TECTONIC HISTORY OF INDIA AND ITS BEARING ON FISH GEOGRAPHY

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(*With 7 text figures*)

INTRODUCTION

As is well known, Geography is a synthetic science, largely dependent for its data on the results of specialized sciences such as geology, oceanography, meteorology, biology, etc. 'The characteristic task of geography is to investigate the control exercised by the forms and vertical relief of the surface of the lithosphere directly or indirectly on the various mobile distributions.'[1]

The distribution of freshwater fishes has been greatly neglected in the past for it does not fall easily into the zoogeographical regions established for mammals or birds. The mode of dispersal of fishes, in spite of suitable ecological niches in their neighbourhood, is dependent on drainage patterns, river captures, flood plains and other phenomena which may help in the commingling of waters of different drainage systems. Further, fishes of various ecological associations can only spread if suitable environmental conditions become available in the intervening areas. For instance, torrential fishes cannot spread over marshy areas though the overflooded waters of a torrent may spread over marshy grounds. Of all the factors responsible for the spread of fishes, the tectonic history of a country can be most fruitful in the study of their distribution. The Indian fish-geographers are, therefore, fortunate in the publication of a recent *Memoir* of the Geological Survey of India by its Director, Dr. M. S. Krishnan, on 'The Structural and Tectonic History of India'.[2] It contains a wealth of material, which was otherwise inaccessible to biogeographers. The language, though unavoidably technical, is quite understandable by a lay reader, especially because the text is illustrated with a number of diagrams and maps. For more serious students of the subject, the author has given a list of references covering 8 pages and an index covering another 8 pages.

STRUCTURE OF INDIA

Structurally, India has been divided into two units, the Peninsula and the extra-Peninsular area. As the stratigraphic and tectonic histories of the two regions are different, Dr. Krishnan has treated

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[1] *Encyclopaedia Britannica*, 14th ed., **10**: 139 (1929).

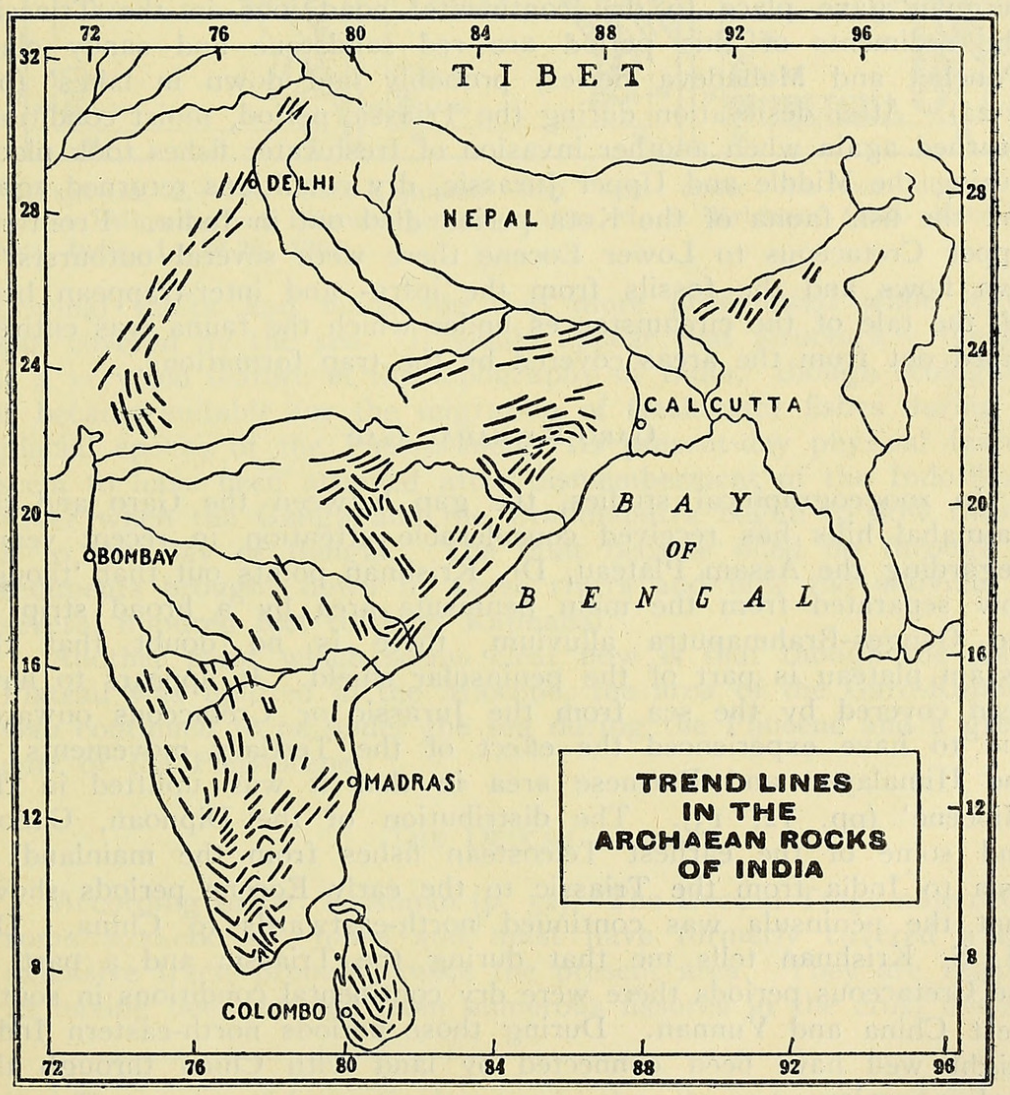
[2] Published in 1953 as *Memoirs* Vol. 81, and obtainable from the Geological Survey of India, 27, Chowringhee, Calcutta 13, for Rs. 2-8.

them separately up till the Tertiary, when they encroached on and influenced each other.

The present writer has the intention to deal with only such facts recorded in this *Memoir* as have bearing on the Fish Geography of India.

Trend Lines in the Archaeans

The trend lines in the Archaeans have influenced the later geological phenomena to a marked extent, though they are much older than the organisms which occupied the country from time to time. The earliest known freshwater fishes of India are now entombed in the Maleri (Triassic) and Kota (Jurassic) beds of the Godavari Valley.[1] The trend lines noticeable in the Archaean rocks of the different parts of India represented by Dr. Krishnan in fig. 1 indicate



Text-fig. 1.—Trend lines in the Archaean rocks of India. After Dr. M. S. Krishnan (*Mem. Geol. Survey of India*, **81** : 4, 1953).

[1] Hora, S. L. & Menon, A. G. K. (1952) : Distribution of Indian Fishes of the past and their bearing on the Geography of India. 2. The extinct freshwater Dipnoan and Ganoid fishes of India. *Everyday Science*, **1**: 26-37.

the route of migration of fishes from north-east to south-west. All the freshwater fish fossil beds (besides Maleri and Kota beds referred to above, we have Dongargaon, Deothan and Kheri beds of the Cretaceous-Eocene periods[1] in Madhya Pradesh) are situated along these trend lines. It is thus reasonable to infer that these trend lines though indicating the mountain chains and axes of rock-folding in the Archaean era have persisted and, have greatly influenced the drainage patterns of the Triassic, Jurassic, Cretaceous and early Eocene periods.

Though Dipnoan, Ganoid and Osteoglossid fishes died out in India, they are still living in some other parts of the world. The causes of their extinction are violent changes in their ecological conditions and the outpouring of lava over a greater part of the country. With regard to the former, one reads that 'The humid conditions which permitted the growth of luxuriant vegetation in the Permian gave place to dry continental conditions in the Triassic. The sediments of this period are red sandstone and sandy clays (Panchet and Mahadeva Series) probably laid down in lakes' (pp. 21-22). After desiccation during the Triassic period, moist conditions returned again when another invasion of freshwater fishes took place. During the Middle and Upper Jurassic, dry conditions returned again and the fish fauna of the Kota period died out in India. From the Upper Cretaceous to Lower Eocene there were several outbursts of lava flows and the fossils from the infra- and inter-trappean beds tell the tale of the circumstances under which the fauna was entirely wiped out from the areas covered by the trap formations.

Garo-Rajmahal Gap

In zoogeographical studies, the gap between the Garo and the Rajmahal hills has received considerable attention in recent years. Regarding the Assam Plateau, Dr. Krishnan points out that 'though now separated from the main peninsula area by a broad strip of the Ganges-Brahmaputra alluvium, there is no doubt that the Assam plateau is part of the peninsular shield. It appears to have been covered by the sea from the Jurassic or Cretaceous onwards and to have experienced the effect of the Tertiary movements of the Himalayan and Burmese area in that it was uplifted in the Miocene' (pp. 12, 13). The distribution of the Dipnoan, Ganoid and some of the earliest Teleostean fishes from the mainland of Asia to India from the Triassic to the early Eocene periods shows that the peninsula was continued north-eastwards to China. Dr. M. S. Krishnan tells me that during the Triassic and a part of the Cretaceous periods there were dry continental conditions in south-west China and Yunnan. During those periods north-eastern India might well have been connected by land with China through the Sadiya region.

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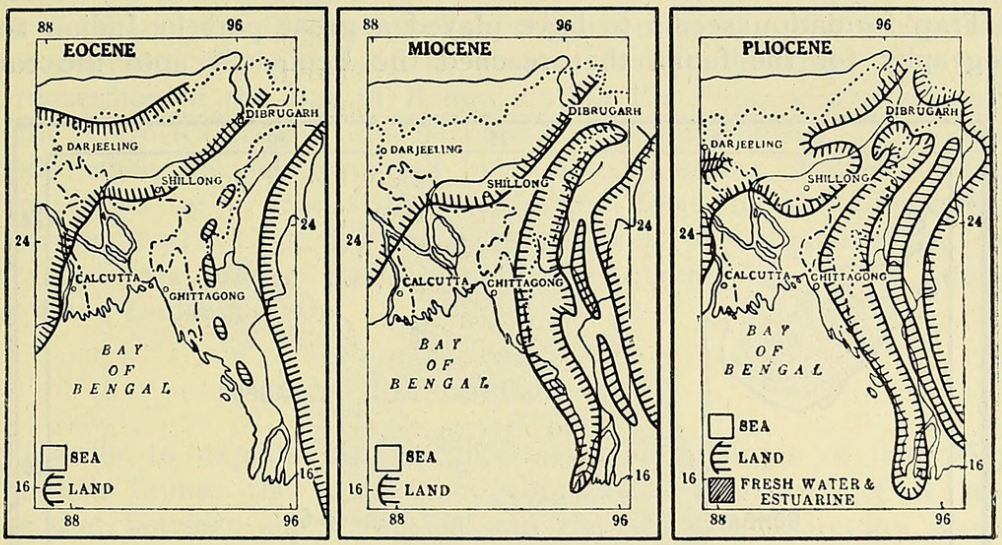
[1] Hora, S. L. & Menon, A. G. K. (1953): Distribution of the Indian fishes of the past and their bearing on the Geography of India. 2. The Extinct Freshwater Teleostean fishes of India. *Everyday Science*, **2**: 105-113.

The western side of the Assam plateau is marked by fracturing which may be connected with the formation of the Garo-Rajmahal Gap. Minor oscillations have occurred even in the Pliocene and Pleistocene times, and these movements may have accentuated the



TEXT-FIG. 2.—The Garo-Rajmahal Gap area under the sea during the Eocene, Miocene and Pliocene periods. After M. S. Krishnan (*Bull. Nat. Inst. Sci., India*, 1: 26-28, 1952).

original faults and made the Gap more pronounced while it was still covered by the sea. It would appear that structurally the Gap is a very old feature of the topography of India,[1] though ecologically it became suitable for the migration of freshwater fishes during the glacial epochs of the Pleistocene.[2] Its present-day physical features seem to have been attained after dismemberment of the Indo-Brahm River when the Ganga and the Brahmaputra began to flow through it to the Bay of Bengal. The fault became filled up through the sediments brought down by these rivers and now the alluvium lies several hundred feet thick at Rajmahal.

Another point which seems clear now is that though the Assam Plateau was uplifted in the Miocene, the area of the Garo-Rajmahal Gap continued to be under the sea during the Pliocene and a greater part of the Pleistocene.

THE DECCAN TRAPS

According to Dr. Krishnan (p. 52), 'The Deccan Traps now occupy some 2,00,000 sq. miles and must have formerly covered a more extensive tract, probably twice the present area. They are regarded as having been erupted from numerous fissures in the crust during a

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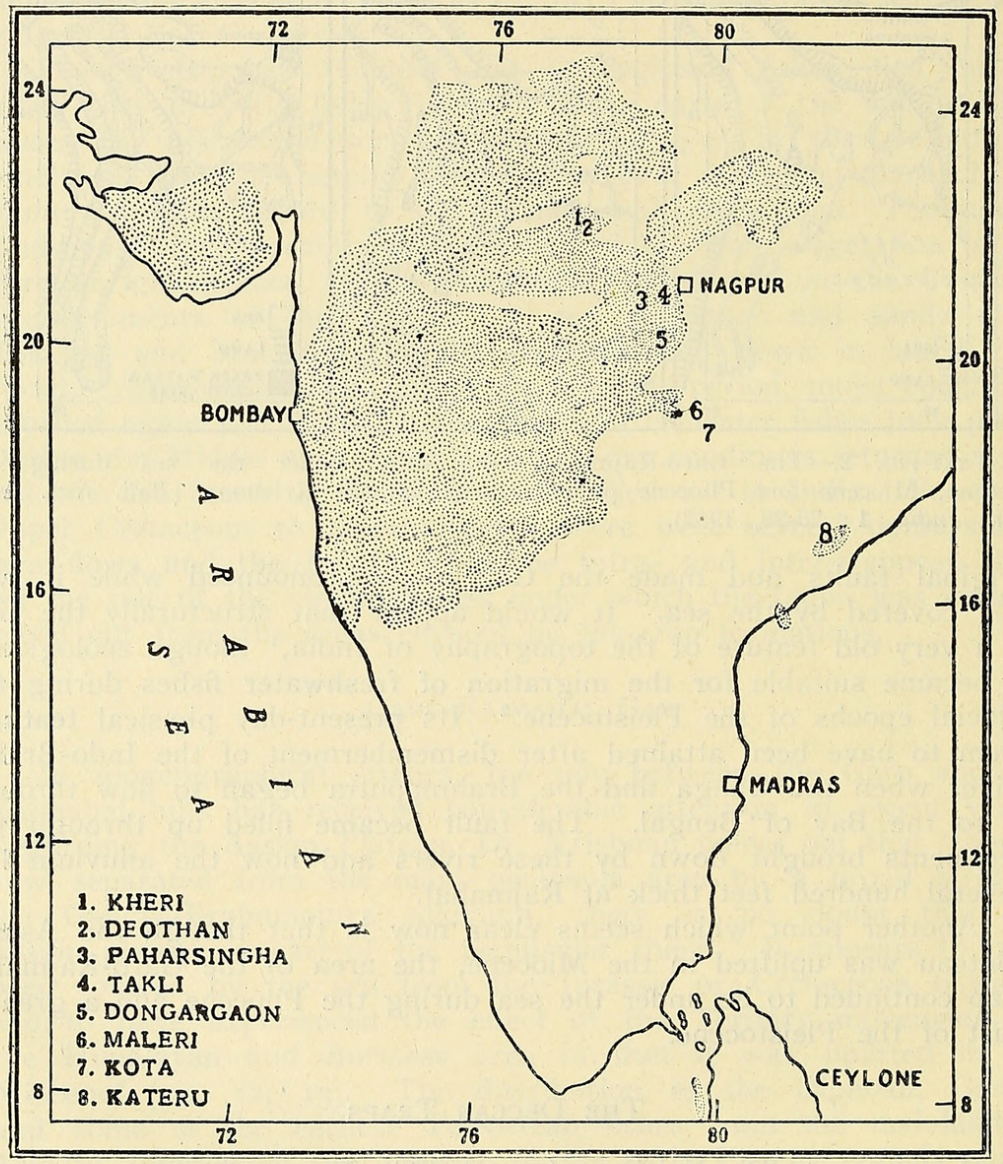
[1] The presence of Lower Gondwana rocks along the western edge of Garo Hills may indicate the possibility of the structural weakness having arisen here in L. Gondwana times, according to Dr. M. S. Krishnan.

[2] Hora, S. L. (1951): Some observations on the palaeogeography of the Garo-Rajmahal gap as evidenced by the distribution of the Malaya fauna and flora to Peninsular India. *Proc. Nat. Inst. Sci., India*, 17 (6): 437-444.

period of tension. They are estimated to have a thickness of over 6,000 ft. near the Western Ghats, but much less in other areas. They must originally have extended also for an unknown distance to the west of India but that part was faulted down in or about the Miocene'.

Trap formation seems to have played a great part in Indian zoogeography for the fauna that reached the Peninsula upto the early



TEXT-FIG. 3.—The present-day extent (shaded portions) of the Deccan Traps with the positions of infra- and inter-trappean fossil beds marked in it. After S. L. Hora (*Proc. Nat. Inst. Sci., India*, 4 (4): 398, 1938).

Eocene period was totally destroyed in the area of the traps which was then perhaps twice its present extent. Some of the early Eocene fishes have, however, persisted in the extreme south of the Peninsula and Ceylon[1] because the Traps did not extend beyond 15°N.

[1] Silas, E. G. (1954): Speciation among the freshwater fishes of Ceylon. *Bull. Nat. Inst. Sci., India*, No. 5 (in press).

latitude in the south. The age of the Deccan Traps is now admitted to be uppermost Cretaceous extending well into the early Eocene period. It was at the close of the Trap formation that transgression of the Bay of Bengal took place and probably severed India's land connection with the mainland of Asia in the Chinese region.[1] Thus there was no new freshwater fish migration to the Peninsula from the north-east till the conditions became favourable again, firstly by the regression of the Bay of Bengal during the Pliocene and secondly by the Garo-Rajmahal Gap becoming dry land during the glacial periods when the sea level fell by 100-200 meters. Later the Gap became filled up by the sediments carried down by the Ganga and the Brahmaputra Rivers. These assumptions are supported by the fact that there are no post-Trappean freshwater fish fossils known from the Peninsula.

Bay of Bengal

In order to explain the so-called Malayan affinities of the freshwater fish fauna, the earlier zoogeographers conceived of a land connection between the Peninsula and the Malayan subregion across the Bay of Bengal. Dr. Krishnan (p. 60) adduces stratigraphical evidence to show that the eastern coast of India took shape during the Jurassic. It is therefore reasonable to believe that an incipient Bay of Bengal had already made its appearance in the Jurassic.

India-Africa Land Connections

There is considerable evidence that during the Pliocene and early Pleistocene the freshwater fish fauna of India migrated to Africa along a northern route,[2] for the main connection over the Peninsula seems to have been cut off when the land beyond the western coast was faulted in the Lower Miocene or earlier. 'Since Middle Miocene rocks have been involved in the downfaulting of the Mekran Sea, the date of faulting may be late Miocene or Pliocene. It may be that the western coast of India was faulted down in Lower Miocene and the faulting extended into the Mekran region somewhat later. Further extension of this faulting into the Persian Gulf and the Euphrates Valley apparently occurred in the Pleistocene' (p. 64). Though the Triassic, Jurassic, Cretaceous and early Eocene waves of migration of freshwater fishes passed over the Peninsula to Africa, only the

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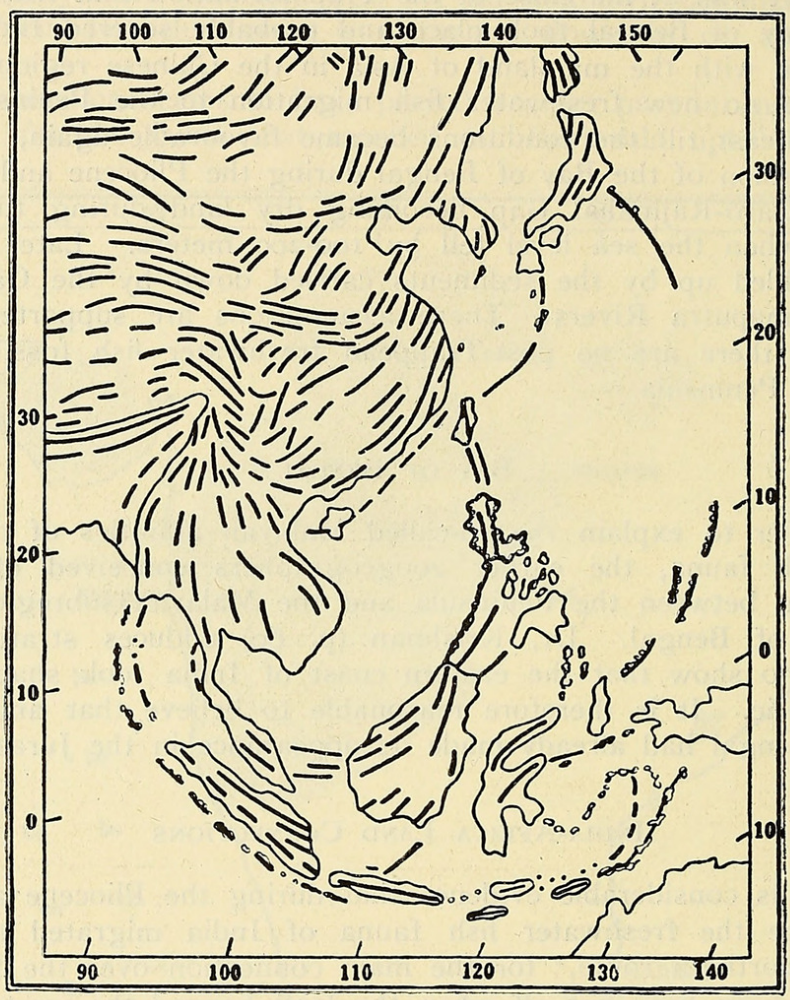
[1] With regard to the migration of the Malayan fauna, Dr. M. S. Krishnan states 'that a ridge was formed (which is now the Arakan ranges and their continuation) during early Eocene, and it was apparently uplifted further during the successive pulses of the Alpine Himalayan movements. This separated Assam from Western Burma in both of which marine conditions continued till much later in the Tertiary period. This parting ridge, or rather its base, will have provided the land connection necessary for migration of freshwater and torrent loving fishes'.

[2] Wiseman, J. D. H. & Sewell, R. B. S. (1937): The Floor of the Arabian Sea. *Geo. Mag.*, **74**: 219-230.

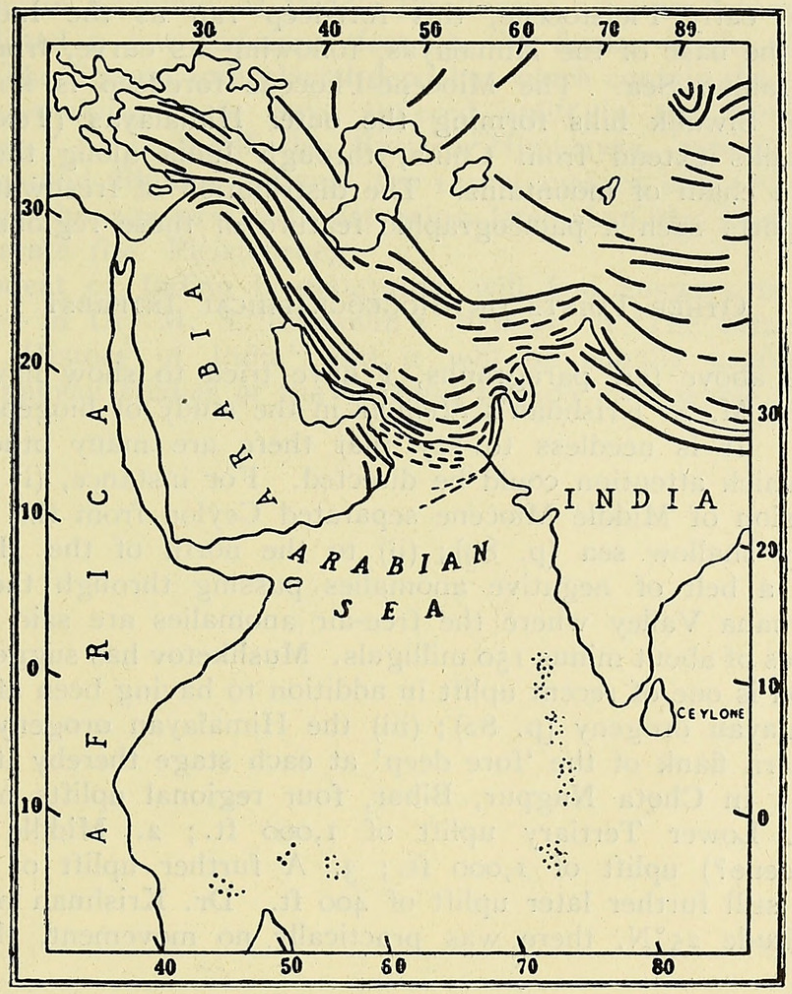
northern route was available when the freshwater fishes appeared again in the Pliocene.



TEXT-FIG. 4.—Radial distribution of mountain arcs of south-east Asia, the pivotal point being the Assam syntaxis of the Himalayas. Modified after M. S. Krishnan (*Mem. Geol. Surv., India*, **81**: 25, 1953).

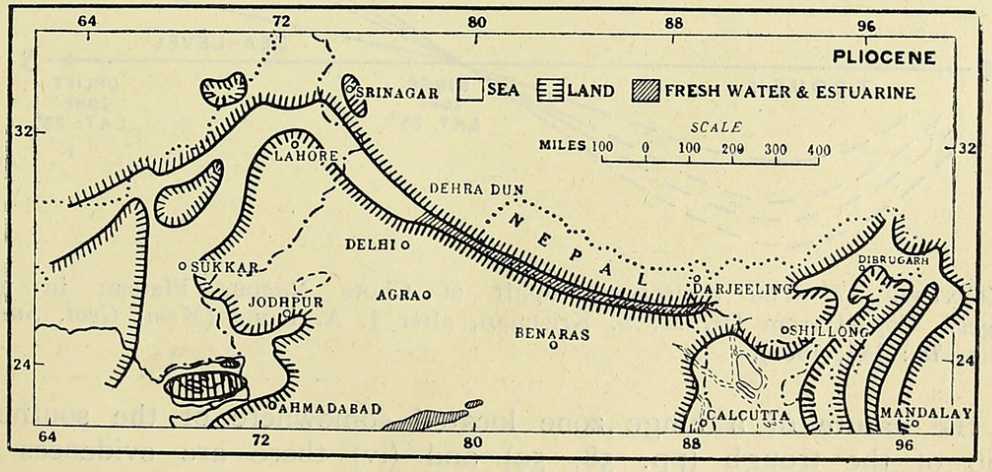
RADIAL DISTRIBUTION OF SOUTH-EAST ASIATIC FRESHWATER FISH FAUNA

Fish geographical studies carried out in the Zoological Survey of India since 1937 have shown that the freshwater fish fauna of south-east Asia is radially distributed from the south-west Chinese or Yunnan region. This is due to the pattern of distribution of the mountain arcs of southern Asia. Dr. Krishnan's map on p. 25 (Text-figs. 4 and 5) brings out this radial distribution in a remarkable way and beautifully explains the dispersal of the torrential fishes of this part of the world. When a mountain arc is uplifted a foredeep is usually formed at its base which would account for the radial distribution of the sluggish water fishes also. For instance, the alluvium-filled trough through which the Ganges flows in the North Indian plains is of the nature of a foredeep, a slight buckling down of the upper crust in front of the convex mountain arc. The



TEXT-FIG. 5.—Continuation of the Himalayan arc westwards into the Alpine system. Modified after M. S. Krishnan (ibid, **81** : 25).

Brahmaputra Valley in Assam is a continuation of the same feature. The thickness of the alluvium is variously estimated to be between 6,000 to 10,000 ft.

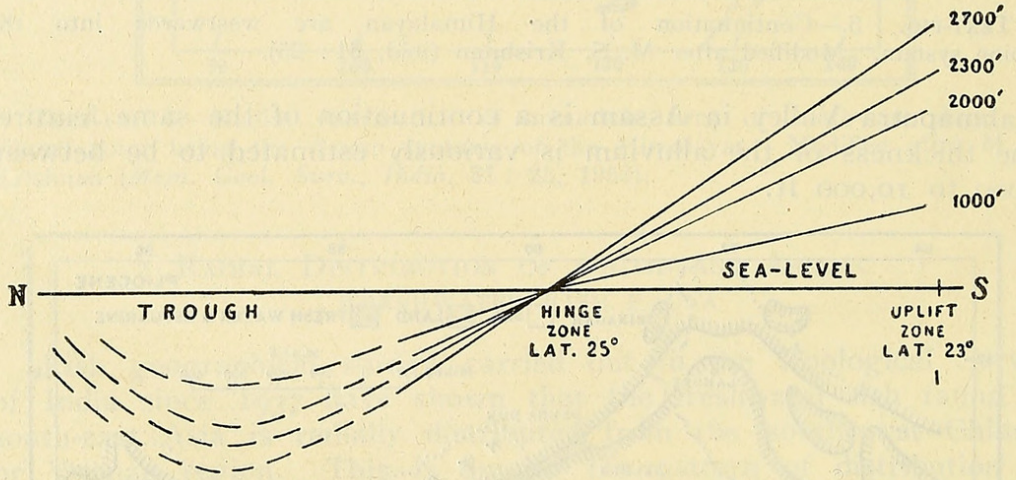


TEXT-FIG. 6.—Pliocene foredeep of Himalayas which later gave rise to the Siwalik Hills and during Pliocene helped in the distribution of freshwater fishes from east to west. After M. S. Krishnan (*Bull. Nat. Inst. Sci., India*, **1** : 28, 1952).

In the early Pleistocene, this foredeep ran as the Indo-Brahm River at the base of the Himalayas, following its curve, from Assam to the Arabian Sea. The Miocene-Pliocene foredeep is now raised up as the Siwalik hills forming the outer Himalayas (Text-fig. 6). The Siwaliks extend from China, through India along the Alpine-Himalayan chain of mountains. The distribution of freshwater fishes fully supports such a palaeographic feature of these regions.

Other Points of Biogeographical Interest

In the above few paragraphs, I have tried to show how helpful can be Dr. M. S. Krishnan's *Memoir* in the study of biogeographical problems. It is needless to say that there are many other points in it to which attention could be directed. For instance, (i) a marine transgression of Middle Miocene separated Ceylon from the mainland by a very shallow sea (p. 89); (ii) to the north of the Himalayan region is a belt of negative anomalies passing through the Pamirs and Ferghana Valley where the free-air anomalies are said to attain magnitudes of about minus 150 milligals. Mushketov has suggested that this region is one of recent uplift in addition to having been affected by the Himalayan orogeny (p. 82); (iii) the Himalayan orogeny affected the southern flank of the 'fore deep' at each stage thereby it suffered elevation. In Chota Nagpur, Bihar, four regional uplifts have been noted—1. Lower Tertiary uplift of 1,000 ft.; 2. Middle Tertiary (Mid-Miocene?) uplift of 1,000 ft.; 3. A further uplift of 300 ft.; and 4. A still further later uplift of 400 ft. Dr. Krishnan notes that along latitude 25°N. there was practically no movement, this being



Text-fig. 7.—The epeirogenic uplift of Chota Nagpur Plateau in four stages. Copied from Dr. M. S. Krishnan, after J. A. Dunn (*Mem. Geol. Surv., India*, **73**: 141, 1939).

of the nature of a hinge zone located somewhere of the southern limb of the trough (pp. 58, 59) and (iv) there are evidences of the recent uplift movements of the Himalayas. For instance, the Siwalik Zone bordering on the Gangetic plains is thrust over by the Miocene rocks in the Kalka region below Simla. The Karewa

formations in Kashmir, of Middle Pleistocene age, are known to have been uplifted a few thousand feet on the flanks of the Pir Panjal range. The Second Interglacial deposits, which contain the remains of early tool-making man, have suffered uplift in the North-western Himalayas. In parts of the Eastern Himalayas, especially in the Darjeeling and Bhutan regions, the thrust masses have advanced on the plains, the age of the thrust being later than the Upper Siwalik Conglomerate (i.e. Pleistocene).

A student of Indian biogeography will find answers to many of his riddles in Dr. M. S. Krishnan's *Memoir* on 'The Structural and Tectonic History of India' and it will be equally useful for the zoogeographical studies of the Oriental Region as a whole.