# FURTHER STUDIES REGARDING HORA'S SATPURA HYPOTHESIS.

## 2. Taxonomic Assessment and Levels of Evolutionary Divergences of Fishes with the so-called Malayan Affinities in Peninsular India.

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Contents.



### Introduction.

Since the enunciation of the Satpura Hypothesis (Hora, 1937), much work has been done on the biogeography of India. Recently a Symposium was held under the auspices of the National Institute of Sciences of India on the 'Satpura Hypothesis of the Distribution of Malayan Fauna and Flora to Peninsular India', (Hora, *et al.*, 1949) containing contributions from different sciences, such as, Geology, Meteorology, Botany and Zoology. In a review of this Symposium, Dr. Ernst Mayr (1950, p. 363) stated that:

> "The members of the Malayan fauna isolated on the Indian Peninsula indicate various levels of evolutionary divergence, ranging from endemic species to subspecific identity. A more complete analysis may shed further light on the period of immigration".

In a letter to Dr. Hora, he also suggested that the Hypothesis be tackled from three other aspects (*vide* Hora, 1951, p. 437). The first of these, namely, the possibility of dispersal of torrential fauna in spite of the existence of the Garo-Rajmahal Gap has been further elucidated by Hora (*loc. cit.*). Menon (1951) investigating the third problem, namely, the possibility of the Eastern Ghats acting as an alternative route of migration, found after a detailed study of the fish fauna of the Eastern Ghats and the Orissa Hills, that there were no typical representatives of the so-called Malayan element there.

The present communication deals with Dr. Mayr's second suggestion, namely, a taxonomic assessment of the fishes with the so-called Malayan affinities in Peninsular India and their different levels of evolutionary divergence. Peninsular India

TABLE 1.

| I | II | | | | | | | | III |
|---|---|---|---|---|---|---|---|---|---|
| List of genera and species with the so-called Malayan affinities restricted to Peninsular India. | Occurrence of forms showing affinities to the genera and species listed in the first column. | | | | | | | | Remarks amplifying the statement made in the second column. |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | |
| **Family CYPRINIDAE** | | | | | | | | | |
| **Osteochilus** Günther .. .. .. | — | x | x | x | x | x | x | x | *Osteochilus* has differentiated into subgenera in South China and in Peninsular India (Hora, 1942, p. 7). Typical *Osteochilus* is now found in Thailand, the Malaya Peninsula and the Indo-Australian Archipelago. Of the three Peninsular species, *O.* (*Kantaka*) *brevidorsalis* is known from the central division of the Western Ghats and *O.* (*Osteochilichthys*) *nashii* from the northern and central divisions. *O.* (*Osteochilichthys*) *thomasii* is known from the central and southern divisions (Silas, 1950). |
| *O.* (*Osteochilichthys*) *thomassi* (Day) .. | — | — | — | — | — | — | — | — | |
| *O.* (*Osteochilichthys*) *nashii* (Day) .. | — | — | — | — | — | — | — | — | |
| *O.* (*Kantaka*) *brevidorsalis* (Day) .. | — | — | — | — | — | — | — | — | |
| **Schismatorhynchus** Bleeker .. .. | — | — | — | — | — | — | — | x | *Schismatorhynchus* of Peninsular India is sub-generically different from the Indo-Australian form, *S.* (*Schismatorhynchus*) *heterorhynchus* Bleeker, (*vide* Hora, 1942). |
| *S.* (*Nukta*) *nukta* (Sykes) .. .. | — | — | — | — | — | — | — | — | |
| **Rohtee** Sykes .. .. .. | — | x | x | — | x | x | x | x | *Rohtee* (*sensu stricto*) is restricted to Peninsular India. The Burmese, Thailand and Malayan forms of *Rohtee* are sub-generically different and are here grouped under the subgenus *Mystacoleucus* (*vide* note on page 8). |
| *R.* (*Rohtee*) *ogilbii* Sykes .. .. | — | — | — | — | — | — | — | — | |
| **Puntius** Hamilton .. .. .. | x | x | x | x | x | x | x | x | *Puntius sarana*, a widely distributed species, has diverged in Southern Burma into a subspecies, *binduchitra* and in Peninsular India and in Malay Peninsula into a closely allied geographical race, *pinnauratus* (Pillay, 1951). |
| *P. sarana* Hamilton .. .. .. | x | x | — | — | x | x | x | — | |
| *P. ticto* Hamilton .. .. .. | x | x | — | — | — | — | — | — | *Puntius ticto*, has diverged in Peninsular India into a subspecies, *punctatus*, and in Burma into another closely allied subspecies, *stoliczkanus*. (*Vide* note on page 431). |
| **Tor** Hamilton .. .. .. | x | x | — | — | x | — | — | — | *Tor mosal* is known from Burma and the Himalayan streams (Hora, 1940). Recently a variety of this species (David, 1952. Seen in MSS.) was discovered from the upper reaches of the Mahanadi. Further west it is replaced by *Tor khudree* (Sykes), which is also found in Ceylon. |
| *T. mosal* Hamilton .. .. .. | x | — | — | — | — | — | — | — | |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Acrossocheilus** Oshima .. .. | x | x | x | x | x | x | x | x | Though *Acrossocheilus hexagonolepis* has been recorded from South India by several workers, the precise systematic position of the Peninsular form still remains to be investigated. It will, therefore, not be included in the discussion here. |
| *A. hexagonolepis* (McClelland) .. .. | x | ? | — | — | ? | ? | ? | ? | |
| **Osteobrama** Heckel .. .. .. | x | x | x | x | x | — | — | — | In either extremity of its range of distribution *Osteobrama cotio* has given rise to two closely allied geographical races, *O. cotio cunma* in Burma, and *O. cotio* var. *peninsularis*, nov. in Peninsular India (*vide* note on page 432). |
| *O. cotio* Hamilton .. .. .. | x | x | — | — | x | — | — | — | |
| **Labeo** Cuvier .. .. .. | x | x | x | x | x | x | x | x | *Labeo dero* and *Labeo dyocheilus* are known from the Sind Hills, all along the Himalayas, Assam and Burma. The latter has also been recorded from Thailand (Smith, 1945). The recent record of these two species from the Mahanadi and Damodar rivers (**David**, *loc. cit.*), west of the Garo-Rajmahal Gap is of interest. |
| *L. dero* (Hamilton) .. .. .. | x | x | — | — | x | — | — | — | |
| *L. dyocheilus* (McClelland) .. .. | x | x | — | — | x | x | — | — | |
| *L.* (*Morulius*) prox. *chrysophekadion* (Bleeker) | — | — | — | x | — | x | — | x | *Labeo* (*Morulius*) *chrysophekadion* is known elsewhere from Thailand, Indo-China and the Indo-Australian Archipelago. The Peninsular specimens show slight variations from the Thailand forms, but for want of material for comparison, details have not yet been worked out. |
| **Crossocheilus** van Hasselt .. .. | x | x | x | ? | x | x | x | x | *Crossocheilus latius* occurs in the Bombay Ghats portion of the Western Ghats, Kaimur Hills and Chota Nagpur plateau on the Vindhya Satpura trend and the Eastern Himalayas. Its distribution throws light as to the route of migration of the freshwater fishes from the Assam Himalayas to the Peninsula. |
| *C. latius* (Hamilton) .. .. .. | x | x | — | — | x | — | — | — | |
| **Garra** Hamilton .. .. .. | x | x | x | x | x | x | x | x | *Garra gotyla* is known from the region of the Eastern Himalayas, the Rajmahal Hills (Hora, 1938) and from Hoshangabad in the Satpuras (Hora and Nair, 1941). Like the preceding species, its distribution along the northern parts of the Peninsula is of interest, for it indicates the probable route of migration of freshwater fishes to the Peninsula. |
| *G. gotyla* (Gray) .. .. .. | x | — | — | — | — | — | — | — | |
| **Thynnichthys** Bleeker .. .. | — | — | — | — | — | x | x | x | *Thynnichthys* is represented in Thailand, Malaya Peninsula and the Indo-Australian Archipelago by one species, *T. thynnoides* Bleeker. The Peninsular species, *T. sandkhol* is known from the Godaveri and Kistna river systems (Hora, 1949, p. 412). |
| *T. sandkhol* (Sykes) .. .. .. | — | — | — | — | — | — | — | — | |

TABLE 1—*Contd.*

| I | II | | | | | | | | III |
|---|---|---|---|---|---|---|---|---|---|
| List of genera and species with the so-called Malayan affinities restricted to Peninsular India. | Occurrence of forms showing affinities to the genera and species listed in the first column. | | | | | | | | Remarks amplifying the statement made in the second column. |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | |
| Family PSILORHYNCHIDAE | | | | | | | | | |
| **Psilorhynchus** McClelland .. .. | x | — | — | — | — | — | — | — | *Psilorhynchus sucatio* is known from the region of the Eastern Himalayas and Northern Burma. David (*loc. cit.*) records a new geographical race of this species from the Damodar river. Being only racially different from its eastern ally, the Damodar form seems to be a recent isolate in the Peninsula. |
| *P. sucatio* Hamilton .. .. .. | x | — | — | — | — | — | — | — | |
| Family HOMALOPTERIDAE | | | | | | | | | |
| **Homaloptera** van Hasselt .. .. | — | x | — | x | x | x | x | x | *Homaloptera* is represented in Peninsular India by a single species, while the genus has a wide range of distribution in the east. The two genera *Bhavania* and *Travancoria* which are endemic in the Peninsula, have evolved from the *Homaloptera*-stock. *Balitora brucei* of the Eastern Himalayas has one geographical race in Peninsular India and two very closely-allied races in Burma. For the distributional significance and affinities of the Homalopterid fishes reference may be made to Silas (1952). |
| *H. montana* Herre .. .. .. | — | — | — | — | — | — | — | — | |
| **Bhavania** Hora .. .. .. | — | — | — | — | — | — | — | — | |
| *B. australis* (Jerdon) .. .. | — | — | — | — | — | — | — | — | |
| **Travancoria** Hora .. .. .. | — | — | — | — | — | — | — | — | |
| *T. jonesi* Hora .. .. .. | — | — | — | — | — | — | — | — | |
| **Balitora** Gray .. .. .. | x | x | — | — | — | — | — | — | |
| *B. brucei* var. *mysorensis* Hora .. .. | — | — | — | — | — | — | — | — | |
| Family SCHIZOTHORACINAE | | | | | | | | | |
| **Lepidopygopsis** Raj .. .. .. | x | x | x | — | — | — | — | — | The Schizothoracine genus *Lepidopygopsis* Raj (1941) which is endemic in the Peninsula (Periyar Lake, Travancore) has its nearest related forms in *Schizothorax* and *Oreinus* which are mainly Central Asiatic in distribution though a few species are found in the Himalayas and South-Western China. For further information reference may be made to Hora (1949, p. 411). |
| *L. typus* Raj .. .. .. | — | — | — | — | — | — | — | — | |
| Family SCHILBEIDAE | | | | | | | | | |
| **Silonia** Swainson .. .. .. | x | x | — | — | x | — | — | — | *Silonia silondia* of Northern India and Burma is also known from the Cauvery watershed in the Peninsula. In the south it seems to have diverged into another species, *S. childreni* (*vide* note on page 433). *Pangasius pangasius* is another species which |
| *S. childreni* (Sykes) .. .. .. | — | — | — | — | — | — | — | — | |
| *S. silondia* (Hamilton) .. .. | x | x | — | — | x | — | — | — | |
| **Pangasius** Valenciennes .. .. | x | x | — | x | x | x | x | x | |
| *P. pangasius* (Hamilton) .. .. | x | x | — | — | x | x | x | x | |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Eutropiichthys** Bleeker | .. | .. | x | x | — | — | x | — | — | — |
| *E. goongwaree* (Sykes) | .. | .. | — | — | — | — | — | — | — | — |
| **Neotropius** Kulkarni | .. | .. | x | x | — | — | x | x | x | x |
| *N. khavalchor* Kulkarni | .. | .. | — | — | — | — | — | — | — | — |
| Family BAGRIDAE | | | | | | | | | | |
| **Batasio** Blyth | .. | .. | x | x | — | — | x | x | — | — |
| *B. travancoria* Hora & Law | .. | .. | — | — | — | — | — | — | — | — |
| *B.* prox. *tengana* (Hamilton) | .. | .. | x | x | — | — | x | x | — | — |
| **Pseudobagrus** Bleeker | .. | .. | — | — | x | x | — | — | — | — |
| *P. brachysoma* Günther | .. | .. | — | — | — | — | — | — | — | — |
| Family SISORIDAE | | | | | | | | | | |
| **Gagata** Bleeker | .. | .. | x | x | — | — | x | x | — | x |
| *G. itchkeea* (Sykes) | .. | .. | — | — | — | — | — | — | — | — |
| *G. cenia* (Hamilton) | .. | .. | x | x | — | — | x | x | — | — |
| *G. gagata* (Hamilton) | .. | .. | x | x | — | — | x | x | — | — |

shows discontinuous distribution for it is known from the Cauvery watershed in Peninsular India and further east from North-Eastern India, Burma, Thailand, Malaya and Java.

Hora (1937, pp. 431–445) elucidated the status of the species of *Eutropiichthys* Bleeker. The Peninsular isolate, *E. goongwaree* seems to have diverged from the widely distributed from *E. vacha* (Hamilton).

Kulkarni (1951, seen in MSS.) describes a new monotypic Schilbeid genus from Satara District in Bombay Presidency. This form shows great affinity to *Pseudeutropius acutirostris* Day and seems to have diverged in Peninsular India from *Pseudeutropius*-like forms.

*Batasio travancoria* Hora and Law (1941) is so far known from the southern division of the Western Ghats in the Peninsula. Hora (1949, p. 414) has commented on the discontinuous distribution of the genus. The recent record of *Batasio tengana* from the Mahanadi river by David (*loc. cit.*), extends the distribution of the genus from the region of the Eastern Himalayas to the northern parts of the Peninsula.

Besides Malabar in Peninsular India, *Pseudobagrus* is elsewhere known from China. This marked discontinuous distribution of the genus is of considerable zoogeographical significance.

The genus *Gagata*, which is found along the Eastern Himalayas, Burma, Thailand and Sumatra is represented in the central and northern division of the Western Ghats by one species, *G. itchkeea* (Sykes). Two other species, *G. cenia* and *G. gagata* which are mainly distributed along the Himalayas is also found in certain places along the Vindhya Satpura trend. They are taxonomically identical with the Eastern Himalayan population. Their absence in the Peninsula proper suggest that they are recent isolates in the northern parts of the Peninsula and have not diverged so far.

TABLE 1—*Contd.*

| I | II | | | | | | | | III |
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| List of genera and species with the so-called Malayan affinities restricted to Peninsular India. | Occurrence of forms showing affinities to the genera and species listed in the first column. | | | | | | | | Remarks amplifying the statement made in the second column. |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | |
| **Glyptothorax** Blyth .. .. .. | x | x | x | ? | x | x | x | x | The Eastern Himalayan form *Glyptothorax horai* was recorded from the Rihand by Hora (1949). Its occurrence in this watershed draining part of the Vindhya Satpura trend and separated from the Eastern Himalayas is yet another instance to show the probable route of migration of fresh-water forms to the Peninsula. |
| *G. horai* Shaw and Shebbeare .. .. | x | — | — | — | — | — | — | — | |
| *G. annandalei* Hora .. .. .. | x | — | — | — | — | — | — | — | Menon (1949, p. 237) recorded *Glyptothorax annandalei* from the Kosi river in the Eastern Himalayas. The species is also known from the Vindhyas and the northern and central parts of the Western Ghats. |
| **Erethistoides** Hora .. .. .. | x | — | — | — | — | — | — | — | A geographical race of the Assam form *Erethistoides montana, var., pipri* was described from the Rihand by Hora (1949). Thus as in the case of *G. horai* the distribution of the genus is of zoogeographical importance. |
| *E. montana* var. *pipri* Hora .. .. | — | — | — | — | — | — | — | — | |
| **Laguvia** Hora .. .. .. | x | — | — | — | — | — | — | — | The occurrence of *Laguvia ribeiroi* in Hoshangabad District on the Vindhya Satpuras (Hora and Nair, 1941), and the Rihand (Hora, 1949) is of distributional significance, for it is elsewhere known from the Tista river (Jalpaiguri District), in the Eastern Himalayas. |
| *L. ribeiroi* Hora .. .. .. | x | — | — | — | — | — | — | — | |
| Family AMBLYCEPIDAE | | | | | | | | | |
| **Amblyceps** Blyth .. .. .. | x | x | — | — | x | x | x | — | The occurrence of *Amblyceps mangois* in Hoshangabad District on the Vindhya Satpuras (Hora and Nair, 1941) and the Rihand, Mahanadi and Rajmahal Hills west of the Garo-Rajmahal Gap is of considerable interest as showing the probable continuity of the Satpura trend of mountains with the hills of Assam and Darjeeling Himalayas. *A. mangois* is also found along the Himalayas, hills of Assam, Burma, Thailand and Malaya Peninsula. |
| *A. mangois* (Hamilton) .. .. | x | x | — | — | x | x | x | — | |
| Family SILURIDAE | | | | | | | | | |
| **Silurus** Linnaeus .. .. .. | x | x | x | x | x | x | x | — | *Silurus* seems to have diverged in Peninsular India |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *S. goae* Haig .. .. .. | — | — | — | — | — | — | — | — | both into a species and a subspecies. *S. goae* Haig is specifically different from *S. berdmorei wynaadensis* which has its nearest related form in *S. berdmorei berdmoeri* of Akyab in Burma. All these forms are allied to the widely distributed *S. cochinchinensis* Cuv. & Val. (*vide* note on page 433). |
| *S. berdmoeri* var. *wynaadensis* (Day) .. | — | — | — | — | — | — | — | — | |
| *S. cochinchinensis* Valenciennes .. .. | x | x | x | x | x | x | — | — | |
| Family CLARIIDAE | | | | | | | | | |
| **Clarius** Gronovius .. .. .. | x | x | x | x | x | x | x | x | *Clarias dussumieri, C. dayi* and *C. brachysoma* of Peninsular India and Ceylon resemble *C. meladerma* and *C. teysmanii* of the Malayan region. Their close similarity suggest a common origin for the Peninsular Indian and the Malayan forms (*vide* note on page 434). |
| *C. dussumieri* var. *dussumieri* Cuv. & Val. .. | — | — | — | — | — | — | — | — | |
| *C. dussumieri* var. *dayi* (Hora) .. .. | — | — | — | — | — | — | — | — | |
| *C. dussumieri* var. *brachysoma* (Günther)* .. | — | — | — | — | — | — | — | — | |
| Family PRISTOLEPIDAE | | | | | | | | | |
| **Pristolepis** Jerdon .. .. .. | x | x | — | x | x | x | x | x | The two Malabar forms *P. marginatus marginatus* and *P. marginatus malabaricus* seem to have diverged from the widely distributed form *P. fasciatus* (*vide* note on page 435). |
| *P. marginatus* var. *marginatus* Jerdon .. | — | — | — | — | — | — | — | — | |
| *P. marginatus* var. *malabaricus* (Günther) .. | — | — | — | — | — | — | — | — | |
| *P. fasciatus* (Bleeker) .. .. | x | x | — | x | x | x | x | x | |
| Family SYMBRANCHIDAE | | | | | | | | | |
| **Amphipnous** Muller .. .. .. | x | — | — | — | — | — | — | — | Recently Krishnan Nair (1951) described a new species of *Amphipnous, A. fossorius* from Southern Travancore in the Peninsula. The other species of *Amphipnous, viz., A. cuchia* is found in North-Eastern India and Burma. |
| *A. fossorius* Nair .. .. .. | — | — | — | — | — | — | — | — | |
| Family TETRAODONTIDAE | | | | | | | | | |
| *Tetraodon* (*Monotretus*) *travancoricus* Hora & Nair. | x | x | — | — | x | — | — | — | *Tetraodon* (*Monotretus*) *travancoricus* has its nearest ally in *T.* (*Monotretus*) *cutcutia* of North Eastern India and Burma. (Hora and Nair, 1941). |

* Found in Ceylon.

is considered here as the triangular Plateau lying south of the Indo-Gangetic alluvium and extending to the north-east as far as the Rajmahal Hills.* In his revision of the Indian freshwater fishes, Dr. Hora has clarified the taxonomic position of many of the Peninsular representatives, but still there remain a number of species with Malayan affinities, the taxonomy of which need further elucidation. It is, therefore, proposed to deal with the taxonomic assessment of the species before discussing their evolutionary divergences.

## Table showing the list of species with the so-called Malayan Affinities in Peninsular India.

In the following table (Table 1) are listed all important Peninsular genera and species of fishes showing Malayan affinities. This table also indicates the eastern affinities of the forms now restricted to the Peninsula. In the remarks column, references are made to previous important works on their taxonomic and zoogeographical aspects. The species, whose taxonomic status needs further elucidation, are dealt with separately in the next section of the paper.

In column two of the following table the localities are arranged as follows: (1) Eastern Himalayas, (2) Northern Burma, (3) Yunnan and Southern China, (4) Indo-China, (5) Lower Burma, (6) Thailand, (7) Malaya Peninsula, and (8) Indo-Australian Archipelago. The distribution of the genera in the above areas and that of the Peninsular isolates are also indicated in this column.

## Taxonomic Assessment of certain forms.

### *Rohtee* Sykes.

Sykes (1841), in erecting the genus *Rohtee* for three species from Peninsular India, did not denote any one of them as the type of his new genus. Jordan (1919) named *R. vigorsii* Sykes as the orthotype of the genus *Rohtee* and this was adopted by later workers, like Mukerji (1934), Hora (1940) and Smith (1945). Smith, however, stated that 'the first designation of the type of *Rohtee* was by Bleeker (1864, 314), 'when *R. ogilbii* was definitely selected'.

*R. ogilbii* Sykes, on account of the presence of a procumbent predorsal spine was placed under the genus *Mystacoleucus* Günther by Hora (1940). But since Bleeker had already designated *R. ogilbii* as the type of *Rohtee*, it is only proper, that, species now assigned to *Mystacoleucus* (forms with procumbent predorsal spine) be placed under *Rohtee*. With this nomenclatorial change, the species other than *ogilbii*, which are included under *Rohtee* (Hora, 1940), have to take another generic name, and the use of *Osteobrama* Heckel for them is considered valid.

Thus, *Rohtee* which is characterised by the presence of a procumbent predorsal spine is represented in Peninsular India on the one hand and Lower Burma, Thailand, Malaya Peninsula and the Indo-Australian Archipelago on the other. The Chinese species with procumbent predorsal spine were grouped under the genera *Spinibarbus* Oshima and *Spinibarbichthys* Oshima. For a satisfactory classification of *Rohtee*, it has been found necessary to split up the genus into two subgenera, both on taxonomic as well as on geographical grounds. The type species, *R. ogilbii* of Peninsular India, which is geographically widely separated from the other species and also differs considerably from the rest in the number of lateral line scales and the anal rays is considered in this revision as *Rohtee* (*sensu stricto*). All the remaining species are grouped under *Mystacoleucus*, which is

* The Shillong Plateau in Assam is only a severed portion of the Peninsula which has been isolated by the alluvium of the lower Ganges and Brahmaputra.

regarded here as a subgenus of *Rohtee*. The known species of *Rohtee* and their range of distribution are given below:

| | |
|---|---|
| *Rohtee* (*Rohtee*) *ogilbii* Sykes | .. Deccan, Peninsular India. |
| *Rohtee* (*Mystacoleucus*) *argenteus* (Day) | .. Burma. |
| *Rohtee* (*Mystacoleucus*) *marginatus* Valenciennes | .. Lower Burma, Thailand, Malaya Peninsula and the Indo-Australian Archipelago. |
| *Rohtee* (*Mystacoleucus*) *chilopterus* Fowler | .. Thailand. |
| *Rohtee* (*Mystacoleucus*) *atridorsalis* Fowler | .. Thailand. |
| *Rohtee* (*Mystacoleucus*) *padangensis* (Bleeker) | .. Sumatra. |

*Puntius ticto* Hamilton.

Day (1878) gave the range of distribution of *Puntius ticto* as, 'Sind, throughout India and Ceylon', and recognised two other closely related species, *viz.*, *Puntius punctatus* in Peninsular India and *Puntius stoliczkanus* in Burma. Regarding the latter he observed:

> 'This species bears a strong resemblance to *B. ticto* H.B., which it appears to supersede in Burma. But it is distinguished by a complete instead of an incomplete lateral line, and its body is not so compressed; its dorsal spine and colouring also differ.'

Smith (1945) also remarked on the great similarity of *P. stoliczkanus* to *P. ticto*. Hora, Misra and Malik (1939), who studied the variations in *Puntius ticto*, assigned *P. punctatus* and *P. stoliczkanus* to its synonymy, as they found it difficult to separate the Peninsular and the Burmese forms from *P. ticto* specifically. They also stated that:

> 'In studying several collections of freshwater fishes from India and Burma, Hora found considerable variation in specific characters usually relied upon for the determination of Hamilton's *Cyprinus* (*Puntius*) *ticto*. Though he recently made an attempt to give the diagnostic features of *Barbus* (*Puntius*) *stoliczkanus* Day, a form closely allied to *B. ticto*, a collection from Dalu, in the Upper Chindwin Drainage showed that these characters were not of much use in separating the two species. Moreover, the specimens of *B. ticto* from Peninsular India were found to exhibit gradations between the two forms, while Day's *B. punctatus* from South India appeared to be identical with the Burmese *B. stoliczkanus*.'

The morphometric data that they gave for a number of specimens of *Puntius ticto* from different localities along its range of distribution has been of considerable help in redefining the present limits of the species. When the characters of *P. ticto* are taken as a whole, they seem to be highly variable and overlapping, thus forming more or less a mix up. But as in the case of *Puntius sarana* Hamilton, (Pillay, 1951) certain characters in *P. ticto* are also more predominant and well defined in some areas than in the others. Both marked qualitative and quantitative variations are present towards either extremity of its range of distribution. Taxonomically as well as on geographical grounds, such localised conditions or divergences from the typical form would entail the institution of separate species, subspecies or races, for such forms. But these divergences of

*P. ticto* in Peninsular India and Burma do not seem to be of specific levels, as can be noted from the following table:

| *Puntius ticto punctatus* (Day). | *Puntius ticto ticto* Hamilton. | *Puntius ticto stoliczkanus* (Day). |
|---|---|---|
| Lateral line complete .. | Lateral line incomplete (perforated scales 6–16). | Lateral line complete. |
| P.15; L.l.23–24 .. | P.15; L.l.23–26 .. | P.14; L.l.25. |
| Predorsal scales 8 .. | Predorsal scales 11 .. | Predorsal scales 8–10. |
| 3 rows of scales between lateral line and pelvics. | 4–5 rows of scales between lateral line and pelvics. | 3½ rows of scales between lateral line and pelvics. |
| *Distribution*: Malabar and Coromandel coast, Peninsular India. | Throughout Ceylon, India and Burma. | Lower Burma and Thailand. |

On these grounds it has been found necessary to resurrect the names *punctatus* and *stoliczkanus*, and they are treated as subspecies of *Puntius ticto*, which has a wide range of distribution, being found in Ceylon, India and Burma. However, it is interesting to note that both in Peninsular India on the one hand and in Burma and Thailand on the other, *P. ticto* has diverged almost along similar lines.

## *Osteobrama* Heckel.

Of the species of *Osteobrama* at present known from India, Burma, Southern China (Yunnan) and Indo-China, *O. cotio* (Hamilton) is of considerable interest, for this species seems to have diverged both in Peninsular India and in Burma into two geographical races. Earlier workers considered the Peninsular and Burmese forms as one and the same variety of *cotio*, namely, *O. cotio* var. *cunma* (Day). In stating the affinities of this form with the *forma typica*, Hora and Misra (1940) observed:

> 'It differs from *Rohtee cotio* in having somewhat larger and more regularly arranged scales (L.l.42–58 *versus* 57–70), predorsal scales 18–24 *versus* 24–28; between lateral line and pelvics 7½–9½ *versus* 10½ to 13 and fewer rays in the anal fin (28–34 *versus* 31–36). In all other respects, except that the variety *cunma* probably grows to somewhat larger size, the two forms are very similar and there seems no doubt that they must have become differentiated not very long ago.'

Vinciguerra (1890) recognised Valencienne's *R. alfrediana* as a distinct species in Burma. The variety *cunma* was described by Day (1878) from specimens collected from Burma. Hora and Misra (*op. cit.*) clarified the status of *alfrediana*, but they have included the Peninsular species under the variety *cunma*. The morphometric data that they gave of a number of specimens of *cunma* from Burma and Peninsular India shows that the Peninsular and Burmese populations of *cunma* are in fact different to a certain extent. The main variations found between *O. cotio cotio* and the Peninsular and Burmese forms ascribed to *cunma* are tabulated below:

| No. | Characters. | *O. cotio* var. (Peninsular India). | *O. cotio cotio*. | *O. cotio cunma* (= *alfrediana*) Burma. |
|---|---|---|---|---|
| 1 | No. of scales along L.I. .. | 55–60 | 58–70 | 42–53 |
| 2 | No. of predorsal scales .. | 21–24 | 24–29 | 28–30 |
| 3 | No. of scales between L.I. and V | 7½–9½ | 10½–13 | 7½–8½ |
| 4 | No. of branched anal rays .. | 28–31 | 33–38 | 25–29 |

It is seen that the Burmese and Peninsular populations do differ from each other, and as *O. cotio cunma* is already applied to the Burmese forms, the Peninsular variety stands without a name. It is, therefore, proposed to denote the latter here as *Osteobrama cotio* var. *peninsularis*, nov. The new variety may be briefly characterised as follows:

*Osteobrama cotio* var. *peninsularis*, nov.

D.3/9; P.16; V.1/9; A.3/28–31; C.19; L.l.55–60.

Head contained 3·75 to 4·5 and height of body 2·25 to 2·75 in standard length. Diameter of eye 2·5 to 3 in head. Diameter of eye about that of inter-orbital width. Dorsal commences nearer to tip of snout than to base of caudal. Pectorals reach slightly beyond pelvic origin and pelvics extend up to anal fin. Anal with 28 to 31 branched rays. Scales 55 to 60 along lateral line. 7½ to 9½ scales between lateral line and pelvics. Predorsal scales 21 to 24. The colour in spirit is pale yellowish, the upper half being darker. Fins are unmarked.

The type locality of this new variety is Poona in the Bombay Presidency. A number of specimens from this type locality are present in the collection of the Zoological Survey of India (Indian Museum).

*Silonia* Swainson.

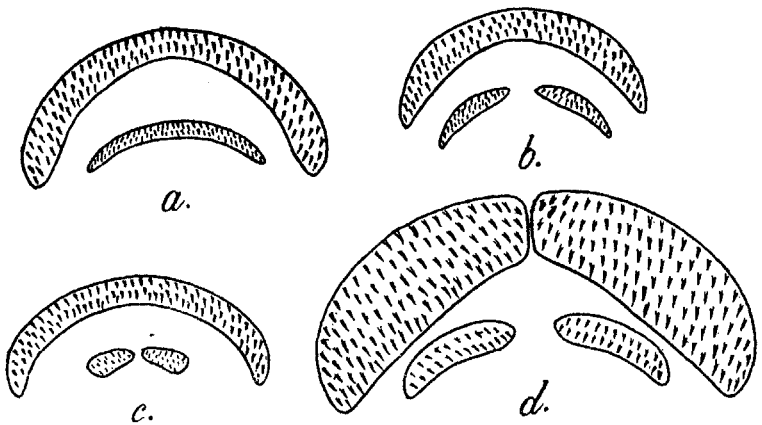
Day (1878) gave the distribution of *Silonia* as 'Estuaries of India and Burma, ascending high up the larger rivers to nearly their sources'. As originally defined *Silonia* possesses two minute barbels and this led Hora (1937) to consider *S. childreni* (Sykes) from Peninsular India with four barbels as falling under a separate genus, *Silonopangasius*. Majumdar (1951) records the presence of four barbels in *Silonia silondia* (Hamilton) in Northern India. In a series of specimens examined by him he found that the mandibulary pair, though present, was embedded in the skin. This being the case, it would seem that the Peninsular forms come within the range of variation of *Silonia* and it has become necessary, therefore, to suppress *Silonopangasius* Hora and treat it as a synonym of *Silonia* Swainson. The two Indian species differ principally by the nature of the air-bladder. It would seem that *S. childreni* of South India has become secondarily specialised owing to the tilting of the Western Ghats and the consequent changes resulting in the rejuvenation of the streams in the Peninsula.

*Silurus* Linneaus.

Miss Haig (1950), while describing a new species of *Silurus*, *S. goae* from Peninsular India also recognised one other Indian species, *viz.*, *S. cochinchinensis* Valenciennes. On the nature of the barbels Hora (1936) had already recognised two Indian species, *S. wynaadensis* Day and *S. cochinchinensis*, and with the latter he synonymised *S. afgana* Günther, *Silurichthys berdmorei* Blyth, and *Pterocryptis gangetica* Peters. Bhimachar and Rao (1940) considered *S. wynaadensis* to be synonymous with *S. cochinchinensis*.

Blyth's type of *Silurichthys berdmorei* is preserved in the collection of the Zoological Survey of India. From an examination of this specimen, as well as the *Silurus* material in the collection, I am led to conclude that *S. berdmorei* differs from *S. cochinchinensis* both in the nature of the dentition as well as the number of anal rays, but shows great affinities to *S. wynaadensis* of Peninsular India. From the latter it differs only in the nature of the barbels. But this character is very highly variable in many of the Siluroid genera and species, and as such, no great

importance can be attached to it. Therefore, on the nature of the dentition and the number of anal rays, *S. wynaadensis* is considered here as a subspecies of *S. berdmorei* (Blyth). Whether *S. cochinchinensis* co-exists with *S. berdmoeri wynaadensis* (Day) or not can be said only after examining more material of these forms from Peninsular India. A detailed account of the taxonomy of this genus will be discussed in a separate paper.




TEXT-FIG. 1. Nature of the dentition in species of *Silurus* Linnaeus.
(*a*) *S. cochinchinensis* Valenciennes. ×5.
(*b*) *S. berdmorei berdmorei* (Blyth). ×5.
(*c*) *S. berdmorei wynaadensis* (Day). ×5.
(*d*) *S. goae* Haig. ×4.

The other Peninsular species, *S. goae* is distinguished from *S. berdmorei* by its much deeper body, more extensive vomerine bands and the maxillary band being divided in the centre.

*Clarias* Gronovius.

In 1936, Hora discussed the systematic position of the various forms of *Clarias* described from India, Burma and Ceylon and concluded that only three species can be recognised from these regions. They are *Clarias batrachus* (Linneaus) (Ceylon, India, Burma, Malaya Peninsula and Indo-Australian Archipelago); *Clarias brachysoma* Günther (Ceylon) and *Clarias dayi* Hora (Wynaad Hills, Western Ghats). Later, in 1941 he revived the name *C. dussumieri* Cuv. & Val., for specimens from Malabar, South Canara, Goa, Belgaum and Pondicherry and stated:

> 'Except for differences in the nature of the pectoral spine and vomerine teeth and the length of the barbels, *C. dussumieri* is closely related to *C. brachysoma* of Ceylon and *C. dayi* of Wynaad.'

Day (1878) identified a single specimen from Wynaad as *Clarias dussumieri* Cuv. & Val., then known from Malabar and Pondicherry. This specimen formed the type of Hora's species *C. dayi* (Hora, 1941). As the specimens had well-defined teeth on the anterior surface of the pectoral spines, as seen in Bleeker's *C. meladerma* of Malaya Archipelago, Day placed the latter in synonymy of *C. dussumieri*. He expressed doubts regarding the validity of *C. brachysoma* of Ceylon as a distinct

species, and placed it in the synonymy of *C. teysmanni* Bleeker of Malaya Peninsula. Hora and Gupta (1941) drew attention to the variations in the shape of the occipital process of *C. teysmanni* in Malaya which intergrades with the condition seen in *C. brachysoma* of Ceylon. Smith (1945) did not consider *C. brachysoma* as distinct from *C. teysmanni*, for, regarding the distribution of the latter he stated:

> 'This species known also from Ceylon, Malaya, Sumatra, Borneo and Java has a very limited distribution in Thailand.'

Undoubtedly, the great similarity between the Malayan and the Peninsular Indian and Ceylonese forms has given rise to this confusion in the taxonomy of these fishes. Therefore, to clarify this, it would seem best, both from distributional data as well as on the nature of morphological characters to consider the Peninsular Indian and Malayan species showing intra-relationships under two complexes or associations. *C. batrachus* being very widely distributed is not of importance in this taxonomic assessment, and hence is left out. To the remaining Peninsular and Ceylonese species the name *dussumieri* may be applied as it has priority over *brachysoma* and *dayi*. The species recognised in the *dussumieri*-group are:

*Clarias dussumieri dussumieri* Valenciennes.
*Clarias dussumieri dayi* (Hora).
*Clarias dussumieri brachysoma* Günther.

A complete taxonomic assessment of the eastern species, namely, *Clarias meladerma* Bleeker; *C. teysmanni* Bleeker; *C. leiacanthus* Bleeker and *C. macrocephalus* Günther is wanting. The first two species, as already indicated, evince great affinity to the *dussumieri*-group. In case *C. leiacanthus* and *C. macrocephalus* also show great similarity to *meladerma* and *teysmanni*, then all four species may have to be placed under one group or super species, and the name *meladerma* is suggested, as it is the oldest in use.

The intra-relationships of the *dussumieri*-group are considered below. In having a more coarsely serrated spine, somewhat shorter barbels and more obtuse teeth on the palate, *C. dussumieri dussumieri* differs from *C. dussumieri brachysoma* of Ceylon. From *C. dussumieri dayi* it can be separated by its much longer nasal barbels, less molariform teeth and less strongly serrated pectoral spine. It is thus intermediate between *brachysoma* and *dayi*. As in the case of the catfishes of the genera *Erethistes* and *Conta* (Hora, 1951) inhabiting the swift streams of the Eastern Himalayas, the serrations on the outer border of the pectoral spines of *C. dayi* may represent an adaptive modification to help the fish to anchor to the substratum in fast-flowing waters. *C. dussumieri dayi* in which these serrations are well developed, is so far known only from the streams of the Wynaad Hills.

The close similarity of the Malayan and Peninsular Indian species of the genus *Clarias* indicate the possibility of a common ancestral stock for these fishes. At either extremities the genus has proliferated giving rise to a number of similar forms.

### *Pristolepis* Jerdon.

Speaking of the distribution of *Pristolepis*, Day (1878) observed:

> 'Freshwaters of the plains and hills of India, Burma, Siam and Malaya Archipelago; those with villiform teeth in the adult on the vomer appear to belong to India proper (*Paranandus*); those with globular teeth on that bone to Burma and eastwards (*Catopra*).'

The three species recognised by Day were: *P. marginatus* Jerdon from Wynaad Hills, *P. malabaricus* (Günther) from the Western Ghats of Malabar and *P. fasciatus* Bleeker from Burma, Thailand and the Malaya Archipelago. Hora and Law (1941) listed *P. fasciatus* in the fauna of Travancore and gave its distribution as:

'Travancore, Burma, Siam, Malaya Archipelago and Cochin China.' The diagnostic characters of the three species are listed in the following table:

| No. | Characters. | *P. fasciatus.* | *P. marginatus.* | *P. malabaricus.* |
|---|---|---|---|---|
| 1 | No. of dorsal fin rays .. | 12–13/14–15 | 15–16/11–12 | 14/12–14 |
| 2 | No. of pectoral fin rays .. | 15 | 14 | 14–15 |
| 3 | No. of anal fin rays .. .. | 3/8 | 4/8 | 3/8 |
| 4 | No. of lateral line scales .. | 26–28 | 27–30 | 25–27 |
| 5 | Vomerine teeth .. .. | Globular. | Villiform. | Villiform. |

But for the differences in the nature of the dentition, the three species seem to be closely related. *P. marginatus* and *P. malabaricus* are more or less similar and it would not be surprising if a detailed study shows that they are only subspecies or races of one species, *P. marginatus*. From the wide range of distribution of *P. fasciatus* and its occurrence in Peninsular India, it would seem that the other two species of *Pristolepis* in the Peninsula have diverged from *fasciatus*-like forms. In any case their close similarity is remarkable.

## Physiographic and Climatic Fluctuations Facilitating Migration.

Recent researches show that the migration of the so-called Malayan stock of fishes to the Peninsula was mainly Pliocene and Post-Pliocene. Hora (1944) drew attention to the possibility of this element having reached the Peninsula in a series of waves of migration. Bhimachar (1945) postulated about four waves of migration of fishes to the Peninsula and Ceylon from the region of the Assam Himalayas. On the basis of the distribution of certain freshwater fishes he divided the Western Ghats into three divisions, namely, a northern division comprising the Deccan Trap area from the Tapti river down to 16°N. Latitude about the level of Goa; a central division, extending from 16°N. Latitude southwards and including the Malnad parts of Mysore State, Coorg, Wynaad and parts of South Canara District and the Nilgiris; and a southern division, comprising the Anamalai, Palani and Cardomom Hills of Travancore. That there were a series of influxes from the east may be inferred from the distributional pattern of the Peninsular Isolates (*vide* table on page 438). As it is evident that the greater part of the migration was Post-Pliocene, let us consider what influence the climatic phases of the Pleistocene period would have had on the dispersal of these forms.

In discussing the effects of Himalayan Glaciation on terrestrial and freshwater animal life in Peninsular India, Hora (1949) opined that the 'Refrigeration', though it affected the terrestrial vertebrates, had no direct effect on the aquatic forms. Recently he (Hora, 1951), however, reconsidered this point of view and on the basis of eustatic movements in the sea-level during the Glacial epochs and their effects on physiography and climatology conceded that migration was made possible through consequential changes as a result of glaciation.

Though opinion still differs as to the Plio-Pleistocene boundary, the total duration of the Pleistocene and the Holocene is considered by most workers to be about 600,000 years (Holocene about 22,000 years). The Pleistocene was characterised by four main Glacial epochs which were intervened by three inter-glacial periods. The absolute chronology for the Pleistocene for India is still unknown, but De Terra and Patterson (1939) investigating the relative climatic succession of North Western India succeeded in linking river terraces with the moraines of Himalayan Glaciation. The relative duration of the Himalayan Glacial and Inter-glacial periods were given by them, and they also found, that

there existed great correlation in the connection of moraines with the aggradation terraces both in North-Western India and the Alps. Zeuner (1945, p. 273) also commented on these similarities, thereby throwing more light on the assumption that the Glaciation of the Himalayas were more or less contemporary with those of Europe.

The glacial epochs, when compared with that of the interglacials were of a much shorter duration and were experienced in the southerly latitudes as a succession of cold 'Pluvial Periods', which were characterised by low temperature, increased humidity and a fall in sea-level. As stated by Hora (*loc. cit.*), the physiographic changes resulting from a fall in the level of the sea during the 'Pluvial Periods' of the Pleistocene, would have facilitated the migration of even torrential fishes from the region of the Assam Himalayas to the Peninsula across the present-day Garo-Rajmahal Gap.

But succeeding phases of aridity and increased desiccation, which resulted in a rise in the sea-level, consequently not only isolated certain forms, but temporarily would have checked dispersal of freshwater forms from the Assam Himalayas to the Peninsula. Geological evidences show that, even during the long interglacial periods, there were minor cold oscillations accompanied by a drop in sea-level. On the assumption that these minor changes could have affected the physiography of India, it would seem that in addition to the major influxes of freshwater forms to the Peninsula which coincided with the four main Pluvials, the minor cold oscillations could have also made possible a succession of small waves of migration of such species as are usually found at the foot of the hills. The overlapping distribution of the Peninsular Isolates points to such a conclusion.

In this connection, the changes undergone by the drainage system of the Peninsula during the Pliocene and the Pleistocene will have to be considered. Menon (*loc. cit.*), reconstructing the past drainage system of the northern part of the Peninsula, has shown that the Narbada-Tapti which flowed to the west as a single river, had Mahanadi and Godavari as its tributaries till comparatively recent times in geological history. The tilting of the Peninsula during the Pleistocene reversed this drainage system to its present-day pattern. It would seem that the Narbada-Tapti which drained the regions probably as far east as the Assam Himalayas and the whole of the Satpura trend of mountains, could have undoubtedly facilitated the migration of the early 'eastern element' to the Peninsula. Only this could account for the occurrence of widely separated forms like *Silurus*, *Pseudobagrus*, *Lepidopygopsis*, etc., in the southern parts of the Peninsula today. The probable time and significance of the distribution of the different genera are discussed in a later section.

## Table showing the range of distribution of the Peninsular Isolates.

The range of distribution of 47 species of Peninsular Isolates along the Vindhya-Satpura trend and the Western Ghats is given in the following table (Table 2). For convenience, the three divisions of the Western Ghats, as given by Bhimachar (*loc. cit.*), are adopted here.

The localities which are indicated by numbers are as follows: (1) Damodar Section; (2) Rihand Section; (3) Mahanadi Section; (4) Narbada-Tapti Section; (5) Northern Division of the Western Ghats; (6) Central Division of the Western Ghats, and (7) Southern Division of the Western Ghats.

From Table 2 the following analysis is made. Of the 16 isolates found in the Southern division of the Western Ghats, 8 are truly endemic, while six are common to the central and one to the northern division. One species, *Pristolepis fasciatus* is elsewhere known from Thailand and the Malayan region. In the central division there are 21 isolates, of which five are truly endemic, six extend

TABLE 2.

*Table showing the range of distribution of the Peninsular Isolates.*

| Name of Species. | Localities. | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| *Osteochilus* (*Osteochilichthys*) *thomassi* (Day) | — | — | — | — | — | x | x |
| *Osteochilus* (*Osteochilichthys*) *nashi* (Day) | — | — | — | — | x | x | — |
| *Osteochilus* (*Kantaka*) *brevidorsalis* (Day) | — | — | — | — | — | x | — |
| *Schismatorhynchus* (*Nukta*) *nukta* (Sykes) | — | — | — | — | x | x | — |
| *Rohtee* (*Rohtee*) *ogilbii* Sykes | — | — | — | — | x | x | — |
| *Tor mosal* Hamilton (a new variety) | — | — | x | — | — | — | — |
| *Puntius sarana* var. *pinnauratus* (Day) | — | — | — | — | — | — | x |
| *Puntius ticto punctatus* (Day) | — | — | — | — | — | x | x |
| *Osteobrama cotio* var. *peninsularis* nov. | — | — | — | — | x | — | — |
| *Garra gotyla* (Gray) | x | — | x | x | — | — | — |
| *Labeo* (*Morulius*) prox. *chrysophekadion* Bleeker | — | — | — | — | — | x | — |
| *Labeo dyocheilus* (McClelland) | x | — | x | — | — | — | — |
| *Labeo dero* (Hamilton) | x | — | x | — | — | — | — |
| *Crossocheilus latius* (Hamilton) | x | x | x | — | x | — | — |
| *Thynnichthys sandkhol* (Sykes) | — | — | — | — | x | — | — |
| *Homaloptera montana* Herre | — | — | — | — | — | — | x |
| *Bhavania australis* (Jerdon) | — | — | — | — | — | x | x |
| *Travancoria jonesi* Hora | — | — | — | — | — | — | x |
| *Balitora brucei* var *mysorensis* Hora | — | — | — | — | x | x | — |
| *Psilorhynchus sucatio* var. | x | — | — | — | — | — | — |
| *Lepidopygopsis typus* Raj | — | — | — | — | — | — | — |
| *Silonia silondia* (Hamilton) | — | — | — | — | — | x | — |
| *Silonia childreni* (Sykes) | — | — | — | — | x | x | x |
| *Pangasius pangasius* (Hamilton) | — | — | — | — | — | x | — |
| *Eutropiichthys goongwaree* (Sykes) | — | — | — | — | x | — | — |
| *Neotropius khavalchor* Kulkarni | — | — | — | — | x | — | — |
| *Batasio travancoria* Hora & Law | — | — | — | — | — | — | x |
| *Batasio* prox. *tengana* (Hamilton) | — | — | x | — | — | — | — |
| *Pseudobagrus brachysoma* Günther | — | — | — | — | — | x | x |
| *Gagata cenia* (Hamilton) | x | x | x | — | — | — | — |
| *Gagata itchkeea* (Sykes) | — | — | — | — | x | x | — |
| *Gagata gagata* (Hamilton) | — | — | x | — | — | — | — |
| *Laguvia ribeiroi* Hora | x | x | x | x | — | — | — |
| *Glyptothorax horai* Shaw & Shebbeare | — | x | — | — | — | — | — |
| *Glyptothorax annandalei* Hora | — | x | — | — | x | x | — |
| *Erethistoides montana* var *pipri* Hora | — | x | — | — | — | — | — |
| *Amblyceps mangois* (Hamilton) | x | x | x | x | — | — | — |
| *Silurus goae* Haig | — | — | — | — | — | x | x |
| *Silurus berdmorei* var *wynaadensis* (Day) | — | — | — | — | — | x | — |
| *Silurus cochinchinensis* Valenciennes | — | — | — | — | — | x | — |
| *Clarias dussumieri dussumieri* Valenciennes | — | — | — | — | — | x | x |
| *Clarias dussumieri dayi* (Hora) | — | — | — | — | — | x | — |
| *Pristolepis marginatus marginatus* Jerdon | — | — | — | — | — | x | — |
| *Pristolepis marginatus malabaricus* (Günther) | — | — | — | — | — | x | x |
| *Pristolepis fasciatus* (Bleeker) | — | — | — | — | — | — | x |
| *Amphipnous fossorius* Nair | — | — | — | — | — | — | x |
| *Tetraodon* (*Monotretus*) *travancoricus* Hora & Nair | — | — | — | — | — | — | x |

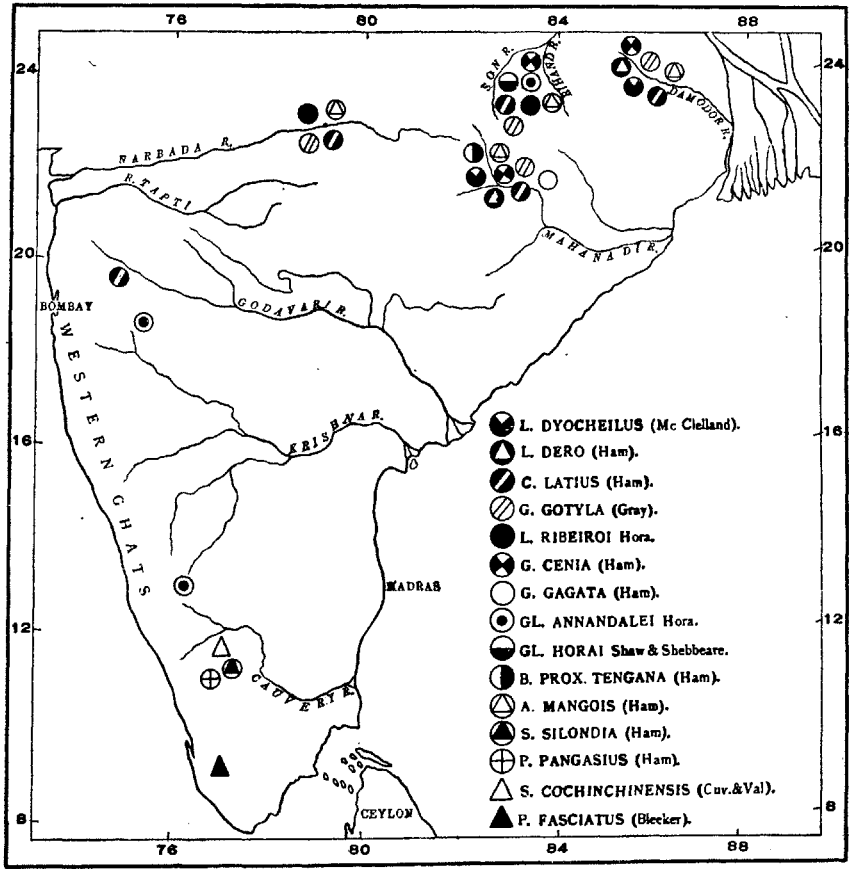
to the southern division, seven to the northern division and one to the Rihand section. The two species *Silonia silondia* and *Pangasius pangasius* are known generally from Northern India and further east. *Silurus cochinchinensis* is elsewhere found in the region of the Eastern Himalayas, Northern Burma, Southern China and Indo-China. In the northern division there are four endemic forms while seven are common to the central and one to the southern divisions; one to the Rihand and one is found all along the Vindhya-Satpura trend. The three isolates found in the Narbada-Tapti section are also found all along the Vindhya

Satpura trend. Of the nine isolates of the Mahanadi section, one is truly endemic, while one is common to the Northern division of the Western Ghats, two to the Narbada-Tapti section, three to the Rihand and six to the Damodar section. In the Rihand section, out of seven isolates, only one is truly endemic, while one is common to the central and northern divisions of the Western Ghats, one to the northern division, two to the Narbada-Tapti section, three to the Mahanadi and four to the Damodar section. Of the eight isolates of the Damodar section, one is truly endemic, while one is common to the northern division of the Western Ghats, three to the Narbada-Tapti and six to the Mahanadi sections.

It will thus be seen that endemicity is more pronounced in the extreme southern section of the Western Ghats below the Palghat Gap and gradually decreases as one goes up along the Ghats and then the Vindhya-Satpura trend of mountains. High endemicity is a clear proof of the longer isolation of the forms in the southern portion of Peninsular India.

## Levels of evolutionary divergences.

In order to get a clear understanding of the status of the Peninsular Isolates, the category of species showing a continuous range of distribution, throughout




TEXT-FIG. 2. Outline map of Peninsular India showing the distribution of species which are represented in the Eastern Himalayas, Burma and further east by taxonomically identical forms.

India, Burma, Thailand, and further east, such as, *Clarias batrachus*, *Oreichthys cosuatis*, *Danio aequipinnatus*, etc., have not been included in the list. Even in the case of some of these forms the range of distribution is great enough, so that variations correlated with geography could exist, which would probably justify the erection of new races or subspecies. But this would entail a detailed study of the species concerned along its whole range of distribution.

Unlike birds (Ripley, 1949), among fishes the various levels of evolutionary divergences have been of a much greater magnitude, ranging from generic to racial levels. Obviously, the rates of evolution are not the same in all the genera. The forms most affected seem to be the torrential fishes, for being highly specialised, they are likely to become isolated in certain river-systems, as a result of which the rate of speciation is accelerated in them. The different levels of evolutionary divergences of the Peninsular Isolates are given below:

### 1. Generic Divergence.

*Bhavania* Hora.
*Travancoria* Hora.
*Lepidopygopsis* Raj.
*Neotropius* Kulkarni.

### 2. Subgeneric Divergence.

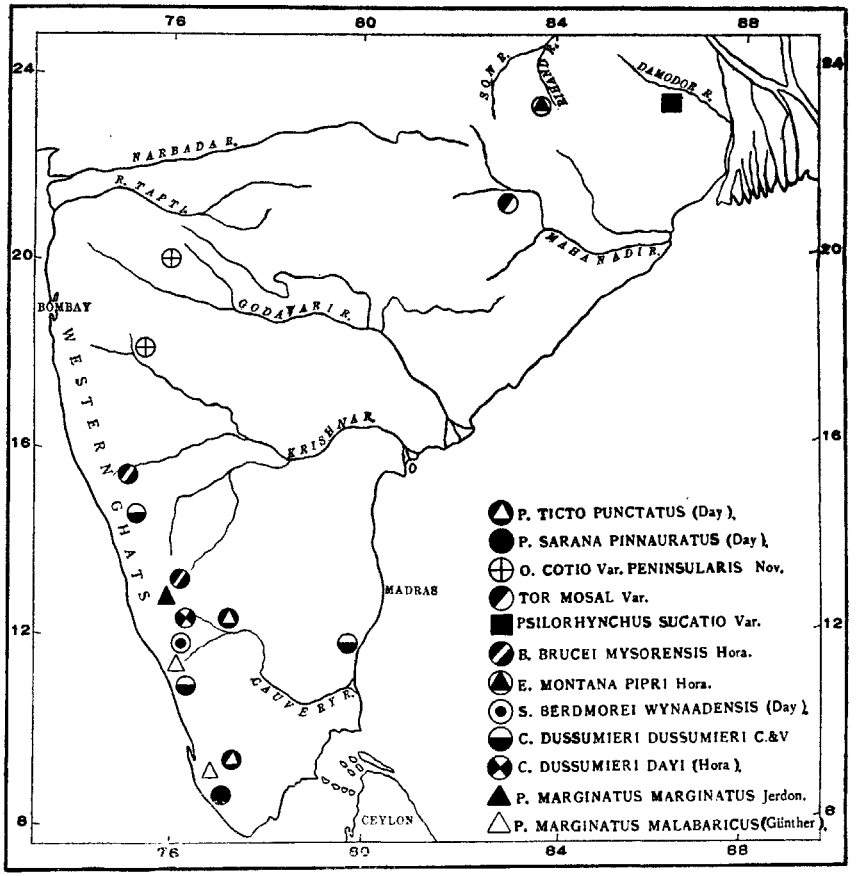
*Osteochilichthys* Hora.
*Nukta* Hora.
*Kantaka* Hora.
*Rohtee* Sykes.

### 3. Specific Divergence.

*Osteochilus* (*Osteochilichthys*) *nashii* (Day).
*Thynnichthys sandkhol* (Sykes).
*Labeo* (*Morulius*) prox. *chrysophekadion* Bleeker.
*Homaloptera montana* Herre.
*Silonia childreni* (Sykes).
*Eutropiichthys goongwaree* (Sykes).
*Batasio travancoria* Hora and Law.
*Pseudobagrus brachysoma* Günther.
*Gagata itchkeea* (Sykes).
*Silurus goae* Haig.
*Amphipnous fosserius* Nair.
*Tetraodon* (*Monotretus*) *travancoricus* Hora and Nair.

### 4. Subspecific and Racial Divergence.

*Puntius ticto punctatus* (Day).
*Puntius sarana pinnauratus* (Day).
*Tor mosal* var.
*Psilorhynchus sucatio* var.
*Osteobrama cotio* var. *peninsularis*, nov.
*Balitora brucei* var. *mysorensis* Hora.
*Erithistoides montana* var. *pipri* Hora.
*Silurus berdmorei* var. *wynaadensis* (Day).
*Clarias dussumieri dussumieri* Val.
*Clarias dussumieri dayi* (Hora).
*Pristolepis marginatus marginatus* Jerdon.
*Pristolepis marginatus malabaricus* (Günther).



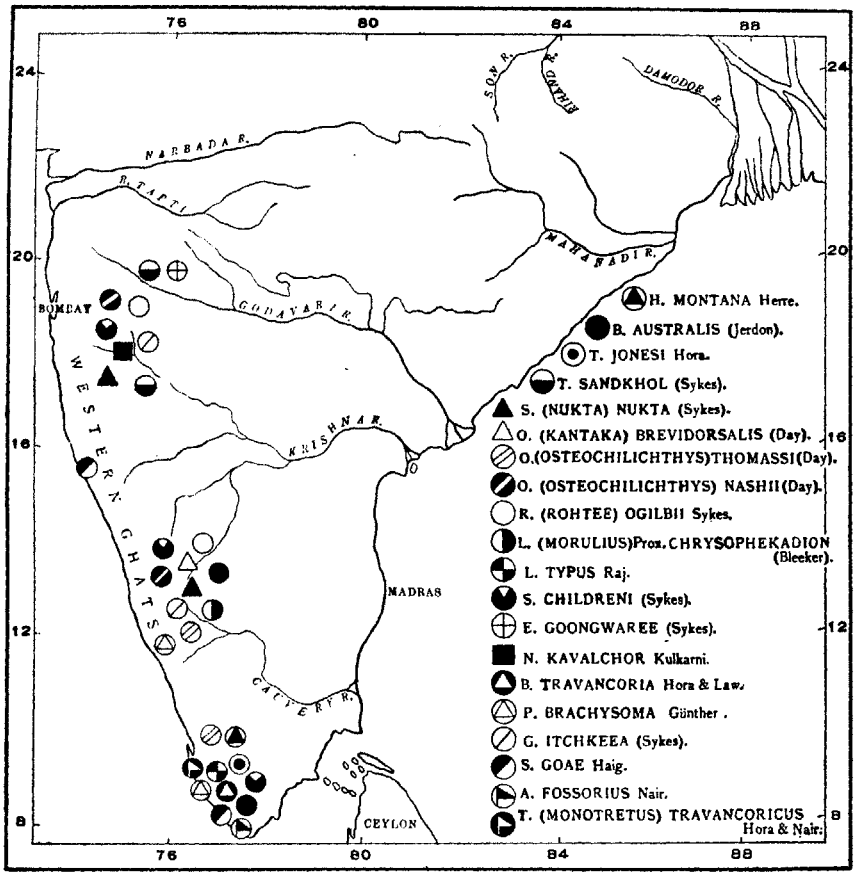

TEXT-FIG. 3. Outline map of Peninsular India showing the distribution of Subspecific and Racial divergents among the Peninsular Isolates with Malayan affinities.

5. Species showing Discontinuous Distribution.

*Garra gotyla* (Gray).
*Labeo dyocheilus* (McClelland).
*Labeo dero* (Hamilton).
*Crossocheilus latius* (Hamilton).
*Batasio* prox. *tengana* (Hamilton).
*Gagata cenia* (Hamilton).
*Gagata gagata* (Hamilton).
*Laguvia ribeiroi* Hora.
*Glyptothorax horai* Shaw & Shebbeare.
*Glyptothorax annandalei* Hora.
*Silonia silondia* (Hamilton).
*Pangasius pangasius* (Hamilton).
*Amblyceps mangois* (Hamilton).
*Silurus cochinchinensis* Valenciennes.
*Pristolepis fasciatus* Bleeker.

The fifteen species included in the fifth category are identical (taxonomically) with the Assam Himalayan and further eastern populations. The approximate percentages of the different levels of divergences of the 47 Peninsular Isolates considered here are given below:

| | |
|---|---|
| Generic Divergence .. .. .. .. | 8·51% |
| Subgeneric Divergence .. .. .. | 8·51% |
| Specific Divergence .. .. .. .. | 25·53% |
| Subspecific and Racial Divergence .. .. | 25·53% |
| Percentage of taxonomically identical forms .. .. | 31·91% |




TEXT-FIG. 4. Outline map of Peninsular India showing the distribution of Generic, Subgeneric and Specific divergents among the Peninsular isolates with Malayan affinities.

Table 3 gives the number of isolates and the approximate percentage* of endemicity in each of the sections.

In Table 4 the degree of divergence (in percentage) of the isolates in each section is given. Under 'identical forms' is given the percentage of isolates which are taxonomically identical with the Assam Himalayan and further eastern populations.

As already stated, the greatest amount of divergence and percentage of endemicity is met with in the southern division of the Western Ghats. It is evident that these forms would have been isolated for a considerably longer period than those found in the northern parts of the Peninsula. Only very slight differentiation seems to have taken place along the Vindhya Satpura trend, for a greater part of the species are taxonomically identical with the Eastern Himalayan and further eastern populations. The distribution of forms like *Amblyceps*, *Laguvia*, *Labeo dyocheilus*, *Labeo dero*, *Garra gotyla*, etc., along this trend, but absent in the Peninsula proper, indicate that they are recent isolates and probably represent the last phases of migration.

* The percentage is calculated from the total number of Peninsular isolates considered here which number 47.

TABLE 3.

| No. | Particulars. | *Vindhya-Satpuras.* | | | | *Western Ghats.* | | |
|---|---|---|---|---|---|---|---|---|
| | | Damodar section. | Rihand section. | Mahanadi section. | Narbada-Tapti section. | Northern division. | Central division. | Southern division. |
| 1 | Total number of species in each section .. .. .. | 8 | 7 | 9 | 3 | 12 | 22 | 16 |
| 2 | Number of truly endemic species .. | 1 | 1 | 1 | .. | 4 | 5 | 7 |
| 3 | Percentage of species in each section as compared to the total number of Peninsular Isolates .. | 17·02 | 14·89 | 19·14 | 6·38 | 25·53 | 46·8 | 34·04 |
| 4 | Percentage of endemicity in each section as compared to the total number of Peninsular Isolates .. | 2·12 | 2·12 | 2·12 | .. | 8·51 | 10·63 | 14·89 |

TABLE 4.

| *Localities.* | No. in each section & percentage. | Generic divergence. | Subgeneric divergence. | Specific divergence. | Subspecific or racial divergence. | Identical forms. |
|---|---|---|---|---|---|---|
| DAMODAR SECTION .. .. | Number .. | .. | .. | .. | 1 | 7 |
| | Percentage .. | .. | .. | .. | 12·5 | 87·5 |
| RIHAND SECTION .. .. | Number .. | .. | .. | .. | 1 | 6 |
| | Percentage .. | .. | .. | .. | 14·3 | 85·7 |
| MAHANADI SECTION .. .. | Number .. | .. | .. | .. | 1 | 8 |
| | Percentage .. | .. | .. | .. | 11·1 | 88·9 |
| NARBADA-TAPTI SECTION .. | Number .. | .. | .. | .. | .. | 3 |
| | Percentage .. | .. | .. | .. | .. | 100 |
| NORTHERN DIVISION .. | Number .. | 1 | 3 | 4 | 2 | 2 |
| | Percentage .. | 8·33 | 25 | 33·3 | 16·66 | 16·66 |
| CENTRAL DIVISION .. .. | Number .. | 1 | 4 | 6 | 7 | 4 |
| | Percentage .. | 4·54 | 18·18 | 27·27 | 31·81 | 18·18 |
| SOUTHERN DIVISION .. | Number .. | 3 | 1 | 7 | 4 | 1 |
| | Percentage .. | 18·75 | 6·25 | 43·75 | 25 | 6·25 |

The taxonomic assessment of the species show that, both in Peninsular India and Burma and further east, subspecific and racial divergences of Polytypic species such as, *Balitora brucei*, *Puntius sarana*, *Puntius ticto*, and *Silurus berdmorei* have taken place on almost similar lines. These, in addition to the occurrence of species, such as, *Clarias dussumieri*, *Batasio travancoria*, *Gagata itchkeea*, etc., which may be components of different super-species give us some idea as to the probable source from which the Peninsular Isolates were derived.

## Factors facilitating fast-rate of speciation among the Peninsular Isolates.

Geographical isolation is recognised as a factor of prime importance in the process of evolutionary divergence. In addition to this, other agents have also been at work, aiding rapid speciation among the Peninsular Isolates. The most important of these are:

(1) The climatic fluctuations during the Pleistocene, and
(2) Changes in the physiography of the Peninsula during the Pleistocene and consequent effects.

Both favourable and unfavourable climatic phases prevailed throughout the Peninsula during the Pleistocene. The increased glaciation of the Himalayas during the Ice-Age considerably lessened the temperature in the Peninsula and as a result more moist conditions prevailed. Consequently, during the 'Pluvial Periods' there was an uninterrupted greater flow of water in the streams and rivers. Succeeding arid climatic phases reversed these conditions and these fluctuations would have also adversely affected the fauna. So far as fish life is concerned, certain physiographic barriers became negotiable during the 'Pluvial Periods' and the 'Arid Periods' isolated faunas on hill tops, thus inducing rapid speciation.

Further impetus to the rate of speciation was added when as a result of scrap-faulting along the West Coast, the tilting of the Peninsula took place. This tilting not only reversed the drainage system, but rejuvenated the streams of the Western Ghats. Such recent and subrecent rejuvenation of tributary streams is known along the Himalayas as a result of intermittent uplift during recent periods. Chibber (1949, p. 23), had adduced evidence to show that during recent and sub-recent periods there were earth movements which rejuvenated the Himalayan streams several times when their vertical corrosion had been stopped. That similar rejuvenation of the streams would have taken place in the Peninsula during the Pleistocene after the tilting is well exemplified by Wadia's account (Wadia, 1944, p. 17) about the irregularities of the 'curve of erosion' of the Peninsular rivers caused by late earth movements. He observed:

> 'It cannot be said, however, that the channels are wholly free from *all* irregularities, for, some of them do show very abrupt irregularities of the nature of *Falls*. Among the best known water-falls of South India are, the Sivasamudram falls of the Cauvery in Mysore, which has a height of about 300 feet, the Gokak falls of the river of that name in Belgaum district, which are 180 feet in height; the 'Dhurandhar' or the falls of the Narbada at Jabalpur, in which though the fall is only 30 feet, the volume of water is large. The most impressive and best known of waterfalls of India are the Gersoppa Falls of the river Sharavati in North Kanara, where the river is precipitated over a ledge of the Western Ghats to a depth of 850 feet in one single fall. The Yenna falls of the Mahableshwar hills descend 600 feet below in one leap, while the falls of Paikara in the Nilgiri Hills descend less steeply in a series of five cataracts over the gneissic precipice. Indeed, it may be said that such falls are more characteristic of Peninsular than extra-Peninsular India and bear evidence of some minor disturbances in a late geological age.'

Whether the tilting of the Peninsula took place as a result of a single disturbance or whether it was intermittent is not definitely known. Whatever may be the case, it would seem that the stock which reached the Peninsula prior to the tilting, or the 'Pre-tilt forms' underwent the greatest amount of divergence, while the 'Post-tilt forms' have differentiated only slightly from the parent stock. It will also be seen that the greatest divergence is found in the extreme south of the Peninsula and to reach that distance these isolates must have reached the Peninsula at a much earlier age than the others. Secondly the divergence is much more marked in the hill-stream forms which were rejuvenated by the physiographic changes of the Peninsula during the Pleistocene.

## Probable sequence of migration.

Of the 'Pre-tilt forms', the earliest to reach the Peninsula would have been genera like *Puntius*, *Tor*, *Garra*, *Homaloptera*, *Lepidopygopsis*, *Nemachilus*, *Glyptothorax*, *Silurus*, *Pseudobagrus*, *Clarias*, *Pristolepis*, *Amphipnous*, etc. Their migration to the Peninsula would not have been later than the earliest Pluvial Period during the Lower Pleistocene. In fact, part of the original stock would have come at a still earlier date. Of the above genera, *Puntius*, *Tor*, *Garra*, *Nemachilus* and *Clarias* are found in Ceylon and they extend as far west as Africa. Since its first severance from India during the late Miocene, Ceylon was intermittently connected to the mainland at different times (Jacob, 1949, p. 341). Its last complete disruption from the mainland took place only about 10,000 years back. This being the case, former temporary land connections with the mainland during the 'Pluvial Periods', when the sea-level fell, would have enabled the migration of the Peninsular species to Ceylon as well as to Africa.

*Homaloptera* has not so far been recorded from Ceylon. I have elsewhere discussed the distributional significance of this form in Peninsular India (Silas, 1951). From the *Homaloptera*-stock which reached the Peninsula during the early 'Pluvial Period', were evolved at a later date two other genera, namely, *Bhavania* and *Travancoria*. This divergence would have taken place consequent to the tilting of the Peninsula which dated probably not later than the earlier part of the Middle Pleistocene.

The distribution of the genus *Silurus* is interesting, for at present it is known to occur in China and along the Trans-Himalayan portion to Asia Minor and Eastern Europe. In the south it has spread to the Eastern Himalayas and to the Peninsula, its westward spread along the Trans-Himalayas would have been of a much earlier date than its migration to Peninsular India. The continuous Narbada-Tapti River of the early Pleistocene which probably drained places as far east as the Assam Hills would have helped in the migration of this form to the Peninsula.

The Schizothoracine genus *Lepidopygopsis* of the Peninsula has its nearest allies in *Schizothorax* and *Oreinus* of the Himalayas and South China. The former to which it evinces greater affinity was probably a widespread genus in the early-Pleistocene Narbada-Tapti River, thus extending to the Peninsula in past ages. On account of long isolation it has evolved into a new genus in the Peninsula, but probably due to lack of large mountain rivers in the Western Ghats has disappeared from the intervening areas.

The spread of *Pseudobagrus* from Southern China to the Peninsula would have been aided considerably by the ancient Narbada-Tapti River.

Forms like, *Osteochilus*, *Schismatorhynchus*, *Rohtee*, *Labeo* (*Morulius*), *Batasio*, *Silonia*, *Neotropius*, and *Tetraodon*, would have reached the Peninsula later, probably during the later part of the Lower Pleistocene. They have spread to the north, central and even southern divisions of the Western Ghats. The early-Pleistocene Narbada-Tapti would have also facilitated the migration of these forms to the Peninsula.

The main tilting of the Peninsula seems to have taken place after their advent. From the distribution of fishes it would seem that this geological event took place probably not later than the earlier part of the middle-Pleistocene. The 'Pre-tilt forms' have generally diverged considerably. The earliest 'Post-tilt forms' would have been species like, *Balitora brucei*, *Silurus berdmorei*, *Thynnichthys*, etc. Mostly racial or subspecific divergence is seen in these forms. Special mention must be made of the distribution of *Thynnichthys*. Though it has only specifically diverged in Peninsular India, the genus as such is an old one. Fossil specimens of *Thynnichthys* have been reported from the Eocene deposits of Java. *Thynnichthys sandkhol* is found in the northern division of the Western Ghats, and as such its spread to the Peninsula would seem to be of a more recent date. *Thynnichthys*, like, *Schismatorhynchus*, *Osteochilus*, *Homaloptera*, etc., indicates that the spread of these forms from the region of Southern China to the Malayan region was much faster and uninterrupted than its spread to Peninsular India.

The differentiation of *Osteobrama cotio*, *Eutropiichthys goongwaree*, etc., would not have been earlier than the upper-Pleistocene. As already stated (*vide supra* p. 442) the distribution of *Amblyceps*, *Laguvia*, *Eristhistoides*, *Tor mosal*, *Psilorhynchus sucatio*, *Garra gotyla*, etc., along the Vindhya Satpura trend, but absent in the Peninsula proper, indicates that they represent the last phases of migration.

## Summary.

In connection with Hora's Satpura Hypothesis, Mayr (*loc. cit.*), suggested certain lines of approach to the problem, one of them being, a close taxonomic study of the Peninsular species showing Malayan affinities, and an analysis of their different levels of evolutionary divergences. In this article, the taxonomic status of certain forms like *Rohtee* Sykes, *Puntius ticto* Ham., *Osteobrama* Heckel, *Silonia* Swainson, *Silurus* Linnaeus, *Clarias* Gronovius, and *Pristolepis* Jerdon, which needed further clarification, is elucidated. A complete list of the important Peninsular Isolates with their eastern affinities is given. Migration of torrential fishes from the region of the Eastern Himalayas across the Garo-Rajmahal Gap was possible during the 'Pluvial Periods' of the Pleistocene, which coincided with the Glacial epochs of the north. During these cold phases there was a general drop in the sea-level, but subsequent rise in sea-level during the 'Arid Periods' (which would have corresponded with the Interglacials) temporarily checked migration and thus isolated certain forms. The continuous Narbada-Tapti River of the early Pleistocene would have also considerably helped in the dispersal of forms to the Peninsula from the east.

The scrap faulting of the West Coast and the tilting of the Peninsula during the Pleistocene reversed the drainage system and also rejuvenated the streams and rivers. This, in addition to the climatic fluctuations gave sufficient impetus for rapid speciation among the Peninsular Isolates. The 'Pre-tilt forms' diverged most, while the 'Post-tilt forms' have only slightly diverged from the parent stock. Endemicity and the degree of divergence is most pronounced in the extreme southern section of the Western Ghats. A gradual decrease is seen as one goes up along the Ghats and then the Vindhya Satpura trend of mountains. High endemicity is a clear proof of the longer isolation of the forms of the Peninsula. The divergence is greatest in the species found in the hill-streams which in turn were rejuvenated by the physiographic changes of the Peninsula during the Pleistocene. The probable sequence of migration of these forms are also dealt with in the last section.

## Acknowledgment.

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