

HORA'S SATPURA HYPOTHESIS¹

An Aspect of Indian Biogeography

IT is fortunate that within a few months of each other, two important contributions² on biogeography, independently conceived and executed in each case by a team of scientists, have been published recently, enabling one to check his results against the findings of the other group of workers. One published in September 1949 in the U.S.A. deals with "Biogeography of the Pleistocene" by Dr. Edward S. Deevey, Jr. of the Yale University. This is one of the 12 contributions on "Pleistocene Research" and deals mostly with the problems of Europe and North America. The second contribution is more restricted in its scope, but the "Symposium on the Satpura Hypothesis of the Distribution of Malayan Fauna and Flora to Peninsular India", published at Calcutta in November-December 1949, contains a series of 21 articles.

Dr. Deevey points out that "from the standpoint of Pleistocene biogeography, North America and Europe resemble each other closely, and differ in the character of their problems rather sharply from Africa, Southeastern Asia, and South America" (p. 1404). Though admittedly the characters of the problems in the two vast regions are different, the fundamental scientific approach for elucidating these problems appears to be the same in both cases. For instance, in both the contributions, attention has been paid not only to the present-day distribution of animals but also to geology, stratigraphy, climatology and glaciology in so far as they have influenced the pattern of distribution in the past ages. In this review of the two contributions, it is intended to apply some of the principles enunciated in the Symposium on "Pleistocene Research" to the findings contained in the Symposium on the "Satpura Hypothesis".

CERTAIN VIEWS SET FORTH IN THE "PLEISTOCENE RESEARCH" SYMPOSIUM

Effects of Glaciation.—Considering the problems of North America and Europe, Deevey stated (p. 1404):

1. This review was sent to Professor F. E. Zeuner for comments and suggestions. His observations are given in the body of the paper in brackets or as foot notes. The reviewer is grateful to him for his kindness and courtesy.

2. "Pleistocene Research," *Bull. Geol. Soc. America*, Sept. 1949, 10, No. 9, 1305-1525.

"Satpura Hypothesis," *Proc. Nat. Inst. Sci. India*, Nov.-Dec. 1949, 15, No. 8, 309-422.

"As would be expected, the two continents where continental glaciation occurred on the most extensive scale differ from the rest of the world where glaciation was confined to high mountains, and where the more spectacular climatic changes during the pleistocene were in the direction of increased precipitation rather than refrigeration".

In dealing with "Problems of Pleistocene Stratigraphy" and in this connection with the "stratigraphy of areas remote from and only indirectly associated with Glaciation", Ray¹ (p. 1469) observed:

"In areas far from glaciated regions where there are no direct means of correlating events with ice advances and recessions, the problems of Pleistocene stratigraphy are manifold and difficult. Their solution must be based ultimately on climatic fluctuations which in these areas were generally not so large nor so important an environmental factor as in glaciated areas or the areas peripheral to glaciers. These climatic fluctuations appear to have produced either intensified or lessened precipitation along with temperature changes. Cool-moist periods are generally correlated with glacial ages, warm-dry with interglacial".

Other observations bearing on the Satpura Hypothesis.—Beside the effect of glaciation in areas remote from it, there are five other considerations which must also be borne in mind in evaluating the Satpura Hypothesis. These are as follows:—

(i) It is generally recognised that there was a sequence of four major glacial ages, separated by interglacial ages as warm or warmer than the present.

(The major glaciations separated by interglacials relate to what is today the temperate zones of the northern hemisphere. This rhythm has not been firmly established yet anywhere else. *F. E. Zeuner*).

(ii) In Pleistocene stratigraphical work, it is generally assumed that climatic fluctuations were broadly synchronous throughout the world.

(You rightly say that it is assumed that climatic fluctuations were broadly synchronous throughout the world. It is important to remember that this is an

1. Ray, L. L., "Problems of Pleistocene Stratigraphy," *Bull. Geol. Soc. America*, 1949, 60, 1463-74.

assumption and that it has never been proved. This refers in particular to glaciations in the northern and southern hemispheres respectively. Personally I think that it is more likely than not that they were synchronous, but we must be honest and admit that it has not been proved, in spite of all the sweeping statements to this effect. *F. E. Zeuner*).

(iii) Climatic fluctuations during the Pleistocene caused fluctuations of sea level in response to the amount of water withdrawn from the oceans and temporarily held in glaciers on the land.

(iv) Besides the normal crustal movements throughout the world, crustal warping and rebound in glaciated and peripheral regions, occasioned by the loading and unloading of the crust with ice, also occurred

(v) Relict floras and faunas generally indicate that the present-day climatic conditions of their habitats are more or less similar to those prevailing in the past ages in those specified areas.

Ecological Specificity of Animals: Biological and Physical Environment.—Besides the above considerations, it is essential in biogeographical studies "to evaluate qualitatively the importance of the adaptations to environmental changes produced through climatic fluctuations, it is essential to know, (1) the magnitude of these fluctuations necessary to change the environment significantly, and (2) the relative sensitivity of fauna, flora, soil, erosive processes, and other factors to these changes. Until more is known of the relative sensitivity of the various indicators of climatic fluctuations, interpretation of the past can be only subjective". (*Ray*, p. 1470).

It is true, as pointed out by *Ray* (p. 1469) that "changes in floral assemblages will be correlative with faunal changes", and that "commonly migrations in altitude of the fauna is the only indication of climatic change unless extinction of the species is known". (*Ray*, p. 1470). It would thus appear that "all life, the environment, and the attendant physical processes were influenced by the sequence of climatic fluctuations on which Pleistocene stratigraphy ultimately must be based" (*Ray*, p. 1471).

*Smith*¹ (p. 1486), in dealing with the effects of Pleistocene climatic changes, has remarked:

"Climatic effects in nonglaciated areas are recorded in two main types of phenomena:

¹ *Smith*, H. T. U., "Physical effects of Pleistocene climatic changes in non-glaciated areas: eolian phenomena, frost action, and stream terracing," *Bull. Geol. Soc. America*, 1949, 60, 1485-1515.

biologic and physical. Investigations of the biologic phenomena, involving the migration and progressive modification of floras and faunas, are fundamental and are dealt with elsewhere in this series of papers. The evidence provided by purely physical phenomena complements the biologic record and, in many places where fossils are absent or inadequate, provides the primary basis for interpretation of former climatic changes. Of the various physical effects related to climatic fluctuations, three are of particular interest for the problems which they present and for their significance in the interpretation of the Pleistocene record: (1) eolian phenomena, including dune building, loess deposition, and sand blasting; (2) frost phenomena, including mechanical weathering, ground-ice development, solifluction, and associated processes; and (3) stream terracing produced by alterations between aggradation and degradation".

Deevey's fundamental conceptions and principles—In his valuable contribution, *Deevey* has referred to certain biological deductions and principles which are well worth reiteration. These are:

1. Species spread much or little according, first, to their inherent abilities to disperse, and second, to the intensity of the geographic barriers opposing them.
2. Existing ranges of species and of larger groups are the product not of existing geographic conditions, but of all geographic conditions obtaining throughout the history of the species or stock. It is fallacious therefore, to assume that the existing distribution pattern of the species is as old as the species itself, or as the genus or family to which it belongs. It is true, however, that in the case of species that arose in the pre-Pleistocene period, during the Pleistocene "there has been sufficient time, and sufficient transfiguration of geography, for the pre-Pleistocene distribution pattern to be completely transformed in a very large number of cases".
3. Pleistocene biogeographical studies are bipolar. "At one pole are grouped ecology, systematic botany and zoology, the study of evolution, and related biologic disciplines. At the other pole are grouped the Earth sciences, all of which are concerned in understanding the geography of the Pleistocene". Pleistocene research is,

however, one integrated subject, pursued in equal partnership by biologists and geologists in the widest sense.

4. "A few kinds of animals, and perhaps a few plants really seem to require continuous land connection for their dispersal, and it is impossible to imagine their crossing a water gap".
5. Recolonization is not so much a matter of accident as of ecological succession. As soon as living conditions are suitable for the survival of an animal species, that species appears.

In order to explain his fundamental position on matters of biogeography, Deevey has set forth the following guiding principles:—

1. Biogeography should deal with species, not with families or orders.¹
2. The age of a distribution pattern is not necessarily the same as the age of a species.
3. All distributions of species are taken to be of Pleistocene date in the absence of a good proof that they are older.²
4. The present range of the parent species is not necessarily the place of origin of the off-spring species.
5. Modern genetic and ecologic theories are in full agreement that species do not arise from other species except through reproductive isolation of segments of a parental population, and that in sexually reproducing animals and plants the reproductive isolation is ordinarily achieved through geographic segregation. . . . Nearly all well-studied cases of sub-speciation and speciation point to the Pleistocene as the time of such previous isolation, and the

1. This is undoubtedly an over-generalisation. What the author really means is that we should work with as detailed information as possible and therefore descend to the species and sub-species level wherever possible. This is a matter-of-course for every serious worker and has always been so in biogeography. On the other hand, there are problems which are peculiar to the higher systematic units. As an example, the distribution of palms or of reef-building corals can, and ought to be, considered on the level of families or orders.—F. E. Zeuner.

2. This is a very narrow outlook indeed, borne from the consideration of glaciated and periglacial areas. In other parts of the world it would be foolish to make any such dogmatic assumption and in recent years much evidence has been accumulating indicating that both species themselves and distribution patterns in some countries are often very much older than the Pleistocene.—F. E. Zeuner.

occurrence of closely related forms in the same area is therefore attributed to post-Pleistocene alterations in geography and in biogeography.

APPLICATION OF THE ABOVE CONSIDERATIONS TO THE SATPURA HYPOTHESIS

Distribution and Ecology of the Present-day Fauna and Flora.—Of the 21 papers, included in the Symposium on the Satpura Hypothesis, as many as 10 papers deal with the distribution of animals (Mammals, Birds, Chelonians, Snakes, Lizards, Fishes and Annelids) and 2 with plants (Paresnath Hill and Bailadila Range). The authors of these papers, dealing with races, sub-species, species and genera, have conclusively established that—

- (i) There is a considerable element of the so-called Malayan fauna and flora in the Peninsula of India and Ceylon.
- (ii) The route of migration of this element lay across the Garo-Rajmahal Gap (from the Assam Hills and Eastern Himalayas on the one hand and the Plateau of Chota Nagpur on the other).
- (iii) From the Chota Nagpur Plateau, there are possibilities of two routes of migrations — Vindhya-Satpura-Western Ghats route and Orissa Hills—Eastern Ghats-Western Ghats route.
- (iv) The specialized flora and fauna are adapted to an evergreen biotope with considerable annual rainfall, about 100 inches or so, spread over a greater part of the year.
- (v) Altitudinal distribution of plants and animals is not so much governed by temperature as by annual precipitation and relative humidity throughout the year.
- (vi) The present-day distribution patterns of various species are governed by ecological considerations and along the routes, wherever and whenever suitable habitats have been investigated, fresh evidence of such migrations has been established.
- (vii) In the case of birds and fishes, it has been opined that the present element in the hills of Peninsular India, is the result of more than one wave of migration.
- (viii) The compositions and inter-relationships of the floras and faunas indicate that migrations of terrestrial forms occurred mostly during the Pleistocene, whereas the dispersal of the

aquatic forms has been going on from much earlier periods.

Climatology.—The two articles dealing with climates have also emphasized the ecological specificity of the fauna and flora being mostly responsible for their dispersal in the past and the present-day distribution pattern. It has also been concluded that during the pluvial periods increased precipitation produced favourable conditions for the dispersal of plants which later contributed to the dispersal of land animals. During the arid or inter-glacial periods, the floras and faunas became restricted to certain suitable areas and thus isolated in patches. This inhibited inter-breeding of isolated stocks, thereby causing speciation. Sometimes the species, thus isolated, had sufficient time to be differentiated and thereby escaped being swamped over by the succeeding waves of migrations while in slow-evolving forms any such differentiation may have been swamped over by the next wave thereby causing reversion to the ancestral stock. The indications of such happenings are many though they have not yet been intensively studied and properly elucidated.

Geological Considerations.—Auden, on p. 337 of his article entitled "A Geological Discussion on the Satpura Hypothesis and Garo-Rajmahal Gap", gives the following as the primary factors involved in the faunal migration:—

- "(1) A secular climatic change, involving 4 or 5 glaciations, with interglacial periods which were probably cooler than any climate experienced now in central and southern India.
- "(2) The glaciers during the period of ice advance reached much lower down the valleys, and glacial boulder beds have been found recently even to be incorporated within the Siwalik succession of northern India.
- "(3) Not only did the glaciers reach to lower levels as a consequence of colder climate, but during the Pleistocene the montane zone must itself have been at smaller elevations. The influence of the glaciation on the climate of the Peninsula must therefore be considered from the dual point of view of an intrinsically colder climate in the mountains and the existence of glaciers at lesser elevations than even the present heights of maximum ice advance indicate. During the phases of maximum glacier advance the snouts of the glaciers may have been, from combined climatic and isostatic

causes, some 6,000 to 8,000 feet lower than at the present time.

- "(4) It is difficult to avoid the conclusion that these conditions in the montane and bordering zones of northern India must have resulted in a diminution of the temperature in the region now represented by the Satpura and Vindhyan ranges. A lowering of the mean annual temperature in these regions of only 20° to 30° F.,¹ which could still be considerably above the freezing temperature of the glaciated region to the north, would permit much greater run-off and larger river discharges for an equivalent rainfall.

- "(5) The greater relative humidity and higher river discharges would perhaps be sufficient explanation for the migrations of the faunas postulated."

With regard to the present Garo-Rajmahal Gap, Auden (pp. 315-340) first reviews the sequence of geological events which have taken place in northern India since the Gondwana period. He lays stress on various unconformities, in particular that at the base of the Deccan Traps, on crustal tension during the period of eruption of the traps, and on uplift taking place concomitantly with erosion which vitiates direct calculation of former elevations from the amount of rock removed by erosion. After concluding that there is little geological evidence for supposing that any major range formerly existed in mid-Tertiary times along the present Vindhyan-Satpura trend, he discusses the climatic factors which may have contributed towards an increased percentage of run-off from a given precipitation. As regards the Garo-Rajmahal Gap, he gives the following tentative conclusions:—

"It is considered probable that a connection did arise between the Shillong plateau and the peninsula during the Miocene and that the final break causing the present Garo-Rajmahal Gap took place during the Pleistocene along a N.W.-S.E. line of fracture extending from the Darjeeling-Himalaya to Comilla and Chittagong. Consequently, it is necessary to suppose that while the central part of the peninsula was undergoing mild uplift during the Pleistocene,

1. It seems to me that the actual amount is likely to have been much less than this. Nevertheless any lowering of the temperature will reduce evaporation and, therefore, increase the run-off even without a rise in precipitation.—F. E. Zeuner.

the bordering areas of Cutch, Saurashtra, and northern Bengal were subjected to depression".

On the other hand, Dey (p. 409) in a short article on "The Age of the Bengal Gap", has considered it "impossible, on available evidence, to accept the idea of a belt of hills across the Bengal Gap, Chota Nagpur, etc., within the time range of living animal species. The vast depression of temperature during the glaciation of the Himalayas (glaciers certainly come below 5,500 ft. and possibly well below 4,000 ft., in the Kangra Himalayas) seems to provide a more reasonable alternative". Dey's contentions are not borne out by the biogeographical researches reported in the Symposium and, as indicated in this review, the gap did not exist at least from the early Tertiary times to the late Pleistocene period.¹

In any Pleistocene research, the evidence from stratigraphy can be very confusing and in such cases biogeography can be extremely useful. The evidence of biogeography recorded in the Symposium on the "Satpura Hypothesis" is clearly in favour of a hilly track bridging up

1. I agree that there is little geological evidence for a major range of hills. I do think, however, that Dey's views have a fairly strong background from the geological evidence and that it is no use overlooking this fact. The arguments having been taken from two different disciplines are inevitably becoming very involved and it seems to me that we have to be very careful and try to steer a straight course instead of arguing in a circle. What I mean is this. Biogeographical evidence of actual distribution of species, etc., calls for an explanation. The easiest explanation would be the former existence of a range of hills across the Bengal Gap. Geological evidence is not on the whole in favour of this explanation. This I think is the matter in a nutshell. It is necessary to try to find a way out of this deadlock. One way is to construct a connection *via* the Himalayas and Rajputana. Another is to change the climate in certain ways so as to get the species through Bengal without requiring a mountain range, and there are other possibilities. This is, of course, the very reason why you have been encouraging a discussion of the whole Satpura Hypothesis and I think that a lot of good work has been done as a result of this, but I feel that we must not go so far as to regard the biogeographical distribution as evidence that a mountain range across the gap existed. The problem is certainly quite as serious, and your merit in having drawn attention to it is quite as great, no matter what the ultimate explanation of this interesting phenomenon will be. Quite honestly I do not believe that we have found the answer yet.—

F. E. Zeuner,

the gap between the Shillong plateau and the Chota Nagpur plateau. As regards the height of the hills that filled the gap from the Miocene to the Pleistocene periods, the position is not quite clear, but the following account of "Dunn's Uplifts in Chota Nagpur" after Auden (p. 328) is very significant in this connection:—

"Dunn has concluded that at the latitude of Rajmahal (25°) the crust has undergone little change in elevation since the Jurassic, and has acted as a hinge zone. North of the hinge there has been progressive down-warping in response to the Miocene and later Himalayan movements, which has allowed the accumulation of over 6,000 feet of freshwater alluvial sediment in the north Bihar basin. Nearly the whole pile of these sediments now lies below sea-level (Wadia and Auden, 1939, pp. 133-35). South of this hinge there has been progressive uplift, which has been summarized by Dunn as follows (1939, p. 141):—

- 1 Uplift of 1,000 feet of an early tertiary peneplane, with a downward tilt to the north-east.
2. Middle or Upper Tertiary uplift of 1,000 feet reaching a maximum in the Ranchi Plateau, with downward tilt to the north-east.
3. Further uplift of 300 feet.
4. Final uplift of 400 feet.

The total uplift in the Chota Nagpur area along latitude 23° was therefore of the order of 2,500 to 2,700 feet, with nil movement along latitude 25°. Since this uplift has been taking place during the Tertiary and Pleistocene, it is evident that in early Tertiary times the land was at a lower elevation, and there is not much support for the idea of a major range existing to account for the migration of faunas".

In view of the fact that during the pluvial periods, when the temperatures were considerably lower and the precipitations higher, low hills provided the same ecological conditions for the migrations of faunas as do the higher hills of the present-day topography of India.

A summary of the above results would indicate that:

- (i) In the early Tertiaries, there were lowlands in the region of the Garo-Rajmahal gap.
- (ii) This gap began to be filled up in the Miocene and progressively continued to be filled up even upto the early Pleistocene.

- (iii) The present gap appeared probably in the late Pleistocene, about the same time as the dismemberment of the Indo-Brahm or the Siwalik River.
- (iv) During the pluvial periods when the sea level fell by 100 to 200 meters, the height of the hills relative to the level of the sea increased by the same figure and thereby induced heavier precipitation in the hilly areas.¹
- (v) During the Pleistocene when the central part of the Peninsula was undergoing mild uplift, the flora and fauna became dispersed to the hills to the north and south of the Vindhya-Satpura Trend.
- (vi) The discontinuity of the Vindhya-Satpura Trend in the region of the Garo-Rajmahal Gap and in the regions of Cutch and Saurashtra occurred during the Pleistocene.

THE SATPURA HYPOTHESIS

In the light of the findings contained in the two Symposia on biogeography, let us now study the Satpura Hypothesis in detail and indicate the lines along which further research should be carried out. Though in the Symposium, attention has mainly been paid to the distribution of Malayan fauna and flora to Peninsular India, the original proposition made in 1937 implied several other biogeographical considerations which may now be taken up. In 1937, it was stated:²

"As the Himalayas rose to a great height in the region of the isthmus (mostly the western part of the Assam Himalayas and the eastern part of the Nepal Himalayas) all the evidence concerning the north-eastward extension of the Indo-Brahm seems to have been obliterated. The uplift movement was probably most active in this region as we find practically all the highest peaks of the Himalayas clustered round this area. This differential movement which probably occurred late in the Miocene period, must have obliterated all traces of the eastward extension of the Indobrahm and also acted as a barrier between the eastern and the western Himalayan fishes. The new stock of specialized hill-stream fishes from the east, not finding means to cross this barrier, were deflected towards south-west along the Satpura Trend which probably at that

period stretched across India as a pronounced range from Gujrat to Assam Himalayas. From Gujrat the hillstream fauna migrated towards the south along the Western Ghats and spread to the hills of the Peninsula in the extreme south".

Since the enunciation of the above hypothesis, considerable field work has been done on the distribution of fishes which is summarized in the Symposium. The distribution of specialized fishes along the southern face of the Himalayas has now been investigated by Shri. A. G. K. Menon, longitude by longitude, with very interesting results. As the results of his investigations are not yet published, I am indebted to him for the use of certain amount of this data here. In view of the advances that have been made during the last 13 years, it is necessary that the thesis should now be redefined so as to encourage more research being focussed on the problems arising out of it.

1. Southern China, mostly the Yunan region, was the cradle of the fauna of south-east Asia.
2. From the Yunan area, through earth movements, river captures, etc., the fauna spread to the east, south-west and south on the one hand and to the west, south-west and south on the other. This dispersal, would seem to have commenced when the Philippines and islands of the Indo-Australian Archipelago north of the Weber Line were connected with the mainland in the east and Ceylon formed a part of India. At that period there would appear to have been a hilly connection between the Himalayan chain of mountains and the north African hills through Persia, Syria, Arabia and Socatra. This enabled the hill-stream fauna of south-east Asia to spread to Africa.
3. This dispersal probably commenced in the Eocene for in the Inter-trappean beds of Dongargaon, C.P., fossil remains of modern widely distributed species of sluggish waters have been found.
4. Judging from the fact that the island of Ceylon "was first severed during the Miocene epoch when a wide arm of the Tertiary sea extended across the southern parts of the peninsula" (Jacob, p. 341), the following biogeographical conclusions would seem irresistible:—

- (i) The dispersal of the hill-stream fishes of such genera as *Nemachilus*, *Garra*, *Tor*, etc., had taken place before the first appearance of the Ceylon-India

1. I do strongly support this point, that a eustatic drop in the sea-level of 800 feet is likely to have had quite considerable climatic implications.—*F. E. Zeuner*.

2. Hora, S. L., *Rec. Ind. Mus.*, 1937, 39, 251-59.

gap and at that time the fauna was spreading to Africa along the Himalayas and to Ceylon along the Satpura Trend of mountains and the Western Ghats. It would imply that the Garo-Rajmahal Gap had already been filled up with low hills. This would thus be the Middle or Upper Tertiary period.

(ii) The next group of fishes, as indicative of the phase of dispersal, could be the remarkable torrential fishes of the family Homalopteridæ. This family is known practically from all over south-east Asia but its range does not extend to Ceylon or to Africa. In fact, along the Himalayas it does not extend westwards beyond longitude 85°. The inferences are:

- (a) The dispersal of the Homalopteridæ commenced in the Upper Tertiaries when the hilly connection between India and Ceylon had already severed.
- (b) The dispersal of the Malayan element from the eastern to the western Himalayas was checked in the Upper Tertiaries.
- (c) The Garo-Rajmahal Gap had by that period a series of hills filling up the gap and with perennial torrential streams enabling the dispersal of the Homalopteridæ.
- (d) The age of the dispersal of the Homalopteridæ is further confirmed by the speciation data.

5. Dispersal of animals and plants, aquatic, semi-aquatic and terrestrial, seems to have been facilitated by the pluvial periods of the Pleistocene glaciation; while the arid interglacial periods, isolated stocks of species and the segregation of stocks induced speciation. From the biogeographical data presented in the Symposium on the Satpura Hypothesis, the following inferences can be drawn:—

- (i) The most direct connection permitting dispersal of hill-stream fishes from the Assam Hills to the Chota Nagpur

plateau and the Vindhya would certainly have been across the present Garo-Rajmahal gap. Geological evidence for a connection in late Tertiary times is somewhat equivocal, but it has been shown that major earth movements involving folding, overthrusting and tear faulting occurred in northern India during the Pleistocene, and would have been sufficient to have severed the bridge during the Pleistocene if, as some geologists consider, the bridge did exist. Reasons are given on page 329 of the Symposium which indicate that no connection probably existed in the Pleistocene between the Monghyr hills and the Nepal-Darjeeling Himalaya, but there may have been a connection along an extension of the Aravalli range.

- (ii) There are successive waves of migrations of terrestrial animals corresponding to the numbers of the pluvial periods. Some work on the double and triple invasion has been done on fishes and birds but lot more remains to be done in all other groups of animals and plants.
- (iii) The environmental facilities for dispersal could be more helpful to the terrestrial organisms but not to the same extent in regard to the aquatic forms, particularly specialized hill-stream fishes for the living of which perennial, torrential streams are essential.

One is able now to say with certainty that there is little evidence of the Ethiopian Element in the fauna of India while the circumstances of dispersal make it abundantly clear that there is a considerable Indian element in the fauna of Africa. The Symposium on the "Satpura Hypothesis" has broadened our outlook by permitting excursions into the realm of other sciences and the Symposium on "Pleistocene Research" has helped us to evaluate some of our views in a comparative way.

S. L. HORA.

PLUTO'S DIAMETER

THE Hale telescope has now been used visually to measure the apparent diameter of Pluto, at the Yerkes and McDonald Observatories, U.S.A. The planet is now believed to have a diameter 0.45 times that of the earth, placing it between Mars and Mercury in order of size in the solar

system, and corresponding to a linear diameter of about 3,550 miles.

Its atmosphere is estimated to be less than 0.1 terrestrial atmosphere, and its mass slightly below 1/10 that of the earth.

—Courtesy of *Sky and Telescope*, October 1950.