skimming and chemical treatments like neutralization of alkalies and acids and precipitation and recovery of important substances. The latter method has gained much importance in India where we can not afford to destroy the raw materials. Several methods of commercial recovery have been developed and practiced by many industries, which is called as waste recycling.

Biological treatment of wastewaters specially sewage and other organic pollution has been in practice for many years. This method is simply an acceleration of the process of natural self purification. Under specialized conditions, the aerobic and anaerobic bacteria decompose quickly the organic matter and reduce BOD load. In case of anaerobic treatment, sewage is stored in a close container and it putrefies. First all D. O. is consumed by aerobic bacteria and then attacked by anaerobic bacteria which breaks the complex organic matters into simple substances. The aerobic method is most common and it is carried out in three different ways, trickling filter, activated sludge, and waste stabilization pond or oxidation pond. The waste stabilization pond which is based on the natural solar energy is most suitable and economical specially in tropical countries like India where temperature and light conditions are optimum throughout the year, which are required for the photosynthesis, the basis of this system. Sewage is stored in open tanks where bacterial decomposition takes place consuming oxygen. At the same time algae produce oxygen by photosynthesis, providing sufficient oxygen for bacterial action. The carbon di-oxide liberated by these bacteria is used by algae for photosynthesis. Thus in the presence of sufficient oxygen bacterial action is accelerated and at the same time the primary productivity rate is also very high leading to good growth of algae and zooplankton. This method of treatment has been used economically for a variety of purposes specially aquaculture and irrigation. Good fishery yield, specially of major carps, has been reported which is about 11545 kg/ha/year. (Sundersan 1977). The water from the oxidation pond is run into primary and secondary fish ponds and then to agricultural fields.

### **Status of Pollution Control Measures**

Prevention and control of pollution have been a concern of civilized man for long time. Many kings, philosophers and religious leaders in earlier days laid great emphasis on the control of pollution of rivers. However, this treatment or what we may call as safe disposal of wastes, has never been done satisfactorily, whatever the law of the religion or land was because of great difficulty and extra expenditure.

In modern India, with the rapid increase in population and industrialization, the importance and urgency of the safe disposal of wastes into inland waters have been realized and a bill dealing with the prevention and control of pollution has been enacted in 1974 and certain standards have been laid down. The present approved system is that, all wastewaters should be treated so as to meet the standard by each industry and municipality individually before they are discharged into the streams. However, as expected, this standard is not at all met with. Industrialists and municipal authorities have their own drawbacks and limitations. It has been estimated that to meet the standard in Calcutta metropolitan district alone, rupees 15,000 million are required, which is quite a huge sum (Nath and Dasgupta, 1977). Nath and Dasgupta (1977) have suggested that pollution control should be taken as joint Government industry where govt. should build the centralized plant for a big district with capital investment and running cost must be realized from the user. However, these are still in a preliminary stage and we have to watch what happens during coming years.

### **Suggestions for Pollution Control**

Various measures have been suggested for the abatement of pollution which are summarized below :

1. Strict enforcement of pollution control law.
2. Cheap and easily practicable methods of treatment should be evolved and installed without delay.
3. Check on further agglomeration of already heavily industrialized centres.
4. The choice of the location of a new industry using huge quantity of water should be determined by detailed consideration of downstream effects, specially during low flow period.
5. No haphazard development and construction work. Before taming any river and regulating its course and discharge, every possible

aspects of its effects downstream should be taken into consideration. Such projects may be examined by a team of experts consisting of engineers, hydrologists and aquatic ecologists.

6. Check on direct discharge of sewage and dumping of garbage in ponds and reservoirs.
7. Detail research in various fields of aquatic pollution from biological viewpoint. Safe concentration of various toxic substances, and the load of deoxygenation which our important fauna can sustain without significant effects, should be worked out.
8. Search for a better system of pollution monitoring by combining physicochemical and biological methods keeping in view the conditions in our rivers and streams.

### Acknowledgements

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## PATHOGENIC PROTOZOA OF MAN AND ANIMALS

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It is usual for all Zoologists to divide the entire animal kingdom into two great sub-kingdoms, the Protozoa and the Metazoa.

The Protozoa, are with few exceptions microscopic or almost microscopic animals, whose very existence is unknown to the average lay person.

Over 15,000 species of Protozoa have so far been described, but it is probable that there are thousands more which are not yet known to Science.

**Physiology :** In their physiology and manner of life the Protozoa differ among themselves almost as much as do the metazoa.

Some ingest solid food through a cystome or wrap themselves around the food, others possess chlorophyll and are nourished in a typical plant manner, and still others absorb nutriment by osmosis from the fluids or tissues in which they live.

Most free-living Protozoa are aerobic, using free oxygen in their respiration, but some, like certain bacteria, are anaerobic.

**Parasitism and host specificity :** It is very likely that parasitism among the Protozoan arose in the begining by the ingestion by animals of free-living forms. Such parasitism would be expected to occur first in cold-blooded aquatic animals and subsequently to extend to warm-blooded land animals. It is significant that most of the common genera of intestinal Protozoa of man i.e. *Entamoeba*, *Chilomastix*, *Trichomonas* and *Giardia* have representatives in the Amphibia.

Many of the blood Protozoa have undoubtedly arisen by a process only slightly more complicated.

The specificity of Protozan parasites for particular hosts is a much disputed question. The striking similiarity between such parasites as the various amebas, *Trichomonas* and *Chilomastix* in different species of mammals, together with the fact that nearly all the species from man are

transferable to rats and other animal, throws grave doubt on the idea of fairly strict host specificity which has been advanced by some protozoologists.

Blood and tissue parasites, in general show more host specificity than intestinal parasites, but even among these there is much variation. The human malaria parasites are strictly confined to primates, but the malaria

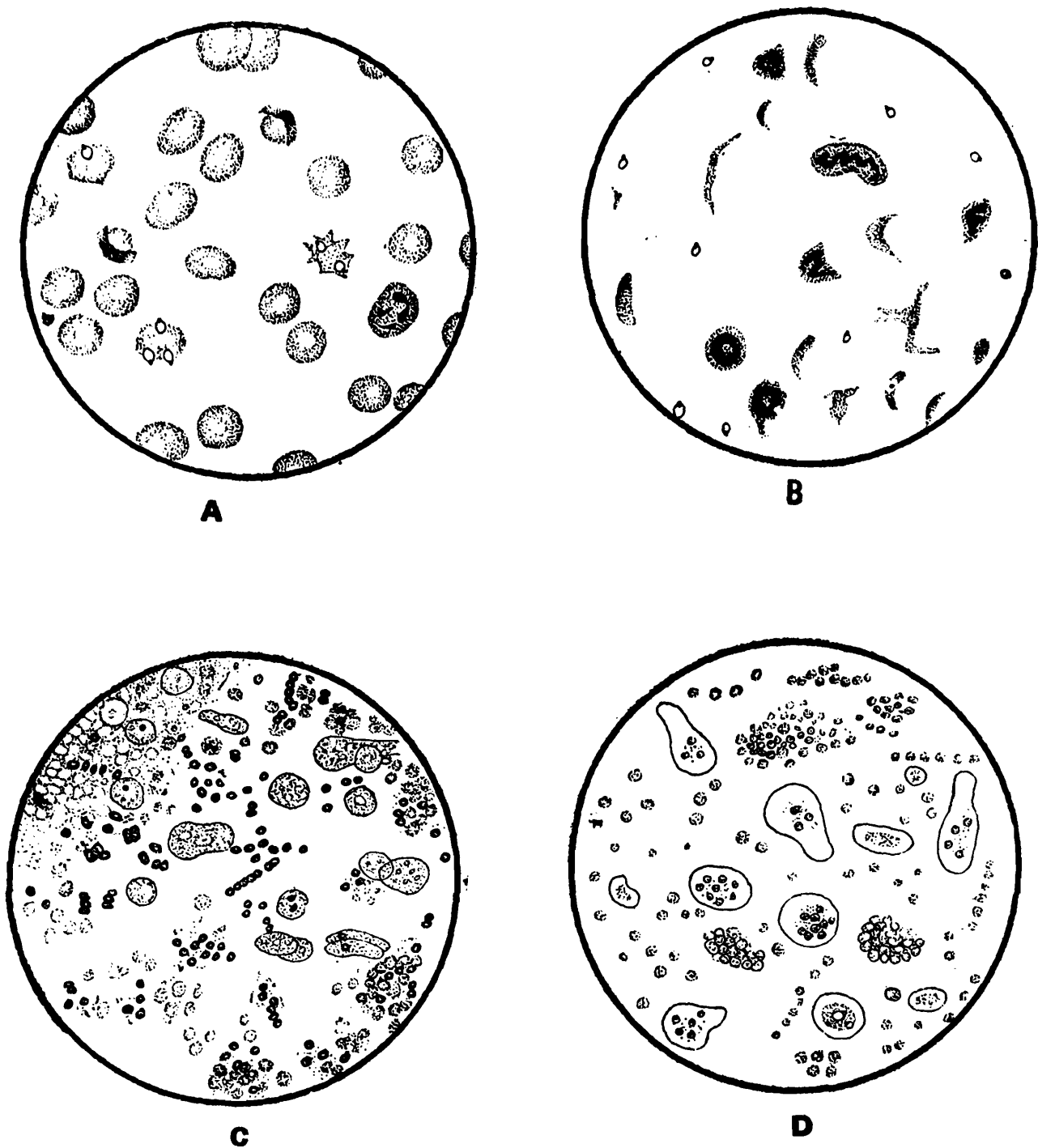


Fig. 1. A & B—Malarial Parasites in thin ( A ) and thick ( B ) smears of peripheral blood.  
C & D—Fresh stool of amoebic dysentery under the microscope. Vegetative *E. histolytica*  
( C and D ) are seen with pseudopodia.

parasites of birds show much less specificity. The question of host specificity is important from an epidemiological stand point, since it involves the question of the extent to which other animals may act as reservoirs for human parasites.

Under the phylum Protozoa are four sub-phyla : (1) Mastigophora (the flagellates) (2) Sarcodina (to which the amebas belong) (3) Sporozoa (which usually have spores or spore like stages and all of which are parasitic) and (4) Ciliophora (the Ciliates).

Most of the Protozoa in all the sub-phyla, except Sporozoa, are free-living, but each contains many parasites of man and animals and plants.

Sub-phylum **Mastigophora** : Very important parasitic flagellates of man and domestic animal includes this group. The best-known within it is the *Histomonas meleagridis*. This flagellate uses another parasite, the caecal nematode worm, as an intermediate host. The parasite usually lives in the liver of poultry, causing infectious enterohepatitis, but it may also infect the caeca, kidney or spleen. The bird's head turns almost black colour—hence the common name of the disease is 'black head' No protective cyst is formed, so when the parasite is eliminated from the host's body with faeces, it soon dies. Black head is one of the most serious disease of turkeys.

The most important parasitic flagellates of man and of domestic animals are trypanosomes. Trypanosomes are usually found in body fluids of vertebrates especially in the blood plasma. Trypanosomes, however, may occur in any body organ and some have a preference for certain organs like the heart. Some species, especially *Trypanosoma congolense*, occur in practically all domestic animals, others like *Trypanosoma lewisi* in rats only. The trypanosomas of man are *Trypanosoma cruzi*, *Trypanosoma rangeli*, *Trypanosoma gambiense* and *Trypanosoma rhodesiense*. *Trypanosoma gambiense* is one of the causative agents of human sleeping sickness. The *Gambian* or chronic form of sleeping sickness primarily involves the nervous system of Man. As the nervous system is invaded by the parasites, the symptoms include weakness, apathy, headache and definite signs of 'sleeping sickness' A patient readily falls asleep at almost any time. Coma, emaciation and often death complete the course of the disease, which may last for several years. Tryparsamide, Suramin, Pentamidine, Pratamidine and Diamindine compounds are effective in treatment, especially during the early stages of the disease.

*Trypanosoma rhodesiense* is closely related to *Trypanosoma gambiense*.

*Trypanosoma rhodesiense* causes the Rhodesian or acute and more rapid type of human sleeping sickness which usually results in death within a year. The incidence of infection is less and the parasite is restricted to a limited area of South-east Africa

*Trypanosoma brucei* causes 'nagana' in live stock and is widely distributed in Africa in dog, sheep, goats, horses and camel. As the parasites spread throughout the body, host reaction is shown by anaemia, fever, nervous symptoms, blindness, paralysis and in horses, death.

*Trypanosoma cruzi* causes South American trypanosomiasis which is found mainly in Central and South America. In some parts of the South-West United States, wood rat nests are inhabited by triatomid bugs which are parasitized with *Trypanosoma cruzi*, and the disease in man has been reported a few times from this country. As the parasites invade various organs of the body, enlargements of the spleen, lymph nodes and liver occur, with headaches, fever, anaemia and prostration. The heart may also be affected. *Trypanosoma evansi* is another serious parasite of horses and camels in which it causes the disease known as 'Surra' This can be found in dogs, in which host the disease is often fatal, and in donkeys, cattle and elephants. It is wide-spread throughout Asia and in parts of Africa and America. The principal vector is the 'horsefly' but other flies also mechanically transmit the flagellate.

*Trypanosoma equinum* in South and Central America attacks horses, causing a disease known as 'Mal de Caderas'. The parasite may also infect elephants, laboratory animals and a South American rodent called a 'capybara'.

*Trypanosoma equiperdum* causes a disease in horses known as 'dourine'. It is transmitted during the mating activity of horses, and thus is a venereal disease.

*Trypanosoma lewisi* is a common blood parasite of rats throughout the world.

*Trypanosoma theileri* is a large blood parasite of cattle.

*Trypanosoma melophagium* is a common blood parasite of sheep in England.

*Trypanosoma vivax* is an active blood parasite of practically all domestic animals of Africa, the West Indies and parts of Central and South America.

*Trypanosoma congolense* is short flagellate without a free anterior flagellum. Usually the infection is serious in cattle in which it causes anaemia with some strains, is almost always fatal. The parasite may also be found in horses, sheep, goats and camels.

*Leishmania* is another very important parasitic flagellates of man and animals.

*Leishmania tropica* causes a serious cutaneous and mucutaneous disease of man in the warmer countries of the world. The name of the commonest variety of lesion is 'Oriental Sore' although the technical name for all types of pathogenic effects caused by *Leishmania* is leishmaniasis. Dogs and other animals may also become infected. The parasites live in the reticuloendothelial cells of the skin. Sandflies bite man and thus pick up the parasites. Treatment for 'Oriental Sore' is usually successful with various antimony compounds.

*Leishmania donovani* causes human visceral leishmaniasis whose symptoms are numerous, depending on the organ or organs infected. Usually the spleen is enormously enlarged in advanced cases. Often headache, fever, weakness and high mortality accompany the infection. The common name of the disease is 'Kala-azar' Visceral leishmaniasis appears in three phases: (1) the Indian variety, which affects mainly human adults and does not occur in dogs; (2) the Mediterranean variety which affects children as well as adults and occurs also in Middle Asia, China, Central and South America and occur in dogs; (3) the Sudanese variety which appears mainly in human adults but does not occur in dogs. Dogs are definitely reservoirs of infection in the Mediterranean form of visceral leishmaniasis. In Middle Asia jackals also serve as reservoirs of infection. Loss of hair on dogs is characteristic of a severe case of visceral leishmaniasis, and ulcers on the lips and eyelids frequently occur. Anaemia, weakness and enlargement of liver are common symptoms. Positive diagnosis relies on discovery of the parasite in infected organs, in skin lesions or in peripheral blood. Antimony compounds are usually effective in treatment.

*Giardia lamblia*, a well known parasitic flagellate, is a universal and common inhabitant of the intestine of man. It is present in at least 10 percent of the people of U. S. A. and is usually harmless, but in rare instances it is pathogenic. *Giardia* have also been reported from many other animals.

*Hexamita meleagridis* flagellate, causing the disease is also known as hexamitiasis and is characterized by diarrhoea, nervousness, loss of weight and death, especially in younger birds. Aureomycin is used in treatment with success.

*Trichomonas hominis* is one of the three trichomonads which parasitize man. It lives in the intestine and caecum of man and is frequently associated with pathogenic conditions.

*Trichomonas vaginalis* is the largest of the three trichomonads of man. The parasite undoubtedly is transferred from one host to another through sexual intercourse. *Trichomonas vaginalis* is world-wide in distribution and the incidence of infection in women usually varies from 20 to 40 per cent, whereas in man it varies from 4 to 15 per cent. In women with abnormal vaginal secretions, the incidence of infection may be as high as 70 per cent. In this leukorrhoeic discharge the flagellates can be found in abundance. As with the other species, no cysts are produced. An antiprotozoal treatment is effective against this flagellate.

*Trichomonas gallinarum* causes avian trichomoniasis in chickens, turkeys and in other domestic birds. It lives in the lower intestine of the birds and is the cause of diarrhoea, loss of appetite and weight.

*Trichomonas gallinae* is a similar parasite which infects the upper intestinal tract of poultry, especially of pigeons.

Sub-phylum Sarcodina : Well known parasitic amebas of man and domestic animal includes this group. Most of the amebas of man are not pathogenic, but one, *Entamoeba histolytica*, causes 'Amoebic dysentery' in tropical and temperate countries.

*Entamoeba histolytica* is probably the best known parasitic amoeba of man, which may not be confined to the intestine. Once a lesion is made in the intestinal wall, the amebas have an opportunity to travel through the body by way of the blood stream or lymph vessels, and to invade any other tissue. In fact, they have been found in almost all other soft tissue, but the commonest locus of extra-intestinal infection is the liver, particularly the right lobe. Here the infection may be mild, or a large abscess may develop. Abscesses may also occur in the skin, lungs, or brain.

Infection is caused by the ingestion of cysts. Viable cysts gain entry into the hosts through contaminated food, water and by flies feeding on cyst containing faeces.

Treatment of intestinal amoebiasis is usually effective with carbasone, erythromycin, oxytetracycline or paromomycin. Many other drugs have been used with varying degrees of success. Extraintestinal amoebiasis is probably best treated with emetine hydrochloride or with the chloroquine phosphate. The pathology of amoebiasis varies a great deal. Only a small percent of carriers show symptoms, among which are abdominal pains, nausea, vomiting, mild fever, diarrhoea, blood and mucus in faeces. Serious infections involve ulceration of the colon, appendicitis, abscess of the liver and rarely abscess of the brain. Another, more common, amoeba found in the human intestine is the non-pathogenic *Entamoeba coli*. The organism has a world-wide distribution and the incidence of infection varies greatly. Monkeys also share with us of this parasite, rats seem to be free from it. One amoeba which frequently available in a class room is the mouth form, *Entamoeba gingivalis*. The amoeba lives in the gingival areas of man and monkeys, and can be gathered by gentle probing around bases of the teeth with a toothpick. The incidence of infection is high, probably around 50 percent, but organisms are found more frequently associated with diseased conditions than with healthy mouths.

**Sub-phylum Sporozoa :** Minute protozoa that produce spores, or comparable stages in their life cycles, belong to this group. A motile sporozoite is the characteristic infective stage but it may enter the host within a spore.

Coccidians are intracellular parasites of this group, occur in vertebrates and invertebrates. The protozoa enter epithelial cells and may cause considerable damage. Their distribution is world-wide. The effect of coccidial infection varies widely with the species of host, species of coccidia, age and resistance of host, degree of infection and many other factors.

The symptoms of coccidiosis may include weakness, nervousness, poor appetite, diarrhoea and loss of weight or poor gains in weight in calves, which might be seen in most animals with heavy infections.

Coccidia are found abundantly in domestic and in wild birds. The parasites cause a serious disease in chickens, geese and turkeys. Coccidia which can be found in chickens and turkeys infect mainly the small intestine but they may also be found in other parts of the gut. In a bird with heavy infection the intestine may be enlarged and thickened, droppings may be bloody, greenish, brownish or watery. Birds may be obviously ill, and many of them die. Treatment is reasonably successful with nitrofurazone, sulfaquinoxaline, nicarbazin or nitrophenide. Clean, uncrowded,

dry living areas for poultry, as for mammals, are of great importance in prevention and control.

*Isospora hcmnis* is the one species of coccidia found in man. This protozoa has been found in man in the Mediterranean area, the Balkan countries, India, the Far East, Hawaii, Mexico, Cuba and South America.

Symptoms include abdominal pain, diarrhoea, digestive disturbances, abdominal cramps, loss of appetite, loss of weight, and fever.

The *Plasmodium* is the best known sporozoa, which is having a tremendous significance to man, because it causes the disease *malaria* but many other animals may also become infected with *Plasmodium*, among them being monkeys, rats, birds and lizards. In man there are three common species of *Plasmodium* : *Plasmodium vivax*, *Plasmodium malariae* and *Plasmodium falciparum*. A fourth species, *Plasmodium ovale*, is quite rare. These plasmodia are world-wide in distribution, occurring largely in the warmer countries but they may be found in areas which are freezing cold during the winter, such as North Korea, Manchuria, Southern Russia and a small part of Central United States. Hundreds of millions of people become infected with plasmodia each year and at least two millions still die of malaria. The life cycle of *plasmodium* starts with a zygote in the stomach of a female mosquito. When a mosquito bites man at this stage of the life cycle, malarial infection may start. It is reported that racial differences appear in relation to malarial infection. Africans, for example, often do not show any symptom with malarial parasites in their blood. Indonesians, however, usually show symptoms even with a few malarial parasites in their blood. It has been suggested that haemoglobin S may be related to the ability of the host to withstand plasmodia. This haemoglobin is present among the Africans. Treatment for malaria is usually successful with quinine containing compounds.

An analysis of the status of malaria today shows that, the disease is finally under control in most areas of the world, or at least the prospects for control are encouraging.

Sub-phylum Ciliophora : Protozoa, which move by means of hair-like projections of the cytoplasm, called cilia, each of which is much like a little flagellum in appearance. *Balantidium coli* is the only ciliate parasite of man, excluding occasional coprozoic species. It is practically world-wide in distribution, lives in the large intestine, and is definitely pathogenic, causing the disease *balantidiasis*.

It may also be found in monkeys. When cysts are ingested through contaminated food they excyst in the host intestine and released ciliates begin to feed on cell fragments, starch grains, faecal material and other organic matter. Often they invade the mucosa and submucosa of the large intestine of caecum, causing ulceration. Symptoms of infection include diarrhoea, abdominal pain, dysentery, nausea, vomiting, weakness and loss of weight. Treatment is reasonably effective with carbarsone, aureomycin or tetracycline.

### **Acknowledgement**

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## THE GOLDEN LANGUR (*PRESBYTIS GEEI* KHAJURIA)

H. KHAJURIA

The discovery of a large mammal is now an extreme rarity ; but that of a large, common, diurnal, arboreal and conspicuously coloured one from a locality near which well planned intensive collections have been made by experienced collectors from leading taxonomic institutions and which is also often visited by naturalists may be considered as nothing short of a sensation. The discovery of golden langur as late as 1955-56 from Goalpara District, Assam, thus generated great interest not only among specialists but also among naturalists and general public. This note embodies a brief review of the information so far available on the species.

### History of discovery

The earliest published and confirmed record of sighting of the species is Pemberton ( 1838, p. 74 ) wherein it is mentioned that one Mr. Griffith saw white monkeys near Tongso in Central Bhutan. That these monkeys were really golden langurs was confirmed by Saha ( MS ), who actually collected the specimens from the locality. Another early published record which has come to notice is Inglis *et al*, 1919 ( quoted by Gee, 1964 ) which states "Pithecus sp ? —A pale yellow coloured langur is common in the adjoining district of Goalpara ( Assam ). Jerdon reported one from the Terai, the adjacent district on the ( west ) side, which Blanford suggested might be *P. entellus*. Recently we have heard of another observed in the Terai." It may be mentioned that Jerdon and Blanford worked in India from 1835-1872 and 1855-1888 respectively and this record, therefore, probably refers to the period between 1855 to 1872. Gee ( 1961 ) states that E. O. Shebbeare ( 1907 ) also reports about the occurrence of the langur but does not give the reference.

There are also several unpublished notings at least dating back to 1947 in the visitors book at Forest Range office, Raimona, Goalpara District, Assam regarding occurrence of this monkey in the nearby forests.

However, no special interest was shown by zoologists in these sightings because these records may possibly be confused with albinistic individuals of Capped Langur or Entellus Langur. The late Shri E. P. Gee, a renowned

wild life conservationist and naturalist, taking note of these records, visited the area in November, 1953 and was able to take a cine film which he showed to specialists in India and England. Dr. S. L. Hora, the then Director, Zoological Survey of India, very kindly permitted the author, then working on the taxonomy of Primates, for collection of these specimens. Six specimens were collected by the author in collaboration with Shri R. Fernandez, a departmental taxidermist, near Jamduar, Goalpara District, Assam and on through examination it was found that the Primate belongs to a new species which was named after Shri Gee, in recognition of his services to the cause of Indian Wildlife (Khajuria, 1956).

However, an unfortunate event occurred because the specific name was published a few weeks earlier by Shri Gee (1955) and caused considerable taxonomic controversy which has now happily been cleared.

**Morphology :—**The important distinguishing characters as compared with the allied species, the capped langur, *Presbytis pileatus* Blyth, are given in Table—I and are sufficient to show that the taxon deserves full specific rank. However, there are still a few doubts to be cleared whether it occurs with *P. pileatus* in any part of its range. The point is of no great moment taxonomically as there are several allopatric species.

Table—I. Important distinguishing characters of *Presbytis geei* and *Presbytis pileatus*.

<i>Presbytis geei</i>	<i>Presbytis pileatus</i>
1. Newly born white	1. Newly born golden red.
2. Hair on the crown not forming a mat.	2. Hair on the crown forming a mat.
3. Hair on the temples not shorter than that on the crown.	3. Hair on the temples shorter than that on the crown.
4. Marked seasonal colour changes.	4. Slight or no seasonal colour change, as far as known.
5. An ill-defined half-whorl on forehead.	5. No whorl on forehead.
6. Crown and distal part of tail much paler than adjoining parts.	6. Crown and distal part of tail are much darker than adjoining parts.
7. Brachial index similar to that of subgenus <i>Presbytis</i> .	7. Brachial index similar to that of the subgenus <i>Trachypithecus</i> .
8. Generally silent and timid in demeanour.	8. Generally noisy and aggressive in demeanour.
9. Glans obliquely truncated in front, oval in cross-section and with deep excision on postero-ventral border in one adult studied.	9. Glans without characters given under <i>P. geei</i> in two adults of nominate subspecies studied.

Special mention may be made of its one of the most remarkable character, *i. e.*, the colour from which the species takes its common name, the Golden Langur. The winter pelage is highly erythristic on several parts producing a general "golden red" effect in bright sun light. Some adult males appear redder. In summer the colour becomes generally white or



**Fig. 1.** The adult female golden langur suckling its young in captivity.

creamy white. The newly born young can be described as typically white but may also be effected by erythrisms. The species appears more closely related to the capped langur, *P. (Trachypithecus pileatus)* but also retains some characters of the possibly ancestral subgenus *Presbytis* such as typically white colour of infant, ill-defined half whorl on the forehead and some osteometric data.

**Distribution :** Within Indian limits between rivers Sankosh and Manas as far south as Raimona Range, Golapara District, Assam but apparently distributed widely in Bhutan.

**Habitat :** Mixed deciduous or semideciduous semimoist sal forest with occasional riverine and savanah forest, Khajuria (1977) has already discussed adaptations to this type of habitat. Mukherjee and Saha (1974) have given weather data at Raimona and Jamduar.

**Food :** Tender parts of *Terminalia belerica*, *T crenulata*, *Bombax ceilia*, *Acacia*, *Bauhina*, *Ficus*, *Cedrela toona*, *Lannea grandis*, *Albizzia lebbek*, *Bischofia javanica*, *Gmelina arborea*, *Oroxylum indicum*, *Salmalia malabarica*, *Dillera pentagyna*, *Careya arbores*, some *Leguminosae*. *Castanopris tribuloides*, *Dalbergia sissoo*. *Acacia* sp., *Darris* sp. *Amoora wallichii*, *Truwia nudiflora*. *Cardamum aromaticum* and other trees. It may come down to drink and is known to take salt earth (Gee, 1961).

**Reproduction :** Breeding season appears to be prolonged from autumn to spring. A single young one is apparently born at birth. More than half of females have been found to be with young.

**Population Study :** In India the total area inhabited by the langur is about 600 Sq. km. (Mukherjee and Saha, 1974) but a large portion of this area is under cultivation and human dwellings. Gee (1961) estimated the total population in India as 540 langurs. Observations made at Jamduar, Raimona and Manas between January and June show that troupe size varies from about 7-20 with mean value varying from 9.2 to 12.5. Home range is about 1 to 1.5 km. A unisexual troupe was seen. The composition of ten troupes containing about 120 individuals is 16.9% males, 39.2% females, 20.8% juveniles, 24.0% infants. The mean number of males in a group is about 1.2.

**Management :** The species is apparently consumed as food by some local people. Prevention of poaching is, therefore, necessary to increase its population. To meet this the water shortage in dry season at least in some parts of its range, provision of artificial water holes is necessary. A study

of food preference should be made and the need met by suitable plantation. A well managed sanctuary, Manas, which is also under Tiger Project exists in a part of its range.

**Miscellaneous :** The importance given to the species by the public can be judged by the fact that its photograph was selected for exhibition on first page of Air India Calendar, 1978. Because of its docility and exquisite beauty, it can make an excellent pet. It is apparently doing well in zoological gardens. Although capable of vocalization in a number ways, it is generally a silent animal. The tiger, the common leopard, and clouded leopard are its potential predators. Other general habits appear somewhat similar to other langur. Other important references dealing with original information on the species are : Achard (1961), Biswas (1969), Chakrabarty (1975), Ghosh and Biswas (1975), Hill (1959), Mukherjee (In press), Oboussier and Maydell (1959), Warye (1968).

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## ROLE OF SOIL FAUNA IN THE FERTILITY OF THE SOIL

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“The soil is the placenta of life” as quoted by Farb (1959) is indeed a complement to the soil given by scientist. Although the soil did not give birth to the teeming world of organisms, it is the incubator for the living world. A handful of soil contains millions of organisms ranging from the ultra microscopic to the gigantic size e. g. virus, bacteria, protozoa, nematode, mite, earthworm etc.

It was a general belief that manures, composts, dead animal bodies all increased the fertility of the land. So the common proverb among people was “Corruption is the mother of vegetation” Ancient workers tried to investigate the phenomenon of Soil fertility and plant growth. Water was considered to be the principal source of nourishment for plants and soil in turn was considered to be the medium through which they could get nourishment. Later on J. R. Glauber advocated the hypothesis that salt-petre addition could increase the fertility of the soil and so would enhance the production of vegetation. Further work on different parametres revealed that soil fertility is more complex problem than was previously thought of. The properties of soil depend on its nature, origin, climate, vegetation and other factors to which it is connected.

Vegetation and plant growth is a complex chemical problem as considered by chemists. The biological process of soil organisms all in a food chain drew attraction of the scientists. E. J. Russel and H. B. Hutchinson at Rothamsted showed that bacteria alone is not responsible in the turn over of the soil fertility but a variety of soil organisms play an integrated role to increase the fertility of the soil.

The soil fauna can be divided in to three groups according to their size, the microfauna consists of protozoa, bacteria etc ; the meso or meiofauna are mites, springtails, rotifers, nematodes which live in the air space of the soil and other small insects. The larger soil fauna or the macro

fauna includes the earthworms, gastropods, millipeds, centipeds and few mammals.

The food supply is a criterion to determine the size of the population of a particular group of animal in the normal soil. The food primarily consists of dead plant tissue along with living plants and soil microflora. There is a group of population which feed on the excreta of the primary population and other which is feeding on the population itself. According to the mode of feeding they can be classified as saprophagous, phytophagous, coprophagous and predaceous.

To start with the microfauna soil protozoans and bacteria generally from a predator / prey relationship. Bacteria from the major food supply of the protozoan population though algae, yeasts, flagellates and amoebae are also ingested. It has been observed that all bacteria can not serve as food for protozoa ( Singh, 1941 ).

Thus the protozoa has a selective influence on the composition of the bacterial population in the soil. The effect of protozoa can not be overruled in the fertility of the soil. It is generally believed that the presence of plenty of organic matter in the field soil will favour an extensive development of bacteria which in their turn will be accompanied by an abundant development of holozoic protozoa. The rise and fall in the numbers of active amoebae in the whole are inversely related to that of bacterial numbers. This indicated that amoebae, which are feeding on bacteria are probably the cause of the fluctuations in bacterial numbers. It has also been observed that the presence of protozoa increased the fixation of nitrogen by *Azotobacter* ( Bhattacharya and De, 1978 ).

The atmospheric nitrogen is also fixed by another symbiotic bacteria of the genus *Rhizobium* with the plants of the Leguminosae. The symbiotic bacteria is able to fix more quantity of atmospheric nitrogen than the free living organisms. The annual fixation of nitrogen of all legumes average between 80 to 100 pounds per acre per year.

Nematodes are nonsegmented worms with thin spindle shaped body. According to the feeding habit the nematodes are classified as herbivores feeding on diatoms or other algae, fungi or on higher plants, some are carnivores feeding on nematodes, olegochaetes, rotifers etc and the third group feeding on the decomposing organic matter, plant or animal. Some of the fungal feeders such as *Aphelenchus avenae* prefers the fungi which attacks the plant roots such as *Fusarium* spp., *Rhizoctonia solani* and

*Armillaria mellea* which in turn take part in the decomposition of the plant root and increase the organic matter of the soil. The nematodes play a very minor role in the fertility of the soil.

The soil inhabiting mites vary from about 0.1 to 1 mm in size and are present in very considerable number of different genus and species. The different species of mites are very specific in their food requirements but usually the mites as a whole feed on the decomposing plant remains and micro-organisms. The collembola are minute wingless insect with a size between 0.5 to 2 mm. The collembolans are less specific in their food requirement and less in number than the mites. The extensive studies on the collembola and mites population have been made in forest soil. The collembola feed on decaying plant tissue, micro-organisms decomposing dead plant tissue and dead insects etc. The collembola and mites are more numerous in the F and H layers of the forest litters. These layers provide them a continuous supply of decomposing litters throughout the year and a non-waterlogging moist habitat. It has been experimentally proved that the primary organic matter after passing through the guts of several groups of animals forms the resistant humus. The formation of resistant humus from the decomposing leaf litters or dead plant roots could be as follows : at first the more resistant material is softened by fungi, then it is eaten by saprophagous animals, particularly mites, which continue the decomposition of the plant material, possibly with the aid of a microbial population in their gut ; and finally the undigested material is excreted and form the food supply for a whole chain of other animals, until it is converted to resistant humus like material. The role of saprophagous fauna in the decomposition of plant debris is not yet clearly known. But it appears probable for example, that some woodlice and millipeds can only digest the sugars, starches and accessible proteins in the plant tissues. Some termites, snails and earthworms can digest part of the cellulose and hemicellulose contained in the plant tissues, and some nematodes and mites can live symbiotically with or predaceously on, the cellulose decomposing bacteria attacking the tissues. It is also possible in many forest soil that fungal mycellium forms the transition compounds between plant and soil faunal tissues for the majority of the soil fauna appears to have no power of digesting the celluloses, hemicelluloses or lignins of the dead plant tissues ; these are attacked by fungi and converted in to their protoplasm, and it is their mycellia that forms the principal food supply of a large proportion of the mites and springtails as is shown by a study of their gut contents. This has the consequence that the soil fauna living on plant remains only oxidise a small fraction of the material they ingest, and it is probable that only rarely do they use more

than 10 percent of the energy in the food they consume. Further they differ from most soil micro-organisms in using most of this energy for their vital processes, and only converting a small fraction into their own tissues. In so far as most of these animals will probably be the primary source of food for the predatory population in the soil, little if any of the carbon they assimilate will contribute to the humus supply of the soil.

The invertebrates that have been most frequently recognised in soils include among the macrofauna enchytreid worms and earthworms, millipedes, centipedes, many insects mainly dipterous flies and beetles and a few crustacea and gastropods.

The major food of earthworms is dead or decaying plant remains including both leaf litter and dead roots, but they are normally specific about litter of different plants. During the process of feeding they mix the dead surface litter with main body of the soil and make the soil more accessible to attack by the soil micro organisms.

The earthworm plays a very important role in the formation of the humus. In addition, they help in the aerations of the soil by burrowing and making extensive channels which improve the drainage of the soil. They can also improve the fertility in irrigated soil by rapid penetration of the water through their channels from surface to subsurface layer. Moreover the earthworm helps to stabilize soil structure by making casts over it. The cast contains nitrogen and other organic matters and so they increase the plant nutrient sources in soil. The body tissue of earthworm after decomposition, increases the ammonium and nitrate content of the soil.

The other common macrofauna are the ants, termites, millipedes, centipedes, gastropods and few mammals like rats and moles. The larger soil fauna play an important role in many ways. They help the aeration and drainage of the soil through the channels and burrows. They grind up plant litter material during the process of eating and the excreta is readily accessible to soil micro organisms. The saprophytic soil fauna can have other effects on the soil. Their excreta compose the typical humus in the soil. The gut of these animals are an important site for humus formation.

The varied composition of the soil community implies that the inter-specific relations in the soil are extremely intricate. Their integrated role indirectly lead to the fertility of the soil. During the process of litter decomposition and humus formation by the soil organisms, the nitrogen in the form of ammonia is released and absorbed by the clay in the soil and

then nitrified. The soil organisms take active part in the formation of humus and this humus contain carbon, oxygen, hydrogen, nitrogen, sulphur and phosphorous in different concentration which increases the fertility of the soil and are essential for the plant growth.

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## OBSERVATIONS ON THE BHARAL AND THE GORAL IN THE HIGH HIMALAYAS

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The bare ridges, ravines and open alpine meadows in the higher domains of the Himalayas may look desolate, but they are not. A great variety of animals from tiny insects to large mammals not only exist on these dizzy heights, but are found to live and flourish against heavy odds. Some of the conspicuous physical factors that confront life at high altitudes are the extreme low temperature, high wind velocity, difficult terrain, scarcity of food and low oxygen and moisture contents of the air. The higher the zone, harsher is the life. How these animals have adapted themselves to such hostile environmental conditions constitutes an interesting and special aspect of study.

The author had the privilege of studying the habits and habitats of two bovid mammals of the high altitudes of the Himalayas, *viz.*, the Bharal and the Goral, in the course of a couple of mountaineering expeditions in which he participated in recent years. Though these two animals have been fairly well known chiefly as games, not much is known about their habits, habitats and adaptive mechanisms. This study is based on the author's personal observations. For detailed descriptions of both the Bharal and the Goral reference may be made to Prater\* (1971, pp. 252-253 and p. 263).

### The Bharal or Blue Sheep

*Pseudois nayaur* (Hodgson)

The author had his first glimpse of the Bharal in the course of an expedition to the upper reaches of Jad Ganga valley in the Garhwal Himalaya during June—July 1974, at an altitude of 3657 metres and was fascinated by its graceful appearance and movements among stupendous rocks. In another expedition in Western Garhwal during May—June 1976, several flocks of the Bharal were seen on precipitous rocky slopes (Fig. 3)

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\* Prater, S. H. 1971. The book of Indian animals. Bombay Natural History Society, Bombay.

around the Base Camp (4267 m.) on Rudugaira glacier. In the course of yet another expedition during September—October 1977, the author located a number of flocks grazing on far-flung grassy slopes around Ralam village (3657 m.) situated in the northern border of the Kumaon Himalaya.

At opportune moments, though rarely, some villagers who possess guns, kill the Bharal, chop the meat into small pieces, sun-dry and preserve them for consumption during the winter months when they are forced to stay inside their stone-huts. The skin is sun-dried too and is used as a saddle on mules' and yaks' back for warmth and comfort. The horns were seen placed in rows on top of their huts, probably for decorative purposes. Being offered by the villagers, the author had his first taste of Bharal's meat in Ralam village and found it delicious. The flesh is reddish and coated with a thick layer of fat. When cooked it becomes quite tender and without any trace of unpleasant odour. Many porters and villagers were seen relishing the sun-dried but uncooked meat.

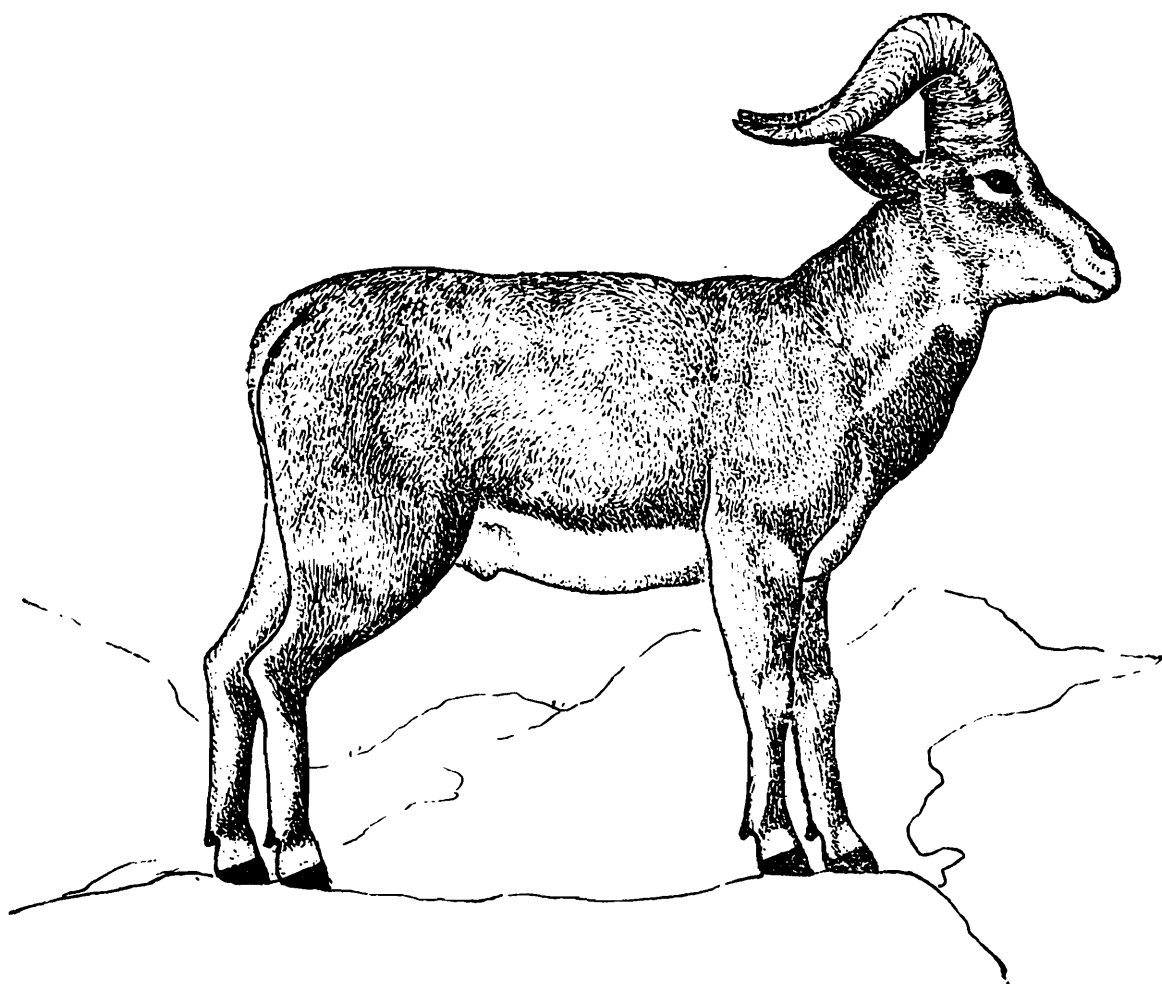


Fig. 1. The Bharal (*Pseudois nayaur*)

Though the Bharal (Fig. 1) has been considered as a wild sheep, in appearance it tends to look more like a goat. The body is coated with short,

thick and brownish fur. A black stripe runs down the front of each leg. Its body colour is reported to vary from season to season, but it always manages to blend itself perfectly with the back-drop of rocks or snow making its detection a difficult task. Compared with the female, the male is more massively built and possesses a pair of huge horns that curve down on either side of the head. The horns are reported to be used in fighting duels amongst the males during the mating season over leadership issue. However, the author had no opportunity of witnessing any such fight since his visits never coincided with the mating season. The author had come across a skull complete with horns in a rock-crag and examined it. The skull was exposed and it bore patches of coagulated blood. No other parts of the body could be traced in the vicinity. Since that spot was surrounded by dangerous rock-fall zones and the horns were intact, the possibility of its being killed by poachers was remote. It must have been eaten up by wolves or snow-leopards after being hit by a falling rock.

The Bharal was seen moving in herds of 15 to 20 individuals on an average under the leadership of a single male. The leader has tremendous sense of responsibility. Whenever others graze, it keeps watch on the surrounding terrain against possible intruders all the time standing on some protruding rock slab. Of all the senses, its eye sight seemed to be most keen. Whenever alarmed, the leader makes some sort of warning sound and the entire herd makes a quick retreat to precipitous cliffs, where no other mountain-dwelling animal can dare to venture.

Moss, lichen and other green vegetations growing on open meadows and undulating mountain slopes form its usual diet. Its feeding hours are restricted to the early hours of mornings and the cool evenings. The rest of the day is spent in chewing the cud in the shades of rock projections. It was never seen grazing under the blazing sun, but was often seen active in cloudy weather. As its feeding hours are limited and long exposure in the open pastures involves grave risk, it has developed the habit of feeding hastily and its ability to consume huge quantities of forage in relatively shorter period is unique.

Cold does not bother the Bharal. The skin is tough and has a short woolly under coat and a thick and long water-repellent outer coat which provide adequate protection against cold. Besides, before the onset of winter the under coat grows thicker and more woolly, which thins out again on the approach of summer.

Apparently, the Bharal appeared to be very lazy but at times of crisis

it was seen either leaping from one rocky ledge to another at tremendous speed or climbing steep rock surfaces with astonishing ease. In doing so it rarely misses its foot hold. The secret of its being sure-footed is that it has specialised hoofs, heeled with soft concave pads that give excellent grip on rocky surfaces.

Another interesting feature of the Bharal is that it neither hibernates nor migrates to the lower valleys during winter. Instead it continues to stay and lead an active life all through the winter with its grazing grounds lying buried under several feet of snow. On such occasions, it subsist on the extra fat accumulated during the summer months.

It was further observed that unlike the Goral it never ventures into expedition camp sites. It was also never seen sharing its own territory with any of its other close relatives of the mountain.

The much-sought after game, the Bharal has survived extinction mainly because of its habitat, which lies beyond the normal reach of poachers. The only predators from which the Bharal has to be alert are the snow-leopard [*Panthera unicia* (Schreber)] and the wolf (*Canis lupus* Linnaeus), which hunt around the same vicinity amongst stupendous rocks. The Bharal has no reason to be afraid of the snow-leopard any more since the latter is almost on the verge of extinction. The only hazard that it cannot evade is the occasional avalanche of rocks and snow with which a good number of it are carried down the gorges.

### Goral

*Nemorhaedus goral* ( Hardwicke )

In the course of yet another expedition in the central Garhwal Himalaya during September-October 1976, the author had the rare opportunity of watching several herds of the Goral from close quarters around the expedition Base camp ( 3657 m. ). The Base camp ( Fig. 4 ) was set up on a plateau full of thick grass, juniper bushes, moss, lichen and multicoloured alpine flowers. Surrounding this pasture are several rocky and snowcapped peaks with the fast flowing Thelu stream nearby. This seemed to be an ideal habitat for high altitude goats and sheep. Being utterly exhausted on arrival at the spot after a long and tedious approach march, the author retired hoping to locate some on the following morning. As soon the author struggled out of his tent at day-break, he was delighted to see a couple of Goral grazing around the tents. At first sight, it appeared

to be Bharal. However, subsequent observations confirmed that it was actually Goral. Its alertness frustrated several moves to get any close-up photographs as at each attempt, it retreated to inaccessible cliffs. On another occasion, when the team ran short of fresh meat, an imaginative porter followed a herd crawling about a thousand feet up a throny slope clutching a *Khurpi*. When he was about to strike, the watchfull male got alarmed and gave a loud 'hiss' and the entire flock fled, never to be seen again throughout the day. It seemed only next to impossible to get close to this animal without being noticed.

The smaller size, short and insignificant horns ( Present in both the sexes ) and the conspicuous white patch on the throat distinguishes the Goral ( Fig. 2 ) from all other high altitude goats, sheep and goat-antelopes.

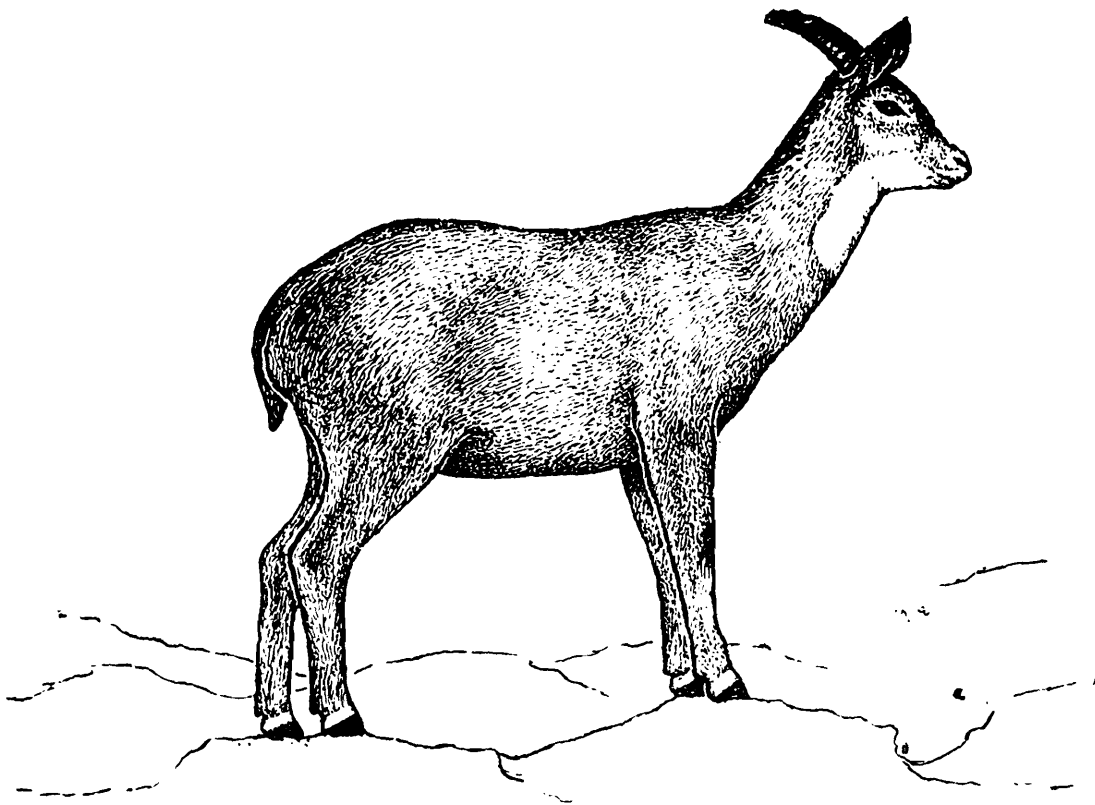


Fig. 2. The Goral ( *Nemorhaedus goral* )

The Goral was seen moving in much smaller groups than the Bharal with the male in the lead. Of all goat-antelopes, the Goral prefers altitudes ranging from 3048-4876 m., depending, of course, on the suitability of the terrain and availability of forage. While negotiating glaciers, the Goral was seen moving in a single file, one following the other. To watch it leaping from one rocky ledge to another against the white background of snow and

rocks is a real treat for the eyes. In all other matters of habits and habitats it is similar to the Bharal with the sole exception that unlike the Bharal the Goral migrates to the lower valleys, sometimes as low as 900 metres with the onset of winter.

The Goral is killed more by poachers, when it occupies the inhabited lower valleys than by predators or natural calamities. Leopards, wolves and wild dogs are its main predators.

Of all high altitude sheep and goats, the Bharal and the Goral are most common and widely distributed throughout the Himalayas. The author noted with satisfaction that when hundreds of wild animals are facing extinction due to various reasons, the Bharal and the Goral are still seen in large numbers and they do not now appear to be in danger of extinction.

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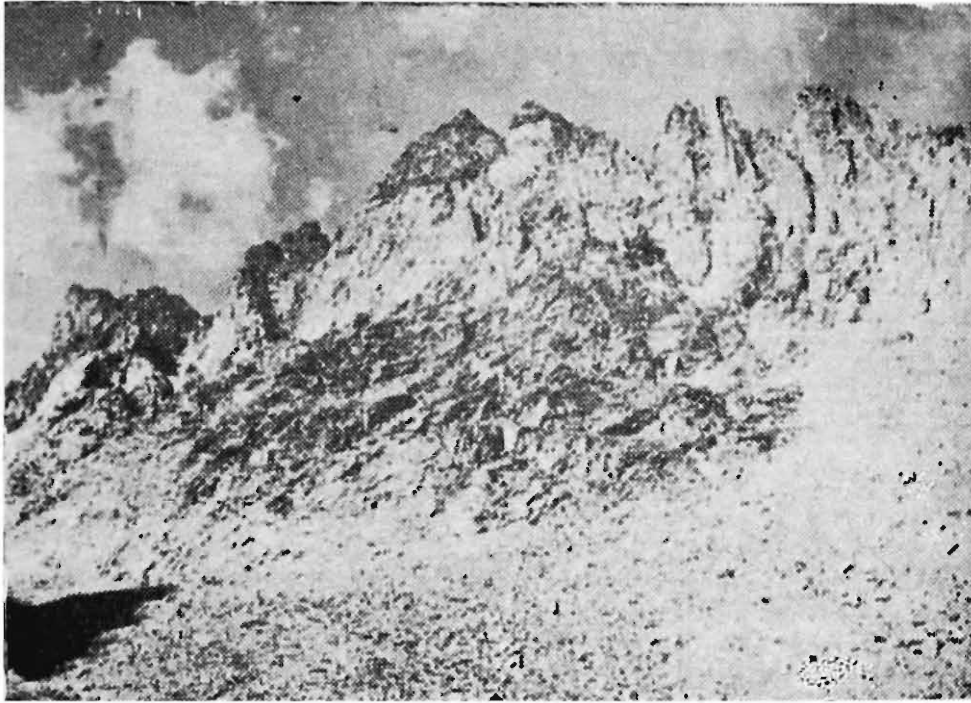


Fig. 3. Typical habitat of the Bharal ( alt. 4267 m. ) in the Garhwal Himalaya. ( Photo by author )



Fig. 4. Typical habitat of the Goral ( alt. 3657 m. ) in the Garhwal Himalaya. ( Photo by author )

## TURTLES : THEIR NATURAL HISTORY, ECONOMIC IMPORTANCE, AND CONSERVATION

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In his never ending quest for tapping hidden resources of food and commerce in nature, man has been relentlessly exploiting the seas and rivers which remain to be the vast media with inexhaustible plant and animal nutrients. The meat, soup, eggs of a turtle are a prized food throughout the world since time immemorial. So has the "tortoise shell" lured man's sense of art.

### What is a Turtle ?

Turtles ( chelonians ) are reptiles like lizards, snakes and crocodiles which we do not look down upon with much aversion. Turtle is the only reptile that has a shell and because of this characteristic "dome" designed to act as a protective armour, nobody can mistake a turtle for anything else. The turtle shell is made up of a top arched part ( carapace ) and the flat lower part ( plastron ) which are joined at each side by a bony bridge. These domed reptiles have a lineage running back to 200 million years and yet this long process of evolution had no effect on the turtle or its shell. Here is a sheer case of conservation with vengeance. Thriving in arid waterless wastes, lakes, rivers and the high seas, about 250 kinds of turtles inhabit the earth today varying greatly in size and shape from the gigantic marine forms weighing over hundreds of pounds to small species less than a pound in weight. About fifty kinds of chelonians are found in our coasts, islands and inland waters. They are included in five families— Emydidae ( Fresh-water Tortoises ), Trionychidae ( Mud Turtles ), and Dermochelidae and Chelonidae ( Marine Turtles ). They can be easily recognised by the following key based upon the external characters :

- |  |     |                     |
|--|-----|---------------------|
| 1. Limbs paddle-shaped                             | ... | 2                   |
| Limbs not paddle-shaped                            | ... | 3                   |
| 2. Limbs clawless ; shell covered with smooth skin | ... | Leather back Turtle |

3. Limbs clawed ; shell covered with horny shields	...	Sea Turtles
4. Digits with four or five claws ; shell covered with horny shields	...	4
Digits with three claws ; shell covered with smooth skin	...	Mud Turtles
5. Limbs more or less flattened ; digits webbed	...	Fresh-water Tortoises
Limbs more or less cylindrical ; digits not webbed	...	Land Tortoises

The varied usage of the word "turtle" in English language has given rise to much confusion. In proper usage "tortoise" is referred to the strictly land dwellers with elephant-like stubby feet, "turtle" for those found in seas and rivers with flippers and webbed toes and "terrapins" for the hard-shelled, edible freshwater tortoises.

Turtles are toothless but have a beak with horny sheaths provided with a cutting edge. They chew the food only to reduce it to fragments for easy swallowing. They feed on both plants and animals and like other reptiles can survive without eating for months or even years. Hearing is dull but the eye sight is fairly good. They are not very vocal creatures either except for making crying, barking and grunting sounds during mating. Though they are proverbially slow in movement, the marine turtles have developed an efficient surmming stroke. With their forefeet modified as "flippers" which are moved with an up-and-down beat similar to that of the wings of a bird in flight, sea turtles swim with a speed at 32 km an hour.

Contrary to popular belief, turtles do not live for ever but their maximum life span may be 100 years or more. One thing is certain that they live longer than any other back boned animal including man and in this respect the giant tortoises are record breakers. Atleast one tortoises in Mauritius lived from 1766 to 1918 when it was killed in an accident. Turtles can be made to learn slowly but on the whole to a casual observer they are stupid animals.

### Marine Forms

Inhabiting the tropical and sub-tropical seas of the world, the present day sea turtles are of 5 kinds—the massive Loggerhead (*Caretta*), the edible Green turtle (*Chelonia*), the Hawksbill (*Eretmochelys*), the Ridley (*Lepidochelys*), and the leatherback (*Dermochelys*). Of these, the edible Green turtle (*Chelonia mydas*) and the Hawksbill turtle (*Eretmochelys imbricata*) have gained world wide recognition because of their immediate utility.

The Green turtle is the most valuable of all living reptiles of the world because of its edible meat, soup and eggs. Though the adult is of olive or brown colour, it derives its popular name 'Green turtle' from the hue of its fat which is greenish. This turtle, widely distributed around the world, has supplemented the diet of peoples of more different cultures than has any other wild vertebrate. In western countries, various kinds of edible concoctions like candy, pickled eggs and egg butter are made out of this turtles' eggs which are claimed to be more nutritious than that of a hen.

### **Edible**

The clear turtle soup called 'Calipee' is obtained from the cartilage of the lower shell of the turtle. It is said that a 300-pound green turtle yields about six pounds of calipee. The green turtle's soup is so much relished by Germans that they gave it another name, "Suppenchildkrote" (Soup turtle).

The home of the green turtle is the Mediterranean, Atlantic, Pacific and the Indian Oceans. It is abundant in and around the Krusadai Island, Palk Bay and Tuticorin. Also plentiful in the Andamans, Nicobars and Lakshadweep, it grows upto 4 feet and may weigh 800-900 pounds which indicates its heaviness and also its helplessness when once it is caught. Though the treatment meted out to it immediately after catch is cruel, it is a necessity that it has to be put on its back soon after the catch as otherwise the heavy carapace and other internal organs exert a fatal pressure on the animal's heart and lungs causing speedy death. Alternatively they are to be kept in capacious tanks of sea water which will not be easy to come by on the coasts. The green turtle has been known to swim 300 miles in 10 days and is capable of migrating to long distances. Green turtles marked after nesting on Ascension Islands have been found feeding 1400 miles away off the coast of Brazil.

Every Sunday live turtles and their products are sold at Tuticorin, Tamilnadu. Sea turtles majority of whom are of edible kind caught in the nearby reef islands fringing the coastal line from Tuticorin to Rameswaram will be brought for slaughter and every part of the turtle is sold for a price. The blood of the green turtle is also sold which is said to be effective in curing haemorrhoids. The shell, flippers, eggs, fat, and meat are sold out or the whole animal fetches a price of about Rs. 300 to Rs. 400 depending on the size.

### **Tortoise-Shell Turtle**

The Hawksbill turtle, so called because its upper jaw resembles the bill of a bird, is another valuable chelonian. Although its flesh is not eaten, it is famous for its yields of the real "tortoise shell" (actually turtle shell) known as "carey" in trade. "Tortoise shell" is derived from the soft and flexible horny coverings of the carapace of this animal. It is said that the best tortoise shell comes from the species of the Indian Ocean. Each turtle may yield about 6 to 8 lb of this valuable product which is used in making jewellery and other objects d'art. The Japanese have been the best of all tortoise shell craftsmen. A small sized industry for the manufacture of ornamental articles like combs, buttons, small snuff boxes, cigar cases etc has developed around this turtle on the coasts of Tamilnadu, Kerala and Andhra but the tempo of the trade remains slow.

The Hawksbill, smaller than all the marine turtles, is generally found in Indian and Indo-Chinese waters.

### **Giant**

The leatherback turtle or Luth is the King of the marine reptiles because of its size, weight and rare appearance on land except as a occasional straggler or as an egg-laying female visiting the coast. It reaches a length of 7ft and weighs up to 1500 lb. It is unique in yet another feature. Unlike other turtles, the shell is covered by black leathery skin resembling the blubber of a whale instead of the usual horny shields. With its large and powerful flippers, it can swim well and is said to cruise the open seas for weeks and months. This remarkably strong and rapid swimmer is widely distributed in tropics but is scarce everywhere. It is an accidental visitor on and off the coasts of Sri Lanka and Kerala. The flesh of this giant is not edible but oil is extracted from its fat and eggs are relished. The other sea going turtles of our coasts, Olive Ridges and the Loggerheads are also not edible but their eggs are relished by fishermen in South India. Sea turtles are caught by nets or harpoons while they are in water. As they are fond of basking asleep on the coasts, they are sometimes stealthily approached in boats and then harpooned. Till recently they were caught by binding a line on to the tail of a sucker fish and getting it to stick fast to a turtle which is basking at the surface.

### **Breeding Habits**

Turtles attain sexual maturity in a surprisingly shorttime. Available data prove that the big sea turtles start breeding when they are 3-8 years

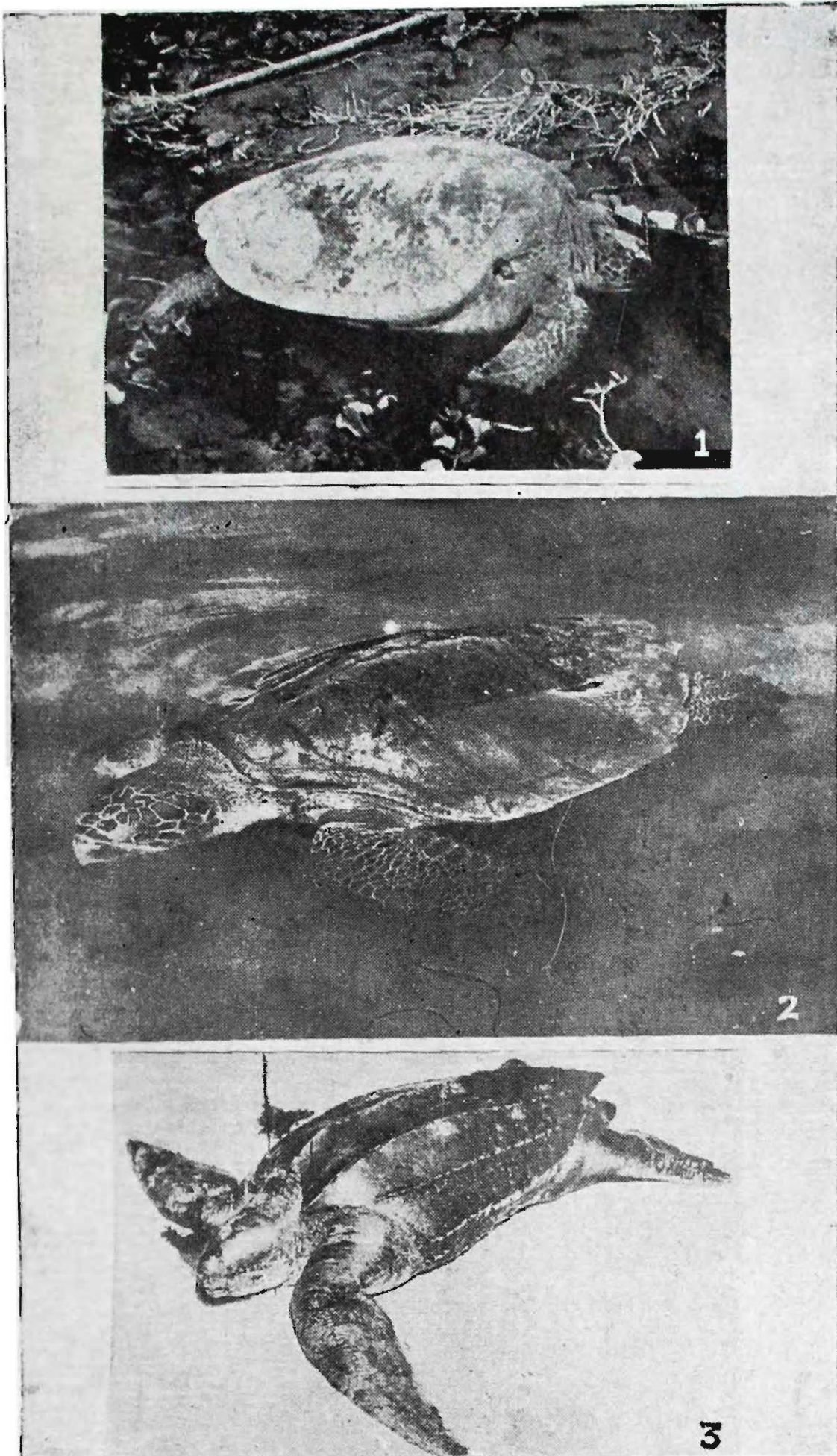


Fig. 1. The Green-turtle (*Chelonia mydas*)  
Fig. 2. The Hawksbill turtle (*Eretmochelys imbricata*)  
Fig. 3. The Leatherback turtle (*Dermochelys coriacea*)

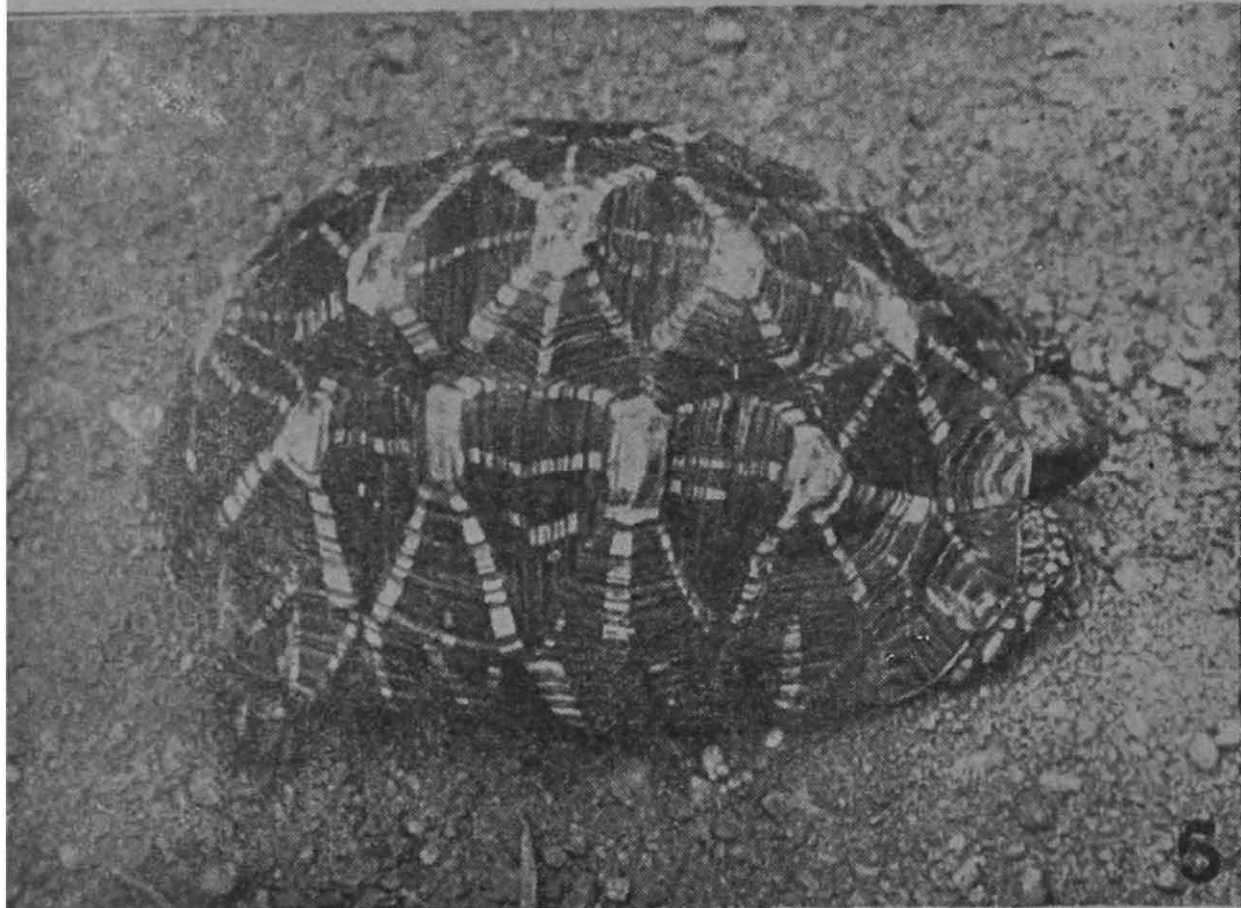
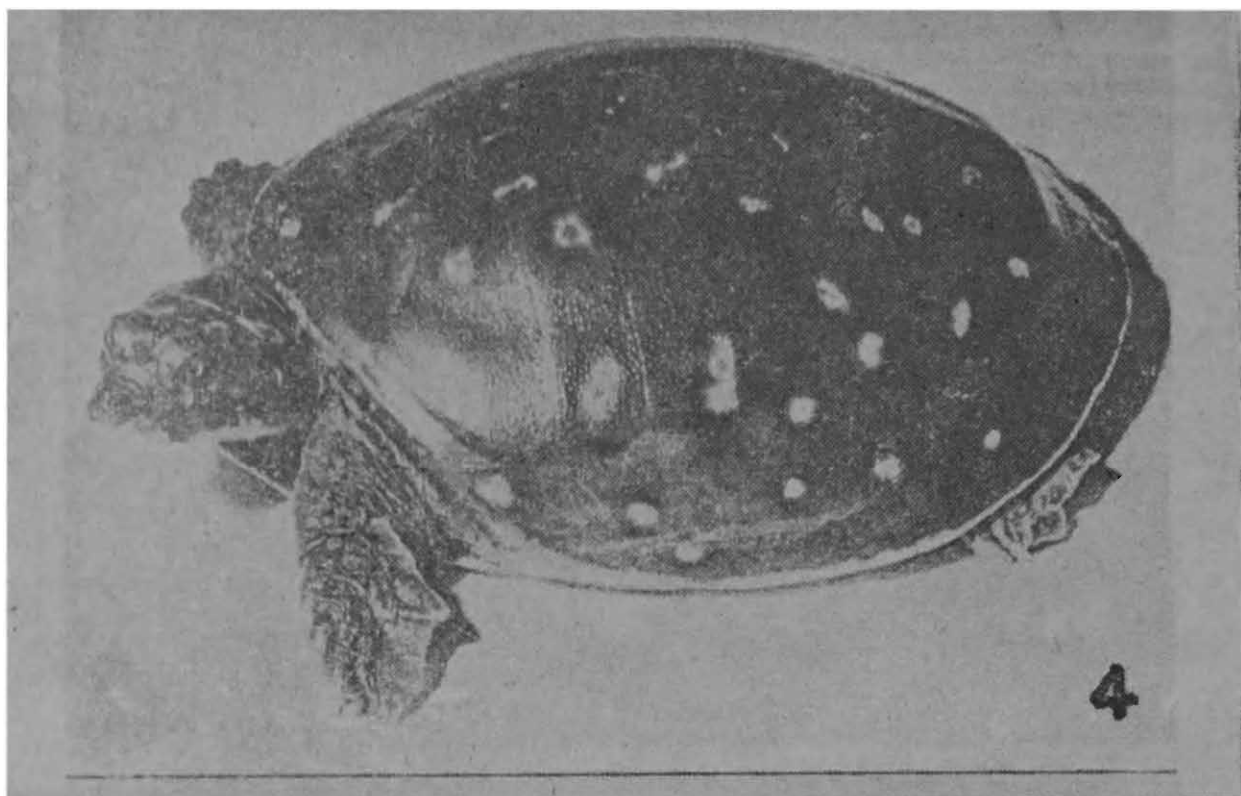


Fig. 4. Indian Flap-shell turtle ( *Lissemys punctata* )

Fig. 5. Land Tortoise ( *Testudo elegans* )

old. All turtles lay their eggs on land. Marine turtles lay many more eggs than the freshwater forms. The breeding of marine turtles makes interesting reading.

The most spectacular thing about the reproductive capacity of the turtles is that the female can store sperm cells to continue to lay fertilized eggs for several years after a single mating. The egg-laden female comes ashore at middle of night during spring and summer months to discharge its parental obligation making painful sighing noises made during the tiresome exercise of dragging its heavy weight up the high tide mark. Then it selects a sunny place and digs a hole depositing the ping-pong ball eggs in clutches, two at a time. A clutch may contain 200 eggs and the whole process of laying is over in a few hours. Thus it breeds several times a year at fortnightly intervals. The laying female takes no notice of her surroundings and goes on laying eggs like a machine set to motion. The presence of a human being or any other animal or even a blow on the shell of the turtle will have no effect. Taking advantage of this defenceless character of the female turtle, some inhabitants of tropical islands often sit at the nesting site and catch the eggs as they are extruded. However, the innocent female turtle fills the empty hole as carefully as though it contained all the eggs and then it lumbers back to the sea, stopping and emitting a great sigh on the way.

### Young

Then the period of crisis in the life of a sea turtle and its progeny starts. The turtle going up the beach to lay eggs or making journey home towards the sea are "turned" and easily captured by poachers as the egg-laden females are especially valuable from the commercial point of view as the turtle as well as its eggs fetch the poacher a good remuneration. The pity is sometimes all the turtles turned over their backs may not be upto the market requirements of the greedy hunters. Thus several turtles either perish or become a ready prey to predators hovering about them.

The numbering of eggs laid by a female sea turtle gives some clue to the extent of the hazards faced by its young. Particularly so when the mother turtle is least bothered about her nest or the tiny turtles that emerge later. The period of incubation which takes about seven to ten weeks in the warm beach sands and thereafter is a saga of terror and tragedy for the emerging young turtles called 'hatchlings'. They emerge out of the egg, scratch their way to the surface and head instinctively towards the sea probably guided by the light which is brighter over the sea. Enroute they

face a gauntlet of terror before they could reach their safe haven for they become the target of attack by sea birds, scuttling crabs, darting lizards, feral dogs, and of course the man, their arch enemy. After such a toll the fraction of the hatchlings that could thank themselves for having reached the sea fall a prey to fishes lurking in shallow waters. Yet sea turtles have persisted for millions of years. Unfortunately for them, the shell which is a most effective armour for the adult does not develop early enough to protect the hatchlings. Perhaps their potential for survival would have been quite different if turtles too, like sea snakes, delivered live young ones.

### River Species

The meat and eggs of Indian river turtles are a staple diet in our country, notably in Assam, Bengal and certain parts of Bihar. Freshwater tortoises ( Terrapins ) like *Hardella*, *Kachuga* and *Batagur* found in the Ganges and Brahmapootra river systems are excellent eating and caught in large numbers for food. Of the mud turtles, mention should be made of the Indian softshell ( *Trionyx* ) the meat of which has an excellent flavour resembling that of beef. It is sold in large numbers in Calcutta markets.

The Star Tortoise of India ( *Testudo elegans* ) found commonly in South India and Sri Lanka is well known for its attractive colour pattern and gentle disposition which makes it a desirable pet. Live Indian tortoises are exported to USA where turtles are very popular pets.

### Turtle Poison

Even the delicious meat of the greatly esteemed green sea turtle becomes a poison sometimes as the turtles often feed on poisonous algae and thus accumulates food poisoning substances in their flesh. Victims of turtle poison become violently ill and soon lapse into coma and there has been no invention of any satisfactory antidote to turtle poison so far. In a most recent outbreak ( 1961 ) of turtle poison reported from Quilon, Kerala, 18 of the victims among the 130 persons poisoned died. The best course is to avoid eating turtle meat, rotten and of a doubtful nature.

### Export

India exports turtle meat, turtle shell, turtle skin and live turtles and our main buyers are U. K., U. S. A., Germany, Switzerland, and Japan. The export figures of our edible chelonians and their products during the period 1971-74 are given in Table I.

Table I. Export figures of edible Chelonians and their products

		Q : Quantity in kgs. of product wt. V : Value in Rs. ( F. O. B. )			
Products		1974	1973	1972	1971
<b>I.</b>	<b>Turtle Meat</b>				
(a)	Japan	Q : ...	100		
		V : ...	6,550	...	...
(b)	E. Germany	Q : 811	...	...	...
		V : 30,331	...	...	...
(c)	Switzerland	Q : ...	63	...	...
		V : ...	3,300	...	...
(d)	U. K.	Q : ...	...	595	...
		V : ...	...	13,109	...
(e)	U. S. A.	Q : ...	...	...	125
		V : ...	...	...	3,681
(f)	W. Germany	Q : 980	2,304	500	2,455
		V : 19,687	69,328	10,380	69,995
	<b>Total</b>	Q : 1,791	2,467	1,095	2,580
		V : 50,018	79,178	23,489	73,676
<b>II.</b>	<b>Turtle Shell :</b>				
	France	Q : 70	...	...	...
		V : 2,100	...	...	...
<b>III.</b>	<b>Turtles</b>				
	( Green Turtle )				
	W. Germany	Q : 70	...	...	...
		V : 3,907	...	...	...
<b>IV.</b>	<b>Tortoise Shell</b>				
(a)	France	Q : ...	...	2	...
		V : ...	...	227	...
(b)	Hong Kong	Q : ...	N. A.	...	...
		V : ...	16,605	...	...
(c)	Italy	Q : ...	780	107	...
		V : ...	70,206	9,269	...
(d)	Japan	Q : 10	200	100	205
		V : 1,800	24,148	3,300	14,562
(e)	Netherlands	Q : ...	...	325	...
		V : ...	...	3,342	...
(f)	Singapore	Q : ...	214	...	...
		V : ...	3,010	...	...
(g)	Spain	Q : ...	...	202	...
		V : ...	...	1,974	...
(h)	W. Germany	Q : 53	20	40	78
		V : 9,376	1,567	1,154	4,655
	<b>Total</b>	Q : 63	1,914	776	283
		V : 11,176	1,15,536	19,266	19,217

Products		1974	1978	1972	1971
V. Tortoise Meat					
W. Germany	Q :	...	800	400	1,492
	V :	...	18,776	9,710	30,817
VI. Living Tortoise					
(a) France	Q :	...	...	N.A.	...
	V :	...	...	1,620	...
(b) Italy	Q :	...	...	N.A.	N.A.
	V :	...	...	1,243	2,635
(c) Japan	Q :	...	...	N.A.	N.A.
	V :	...	...	2,068	1,350
(d) Netherlands	Q :	17	...	...	N.A.
	V :	600	...	...	570
(e) Switzerland	Q :	18	...	...	...
	V :	498	...	...	...
(f) U.S.A.	Q :	...	...	N.A.	N.A.
	V :	...	...	281	795
(g) U.K.	Q :	...	...	...	N.A.
	V :	...	...	...	650
(h) W. Germany	Q :	145	...	N.A.	N.A.
	V :	3,779	...	5,501	2,975
Total	Q :	180	...	N.A.	N.A.
	V :	4,877	...	10,713	8,975
VII. Tortoise Belly					
(a) Japan	Q :	...	...	100	...
	V :	...	...	3,420	...
(b) Singapore	Q :	...	...	...	25
	V :	...	...	...	740
Total	Q :	...	...	100	25
	V :	...	...	3,420	740
VIII. Tortoise skin	Q :	442	...	...	...
Singapore	V :	2,240	...	...	...

Notes : 1. N.A. —Not available

2. .... —No exports

3. The figures are compiled from the daily list of exports issued by the various customshouses in India.

### Turtle Farming

The main objectives of farming turtles are to raise wild. Stocks of breeding populations of the endangered turtles in specially constructed "pens" on the coasts where turtles abound and to provide employment to the locals at the spot. Possibly a cottage industry of the culture of green

and other valuable sea turtles may be attempted initially in the Andamans and Lakshadweep which offer excellent breeding beaches and other facilities for rearing the young turtles. Now we have to perfect ways of rearing and feeding the baby turtles since survival of hatchlings is the vital factor in turtle farming. Simultaneously small scale industries in tortoise shell, turtle oil etc. can be set up.

Thanks to the I. U. C. N. sea turtles are listed as species threatened with extinction and the government of India has made them protected species. Unless the breeding beaches are properly policed, the degradation of turtles and their eggs by the beasts and human alike continue unabated. India with a coast line of over 4,000 miles and about 1,280 islands is actually aware of the need to draw maximum food yields and in this context turtle culture can offer a partial solution to the protein food shortage. We cannot afford to ignore turtles any more.



## TRENDS IN THE MANAGEMENT OF FRESH WATER BODIES FOR FISH PRODUCTION

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### Introduction

Population experts predict that the world population will be doubled in the early next century. Though in the field of Agriculture considerable progress is made in the discovery of high yield varieties, better utilization of hitherto ill used agricultural land and bringing out maximum yield with the help of fertilizers etc., it is felt that the aquatic environment which is the source of valuable proteins needs improved management for better yields making the best use of available facilities.

The main sources of food from water are fish, Crustaceans, molluscs and algae. Considerable progress has been made during the last two decades, especially in India, in increasing the exploitation of these animals in the sea by mechanizing the fishing vessels and exploring hitherto unexploited waters by going considerably inside the sea. Storage facilities have been increased by setting up ice plants, fish etc., were transported to interior areas by using the cold carriages and trucks and to some extent canning is also being done for export purposes. Of late attention is also paid to marine and brackishwater aquaculture especially for prawns. Government—both Centre and State—semigovernmental and private agencies are all involved, nowadays, making fishing a major industry in the country.

However, it is felt that freshwater bodies need more attention in countries like India. Nature of water bodies, conditions and facilities will not be uniform in all cases and hence methods have to be evolved to make the best use of a given water body for production. That is where management plays an important role. For instance, ponds can be built on land which is uneconomic or unsuitable for farming. Swamps and deserted pools can be used for fish and allied production. Similarly water reservoirs and

irrigation systems have secondary utility for fish and prawn production. In many coastal places unused mangroove swamps are good for brackish-water fishery. Building of ponds in swamp, flood areas, and irrigated fields will turn out to be profitable.

### Forms of Aquaculture

#### *Methods of Pond Rearing :*

The following methods of rearing of fish and allied food organisms are resorted to for optimum production depending on the body of water and availability of species.

*Monoculture :* Only one species of fish is reared in the pond. It is used primarily to produce fish species of a high trophic level, such as trout, eel or catfish, which feed on animal protein.

*Polyculture :* Several different species of fish are kept in the same water body thus making the maximum possible use of the natural food in the pond. Examples are Chinese and Indian species of Carp, Tilapia with Carp or with fish of prey ; milkfish with shrimps.

*Intensive rearing :* Here stocking is done heavily and are fed with high value artificial feed. Pond is specially constructed to control the water quality, if necessary purify the waste waters and water supplied with adequate oxygen. Since this type is scientifically managed, it will be costly and yield will be higher—normally possible in a departmental pond. Risks are also great due to disease or technical breakdown and a lot of management expertise is required.

*Extensive rearing :* Fish and allied forms will exclusively feed on the natural food in the pond. Stocking density and consequently the yield is low in this type of rearing. Water quality is not affected in this type of rearing. This does not require expertise and less expensive.

*Semi-intensive rearing :* Here the natural food is supplemented by such inexpensive material like animal or vegetable waste products. This is suitable for omnivorous and herbivorous fish species.

*Recycling :* Recycling of domestic and agricultural waste for fish production is the main feature here. Fish ponds manured with the excrements of duck, pig, or cattle increases primary production and hence fish production. Pollution of the environment is also reduced. Treated domestic sewage can also be used, provided care is taken to see that it is not contaminated with detergents or biocides and also that transmission of disease or parasites should not occur from fish to man.

*Fish culture in net pens and enclosures :*

Net pens and enclosures can be used for the controlled rearing of the various species of fish like carp, tilapia, trout, salmon, mullet etc. Here also intensive, semi intensive or extensive rearing methods can be used according to fish species, local conditions, profitability and the training standard of the staff. Net pens are used in coastal areas, in lakes or in rivers. Enclosures ( Bamboo fencing ) are used in shallow waters, lagoon, estuaries or bays.

*Fish culture in irrigation canals and paddy fields :*

This is an age old method. The agricultural soil is very productive. The fish used here should be able to live and produce in shallow slow running water, e. g., Tilapia, carp, Cat fish etc. They must withstand high temperature and low oxygen also. Shrimps and mussels also grow in good numbers in such waters. Care should be taken that insecticides used in the fields should not effect the fish and allied organisms.

**Factors to be taken into consideration in Aquaculture***Management aspects of Aquaculture :*

Depending on the conditions of a given region the suitable aquaculture methods should be devised for a maximum yield. The following aspects should be taken into consideration for the proper management of fresh-water bodies.

*Parasites :*

Disease and parasites should be watched otherwise the whole crop of fish ( or cultured animals ) will vanish.

From causative point of view, the different fish diseases may be classified as follows :

- (i) Parasitic infections caused by
  - (a) Fungi, (b) Bacteria, (c) Protozoa, (d) Worms, (e) Crustacea.
- (ii) Non-parasitic diseases :
  - (a) asphyxiation, ( gas disease and other asphyxiation ) (b) miscellaneous.

*Pollution :*

Pollutions like herbicides, pesticides or industrial wastes will effect the fry which are very delicate. Hence the project should be planned, fully in advance.

Pollution has the following adverse effects on the freshwater bodies and their inhabitants. (i) an increase in the osmotic pressure (ii) violent alteration of the pH of the water, all acids being lethal when pH is less than 4, (iii) oxygen can become a limiting factor when it is reduced by substances with a high oxygen demand. (iv) toxic ingredients which may injure the gills and other external structures, cause death either from anoxemia or by intake and absorption, (v) destruction of biota. The fish is affected indirectly when its habitual food organisms are destroyed. The covering of the bottom of a water body by a coating of waste matter greatly reduce the food supply of the fish. (iv) Destruction of spawning grounds, as in the case of major carps which require special environment for breeding. (vii) Mechanical injury or blocking of gills from silt or other suspended material. (viii) Blocking of migration channel, (ix) Pathogens being carried to human beings through fish cultured in polluted waters as well as imparting foul odour to fish flesh rendering it unpalatable, (x) Cumulative effect of insecticides, pesticides etc., on fish (xi) Sewage pollution, even in small quantities may change the character of our aquatic environment over a period of years. Thus, with the gradual process of aging, deep clear, oligotrophic lakes may be sedimented, becoming mesotrophic, then eutrophic and eventually turning into bogs (xii) some of the industrial pollutants acting as catalysts in the abnormal growth of undesirable plant material like water hyacinth and some phytoplanktonic organisms which use up the nutrients of the lake making other forms of life impossible in the water bodies.

Industries whose effluents contribute to the pollution are pulp and paper, textiles, tanneries, sugar, distilleries, shellac, hydrogenated vegetable oils, coal washeries, petrochemicals, drugs and chemicals etc. Domestic wastes add considerably to pollution. Pesticides used extensively in modern agriculture, spread and diffuse the hazards of pollution through drainage to freshwater bodies.

The particular product should have local market or can be exported, before selecting the site.

Beforehand planning should be done regarding rearing feeding system, methods of disease prevention, harvesting, processing and marketing.

The biology and life history of the cultured organisms as well as the chemical and biological parameters of the waters in which it is reared should be known before hand.

The following ecological, economic and social parameters should be taken into consideration before choosing the site of the projects.

*Ecological Parameters :*

The nature of the environment and the water must be clearly understood. The chemical properties of the water and daily, seasonal and annual temperature fluctuations must be examined. The salt content, the concentration of dissolved nutrients, gases and possibly existing toxic or inhibiting substances should be examined. Flow conditions and the transparency and light absorptions of the water must be measured. Water quality, pH values, buffer properties, alkalinity and hardness should be known. The geographical location of the watershed, the ground water reserve, the incoming water supply should be determined before hand.

Meteorological factors such as prevailing, wind directions, wind speeds and their various seasonal fluctuations must be studied. Daily, seasonal and annual amounts of sunshine, fluctuations in air temperature and air humidity and rainfall should be noted. Information regarding the soil, like type of soil, its porosity, fertility, colour and microorganism populations should be known.

*Biological factors :*

Primary and secondary production and total natural production available as potential food for the relevant water organisms (fishes etc.) should be ascertained. It should be determined whether there are ways of enriching the water with nutrients in order to increase the production of microorganisms.

The productivity of a water body connotes a characteristic whereby living substance is manufactured through interactions of the constituents of the natural environment. Some ecosystems like ponds and lakes are essentially self sustaining. The fundamental steps in the operations of a self contained ecosystem are (i) the reception of energy, (ii) production of organic material by producers, (iii) consumptions of this material by consumers and its further elaboration, (iv) decomposition on inorganic compounds and (v) its transformation into suitable forms for the nutrition of the producers. In a self sufficient ecosystems, all these steps are contained within it. The nonliving constituents are light energy and inorganic nutrients, both required for the growth of photosynthetic plants. The living components of the ecosystem consist of producers and consumers. Producers are the chlorophyll bearing phytoplankton, large green plants and photosynthetic bacteria, which are capable of synthesizing energycontaining organic substance through utilization of solar radiation and inorganic materials. The consumers are all other types of organisms in the community.

Consumers depend directly or indirectly upon the producers (Herbivores or other carnivores). Decomposers are the heterotrophic bacteria and fungi which reduce organic substance to their elemental state, thereby returning the nutrients into the cycle for use by producers. The plants and animals that depend successively one upon the other, form the links of a food chain. Each successive level of nourishment as represented by the links of the food chain, is known as a *trophic level*.

Three measures of productivity namely (i) standing crop, (ii) rate of removal and (iii) rate of production are in common use and form the core of the concept of productivity in an ecosystem. The standing crop is the total biomass of the organisms existing in the area at the time of observation and may be expressed as number of individuals, as biomass, as energy content etc. The measurements of standing crop can only reveal the population density of individuals in the ecosystem at a given time. Rate of removal refers to the yield of harvest from an ecosystem per unit of time. The emigrations of animals or plant life, predation of terrestrial animals, outflow of organisms through effluent streams, loss of nutrients to sediments, commercial harvesting of fish etc., are some of the ways of removal. The natural supply of materials entering the ecosystem may be augmented artificially by adding fertilizers or by stocking. In addition the degree of crowding of the desired species may be adjusted to the optimal level and the competitors of this species may be removed. The population of the species to be harvested should also be adjusted to the level of abundance at which its growth rate will be as high as possible without disturbing the equilibrium of community. Rate of production refers to the amount of organic substance synthesized in a certain space per unit of time. It involves the cycle of growth, reproduction, death and decomposition of organisms or the "turn over of nutrient energy" as it is called in an ecosystem. The energy of carbohydrate formed represents the gross plant production or the gross primary production. The accompanying catabolism of the plant is measured by the amount of respiration. Actual plant growth is represented by an amount of energy equal to the total carbohydrate formed minus the respiration and is termed as the "net primary production" The amount of plant substance produced per unit of time and space is defined as "rate of gross primary production" and the rate of net primary production represents the rate at which organic matter is stored. Both the rates of primary production, *i.e.*, gross and net, are measured on the basis of organic Carbon present in the unit of volume or beneath unit area of the pond surface and area expressed in units  $\text{mg C/m}^3/\text{day}$  or  $\text{mg C/m}^2/\text{day}$ . The word 'day' generally refers to day light hours during which gross or net photosynthesis occurs in

the surface water. The *secondary production* constitutes the energy food actually assimilated by heterotrophic organisms, such as primary, secondary and tertiary consumers and the decomposers. The rate of energy stage in these levels is called the *rate of secondary production*. The rate of production at each higher level decreases from herbivore to top carnivore.

Neutral condition of pH (6.5-7.5) is most favourable for productive pond. Acid waters (pH 5.5-6.5) and highly alkaline waters (pH > 8.5) are unproductive and pH 7.5-8.5 may be considered favourable for average production. Total alkalinity below 20 ppm, is indicative of poor production and alkalinity above 20 ppm., does not appear to influence productivity. Dissolved oxygen below 5 ppm., may be considered unfavorable for a productive fish pond. Under normal conditions, concentration of dissolved oxygen above 7 ppm., is suitable for productive water body. Values of dissolved inorganic nitrogen below 0.2 ppm. are indicative of poor production and above this value is favorable for productive ponds. Dissolved phosphate as  $P_2O_5$  < 0.05 ppm., is indicative of an unproductive fish pond, 0.05-0.20 ppm., of medium productivity and > 0.20 ppm., of very high fish productivity.

*Preparation and Management of Nursery Ponds*: Generally the mortality of spawn experienced by fish culturists is due to (i) appreciable difference in the physico-chemical conditions of water in the nursery ponds and those in the 'hapa' in which fry are temporarily kept before stocking, (ii) lack of adequate amount of the requisite kind of fish food in water, (iii) voracity of predatory fish fry that are inadvertently introduced in pond along with carp fry, (iv) predatory propensity of aquatic insects that abound in all pieces of freshwaters, (v) predatory nature of minnows and other unwanted fish which are usually present in most of the nursery ponds (iv) Cannibalism among carp fry, particularly when fry of different sizes are stocked together, (vii) sudden rise in temperature of water particularly when the water level is low, (viii) Overgrowth of phytoplankton and possible depletion of dissolved oxygen particularly during nights and supersaturation during day time and (ix) Over growth of macrovegetation and benthic algae which is generally associated with a marked paucity of plankton in water.

The steps adopted towards preparation of nurseries are (i) Control of predatory and weed fishes (ii) fertilization of ponds aimed at sustained production of Zooplankton to serve as food for spawn, (iii) Control of algal bloom and (iv) eradication of predatory insects.

The criteria for a successful fish food are (i) ready acceptability,

- (ii) easy digestibility (iii) high conversion value (iv) easy transportability  
(v) abundant availability (vi) high keeping quality and (vii) low cost.

*Preparation and management of stocking ponds* : Consideration for attaining high fish production in stocking ponds are species combination, their ratio and rate of stocking. Every pond, irrespective of in what manner it is managed, can support a fish biomass only upto a certain weight limit. This limit is called the *carrying capacity* or the *maximum standing crop*. The carrying capacity of ponds is intimately related to their natural productivity and management practices adopted, including fertilization, artificial feeding, the species stocked and their stocking rate.

*Weeds and their control* : Weed choking of a body of water severely restricts plankton production ; limits the living spaces for fish ; upsets the equilibrium of physico-chemical quantities of water ; checks oxygen circulation ; promotes accumulation of deposits leading to siltation ; provides shelter to predatory and weed fishes, molluscs and aquatic insects and obstructs netting operations. The following precautions should be taken to check weeds from establishing themselves ; (i) keeping minimum depth of water at not less than 0.5 M ; (ii) deepening of the pond edge to reduce the hazard of marginal and shallow water weed growth ; (iii) shaping and sodding of the pond edge above water level to reduce the area where marginal weeds could appear and (iv) providing a diversion ditch to carry excessive and/or muddy water around the pond.

*Sewage-fed Fisheries* : Sewage includes the combined liquid wastes discharged from all domestic and industrial sources within a given area. Raw sewage is detrimental to fish life because of its (i) high BOD and OC values (ii) low dissolved oxygen content (iii) high carbon dioxide content (iv) high ammonia and hydrogen sulphide values, (v) high bacterial load etc. Sewage waste treatment consists of mechanical, chemical and biological processes. The mechanical treatment comprises (a) use of screening and filtration devices, (b) skimming, which is applicable only to suspended matter having a relative density lower than that of the liquid part of waste and (c) sedimentation which is applicable to suspended matter having a relative density greater than that of liquid. The chemical treatment consists of coagulation or chemical precipitation, deodorization and disinfection or sterilization. The biological treatment is related to a systematic use of the natural activity of bacteria for biochemical reactions resulting in the oxidation of organic matter into carbon dioxide, water, nitrogen oxide, sulphates etc.

*Economic factors :*

It should be ascertained before hand whether there is a domestic or export market for the proposed aquatic products. Terms of trade and credit and finance facilities must be discussed. It must be ensured that land, manpower, transport and storage facilities are available in the project area and that fertilizers and food stuffs, fishing equipment, spare parts etc. can be supplied.

*Social parameters :*

It should be checked up before hand that whether the project could have a detrimental effect on the environment or whether detrimental effects might be produced by the environment. The project should not cause competition for the local fishermen and if possible the local fishermen should be incorporated into the project. Using the water for aquaculture should have no undesirable effect on navigation or land irrigation and the extent of losses expected from theft should be less.

*Choice of aquatic organisms :*

Herbivorous, filtering or detritus feeding fish, as well as shellfish are the biggest protein producers and give big yields of animal protein in a short period of time. These animals produce more when they are supplemental feed on vegetable waste products like rice bran, soya bean meal or the pulps of coffee beans or if the ponds are manured with natural or artificial fertilizer. The production of carnivorous fish and shrimp causes considerable feed costs and requires special technologies.

The following aspects should be taken into consideration while selecting the species for an aquaculture project—(i) demand for the product should come from as wide a section of the population as possible, (ii) the fish or allied animal selected for breeding should have a wide geographical distribution, (iii) the fish or allied organism selected should come low down in the food chain, (iv) the selected organisms should be able to be cultured in polyculture with other organisms, (v) the reproductive process of the cultured organism, its food requirements, food conversion rate, growth and age should be known before hand, (vi) the selected fish or allied organism should not be ordinarily susceptible to disease and not sensitive to changes in the physical or chemical properties of the water, (viii) the product could be preserved by primitive or modern methods.

Introducing a new species often reduces the number of species in the ecosystems which in turn alters nature's balance in an unforseeable way.

These changes are not easily reversed. They also spread sooner or later, into water they are not welcome.

### Summary

Trends of modern freshwater fishery management covering aspects like different types of rearing, management aspects like parasites and their control, pollution, ecological biological economic and social parameters which should be taken into consideration for a successful freshwater fishery management were discussed.

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## OBSERVATIONS ON THE FLORA AND FAUNA OF THE KUMAON HIMALAYA

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### **The Expedition**

Keeping in view the importance of the Himalaya as an open laboratory for scientific exploration of its vast natural wealth, the Himalayan Association, Calcutta, launched a multidisciplinary 'Kumaon Himalayan Expedition—1977' with the twin objectives of climbing peaks as well as undertaking scientific studies of the hitherto little explored higher reaches of the area. The exploratory projects included studies on the fauna, flora and high altitude physiology. The expedition was supported by the Indian Mountaineering Foundation, New Delhi, and the Himalayan Mountaineering Institute, Darjeeling.

The team under the able leadership of Mr. M. Banerjee consisted of 16 trained members including the author and three high altitude sherpa guides from Darjeeling. The author's participation in this venture was sponsored by the Zoological Survey of India. This gave the author an opportunity to undertake preliminary studies on the flora and fauna of the areas covered by this expedition. In this article an attempt is made to project the results of this study.

The duration of the expedition was spread over 34 days from 7th September to 10th October, 1977. Of these, only 17 days were spent on the high altitude ( Base camp and above ).

The team had initially chosen to climb two virgin peaks, Chirring We ( 6,556 m. ) and Bomba Dhura ( 6,334 m. ) and make reconnaissance for finding suitable routes to climb two other peaks, Suli Top ( 6,300 m. ) and Burfu Dhura ( 6,145 m. ), all situated in the vicinity of Kalabaland glacier ( 4,376 m. ). Members selected for the climbs had to face a treacherous ice-fall, spread over a vast stretch of the glacier, and unforeseen weather conditions. Though the team succeeded in negotiating the ice-fall, the weather continued to play havoc. But the determined members gave a

gallant fight and three of the members reached the summit of Bomba Dhura ( 6,334 m. ) on 5th October. Soon after the expedition was called off.

In the course of these hectic days of climbing the author also undertook the task of collection and study of the high altitude fauna of the region. The findings, in respect of collections and other relevant matters are furnished in the following paragraphs.

### **The Kumaon Himalaya**

Geographically, the Kumaon Himalaya is one of the four major divisions of the vast Himalayan range and extends from the upper course of Sutlej river in southwest Tibet and Himachal Pradesh to Kali ( Sarda ) river on the Indi-Nepal border. The present survey was conducted from Muniary ( 2,195 m. ), a sub-divisional town in the district Pithoragarh to Kalabaland glacier ( 4,876 m. ) on the northern extremity of Kumaon Himalaya bordering Tibet. Pithoragarh is a fast developing district with an area of about 7,243 sq. km. on the northeastern spur of the Kumaon Himalaya. Pithoragarh district includes some of the most beautiful Himalayan valleys of great historical importance. It offers tremendous scope to scientists for exploration in the field of flora, fauna and other allied subjects.

Topographically the area is diverse and at places rugged and cut by deep river gorges. The eastern slope towards Nepal consists of a deep gorge of the Kali and Sarda rivers. A number of glaciated valleys including Darma Ganga and Gouri Ganga run from the snowy border in the north-west towards the south-east. Other important rivers and their tributaries towards the southern slopes are Pindar, Sarju and Gomti. The slopes of the hills are usually steep. Terraced cultivation is widely practised in the lower valleys. Soil erosion and land slides are rampant during the monsoon. A number of steep rocky ridges were present en route and had to be negotiated with caution.

The monsoon here sets in late and lasts till mid September. Rainfall is moderate to heavy. The weather in the lower valleys is warm and humid, but with the rise of altitude it turns to cold, dry and windy. In the course of the present expedition temperature on the glaciers varied from 0°C to -7°C. Normally it used to be sunny in the morning revealing dazzling snow-capped peaks and gorgeous land scapes all around, but towards the afternoon clouds appeared from all directions engulfing the entire panorama. As a result, by the late afternoon it invariably used to be

dark and chilly. This phenomenon became more conspicuous as the team climbed higher and higher. Snow-fall and blizzard of moderate to high intensity were of daily occurrence on the glaciers.

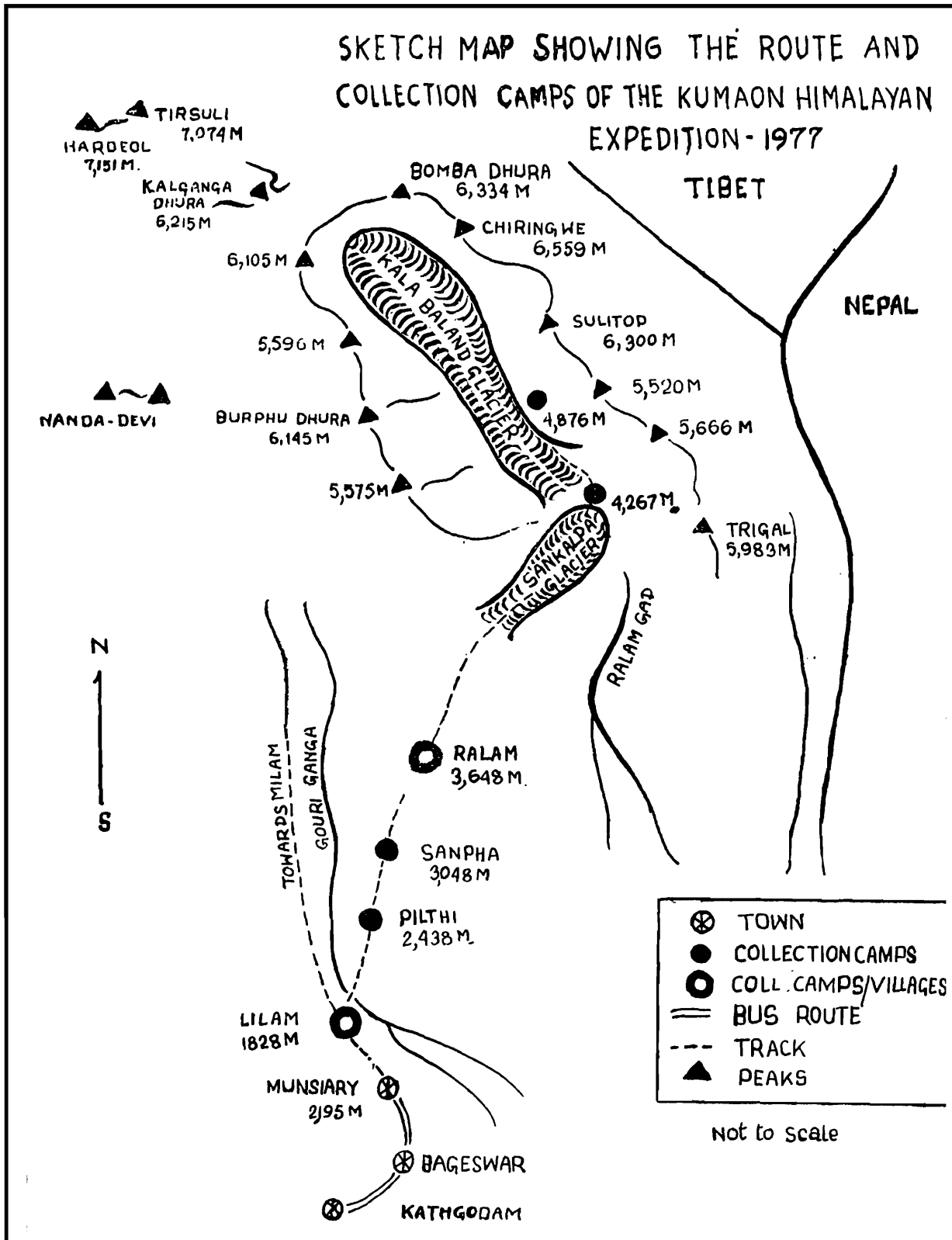


Fig. 1. Sketch map of the route and collection camps.

**Flora**

Marked variation in the growth and composition of flora were observed

with increasing altitude right from the tropical sub-Himalayan range up to the alpine meadows, in the arctic cold. The sub-Himalayan range is thickly forested and well-known trees of the plains are common. Bamboo (*Arundinaria* sp.) and Sal (*Shorea robusta*) are common up to 1,828 metres. Coniferous trees, such as the pine, the deodar, the fir, and the juniper are the most remarkable trees which adorn the high altitude terrains. The Chir pine (*Pinus roxburghi*) grows between the altitudes of 500 and 2,500 metres. At lower elevations it is raised only in plantations. At higher elevations it grows along with other conifers to form mixed forests. In its natural habitat, a Chir pine may grow up to a height of more than fifty metres. But at higher elevations it tends to become shorter and the trunk is often twisted, a condition brought about by snow and wind. Large logs of Chirpine are often seen floating down the hill streams, which is ultimately used in the production of railway sleepers, paper pulp and packing boxes. Turpentine oil is distilled from the oleoresin which exudes from its cut trunk and is utilised in the production of medicine, paint, soap, paper and even cosmetics. The pine needles after extraction of its volatile oil by steam distillation is made into fibrous mass called "pine-wool" This pine-wool is used as stuffing material for cushions, pillows and also as packing material.

The Oak (*Quercus* sp.) constitutes the bulk of the forest between 1,828 and 2,743 metres. The Deodar (*Cedrus deodara*) is another principal component of forest of the heights. These tall dark and ever-green conifers add much to the beauty of the landscape. The wood of deodar is much harder and is used in the manufacture of railway sleepers and wagons. Oleoresin obtained from its stem is reported to be an useful medicine for the treatment of skin disease. The wood chips are also ground to a paste and applied to treat headache.

Another important conifer of the height is the Silver Fir (*Abies pindrow*) which grows in the mixed coniferous zones between the altitudes of 2,000 and 3,000 metres. The wood is soft and creamy-white to light brown in colour and is therefore, hardly put to any economic use other than as firewood. But from the scenic point of view it is highly admired and is widely known as the "Christmas tree"

Juniper (*Juniperus* sp.) is the tiniest of all coniferous trees occurring at the highest elevations. It appears as many branched shrub on alpine meadows and semi-rocky mountain slopes at about 4,000 metres. Juniper twigs brun instantaneously when put to fire because of the presence of resin. While burning, it emits a fragrant smoke and hence it is highly

esteemed by the mountain people as incense ( dhup ). Being the last and the only source of firewood in the heights it is extravagantly used by shepherds, trekkers and expeditionists mainly for cooking and heating. High altitude birds relish the fleshy cones of the juniper. Apart from providing shelter to countless insects and grubs, it checks land erosion to a great extent on vulnerable mountain slopes. Therefore, indiscriminate destruction of juniper seen in these areas need to be regulated.

Besides the conifers, the other conspicuous trees of the heights are the Birch ( *Betula utilis* ) and the rhododendron ( *Rhododendron sp.* ). The Birch trees occur at heights of 2,300 to 4,300 metres and may grow to a height of 15 to 20 metres. The wood is creamy white and somewhat elastic. This elasticity of the wood makes it resistant to weight of heavy snow as well as fierce wind. Its paper-like thin bark, consisting of many layers is known as the *khurjpatra*. It is believed that prior to the invention of paper, this bark provided one of the first writing material to our ancient scholars. The rhododendron, which bears elegant flowers in multiple colours is the most admired tree of the heights. Of the several species of Rhododendron known from this region the tree rhododendron, known as *burans* in Hindi, is the most common. This tree grows with conifers and birch. The tree rhododendron is soon replaced by bush rhododendron at still higher elevations. Though highly esteemed for its beautiful flowers, it causes severe poisoning when accidentally ingested by livestock.

In the vast wilderness of the heights between the tree-line and the permanent snow-line there exists a number of alpine meadows which are stacked with coarse grass, juniper bushes, moss, ferns, lichens and a wide array of medicinal plants. These meadows are the only means of subsistence to the high altitude goats, sheep and yaks. Birds often frequent these meadows to feed upon the juniper seeds and grubs of many kinds.

### **Fauna**

The higher ranges of the Kumaon Himalaya is rich with a bewildering variety of ecological niches and an equally rich and varied fauna. The fauna of the sub-Himalayan ranges is fairly known, but not of the heights. Hence, it has been the author's constant endeavour to study the fauna of the heights and to collect specimens belonging to as many groups as possible. As a result 1581 specimens ranging from insects to mammals were collected. The collection includes representatives of sixteen insect orders. Collection of thysanopterans from alpine vegetations at an altitude of 4,267 metres and

collembollans from glaciers at an altitude of 4,376 metres are of special interest.

Collections were mainly made from the following camp: Munisary (2,195 m.), Lalam (1,323 m.), Pilthi (2,438 m.), Sanpha (3,048 m.), Ralam (3,657 m.), and Shankalpa glacier (4,376 m.). Of the various habitats from where collections were made mention may be made of glacial fields, glaciated streams, moraine beds, grassy mountain slopes and alpine meadows.

In addition, observations were made on the habits and habitats of a couple of animals of interest and an account of each of them is furnished in brief.

#### **Domestic Sheep & Goats :**

The animals which took the author's fancy on arrival at Munsary are the domestic varieties of sheep and goats. They are larger and more robust than their counterpart in the plains. The sheep are mainly bred for wool and meat. The goats are bred for milk as well as meat. Both are extensively used as 'Pack animals' and made to carry 10 to 15 kilograms of load neatly tied on their backs. The advantage of carrying loads by sheep and goats are manifold. Mules and Yaks too are used as 'Pack animals' but the disadvantage is that they cannot move along very narrow tracks. Sheep and goats, on the contrary, require minimum of space to move up hills, cost of transportation is the minimum and their ability to climb steep mountain slopes is remarkable.

Whenever on the move, every herd is accompanied by a shepherd and a huge Bhutia dog. The dog with a dangling bell from its neck moves ahead and guards the inmates against the ravages of carnivores. A major portion of this expedition's load was ferried by a troop of about 50 sheep and goats from the starting of trek at Munisary to the Base camp.

They are often attacked by a dreadful disease of which the keepers are always apprehensive. According to one owner "the disease strikes when certain poisonous plants are accidentally ingested by a sheep or goat. When attacked with the disease the victim becomes restless and fumes through the mouth. Soon the disease spreads to other inmates of the herd and death follows in quick succession till the entire herd is killed. The breeders have no knowledge of any remedy. The only precaution they take is to single out and isolate the affected one as quickly as possible. But in a herd of hundred or more sheep and goats detection of the diseased one is not always possible and the inevitable happens.

Fig. 2. Members poised for a breather while on the track. (The author at the extreme left.)

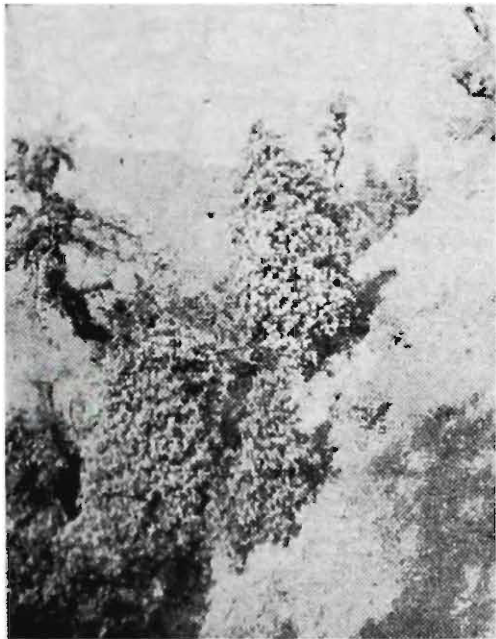


Fig. 3. A view of Rhododendron bushes on a mountain slope.

Fig. 4. Herd of goats and sheep which carried our expedition load up to the base camp.





Fig. 5. Members and porters negotiating a glacier.



Fig. 6. Part of the mountain range from the base camp

**Langur ( *Presbytis entellus* ) :**

At the end of the first day's trek, while scanning the surrounding landscape dominated by pine forest at Lilam ( 1,828 m. ) the author noticed a single troop of langurs relaxing on a huge flat rock under a shady grove. This troop consisted of 20 individuals of both sexes including four juveniles. On the following day the team climbed about 1000 metres up a thickly wooded slope and reached Pilthi ( 2,438 m. ) around midday. Being the highest spot in the area one could have a clear view of the forested slopes below with the back drop of high and barren ridges above. Here several troops of langurs were noticed perched on tree-tops. Others were seen jumping from one tree top to another, apparently in search of wild fruits. These langurs seemed to be more glossy and heavily coated than those in the plains. Some village elders reported that these langurs are in the habit of raiding their vegetable gardens. They are particularly fond of potatoes, the only cash-crop of the village. The loss incurred due to the ravages of the langurs is immense. No langur was observed above Pilthi. The advantage to the langurs of being close to human habitation is that when their natural source of food consisting mainly of wild flowers, fruits and leaves dwindle they can compensate it by invading cultivated fields.

**Himalayan Black Bear ( *Selenarctos thibetanus* ) :**

The author's curiosity for bear grew while trekking across a vast stretch of undulating plateau full of thick and tall grass, a few kilometres ahead of Sanpha. This plateau seemed to be an ideal habitat for bears which are reported to abound in the Kumaon Himalaya. Several shepherds were noticed tending their herds of sheep and goats with huge Bhutia dogs giving security rounds with the twinkling of bells. When contacted, the shepherds were lamenting that this place is heavily infested with bears and that hardly a day passes without one or two sheep or goats being molested by the bears. Their only consolation is the Bhutia dogs which can sense the presence of bears and chase them away. In spite of this hazard involved, the shepherds have no other choice but to visit the place for the richness of the grass.

When the team reached Ralam after a most arduous and long trek, it was almost dark. Soon after the members settled down for rest, a villager confronted the author and offered to show a freshly killed bear lying a few kilometres down Ralam. The offer seemed tempting. But on a second thought, the author, considering the inclement weather put off the idea and instead requested the informer to skin the beast and keep it. This,

the author promised to collect on the return trek and pay him generously. When the team reached Ralam on the return journey after a fortnight of climbing, the man in question could not be traced. Hence, the author himself traced the examined the carcass and decided to make an enquiry to find out as to who could be the killer and the motive behind it. since the flesh of bear is not even touched by the local people. The villagers were reluctant to tell the truth, but some porters were helpful. The bear in question was spotted singly in a thick bush by a poacher and was shot and killed from close range. It rolled down several feet and rested in a pool of ice-cold water. The abdomen was cut open and the gall-bladder removed. All other parts of the body were left untouched. They refused to name the person, perhaps, for fear of being apprehended. The gall-bladder is readily sold to traders at Munsiaiy @ Rs. 2000/- to Rs. 250/- depending upon the quantity of bile it contains. Poaching of bears for their gall bladder is widely prevalent here. Apart from the bear in question which the author noticed during his return trek, several other live pairs were seen in far flung plateaus around Ralam.

**Bharal (*Pseudois nayaur*) :**

The Bharal or the Blue sheep is the most remarkable mammal of the heights. Several herds of them were seen grazing in remote alpine meadows and on occasions moving majestically on high cliffs around the Base Camp (4,267 m.) above Ralam.

In appearance and habits the Bharal hold a place intermediate between sheep and goats. The enormous horns (in case of the males only) and a black stripe that runs down the front of each leg immediately distinguishes the Bharal from all other bovid mammals of the heights. Bharal moves in herds of 15-20 or at times even more with a single male at the lead. Their entire life is spent in the rocks between the tree and the snow-lines around 4,876 metres and makes a comfortable living on the sparsest forage growing either on the mountain slopes or on the meadows. Their ability to climb steep rocks and the agility and fastness with which they move around is fantastic.

Bharals are in much demand here for their delicious flesh and the soft and thickly coated furs. Whenever killed, the flesh is cut into small pieces, sundried and preserved for consumption during the winter months. The skin is sundried too and is used as a saddle on yaks and mules for warmth and comfort. The horns are placed on house tops as object of decoration.

Unlike other wild mammals, the Bharal does not face the danger of being extinct at the moment. The reason being their habitats which lie beyond the normal reach of poachers. The only calamity they face, is the sudden fall of snow or rocks with which a good many of them are eliminated.

#### **Himalayan Mouse-Hare (*Ochotona* sp.) :**

On return trek the author had an opportunity to study the habits and habitats of the Himalayan Mouse-hare. The surroundings of Ralam with summer crops and wide array of alpine vegetation makes an ideal habitat for the mouse-hare. In appearance this rodent resembles a guinea pig, but can be easily distinguished by the presence of a short muzzle, small and rounded head, rounded ears and absence of tail. Mouse-hares make no burrows and prefer to live under loose rocks and heaps of stones. They feed on anything green and at tremendous speed seating on their hindlegs and grasping the twigs by the forelimbs. Feeding hours are restricted to the sunny weather and each feed lasts only a few seconds. They seemed to be always on the alert and after each feed return quickly into the rock crags for fear of being caught by the predators.

This remarkable rodent is widely distributed throughout the Himalayas ranging from altitude as low as 2,000 metres to as high as 4,000 metres.

#### **Voles (*Alticola* sp. ) :**

The presence of voles was observed by locating by burrows, hidden under coarse grass on the open meadows. A good number of them were noticed living in areas occupied by the mouse-hares. Unlike the mouse hares, the voles have a tail, almost half the total length of the body and the body is almost cylindrical. The voles are mainly burrowers and their body is fully adapted for this purpose. They make a comfortable living on the coarse grass and roots and their feeding habits are similar to that of the Mouse-hares. Voles are also widely distributed in the Himalayas ranging from altitudes of 3,000 to 4,000 metres.

#### **Himalayan Choughs :**

Enroute to Ralam from Munsiri were seen many kinds of colourful birds, such as the sun bird, minivet, golden oriole, thrush, hornbill, bulbul, cuckoo, pheasant, woodpecker and dove to name a few. However, above the timber-line only the Red-billed chough (*Pyrrhocorax pyrrhocorax*) and Yellow-billed chough (*P. graculus*) were seen in plenty. As their names

indicate the former have red-coloured beaks and the latter yellow-coloured beaks. But for the colour of the beak and the more glossy jet black body the choughs resemble the crow of the plains. They used to fly over the camp in huge numbers and occasionally came down and settled on our tent poles and when no one was around fed upon the camp refuse. While changing camps they also followed us but not to the glaciers. These birds nest in rock crags and feed upon juniper seeds and grubs of many kinds on the open meadows. Their usual habitat lies between the tree-line and the permanent snow-line.

#### **Rock Lizards :**

Rock lizards, mostly *Agama* sp., were seen at altitudes ranging from 2,195 to 3,200 metres. Their body colour camouflages so closely with the surrounding rocks that it is difficult to notice their presence unless they moved. They live in natural rock crags or else under heaps of smaller rocks. When no one is round they move about on the open track. If alarmed, they stop instantaneously and peep towards the source of the danger and then hurriedly enter the nearest crag.

#### **Colourful Insects :**

In the course of our onward and return march colourful insects hovering over equally colourful flowering plants made a delightful sight. Presence of butterflies in various shades and colour seemed to be more conspicuous than other insects.

Before conclusion I would like to stress upon the necessity of training for work on the high altitude. Apart from a great deal of stress and strain, work in high elevations involves grave risk not only on account of hazardous terrain and the bitter weather conditions, but also due to the physical and psychological effects of high altitude that become harsher and harsher as one climbs higher and higher. However, these adversities can be overcome by gradual acclimatisation, but the degree of acclimatisation vary from person to person. Therefore, before proceeding to the heights one must be equipped with sufficient knowledge to identify these ailments and be able to face them effectively. No amount of theoretical knowledge will help unless one confront these realities himself. One can learn all these and much more by attending a course in any of the three mountaineering Institutes in the country.

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## MILLIPEDE A UNIQUE ANIMAL

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Everyone might have seen a joint-footed, many segmented animal having double pairs of legs on each body segment, coils when disturbed or exudes some badly odourous fluids for self-defence, are known as millipedes. The body (trunk) segments are being formed by the fusion of two originally separate somites. Due to presence of diplosegment these are grouped under the class Diplopoda of the phylum Arthropoda. But all the body segments are not always diplosegmented. The first post cephalic segment (Collum) forms a large collar behind the head and devoid of any legs and second to fourth segments carry only a pair of legs. Body terminates in telson on which the anus opens ventrally.

The number of body segments in millipedes range from 11 to more than 100 and length varies from 0.2 cm to 28 cm. Some have eyes with 2-8 ocelli or without eyes. They are mostly negatively phototactic, *i.e.*, they move away from light and prefer shady places. Antennae are covered with sensory bristles and the last segment bears hook like structures called peg organs which act as both chemoreceptor and taste organs. It is presumed that these sensory bristles are richly supplied with chemoreceptors. The eyeless animals use their antennae very frequently to detect food, danger, sex mates etc. Chemical repellent and speed are two chief defence mechanisms. It is recorded that a rock dwelling millipede can move even at a speed of 80 cm/Sec. Some millipedes possess chemical secreting glands known as "repugnatorial glands" present in body segments. These glands produce chemicals which are toxic or repellent to other small animals. The principal components are aldehydes, quinones, phenols and hydrogen cyanide which varies from species to species. The fluid is discharged slowly but some times gives out as spray upto remarkable distance. Cloudsely-Thompson (1953) reported that a Haitian species of millipede can emit a spray of fluid for a distance upto 70 cm or more on either side of the body.

Millipedes prefer damp, humid and shady places. Usually they are

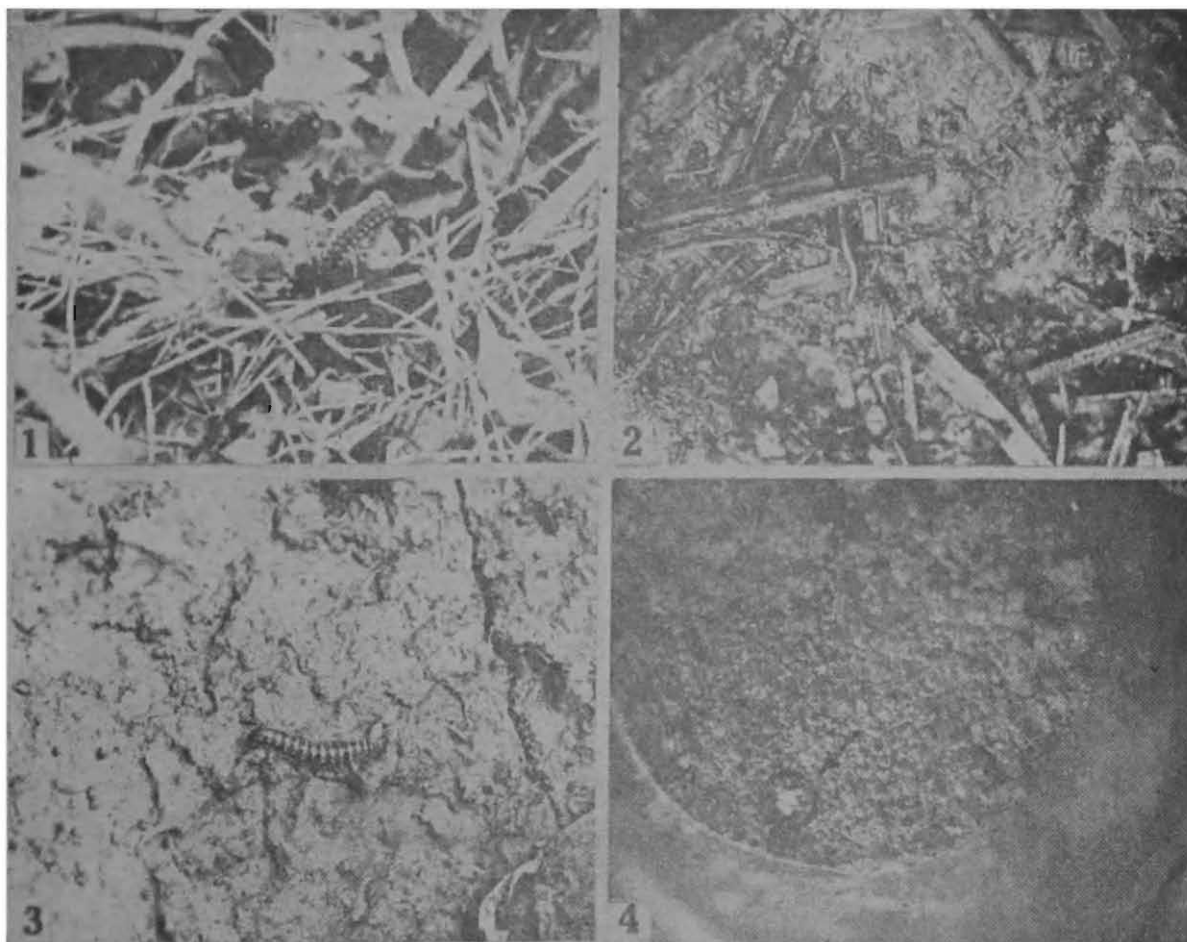
found beneath the fallen leaves, stones, barks, rotten logs and in the soil (figs. 1—3). Some are seen even in the houses, or underside of the thatch of the cottages.

The millipedes show a wide choice of food preference. They are primarily herbivorous. mostly feed on decaying plant tissue, including leaf litter, fungi, fruiting bodies and the excrement of herbivorous mammals. But a large number of species also consume food of animal origin—they are obviously omnivores. It is most curious to note that a good number of millipedes appear to be preferentially carnivores (Hoffman *et. al* , 1969).

Millipedes are sexually dimorphic but in some groups males are rare and parthenogenesis is common. In most of the male millipedes, legs are modified into gonopods through which sperm is transferred directly into the vulva of the female. These gonopods provide useful characters for identifying various species. In the groups where there are no gonopods, *e.g.*, African pill-millipede ( *Sphaerotherium dorsale* ), the male uses normal walking legs for the transfer of sperm. Sperm transfer is indirect in Sub-class Pselaphognatha. The male *Polyxenus lagurus* spins a double zig-zag thread above a small depression, with his "penis appendage", and places two drops of sperm on it. He then moves away, spinning a couple of parallel threads as he retreats. The threads contain a pheromone which attracts sexually mature females so that they follow them to the sperm droplets which are taken up with the vulvae. The signal threads also stimulate other males, which eat the old sperm drops and replace them with new ones, thus not only economizing in protein and nucleic acid, but also providing constantly fresh sperm for the female ( Schaller, 1971 ).

The egg laying is very much different in different groups. Either the eggs are laid in clusters ( Fig. 4 ) or singly in specially made chambers or in the litter. The newly hatched youngs are usually of seven segmented having 3 pairs of legs. With successive moults additional post-cephalic segments and legs are added to the trunk till attain the number of post-cephalic segments of adult individuals. There after the animals may undergo moulting without addition of any further segments or legs ; only sexual maturation occurs during this phase. The moulted individuals usually eat the shaded exoskeletons, probably to replenish calcium.

Economically the millipedes are important both as friend and foe. A good number of millipedes are found in the agricultural fields, such as jute, cotton, banana, guava etc., and help us in soil aeration as well as humification of the soil. In *Jonespeltis splendidus* the excrement contain more humus



**Figs. 1-3.** Millipedes in different ecological habitats.

1. On fallen leaves ; 2. in litter ; 3. in cultivated agricultural field.

**Fig. 4.** Egg cluster of millipede.

than the ingested soil, as the gut is harboured with bacterial and fungal population where particularly the fungal population play a great role in humifying the soil ( Bano *et. al.*, 1975 ). Many millipedes feed on soil and litter in varying stages of decomposition ( Blower, J. G. 1955 ). Their feeding activity is dependent on humidity and moisture content of the soil as most of the millipedes are known to aestivate during drought ( Krishnan, 1968 ). Satchall ( 1967 ) has reported that many soil animals harbour in their gut symbiotic microflora which convert the decaying organic matter to an assimilable form of energy. The millipedes play a prominent role in the ecosystem and can be easily called as "Macrodegrader" Apart from this they build tunnels in the substratum to build nests for egg laying, to protect from enemy and to hibernate and aestivate during unfavourable seasons. These tunnels are inter-communicated inside the soil. These tunnels also help in soil aeration.

The undesirable effect of millipedes on cultivated plants have been reported by many scientists. Under some circumstances a number of millipedes feed upon living plant tissue instead of decaying organic materials. Ormerod ( 1890 ), observed *Blaniulus guttulatus* attacking strawberry fruits and germinating marigold seed. Rolfe ( 1937-39 ) while listing the species of millipedes has reported that millipede damage to a wide range of horticultural and field crops including beans, peas, cucumbers, cabbage, cereals, lettuce, potatoes and sugar beet. Wilson ( 1943 ) commented that, although they are usually secondary pests, millipedes will feed on the skin of soft skinned varieties of potatoes. *Brachydesmus superus* ( Latz. ) and *Blaniulus guttalatus* ( Bosc. ) can stunt and even kill sugar-beet seedlings in the spring by their aggregated feeding on the young roots ( Baker, 1974 ). Puttarudriah ( 1958 ) has reported that a species of millipede appeared as a pest for damaging chillies, cotton etc. in Mysore state.

It is interesting to note that some luminous millipedes, e.g., *Fontaria luminosa*, *Luminodesmus sequoiae* have been reported by Kenyon ( 1893 ) and Loomis and Davenport ( 1951 ) respectively. In darkness, the entire animal and its appendages give off a brilliant greenish white glow, plainly visible to the dark adapted eye at a considerable distance. Luminescence is continuous, under no voluntary control, and first appears on hatching ; its sources apparently lies in the deeper layers of the integument ( Davenport *et. al.*, 1952 ).

Different behavioural aspects of millipedes pointout the diverse impact on ecosystem. Their various food preference need close watch by the scientists. Possession of intestinal symbionts and consequent humification

of soil by them essentially help the farmers on the other hand they do harm by damaging various plants of agricultural importance. Tunneling in the soil, secretion of toxic repellants and presence of luminescence in some groups are still very much interesting. Summarizing all these aspects of millipede behaviour it can be concluded that they are friend as well as foe to the farmers. More attention is needed for this neglected group of terrestrial arthropods to assess their role in the organic world and to elucidate their economic importance.

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## THE SEXUALITY IN FISHES

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The status of sexuality, its meaning and interpretation has been confusedly expressed by various authors in the literature. A more meaningful approach to terminology is now proposed on a common plan applicable to invertebrates and vertebrates.

The most extensively reviewed work on invertebrates, L. H. Hyman (1951-1967) defined some terms in sexuality correctly but expressed doubts in others. She has also doubted the use of the term '*follicle*'. As in fishes, she used the terms 'simultaneous hermaphrodite' for pulmonate gastropods. She has further discussed very clearly and accurately the various author's work on protandric hermaphrodites in Prosobranchia. She even suggested that reproductive system can be used for the species identification of pulmonates.

In the other groups of invertebrates, the types of sexuality exhibited by various groups are less clear. In some groups where studies have been more less complete, sexuality of a particular population is known to be fixed and shows very little variation from place to place though some of its phases may change. In order to arrive at a common system of classification of sexuality both for invertebrates and vertebrates, the following revised terminology is proposed.

In so doing, follicular concept of gonad formation is briefly explained. It is not necessary to go into the gonocoel theory of Hatscheck and Lang for the origin of coelome in Metazoa, it would suffice to know that the gonads arise from the mesoderm, the germ cells from the coelomic wall and the gonad itself is of coelomic origin. The gonad is made of a series of sacs called 'follicles' Hyman (1951) viewed that the scattered condition of the gonad as follicular but doubted its use here as the same term is applied to a developing egg encircled by nutritive cells. The familiar meaning of the term '*follicle*' is a sac with clear cut lining which produces germ cells of

either sex inside the gonad. The same term may have been applied to other cases also as stated by Hyman, but then, it is a question of choosing one from among the homonymic names. A term 'ampulla' is applied to a fish follicle. But even this term is also occupied by a structure in echinoderms. The present author is of the view that the term '*follicle*' may be retained with the meaning of a sac capable of producing germ cells within the gonad. This concept is important as the status of hermaphroditism can be understood only by the type of sex cells that the follicles can produce and of its their arrangement inside the gonad.

### Classification of Sexuality

The following revised scheme is proposed to identify the various types of sexuality. Other names of equal meaning are also provided in brackets.

- I. *Dioecious* : Applied to species in which the sexes are separate, *i.e.*, Testes are produced in one individual and ovaries in another individual. ( Other terms : Gonochorism. unisexual ) *e.g.*, Most groups, especially vertebrates.
  - a. *Reversible* : The young population of a species first appear as males, then pass through a transitional phase and function as females for the remaining part of their lives. ( Other terms : Protandric hermaphrodite, syngamy ) *e.g.*, Lower proso-branches, oysters and scallops among lamellibranchs, some ophiuroids and asteroids, trematodes, gymnolaemates. The young population appearing first as females may be conversely called protogynic hermaphrodite. Atleast one case is known in pulmonate gastropods. The transitional phase may contain hermaphroditic gonads as in category III below. ( Other terms : Protandric hermaphrodite/ protogynic hermaphrodite )
  - b. *Non-reversible* : The entire population of a species has almost equal proportions of sexes in all stages during a species life time. There is very little scope for sex reversal, *e.g.*, several groups in the animal kingdom, most common in vertebrates.
  - c. *Parthenogenetic* : The entire population of a species contain female gonads, *e.g.*, some nematodes.

- d. *Intersex* : Females possess some male characters in part of their life or throughout their lifetime, *e.g.*, some nematods.
- II. *Monacious* : Species in which both testes and ovaries occur in one individual throughout the species lifetime. ( Other terms : hermaphrodite. bisexual )
- a. *True hermaphrodite* : species in which every follicle of the gonad produces germ cells of both sexes irrespective of the state of maturity, in a few individuals or in a species lifetime. ( Other terms : genuine hermaphrodite and simultaneous hermaphrodite ) *e.g.*, some opisthobranchs, prosobranchs and Bivalves.
- b. *Functional hermaphrodite* : Species in which both male and female cells mature at the same time in a single gonad or all gonads throughout the life time. (This is also referred as simultaneous hermaphroditism by some authors) *e.g.*, some prosobranchs. The term successive hermaphrodite used by some authors as one type of cells maturing earlier than the other becomes defunct in view of the categories I a.
- III. *Mixed sexes* : Where a group of follicles of one sex follow or embed in the group of follicles of another sex irrespective of the stage of maturity. This state may occur in all the individuals in a species lifetime but generally in some individuals of a population. It is also referred as islands of one sex in the gonad of another sex. *eg.* several species of molluscs and fish. Gonads in which the anterior portion is male and posterior female or *vice versa*, also belongs to this category, *eg.* solenogastrics. It also applies to cases where ovaries are on dorsal side and testes on ventral side or *vice versa* as in some phoronids. Protandry or protogyny can also be applied in this case but with reference to particular gonad or population depending upon the state of maturity.
- IV *Neoteny* : Where the gonads mature in a larval or juvenile stage, *e.g.*, Amphibia.

### Sexuality in fishes

The earliest living fish ancestors, the cyclostomes, are known to be protandrous ( Storer and Usinger, 1957 ). Most of the modern fishes are dioecious. Some form of hermaphroditism has been recorded in sea perches (Serranidae) and sea breams (Sparidae), deep sea fishes of the order Inio

and some minnows among teleosts. (Marshall, 1965). Among the fresh water groups, hermaphroditism is reported in catfishes (Siluridae), Carps (Ciprinidae) and Channidae. Presently, smear examination of gonads had revealed hermaphroditism in Nandidae, Channidae and Centropomidae in the Jabalpur area. Detailed work on the precise nature of hermaphroditism in these species are in progress.

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## THE MINNOWS OF INDIA

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Any small fish is usually called a 'minnow' by the layman. Aquarists and biologists in India working on aquarium fishes are often curious to know the actual meaning of the group of fishes, popular term 'Minnow', its true identity, the popular aquarium minnows of India, its taxonomy, its place of origin, popular names, its colour pattern, growth, food and breeding habits, etc. According to New Gem Dictionary by E. Weekley and A. Scott (1960), a minnow means 'small freshwater fish, stickleback'. But taxonomically minnows are strictly confined to the group of small freshwater fishes belonging to the order Cypriniformes of the family Cyprinidae, with varying length from 25 to 1,524 mm. Hol'cik and Miha'lik (1968) defined a minnow as 'a small cyprinid fish typical of clear mountain waters which it inhabits in association with the Trout, Bull-head, Schneider and Stone-Loach'. Minnows may, however, be defined as small-sized freshwater cyprinid fishes living in freshwater pools and streams, usually brilliantly coloured and mostly suitable for the aquarium.

The largest freshwater cyprinid fishes of paramount economic importance are popularly known as the 'Carps' (genera *Labeo*, *Catla*, *Cyprinus*, *Cirrhina*, *Tor* etc. with varying length from 304 to 1,824 mm) and the smallest ones as the 'Minnows' belonging to the genera *Danio*, *Puntius* (*Barbus*), *Brachydanio*, *Esomus*, *Rasbora*, *Chela*, *Amblypharyngodon*, *Barilius* etc. Among the minnows which are the most attractive and gorgeous in colour patterns and possessing the maximum adaptive nature with the aquarium environment are known as the 'aquarium minnows' and the remaining minnows are simply regarded as mere food fishes of less economic importance.

### Popular aquarium minnows of India

The minnow-like fishes and their relatives belong to the family Cyprinidae. This very large group probably originated in southern Asia

(Yunnan region), then spread to northern Asia, Europe and north America. Minnows have soft rays without true spines; however, in some carps the first ray of the dorsal fin is hardened into a stiff spine like structure, and sometimes the first ray of anal fin is also hardened. They have toothless jaws but compensate this by having strong throat teeth, which are very important in classification. All minnows lack the adipose fin; the scales of the cycloid type. The popular minnows often seen in aquarium of India are :

### 1. *Danio malabaricus* (Jerdon)

Place of origin—Malabar, Kerala

Popular name—Giant Danio

Colour pattern—Vertical and horizontal golden bars and stripes on the sides of the matured ones with bluish lateral bands which are broken in females; fins and anal region orange coloured during breeding season otherwise ordinarily does not appear. Adult female is slightly larger than the male.

Length — Grows to 102 mm. (4 inches)

Actual meaning of species name—*Danio*, after a native name "*Dhani*", "*malabaricus*", from Malabar, Kerala.

Temperature range—68° to 80°

Food — Eats everything.

### 2. *Danio* (*Brachydanio*) *rerio* (Ham.) (= *Brachydanio rerio*)

Place of origin — River Koshi, Bihar.

Popular name — Zebra Fish, Zebra Danio. Zebra Danio is a misnomer, as the stripes of a zebra are vertical.

Colour pattern — An ideal attractive aquarium fish noted for its colour pattern. Very beautiful horizontal bluish stripes in repeated pattern give a streamline effect. More yellowish cast over the female particularly in the caudal fin, can be seen during breeding time.

Length — Grows to 44 mm. ( $1\frac{1}{3}$  inches)

Actual meaning of species name—"*Brachydanio*" means short Danio, a native name, also known as *Danio rerio*.

Breeding age — One year age is the best for breeding; at two years they become old and seldom live beyond 3-years (Innes, 1944).

Temperature range—Suitable aquarium temperature 72° to 76°  
 Food — They take any kind of food but live food is preferred.

### 3. *Rasbora daniconius* ( Ham. )

Place of origin — Rivers of Southern Bengal.

Popular name — Common Rasbora.

Colour pattern — Greenish yellow above, silvery tinge at sides with blue black lateral stripe narrowly bordered with golden yellow ; fins tinged with pale orange.

Length — Attains 1,02 mm. ( 4 inches ).

Actual meaning of species name — “*Rasbora*” and “*daniconius*” both derived from native names.

Temperature range — Suitable range being 72° to 85° They spawn on fine plants.

Food — Eats all kinds of food.

### 4. *Esomus danricus* ( Ham. )

Place of origin — Ponds and ditches of Bengal.

Popular name — Popularly known as “Flying Barb” for its widespreading pectoral fins which enable it sizable leaps from the water surface.

Colour pattern—A black line along the body with an upper ribbon of gold, separating an olive back from silver sides ; these lines become faint towards the caudal region. The male develops a reddish tinge towards the end of its body.

Length—Attains 102-125 mm. ( 4-5 inches ).

Actual meaning of species name—“*Esomus*” means slender body ; “*danrica*” derived from native name. It is also known as *Nuria danrica*.

### 5. *Puntius chola* (Ham.) (= *Barbus chola*)

Place of origin—North-eastern parts of Bengal.

Popular name—Green Barb.

Colour pattern—Pale olive dorsally with green scale pockets, opercles golden, belly and sides silvery. Dorsal fin pale orange, with two rows or dark blotches. Black spot on 22-24 lateral line scales. Pectoral and ventral fins tinged with orange.

Length—Attains 88 mm. ( $3\frac{1}{2}$  inches). Lives for many years.

Actual meaning of species name—“*Barbus*” means barbels and “*chola*” is a native name.

Food—Eats everything preferably live food.

6. *Puntius conchonus* (Ham.)  
(= *Barbus conchonus*)

Place of origin—Ponds and ditches of north-eastern parts of Bengal and in the rivers of Kosi and Ami.

Popular name—Rosy Barb.

Colour Pattern—A brilliantly coloured fish specially during breeding season. Greenish gray above and silvery towards the sides ; a large black lateral spot above posterior part of anal ; fins tinged with orange. During courtship the male develops a red attractive courting costume and when the love making is over, it lays aside this gay attractive costume.

Food—Eats everything.

Special remark—A well-known attractive aquarium minnow and hardiest too.

7. *Puntius gelius* (Ham.)  
(= *Barbus gelius*)

Place of origin—North-east parts of Bengal.

Popular name—Spotted Barb.

Colour pattern—Not very much attractive in colour. The distinct broad dark stripes and blotches over the body are dark or brownish, while the nearly transparent fins slightly tinged with yellow.

Length—Male 31 mm. ( $1\frac{1}{2}$  inches) ; female 43 mm. ( $1\frac{3}{4}$  inches)

Actual meaning of species name—“*gelius*” is a native name.

Temperature range—Breeding as well as suitable temperature is  $75^{\circ}$  ; they can thrive well even at  $65^{\circ}$

Food—Live foods viz., *Daphnia*, *Enchytraeids* and *Tubifex* worms.

8. *Puntius terio* (Ham.)  
(= *Barbus terio*)

Place of origin—North-eastern parts of Bengal.

Popular name—Terio Barb.

Colour pattern—The male with a cast of yellow with the anal and ventral fins tinged with orange. Female silvery, with clear fins. The male, during its mating turns to beautiful orange instead of red.

Length—62 mm. (  $2\frac{1}{2}$  inches )

Actual meaning of species name—“*terio*” is a native name.

Special remark—This species does not breed easily.

9. *Puntius phutunio* ( Ham. )  
( = *Barbus phutunio* )

Place of origin — North-east parts of Bengal.

Popular name — Dwarf Barb.

Colour pattern — The sparkling silvery glow or sheen of its scales is remarkable ; body with black spots or blotches ; the dark spot on the gill is translucent exposing the pink of the gills ; fins pale-orange coloured, slightly darker in the male.

Length — 31 mm. (  $1\frac{1}{4}$  inches ).

Actual meaning of species name — “*phutunio*” is a native name, “*phutuni*” means boasting in Bengali and its local name is “*Phutuni Puthi*”

Temperature range — This species does not require high temperature. Eggs hatch in two days at 75°

Food — Very easy to feed, cyclops should be avoided among the living food.

Special remark — Very difficult to differentiate between male and female.

10. *Puntius vittatus* ( Day )  
( = *Barbus vittatus* )

Place of origin — Madras, S. India.

Popular name — Striped Barb.

Colour pattern — Bright silvery body, yellowish towards the posterior ; black spots on the anal, caudal and dorsal fins ; the sides are also with small dots ; rarely fins are yellowish.

Length — 50 mm. ( 2 inches ).

Actual meaning of species name — “*vittatus*” means stripes.

Temperature range — 65 to 85 degrees.

Special remark — No barbels. This is a hardy fish and a good breeder and quite inoffensive. No stripes actually can be seen as its name indicates.

11. *Puntius ticto* ( Ham. )  
( = *Barbus ticto* )

Place of origin — South-eastern parts of Bengal.

Popular name — Fire-Fin Barb, Ticto Barb, Teeta-Puthi ( Bengali local name ).

Colour pattern — Pale olive dorsally with silvery sides. Black spots under 3rd, 4th and 16-17th lateral line scales. Two indistinct rows of dots on the dorsal. Male with arched band of red on dorsal fin, becoming very vivid in breeding season.

Length — Attains 37 mm. (  $1\frac{1}{2}$  inches ) or more ( Munro, 1955 ); 87 mm. (  $3\frac{1}{2}$  inches—Innes, 1944 ).

Food — Voracious eater, prefers living food.

Special remark — A hard durable species, easily breeds. Both the partners are very active specially the male *ticto*, who is never at rest, sometime chasing a slower colleague in a challenging mood.

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