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FISH DISTRIBUTION AND CENTRAL ASIAN OROGRAPHY

IT has been maintained[1,2] that the Yangtze Kiang basin was upraised 6,000′ to 10,000′ in very recent geological times, similar opinions being advanced by Deprat (not consulted) for Tongking and Eastern Yunnan. These conclusions were supported by lack of any evidence of glaciation, and of canyon formation by the rivers of Yunnan and Western China; but Gregory and Gregory[3] considered these reasons inadequate "for so great an uplift at so recent a date". In their opinion, "Any change in rivers by which their currents become swifter and their fall steeper enables them to wear away their beds. This change may be produced on a high plain by the subsidence of the surrounding country or of deep internal basins." Therefore, "The evidence of the glaciers of Chinese Tibet is rather in favour of a subsidence of the area than of its uplift."

Dr. M. S. Krishnan, Director, Geological Survey of India, from whom I have had much friendly help, favours the possibility of quaternary uplift. "The Middle or Upper Miocene", he informs me, "is thought to be the period of the greatest comprehensive movements, but this actual uplift due to isostatic compensation in the crust took place during the Pliocene or even later. While it is possible that the last uplifts of Central Asia took place in the Pleistocene, we cannot be sure whether a larger part of the elevation was not attained during the Pliocene". He added that as "Parts of Yunnan

and S-W. China were in a tertiary orogenic belt, there is no reason why the uplift could not be as late as the Pleistocene or Sub-Recent."

There seems to be no way of resolving this controversy without further evidence, which I believe, can be found to a large extent in relevant zoogeographical studies. An analysis of the distribution of the fresh-water fishes of South-East Asia is accordingly presented here as a contribution to this problem. It supports the theory of recent uplift in the regions considered.

Geography of the Fish-Fauna of South-East Asia

The distribution of the fresh-water fishes of South-East Asia[4] suggests that the centre of dispersal of this remarkable fauna can be traced to south-west China, particularly Yunnan. It is so rich and highly diversified that there must have been favourable ecological conditions for it to flourish and speciate. Moreover, as this fauna now extends to Africa in the west, to Ceylon and the Malay Archipelago in the south, to Formosa and the Philippine Islands in the east, and to the Tien Shan Mountains and the Central Asiatic Highlands on the north, the questions of its age and periods of dispersal are of considerable general interest.

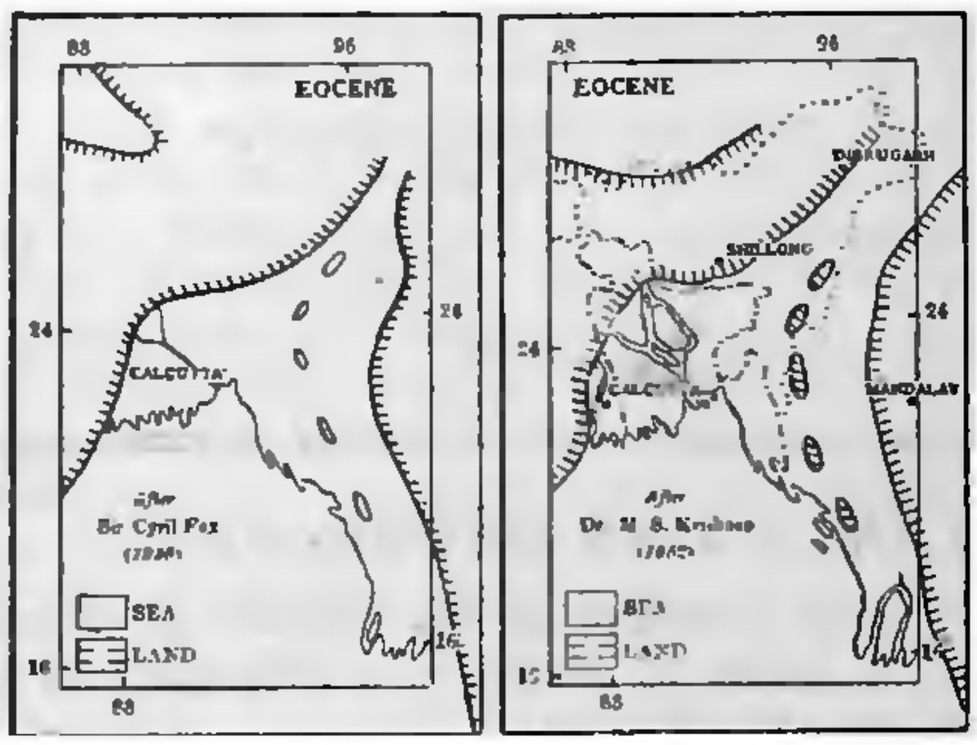

FIG. 1. The Bay of Bengal during Eocene Times

Geographically, it can be divided broadly into two groups: the trans-Himalayan fauna and the cis-Himalayan fauna. Day,[5] Stewart,[6] and Hora[7] have shown that there is no noteworthy similarity between the fish-faunas of the northern and southern faces of the Himalayas: a few forms characteristic of the Asian Highland are found to the south of the Himalayas, but none of the typical southern forms is found in the trans-Himalayan areas of the region. Of course, according to our present taxonomic knowledge, allied or identical genera are found in both the regions, but they look very different from one another and need more critical evaluation.

Tertiary Barriers to Dispersal

Geologists tell us that during the Eocene and Miocene periods there was an arm of the sea separating India from Burma (Figs. 1, 2),

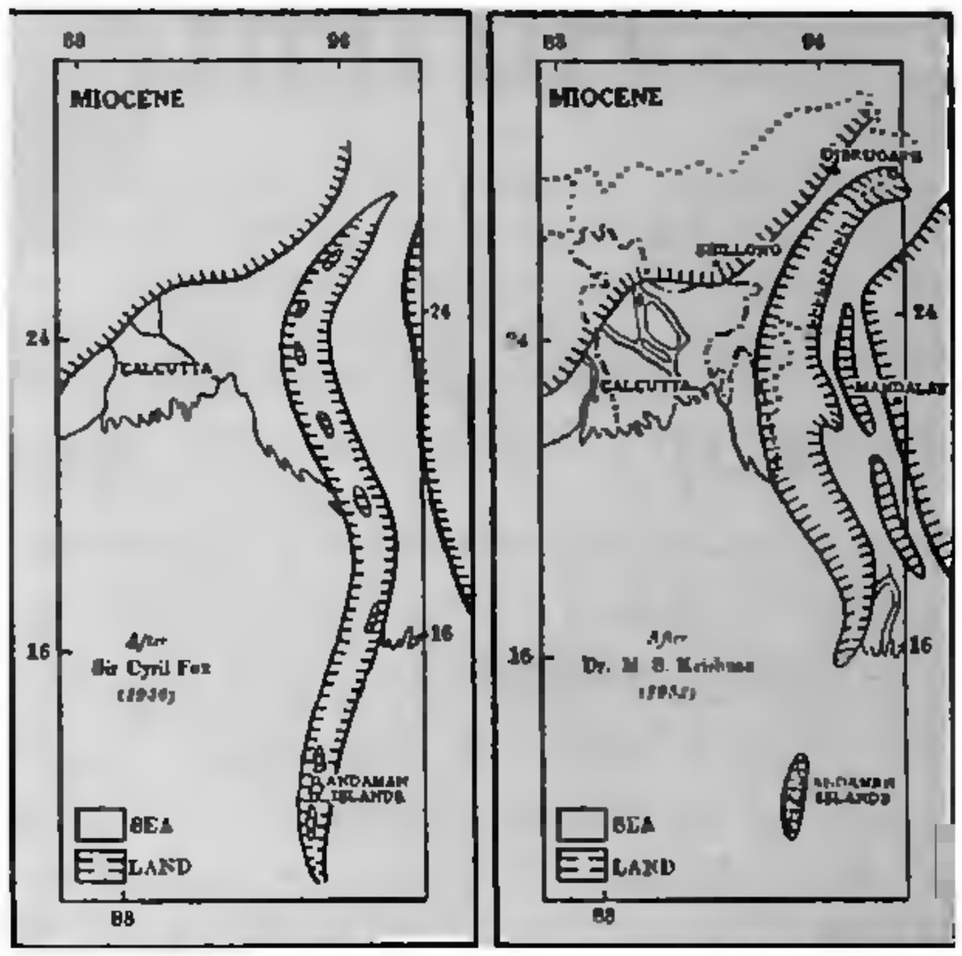

FIG. 2. The Bay of Bengal during Miocene Times

though Dr. M. S. Krishnan informs me that there is no evidence that "the Mishmi Hills region (E and NE of Sadiya) was the sea at all in the Upper Tertiary, even if we take it that the Tethys extended over it and into Burma up to the end of the Eocene". Even so, the dispersal of fresh-water fishes from Yunnan to India could not have been possible during these periods, and there is no contrary palæontological evidence.

The climate during these periods was probably temperate and equable, for the hot and moist winds from the south could then blow through the gap and over the northern regions. Dr. S. K. Banerji (former Director-General of Observatories, India), supports this view. After analysing the geological evidence, he informed me that: "Our present arctic regions were, during Eocene times, in about Lat. 45° N., and the lower part of the Archiboreis (Asiatic Block) was on the equator. The low pressure system during summer was apparently in the central part of this block, which caused an air-drift from the Thetis, as well as from the Pacific Ocean. At this time Yunnan was much nearer the equator than it is at present. The statement that hot and moist winds from the Tethys rendered the climate temperate and equable thus appears to be reasonably correct."

The effects of such a climate need little comment. In general they are conducive to the maintenance and gradual spread of animal species, but they do not enlarge the biological conditions and pressures that provoke migrations. This is especially true of fresh-water fishes.

The Beginnings of Dispersal

In the Pliocene the picture changes (Fig. 3). The major upheaval of the Himalayas, which

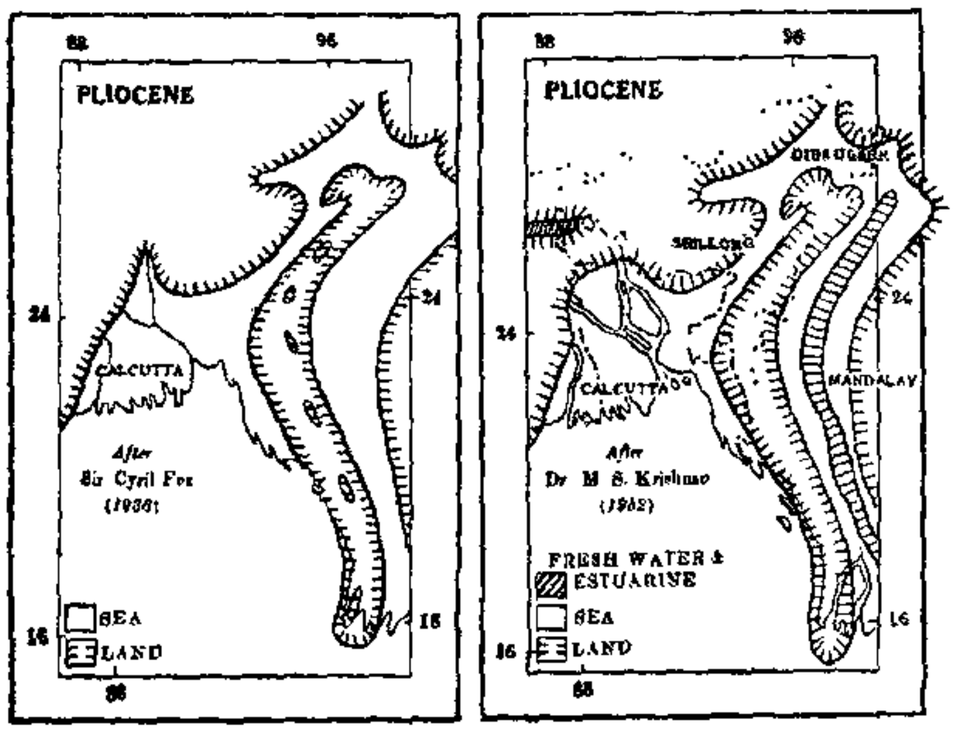

FIG. 3. The Bay of Bengal during Pliocene Times

seems to have occurred towards the close of the Miocene or early in the Pliocene, probably rendered the arm of the sea shallow and may have cut it up into brackish water lakes and lagoons. With the advance of time, and concomitant with the Himalayan uplift movements, marshy conditions corresponding to those of the Siwaliks seem to have been established in this area.

Marsh-loving and sluggish-water fishes could now migrate to India. We know definitely that they did so from the occurrence of Bagrid fishes of the genera *Chrysichthys*, *Mystus* and *Rita*, Clariids[8] of the genera *Clarias* and *Heterobranchus*, and various *Ophicephalids*, in the Siwalik rocks of India.

Low hills also made their appearance in the Pliocene. This is indicated by the occurrence of *Bagarius*, a characteristic hill-stream catfish of the family Sissoridæ, in the Siwalik formations. It is found in south-west China, and is clearly a migrant from the Malayan region, where it is known from the tertiary deposits of the highlands of Padang in Sumatra.

The Pliocene climate of the Central Asian region, particularly south-west China, remained temperate and equable, while the area it affected was flat and fairly low. This can be inferred from the topography of the area between south-west China and India (Fig. 3) at that time, as well as the ecological requirements of the fishes that then migrated to India in fact, the nature of these fishes suggests that the climatic and topographical conditions of the period were somewhat similar to those now prevailing in Bengal.

It follows that the totality of the influencing Pliocene circumstances produced new environmental dynamics favourable to the migration of many species, but the westwards dispersal of the remarkably adapted torrential fishes is a much later phenomenon.

Pleistocene Conditions and Fish Dispersal

There is abundant geological evidence that there was another major uplift of the Himalayas after the Pliocene. Therefore, the closing of the marine, estuarine and marshy gap between India and the countries to the east and north must have taken place during the Pleistocene.

The effect of this upheaval on the monsoons, which have an evident bearing on the ecology of fresh-water fishes, also concerns our argument. For the monsoons, as we know them in India to-day, could not have been established till their passage to the Central Asiatic region had been blocked by a mountainous barrier in the north-east; and Central Asia would accordingly have remained wetter and more favourable to fish-life than it is now.

Meteorological confirmation of this point again comes from Dr. S. K. Banerji, who writes (*in litt.*) that "The south-west monsoon in its present form apparently commenced to be established at the close of the Würm glaciation, that is about 20,000 years ago. But the temperature conditions that prevailed 10,000 years ago, as deduced from Milancovitch's curves, would strongly support your argument about the comparatively recent dispersal of fishes along the Western Himalayas". He also stated that the present monsoon system must have developed when the Himalayas attained a height of 10,000′ to 15,000′, which is roughly the depth of the south-west monsoon current.

Moreover, during the Pleistocene, there was periodic refrigeration and five periods of glaciation,[9] each one of which lasted several thousand years. In the Western Himalayas (Kangra Valley), according to Wadia,[10] the glaciers seem to have descended below 3,000′. In the Eastern Himalayas (Sikkim and Naga Hills), Blanford[11] recorded moraines, on the evidence of W. T. Blanford and H. H. Godwin-Austen, from elevations of 6,000′ and 4,500′.

Consequently, the fish-fauna, if any, of the southern slopes of the Himalayas must have

been exterminated at higher altitudes during the glacial periods. Only a few forms, which have been either introduced or have means of migration, are now found at higher elevations, though fishes are found in some abundance and variety at lower elevations. The lakes and rivers of Central Asia, on the other hand, support a uniform but fairly rich fish-fauna, which seems to have escaped all the periods of Pleistocene glaciation or intense refrigeration. Their survival strengthens the view that the Central Asian region was at a quite low level even during the last glacial phase, and that its uplift took place during the last 10,000 to 15,000 years. The Central Asian fish-fauna is thus an antecedent fauna so far as the recent uplift is concerned.

The Evidence of the Schizothoracine Fishes

This assumption gains from the fact that the remains of typical Central Asiatic Schizothoracine fishes have been found in the Karewas of Kashmir.[12] According to de Terra,[13] the remains of the Schizothoracine fishes came from an exposure of Lower Karewa beds of the first interglacial period (approximately 560,000 to 500,000 years ago), which indicates the differentiation of the Central Asian fish-fauna about the middle of the Pleistocene. It should be noted, too, that the Karewa fossils were laid down in the bed of a lake or sluggish river at a much lower elevation; and were, as Sahni[14] writes, "*lifted out* of their original horizontal position and upheaved through at least 5,000' with the (geologically speaking) recent upheaval of the Pir Panjal Range".

The first glacial period, through eustatic changes in the sea-level,[15] seems to have produced a false uplift of a few hundred feet, thereby increasing torrential conditions in the streams of the young Himalayas and the adjoining regions. During this period, the Schizothoracine fishes seem not only to have spread along the northern face of the Himalayas, but a representative of the primitive stock also crossed the flat strip between the Garo and Rajmahal Hills, which we call the Garo-Rajmahal Gap. It came down the Western Ghats to the Periyar Lake of Travancore, where it developed, through isolation, into a new genus recognisably descended from its *Schizothorax*-like ancestor. Sundara Raj[16] gave the fish providing this remarkable case of discontinuous distribution the name *Lepidopygopsis typus*; and pointed out that it occupies an intermediate position between the primitive and nearly related genera *Paratylognathus*[17] and *Schizothorax*, and such specialised genera as *Schizopygopsis* and *Gymnocypris*.

The differentiation of *Lepidopygopsis* can be simply explained. The primitive Schizothoracine stock that migrated to Peninsular India during the first glacial period had ample time to diverge from the stock that remained in Central Asia, particularly since the streams of the Peninsula were rejuvenated during the Pleistocene owing to a west-to-east tilt not amounting to actual uplift.[18]

Conclusions and Implications

From the above evidence it would appear that in bulk the modern Ostariophysi (carps and catfishes) made their appearance in India in the Pliocene,* when the marine gap between India and south-west China had become a marshy area. *Bagarius*, a fish normally living in the deeper waters of rapids and cascades, also appeared about the same time; but the Schizothoracinæ came later and did not become widely distributed until the first glacial period of the Pleistocene. Fishes characteristic of the smaller torrential streams have a more or less parallel history of emergence in the early Pleistocene and wide distribution during its first glacial period, their present occurrence at lower elevations throughout their range being suggestive of their evolution in, and dispersal through, streams at lower altitudes. Radial dispersal of this remarkable fauna from Yunnan strongly favours the theory that this area was uplifted in geologically recent times.

The acceptance of this view involves some interesting general implications. For example, it would place the migration of the supposedly Aryan pre-historic peoples inhabiting the plateau of Central Asia somewhere between 7,500 and 10,000 years ago, because the last glaciation, which commenced about 18,000 years before the beginning of the Christian era, seems to have lasted for nearly 10,000 years. The Central Asian region must have been at a low level during this last glacial period, thereby permitting the survival of its fish-fauna and human populations.

Finally, the major evolutionary thesis prompted by the orographic history of the regions considered is that the relatively recent uplifts pro-

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* I have recorded, *Rec. Geol. Surv. India*, 1938, **73**, 267-94, an incomplete Cyprinid scale from the Inter-Trappean beds of Deothan and Kheri, but was not able to assign to it any generic position. It is probable that early in the Eocene Cyprinoid fishes entered India through the then existing Cretaceous land bridge between India and China.

vided a dynamic environment conducive to migration, isolation and rapid speciation. The rich and very diverse fauna and flora of south-east Asia becomes more understandable in the light of this theory. Particular studies have accordingly been designed, with encouraging results, to prove its validity ; but their discussion belongs to another and later synthesis.

Zool. Survey of India, SUNDER LAL HORA.
Calcutta.

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PREDICTION OF ELECTRONIC FAILURES

A RELATIVELY unexplored approach to the problem of insuring higher reliability of electronic equipment is being investigated at the National Bureau of Standards, U.S.A. A technique has been evolved experimentally in which a maintenance man simply plugs a portable failure-prediction unit into the slightly modified equipment to be checked and turns a multi-point selector switch ; a red light flashes on to identify stages or components that have deteriorated below safe levels and have become prospective causes of equipment failure.

Failure of electronic equipment to function properly may be caused either by sudden or by gradual failure of a tube or other component. Although improvement of quality seems to be the only way to reduce sudden failures of components, surveys have indicated that at least half of all equipment failures are produced by gradual deterioration of components The NBS work has been concerned with practical means of spotting these gradual failures before the equipment becomes inoperative. The success of the experimental work at NBS suggests that provision for simple failure-prediction routines for the maintenance of important electronic equipment deserves the serious attention of design engineers.

COBALT 60 TO REPLACE RADIUM FOR CANCER THERAPY

A COBALT 60-beam therapy unit, a gift to Britain from Canada, is shortly to be installed at Mount Vernon Hospital, Northwood, Middlesex. The unit is described as being 200 times more powerful than the radium units in use at present. It is more stable, more reliable and simpler to control than super-voltage X-ray machines and might prove more effective in the control of cancer. It is expected to treat deep-seated, internal, inaccessible tumours which so far have proved beyond the effective range of existing apparatus. A further advantage of the unit is that a greater quantity of radiation could be delivered to the tumour with less damage to the surrounding normal tissues and less disturbance to the general state of the patient.

Cobalt 60 is produced by the exposure of natural cobalt in the nuclear reactor or atomic pile. It is particularly suitable as a substitute for radium in some methods of application. The cobalt itself is relatively cheap and readily obtainable. The cobalt 60 source in the units is a disk only 1" in diameter and ½" thick. The beam of radiation could be compared in penetrative power to that produced by an X-ray machine working at three million volts. The cobalt 60 deteriorates to half its original intensity in just over five years, and it is, therefore, necessary to arrange for reactivation in a nuclear reactor at regular intervals. The cost of a radium unit of such activity would be well over one million pounds, as compared with a cost of £ 25,000 of the cobalt unit.