MONOGRAPH OF THE CYPRINID FISHES OF THE GENUS *GARRA* HAMILTON

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(With 1 Table, 29 Text-figs. and 6 Plates)

CONTENTS

I—Introduction

The distribution of the genus *Garra* is from South China and Borneo in the east, through Burma, India and Ceylon, Afghanistan, Persia, Syria and Arabia to Somaliland, Eritrea and Abyssinia in East Africa, and then westward to French Guinea through the Congo. The outstanding characteristic of the genus is the possession of a more or less well-developed suctorial disc on the undersurface just behind the mouth. Most of its species inhabit rapid running waters and maintain themselves against swift currents by clinging to the substratum, mainly by means of their suctorial disc but also by the horizontally placed paired fins, especially the pectorals. Some occur, too, in small lakes, tanks and pool, but the only species from brackish water is *Garra tibanica* Trewavas (1941), of which twelve specimens were doubtfully recorded as from the "foreshore, Aden Peninsula" Therefore, I have defined *Garra* as an assemblage of strictly continental or primary fresh-water fishes (Myers, 1938) in evaluating the Zoogeographical evidence that has emerged from studies of this genus.

This systematic work has produced many interesting results. The type-locality of *Garra lamta* has been fixed as Butwal stream (Rapti River) at the foot of the Nepal Himalayas, 21 miles north of Nautanwa in Gorakhpur District, Uttar Pradesh, and not the streams in Kharagpur Hills in Monghyr District, Bihar. The Kharagpur species is *G. mullya*, a widely distributed Peninsular species. The members of the genus are divisible into three groups consisting of nine species complexes ; and from the limits of the various complexes there emerges a significant distributional pattern. In particular, the occurrences of a primitive species of *Garra* in South West Arabia and Somaliland in East Africa is of much interest as it indicates a connection between the Arabian, Peninsula and East Africa by way of Somaliland during geologically recent times and that the Oriental element in strictly or primary fresh-water fishes in Africa reached there along this route.

The largest part of the material I have examined is in the Zoological Survey of India. It is supplemented by important material borrowed from institutions in Europe, Asia and the United States, or received through the co-operation of Indian Diplomatic Missions in countries adjoining India where *Garra* occurs. These facilities have permitted the examination of all the thirty-seven species, including three sub-species, recognized as valid in this paper.

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II—Purpose and General results

The main purpose of the work is a thorough revisional study of the genus in order to understand the inter-relationships—hence the course of evolution—within this very widely distributed and well-defined group of fishes and to provide material of value in terrestrial zoogeography.

Previous studies on the systematics of the genus have all been done on a regional basis and this is the first attempt of the study of the systematics of the genus in the strict sense understood by Myers (1952).

III—Methods and Approaches

(a) *The definition of Measurements*

Measurements were made with fine pointed dividers and recorded to the nearest one-tenth of a millimetre. The *standard length* is measured from the tip of the snout to the posterior edge of the hypural fan. The term caudal base also refers to the end of the hypural fan.

The *length of the head* has been taken from the tip of the snout to the posterior edge of the operculum, the membranous opercular flap being omitted. The *diameter of the eye* has been taken between the anterior and posterior walls of the bony orbit. The *snout length* is measured from the tip of the snout to the anterior rim of the orbit. The inter-orbital width is measured at the nearest point between the upper rim of each orbit and is a straight-line measurement whether the inter-orbital region is flat or otherwise. The *height of the head* is taken as a straightline distance between a point on the occiput and the isthmus at right angles to the longitudinal axis of the head. The *width of the head* is measured as the distance through the head, taken at the extreme posterior limit of the head between the opercula on either side.

The *length of the disc* is the longitudinal distance between the anteriormost end of the posterior labial fold and the posteriormost end of the free border of the disc ; in cases where the posterior border of the disc is wanting, the point at the extreme posterior end of the callous portion of the disc is taken into consideration. The *width of the disc* has been taken as a straightline measurement between the bases of the maxillary barbels ; in the case of *taeniata* and *bicornuta* it is taken between the outer ends of the anterior part of the posterior border of the disc on either side.

The number of *gill rakers* is the number of the outer gill rakers on the lower portion of the anterior arch of the left side.

The *distance between the snout and dorsal fin* is measured in a straight line, and is the distance between the anteriormost end of the snout and the insertion of the 1st ray of the dorsal fin. Similarly, the *distance between the anterior origins of the pelvic and anal fins* is a straight-line measurement between the insertions of the 1st ray of the pelvic and that of the anal fins. The *distance between the anterior origin of pelvic and base of the caudal fin* is a straight-line measurement between the insertion of the 1st ray of the pelvic and the centre of the end of the hypural plate. The *distance from vent to anal fin* is measured in a straight line between the posterior end of the anal opening and the insertion of the 1st ray of the anal fin.

The *depth of the body* is taken as a straight vertical distance measured from the belly to the dorsum just in front of the dorsal fin. The *length of the caudal peduncle* is measured obliquely between the centre of the end of the hypural plate and the posterior end of the anal base. The *width of the caudal peduncle* is measured from dorsum to ventum at the narrowest part of the peduncle.

Scales on Lateral Line is the number of scales counted along the lateral line, including the scale on the caudal base. *Scales on the mid-dorsal streak* is the number of scales counted from the occiput to the origin of the dorsal fin. In certain African forms scales on the mid-dorsal streak vary considerably, the scales on the anterior half of the streak, or sometimes even the entire streak, being absent. *Scales from the origin of the dorsal to the lateral line* are counted on the anterior diagonal, from the place of insertion of the 1st ray of the dorsal fin, whereas scales between *the lateral line and pelvic* are counted on the posterior diagonal, from the lateral line to the insertion of the 1st ray of the pelvic.

The length of the pectoral fin is taken as the length of the longest ray. The *length of the air bladder* is the length of the posterior chamber of the air bladder.

The morphometric characters of all the available material were examined in detail. The characters considered important were those shown below :—

1. Depth of body	in standard length.
2. Length of head	in standard length.
3. Width of head	in length of head.
4. Height of head	in length of head.
5. Length of snout	in length of head.
6. Diameter of eye	in length of head.
7. Inter-orbital distance	in length of head.
8. Length of disc	in length of head.
9. Width of disc	in width of head.
10. Length of disc	in width of disc.
11. Distance between snout and dorsal fin	in standard length.
12. Length of pectoral	in length of head.
13. Distance between pelvic and anal fin	in distance between pelvic and base of caudal.
14. Distance from vent to anal fin	in distance between pelvic and anal fins

15. Length of caudal peduncle	in length of head.
16. Width of caudal peduncle	in length of caudal peduncle.
17. Length of air bladder	in standard length.
18. Scales in lateral line . . .	....
19. Scales from dorsal to lateral line	....
20. Scales from lateral line to pelvic	....
21. Scales on mid-dorsal streak	....
22. Number of gill-rakers	...

(b) *The analysis of Intergradation*

Taxonomic characters are generally found to intergrade between closely related populations when a sufficiently large number of individuals are studied in detail. In estimating whether two populations constitute distinct species or only geographical populations or subspecies, the decision has been based on the degree of intergradation—in other words the degree of divergence.

Different methods of measuring intergradation or divergence have been proposed (Ginsburg, 1938; Simposon and Roe, 1942; Hubbs and Perlmutter, 1942; Hubbs, 1952; Mayr, Linsley and Usinger, 1953, and Hubbs and Hubbs, 1953). Ginsburg used a simple method which consists of determining the point of intersection of the frequency distribution of the characters of two populations that is to say by defining the number of individuals of one population that pass to the right of the vertical line drawn from the point of intersection, and the number of individuals of the other population that pass to the left of this line. The simple average of the percentages of such intergrading individuals of the total of each population studied gives the measure of intergradation of the two populations. Based on this method he designated species and its subdivisions as follows:

"Other things being equal, a given population is to be considered a race with respect to another closely related population when the average intergradation of the character showing the greatest divergence is between 30 per cent and 40 per cent; a subspecies constitutes a population intergrading between 15 per cent and 25 per cent; it is to be considered a full species when the degree of intergradation is not more than 10 per cent. Concomitantly, the divergence between races is 60 per cent to 70 per cent, between subspecies 75 per cent to 85 per cent and full species divergence to an extent of 90 per cent or more"

Several workers, however, based their studies on "Probability" which in its numerical expression, is often referred to as the "test of significance" The taxonomist judges the systematic position of the entire population by the study of relatively small samples drawn from them. We know that different samples drawn even from the same variable population may show differences. By this test it can be determined how often such a difference in any given character is likely to be obtained at random by mere chance, from two samples of the same populations. Several authors have employed this method in different forms in their work.

The graphical method of Dice and Leraas, as quoted by Hubbs and Perlmutter (1942), has distinct advantages in that it is easier to prepare and can be readily interpreted and compared. They improved this method and presented formulae and tables to test significance accurately. In this method, for each variable character, the range, mean, one standard deviation on each side of the mean and two standard errors on each side of the

mean are delineated on a graph. They noted that "when two samples showing normal variation are compared, an overlap in the frequencies of about 16 per cent only is indicated when the broad bars representing the standard deviations neither overlap nor are separated on the ordinate scale. That is about 84 per cent of the species of both categories would then be separable, in that their values for a given character would lie on the proper side of the line best separating the two populations. Such differences are approximately of the order that may be utilised for subspecies separation"

Hubbs, and Hubbs and Hubbs modified the presentation of the parameters on the graph and presented them on a horizontal alignment. This improved method of plotting the parameters has been followed in the present study (see Graphs). In typical conditions the horizontal line represents the range of variation and the small streak projecting upwards in the middle of it the mean. The blackened area of each bar comprises two standard errors of the mean (2σ M) on either side of the mean, and onehalf of each black bar plus the white bar at either end outlines one standard deviation (σ) on either side of the mean. Presentation of parameters, where deviation from the typical case occurs, has been done according to the method adopted by Hubbs (1952 : 45).

Mayr, Linsley and Usinger (p. 148) have presented the method proposed by Hubbs and Perlmutter, but they suggest the plotting of 1·5 standard deviation on either side of the mean, instead of 1·0 standard deviation in order to indicate probable subspecific differences by a non-overlap of the bars. They thus insist the separability of at least 90 per cent of the specimens to indicate "the conventional level of subspecific difference", while Hubbs and Perlmutter (p. 58) require only 84 per cent separation. Both these values, however, are considered higher by some who favour the "75 per cent rule", while the "splitters" favour the "50 per cent rule" Thus, there is no agreement as to what factors and percentages should be adopted in the determination of the subspecific category.

(c) *The recognition of subspecies*

Mayr (1942) was mainly concerned with the variation of populations as correlated with geography, and particularly with the properties and evolutionary significance of the subspecies, a category generally regarded as synonymous with the geographical race. He defined subspecies as genetically distinct, geographically separate populations belonging to the same species and therefore interbreeding freely at the zone of contact. The International Commission on Zoological Nomenclature at its meeting in Paris in 1948 defined a subspecies as "a population (geographic or ecological) within a species which differs from any other such population within the same species" Mayr, Linsley and Usinger (p. 30) define subspecies as " geographically defined aggregates of local populations which differ taxonomically from other such subdivisions of a species" None of the above definitions, it will be noted, state by what percentage populations must differ in order to claim the status of a subspecies.

Nevertheless, there has been in recent years a great deal of discussion on the recognition of the sub specific category, the most important being the recent paper by Wilson and Brown (1953). They present an excellent discussion of many aspects of the problem of the present-day subspecies concept and suggest that the use of the simple vernacular locality citation, or a brief statement of the range involved, should be preferred to the formal latinised trinomial for geographical variations within the species. They even suggest altering the current unhealthy practice of naming vague and insignificant populations as subspecies by depriving subspecies names of the protection of the Law of Priority. Gordon Edwards (1954) while strongly deprecating the practice of naming vague, insignificant and poorly delimited populations as subspecies feels that "the best method of avoiding an eventual absurd taxonomic situation is to recognise only truly distinctive allopatric populations as 'subspecies' and reduce the vague, somewhat sympatric, interbreeding populations to a lower rank" Over enthusiasm in recognising too many subspecies sometimes result in

obscuring the presence of clines the importance of which in population studies need not be overemphasised (Huxley, 1940). Naming all populations that fit in with the Commission's definition of subspecies is not going to prove of great value. On populations that are separated to the extent that no zone of hybridization occurs between them and have developed distinctive structures which enable their members to be identified correctly are going to be of interest to scientists and deserve a name with taxonomic priority (Linsley, 1944). Often such populations are described as distinct species, but in many cases the differences are slight and the members of the two populations would still be capable of freely interbreeding if they occur together under natural conditions at mating time. Such potentially interbreeding populations seem to fit in admirably into the subspecies category. While commenting on my work Dr. G. S. Myers stated that :

"I am sure that the views of subspecies recognition which you quote from Mayr *et al* (1953) are not too well accepted by ichthyologists. Subspecies, in the view of most American systematists, do usually "intergrade" or overlap in their characteristics, but they must have some sort of geographical and morphological coherence. Populations that are always distinguishable morphologically, are usually called species ; they may be either sympatric or allopatric. Mayr's dicta on birds simply do not work for many fishes, where species that are often quite or nearly generically distinct (*e.g.*, in *Xiphophorus* and its Subgenus *Platypoecilus*) may hybridize freely in the laboratory or the field, yet in their natural habitat, if sympatric, there may or may not be hybridization. The situation is, of course, a complex one, far more so than Mayr's book on "Systematics and the Origin of Species" would indicate (Personal communication).

(d) *Procedures in the paper*

I have carefully taken into consideration all the above views and have refrained myself from giving latinised trinomials to geographical populations connected by intergradations. The status of isolated allopatric populations has been decided on the basis of the level of morphological differences and on the nature of the barrier separating them. The overlap or the divergence of the standard deviations of any of the characters of primary taxonomic significance in the genus (*see* below) has been taken to determine the status of isolated allopatric populations. A comparison of the diagnoses of *G. kempi* and *G. naganensis* (Text fig. 20), *G. lamta* and *G. mullya* (Text-fig. 11) and *G. dembeensis* and *G. quadrimaculta* (Text-fig. 5) will immediately reveal the significance of the position of the vent in relation to the origin of the pelvic and anal fins in isolating sympatric species within the genus ; a non-overlap or divergence of the standard deviations for this character is, therefore, regarded as a yardstick for determining the status of isolated allopatric populations. The evolutionary significance of this character is discussed elsewhere (p. 245). In the case of isolated allopatric populations where the divergence in the primary taxonomic characters (*vide*, p. 20) is not very great, sufficient divergence (non-overlap of standard deviations) of any of the less important characters has been considered sufficient enough to treat them as subspecies provided the geological barrier separating the populations is not very formidable and is known to have existed from a period that is geologically not very long.

For want of sufficient material the statistical analysis of a number of forms recognised here as full species has not been carried out. I have, however, grouped some of the closely related forms into complexes some of which may be shown in the future to include super species.

The statistical procedure followed is after Simpson and Roe (*op. cit*).

The description of species is arranged according to a uniform plan so that comparisons may be made very easily. In cases where the description is based upon more than one specimen, the initial values given in the text are arithmetic means of all the specimens measured ; the values included within brackets are the extremes.

Synonymies and bibliography have been given as completely as possible. I have not altered the spelling given for the localities cited in the synonymies, nor have I emended the spellings given on the labels accompanying the species examined by me.

(e) *Evaluation of systematic characters*

There has been a great deal of confusion in the taxonomy of the genus because of the remarkable individual variation among species, even in series from the same locality and much emphasis placed on variable characters in species differentiation. A detailed morphometric study and the taxonomic assessment of all the characters used in segregating species by earlier workers have, however, shown that the presence or absence and the number of barbels, the presence or absence of the proboscis, the position of the vent in relation to the origin of the pelvic and the anal fins, the number of scales along the lateral line, the number of gill rakers and the colouration are the most dependable characters in the genus. Caution has to be exercised in using characters like the position of the dorsal fin in relation to standard length, the position of the anal in relation to pelvic fin and caudal base, the presence or absence of a deep transverse groove marking off the tip of snout, the height of body, the length of head, the nature (the degree of reduction or absence of scaless)of the back, chest and belly and the inter-orbital width, as these characters are found to vary depending either on growth or environment. The position of the eye in relation to head length, the nature and size of the adhesive disc, the size of the eyes and snout, general body proportions and position of the fins in relation to one another, length of air bladder, the number or nature of the tubercles on snout, are perhaps the most plastic of all characters and so little reliance can be placed on them.

Fin structure in *Garra* is not remarkable. There is neither unusual elaboration nor any great variation in the fin-ray counts. Pectoral rays vary from 1, 11 to 1, 17 ; pelvic rays 1, 7 to 1, 8 ; dorsal rays 11, 6 to 111, 9 ; and anal rays 1, 5 to 111, 5 ; caudal rays 18 to 19. Consequently fin formulae are of no help in defining the species of *Garra*.

The number, size and shape of the pharyngeal teeth are of little importance in separating species as there exists as much variation between individuals of the same species as between the various species ; they are in three series and vary from 2 or 3, 3 or 4, 4 or 5—5 or 4, 3 or 4, 3 or 2.

(f) *Abbreviations of names of Institutions*

AMNH, American Museum of Natural History, New York (U.S.A.).
ANSP, Academy of Natural Science of Philadelphia, Philadelphia (U. S. A.).
BM, British Museum (Natural History), London (England).
CM, Ceylon National Museum, Colombo (Ceylon).
CHHM, Chicago Natural History Museum, Chicago (U. S. A.).
GM, Genoa Museum, Genoa (Italy).
HUJ, Hebrew University, Jerusalem (Israel).
LM, Rijksmuseum van Naturlijke Histoire, Leiden (Netherlands).
MCZ, Museum of Comparative Zoology, Harvard College, Cambridge (U. S. A.).
MHNP, Museum National Di Histoire Naturelle, Paris (France).
NMW, Naturhistorisches Museum, Vienna (Austria).
RM, Raffles Museum, Singapore (Malaya).
SNG, Museum Senckenbergischen naturforschenden Gesellschaft, Frankfurt (Germany).
TM, Museo Civico Di Storia Naturale Trieste (Italy).
USNM, United States National Museum, Washington, D.C. (U. S. A.).
ZSI, Zoological Survey of India, Calcutta (India).

IV—Historical Sketch

The first species of the genus *Garra* known to science was described by Hamilton Buchanan (who changed his name subsequently to Hamilton) in 1822 in his classical work on the fishes of the River Ganges. This species, now known as *Garra lamta*, was originally described as *Cyprinus lamta* (the specific name being the native name for the fish in Gorakhpur) which Hamilton " found in rivulets with rocky bottom, in the province of Bihar, and in the Rapti River of the Gorakhpur District "

Ten years afterwards in 1832 Gray in his *Illustrations of Indian Zoology* figured a similar species, *Cyprinus gotyla*. Gray did not give any description of his species, but as most of his figures were made from specimens collected in Northern India the specimen for his illustration of *Cyprinus gotyla* must also have come from the same locality, probably from the hill-streams at the foot of the Himalayas.

In 1837 Ruppell described two species under two different generic names, *Chondrostoma dembeensis* and *Gobio quadrimaculatus*, both from Abyssinia.

In the years 1838, 1839 and 1842 McClelland described a number of species from streams in the Eastern Himalayas under two different generic names, *Gonorhynchus* and *Platycara*, and Sykes in 1841 erected another genus *Chondrostoma* to accommodate his species from the "Dukhun"

In 1843 and 1844 Heckel described specimens from Syria, Iraq, and Iran under a new genus *Discognathus* (*D. rufus*, *D. obtusus* and *G. crenulatus*), evidently placing great emphasis on the disc character, whereas McClelland and Sykes apparently did not pay much attention to the character of the disc. He also referred to Gray's species and also to those described by McClelland, but did not make any mention of either *Cyprinus lamta* or *Chondrostoma mullya*. Further, in 1844 he described *D. fusiformes* from Bombay and in 1846 recorded the occurrence of his genus in Abyssinia.

In 1849 Jerdon recorded *Gonorhynchus gotyla*, *G. mcClellandi* and *G. stenorhynchus* from the Cauvery drainage in the Western Ghats, South India.

In 1860 Blyth following McClelland described a species from Tenasserim, Burma under the name *Platycara notata*.

In 1863 Bleeker recognised Hamilton's *Garra* as a distinct genus and described *G. ceylonensis* from Ceylon. In the same year (1863*a*) in his superbly illustrated 'Atlas ' he recognised two subgenera of *Garra*, *Garra* and *Discognathus* distinguishing them merely by the number of barbels.

In 1865, in a paper entitled "On the fishes of Cochin, on the Malabar Coast of India", Day described *G. malabarica* and in the same year (1865*a*) re-described it illustrating it with a coloured plate in his *Fishes of Malabar*. In 1867 in another article entitled " On the fishes of the Neilgherry Hills and Rivers around their Bases" he described another new species, *G. jerdoni* and also recorded *G. gotyla*. In the same year (1867*a*) he described another new species *G. alta* from Wynaad at the base of the Nilgiri Hills and in 1869 erected a new genus *Mayoa* for the two specimens he found in the Calcutta Museum which probably had come from Northern India.

In 1867 Steindachner recorded *G. gotyla* from Simla and added a few notes on *G. lamta*.

In 1868 Gunther listed four species *D. lamta*, *D. macrochir*, *D. nasutus* and *D. variabilis* in his " Catalogue of Fishes in the British Museum " His treatment of the genus virtually constituted a revision of it as he had material of almost all the species then known to science.

In 1871, after the publication of Gunther's Catalogue, Day in his " Monograph on Indian Cyprinidae " synonymised all the species, except *D. variabilis*, with *D. lamta*, however, retaining his new genus *Mayoa* to stand with a single species, *M. modesta*. In 1872 in the fourth part of the same series on " Monograph on Indian Cyprinidae " Day referred to some specimens obtained from the Salt Range, Punjab to *D. lamta*. In 1878 in his " Fishes of

India " Day abolished his new genus and recognised three species, *D. lamta*, *D. jerdoni*, and *D. modestus*. These three species he again described in his *Fauna of British India* in 1889.

Gunther (1889), Playfair (1870), and Blanford (1870) referred to *D. lamta* specimens from Afghanistan, Arabia and Abyssinia, and Eritrea respectively. Blanford (*op. cit.*) also remarked that his specimens did not differ in any respect either from specimens fromPalestine in the British Museum or from specimens obtained by Lieut. Mockler at Lahej, near Aden.

In 1883 Lortet referred specimens he obtained from Palestine to *D. lamta* while in 1884 Tristram also referred specimens obtained from Ramoth Gilead, near Palestine to the same species. In the same year Vinciguerra recorded *D. lamta* from Africa and described his Shoan specimens under the name *D. chiarinii*. Vinciguerra in his account of fishes of Burma recorded *D. lamta* and described *D. imberbis* in 1889.

In 1897 and 1899 Nikolsky recorded *D. variabilis* and *D. lamta* from Persia and its vicinity ; but in 1900 he described *D. rossicus* from specimens he referred to *D. variabilis* in 1897 and later in 1913 Berg made the specimens which Nikolsky referred to *D. lamta* the type of his new species, *D. persica*.

In 1901 Boulenger in his paper entitled " On a small collection of Fishes from Lake Victoria made by order of Sir H. H. Johnston, K.C.B." described *D. johnstoni*. He also suggested in the same work the name *D. blanfordii* to the Abyssinian and 'Erythrean ' specimens which Blanford referred to *D. lamta* in 1870 and also described *D. vinciguerrae* from the Nile River.

In 1902 Vaillant described a new species *D. borneensis* from Borneo. This species was afterwards in 1905 referred to the genus *Garra* by Fowler and again taken back to the genus *Discognathus* by Weber and De Beaufort in 1916.

In 1903 Boulenger described *D. makiensis* from specimens obtained in the Maki River in Abyssinia and recorded *D. blanfordii* and *D. quadrimaculatus* from Abyssinia with a diagnostic key for the identification of all the six African species then known from that continent. In 1905 Boulenger described another new species *D. hindii* from the Nyiro River in Kenya and Pellegrin (1905) yet another *D. rothschildi* from the Gotta River in Abyssinia. In 1907 in his " Fishes of the Nile " Boulenger gave description of *D. dembeensis*, *D. johnstonii*, *D. vinciguerrae* and *D. quadrimaculatus* giving a diagnostic key for the identification of these species. In his " Catalogue of the Fresh-Water Fishes of Africa " Vol. 1, published in 1909 he recognised seven species as valid synonymising *D. rothschildi* and *D. chiarinii*, the former with *D. dembeensis* and the latter *D. quadrimaculatus*.

In 1907 Regan described a new species *D. yunnanensis* from Yunnan in S. China and in 1914 yet another new species *D. phryne* from Waziristan.

In 1909 Jenkins after examining the entire specimens in the Indian Museum concluded that " there are no specimens of *Discognathus* in the Indian Museum which justify me in considering that there is more than one Indian species of this genus, but probably the examination of large number of specimens from different districts might lead to the establishment of well defined varieties " Again in 1910 he referred a fish from Baluchistan to *D. lamta*.

In 1912 Garman described a new species, *G. imberba* from Western Szechwan, S. China, and referred it to a new subgenus of *Garra*, *Ageneiogarra* distinguished by the absence of barbels.

In 1917 Nichols and Griscom while reporting on a collection of fish made in the Congo basin by Messrs. Lang and Chapin during 1909 to 1915 described a new species, *D. ornatus* and recorded *D. dembeensis* from the Congo basin.

In 1913 Zugmayer referred to specimens from Pishin in Baluchistan to two species, *D. lamta* and *D. variabilis* while in the same year Chaudhuri (1913) recorded *D. lamta* from the Abor Hills and pointed out that the Abor form might represent an Assamese race of Mc Clelland's *nasutus*. While writing on the fish fauna of the Tiberias Lake in Palestine

Annandale (1913) recognised a close relationship between the fish from Lake Tiberias and that from India, but considered the Palestine form as a subspecies, *D. lamta-rufus*. He considered the barbel and the disc characters as distinctive and figured them.

Prashad (1919) described *D. kangrae* from the kangra valley, Punjab. Annandale (1918, 1919) described *D. gravelvi* from S. Shan State, Burma and also (1919*a*) described *D. adiscus*[1] and *D. phryne* from Seistan, and *D. elegans* from S. India and considered Prashad's *D. kangrae* as a subspecies of *D. lamta*.

In 1920 Rao described two new species, *G. platycephala* and *G. bicornuta* and a new variety *G. jerdonia brevimentalia* from Mysore ; *platycephala* and *brevimentalia* from the Cauvery drainage while *bicornuta* from the Thunga River, a tributary of the Thungabhadra (Kistna). Annandale and Hora (1920) discussed the advisability of recognising both *Garra* and *Discognathus* and considered *Discognathus* with *D. variabilis* as the type of the more primitive of the two, departing less from the normal Cyprinid type. Hora (1920) while revising the Indian Homalopteridae and the genus *Psilorhynchus* discussed the evolution of *Garra* and remarked :

"Taking *Labeo* as a Central type of Cyprinidae I believe that the evolution of a form like *Crossocheilus* has taken place, from this evolution proceeded along two lines which ran more or less parallel to one another. One of these lines culminated in *Psilorhynchus* and the other in *Garra* with *Discognathus* as an intermediate form."

In 1920 Lonnberg and Rendahl described *D. occidentalis* from Kingoyi at the watershed between French and Belgian Congo.

In 1921 Hora made a thorough revisional study of the Indian species of *Garra* and briefly commented on certain foreign species. From a developmental study of the disc in *Garra* he concluded that *Discognathus* should not be separated as a distinct genus from *Garra*. He included in his revision the following nine new species : *G. montisalsa*, *G. annandalei*, *G. abhoyai*, *G. kempi*, *G. naganensis*, *G. prashadi*, *G. chaudhuri*, *G. jenkinsonianum* and *G. arabica*, of which only *annandalei*, *kempi* and *naganensis*, are recognised here as valid species.

In 1923 Pellegrin described *D. boudoni* from French Equatorial Africa and in 1927 another new species *G. aethiopica* from Abyssinia. In 1924 Gianferrari recorded *D. blanfordii* from material collected from Giarraba in the Cunama region in Eritrea.

In 1925 Norman described *D. apogon* from Tongking, Nichols (1925) described *G. orientalis* from Fukien in South China and Gianferrari (1925) *D. ignestii* from the Kahha and Angrab torrents, tributary of the Modetsch river in Abyssinia. Koller described *G. rhynchota* from Hainan in 1926. Nichols and Pope (1927) described *G. schismatorhyncha* from Hainan and Koller (1927) referred to three types of snouts, sulcata, rhynchota and bicornuta in his material of *G. lamta*. In 1928 Pellegrin described *D. bourreti* from Tongking, Indo-China and in the next year Tehang (1929) described *G. pingi* from Szechwan, South China.

In 1930 Deraniyagala re-described *G. ceylonesis* and pointed out certain resemblances in the mouth structure of *Garra* and *Tor* and considered *Garra* closer to *Tor* than to *Labeo*. In 1933 he described a subspecies of *ceylonensis G. c. phillipsi* from the Gammaduva Hills in Ceylon.

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[1]On examination of the type of *D. adiscus* I am convinced that it is more closely related to *Crossochilus* than to *Garra* : its branchial openings extend well on the ventral surface and it is practically devoid of a mental disc. Recently, while working out the fresh material of *Crossochilus* from the Kashmir Valley procured by the late Dr. Hora, I had the opportunity of examining the entire *Crossochilus* material of the Survey. *D. adiscus* of the sluggish waters of Seistan closely resembles the *Crossochilus* species of the Kashmir Valley, *C. diplochilus* (Heckel). It is probable *Crossochilus* having originated somewhere in S. China during the Miocene period first spread along the northern side of the Himalayas as far west as Seistan and through isolation in Kashmir and in Seistan, especially in lakes and sluggish rivers, evolved into distinct species there. Origin and distribution of *Crossochilus* seems to be somewhat parallel to that of *Garra*, with the exception that *Garra* is absent in the Kashmir Valley at the present day. It is, however, represented to-day by *G. rossicus* in Seistan (*vide infra* p. 191).

In 1931 Smith described *G. taeniata* from Peninsular Siam. Fowler in 1934 described *G. spinosa* and *G. fuliginosa* in 1935 *G. taeniatops*, in 1937 *G. fasciacauda*, and in 1939 *G. parvifilum*, all from Siam.

Petit and Tchang described *G. poilanei* from Annam in 1933 and Pellegrin and Chevey recorded it from Tongking in 1936.

In 1932 Gianferrari described the specimens which he referred to as *D. blanfordii* in 1924 as a new species *D. giarrabensis*. In 1935 Pellegrin described *D. waterloti* from French Guinea and in 1936 Gianferrari described a subspecies of *blanfordii*, *D. blanfordii* sub. sp. *cimmaruta* from Adua in Abyssinia.

In 1934 Hora and Mukerji described *G. salweenica* from Salween river in Burma and remarked on its relationships with *G. arabica*, *G. fuliginosa*, and *G. schismatorhynchus*.

In 1936 Pellegrin and Chevey described *D. gracilis* from Tongking and remarked that the closest relationships of it is with Pellegrin's *D. bourreti* which is a form with a proboscis on the snout and is here synonymised with *G. nasutus*. Again in the same year Pellegrin and Chevey (1936) described a new species, *D. caudofasciatus* from Tongking which I have synonymised here with *G. gracilis*.

In 1937*b* Hora defined and restricted *G. lamta* from new material from Kharagpur Hills in Monghyr District, Bihar.

In the following year 1938 Tortonese showed that *G. rufus* and *G. lamta* are practically indistinguishable, but preferred to keep the Middle East form under the name *G. rufus*. In 1950 Berg described a subspecies, *G. rufus gymnothorax* from the Tigris River. In 1953 in his annotated list of fresh-water fishes of Palestine, Steinitz agreed with Tortonese's finding that the Palestine form of *Garra* is indistinguishable from the Indian species, *G. lamta*, but considered advisable to retain the name *rufus* for the Palestine form from a purely zoogeographical point of view.

In 1941 Trewavas described *G. tibanica* and *G. brittoni* from S. W Arabia and pointed out their close relationships with the African species *G. blanfordii*.

In 1950 Monod described *G. trewavasi* from Nigeria giving a diagnostic key for the identification of the West African species. As late as 1954 Silas described a new species, *G. hughi* from the High Ranges in Travancore and the same year Steinitz (1954) traced the evolution and distribution of the group of primitive species of *Garra* in which he included *G. lamta*, *G. rossicus*, *G. variabilis* and *G. blanfordii*.

Hora (*loc. cit.* pp. 636—38) referred to the chequered history of the genus *Garra* and narrated the circumstances which led to the great confusion centred round *Garra lamta* of which, as has been pointed out earlier, only a short and inadequate description without a figure was given by Hamilton (*op. cit.*) in his "Account of the Fishes of the Ganges" stating that he found the fish in "rivulets with rocky bottom, in the province of Bihar and in the Rapti River of the Gorakhpur district"

Hamilton's manuscript notes, however, cast some light in conjunction with the same author's original figure of " Cyprinus godiyari " on the identity of his *Cyprinus lamta*. Both *godiyari* and *lamta* are local names of the same species in Bhagalpur and Gorakhpur districts respectively as indicated by the remarks made by Day while enumerating the names of fishes found in Bhagalpur and Gorakhpur districts in his volume on the fisheries and botany of Bengal in Hunters' *Statistical Account of Bengal* (1877). On page 81 quoting Hamilton, Day says : " the Godiyari is another small *Cyprinus* found in the same places ", *i.e.*, in small streams among rocks in the Bhagalpur district ; while in a foot-note to the name Godiyari he adds apparently on his own authority, " *Cyprinus lamta* Ham. Buch. *Fish Ganges*, p. 343 and MS drawing No. 105, as *Cyprinus godiyari* " On page 103 of the volume cited above while enumerating the names of fishes found in the district of Gorakhpur he remarks " the Godiyari of the Bhagalpur list is here called Lamta " ; while in a

foot-note to the name *lamta* he adds, "*Cyprinus lamta* Ham. Buch. *Fish Ganges*, p. 343 and MS drawing No. 105 as *C. godiyari*.

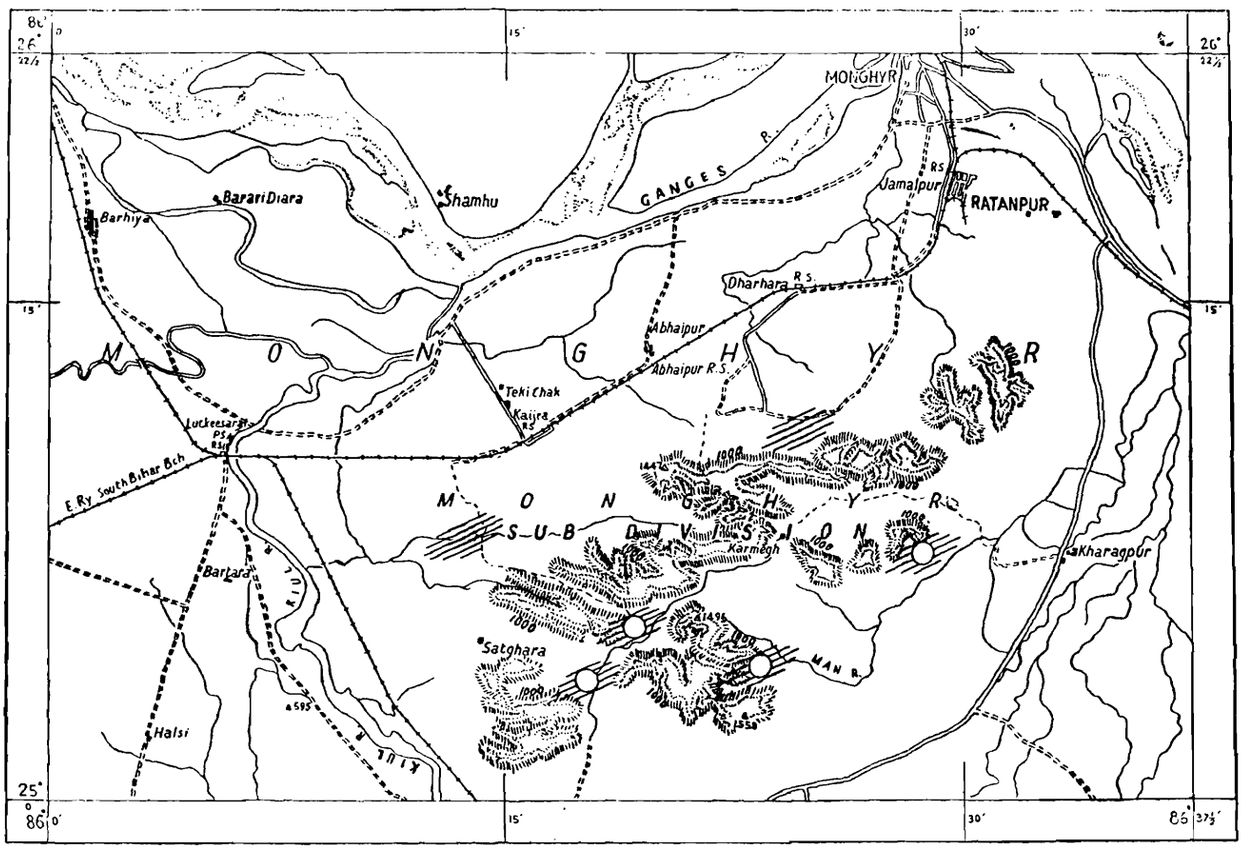
From the above remarks it is evident that Hamilton included both the forms of the Bhagalpur and the Gorakhpur districts under his *Cyprinus lamta*. Now, the important points to be clarified are: (1) Which of these two localities should be considered as the type locality of *Cyprinus lamta* ?, and (2) whether the two forms are the same or Hamilton's *C. lamta* was a composite group consisting of two distinct species.

Hora (*loc. cit.*, pp. 636-37), after a survey of the Kharagpur Hills, Monghyr district (formerly included under the Bhagalpur district), restricted the type-locality to Kharagpur Hills, Monghyr district, Bihar, having failed to get any specimen of *Garra* from Gorakhpur.

Now, when Dr. Trewavas' enquiry regarding the topotype specimens of *G. lamta* was received in the Survey the first thing I did was to hunt for Hamilton's manuscript, and I was fortunate to get a copy of his field notes in which he noted the localities where he collected ; on page 222 the following is written :—

"Gorakhpur 12th April 1814. *Cyprinus lamta*, of Munger. Habitat in rivulis sanis repleles Magada in Rapti Cosala "

Equipped with the above valuable information I planned out my itinerary for the surveys of the small streams of the Monghyr district in Bihar and the Rapti drainage in Gorakhpur district in Uttar Pradesh.



TEXT-FIG. 1.—Map of the Monghyr District (Bihar), showing the areas surveyed (indicated by thick black lines and the collecting localities of *Garra mullya* (indicated by circles).

A brief account of the history of Gorakhpur district with special reference to Hamilton's remarks "sanis repleles Magada in Rapti Cosala" is essential at this stage for a clear understanding of the extent of the Gorakhpur district in 1914.

According to Law (1951) "the kingdom of Kosala rightly corresponded to modern Oudh. It was probably bounded by the Sadanira (Gandak) river on the east, Panchal on the West, the Saipika or Syandika (Sai) river on the south and Nepal Hills on the north"

From Law's remarks it is certain that the Kosala Kingdom included the Gorakhpur district and it extended as far north as the foot of the Nepal Himalayas. However, during the period Hamilton stayed in India, this country was under the British rule and his reference to " Cosala " Kingdom of the 16th Century, therefore, does not seem to be relevant. There is, however, ample evidence to show that the Gorakhpur District extended as far north as the foot-hills of the Nepal Himalayas during the early half of the last Century (Neville, 1909, pp. 171 to 194) and Hamilton's reference to the Rapti River in Gorakhpur District is, therefore, considered here to include the small rocky streams and tributaries of the Rapti River at the foot of the Nepal Himalayas, north of the present-day Gorakhpur District. The Rapti River in the present-day Gorakhpur District is a muddy channel and is not ecologically suited for *Garra*.

Accordingly, in February-March, 1955, I went out for a month to the Kharagpur Hills for a thorough ichthyological survey of the small streams there. The places surveyed during this tour are marked in the map (Text-fig. 1). After having made collections at Kharagpur, I went to Gorakhpur in search of *Garra* in the Rapti River and I was successful in getting a large number of specimens of *G. lamta* from the Butwal stream as well as the Rohini and the Kerwani streams, all of them being tributaries of the Rapti River in the Nepal territory north of Gorakhpur District.

The material collected from the Kharagpur Hills and the Rapti drainage in Nepal were statistically analysed and found to differ in the characters of the positions of the vent (Text-fig. 11, Graph 12). Since Hamilton designated his first species of *Garra* as *Cyprinus lamta*, I have considered here the Butwal stream a tributary of the Rapti River about 21 miles of Nautanwa in Gorakhpur District as the type-locality of *G. lamta*. The Kharagpur form is distinct from *G. lamta*, but is the same as *G. mullya*, the widely distributed Peninsular species (*vide*, Text-figs. 14 & 15).

V—DEFINITION OF THE GENUS

Genus **Garra** Hamilton

1822. *Garra* Hamilton, *Fish. Ganges*, Edinburg, pp. 343, 393 (Type *Cyprinus lamta* Hamilton, by monotypy).

1838. *Platycara* McClelland, *J. Asiat. Soc. Beng.;* Calcutta, 7(2), p. 947 (Type *Platycara nasuta* McClelland, by monotypy).

1843. *Discognathus* Heckel, Russenger's *Reisen in Europa, Asien Und Afrika* 1, p. 1069 (Type *Discognathus variabilis* Heckel, by subsequent designation of Bleeker, 1863*a*, p. 24).

1860. *Lissorhynchus* Bleeker, *Ichthyologiae archipelagi Indici Prodromus*, Batavia, pp. 38, 85, 86 (name spelt both *Lissorhynches* and *Lissorhynchus* by Bleeker; type *Platycara Lissorhynchus* McClelland, by absolute tautonymy).

1860. *Discognathichthys* Bleeker, *Ichthyologiae archipelagi Indici Prodromus*, Batavia, p. 128 (Type *Discognathus variabilis* Heckel, by original designation).

1869. *Mayoa* Day, *Proc. Zool. Soc. Lond.*, London, p. 553 (Type *Mayoa modesta* Day, by monotypy).

1912. *Ageneiogarra* Garman, *Mem. Mus. Comp. Zool. Harvard*, U.S.A. 40, p. 114 (Type *Garra imberba* Garman, by monotypy).

Cyprininae[1] with elongated subcylindrical body. Mouth transverse, semicircular and inferior; lips continuous covered with anterior and posterior labial folds[2], jaws covered with horny sharp-edge; a suctorial disc behind lower lip consisting of semi-cartilaginous pad bordered anteriorly by a papillated posterior labial fold and posteriorly by a free papillated integument in all species except those regarded here as most primitive (*variabilis*

[1]Chu (1935) placed *Garra* under the subfamily Cyprininae, but Smith (1945) assigned it to his subfamily Garininae.

[2]The true lips are visible only in the younger stages. With the growth of the fish, however, they are covered by secondary folds, the anterior and posterior labial folds. These anterior or posterior labial folds are sometimes erroneously termed as the upper and lower lips (*vide*, Hora, 1921, *loc. cit.*, p. 640).

and *rossicus*) where the posterior specialised border always absent[1] ; the edge of the anterior labial fold always fimbriated. Snout more or less rounded or slightly conical, somewhat depressed and projecting beyond the mouth ; either smooth or with a proboscis. Barbels generally four, sometimes two or none. Margins of opercula widely separated except in those species considered most primitive (*variabilis* and *rossicus*) where they meet in the middle line behind the disc[2]. Gill openings restricted to side. Pharyngeal teeth edentulous in three closely approximating rows : the inner 5 or 4, the middle 4 or 3, outer 3 or 2 ; the typical number is 2, 4, 5/5, 4, 2. Lateral line equally distant from back and belly and continued to base of centre of caudal. Scales of moderate size. Dorsal fin with 9 to 12 rays, 6 to 9 of which branched (11, 6 to 111, 9), originating in advance of pelvics. Anal fin short with 6 to 8 rays (1, 5 to 111, 5) ; pectoral 1, 11 to 1, 17 ; caudal with two principal simple rays with 16 or rarely 17 branched rays between them and 2 or 3 rudimentary rays on either side.

Gill rakers short, few and widely set.

Air bladder varies considerably in form and extent.

VI—Systematic Section

(*a*) The '*variabilis*' group

G. variabilis (Heckel) and *G. rossica* (Nikolsky) may together be put under what may be called the " *variabilis*-group ", *variabilis* being closest to the evolutionary stem of the group and probably of the entire genus. In this group the adhesive apparatus on the ventral surface of the head is comparatively little differentiated, the free posterior margin of the adhesive disc being absent, the snout projects little beyond it, the margins of the opercula meet at an acute angle some distance behind the mental disc and the general facies of the fish is less peculiar the ventral surface being less flattened. The posterior chamber of the air bladder is cylindrical with an almost uniform thickness throughout and is like those of the other less specialised cyprinid fishes, such as *Crossochilus*.

The vent is almost immediately in front of the anal fin. Their distribution is now towards the north-western periphery of the genus and are probably relicts of the earliest wave of migration which took place along the northern face of the Himalayas. The detailed account of the distribution of the genus is given under " Zoogeography "

(i) The ' *variabilis* ' complex

Garra variabilis and *G. rossica* form the *variabilis* Complex of species which is the only Complex of the *Variabilis*—group. The characteristics of the Complex are, therefore, the same as given above for the group.

1. **Garra variabilis** (Heckel)

1843. *Discognathus variabilis* Heckel, Russeger's *Reisen in Europa, Asien Und Afrika* 1, p. 1069, taf. 8, fig. 1 [Type-loc. : Allepo, Syria. Type in NMW., examined].

1868. *Discognathus variabilis*, Gunther, *Cat. Brit. Mus. Fish.*, London, 7, p. 71.

1923. *Discognathus variabilis*, Pellegrin, *Poiss. Syrie*, 4, p. 16.

Specimens examined.—Syria : 5, 47·0 to 117·0 mm., Aleppo. Iraq :—2, 39·5 to 45·0 mm., from Tigris river at Mossul.

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[1]In the West-Asian and African species it is common to meet with in large collections the adhesive disc in all possible grades of development ; the posterior and the anterior borders of the disc are not infrequently found to be poorly developed sometimes even in big specimens.

[2]The West-African forms show considerable variation in this character depending upon the variation exhibited by structure of disc ; it is not uncommon to find in large collections specimens in which the branchio-stegal rays meet at an acute angle behind the disc and the branchial isthmus narrow.

Description.—Depth of body 4·58 (4·36—4·94) in standard length, length of head 4·35 (3·76—5·18). Width of head 1·53 (1·36—1·66) in length of head, height of head 1·61 (1·47—1·70). Pupil of eye before middle of the length of head. Interorbital region convex. Snout smooth, 2·46 (2·23—2·75) in length of head, diameter of eye 4·07 (3·50—4·75), inter-orbital width 2·09 (1·90—2·27). A pair of small blunt barbels at each angle of mouth. 16 to 18 outer gill rakers on the lower part of the anterior arch. Length of disc 4·67 (3·33—6·25) in length of head, width 2·52 (2·27—3·11) in width of head ; length of disc 1·34 (1·00—1·50) in its own width. 34 to 38 scales along lateral line, 4·0 or 4·5 or 5·5 from origin of dorsal to lateral line, 3·5 or 4 between this and pelvic. 12 to 14 scales on mid-dorsal streak, Chest and belly scaled. Dorsal III, 7 ; distance between its anterior origin and tip of snout 1·98 (1·84—2·21) in standard length. Length of pectorals 1·17 (1·03—1·31) in length of head. Distance between anterior origins of pelvic and anal fins 1·89 (1·79—2·03) in that between anterior origin of pelvic and base of caudal fin. Anal II, 5. Distance from vent to anal fin 9·19 (7·12—12·0) in that between anterior origins of pelvic and anal fins. Length of caudal peduncle 1·46 (1·09—1·75) in length of head, width 1·13 (1·00—1·35) in its own length.

Posterior chamber of air bladder measured in 5 specimens, 25·24 (23·33—27·87) per cent in standard length.

Coloration.—In alcohol, the specimens are uniformly dark brown with no pigment pattern ; the specimens examined are of over hundred years old and hence they have become uniformly dark brown.

Distribution.—Asia : Syria and Iraq (Tigris river at Mossul).

Relationships.—I consider this species to be the most primitive in the genus. It can be easily distinguished from its nearest relative *G. rossicus* by the presence of scales on back, chest and abdomen and the position of the anal fin which originates midway between the origin of pelvic and base of caudal ; it has a larger number of gill rakers and a more highly developed air bladder.

2. **Garra rossica** (Nikolsky)

(Plate VIII, Figs. 1—6)

1889. *Discognathus lamta*, Gunther, *Trans. Linn. Soc. London*, London, **5**(2), p. 107.

1897. *Discognathus variabilis*, Nikolsky, *Ann. Mus. Zool. Ac. St. Petersb*, Petersbourg, 72, p. 347.

1899. *Discognathus variabilis*, Nikolsky, *Ann. Mus. Zool. Ac. St. Petersb ;* Petersbourg, 4, p. 412.

1900. *Discognathus rossicus*, Nikolsky, *Ann. Mus. Zool. Ac. St. Petersb ;* Petersbourg, **5**, p. 239 [Type loc. : East Persia].

1905. *Discognathus rossicus*, Berg, *Izv. Vostoch. sib. Old. R. G. O.*, Irkutsk, **4**(6), p. 261, pl. 4.

1906. *Discognathus variabilis*, Regan, *J. Asiat. Soc. Beng.*, Calcutta, 2, p. 8.

1914. *Discognathus wanae*, Regan, *Ann. Mag. Nat. Hist.*, London, (8)**13**, p. 263, fig. 4 [Type-loc. : Wiziristan, Pakistan. Type in BM].

1919. *Discognathus wanae*, Annandale, *Rec. Indian Mus.*, Calcutta, **18**, p. 69.

1919. *Discognathus phryne*, Annandale, *Rec. Indian Mus.*, Calcutta, **18**, p. 70, pl. 10, fig. 3 ; pl. 11 fig. 2 [Type-loc. : Nasratabad, Seistan, East Persia. Type in BM ; Co-types ' ; ZSI " Co-types ", examined].

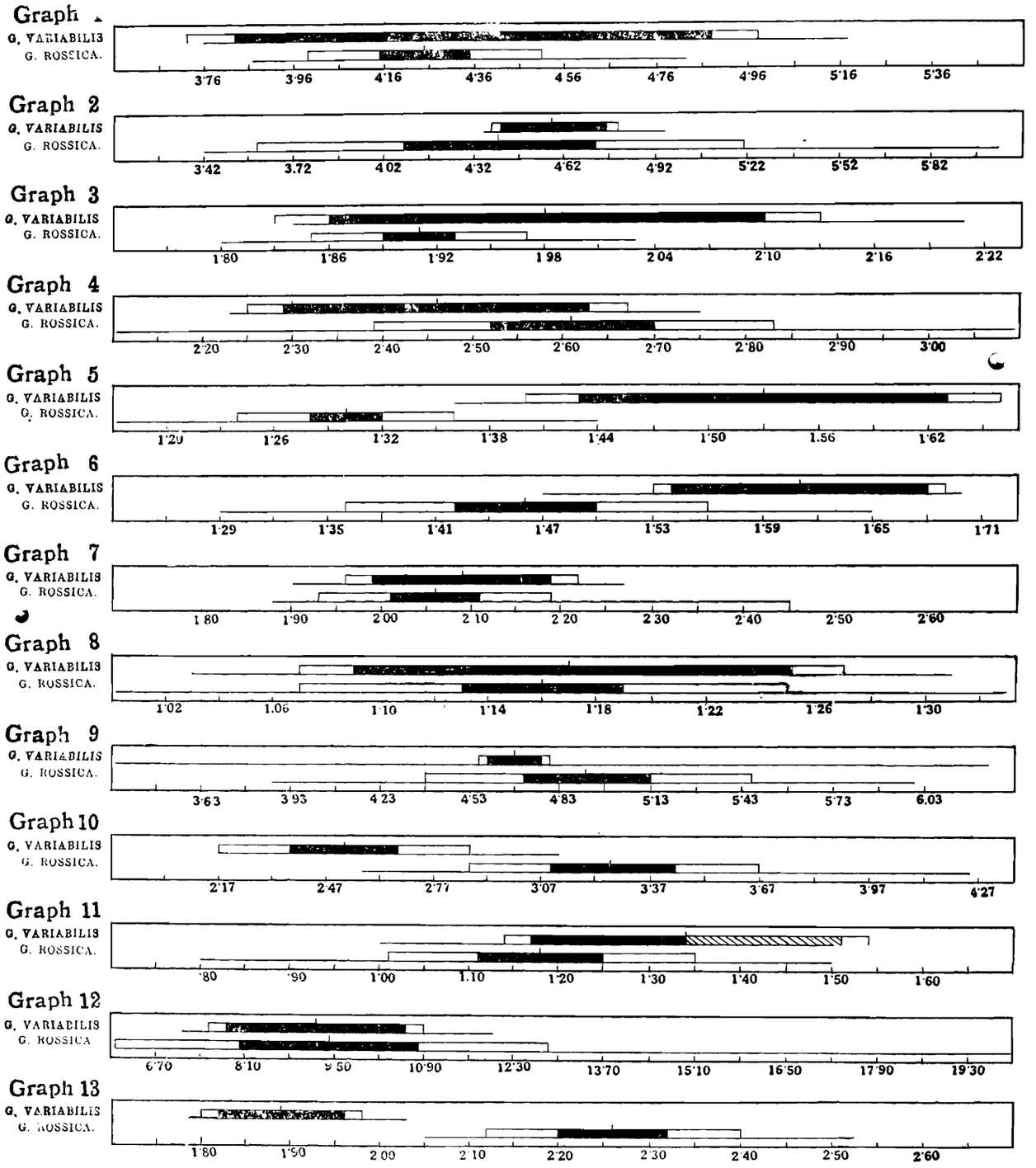
1920. *Discognathus phryne*, Annandale and Hora, *Rec. Indian Mus.*, Calcutta, **18**, p. 166.

1921. *Garra* sp., Hora, *Rec. Indian Mus.*, Calcutta, **22**, p. 680.

1921. *Garra rossicus*, Hora, *Rec. Indian Mus.*, Calcutta, **22**, p. 682.

Specimens examined.—Persia : 1, 47·0 mm., from Nasratabad, Seistan. Baluchistan 24, 46·0 to 76·0 mm.

Description.—Depth of body 4·40 (3·42—6·04) in standard length, length of head 4·25 (3·87—4·83). Width of head 1·30 (1·17—1·44) in length of head, height of head 1·46 (1·29—1·65). Pupil of eye at or before middle of the length of head. Inter-orbital region convex. Snout smooth, 2·61 (2·61—3·14) in length of head, diameter of eye 4·62 (3·67—5·67), inter-



TEXT-FIG. 2.—Species of *variabilis* group.

Graph 1. Length of head in standard length. Graph 2. Depth of body in standard length. Graph 3 Distance between snout and dorsal fin in standard length. Graph 4. Length of snout in length of head. Graph 5. Width of head in length of head. Graph 6. Height of head in length of head. Graph 7. Inter-orbital width in length of head. Graph 8. Length of head in length of pectoral. Graph 9. Length of disc in length of head. Graph 10. Width of disc in width of head. Graph 11. Length of disc in width of disc. Graph 12. Distance from vent to anal fin in distance between pelvic and anal fins. Graph 13. Distance between pelvic and anal fin in distance between pelvic and base of caudal.

orbital width 2·06 (1·88—2·45). A pair of small barbels at each angle of mouth ; its size variable, sometimes reducing to a mere tubercle. 9 to 11 outer gill rakers on the lower part of the anterior arch. Length of disc 4·93 (3·87—6·00) in length of head, width 3·26 (2·57—4·25) in width of head ; length of disc 1·18 (·80—1·50) in its own width. 34 to 38 scales in lateral line, 6·5 or 7·5 from origin of dorsal to lateral line, 5·5 or 6·5 or 7·5 between this and pelvic. Back, chest and belly naked. Dorsal III, 7 ; distance between its anterior origin and tip of snout 1·91 (1·80—2·03) in standard length. Length of pectorals 1·16 (1·00—1·33) in length of head. Distance between anterior origins of pelvic and anal fins 2·26 (2·05—2·53) in that between anterior origin of pelvic and base of caudal fin. Anal II, 5. Distance from vent to anal fin 9·44 (6·00—10·00) in that between anterior origins of pelvic and anal fins. Length of caudal peduncle 1·50 (1·26—1·83) in length of head, width 1·22 (1·00—1·53) in its own length.

Posterior chamber of air bladder, measured in 25 specimens 24·24 (20·00—29·52) per cent in standard length.

Coloration.—In alcohol, dark grey above, white beneath, a light dark mid lateral streak along the body and a very narrow blackish band at the distal end of caudal peduncle.

Distribution.—Asia : Baluchistan, Helmand system, Afghanistan and East Persia.

Relationship.—It is closely related to *G. variabilis* but can be separated by such characters as the number of outer gill rakers on the lower portion of the anterior arch, position of the anal in relation to that of the pelvic and the base of the caudal fins (Text-fig. 2, Graph 13) and the scaleless nature of the back, chest and abdomen. The air bladder is highly developed, but not so extensive as in the case of *G. variabilis*.

(*b*) The '*tibanica*' group

Several related species complexes of the genus *Garra* may be assembled together in what may be called the "tibanica-group", *tibanica* being closest to the evolutionary stem of this group. This group is more highly developed than the *variabilis*-group and is typified by a relatively large and highly specialised mental disc with a specialised posterior free margin and the antero-ventral margins of the opercula being widely separated. The snout is smooth, produced between or outside the nostrils and may or may not be tuberculated.

Included in this group are the *tibanica, rufa, lamta, lissorhynchus, taeniata, yunnanensis,* and *imberbis* complexes.

(i) The '*tibanica*' complex

This Complex includes the most morphologically generalised species of the *tibanica*-group. These species exhibit 9 to 11, rarely 12 outer gill rakers on the lower part of the anterior arch, a well-developed air bladder, a row of fine prominent dark spots at the base of the branched dorsal rays, and a broad dark band from behind the gill openings to the base of the caudal fin mostly in young specimens, this band being merged with the dark grey of the upper half of the body in larger examples. Their distribution is now at or towards the western extremity of the range of the genus apparently because they are evolutionarily very old and most probably the second stock to be given off from the evolutionary centre of the genus (S. China), the 1st being the *variabilis*-group of species.

Included in this complex are *tibanica, quadrimaculata, ignesti, ornata, trewavasi makiensis, dembeensis* and *ethelwynnae.*

3. **Garra tibanica** Trewavas

(Plate VIII, figs. 7-9)

1870. *Discognathus lamta*, Plyfair, *Proc. Zool. Soc. Lond.*, London, p. 85.

1941. *Garra tibanica* Trewavas, Fresh-water fishes in : *Expedition to south west Arabia* (Brit. Mus. Nat. Hist.), London, **1**, p. 8 [Type-loc. : "Pond at Usaifira, one mile north of Taizza" Yemen. Type in BM].

1941. *Garra brittoni* Trewavas, Fresh-water fishes in : *Expedition to south west Arabia* (Brit. Mus. Nat. Hist.), London. 1, p. 11 [Type-loc. : " Migyal al Alaf, a cistern 8 miles south of Sana ", Yemen. Type in BM ; examined].

Specimens examined.—Arabia : 32, 26·0 to 87·0 mm., from Aden Protectorate ; 48, up to 107 mm., from Yemen. Africa : 17, 32·0 to 79·5 mm., from Somaliland.

Description.—Depth of body 4·42 (3·83—5·42) in standard length, length of head 3·98 (3·67—4·50). Width of head 1·42 (1·22—1·70) in length of head, height of head 1·56 (1·40—1·75). Pupil of eye at or a little before the middle of the length of head. Inter-orbital region is more or less flat. Snout rounded, scarcely tuberculate, 2·40 (1·94—2·83) in length of head, diameter of eye 4·17 (3·17—5·50), inter-orbital width 2·19 (1·83—2·67). Two pairs of barbels as long as or a little shorter than diameter of eye. 9 to 11 or 12 outer gill rakers on the lower portion of the anterior arch. The mental disc is well developed with the posterior free border distinct, but great range of variation in the development of the disc is met with ; in young specimens the posterior border is wanting. Length of disc 3·54 (2·58—5·33) in length of head, width 2·14 (1·50—3·33) in width of head ; length of disc 1·19 (·75—1·50) in its own width. 31 to 36 scales in lateral line, 3·5, 4·5 or 5·5 from the origin of dorsal to lateral line, 3·5, 4 or 4·5 between this and pelvic. 10 to 14 scales on mid-dorsal streak. Chest and belly fully scaled, but with scales not or barely overlapping. Dorsal III, 7 ; distance between its anterior origin and tip of snout 1·99 (1·88—2·10) in length. Length of pectorals 1·15 (·95—1·40) in length of head. Distance between anterior origins of pelvic and anal fins 2·13 (1·87—2·64) in that between anterior origin of pelvic and base of caudal fin. Anal III, 5. Distance from vent to anal fin 8·94 (5·00—17·00) in that between anterior origins of pelvic and anal fins. Length of caudal peduncle ·54 (1·19—2·00) in length of head, width 1·33 (1·11—1·78) in its own length.

Posterior chamber of air bladder, measured in 15 specimens 22·97 (18·18—28·09) per cent in standard length.

Coloration.—In alcohol, dark grey or brownish grey above, paler beneath, a single dark lateral band in young specimens merging with the upper grey in bigger examples, generally five dark spots at bases of last five dorsal rays, and a black spot behind the upper angle of the gill opening.

Distribution.—Asia : S. W Arabia. Africa : Somaliland.

Relationship.—This species is most closely allied to *G. quadrimaculata* differing principally in the position of the vent which in this species is almost immediately in front of the anal fin (Text-fig. 3, Graph 12).

4. **Garra quadrimaculata** (Rüppell)

(Plate VIII, figs. 10-12)

1837. *Gobio quadrimaculatus* Rüppell, *Mus. Senckenb.*, Frankfurt, 2, p. 22, taf. 3, fig. 3 [Type-loc: Abyssinia. Type in SNG].

1837. *Gobio hirticeps* Ruppell, *Mus. Senckenb.*, Frankfurt, 2, p. 23, pl. III, fig. 4 [Type-loc : Abyssinia. Type in SNG].

1846. *Discognathus hirticeps*, Heckel, Russegger's *Reisen in* Europe, Asien Und Afrika, 3, p. 329.

1846. *Discognathus quadrimaculatus* Heckel, Russegger's *Reisen in Europe, Asien Und Afrika*, 3, p. 329.

1868. *Barbus quadrimaculatus*, Gunther, *Cat. Brit. Mus. Fish*, London, 7, p. 98.

1870. *Discognathus lamta*, Blanford, *Geol. Zool. Abyssin.*, London, p. 460.

1883. *Discognathus lamta*, Vinciguerra, *Ann. Mus. Stor. nat. Genova*, Geneva, 18, p. 695.

1901. *Dissognathus blanfordii*, Boulenger, *Proc. Zool. Soc. Lond.*, London, 2, p. 160 [Type-loc. s " Streams at Suru " and small pool left in the water course at Amba, about twenty-five mile: north of Mossowa ". Type in BM].

1907. *Discognathus dembeensis*, Boulenger (in part), *Fish Nile*, London, p. 181, pl. **44**, Fig. 1.

1097. *Discognathus vinciguerrae* Boulenger (in part), *Fish Nile*, London, p. 185, pl. **31**, fig. 4 [Type loc : Near Kermeh, 3rd Cataract (Nile R.) Abyssinia. Type in BMJ.

1909. *Discognathus dembeensis.* Boulenger (in part), *Cat. Freshwater Fish Africa*, London, **1**, p. 345 fig. 259.

1909. *Discognathus vinciguerra* Boulenger (in part), *Cat. Freshwater Fish Africa*, London, **1**, p. 347 fig. 261.

1909. *Discognathus blanfordii* Boulenger (in part), *Cat., Freshwater Fish Africa*, London, **1**, p. 349 fig. 263.

1927. *Garra aethiopicus* Pellegrin, *Bull. Soc. Zool. Fr.*, Paris, **52**, p. 232 [Type-loc : Kabana River» Abyssinia. Type in MHNP., examined].

1936. *Discognathus blanfordii cimmaruta* Gianferrari, *Atti. Soc. Ital. Milano*, Milan, **75**, p.295 [Type-loc : " Gherungura Adua, " Abyssinia. Type in TM., examined].

Specimens examined.—Abyssinia :—6, 43·0 to 71·0 mm., from Jerrer river, Harrar 1, 80·5 mm., from Adowa., 1, 94·5 mm., from Kabana river, 2,98·0 to 107·5 mm., from Gib river.

Description.—Depth of body 5·17 (4·39-6·41) in length, length of head 4·45 (3·95-5·00) Width of head 1·37 (1·23-1·50) in length of head, height of head 1·58 (1·48-1·77). Pupil of eye at or slightly in front of the middle of the length of head. Inter-orbital region flat. Snout rounded, scarcely tuberculate, 2·17 (1·87-2·42) in length of head, diameter of eye 5·25 (3·67-6·28,) inter orbital width 2·10 (2·00-2·23). Two pairs of barbels as long as or shorter than diameter of eye. 11 outer gill rakers on the lower part of anterior arch. Mental disc is well developed with the posterior free border distinct ; in young specimens it is, however, wanting ; sometimes the disc is reduced even in fairly big specimens. Length of disc 2·17 (2·69-3·25) in length of head, width 1·72 (1·50-2·00) in width of head ; length of disc 1·27 (1·12-1·43) in its own width. 34 to 36 scales in lateral line, 4·5 or 5·5 from the origin of dorsal to lateral line, 3, 3·5 or 4·5 between this and pelvic. 13 to 14 scales on mid-dorsal streak. Chest and belly fully scaled, but with scales barely overlapping. Dorsal 11—111, 7 ; distance between its anterior origin and tip of snout 2·07 (1·94-2·19) in standard length. Length of pectorals 1·07 (·88-1·16) in length of head. Distance between anterior origins of pelvic and anal fins 2·09 (1·86-3·32) in that between anterior origin of pelvic and base of caudal fin. Anal 11, 5. Distance from vent to anal fin 4·83 (4·00-5·80) in that between anterior origins of pelvic and anal fins. Length of caudal peduncle 1·35 (1·02-1·69) in length of head, width 1·40 (1·08-1·83) in its own length.

Posterior chamber of air bladder, measured in 2 specimens 12·20 (12·17-12·24) per cent in standard length.

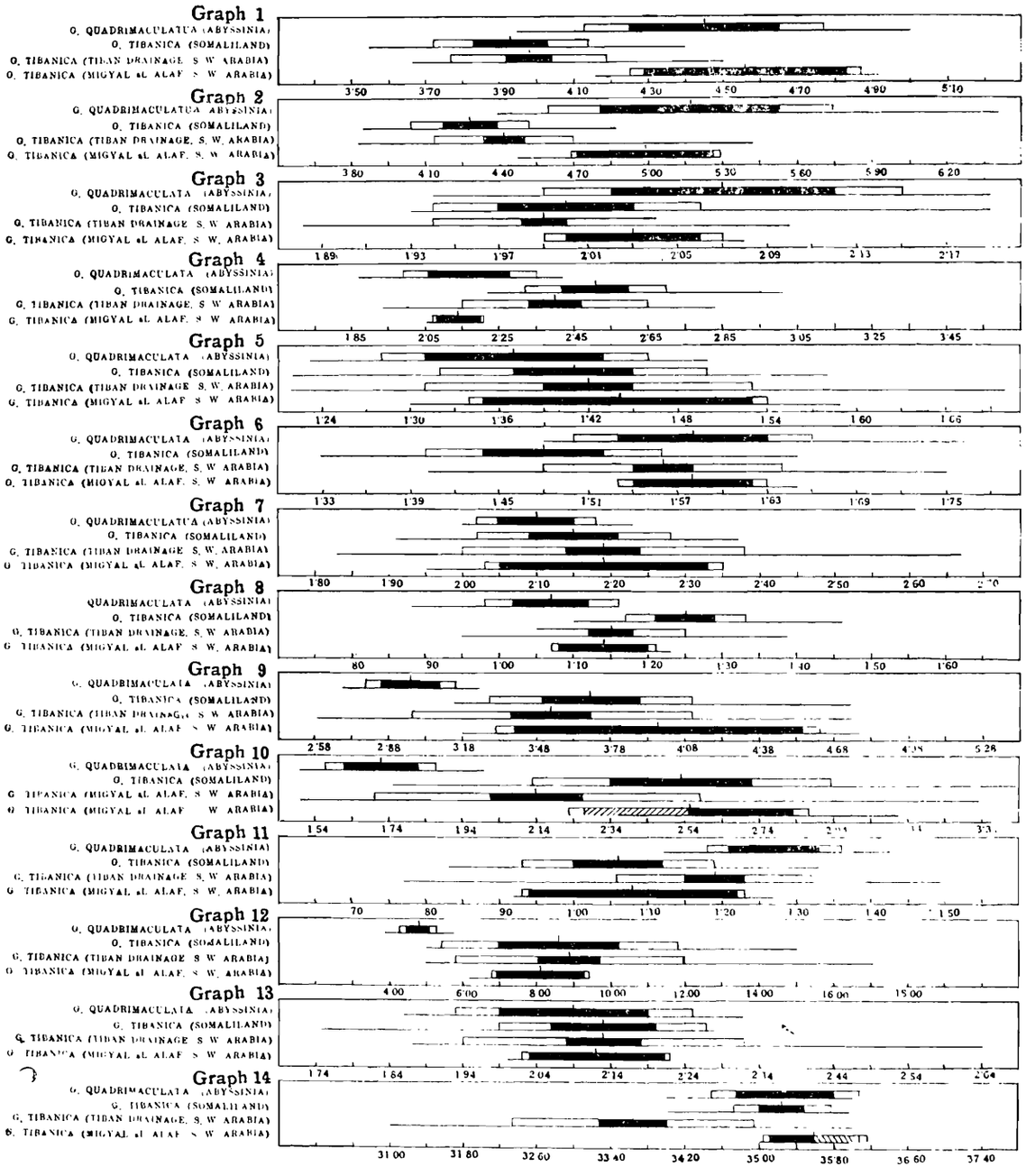
Coloration.—In alcohol, dark grey or brownish grey above, paler beneath, a single dark lateral band in young specimens, usually five dark spots at bases of the last five dorsal rays and a black spot behind the upper angle of the gill opening.

Distribution.—Africa, Abyssinia and Eritrea.

Relationships.—This species is closely related to *G. tibanica* but can be readily separated by the more advanced position of its vent. Trewavas (*op. cit.*) pointed out the close relationships of these two species and doubted that they may be geographical races or subspecies of the same species. They can, however, be separated on the relative positions of their vents (Text fig. 3, Graph 12).

Remarks.—Ruppell (*op. cit.*) evidently based his description on specimens he examined from the Nile system in Abyssinia. He, however, stated (*loc. cit.*, p. 23) that the fish is abundant in all streams in Abyssinia and even in those on the eastern side of the Terranda mountains. At the time of Ruppell's description of *quadrimaculata* the Terranda mountain was part of Abyssinia though subsequently it was included within Eritrea (*vide*, Blandford's (*op. cit.*) map of the portion of Abyssinia traversed by the British Expedition in 1868 from

Annesley Bay to Higdala and of the country between Mossowa and Anseba Valley). He characterised the fish with 35 scales in the lateral line without, however, mentioning anything on the nature of the disc.



TEXT-FIG. 3.—*Garra tibanica* compared with *G. quadrimaculata*.

Graph 1. Length of head in standard length. Graph 2. Depth of body in standard length. Graph 3 Distance between snout and dorsal fin in standard length. Graph 4. Length of snout in length of head. Graph 5. Width of head in length of head. Graph 6. Height of head in length of head. Graph 7. Interorbital width in length of head. Graph 8. Length of pectoral in length of head. Graph 9. Length of disc in length of head. Graph 10. Width of disc in width of head. Graph 11. Length of disc in width of disc. Graph 12. Distance from vent to anal fin in distance between pelvic and anal fins. Graph 13. Distance between pelvic and anal fins in distance between pelvic and base of caudal. Graph 14. Lateral line scale

Boulenger (*loc. cit.*, p. 160), however, proposed the name *D. blanfordii* to the specimens obtained by Blanford from streams at Suru and " in a small pool left in the water course at Amba, about twenty-five miles north of Mossowa ", both these localities being on the eastern side of the Terranda mountains in Eritrea and referred to as *D. lamta* by Blanford

(*op. cit.*) and Vinciguerra (*op. cit.*). Boulenger (*loc. cit.*, p. 160) characterised his *blanfordii* with 33 to 35 scales along the lateral line *i.e.*, the same number as given by Ruppell for the *quadrimaculata*, though subsequently Boulenger (*loc. cit.*, p. 349) in his description of the species basing on more specimens from Abyssinia gave a higher scale count (33 to 38).

In his "Fishes of the Nile" Boulenger (*loc. cit.*, p. 181), however, differentiated *D quardimaculata* from the other forms from the Nile basin, namely *D. dembeensis*, *D. johnstonii* and *D. vinciguerrae* on the basis that in *quadrimaculata* the "mental disc is small, often very indistinct or reduced to a mere, pad, without or with a very slight free posterior border" and further characterising it with 37 to 42 scales in the lateral line. After having examined large series of specimens of *Garra* from Abyssinia I have now come to the definite conclusion that the disc character is of no taxonomic significance and cannot be relied upon for species differentiation. Boulenger's (*loc. cit.*, p. 186) *quadrimaculata* from the Nile basin is, therefore, only the species Ruppell described as *dembeensis* and characterised by a larger number of scales along the lateral line in his *quadrimaculata*.

In view of the above I have synonymised *G. blanfordii* with *G. quadrimaculata*. *G. quadrimaculata* exists in Abyssinia together with *G. dembeensis* (*vide*, Text fig. 28) but the former can be easily separated by the lesser number of scales along the lateral line (33—364), its back, chest and belly being covered with scales and the position of the vent which is 4 to 5 times between the anterior origins of the pelvic and the anal fins. *D. dembeensis*, on the other hand, has a greater lateral-line scale-count (38—42), its back is only partially scaled and the vent is more anteriorly placed, the position of the vent being at a distance from the base of the anal which is 3 to 4 times in the distance between the anterior origins of the pelvic and the anal fins.

The types of *blanfordii* in the British Museum were examined for my sake by Dr. E. Trewavas and relevant informations kindly supplied. Her lateral-line scale-count for twenty specimens of the type, however, vary from 31—33, whereas in specimens I have considered here as *quadrimaculata* the lateral-line scale-count vary from 34 to 36. This difference is probably due to the difference in the method of counting followed by us.

5. **Garra ignestii** (Gianferrari)

1925. *Discognathus ignestii* Gianferrari, *Atti. Soc. Ital. Milano*, Milan, **64**, p. 185 [Type-loc.: The Kahha and the Angrab Rivers, Abyssinia. Type in TM., examined].

Specimens examined.—Abyssinia: 1, 62·5 mm., from Kahha river.

Description.—Depth of body 5·43 in length, length of head 4·17, Width of head 1·36 in length of head, height of head 1·76. Pupil of eye slightly before the middle of the length of head. Inter-orbital region flat. Snout somewhat pointed, smooth, 2·14 in length of head, diameter of eye 5·00, inter-orbital width 2·14. Two pairs of barbels, rostral almost as long as the diameter of the eye, the maxillary smaller. The mental disc well-developed. Length of disc 3·00 in length of head, width 1·83 in width of head; length of disc 1·20 in its own width. 36·0 scales in lateral line, 4·5 from the origin of dorsal to lateral line, 4·0 between this and pelvic. Scales on middorsal streak absent. Chest, belly and the post-pelvic regions naked. Dorsal III, 7; distance between its anterior origin and tip of snout 2·08 in standard length. Length of pectorals 1·00 in length of head. Distance between anterior origins of pelvic and anal fins 2·37 in that between anterior origin of pelvic and base of caudal fin. Anal II, 5. Distance from vent to anal fin 4·80 in that between anterior origins of pelvic and anal fins. Length of caudal peduncle 1·50 in length of head, width 1·33 in its own length.

Posterior chamber of air bladder, measured in 1 specimen 12·8 per cent in standard length.

Coloration.—In alcohol, dark grey or bluish grey above, paler beneath; an indistinct lateral band; five dark spots at the base of the last five dorsal rays and a black spot behind the upper angle of the gill openings.

Distribution.—Africa : Abyssinia : The Angrab and the Kahha rivers.

Relationships.—This species is closely related to *G. quadrimaculata* ; it can, however, be easily distinguished by the pre-dorsal streak, the chest, belly and the post-pelvic regions being naked.

6. **Garra ornata** (Nichols and Griscom)

1917. *Discognathus dembeensis*, Nichols and Griscom, *New York Bull. Amer. Mus. nat. Hist.*, New York, **37**, p. 695.

1917. *Discognathus ornatus* Nichols and Griscom, *Bull. Amer. Mus. nat. Hist.*, New York, **37**, p. 696 [Type-loc : Stanleyville, Belgium Congo. Type in AMNH].

1920. *Discognathus occidentalis* Lonnbergh & Rendahl, *Ann. Mag. Nat. Hist.*, London, (9) **6**, p. 169 [Type-loc : Kingoyi, Lower Congo, Type in BM].

1923. *Discognathus baudoni* Pellegrin, *Bull. Soc. Zool. Fr.*, Paris, **48**, p. 338 [Type-loc : Gabon, Fr. Equatorial Africa. Type in MHNP., examined].

1935. *Discognathus waterloti* Pellegrin, *Bull. Soc. Zool. Fr.*, Paris, **60**, p. 463 [Type-loc : Banamanan. Kissidougou (French Guinea). Type in MHNP., examined]

1950. *Garra waterloti* Monod, *Bull. de l'Ifan.*, Noire, **12** (4), p. 276, fig. 2, 5.

1950. *Garra waterloti* var. *dageti* Monod, *Bull. de l'Ifan.*, Noire, **12** (4), p. 276 [Type-loc. : Markala, French Sudan. Type in MHNP, holotype ; BM, a paratype].

Specimens examined.—Africa : 2, 50·5 mm. & 55·5 mm., from Kisala, Belgium Congo ; 1,50·0 mm., from Loukoula river, French Equatorial Africa ; 1, 48·5 mm., from Banamanan French Guinea.

Description.—Depth of body 5·36 (5·18-5·55) in length, length of head 4·72 (4·62—4·83). Width of head 1·32 (1·32—1·33) in length of head, height of head 1·77 (1·70—1·85). Pupil of eye almost in the middle of the length of head. Inter-orbital region flat. Snout rounded smooth 2·03 (2·00-2·07) in length of head, diameter of eye 4·07 (4·00-4·14), inter-orbital width 2·20 (2·18—2·23). Two pairs of barbels, smaller than the diameter of the eye. 10 to 11 gill rakers in the lower part of anterior arch. Mental disc well-developed. Length of disc 2·78 (2·67—2·90) in length of head, width 1·90 (1·80—2·00) in width of head ; length of disc 1·10 (1·10—1·11) in its own width. 36 to 37 scales in lateral line, 5·5 or 6·5 from the origin of dorsal to lateral line, 3·5 or 4·5 between this and pelvic. 9 to 10 scales in front of dorsal fin and in front of these a row of very reduced scales towards head ; chest and a portion of the mid-belly behind it naked with 6 rows of scales in front of pelvic. Post-pelvic region scaly. Dorsal 111, 7 ; distance between its anterior origin and tip of snout 2·09 in standard length. Length of pectorals 1·03 (1·03-1·04) in length of head. Distance between anterior origins of pelvic and anal fins 1·88 (1·85—1·91) in that between anterior origin of pelvic and base of caudal fin. Anal 11, 5. Distance from vent to anal fin 3·10 (2·83—3·37) in that between anterior origins of pelvic and anal fins. Length of caudal peduncle 1·56 (1·53—1·60) in length of head, width 1·06 (1·05—1·07) in its own length.

Posterior chamber of air bladder, measured in 1 specimen 17·27 per cent in standard length.

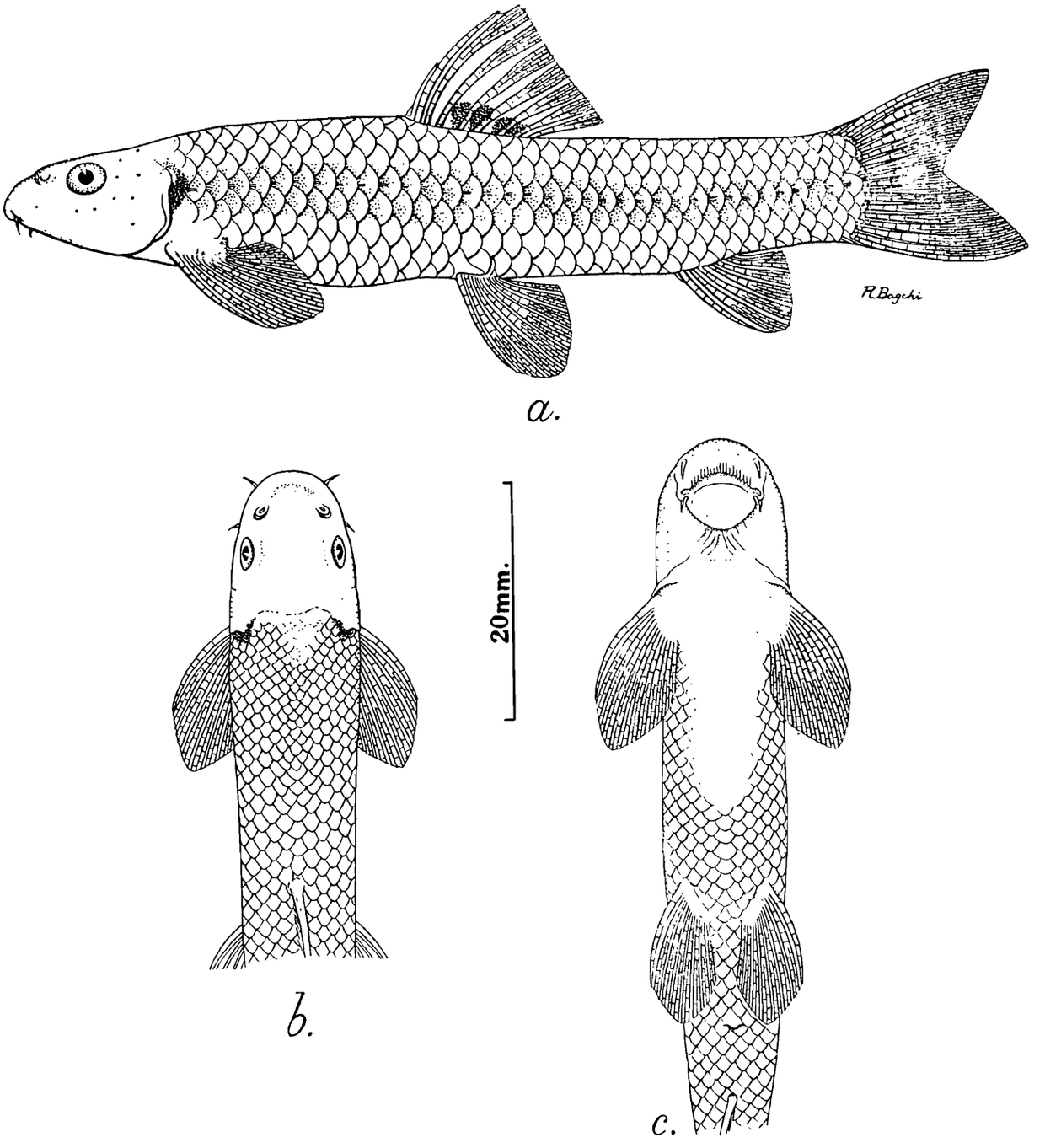
Coloration.—In alcohol, dark brownish grey above, paler beneath, a broad lateral band from behind the gill openings to the base of the caudal fin, with four dark spots at the bases of the third to sixth dorsal rays and a black spot behind the upper angle of the gill openings.

Distribution.—Africa : Belgium Congo, French Equatorial Africa and French Guinea.

Relationships.—This species is related to *G. quadrimaculata*, but can be separated from it by the more advanced position of its vent.

Remarks.—Examination of the type specimens of *D. boudoni* and *D. waterloti* was made possible for me through the kindness of the late Dr. Leon Bertain of the Museum National D'Histoire Naturelle, Paris. I have not examined the types of *D. occidentalis* and *D. ornata*, but they were examined for my sake by Dr. E. Trewavas of the British Museum and

Mr. Francesca La Monte of the American Museum Natural History respectively and they both sent me drawings of the specimens. Mr. Monte has given me the following particulars regarding the type of *ornata* :



TEXT-FIG. 4.—*Garra ornata* (Nichols & Griscom).
(*a*). Lateral view of a specimen (MHNP 26-89-90) from Kisala, Belgium Congo. (*b*). Dorsal view of *a*. (*c*). Ventral view of *a*.

" The specimen is very small and somewhat withered, especially in the midlines both ventrally and dorsally. However, from what I can discover, the distance of the vent from the origin of the anal fin in that between the origins of the pelvic and anal is 2·6. "

Dorsally there are no scales on the midlines of the body until the distance indicated on my extremely poor sketch as I can not draw, but the proportions are exact, not the size. The scales on the dorsal midline are very fragile and imbricated. The ventral scalation

is more complicated. The chest is not scaled. Beginning at the origin of the pectorals, there is an overlap around the sides of the body slightly into the belly about $1\frac{1}{2}$ scales. Before the origin of the ventral, as indicated there are about three scales. After the origin of the ventral, scalation is completely around the body-large vary, fragile scales ; larger than those on the upper part of the body. These continue to the origin of the caudal "

In the case of the type specimen of *occidentalis* there are 9 scales in front of the dorsal fin and in front of these there is a narrow scaleless strip towards the head ; the scales on the ventral aspect are, however, exactly like that described here. Types of *boudoni* and *waterloti* are in every respect similar to the specimens from Belgium Congo described here.

7. **Garra trewavasi** Monod

(Plate IX, Figs. 1-3)

1950. *Garra trewavasi* Monod, *Bulletin de l'Ifan.*, Noire, **12** (4), p. 276 [Type-loc. : Bargesh River, Nigeria. Type in MHNP, holotype examined ; BM, a paratype ; Institute Franca's d' Afrique, Noire, a paratype].

Specimens examined.—Africa : 1, 70·5 mm., from Bargesh river, Nigeria.

Description.—Depth of body 4·27 in length, length of head 4·15. Width of head 1·21 in length of head, height of head 1·03. Pupil of eye at the middle of the length of head. Inter-orbital region flat. Snout rounded smooth, 2·00 in length of head, diameter of eye 4·86, inter-orbital width 2·43. Two pairs of barbels, smaller than diameter of the eye. 10 outer gill rakers on the lower part of anterior arch. Mental disc well-developed. Length of disc 3·09 in length of head, width 2·15 in width of head ; length of disc 1·18 in its own width. 36 scales in lateral line, 4·5 from the origin of dorsal to lateral line, 4·5 between this and pelvic. 5 scales in front of dorsal fin and in front of these a naked area forward to head. Chest and mid-belly naked. Post-pelvic region scaly. Dorsal III, 7 ; distance between its anterior origin and tip of snout 1·96 in standard length. Length of pectorals 1·17 in length of head. Distance between anterior origins of pelvic and anal fins 1·86 in that between anterior origins of pelvic and anal fins 1·86 in that between anterior origin of pelvic and base of caudal fin. Anal II, 5. Distance from vent to anal fin 4·00 in that between anterior origins of pelvic and anal fins. Length of caudal peduncle 1·70 in length of head, width 1·11 in its own length.

Posterior chamber of air bladder, measured in 1 specimen 12·76 per cent in standard length.

Coloration.—In alcohol, brownish grey above, paler beneath, an indistinct lateral band from behind the gill openings to the base of caudal, five dark spots at the bases of the last five dorsal rays and a black spot behind the upper angle of the gill openings.

Distribution.—Africa : Neigeria : Bargesh river, S.W of Bauchi Plateau.

Relationships.—This form may be easily distinguished by its deeper body, naked predorsal streak and the scaly post-pelvic area. It is closely allied to *quadrimaculata*, *ignesti* and *ornata*.

8. **Garra makiensis** (Boulenger)

1903. *Discognathus makiensis* Boulenger, *Proc. Zool. Soc. Lond.*, London, **2** p. 330, pl. 21, fig. 1 [Type-loc : Maki River, Abyssinia ; Type in BM].

1905. *Discognathus rothschildi* Pellegvin, *Bull. Mus. Hist. nat. Paris*, Paris, **2**, p. 291 [Type-loc : Gotta River, Abyssinia. Type in MHNP ; examined].

1909. *Discognathus makiensis* Boulenger, *Cat. Freshwater Fish Africa*, London, **1**, p. 348, fig. 262.

Specimens examined.—Abyssinia : 1 from Gotta river, 108·0 mm.

Description.—Depth of body 4·50 in standard length, length of head 5·02. Width of head 1·39 in length of head, height of head 1·48. Pupil of eye at the middle of the lengtb

of head. Inter-orbital region nearly flat. Snout rounded, scarcely tuberculate, 1·95 in length of head, diameter of eye 5·37, inter-orbital width 1·95. Two pairs of barbels, smaller than diameter of the eye. 11 gill rakers on the lower part of anterior arch. Mental disc well-developed. Length of disc 3·31 in length of head, width 1·94 in width of head ; length of disc 1·23 in its own width. 38 to 42 scales in lateral line, 4·5 from the origin of dorsal to lateral line, 4·5 between this and pelvic. 13 scales on mid-dorsal streak. Chest and belly scaly. Dorsal III, 7 ; distance between its anterior origin and tip of snout 2·27 in length. Length of pectorals 1·00 in length of head. Distance between anterior origins of pelvic and anal fins 2·02 in that between anterior origin of pelvic and base of caudal fin. Anal II, 5. Distance from vent to anal fin 10·39 (9·17—11·00) in that between anterior origins of pelvic and anal fins. Length of caudal peduncle 1·10 in length of head, width 1·62 in its own length.

Posterior chamber of air bladder, measured in 1 specimen 18·98 per cent in standard length.

Coloration.—In alcohol, brownish grey above, paler beneath, four dark spots at the bases of third to sixth branched dorsal rays and a dark spot behind the upper angle of the gill openings.

Distribution.—Africa : Abyssinia : Maki and Gotta rivers.

Relationships.—In the lateral-line scale-count this species is related to *G. dembeensis*, but can be easily distinguished from it by the position of the vent which is close to the base of the anal fin and by the scaly back, chest and belly ; in these characters it approaches *tibanica* and *quadrimaculata*. In the location of the vent close to the base of the anal fin *G. makiensis* is more closely related to *tibanica* than to *dembeensis*.

Remarks.—I have not examined the type of this species, but Dr. Trewavas kindly supplied me the necessary particulars.

9. **Garra dembeensis** (Ruppell)

(Plate IX, Figs. 11-13)

1837. *Chondrostoma dembeensis* Ruppell, *Mus. Senckenb.*, Frankfrut, 2, p. 16, pl. **2**, fig. 4[Type-loc. : Dembea Lake at Goraza, Abyssinia, Type in SNG].

1846. *Gymnostomus ? dembeensis*, Heckel,Russeger's *Reisen in Europa, Asien Und Afrika*, **3**, p. 329. (Original not seen).

1883. *Discognathus chiarinii* Vinciguerra, *Ann. Mus. Genova*, Geneva, **18**, p. 696, [Type-loc. : Lake Arsade, Adda Gallaland, Abyssinia. Type in GM, holotype ; BM, a paratype].

1889. *Discognathus chiarinii* Vinciguerra, *Ann. Mus. Genova*, Geneva, **29** p., 280.

1901. *Discognathus johnstonii* Boulenger, *Proc. Zool. Soc. Lond.*, London, **2**, p. 159 [Type-loc. : Lake Victoria, Kenya. Type in BM].

1901. *Discognathus chiarinii*, Boulenger, *Proc. Zool. Soc. Lond.*, London, **2**, p. 160.

1901. *Discognathus vinciguerrae* Boulenger, *Proc. Zool. Soc. Lond.*, London, **2**, p. 160 [Type-loc. : Near Kermeh, 3rd Cataract (Nile R.), Abyssinia. Type in BM].

1903. *Discognathus quadrimaculatus*, Boulenger, *Proc. Zool. Soc. Lond.*, London, **2**, p. 330.

1903. *Discognathus dembeensis*, Boulenger, *Ann. Mag. Nat. Hist.*, London, (7) **11**, p. 54.

1905. *Discognathus hindii* Boulenger, *Proc. Zool. Soc. Lond.*, London, **1**, p. 62, pl. 7, fig. 1 [Type-loc.: Nyiro River, Kenya. Type in BM, syntypes ; MHNP, syntypes, examined].

1907. *Discognathus dembeensis*, Boulenger (in part), *Fish Nile*, p. 181, pl. 48, fig. 1.

1907. *Discognathus johnstonii* Boulenger, *Fish Nile*, London, p. 184, pl. 32, fig. 2.

1907. *Discognathus vinciguerrae Boulenger* (in part), *Fish Nile*, London, p. 185, pl. 31, fig. 4.

1907. *Discognathus quadrimaculatus*, Boulenger, *Fish Nile*, London, p. 186, pl. 31, fig. 5.

1909. *Discognathus dembeensis*, Boulenger (in part), *Cat. Freshwater Fish. Africa*, London, **1**, p. 345, fig. 256.

1909. *Discognathus johnstonii*, Boulenger, *Cat. Freshwater Fish Africa*, London, **1**, p. 346, fig. 260.

1909. *Discognathus vinciguerrae* Boulenger (in part), *Cat. Freshwater Fish Africa*, London, **1**, p. 347, fig. 261.

1909. *Discognathus blanfordii* Boulenger, *Cat. Freshwater Fish Africa*, London, **1**, p. 349, fig. 263.

1909. *Discognathus hindii* Boulenger, *Cat. Freshwater Fish Africa*, London, **1**, p. 350, fig. 264.

1909. *Discognathus quadrimaculatus*, Boulenger, *Cat. Freshwater Fish, Africa*, London, **1**, p. 351, fig. 265.

1926. *Discognathus quadrimaculatus*, Gianferrari, *Atti. Soc. Ital. Milano*, Milan, **64**, p. 184.

1926. *Discognathus dembeensis*, Gianferrari, *Atti. Soc. Ital. Milano*, Milan, **64**, p. 190.

1932. *Discognathus giarrabensis* Gianferrari, *Boll. Zool. Napoli, Naples*, Naples, **1**, p. 2 [Type-loc. Giarraba, Eritrea. Type in TM, examined].

Specimens examined.—Abyssinia : 4, 97·5 to 110·5 mm., from Gibe river ; 7, 37·5 to 64·5 mm., from Tsana lake ; 8, 29·5 to 41·5 mm., from Addis Abeba ; 22, 70·0 to 101·5 mm., from " Ethiopia meridionale " ; 2, 41.5 & 50.0 mm., from Godschimboda river. Kenya :— 5, 51·0 to 70·0 mm., from Ndula falls, Thika river ; 14, 30·0 to 64·0 mm., from M'bakasi, Athi river ; 5, 55·5 to 86·0 mm., from Saya, British East Africa ; 2, 71·5 mm. each, from Nairobi river, Kilimenjaro ; 3, 35.5 to 50.0 mm., from Nero river, 5, 46·5 to 97·5 mm., from Rumuruti, Waso Nacok. Eritrea : 1, 50.0 mm., from Gizarraba.

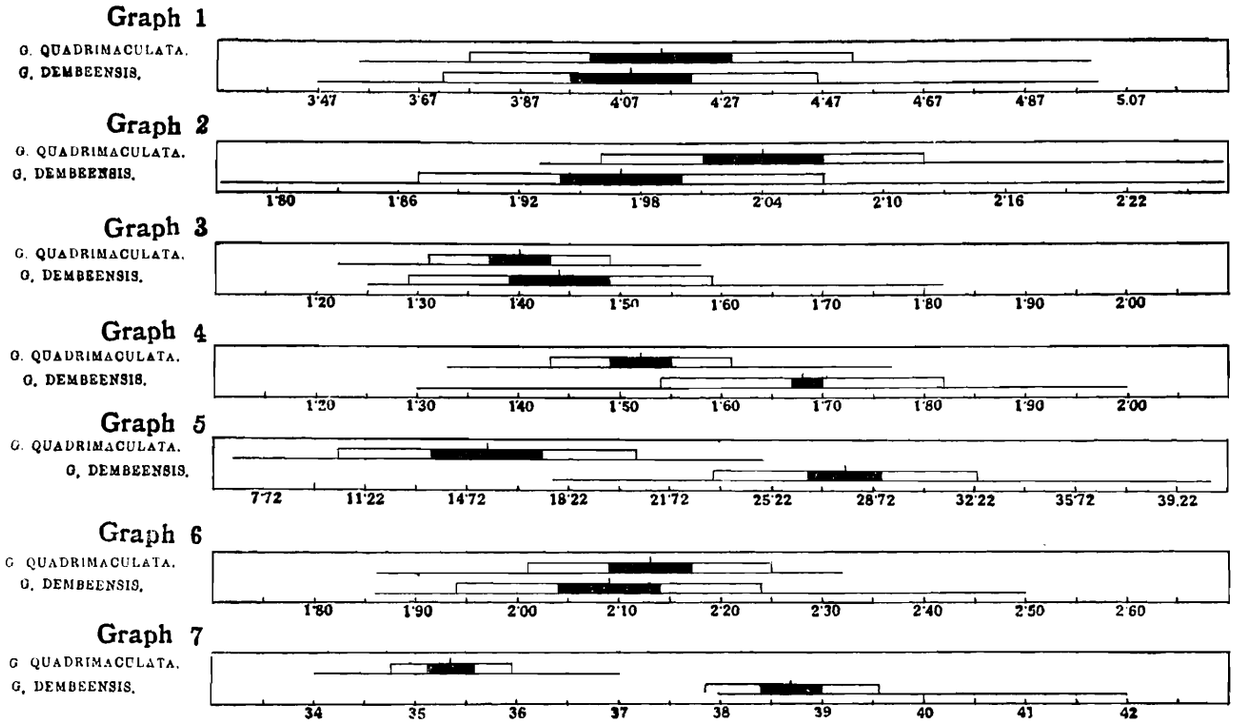
Description.—Depth of body 5·19 (4·39—6·55) in standard length, length of head 4·14 (3·47—4·91). Width of head 1·44 (1·25—1·82) in length of head, height of head 1·68 (1·30—2.00). Pupil of eye at or in the front of the middle of the length of head. Inter-orbital region flat. Snout rounded, scarcely tuberculate, 2·39 (1·67—3·00) in length of head, diameter of eye 6·09 (3.40-7·67), inter-orbital width 2·33 (2·00—2·67). Two pairs of barbels smaller than diameter of the eye. 9 to 11 outer gill rakers on the lower portion of the anterior arch. Mental disc is well-developed, but great range of variation in the development of the posterior free border is met with ; in young specimens it is wanting. Length of disc. 3·83 (2·62—5·67) in length of head, width 3·21 (1·45—6·00) in width of head ; length of disc 0·89 (0·50—1·54) in its own width. 38 to 42 scales in lateral line 4·5, 5·5 or 6·5 from the origin of dorsal to lateral line, 3·5 or 4·5 between this and pelvic. 4 to 10 scales in front of dorsal fin and in front of these a narrow scaleless streak towards head or the entire mid-dorsal streak is scaleless. Chest and mid-belly naked, post-pelvic region scaly. Dorsal 111, 7; distance between its anterior origin and tip of snout 1·99 (1·80—2·38) in standard length. Length of pectorals 1·22 (1·00-1·75) in length of head. Distance between anterior origins of pelvic and anal fins 2·09 (1·86—2·50) in that between anterior origin of pelvic and base of caudal fin. Anal 11, 5. Distance from vent to anal fin 3·72 (2·47—5·67) in that between anterior origins of pelvic and anal fins. Length of caudal peduncle 1·67 (1·17—2·43) in length of head, width 1·33 (1·09—1·60) in its own length.

Posterior chamber of air bladder, measured in 22 specimens 18·06 (10·96—26·31) per cent in standard length.

Coloration.—In alcohol, brownish grey above, paler beneath, a broad lateral band from behind gill opening to base of caudal fin in young specimens, but usually it gets merged with the uppper grey, generally five dark spots at bases of the last five dorsal rays and a dark spot at the upper angle of the gill openings.

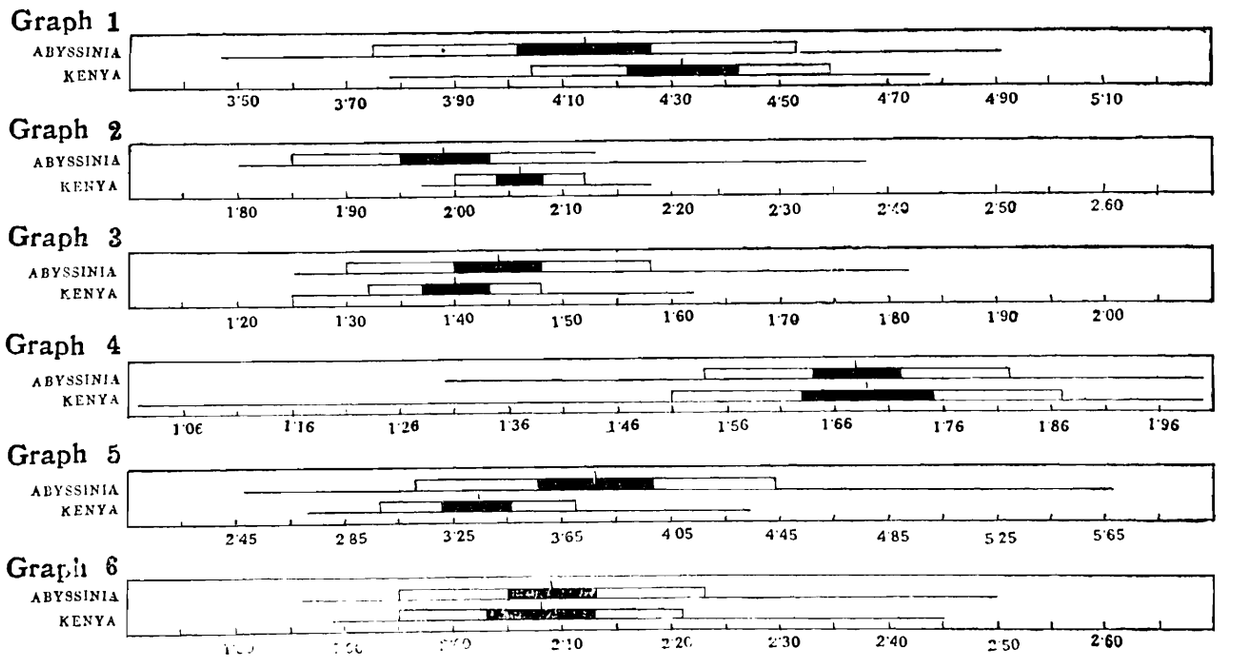
Distribution.—Africa : Abyssinia, Kenya and Eritrea. It occurs with *quadrimaculata* but can be readily separated by the larger number of scales along the lateral line, the more anteriorly placed position of the vent (Text-fig. 6, Graph 5), the absence or reduced number of scales on the pre-dorsal streak and the chest and the mid-belly being naked. In the larger number of scales along the lateral line its relationships are closer to makiensis than to *quadrimaculata*. The more anteriorly placed position of the vent, however, indicates its more highly evolved nature than *makiensis*.

Remarks.—I have synonymised *G. hindii* with *G. dembeensis* as the variation in the characters of the former falls within the normal variation of the individuals of the latter (Text-fig. 6).



TEXT-FIG. 5.—*Garra quadrimaculata* compared with *Garra dembeensis*.

Graph 1. Length of head in standard length. Graph 2. Distance between snout and dorsal fin in standard length. Graph 3. Width of head in length of head. Graph 4. Height of head in length of head. Graph 5. Distance from vent to anal fin in distance between pelvic and anal fins. Graph 6. Distance between pelvic and anal fins in distance between pelvic and base of caudal. Graph 7. Lateral line scales.



TEXT-FIG. 6.—*Garra dembeensis* from Abyssinia and Kenya compared.

Graph 1. Length of head in standard length. Graph 2. Distance between snout and dorsal fin in standard length. Graph 3. Width of head in length of head. Graph 4. Height of head in length of head. Graph 5. Distance from vent to anal fin in distance between pelvic and anal fins. Graph 6. Distance between pelvic and anal fins in distance between pelvic and base of caudal.

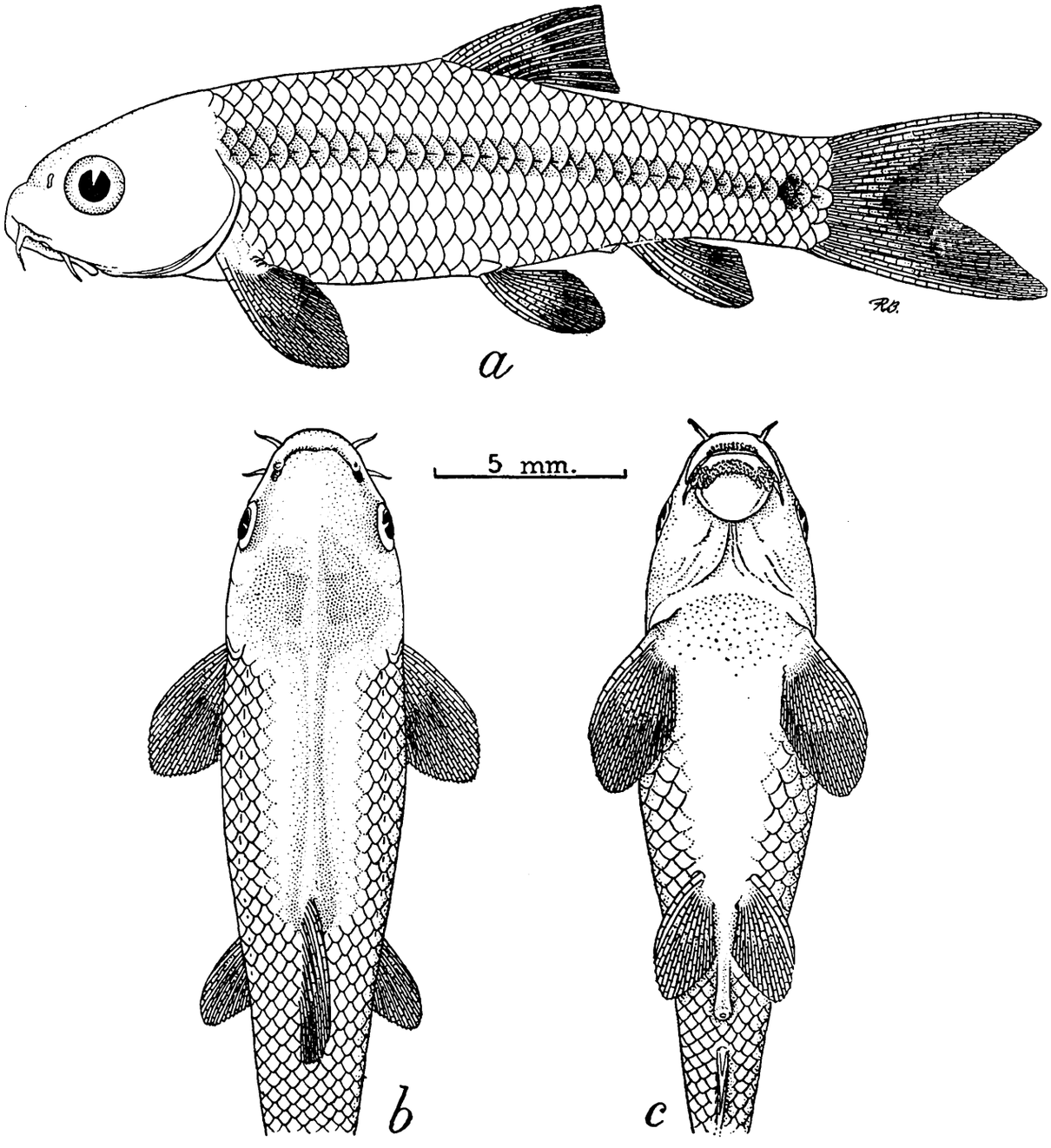
In the type specimen which Dr. W Kausewitz kindly examined for my sake there are 40 scales along the lateral line.

10. **Garra ethelwynnae** Menon

1958. *Garra ethelwynnae* Menon, *Curr. Sci.*, Bangalore, **27**, p. 450.

Specimens examined.—Eritrea :—3, 21·5 to 28·0 mm., from Salamona.

Description.—Depth of body 3·51 (3·11—3·91) in standard length, length of head 3·53 (3·50—3·58). Width of head 1·29 (1·20—1·33) in length of head, height of head 1·29



TEXT-FIG. 7.—*Garra ethelwynnae* Menon.

(*a*). Lateral view of a paratype (ZSI/F589/2) from Salamona, Eritrea. (*b*). Dorsal view of *a*. (*c*). Ventral view of *a*.

(1·20—1·33). Pupil of eye a little in front of the middle of the length of head. Inter-orbital regior flat. Snout rounded, smooth, 2·58 (2·40—2·67) in length of head, diameter of eye 3·40 (3·00—4·00), inter-orbital width 1·99 (1·71—2·28). Two pairs of barbels smaller than

diameter of the eye. 9 outer gill rakers in the lower part of anterior arch. Mental disc well-developed. Length of disc 3·40 (3·00—4·00) in length of head, width 2·33 (2·00—3·00) in width of head ; length of disc 1·15 (1·00—1·25) in its own width. 32 to 34 scales in lateral line, 4·5 from the origin of dorsal to lateral line, 3·5 or 4·5 between this and pelvic. Back, chest and belly naked ; postpelvic region scaly. Dorsal III, 7 ; distance between its anterior origin and tip of anout 1·82 (1·79-1·87) in standard length. Length of pectorals 1·29 (1·20—1·33) in length of head. Distance between anterior origins of pelvic and anal fins 1·99 (1·80—2·08) in that between anterior origin of pelvic and base of caudal fin. Anal II, 5. Distance from vent to anal fin 9·33 (6·00—12.00) in that between anterior origins of pelvic and anal fins. Length of caudal peduncle 1·85 (1·78—2·00) in length of head, width, 1·15 (1·12—1·20) in its own length.

Posterior chamber of air bladder, measured in one specimen 25·0 per cent in standard length.

Coloration.—In alcohol, dark grey above, paler beneath, a broad lateral band from behind gill openings to the base of the caudal fin, a few dark spots at the bases of the last few drosal rays and a black spot at the upper angle of the gill openings.

Distribution.—Africa : Eritrea : Salamona.

Relationships.—*G. ethelywynnae* is a dwraf cognate of *G. tibanica*. The scaleless nature of its back, chest and belly, however, easily distinguish it.

(ii) The 'Rufa' complex

This is a small Complex of species whose distribution centres about Persia, Oman, Iraq, Palestine, Syria and Armenia. Their most prominent difference from the members of the *tibanica*-complex is an increased number of gill raker count, the number of outer gill rakers on the lower part of the anterior arch being 12 to 20. The colour pattern in these species is almost like that of the members of the *tibanica*-complex, but there is an increased intensity of the dark pigmentation along the mid-lateral band which is more or less visible even in large specimens. In specimens preserved in alcohol for a considerably long period and have become uniformly dark brown the lateral band is more or less discernible as a pale whitish band. The snout is more pointed or conical than in the *tibanica*-complex, the tip of it in most cases being tuberculated and marked off by a shallow transverse groove. The posterior chamber of the air bladder is extensive, but almost of the same extent as that of the members of the *tibanica*-complex.

Included in this complex are *rufa*, *r. obtusa* and *barreimiae*.

11. **Garra rufa rufa** (Heckel)

(Plate IX, Figs. 4—10)

1843. *Discognathus rufus* Heckel, Russeger's *Reisen in Europa Asien Und Afrika* **1**, p. 1071, pl. 8, fig. 2 [Type loc. : Aleppo, Syria. Type in NMV ; examined].

1864. *Discognathus rufus* Gunther, *Proc. Zool. Soc. Lond.*, London, p. 490.

1868. *Discognathus lamta* Gunther (in part), *Cat. Brit. Mus. Fish.*, London, **7**, p. 69.

1883. *Discognathus lamta*, Lortet, *Arch. Mus. Lyon*, Lyon, **3**, p. 153, pl. 16, figs. 4, 5.

1884. *Discognathus lamta*, Tristram, *Fauna and Flora of Palestine*, London, p. 172.

1893/94. *Discognathus lamta*, Barrois, *Rev. Biol. Nord. Fr.*, Lille, **6**, p. 287.

1912. *Discognathus lamta*, Aharoni, *Naturwissenchaftliche studien am Toten Meer*, Berlin, p. 434.

1913. *Discognathus lamta* var. *rufus*, Annandale, *J. Asiat. Soc. Beng.*, Calcutta, (N.S.) **9**, p. 31.

1921. *Garra rufus*, Hora, *Rec. Indian Mus.*, Calcutta, **22**, p. 681.

1923. *Garra lamta*, Pellegrin, *Poiss. Syrie*, Paris, p 15.

1926. *Discognathus rufus*, Vinciguerra, *Ann. Mus. stor. nat. Genova*, Geneva, **52**, p. 225.

1935. *Discognathus rufus*, Bodenheimer, *Animal life in Palestine*, Jerusalem, p. 417.

1937. *Discognathus lamta rufus*, Bodenheimer, *Mem. Inst. Egypt.*, Cairo, **33**, p. 268.

1937/38. *Discognathus rufus*, Tortonese, *Boll. Mus. Zool. Anat. Camp. Torino*, Turin, **46** (3), p. 325.

1951. *Discognathus rufus*, Steinitz, *Nature*, London, **167**, p. 531.

1953. *Discognathus rufus*, Steinitz, *Bull. res. Council Israel*, Jerusalem, **3** (3), p. 211.

1954. *Discognathus refus*, Steinitz, *Pub. hidrobil. res. Inst.*, Istanbul, (B) **1** (4), p. 244.

Specimens examined.—Syria : 2, 55·0 & 58·5 mm., from Alleppo ; 2, 78·5 & 65·0 mm., from Arsus ; 4, 76·0 to 83·5 mm., from Hama ; 4, 103·5 to 119·0 mm., from Antioche. Palestine : 1, 24·5 mm., from Dead Sea ; 2, 3·3 mm., from Lake Tiberias., 43, 33·0 to 120·0 mm., from Assi river ; 4, 24·0 to 114·0 mm., from Jassak ; 3, 76·5 to 98·0 mm., from Uncheschek ; 1, 47·5 mm., from Nirdavid ; 3, 27·5 to 43·5 mm., from Tabgha.

Description.—Depth of body 4·97 (4·33—5·78)) in standard length, length of head 4·59 (4·40—4·78). Width of head 1·38 (1·19—1·50) in length of head, height of head 1·62 (1·44—1·75). Pupil of eye at or slightly behind the middle of the length of head. Inter-orbital region somewhat convex. Snout somewhat pointed, usually with a shallow transverse groove at the tip, tuberculated 2·04 (1·73—2·36) in length of head, diameter of eye 4·03 (3·10—4·90), inter-orbital width 2·10 (1·95—2·40). Two pairs of barbels, shorter than diameter of the eye. 16 to 18 outer gill rakers on the lower part of the anterior arch. Mental disc is well developed with the posterior free border distinct, but great range of variation in the development of the disc is met with ; in young specimens it is wanting. Length of disc 3·68 (3·00—4·62) in length of head, width 2·04 (1·69—2·71) in width of head ; length of disc 1·31 (1·10—1·50) in its own width. 34 to 38 scales in lateral line, 3·5, 4·5 or 5·5 from the origin of dorsal to lateral line, 2·5, 3·0, 3·5 or 4·5 between this and pelvic. 11 to 13 scales on middorsal streak. Chest and belly scaly, but with scales barely overlapping. Dorsal 111, 7 ; distance between its anterior origin and tip of snout 2·22 (2·14—2·35) in standard length. Length of pectorals 0·98 (0·86—1·25) in length of head. Distance between anterior origins of pelvic and anal fins 2·06 (1·93—2·29) in that between anterior origin of pelvic and base of caudal fin. Anal 11, 5. Distance from vent to anal fin 4·57 (3·40—7·50) in that between anterior origins of pelvic and anal fins. Length of caudal peduncle 1·23 (1·07—1·42) in length of head, width 1·43 (1·30—1·67) in its own length.

Posterior chamber of air bladder, measured in 3 specimens 12·16 (9·09—15·48) per cent in standard length.

Coloration.—In alcohol, dark grey above, paler beneath, a dark broad lateral band from gill openings to the base of caudal fin where ending in a rounded spot, usually five dark spots at the bases of last five dorsal rays and a dark spot at the upper angle of the gill opening.

Distribution.—Asia. Syria and Palestine.

Relationships.—This form is most easily separated from its allied form *obtusa* by the position of the anal fin which originates at a distance nearer to the origin of the pelvic than to the caudal base (Text-fig. 8, Graph 7) and by the presence of scales on the chest and belly. There has been great confusion regarding the systematic position of this species as would be seen from the synonyms cited at the beginning. Of course, it resembles *lamta* and *tibanica* complexes of species even though they are all well separated geographically. It has been shown that they can be easily separated by the use of such characters as the colour pattern, position of vent in relation to the origins of the pelvic and anal fins, number of gill rakers on the lower part of the anterior arch, the number of scales along the lateral line and the nature of the snout. *Tibanica-rufa-lamta* complexes have all no doubt originated from an ancestral *Garra* of a primitive type which occupied the whole area from the east probably South China as far west as Africa *via* Afghanistan, Persia, Syria and Arabia during the

Pliocene (*vide*, infra, p. 251). Geological evolution of this wide area naturally disrupted the continuity and facilitated speciation amongst different isolated populations.

12. **Garra rufa obtusa** (Heckel)

1843. *Discognathus obtusus* Heckel, Russeger's *Reisen in Europa, Asien Und Afrika*, **1**, p. 1072, pl. 8, fig. 3 [Type-loc.: Tigris River, Mossul, Iraq. Type in NMW; examined].

1844. *Discognathus crenulatus* Heckel, *Russeger's Reisen in Europa, Asien Und Afrika*, **2**, p. 262 [Type-loc.: Kara Agasch, Schiraz, Iran. Type in NMV; examined].

1868. *Discognathus crenulatus*, Gunther (in part), *Cat. Brit. Mus. Fish.*, London, **7**, p. 69.

1899. *Discognathus lamta*, Nikolsky, *Ann. Mus. Zool. Ac. St. Petersb.*, St. Petersbourg, **4**, p. 411.

1913. *Garra persica* Berg, *Ann. Mus. Zool. Ac. St. Petersb.*, St. Petersbourg, **18**, p. 61, pl. 61 [Type loc.: Bampur River, Eastern Persia. Type in ZSI, examined].

1919*a*. *Discognathus persicus* Annandale, *Rec. Indian Mus.*, Calcutta, **18**, p. 72.

1950. *Garra rufus gymnothorax* Berg, *Tray. Inst. Zool. Acad. Sci. U.S.S.R.*, Leningrad, **8**, p. 792 [Type-loc.: "Tigris River"].

Specimens examined.—Iraq: 2, 100·0 & 108·5 mm., from Tigris river at Mossul., 12, 70·0 to 108·00 mm., from Dialah river near Baghdad., 6, 30·0 to 58·0 mm., from Baled Sinjar, Mesopotamia; 6, 37·0 to 51.0 mm., from Baghdad; 3, 92·5 to 112.00 mm., from Haso, Kurdistan. Armenia; 2, 101·5 to 105·0 mm., from Batschkaja. Persia: 3, 39·0 to 48·0 mm., from Bampur river E. Persia; 1, 84·5 mm., from Kara Agatsch, Schiraz.

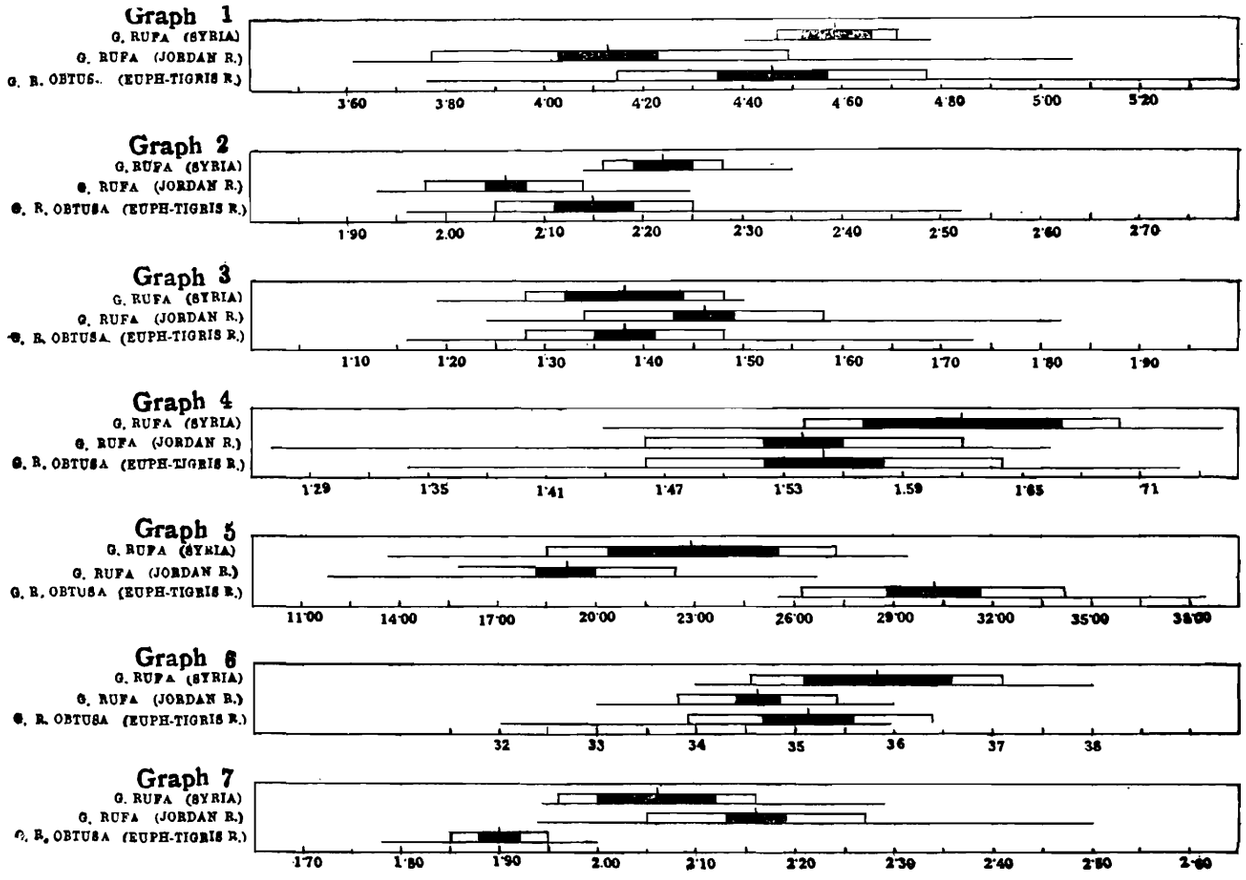
Description.—Depth of body 4·61 (4·25—5·21) in standard length, length of head 4·46 (3·76—5·39). Width of head 1·38 (1·16—1.73) in length of head, height of head 1·55 (1·34—1·73). Pupil of eye at or slightly in front of the middle of the length of head. Inter-orbital region somewhat convex. Snout somewhat pointed, usually with a shallow transverse groove at the tip, tuberculated, 1·93 (1·75—2·37) in length of head, diameter of eye 4·14 (3·14—5·00), inter-orbital width 2·23 (2·00—2·64). Two pairs of barbels, shorter than the diameter of the eye. 16 to 20 outer gill rakers on the lower part of the anterior arch. Mental disc is well developed with the posterior free border distinct, great range of variations in the development of the disc is met with; in young specimens it is wanting. Length of disc 3·41 (2·78—4·00) in length of head, width 1·85 (1·47—2·20) in width of head; length of disc 1·33 (1·10—1·70) in its own width. 32 to 36 scales in lateral line, 4·0, 4·5 or 5·0 from the origin dorsal to lateral line, 3·5, 4·0 or 4·5 between this and pelvic. 9 to 12 scales on middorsal streak. Chest naked to pectoral or sometimes even behind it, belly scaled. Dorsal III 7; distance between the anterior origin of dorsal fin and tip of snout 2·15 (1·96—2·52) in standard length. Length of pectorals 1·01 (0·89—1·13) in length of head. Distance between anterior origins of pelvic and anal fins 1·90 (1·78—2·00) in that between anterior origin of pelvic and base of caudal fin. Anal II, 5. Distance from vent to anal fin 3·37 (2·60—4·25) in that between anterior origins of pelvic and anal fins. Length of caudal peduncle 1·36 (1·09—1·91) in length of head, width 1·33 (1·10—1·63) in its own length.

Posterior chamber of air bladder, measured in 8 specimens 7·29 (2·88—10·45) per cent in standard length.

Coloration.—In alcohol, dark grey above, paler beneath, a dark lateral band from gill opening to the base of caudal fin with usually five dark spots at the bases of last five dorsal rays and a dark spot at the upper angle of the gill opening.

Distribution.—Asia:—Persia, Iraq, and Armenia.

Relationships.—This form can be readily separated from the typical *rufus* by the position of the anal fin which originates at a distance equidistant between the origins of the pelvic and the base of the caudal fins (Text-fig. 8, Graph 7).



TEXT-FIG. 8.—Subspecies of *Garra rufa*.

Graph 1. Length of head in standard length. Graph 2. Distance between snout and dorsal fin in standard length. Graph 3. Width of head in length of head. Graph 4. Height of head in length of head. Graph 5. Distance between pelvic and anal fin into distance from vent to anal fin in percents. Graph 6. Lateral line scales. Graph 7. Distance between pelvic and anal fins in distance between Pelvic and base of caudal.

13. **Garra barreimiae** Fowler & Steinitz

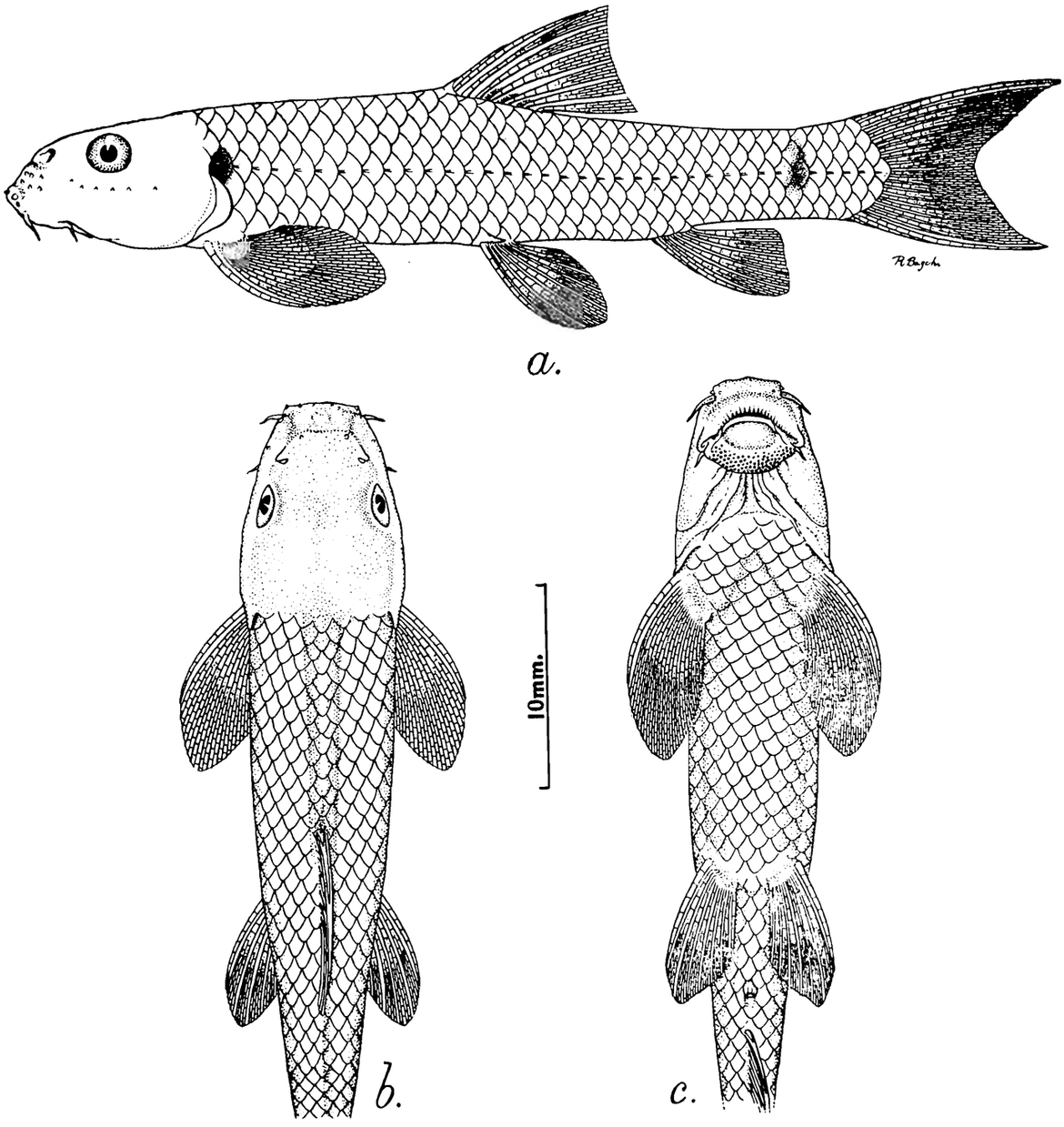
1956. *Garra barreimiae* Fowler and Steinitz, *Bull. Res. Counc.* Israel, Jerusalem, 5B (3 & 4), p. 262 [Type-loc.: Barreimi, Oman. Type in ANSP].

Specimens examined.—Arabia :—4, 29·0 to 49·0 mm., from Oman.

Description.—Depth of body 5·25 (4·83—5·53) in standard length, length of head 3·79 (3·62—3·92). Width of head 1·44 (1·39—1·47) in length of head, height of head 1·59 (1·56—1·61). Pupil of eye at or in front of the middle of the length of head. Inter-orbital region somewhat convex. Snout pointed, with a shallow groove at the tip, tuburculated, 2·17 (2·08—2·28) in length of head, diameter of eye 4·20 (3·80—4·80), inter-orbital width 2·49 (2·37—2·67). Two pairs of barbels, shorter than the diameter of eye. 12 to 14 outer gill rakers on the lower part of the anterior arch. Length of disc 3·65 (3·12—4·00) in length of head, width 1·87 (1·67—2·17) in width of head, length of disc 1·30 (1·20—1·50) in its own width. 33 to 34 scales in lateral line, 4·5 from the origin of dorsal to lateral line, 3·0 or 3·5 between this and pelvic. 12 scales on middorsal streak. Chest naked to pectoral, belly scald. Dorsal III, 6 ; distance between its anterior origin and tip of snout 1·99 (1·97—2·04) in length of head. Distance between anterior origins of pelvic and anal fins 1·97 (1·84—2·11) in that between anterior origin of pelvic and base of caudal fin. Anal III, 5. Dis-

tance from vent to anal fin 5·00 (4·50—6·00) in that between anterior origins of pelvic and anal fins. Length of caudal peduncle 1·68 (1·40—2·00) in length of head, width 1·31 (1·14—1·67) in its own length.

Posterior chamber of air bladder, measured in 4 specimens 20·19 (19·18—20·69) per cent in standard length.



TEXT-FIG. 9.—*Garra barreimiae* Fowler & Steinitz.

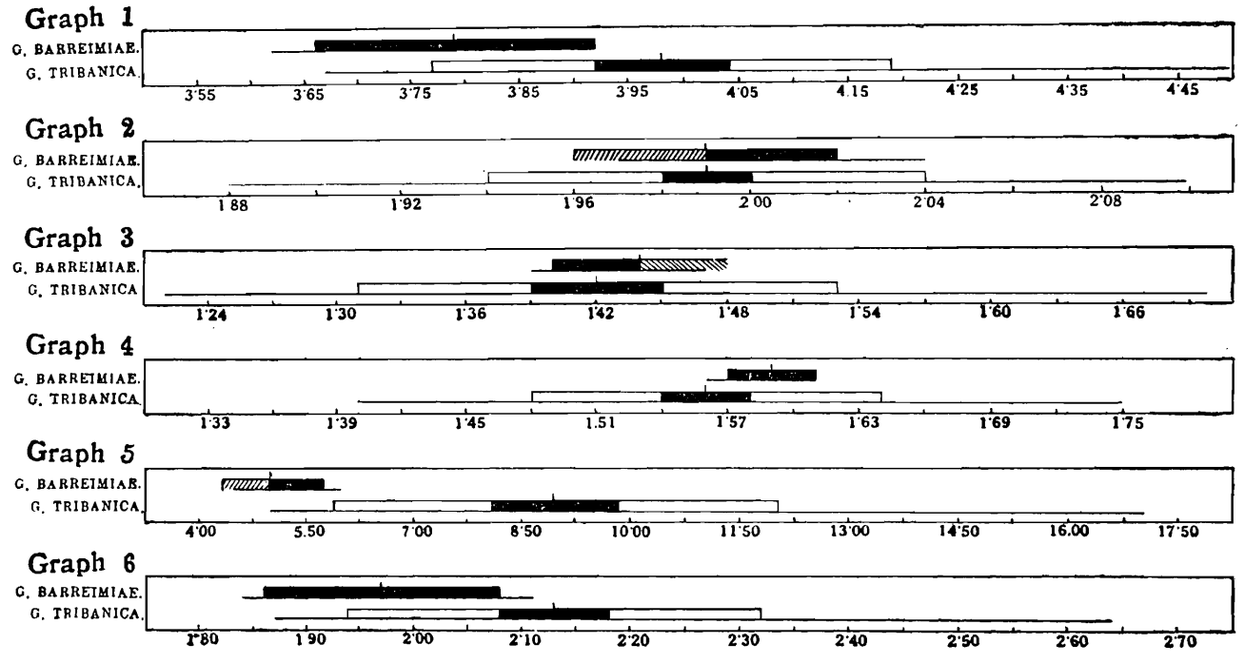
(*a*) Lateral view of a syntype from Barreimi, Oman. (*b*) Dorsal view of *a*. (*c*) Ventral view of *a*.

Colouration.—The material appears to have been obtained many years ago and hence the body markings have faded away ; a series of three dark spots at bases of the 3rd to 5th dorsal rays and a dark spot at the upper angle of the gill opening can however be still seen.

Distribution.—Asia : Arabia :—Oman.

Relationships.—This species is closely related to *G. rufus* but can be readily separated from it by the more elongated nature of the body and a relatively shorter head. From

G. tibanica, the other known Arabian species, it can be easily distinguished by its more anteriorly placed position of the vent (Text-fig. 10, Graph 5).



TEXT-FIG. 10.—*Garra barreimiae* compared with *G. tibanica*.

Graph 1. Length of head in standard length. Graph 2. Distance between snout and dorsal fin in standard length. Graph 3. Width of head in length of head. Graph 4. Height of head in length of head. Graph 5. Distance from vent to anal fin in distance between pelvic and anal fins. Graph 6. Distance between pelvic and anal fins in distance between pelvic and base of caudal.

Remarks.—The material was supplied to me by Mr. Henry W. Fowler of the Academy of Natural Sciences of Philadelphia, Philadelphia who received it from Professor H. Steinitz of the Hebrew University, Palestine.

(iii) THE 'LAMTA' COMPLEX.

Included in this assemblage are *lamta*, *mullya*, *ceylonensis ceylonensis*, *c. phillipsi* and *annandalei*. Of these, *lamta*, *mullya*, *c. ceylonensis* and *c. phillipsi* from a basically natural assemblage and *annandalei* is here included for reasons of convenience. They are characterised by a smaller number of scales along the lateral line than in the case of the members of the previous complexes. Excepting *annandalei*, they are further characterised by the tip of the snout being marked off by a deep transverse groove, the transverse lobe at the tip and the sides of snout in front of nostrils being covered by horny tubercles arranged in bilaterally symmetrical patches. The characteristic colour pattern consists of a dark mid-lateral band bordered above and below by incomplete dark narrow lateral stripes, especially in the posterior half of the body. The row of dark spots at the base of the branched rays found in the case of the members of the previous complexes is conspicuously absent in the members of this complex. The length of the posteror chamber of the air bladder is considerably reduced.

G. annandalei is very much like *G. lamta* in general appearance but it lacks the characteristic longitudinal stripes. It is further distinguished by the absence of the transverse groove at the tip of the snout and the tubercles.

The *lamta* complex has a centre of distribution in India including Ceylon.

14. **Garra lamta** Ham.

(Plate X, Figs. 2-6)

1822. *Cyprinus (Garra) lamta* Hamilton (in part). *Fish Ganges*, Edinburg, pp. 344, 393 [Type-loc. : Tinau River, tributory of the Rapti River, at Butwal (Nepal), 21 miles north of Nautanwa in Gorakhpur District, U.P., India].

1868. *Discognathus lamta*, Gunther (in part), *Cat. Brit. Mus. Fish.*, London, 7, p. 69.

1878. *Discognathus lamta*, Day (in part), *Fish India*, London, 3, p. 527, pl. 122, fig. 4 ; pl. **123**, fig. 1.

1889. *Discognathus lamta*, Day (in part), *Faun. Brit. Ind. Fish.*, London, **1**, p. 246.

1921. *Garra prashadi* Hora, *Rec. Indian Mus.*, Calcutta, **22**, p. 669, pl. 24, fig. 3 [Type-loc : Malwa Tal, U. P. Type in ZSI ; examined].

1937*a*. *Garra prashadi* Hora, *Rec. Indian Mus.*, Calcutta, **39**, p. 399.

1949. *Garra prashadi*, Menon, *J. Bombay nat. Hist. Soc.*, Bombay, **48** (3), p. 541.

1950*b*. *Garra mullya*, Menon, *Rec. Indian Mus.*, Calcutta, **47**, p. 233.

1954. *Garra lamta*, Menon, *Proc. nat. Inst. Sci. India*, New Delhi, **22** (4), p. 480.

Specimens examined.—Nepal :—109, 30·0 to 95·0 mm., from Butwal, 76, 36·0 to 71·0 mm., from Bhaluri., 105, 25·0 to 63·0 mm., from Kerwani., 92, 24·5 to 47·6 mm., from Nepalganj ; 5, 45·5 to 77·5 mm., from Kosi river at Barahakshetra ; 1, 67·5 mm., from chhatra. Sikkim : 18, 18·5 to 67·0 mm., from Manjhitar ; 1, 36·0 mm., from Rongin Chu, Martani. India : 85, 35·0 to 133·5 mm., from Tista drainage in Darjeeling District, 7, 49·5 to 68·0 mm., from Nainital ; 86, 38·5 to 66·0 mm., from Almorha.

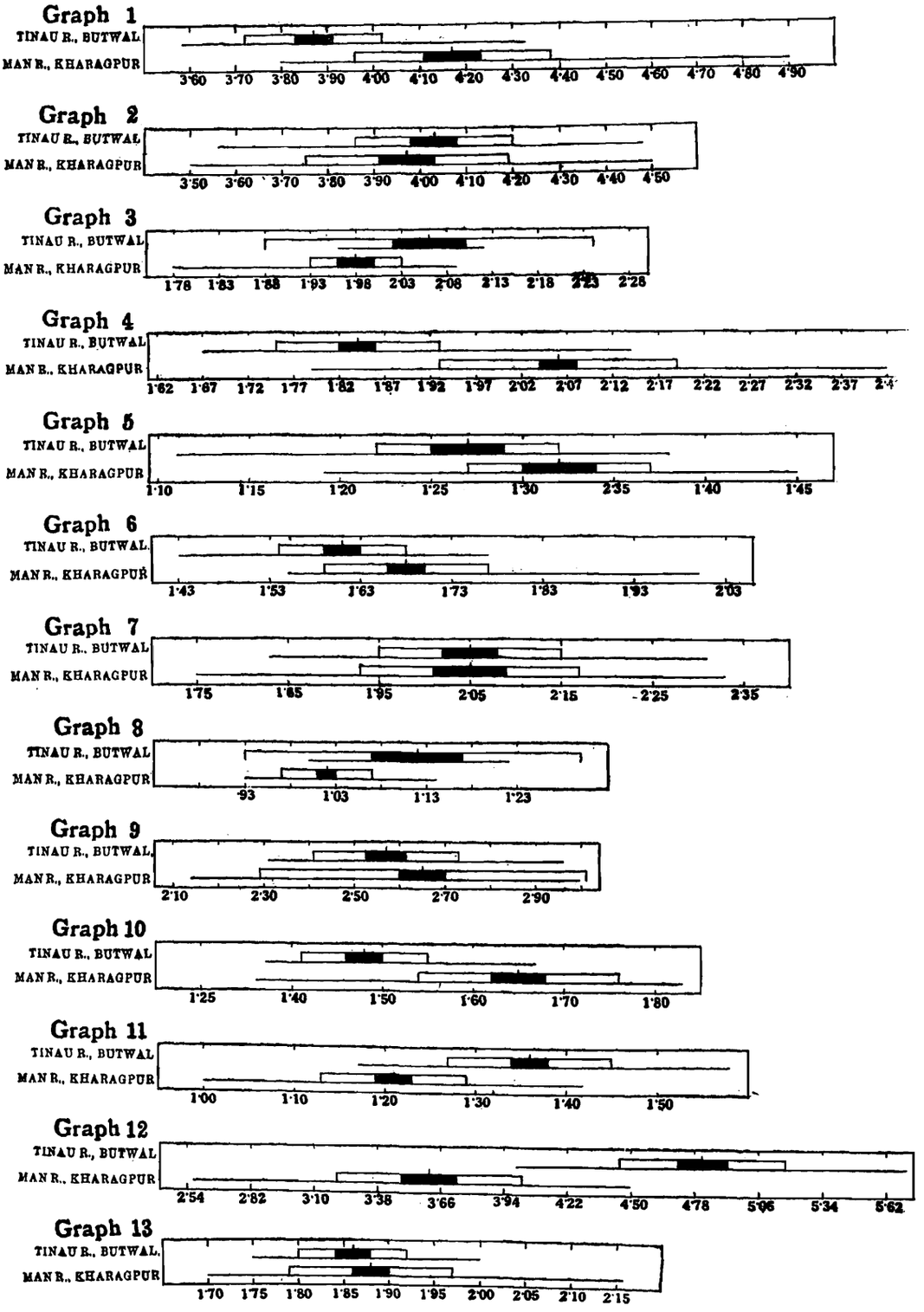
Description.—Depth of body 4·03 (3·56—4·48) in standard length, length of head 3·87-(3·58—4·33). Width of head 1·27 (1·11—1·38) in length of head, height of head 1·61 (1·43—1·77). Pupil of eye at or slightly behind the middle of the length of head. Inter-orbital region somewhat convex. Snout 1·84 (1·67—2·00) in length of head, diameter of eye 4·5 (3·71—5·33), inter-orbital width 2·06 (1·83—2·31). Two pairs of barbels, the rostral pair as long as slightly shorter than diameter of eye ; maxillary pair shorter than rostral. Snout rounded, smooth, the tip marked off by a deep transverse groove ; the tansverse lobe at the tip, and the sides of snout in front of nostrils covered by horny tubercles arranged in bilaterally symmetrical patches. 9 to 14 outer gill rakers on the lower part of the anterior arch. Length of disc 2·57 (2·31—3·00) in length of head, width 1·48 (1·32—1·67) in width of head ; length of disc 1·36 (1·17—1·58) in its own width. 31 to 34 scales in lateral line 3·5 or 4 between this and pelvic. 8 to 10 scales on middorsal streak. Chest and bellys scaled, but scales on chest much reduced. Dorsal III, 7-8 ; distance between its anterior origin and tip of snout 2·06 (1·96—2·12) in standard length. Length of pectorals 1·12 (1.00—1·22) in length of head. Distance between anterior origin of pelvic and anal fins 1·87 (1·75—2·00) in that between anterior origins of pelvic and base of caudal fin. Anal II,5. Distance from vent to anal fin 4·81 (4·00—5·67) in that between anteior origins of pelvic and anal fins. Length of caudal peduncle 1·72 (1·36—2·13) in length of head, width 1·16 (1·05—1·31) in its own length.

Posterior chamber of air bladder, measured in 50 specimens 16·36 (7·51—25·21) per cent of standard length.

Coloration.—In alcohol, dark grey above, paler beneath, a broad lateral band from gill openings to caudal base bordered above and below by incomplete dark narrow lateral stripes, especially in the posterior half of body, a black spot on the upper angle of the gill openings and a black blotch at the caudal base.

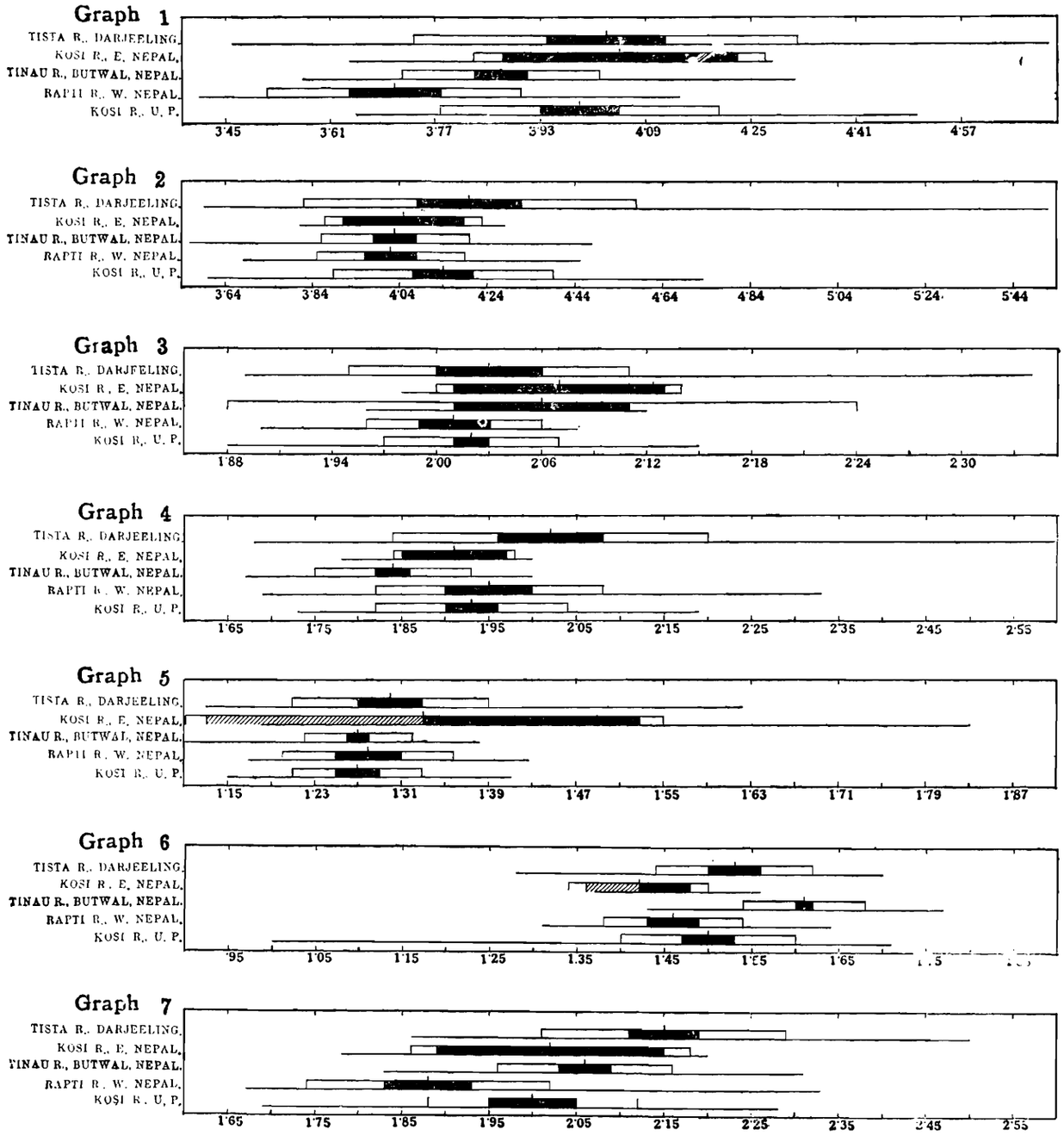
Distribution.—Asia : India :—Darjeeling and Kumaon Himalayas, Eastern Nepal and Sikkim.

Relationships.—It has been pointed out in the beginning that a great deal of confusion centred round the systematics of this species. Since Hamilton's description of the species in his "An Account of the Fishes of the Ganges" was inadequate, specimens from almost in the whole range of the genus have been by various authors referred to this species. It is shown here that this species can be separated from other members of this genus through the several differences listed in the key.



TEXT-FIG. 11.—*Garra lamta* from the Tinau river (Rapti drainage) compared with *G. mullya* from the Man river in Kharagpur Hills, Bihar.

Graph 1. Length of head in standard length. Graph 2. Depth of body in standard length. **Graph 3.** Distance between snout and dorsal fin in standard length. Graph 4. Length of snout in length of head Graph 5. Width of head in length of head. Graph 6. Height of head in length of head. **Graph 7. Inter**orbital width in length of head. Graph 8. Length of pectoral in length of head. Graph 9. **Length of disc** in length of head. Graph 10. Width of disc in width of head. Graph 11. Length of disc in **width of disc.** Graph 12. Distance from vent to anal fin in distance between pelvic and anal fins. **Graph 13. Distance** between pelivic and anal fins in distance between pelvic and base of caud**al.**

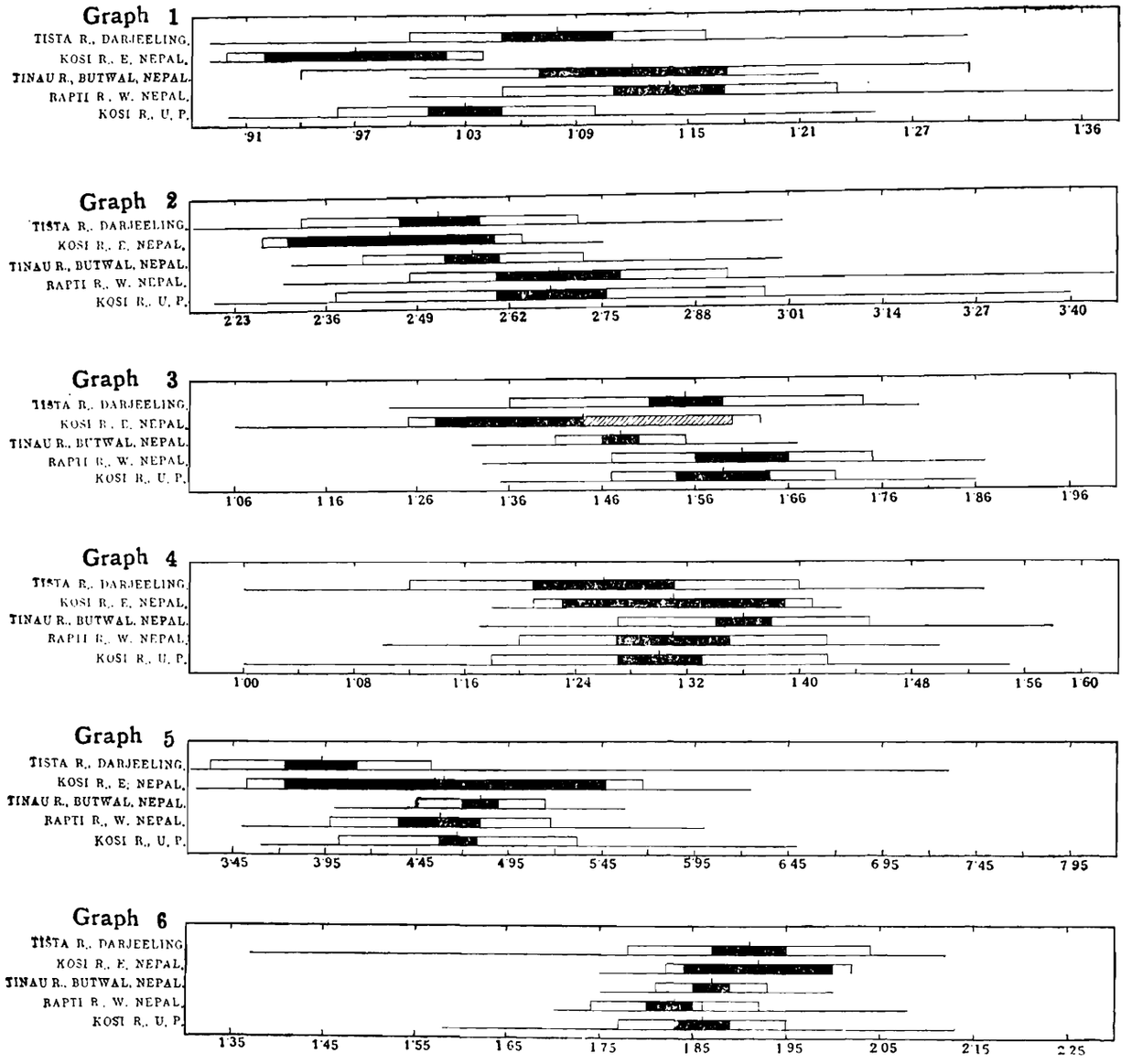


TEXT-FIG. 12.—Variations in different populations of *Garra lamta* from the various Himalayan drainages.

Graph 1. Length of head in standard length. Graph 2. Depth of body in standard length. Graph 3. Distance between snout and dorsal fin in standard length. Graph 4. Length of snout in length of head. Graph 5. Width of head in length of head. Graph 6. Height of head in length of head. Graph 7. Inter-orbital width in length of head.

This species is most closely related to *G. mullya*, a form now confined to Peninsular India. The two can, however, be easily separated by the relative position of their vents in relation to the origins of the pelvic and anal fins (Text-fig. 11, Graph 12) ; they seem to have evolved in the Himalayan streams on the one hand and in the Peninsula of the other from

a common ancestral form. The range of variations of the different populations of the species from the different drainages is not of any taxonomic significance (Text-figs. 12, & 13).



TEXT-FIG. 13.—Variations in different populations of *Garra lamta* from the various Himalayan drainages (continued).

Graph 1. Length of pectoral in length of head. Graph 2. Length of disc in length of head. Graph 3. Width of disc in width of head. Graph 4. Length of disc in width of disc. Graph 5. Distance from vent to anal fin in distance between pelvic and anal fins. Graph 6. Distance between pelvic and anal fins in distance between pelvic and base of caudal.

15. **Garra mullya** (Sykes).

(Plate X, Figs. 1, 7-8).

1822. *Cyprinus (Garra) lamta* Hamilton (in part), *Fish Ganges*, Edinburg, pp. 343, 393.

1841. *Chondrostoma mullya* Sykes, *Trans. Zool. Soc. Lond.*, London, **2,** p. 359, pl. 62, fig. 3 [Type-loc. : "The Beema river at Dounde"].

1844. *Discognathus fusiformis* Heckel, in Hugel's *Fishes Kashmir*, p. 387. [Type-loc. : Bombay]. (*Original not seen*).

1848. *Gonorhynchus gotyla* Jerdon, *Madras Journ. Lit. Sci.*, Madras, **15,** p. 309 (Type-loc. : "Bhowany river at the foot of the Nilgherries, and also in the Manantoddy river, both tributaries of the Cauvery"].

1865. *Garra malabarica* Day, *Proc. Zool. Soc. Lond.*, London, p. 297 [Type loc. : "Kurriavanoor river" Malabar. Type in BMJ.

1865. *Garra malabarica* Day, *Fish Malabar*, London, p. 205, pl. 15, fig. 1.

1867*a*. *Garra alta* Day, *Proc. Zool. Soc. Lond.*, London, p. 349 (Type-loc. : Wynaad Hills, Western Ghats, S. India].

1868. *Discognathus lamta*, Gunther (in part), *Cat. Brit. Mus. Fish.*, London, **7**, p. 69.

1878. *Discognathus lamta*, Day (in part), *Fish India*, London, **2**, p. 527, pl. 122, fig. 4. & 113 fig. 1.

1889. *Discognathus lamta*, Day (in part), *Faun. Brit. Ind. Fish.*, London, **1**, p. 246.

1910. *Garra lamta*, Jenkins, *Rec. Indian Mus.*, Calcutta, **5**, p. 128.

1919. *Discognathus lamta*, Annandale, *Rec. Indian Mus.*, Calcutta, **16**, p. 131, fig. **1** ; pl. **2**, figs. 1, 1*a*.

1919. *Discognathus jedoni*, Annandale, *Rec. Indian Mus.*, Calcutta, **16**, p. 132.

1919. *Discognathus nasutus*, Annandale, *Rec. Indian Mus.*, Calcutta, **16**, p. 132, pl. 2, figs. 2, 2*a*.

1919. *Discognathus lamta*, Annandale, *Rec. Indian Mus.*, Calcutta, **18**, p. 72.

1919*a*. *Discognathus jerdoni*, Annandale, (in part), *Rec. Indian Mus.*, Calcutta, **18**, p. 73, pl. 9, fig. 1 ; pl. xi, fig. 3.

1920. *Discognathus lamta*, Rao, *Ann. Mag. Nat. Hist.*, London, (9) **6**, p. 49.

1920. *Garra jerdonia*, Rao (in part), *Ann. Mag. Nat. Hist.*, London, (9) **6**, p. 53.

1920. *Garra jerdonia* var. *brevimentalia* Rao, *Ann. Mag. Nat. Hist.*, London, (9) **6**, p. 54, pl. I, figs. 1*a*, 1*b* (Type-loc. : "Harangi River (Madapur, Coorg)" ; Type in BM].

1921. *Garra mullya*, Hora, *Rec. Indian Mus.*, Calcutta, **22**, p. 658.

1921. *Garra lamta*, Hora, *Rec. Indian Mus.*, Calcutta, **22**, p. 660, pl. 24, figs. 2, 2*a*.

1921. *Garra jenkinsonianum* Hora, *Rec. Indian Mus.*, Calcutta, **22**, p. 673, pl. 25, fig. 1 [Type-loc. : Sita Nullah, Parasnath Hills, Bihar. Type in ZSI ; examined].

1936. *Garra mullya*, D'Abrue, *Rec. Nagpur Mus.*, Nagpur, **9**, p. 27.

1937*b*. *Garra lamta*, Hora, *Rec. Indian Mus.*, Calcutta, **39**, p. 344, figs. 9 & 10.

1938*a*. *Garra mullya*, Hora, *Rec. Indian Mus.*, Calcutta, **40**, pp. 237, 239.

1939. *Garra mullya*, Das, *Rec. Indian. Mus.*, Calcutta, **42**, p. 444.

1941. *Garra mullya*, Hora, *Rec. Indian. Mus.*, Calcutta, **42**, p. 370.

1942. *Garra mullya*, Hora and Law, *Rec. Indian Mus.*, Calcutta, **43**, p. 248.

1942. *Garra mullya*, Hora and Nair, *Rec. Indian Mus.*, Calcutta, **43**, p. 369.

1942. *Garra mullya*, Hora, *Rec. Indian Mus.*, Calcutta, **44**, p. 196.

1942. *Garra mullya*, Fraser, *J. Bombay nat. Hist. Soc.*, Bombay, **52** (1), p. 79.

1942. *Garra mullya*, Hora and Misra, *J. Bombay nat. Hist. Soc.*, Bombay, **43**, p. 220.

1942. *Garra mullya*, Bhimachar, *Fisheries Bull. Dept. Agri. Mysore*, Bangalore, **1**, p. 38.

1947. *Garra mullya*, Chauhan, *Rec. Indian Mus.*, Calcutta, **45**, p. 274.

1949. *Garra mullya*, Hora, *J. Zool. Soc. India*, Calcutta, **1** (1), pp. 2, 3.

1950*c*. *Garra lamta*, Menon, *Rec. Indian Mus.*, Calcutta, **48**, pp. 71, 72.

1951. *Garra mullya*, Silas, *J. Bombay nat. Hist. Soc.*, Bombay, **49**, p. 474.

1951. *Garra mullya*, Silas, *J. Bombay nat. Hist. Soc.*, Bombay, **50**, p. 470.

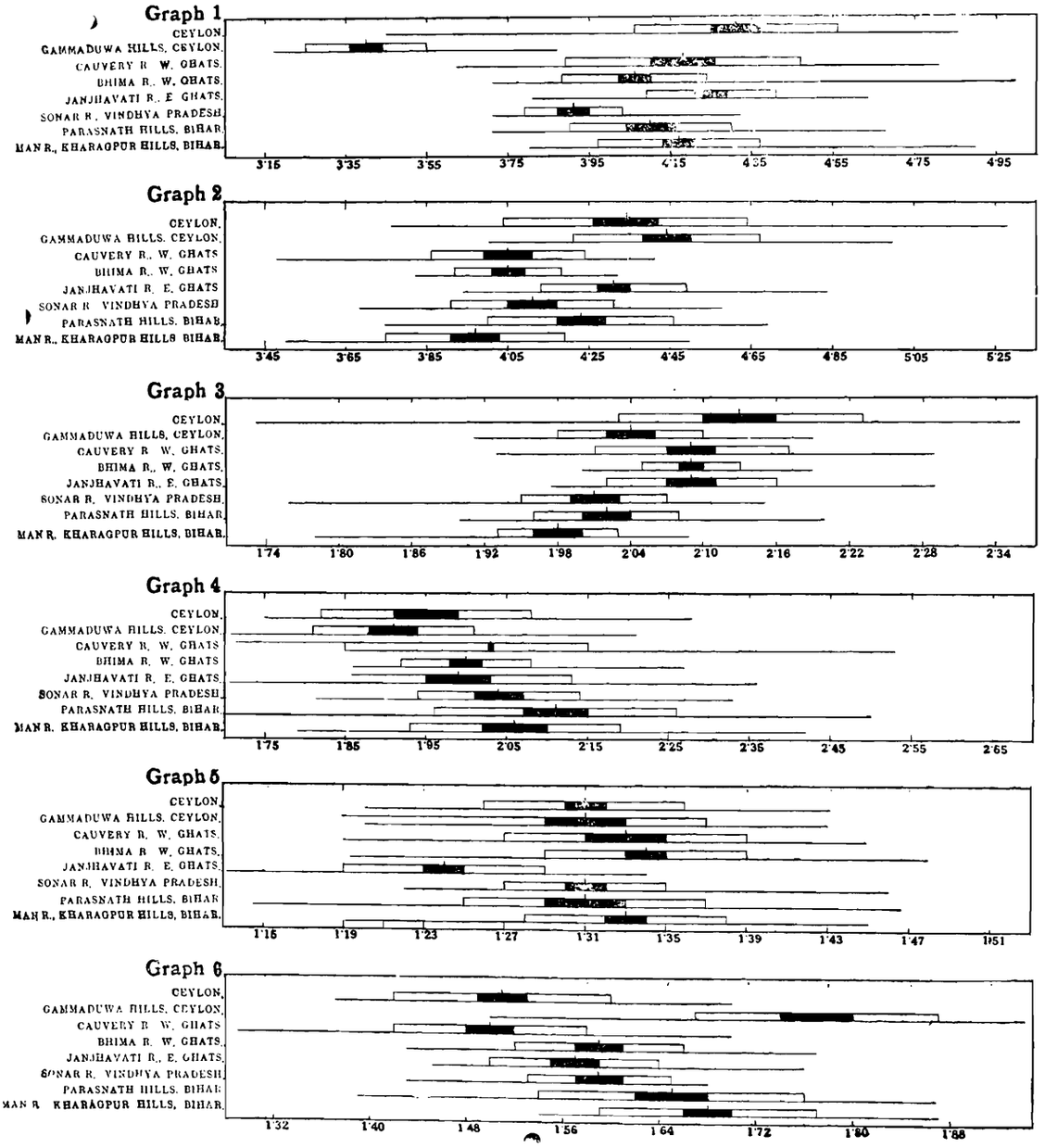
1951. *Garra mullya*, Menon, *Proc. nat. Inst. Sci. India*, New Delhi, **17** (6), p. 484.

1955. *Garra mullya*, Rajan, *J. Bombay nat. Hist. Soc.*, Bombay, **53** (1), p. 45.

Specimens examined.—326, 28·5 to 168·00 mm., from Bombay State, 66, 57·0 to 116·5 mm., Mysore ; 142, 36·5 to 140·0 mm., from Western ghats, Madras and Kerala States, 853, upto 122·5 mm., from Eastern ghats, Orissa State ; 72, 35·0 to 83·5 mm., from Madhya Pradesh ; 335, 33·5 to 88·5 mm., from Uttar Pradesh ; 11, upto 42·5 mm., from Rajasthan ; 13, 46·0 to 75·5 mm., West Bengal and 223, 18·0 to 113·5 mm., from Bihar.

Description.—Depth of body 4·05 (3·82—4·32) in standard length, length of head 4·06 (3·71—5·00). Width of head 1·34 (1·24—1·48) in length of head, height of head 1·59 (—1·43—1·77). Pupil of eye at or in front of the middle of the length of head. Inter-orbital region somewhat convex. Snout rounded, smooth, with the tip marked off by a deep transverse groove ; the transverse lobe at the tip and the sides of snout in front of nostrils are covered by horny tubercles, arranged in bilaterally symmetrical patches 2·00 (1·86—2·27) in length

of head, diameter of eye 4·36 (3·75—5·12), inter-orbital width 2·05 (1·80—2·27). Two pairs of barbels, the rostral pair as long as or slightly shorter than diameter of eye, maxillary pair shorter than rostral. 9 to 10 outer gill rakers on the lower part of the anterior arch. Length of disc 2·97 (2·93—3·90) in length of head, width 1·87 (1·53—2·17) in width of head ; length of disc 1·19 (1·00—1·40) in its own width. 32 to 34 scales in lateral line, 4·5 from the origin of dorsal to lateral line, 3·5 between this and pelvic. 9 to 11 scales on middorsal streak. Chest and belly scaled, but scales on chest very reduced. Dorsal III, 7-8 ; distance between its anterior origin and tip of snout 2·09 (2·00—2·19) in standard length. Length of pectorals 1·13 (1·05—1·27) in length of head. Distance between anterior origins of pelvic and anal



TEXT-FIG. 14.—*Garra mullya* from the different drainages in the peninsula of India compared with *G. ceylonensi* and *G. c. phillipsis* from Ceylon.

Graph 1. Length of head in standard length. Graph 2. Depth of body in standard length. Graph 3. Distance between snout and dorsal fin in standard length. Graph 4. Length of snout in length of head. Graph 5. Width of head in length of head. Graph 6. Height of head in length of head.

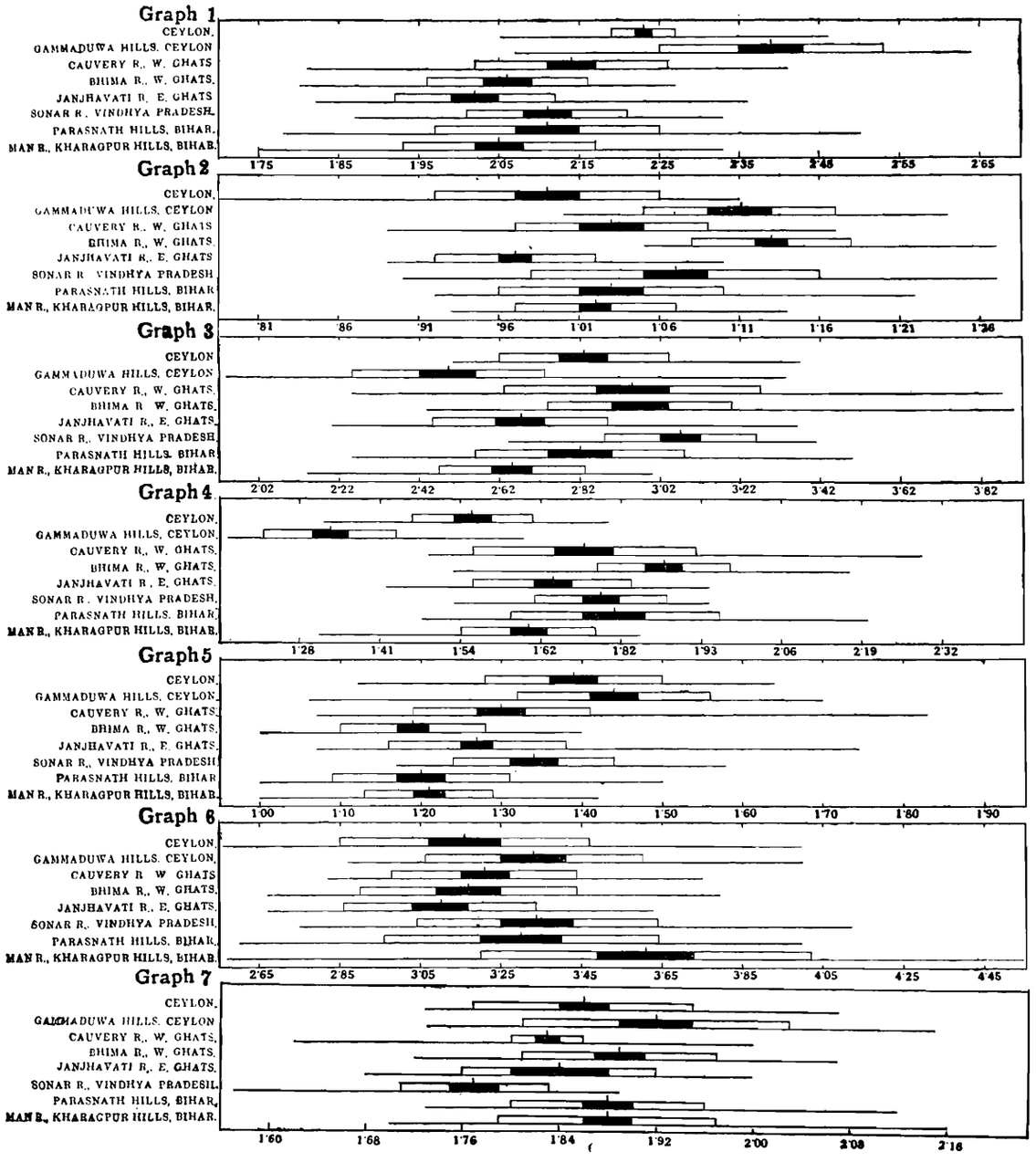
fins 1·89 (1·72—2·07) in that between anterior origin of pelvic and base of caudal fin. Anal 1-11, 5. Distance from vent to anal fin 3·17 (2·67—3·80) in that between anterior origins

of pelvic and anal fins. Length of caudal peduncle 1·51 (1·28—1·79) in length of head, width 1·24 (1·05—1·40) in its own length.

Posterior chamber of air bladder, measured in 50 specimens 21·36 (16·13—29·03) per cent in standard length.

Coloration.—In alcohol, dark grey above, paler beneath, a broad lateral band from gill openings to base of caudal fin bordered above and below by incomplete dark narrow lateral stripes especially in the posterior half of the body ; a black spot on the upper angle of the gill openings and a black blotch at the caudal base.

Distribution.—Asia : India :—Throughout India except Assam and the Himalayas.



TEXT-FIG. 15.—*Garra mullya* from the different drainages in the peninsula of India compared with *G. ceylonensis* and *G. c. phillipsi* from Ceylon.

Graph 1. Inter-orbital width in length of head. Graph 2. Length of pectoral in length of head. Graph 3. Length of disc in length of head. Graph 4. Width of disc in width of head. Graph 5. Length of disc in width of disc. Graph 6. Distance from snout to anal fin in distance between pelvic and anal fins. Graph 7. Distance between pelvic and anal fins in distance between pelvic and base of caudal.

Relationships.—*Garra mullya* is the most widely distributed species of the genus in the Peninsula ; this species is most closely related to *G. lamta* (*vide*, Text-fig. 11) and *G. c. ceylonensis*.

16. **Garra ceylonensis ceylonensis** Bleeker

(Plate X, Figs. 9-11)

1863. *Garra ceylonensis* Bleeker, *Versl. gewone Vergad. Akad. Amst.*, Amsterdam, **15,** p. 239 [Type loc. : Ceylon].

1868. *Discognathus lamta*, Gunther (in part), *Cat. Brit. Mus. Fish.*, London, **7,** p. 69.

1878. *Discognathus lamta*, Day (in part), *Fish India*, London, **2,** p. 527, pl. 122, fig. 4 ; 123, fig. 1.

1889. *Discognathus lamta*, Day (in part), *Faun. Brit. Ind. Fish.*, London, **1,** p. 246.

1930. *Garra ceylonensis*, Deraniyagala, *Spolia Zeylanica*, Colombo, **16,** pp. 26, 28, pls. 1, 5.

1952. *Garra ceylonensis ceylonensis*, Deraniyagala, *Atlas of Vertebrates from Ceylon*, Colombo, **1,** p. 36, pl. 8.

Specimens examined.—Ceylon :—54, 58·0 to 122·0 mm., from C. P., 1, 40·0 mm., from N. C. P., 2, 88·0 mm. each, U. P., 3, 86·0 to 97·5 mm., Sab. P.

Description.—Depth of body 4·34 (3·76—5·28) in standard length, length of head 4·31 (3·45—4·86). Width of head 1·31 (1·20—1·45) in length of head, height of head 1·51 (1·37—1·70). Pupil of eye at or slightly in front of the middle of the length of head. Inter-orbital region somewhat convex. Snout rounded, smooth with the tip marked off by a deep transverse groove. The transverse lobe at the tip and the sides of snout in front of nostrils are covered by horny tubercles arranged in bilaterally symmetrical patches. 1·95 (1·75—2·28) in length of head, diameter of eye 4·36 (3·44—6·50), inter-orbital width 2·23 (2·05—2·46). Brabels two pairs, the rostral pair as long as or slightly shorter than diameter of eye, the maxillary pair shorter than the rostral. 8 to 10 outer gill rakers on the lower part of the anterior arch. Length of disc 2·83 (2·50—3·37) in length of head, width 1·56 (1·32—1·78) in width of head ; length of disc 1·39 (1·12—1·64) in its own width. 32 to 34 scales in lateral line, 4·5 from the origin of dorsal to lateral line, 3·0 or 3·5 between this and pelvic. 9 to 11 scales on middorsal streak. Chest and belly scaly, but scales on chest much reduced. Dorsal III, 8-9 ; distance between its anterior origin and tip of snout 2·13 (1·72—2·36) in standard length. Length of pectorals 0·99 (0·79—1·11) in length of head. Distance between anterior origins of pelvic and anal fins 1·86 (1·73—2·07) in that between anterior origin of pelvic and base of caudal fin. Anal II, 5. Distance from vent to anal fin 3·16 (2·55—4·00) in that between anterior origins of pelvic and anal fins. Length of caudal peduncle 1·41 (1·10—1·75) in length of head, width 1·30 (1·10—1·52) in its own length.

Posterior chamber of air bladder, measured in 50 specimens 11·43 (5·42—23·89) per cent in standard length.

Coloration.—In alcohol, dark grey above, paler beneath, a broad lateral band from gill openings to caudal base bordered above and below by incomplete dark narrow lateral stripes especially in the posterior half of body and a black spot on the upper angle of the gill openings and a black blotch at the caudal base.

Distribution.—Asia : Ceylon.

Relationships.—This form is most closely related to *G. mullya* of the Peninsula of India ; it has, however, been considered distinct from the mainland form, mainly from a geographical point of view (Text-figs. 14 & 15).

17. **Garra ceylonensis phillipsi** Deraniyagala

(Plate XI, Figs. 1-3)

1933. *Garra ceylonensis phillipsi* Deraniyagala, *Spolia Zeylanica*, Colombo, **17,** p. 228 [Type-loc. : Gammaduwa, C. P., Ceylon. Type in BM, holotype ; ZSI, paratype, examined].

1952. *Garra ceylonensis phillipsi* Deraniyagala, *Atlas of Vertebrates from Ceylon*, Colombo, **1**, p. 40, fig. 19.

Specimens examined.—Ceylon : 60, 44·0 to 75·5 mm., from Gammaduwa, C. P.

Description.—Depth of body 4·44 (4·00-5·00) in standard length, length of head 3·40 (3·17-3·87). Width of head 1·31 (1·20-1·43) in length of head, height of head 1·77 (1·50-1·94). Pupil of eye at or slightly behind the middle of the length of head. Inter-orbital region somewhat convex. Snout rounded, smooth, the tip marked off by a deep transverse groove, horny tubercles on the transverse lobe at the tip and on the sides of snout in front of nostrils arranged in bilaterally symmetrical patches ; 1·91 (1·70-2·21) in length of head, diameter of eye 4·66 (3·71-6·20), inter-orbital width 2·39 (2·07-2·64). Two pairs of barbels, shorter than diameter of eye. 9 to 10 outer gill rakers on the lower part of the anterior arch. Length of disc 2·49 (1·94-3·33) in length of head, width 1·33 (1·16-1·64) in width of head ; length of disc 1·44 (1·06-1·70) in its own width. 32 to 34 scales in lateral line, 4·5 from the origin of dorsal to lateral line, 2·5, 3·0 or 3·5 between this and pelvic. 9 to 11 scales on middorsal streak. Chest and belly scaled, but the scales on chest very reduced. Dorsal III, 8-9 ; distance between its anterior origin and tip of snout 2·04 (1·91-2·19) in standard length. Length of pectorals 1·11 (1·00-1·24) in length of head. Distance between anterior origins of pelvic and anal fins 1·92 (1·73-2·15) in that between anterior origin of pelvic and base of caudal fin. Anal 11, 5. Distance from vent to anal fin 3·33 (2·86-4·00) in that between anterior origins of pelvic and anal fins. Length of caudal peduncle 1·66 (1·40-2·31) in length of head, width 1·52 (1·08-1·80) in its own length.

Posterior chamber of air bladder, measured in 4 specimens 17·39 (14·70-22·86) per cent in standard length.

Coloration.—In alcohol, dark grey above, paler beneath, a broad lateral band from gill openings to caudal base bordered above and below by incomplete dark narrow lateral stripes especially in the posterior half of body, a black spot on the upper angle of the gill opening and a black blotch at the base of the caudal.

Distribution.—Asia : Ceylon : Gammaduwa, C.P.

18. **Garra annandalei** Hora

1921. *Garra annandalei* Hora, *Rec. Indian Mus.*, Calcutta, **22,** p. 657 [Type-loc.: Mahananda River, below Darjeeling. Type in ZSI ; examined].

1921. *Garra chaudhurii* Hora, *Rec. Indian Mus.*, Calcutta, **22,** p. 617, pl. 25, fig. 3 [Type-loc. : Darjeeling district. Type in ZSI ; examined].

1937. *Garra annandalei,* Shaw & Shebbeare, *J. Asiat. Soc. Beng.*, Calcutta, (3) **3**, p. 48, fig. 44.

1950*b*. *Garra annandalei,* Menon, *Rec. Indian Mus.*, Calcutta, **47,** p. 233.

Specimens examined.—Nepal :—205, 23·5 to 60·0 mm., from Kosi drainage, E. Nepal, India :—39, 35·0 to 146·0 mm., from Darjeeling district, West Bengal.

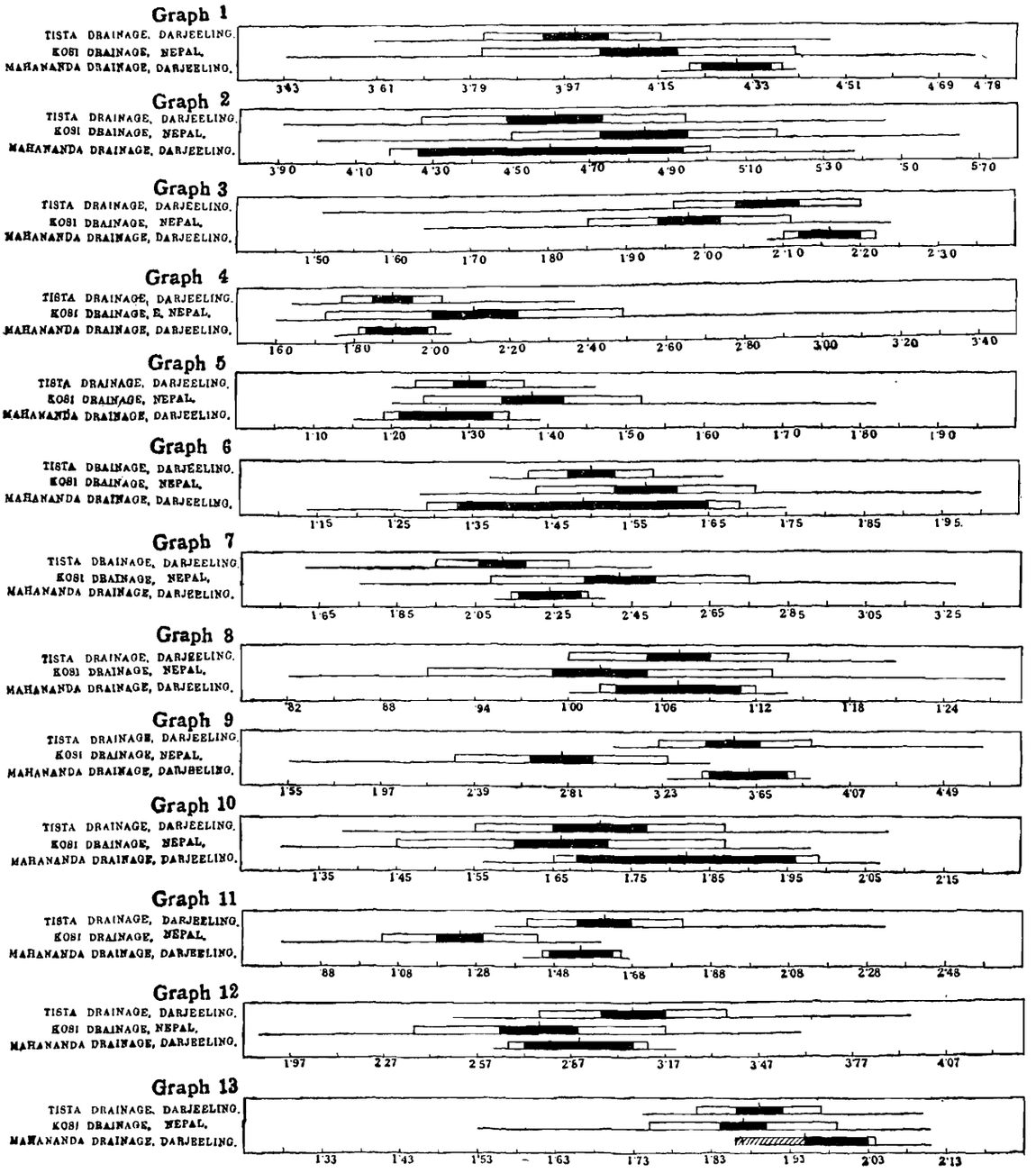
Description.—Depth of body 4·60 (4·26-5·38) in standard length, length of head 4·30 (4·16-4·41). Width of head 1·27 (1·15-1·39) in length of head, height of head 1·49 (1·15-1·75). Pupil of eye at or behind the middle of the length of head. Inter-orbital region somewhat convex. Snout more or less pointed, smooth, 1·91 (1·75-2·05) in length of head, diameter of eye 4·71 (4·20-5·28), inter-orbital width 2·24 (2·10-2·38). Barbels, two pairs, shorter than diameter of eye. 9 to 12 outer gill rakers on the lower part of the anterior arch. Length of disc 3·61 (3·25-3·89) in length of head, width 1·82 (1·56-2·07) in width of head ; length of disc 1·55 (1·40-1·67) in its own width. 33 to 34 scales in lateral line, 3·5 from the origin of dorsal to lateral line, 3·0 or 3·5 between this and pelvic. 9 to 10 scales on middorsal streak. Chest and belly scaled, but scales on chest very reduced. Dorsal III, 7-8 ; distance between its anterior origin and tip of snout 2·16 (2·08-2·22) in standard length. Length of pectorals 1·07 (1·00-1·14) in length of head. Distance between anterior origins of pelvic and anal fins 1·95 (1·89-2·11) in that between anterior origin of pelvic and base of caudal fin. Anal 11, 5. Distance from vent to anal fin 2·89 (2·62-3·21) in that between anterior origins of

pelvic and anal fins. Length of caudal peduncle 1·07 (1·00-1·14) in length of head, width 1·57 (1·47-1·65) in its own length.

Posterior chamber of air bladder, measured in 3 specimens 9·38 (7·10-12·99) per cent in standard length.

Coloration.—In alcohol, dark grey, paler beneath with a black spot on the upper angle of the gill openings and a dark mid-lateral band in young specimens.

Distribution.—Asia : India : Darjeeling Himalayas. Nepal : Kosi drainage, E. Nepal.



TEXT-FIG. 16.—Variations in different populations of *Garra annandalei*.

Graph 1. Length of head in standard length. Graph 2. Depth of body in standard length. Graph 3. Distance between snout and dorsal fin in standard length. Graph 4. Length of snout in length of head. Graph 5. Width of head in length of head. Graph 6. Height of head in length of head. Graph 7. Inter-orbital width in length of head. Graph 8. Length of pectoral in length of head. Graph 9. Length of disc in length of head. Graph 10. Width of disc in width of head. Graph 11. Length of disc in width of disc. Graph 12. Distance from vent to anal fin in distance between pelvic and anal fins. Graph 13. Distance between pelvic and anal fins in distance between pelvic and base of caudal.

Relationships.—The individuals are very much like *G. lamta* in general appearance, but lack the characteristic colouration and the transverse groove at the tip of snout. A more anteriorly placed vent further distinguishes it from *lamta*. The range of variation of characters within the various populations is not of taxonomic significance.

(iv) The *'lissorhynchus'* complex

Lissorhynchus and its relative *rupeculus* have their centre of distribution in the Assam region. This complex appears to be related to *annandalei* of the *lamta* complex. Both *lamta* and *lissorhynchus* complexes may have evolved, the former along the Himalayan base and the latter in the Assam region from a common ancestral stock. The most outstanding characteristics of the members are : a dark streak near the free margin of the dorsal fin, a broad black W-shaped band on the anterior half of the caudal fin and the chest and belly being naked.

19. **Garra lissorhynchus** (McClelland)

1842. *Platycara lissorhynchus* McClelland, *Calcutta Journ. Nat. Hist.*, Calcutta, **2**, p. 587, pl. 68, fig. [Type-loc. : "Kasyah Mountains", Assam].

1868. *Disognathus macrochir* Gunthur, *Cat. Brit. Mus. Fish.*, London, **7**, p. 70 [Type-loc. : Assam. Type in BM].

1869. *Mayoa modesta* Day, *Proc. Zool. Soc. Lond.*, London, p. 553 [Type-loc. : "Northern India"].

1871. *Mayoa modesta* Day, *J. Asiat. Soc. Beng.*, Calcutta, **40** (2), p. 108, pl. 9, fig. 2.

1878. *Discognathus modestus* Day, *Fish India*, London, 2, p. 528, pl. 122, fig. 5.

1889. *Discognathus modestus* Day, *Faun, Brit. Ind. Fish.*, London, **1**, p. 247.

1921. *Garra lissorhynchus* Hora, *Rec. Indian Mus.*, Calcutta, **22**, p. 662, pl. 26, figs. 2, 2*a*.

1935. *Garra lissorhynchus* Hora, and Mukherji, *Rec. Indian Mus.*, Calcutta, **37**, p. 390.

1955. *Garra lissorhynchus* Menon, *Rec. Indian Mus.*, Calcutta, **52**, p. 22.

Specimens examined.—India :—33, 31·5 to 73·5 mm., from Khasi, Jaintia and Naga Hills, Assam.

Description.—Depth of body 5·07 (4·45-6·60) in standard length, length of head 4·18 (3·50-4·50). Width of head 1·21 (1·13-1·38) in length of head, height of head 1·74 (1·58-1·93). Pupil of eye at or slightly behind the middle of the length of head. Inter-orbital region somewhat convex. Snout somewhat broadly rounded, smooth ; 1·94 (1·71-2·08) in length of head, diameter of eye 4·95 (3·71-6·60), inter-orbital width 1·95 (1·80-2·40). Two pairs of barbels, smaller than the diameter of eye. 7 to 9 outer gill rakers on the lower part of the anterior arch. Length of disc 2·71 (2·36-3·57) in length of head, width 1·60 (1·25-1·92) in width of head ; length of disc 1·50 (1·20-1·80) in its own width. 32 to 35 scales in lateral line, 3·5 or 4·5 from the origin of dorsal to lateral line, 2·5, 3·0 or 3·5 between this and pelvic. 11 to 14 scales on middorsal streak. Chest and belly naked ; post-pelvic region scaled. Dorsal 11, 6-7; distance between its anterior origin and tip of snout 1·95 (1·85-2·04) in length. Length of pectorals 1·02 (0·86-1·18) in length of head. Distance between anterior origins of pelvic and anal fins 1·94 (1·72-2·08) in that between anterior origin of pelvic and base of caudal fin. Anal 1, 5. Distance from vent to anal fin 3·52 (2·54-4·57) in that between anterior origins of pelvic and anal fins. Length of caudal peduncle 1·35 (1·20-1·73) in length of head, width 1·36 (1·18-1·57) in its own length.

Posterior chamber of air bladder, measured in 17 specimens 16·15 (6·06-25·49) per cent in standard length.

Coloration.—In alcohol, dark grey, paler beneath, a dark streak near the free margin of the dorsal, a broad black W-shaped band on the anterior half of caudal fin, an indistinct black blotch near the base of caudal and a black spot behind the upper angle of the gill openings.

Distribution.—Asia : India : Brahmaputra system, Assam Himalayas.

Relationships.—This form is most easily separated from its nearest relative, *G. rupecula* by its having the back and the post-pelvic regions covered with scales.

20. **Garra rupecula** (McClelland)

1839. *Gonorhynchus rupeculus* McClelland, *Asiatic Res.*, **19,** pp. 281, 343, pl. 53, figs. 4, 5 [Type-loc.: "Mishmee Mountains", Assam].

1839. *Gonorhynchus brachypterus* McClelland, *Asiatic Res.*, Calcutta, 19, pp. 283-374 [Type-loc. : "Mishmee Mountains", Assam].

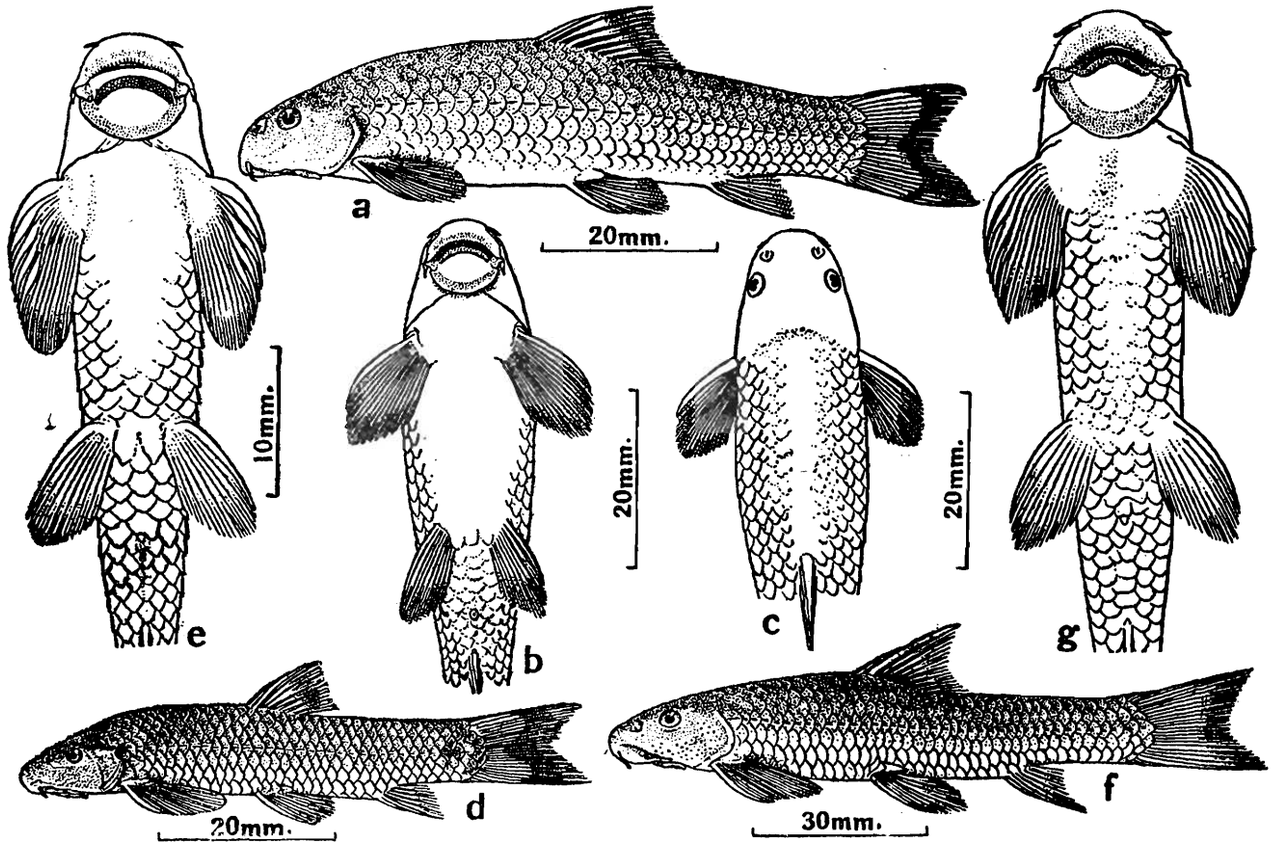
1921. *Garra abhoyai* Hora, *Rec. Indian Mus.*, Calcutta, **22,** p. 664, pl. 26, Figs. 1, 1a, 16 [Type-loc. : Ukhrul, Naga Hills, Assam. Type in ZSI ; examined].

1921. *Garra rupeculus*, Hora, *Rec. Indian Mus.*, Calcutta, **22,** p. 674, pl. 24, Fig. 1.

1935. *Garra rupeculus* Hora, *Rec. Indian Mus.*, Calcutta, **37,** p. 383.

1935. *Garra abhoyai* Hora, *Rec. Indian Mus.*, Calcutta, **37,** p. 383.

1955. *Garra abhoyai* Menon, *Rec. Indian Mus.*, Calcutta, **52,** p. 22.



TEXT-FIG. 17.—*Garra rupecula* (McClelland), *G. lissorhynchus* (McClelland), and *G. kempi* Hora.

(*a*) *Garra rupecula* (McClelland), lateral view. (*b*) Ventral view of *a* in front of anal fin. (*c*) Dorsal view of *a* in front of dorsal fin. (*d*) *Garra lissorhynchus* (McClelland), lateral view. (*e*) Ventral view of *d* in front of anal fin. (*f*) *G. kempi* Hora, lateral view. (*g*) Ventral view of *f* in front of anal fin.

Specimens examined.—India :—64, 20·5 to 55·5 mm., from Manipur, 3, 61·5 to 64·5 mm., from Naga Hills, Assam.

Description.—Depth of body 5·68 (4·16-6·17) in standard length, length of head 4·44 (3·67-4·90). Width of head 1·23 (1·08-1·50) in length of head, height of head 1·67 (1·43-2·00). Pupil of eye at or in the front of the middle of the length of head. Inter-orbital region somewhat convex. Snout somewhat broadly rounded, smooth ; 2·01 (1·73-2·50) in length of head, diameter of eye 4·33 (3·00-5·50), inter-orbital width 1·88 (1·60-2·11). Two pairs of barbels, smaller than the diameter of eye. 7 to 9 outer gill rakers on the lower part of the anterior arch. Length of disc 2·67 (2·17-3·17) in length of head, width 1·50 (1·25-1·80) in width of head ; length of disc 1·45 (1·25-1·75) in its own width. 32 to 34 scales in lateral

line, 4·5, 5·5 or 6·5 from the origin of dorsal to lateral line, 3·5, 4·0 or 4·5 between this and pelvic. Back, chest, belly and the post-pelvic regions naked. Dorsal II, 6-7 ; distance between its anterior origin and tip of snout 1·88 (1·76-1·96) in standard length. Length of pectorals 1·12 (1·00-1·26) in length of head. Distance between anterior origins of pelvic and anal fins 1·99 (1·69-2·38) in that between anterior origin of pelvic and base of caudal fin. Anal I, 5. Distance from vent to anal fin 3·40 (2·67-5·09) in that between anterior origins of pelvic and anal fins. Length of caudal peduncle 1·30 (1·05-1·87) in length of head, width 1·38 (1·12-1·73) in its own length.

Posterior chamber of air bladder, measured in 7 specimens 5·78 (5·40-6·30) per cent in standard length.

Coloration.—In alcohol, dark grey, paler beneath a dark streak near the free margin of the dorsal, a broad black W-shaped band on the anterior half of caudal fin, an indistinct blotch near the base of caudal fin and a black spot behind the upper angle of the gill openings.

Distribution.—Asia : India : Manipur and the Mishmi Hills, Assam.

Relationships.—This species is quite close to *G. lissorhynchus* and may have evolved from it by a reduction of scales on the back and the post-pelvic regions.

Remarks.—This species is said by Hora (*l.c.*, p. 675) to reach only a maximum length of 2 inches and on basis of this he separated the bigger specimens of it into a distinct sepcies *G. abhoyai*. After having examined large number of specimens of this species freshly collected from the Manipur Valley by myself I have come to the conclusion that *G. abhoyai* is the same as *G. rupecula*. Following Hora (*op. cit.*), I have based my description of the species on specimens collected from the Manipur Valley though the type-locality of the species is the adjacent Mishmi Hills.

(v) The '*taeniata*' Complex

The *taeniata* complex has its centre of distribution in the Siam-Malaya-North Borneo region. The complex is related to the *lissorhynchus* complex and both may have descended from a common ancestral stock.

The principal characters distinguishing this complex are the reduction in the number of scales along the lateral line (32 to 33 in *taeniata* ; and 28 to 31 in *borneensis*), their brilliant colouration with a broad dark lateral band and a brownish streak in the upper and lower caudal rays and the position of the vent the distance of it from the anal base is three or less than three times in that between the anterior origins of the pelvic and anal fins.

21. **Garra taeniata** Smith

(Plate xi, Figs. 9-12)

1931. *Garra taeniata* Smith. *Proc. U. S. Nat. Mus.*, Washington, **79**, p. 19, pl. 1 [Type-loc.: Tadi stream, Nakron Sritamarat, Peninsular Siam. Type in USNM ; examined].

1934. *Garra taeniata* Fowler *Proc. Acad. Nat. Sci. Phild.*, Philadelphia, **86**, p. 138, fig. 107.

1934 *Garra spinosa* Fowler, *Proc. Acad. Nat. Sci. Phild.*, Philadelphia, **86**, p. 138 [Type-loc.: Metang River, north of Chieng Mai, Northern Siam. Type in ANSP ; examined].

1935. *Garra taeniatops* Fowler *Proc. Phild.. Acad. Nat. Sci. Phild.*, Philadelphia, **87**, p. 129, figs. 75-77 [Type-loc. : Khoa Nam Poo, Central Siam. Type in ANSP ; examined].

1937. *Garra taeniatops* Fowler, *Proc. Acad. Nat. Sci. Phild.*, Philadelphia, **89**, p. 211.

1937. *Garra fasciacauda* Fowler, *Proc. Acad. Nat. Sci. Phild.*, Philadelphia, **89**, p. 212, figs. 187, 188 [Type-loc. : Mekong river, Kemarat, E. Siam. Type in ANSP ; examined].

1937. *Garra taeniata*, Koumans, *Zool. Med. ed.*, **22**, p. 63.

1939. *Garra parvifilum* Fowler, *Proc. Acad. Nat. Sci. Phild.*, Philadelphia, **89**, p. 73, figs. 21, 22 [Type-loc. : Waterfall stream near Trang, Peninsular Siam. Type in ANSP ; examined].

1945 *Garra taeniata* Smith, *Bull. U.S.. Nat. Mus.*, Washington, No. 188, p. 260, fig. 50.

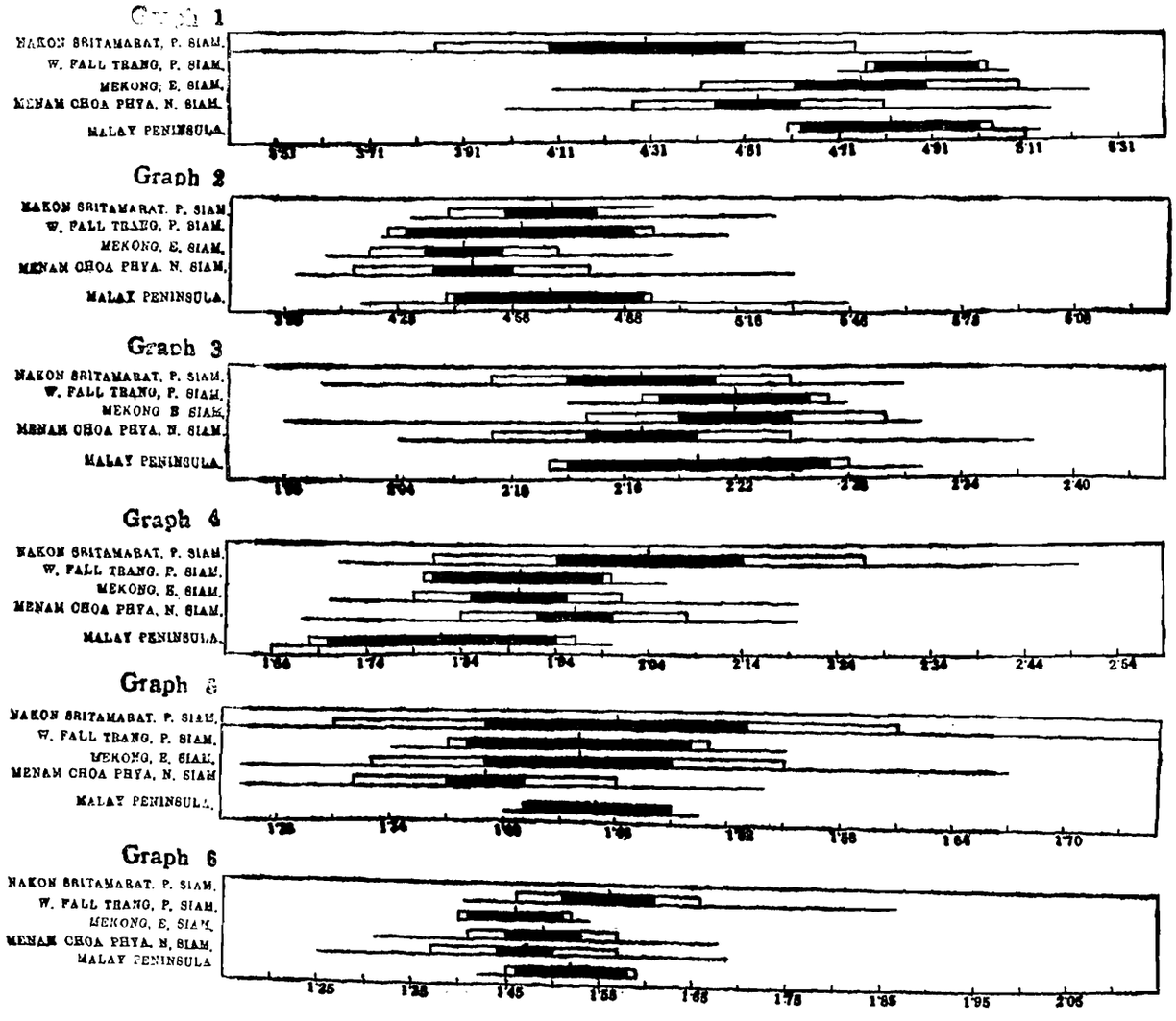
1945. *Garra parvifilum* Smith, *Bull. U. S. Nat. Mus.*, Washington, No. 188, p. 262.

1945. *Garra fasciacauda* Smith, *Bull. U. S. Nat. Mus.*, Washington, No. 188, p. 262.

1945*a*. *Garra taeniata* Menon, *Bull. Raffles Mus.*, Singapore, No. 25, p. 25.

Specimens examined.—Siam :—45, 34·0 to 120·0 mm., from Northern Siam, 25, 24·0 to 106·0 mm., from Peninsular Siam, 5, 29·0 to 59·0 mm., from Central Siam and 10, 76·0 to 113·5 mm., from Eastern Siam. Malaya :—3, 62·5 to 89·0 mm., from Kedah, 2,108·0 to 126·0 mm., from Kelantan.

Description.—Depth of body 4·68 (4·31-5·27) in standard length, length of head 4·30 (3·43-5·00). Width of head 1·46 (1·25-1·75) in length of head, height of head 1·56 (1·40-1·87). Pupil of eye at or slightly in front of the middle of the length of head. Inter-orbital region somewhat convex. Snout conical, smooth, tip marked off by a groove, tuberculated from

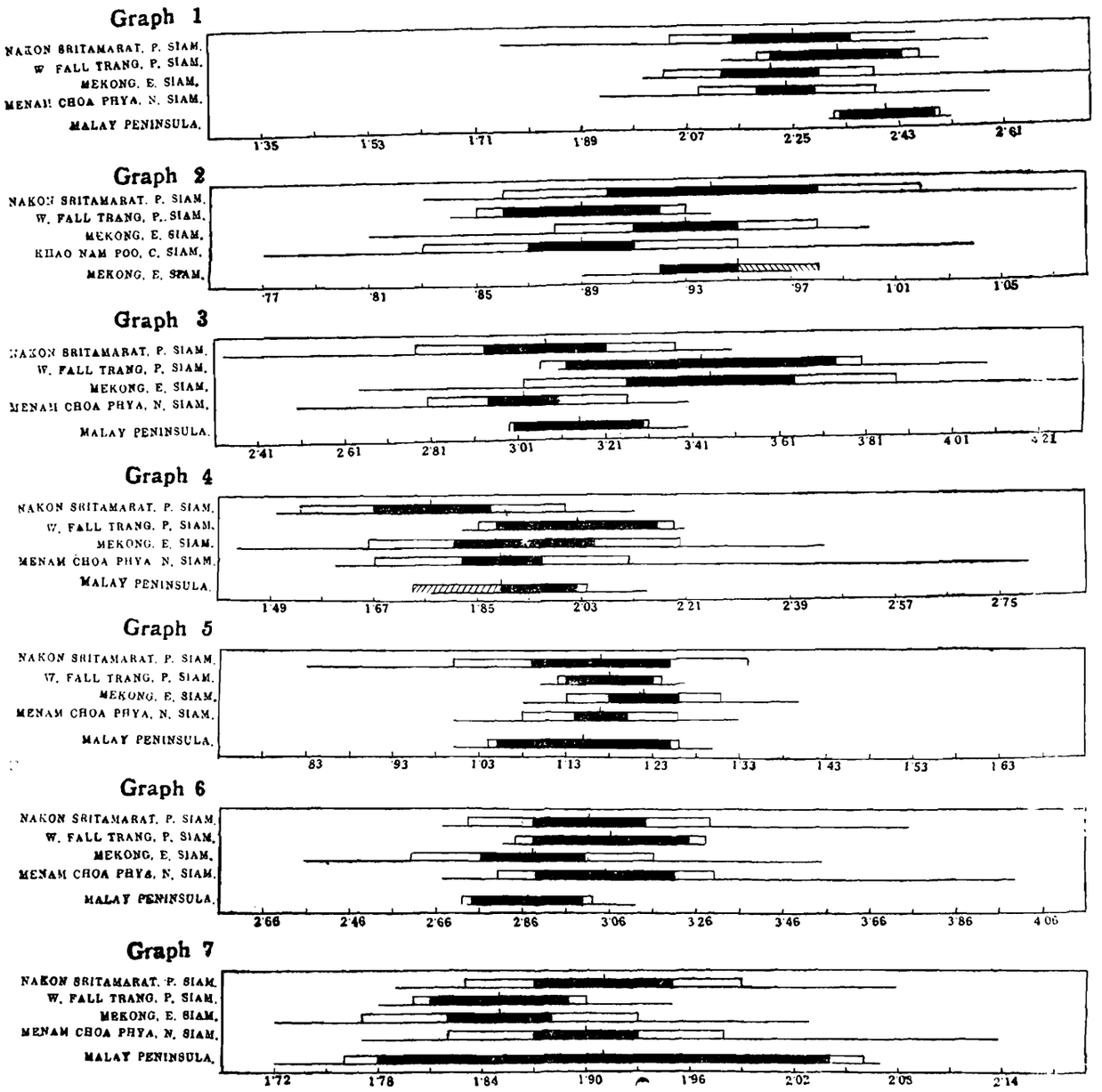


TEXT-FIG. 18.—Variations in the different populations of *Garra taeniata*.

Graph 1. Length of head in standard length. Graph 2. Depth of body in standard length. Graph 3. Distance between snout and dorsal fin in standard length. Graph 4. Length of snout in length of head. Graph 5. Width of head in length of head. Graph 6. Height of head in length of head.

end of snout back to inter-nasal space and below nostrils on pre-orbital space ; 2·04 (1·71-2·50) in length of head, diameter of eye 3·46 (2·80-4·80), inter-orbital width 2·25 (1·75-2·58). Barbels one rostral pair, as long as or slightly shorter than diameter eye. 9 outer gill rakers on the lower part of the anterior arch. Length of disc 3·07 (2·33-3·50) in length of head, width 1·77 (1·50-2·12) in width of head ; length of disc 1·17 (0·83-1·25) in its own width. 32 to 33 scales in lateral line, 4·0 or 4·5 from the origin of dorsal to lateral line, 3·0 between this and pelvic. 9 to 10 scales on middorsal streak ; the chest and belly scaled. Dorsal III, 8 ;

distance between its anterior origin and tip of snout 2·17 (2·00-2·31) in standard length. Length of pectorals 0·94 (0·83-1·08) in length of head. Distance between anterior origins of pelvic and anal fins 1·91 (1·79-2·08) in that between anterior origin of pelvic and base of caudal fin. Anal II-III, 5. Distance from vent to anal fin 3·01 (2·67-3·75) in that between anterior origins of pelvic and anal fins. Length of caudal peduncle 1·29 (0·91-1·62) in length of head, width 1·55 (1·25-2·00) in its own length.



TEXT-FIG. 19.—Variations in the different populations of *Garra taeniata* (continued.)

Graph 1. Inter-orbital width in length of head. Graph 2. Length of pectoral in length of head. Graph 3. Length of disc in length of head. Graph 4. Width of disc in width of head. Graph 5. Length disc in width of disc. Graph 6. Distance from vent to anal fin in distance between pelvic and anal fins. Graph 7. Distance between pelvic and anal fins in distance between pelvic and base of caudal.

Posterior chamber of air bladder, measured in 6 specimens 10·24 (5·39-14·81) per cent in standard length.

Coloration.—In alcohol, dark brown above, pale white below, a broad dark lateral band from behind gill openings to the base of caudal fin, two broad black cross bands on the dorsal fin and a brownish streak in the upper and lower caudal rays.

Distribution.—Asia : Siam and Malaya, widely distributed.

Relationships.—*G. taeniata* is quite distinct from any other member of the genus ; the slender and trim body, the characteristic brilliant colouration, the pointed snout, the presence of a single rostral pair of barbels and the pattern of distribution of tubercles on the snout are the characters which distinguish it from other members of the genus. This species, is, however, closer to *G. borneensis* than to any other member of the genus and may have had a common ancestor.

Remarks.—*G. spinosa* Fowler, *G. taeniatops* Fowler, *G. fasciacaudata* Fowler, *G. parvifilum* Fowler have all been synonymised with *G. taeniata* Smith as the differences on which these species have been erected are of no specific value and they fall within the limits of normal variation in *G. taeniata.*

22. **Garra borneensis** (Vaill.)

(Plate xi, Figs. 7-8)

1902. *Discognathus borneensis* Vaillant, *Notes Leyden Mus.*, Leiden, **24** p. 91 [Type-loc. : Baram River, North Borneo. Type in LM].

1905. *Garra borneensis* Fowler, *Proc. Acad, Nat. Sci. Phild.*, Philadelphia, **57**, p. 482.

1919. *Discognathus borneensis* Weber & de Beaufort, *Fish, Indo-Aust. Archipelago*, Leiden, **3**, p. 228.

Specimens examined.—Borneo :—21, 34·5 to 110·5 mm., from North Borneo.

Description.—Depth of body 4·81 (4·28-5·19) in standard length, length of head 4·63 (4·06-4·91). Width of head 1·29 (1·24-1·39) in length of head, height of head 1·53 (1·37-1·67). Pupil of eye at or slightly behind the middle of the length of head. Inter-orbital region somewhat convex. Snout somewhat pointed, scarcely tuberculated ; 1·79 (1·65-2·00) in length of head, diameter of eye 4·28 (3·33-4·44), inter-orbital width 2·22 (2·00-2·46). Two pairs of barbels, rostral almost as long as the diameter of eye, maxillary shorter. 5 to 7 outer gill rakers on the lower part of the anterior arch. Length of disc 2·93 (2·40-3·30) in length of head, width 1·68 (1·39-2·08) in width of head ; length of disc 1·36 (1·10-1·54) in its own width. 28 to 31 scales in lateral line, 3·0, 3·5 or 4·5 from the origin of dorsal to lateral line, 25 or 3·0 between this and pelvic. 9 to 10 scales on middorsal streak ; chest and belly scaled. Dorsal 111, 8 ; distance between its anterior origin and tip of snout 2·22 (2·03-2·43) in standard length. Length of pectorals 1·03 (0·92-1·13) in length of head. Distance between anterior origins of pelvic and anal fins 1·87 (1·73-2·06) in that between anterior origin of pelvic and base of caudal fin. Anal 11, 5. Distance from vent to anal fin 2·13 (1·89-2·45) in that between anterior origins of pelvic and anal fins. Length of caudal peduncle 1·27 (0·90-1·40) in length of head, width 1·82 (1·25-1·83) in its own length.

Posterior chamber of air bladder, measured in 5 specimens 3·55 (2·84-4·96) per cent in standard length.

Coloration.—In alcohol, dark grey or brown above, paler beneath, a broad dark lateral band from behind gill openings to the base of caudal fin and faint brownish streaks on upper and lower caudal rays.

Distribution.—Asia : Borneo : North Borneo.

Relationships.—This species is related to *G. taeniata*, but is readily separated by the location of the vent which in this species is about half way between the orgins of the pelvic and anal fins. Both *borneensis* and *taeniata* seem to have originated from a common ancestral form.

(vi) The '*yunnanensis*' complex

The centre of evolution of this complex seems to be Yunnan though the present day distribution of the member of the complex is in South China and Assam on the one hand and the Western-ghats of the Peninsular India on the other.

The members of the *Yunnanensis* Complex exhibit considerable differences in colour pattern, in the number of outer gill rakers on the lower part of the anterior arch, the size or the posterior chamber of the air bladder and the relative position of the vent, but are undoubtedly tied together by a basic underlying similarity. In the normal morphologic structure especially in the scale count along the lateral line they show great similarity.

23. **Garra yunnanensis** (Regan)

(Plate xi, Fig 4-6)

1907. *Discognathus yunnanensis* Regan, *Ann. Mag. Nat. Hist.*, London, (7) **19**, p. 63 [Type-loc. " Lake at Yunan Fu ", Yunan Type in BM].

1943. *Garra yunnanensis* Nichols, *Natural History of Central Asia*, New York, **9**, p. 111.

Specimens examined.—China :—2, 79·5 to 88·0 mm., from Yunan.

Description.—Depth of body 4·86 (4·54-5·18) in standard length, length of head 4·78 (4·54-5·03). Width of head 1·40 (1·35-1·46) in length of head, height of head 1·55 (1·52-1·59). Pupil of eye at the middle of the length of head. Inter-orbital region slightly convex. Snout rounded, smooth ; 1·95 (1·84-2·06) in length of head, diameter of eye 4·37, inter-orbital width 1·95 (1·84-2·06). Two pair of barbels, subequal, shorter than the diameter of eye. 18 to 20 outer gill rakers on the lower part of the anterior arch. Length of disc 4·13 (3·89-4·37) in length of head, width 1·93 (1·86-2·00) in width of head ; length of disc 1·52 (1·50-1·55) in its own width. 40 scales in lateral line, 6·5 from the origin of dorsal to lateral line, 4·5 between this and pelvic, 16 scales on middorsal streak. Chest and belly scaled. Dorsal 11, 8 ; distance between its anterior origin and tip of snout 2·07 (1·99-2·15) in standard length. Length of pectorals 1·01 (1·00-1·03) in length of head. Distance between anterior origins of pelvic and anal fins 2·27 (2·27-2·28) in that between anterior origin of pelvic and base of caudal fin. Anal 11, 5. Distance from vent to anal fin 6·24 (5·28-7·20) in that between anterior origins of pelvic and anal fins. Length of caudal peduncle 0·99 (0·92-1·06) in length of head, width 1·77 (1·65-1·90) in its own length.

Posterior chamber of air bladder, measured in 2 specimens 10·46 (10·23-10·69) per cent in standard length.

Coloration.—In alcohol, no well defined markings.

Distribution.—Asia : China : Yunan.

Relationships.—Close to *G. gracilis*, but can be separated by the greater number of scales along its lateral line. This species characterised by the position of its vent almost immediately in front of the anal fin, larger number of gill rakers on the anterior arch and a fairly extensive air bladder appears to be somewhat primitive and probably ancestral or an immediate descendant of the ancestral form which had given rise to the other members of the *Yunnanensis* complex.

24. **Garra gracilis** (Pellegrin & Chevey)

(Plate xii, Figs. 3-5)

1936. *Discognathus gracilis* Pellegrin & Chevey, *Bull. Soc. Zool. Fr.*, Paris, **61**, p. 26 [Type-loc. Hagiang, Tongking. Type in MHNP, examined].

1936. *Discognathus caudofasciatus* Pellegrin & Chevey, *Bull. Soc. Zool. Fr.*, Paris, **61**, p. 223, figs. 1, 2 [Type-loc. Lai Chau, Tongking. Type in MHNP].

Specimens examined.—Indo-China :—5, 27·5 to 100·5 mm., from Tongking.

Description.—Depth of body 5·49 (4·58-6·73) in standard length, length of head 4·03 (3·55-4·78). Width of head 1·63 (1·31-1·80) in length of head, height of head 1·61 (1·50-1·70). Pupil of eye at or in front of the middle of the length of head. Inter-orbital region slightly convex. Snout rounded, smooth, 2·42 (1·91-3·00) in length of head, diameter of eye 3·53 (3·00-4·20), inter-orbital width 2·54 (2·33-2·83). Two pairs of barbels, rostral

pair as long as diameter of eye, maxillary pair shorter. 18 outer gill rakers on the lower part of antrior arch. Length of disc 3·75 (3·00-4·25) in length of head, width 1·92 (1·67-2·50) in width of head ; length of disc 1·24 (1·00-1·73) in its own width. 36 to 38 scales in lateral line, 4·0 or 4·5 from the origin of dorsal to lateral line, 3·0 or 3·5 between this and pelvic 9 to 11 scales on middorsal streak ; chest and belly scaled. Dorsal 11, 8 ; distance between its anterior origin and tip of snout 2·28 (2·11-2·25) in standard length. Length of pectorals 1·10 (1·06-1·13) in length of head. Distance between anterior origins of pelvic and anal fins 2·11 (1·78-2·94) in that between anterior origin of pelvic and base of caudal fin. Anal III, 5. Distance from vent to anal fin 5·21 (4·25-6·00) in that between anterior origins of pelvic and anal fins. Length of caudal peduncle 1·60 (0·89-1·87) in length of head, width 1·57 (1·25-2·35) in its own length.

Posterior chamber of air bladder, measured in one specimen 18·90 per cent in standard length.

Coloration.— In alcohol, no well defined markings.

Distribution.— Asia : Indo-China : Tongking.

Relationships.— Close to *G. yunnanensis* but tend to have a lesser number of scales along the lateral line.

25. Gaara naganenisis Hora

1921. *Garra naganensis* Hora, *Rec. Indian Mus.*, Calcutta, **22**, p. 667, pl. 25, figs. 2, 2*a* [Type-loc. : " Senapati Stream, near Kairong among the Naga Hills, Assam ", India. Type in ZSI, examined].

1935. *Garra naganensis* Hora, *Rec. Indian Mus.*, Calcutta, **37**, p. 390.

1936. *Garra naganensis* Hora, *Rec. Indian Mus.*, Calcutta, **38**, p. 318.

Specimens examined.—India :—51, 29·5 to 104·5 mm., from Naga Hills, Assam.

Description.—Depth of body 5·21 (4·47-5·69) in standard length, length of head 4·62 (4·25-4·97). Width of head 1·24 (1·11-1·36) in length of head, height of head 1·57 (1·40-1·68). Pupil of eye at or slightly behind the middle of the length of head. Snout semi-circular, scarcely tuberculated ; 0·97 (1·70·2·17) in length of head, diameter of eye 4·50 (3·33-5·57), inter-orbital width 2·02 (1·67-2·47). Two pairs of barbels, shorter than diameter of eye. 8 to 10 outer gill rakers on the lower part of the anterior arch. Length of disc 3·25 (2·86-3·67) in length of head, width 1·72 (1·50-2·13) in width of head ; length of disc 1·53 (1·20-2·00) in its own width. 38-40 scales in lateral line, 4·5 from the origin of dorsal to lateral line, 3·0 or 3·5 between this and pelvic. 12 to 14 scales on middorsal streak. Chest and abdomen scaled, but scales on chest are much reduced. Dorsal 11, 7-8 ; distance between its anterior origin and tip of snout 2·11 (1·91-2·32) in standard length. Length of pectorals 1·03 (0·94-1·12) in length of head. Distance between anterior origins of pelvic and anal fins 1·88 (1·63-2·15) in that between anterior origin of pelvic and base of caudal fin. Anal I-11, 5. Distance from vent to anal fin 2·49 (2·14-3·05) in that between anterior origins of pelvic and anal fins. Length of caudal peduncle 1·25 (1·07-1·67) in length of head, width 1·40 (1·12-1·61) in its own length.

Posterior chamber of air bladder, measured in 12 specimens 10·95 (8·26-17·07) per cent in standard length.

Coloration.—In alcohol, dark grey above, pale white beneath, an indistinct narrow lateral band from behind gill opening to the base of caudal fin ; and a minute black spot behind the upper angle of the gill openings.

Distribution.—Asia : India : Naga Hills, Assam.

Relationships.—This species is more closely related to *G. kempi* than to any other member of the *Yunnanensis* Complex ; it is, however, easily separated by the position of its vent which is situated at a distance less than half the distance between the anterior origins of the pelvic and anal fins, whereas in *G. kempi* it is located almost midway (Fig. 20, Graph 12). The range of variation of characters between the Chindwin and the Brahmaputra populations of the species is of no taxonomic significance.

26. *Garra kempi* Hora

1913. *Discogmathus lamta*, Chaudhuri, *Rec. Indian Mus.*, Calcutta, **8**, p. 247.

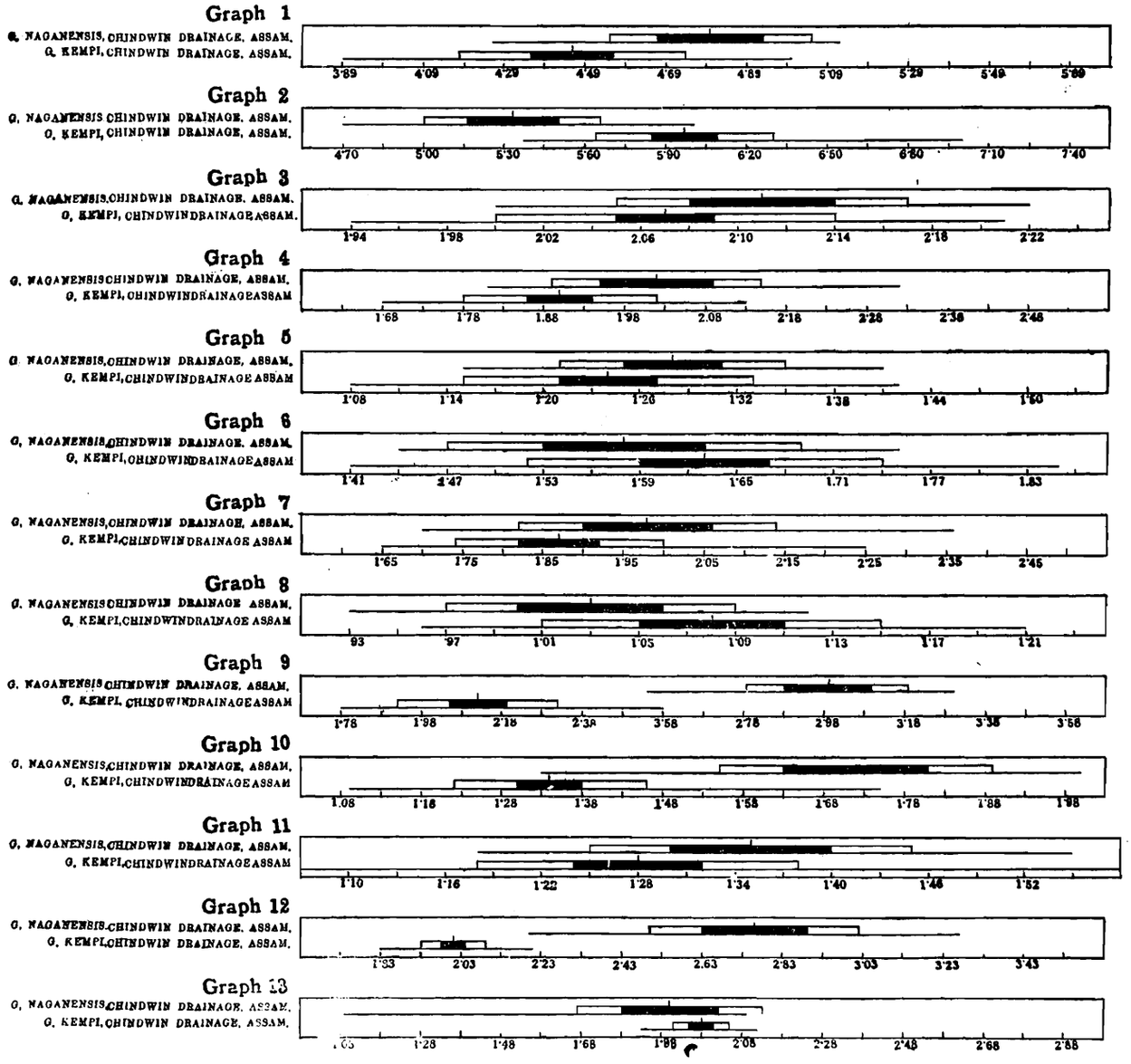
1921. *Garra nasutus*, Hora, *Rec. Indian Mus.*, Calcutta, **22**, p. 655, pl. 24, fig. 4.

1921. *Garra kempi* Hora, *Rec. Indian, Mus.*. Calcutta **22**, p. 655, pl. 26, figs. 3, 3*a* [Type-loc. : "Siyom River, below Damda at an altitude of 1,300 ft., among the Abor Hills", Assam, India, Type in Z. S. I. ; examined].

1935. *Garra kempi* Hora, *Rec. Indian Mus.*, Calcutta, **37**, p. 390.

Specimens examined : India :—Assam :—2, 86, 0 & 112·5 mm., from Abor-Hills, **104**, 32·0 to 91·0 m.m. from Naga-Hills.

Description.—Depth of body 5·97 (5·38-7·00) in standard length, length of head 4·46 (3·89-5·00). Width of head 1·24 (1·08-1·42) in length of head, height of head 1·63 (1·41-1·85). Pupil of eye at or slightly behind the middle of the length of head. Inter-orbital region slightly convex. Snout broad, semicircular, with minute tubercles ; 1·90 (1·68-2·13)



TEXT-FIG. 20.—*Garra naganensis* compared with *G. kempi*

Graph 1. Length of head in standard length. Graph 2. Depth of body in standard length. Graph 3. Distance between snout and dorsal fin in standard length. Graph 4. Length of snout in length of head. Graph 5. Width of head in length of head. Graph 6. Height of head in length of head. Graph 7. Inter-orbital width in length of head. Graph 8. Length of pectoral in length of head. Graph 9. Length of disc in length of head. Graph 10. Width of disc in width of head. Graph 11. Length of disc in width of disc. Graph 12. Distance from vent to anal fin in distance between pelvic and anal fin. Graph 13. Distance between pelvic and anal fins in distance between pelvic and base of caudal.

in length of head, diameter of eye 4·54 (3·50-6·17), inter-orbital width 1·87 (1·65-2·25). Two pairs of barbels, the rostral slightly longer than diameter of eye, the maxillary smaller. 7 to 9 outer gill rakers on the lower part of the anterior arch. Length of disc 2·12 (1·78-2·58) in length of head, width 1·34 (1·09-1·75) in width of head ; length of disc 1·28 (1·07-1·58) in its own width. 38 to 40 scales in lateral line, 3·5, 4·0 or 4·5 from the origin of dorsal to lateral line, 3·0 or 3·5 between this and pelvic. 12 to 14 scales on middorsal streak. Chest naked ; belly scaled, but reduced especially along middle line. Dorsal 11,8 ; distance between its anterior origin and tip of snout 2·07 (1·94-2·21) in standard length. Length of pectorals 1·08 (0·96-1·21) in length of head. Distance between anterior origins of pelvic and anal fins 1·98 (1·83-2·12) in that between anterior origin of pelvic and base of caudal fin. Anal 11, 5. Distance from vent to anal fin 2·01 (1·83-2·20) in that between anterior origins of pelvic and anal fins. Length of caudal peduncle 1·15 (0·96-1·64) in length of head, width 1·73 (1·22-1·83) in its own length.

Posterior chamber of air bladder, measured in 6 specimens 6·31 (4·00-8·33) per cent in standard length.

Coloration.—In alcohol, dark grey above, dirty white beneath, an indistinct narrow lateral band from behind gill opening to the base of caudal and a minute black spot behind the upper angle of the gill openings.

Distribution.—Asia : India : Assam (Abor and Naga Hills).

Relationships.—This species is most closely related to *C. naganensis* but is readily separated from it by its position of the vent which is situated midway between the anterior origins of the pelvic and anal fins (Fig. 20, Graph 12) ; this seems to have evolved from *G. naganensis*. The range of variation of characters between the populations of the Brahmaputra and the Chindwin drainages is of no taxonomic significance.

27. **Garra mcClellandi** (Jerdon)

1849. *Gonorhynchus mcClellandi* Jerdon, *Madras Journ. Lit. Sci.*, Madras, **15**, p. 309 [Type-loc. : " Bowany River at the foot of the Neilgherries and also in the Manantoddy river "].

1867. *Garra jerdoni* Day, *Proc. Zool. Soc. Lond.*, London, p. 288 [Type-loc. : " Very common in the Seegoor River ; rare in the Bowany ". Type in ZSI ; examined].

1878. *Discognathus jerdoni* Day, *Fish India*, London, **2**, p. 528, pl. 122, fig. 6.

1889. *Discognathus jerdoni* Day, *Fauna. Brit. Ind.*, London, **1**, p. 247.

1919*a*. *Discognathus elegans* Annandale, *Rec. Indian Mus.*, Calcutta, **19**, p. 76, pl. 9, fig. 4 ; pl. II, fig. 5 [Type-loc. : " Nierolay stream base of the Niligiris ". Type in BM ' Cotype ' ; ZSI ' Cotype ' ; examined].

1920. *Discognathus platycephala* Rao, *Ann. Mag. Nat. Hist.*, London, (9) **6**, p. 56, pl. 1, figs. 2, 2*a*, 2*b* [Type-loc. : Cauvery River, Seringapatam, Mysore. Type in BM, syntype ; Central College, Bangalore, syntype ; ZSI, syntype examined].

1921. *Garra jerdoni*, Hora, *Rec. Indian Mus.*, Calcutta, **22**, p. 657.

1941. *Garra jerdoni* Bhimachar and Raw, *J. Mys. Univ.*, Bangalore, (N.S.) **1**, (16), p. 146.

1942. *Garra jerdoni*, Hora, *Rec. Indian Mus.*, Calcutta, **44**, p. 196.

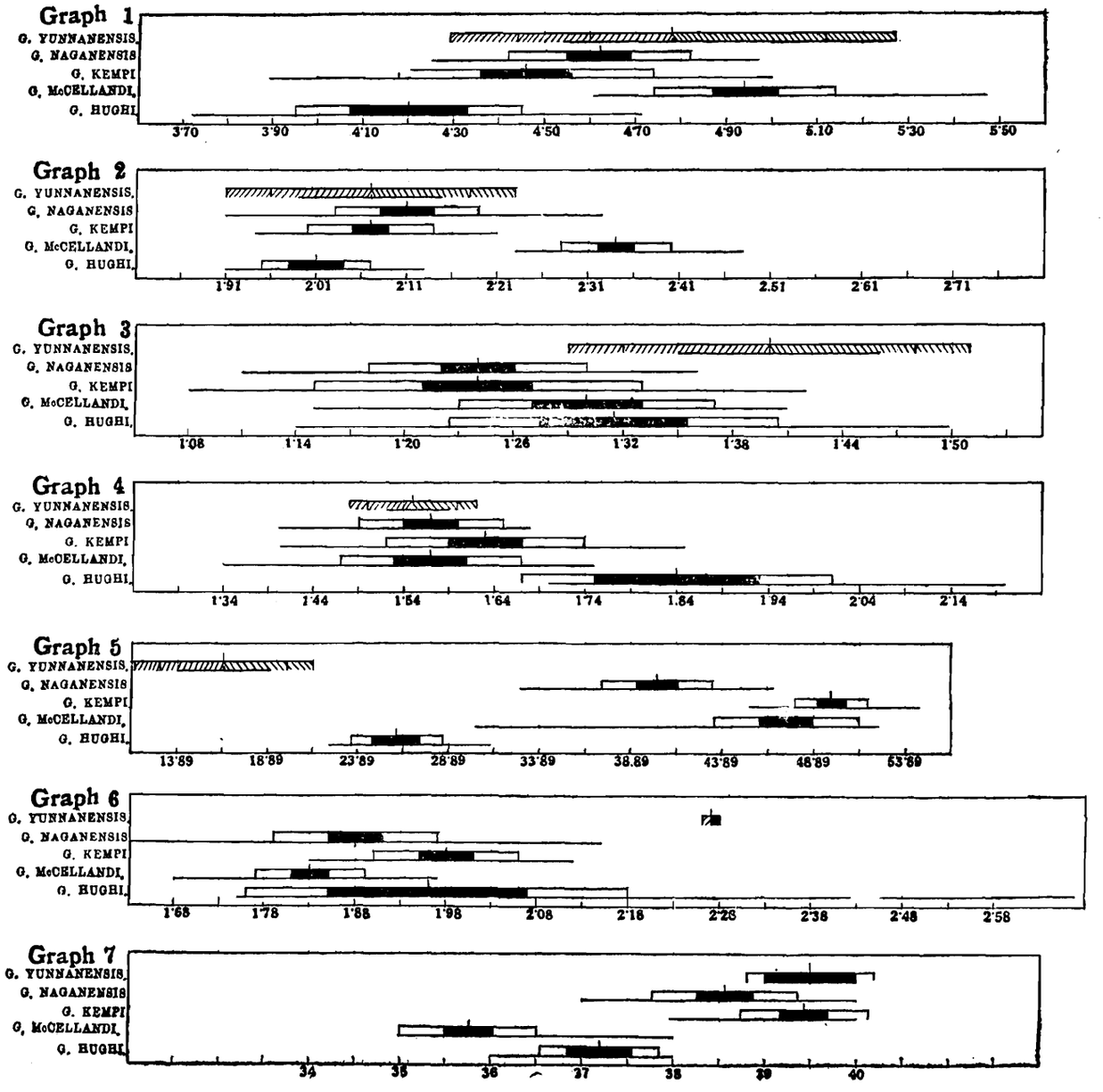
1955. *Garra jerdoni*, Rajan, *J. Bombay nat. Hist. Soc.*, Bombay, **53**, (1), p. 45.

Specimens examined.—India :—22, 83·0 to 174·0 mm., from Nilgiri District, Madras.

Description.—Depth of body 4·96 (4·30-5·67) in standard length, length of head 4·94 (4·58-4·47). Width of head 1·30 (1·15-1·41) in length of head, height of head 1·57 (1·34-1·75). Pupil of eye slightly behind the middle of the length of head. Inter-orbital region somewhat flat ; slightly concave in bigger examples. Snout conical, smooth, tip marked off by a transverse groove, tubercles on the transverse lobe at the tip, on the sides in front of orbit and in the inter-nasal region, arranged in bi-laterally symmetrical patches. 1·74 (1·63-2·04) in length of head, diameter of eye 4·03 (3·40-4·90), inter-orbital width 2·08 (1·87 2·23). Barbels two pairs, subequal, rostral shorter than diameter of eye, maxillary much shorter. 7 to 8 outer gill rakers on the lower part of the anterior arch. Length of disc 2·77 (2·53-3·40) in length of head, width 1·65 (1·47-1·91) in width of head ; length of disc 1·30 (1·13-1·50) in its own width. 35 to 38 scales in lateral line 4·5 from the origin of dorsal to lateral lines 3·5 between this and pelvic. 8 to 10 scales on middorsal streak. Chest and

belly scaled. Dorsal 11-111, 8, distance between its anterior origin and tip of snout 2·34 (2·23-2·48) in standard length. Length of pectorals 0·92 (0·85-1·02) in length of head. Distance between anterior origins of pelvic and anal fins 1·83 (1·68-1·97) in that between anterior origin of pelvic and base of caudal fin. Anal 1-11, 5. Distance from vent to anal fin 2·13 (1·92-3·30) in that between anterior origins of pelvic and anal fins. Length of caudal peduncle 1·22 (1·06-1·39) in length of head, width 1·56 (1·31-1·69) in its own length.

Posterior chamber of air bladder, measured in 30 specimens 4·98 (2·87-6·28) per cent in standard length.



TEXT-FIG. 21.—Species of *Yunnanensis* complex.

Graph 1. Length of head in standard length. Graph 2. Distance between snout and dorsal fin in standard length. Graph 3. Width of head in length of head. Graph 4. Height of head in length of head. Graph 5. Distance between pelvic and anal fins into distance from vent to anal fin in per cents. Graph 6. Distance between pelvic and anal fins in distance between pelvic and base of caudal. Graph 7. Lateral line scales.

Coloration.—In alcohol, dark grey above, paler beneath, a distinct dark mid-lateral band from behind gill openings to the base of caudal fin in young specimens which merges with the dark grey of the upper half of body in larger examples ; a black spot behind the upper angle of gill openings.

Distribution.—Asia : India :—Cauvery drainage, Nilgiri District, Madras.

Relationship.—This species is related to *G. hughi* and also to *G. naganensis* and *G. kempi* even though the latter two species are geographically very widely separated from *G. mcClellandi*. Further, its inclusion in the *Yunnanensis* complex indicating its relationship to a species in S. China is of great zoogeographical significance. *G. mcClellandi* can be easily separated from *G. hughi* by the position of its vent which is located more anteriorly than in *G. hughi* (Fig. 21, Graph 5).

Remarks.—This species was noted as occurring in the " Bowany river at the foot of the Nilgherries and also in the Manantaddy river ", both tributaries of the Cauvery river. I have examined large number of specimens from the Cauvery drainage in the Nilgiri Hills and I find that Jerdon was wrong in characterising his species, *Gonorhynchus mcClellandi* as having only two " longish cirri " for my specimens show two pairs of barbels—a fairly long rostral pair which Jerdon seems to have also noted and a very short and rudimentary pair of maxillary barbels which are situated in the labial groove at the place where the rostral fold joins the adhesive disc and is generally overlapped by the velum of the disc, thereby hiding it from view. Thus, with the re-discovery of *G. mcClellandi*, *G. platycephala* Rao described from the Cauvery river in Mysore, *G. jerdoni* Day and *Discorgnathus elegans* Annandale described from the Bhavani river do not seem tenable. None of these are specifically distinct, although Rao (*op. cit.*) gave the lateral line scale count in *platycephala* as 37 to 39 which seems to be an exceptionally high count for *mcClellandi* where it does not exceed 38. I have, therefore, considered here *G. jerdoni* Day, *D. elegans* Annandale, and *D. platycephala* Rao as synonyms of *G. mcClellandi*.

28. **Garra hughi** Silas

1955. *Garra hughi* Silas, *Rec. Indian Mus.*, Delhi, **52**, p. 1 [Type-loc. : Streams in the Lower Vauguvarrai Estate, High Range Travancore. Type in ZSI ; examined].

Specimens examined.—India :—53, upto 77·0 mm., from High Range, Travancore 54, 19·5 to 55·0 mm., from Palni Hills, Madras.

Description.—Depth of body 5·63 (4·78-6·65) in standard length, length of head 4·20 (3·72-4·71). Width of head 1·31 (1·14-1·50) in length of head, height of head 1·84 (1·70-2·20). Pupil of eye at or slightly in front of the middle of the length of head. Inter orbital region slightly convex. Snout broadly rounded, smooth, 2·07 (1·71-3·00) in length of head, diameter of eye 4·35 (3·00-5·50), inter-orbital width 2·11 (1·89-2·25). Barbels two pairs shorter than the diameter of eye, the maxillary pair shorter and stumpy. 6 to 7 outer gill rakers on the lower part of the anterior arch. Length of disc 2·62 (2·40-3·00) in length of head, width 1·49 (1·25-1·86) in width of head ; length of disc 1·36 (1·14-1·60) in its own width. 36 to 38 scales in lateral line, 5·0 or 5·5 from the origin of dorsal to lateral line, 3·0 or 3·5 between this and pelvic. Back, chest and belly naked ; post-pelvic region scaled. Dorsal 11, 7, distance between its anterior origin and tip of snout 2·01 (1·91-2·13) in standard length. Length of pectorals 1·09 (1·00-1·33) in length of head. Distance between anterior orgins of pelvic and anal fins 1·96 (1·75-2·67) in that between anterior origin of pelvic and base of caudal fin. Anal 1-11, 5. Distance from vent to anal fin 3·88 (3·20-4·50) in that between anterior origins of pelvic and anal fins. Length of caudal peduncle 1·55 (1·39-1·75) in length of head, width 1·49 (1·20-1·80) in its own length.

Posterior chamber of air bladder, measured in 6 specimens 16·99 (12·39-25·00) per cent in standard length.

Coloration.—In alcohol, dark grey above, yellowish white beneath, a dark lateral band from behind the gill openings to the base of the caudal fin ending in a black blotch ; a very indistinct black spot behind the upper angle of the gill openings.

Distribution.—Asia : India ; Kardamen and Palni Hills, Western-ghat.

Relationships.—Although this species is very distant, it is closer to *G. mcClellandi*, *G. naganensis* and *G. kempi* than to any other member of the genus. These species together with *G. yunnanensis* and *G. gracilis* may have evolved from a common ancestor. The late Pleistocne orogenic movements in the Assam and the Western Ghats have probably caused the evolution of the species in these areas (*vide infra*, p. 254).

(vii) THE IMBERBIS COMPLEX

The species of this complex are distributed in Burma, South-China and Indo-China. Its centre of evolution was first probably in Yunan plateau and may have been derived from *Yunnanensis* or most probably a form ancestral to it. Their most pronounced tendency is towards an increase of scales along the lateral line, the shifting of the vent far away from the base of the anal fin, the distance between the vent and the anal fin being less than two times in that between the anterior origins of the pelvic and the anal fins, an increase in the number of outer gill rakers on the lower portion of the anterior arch, a general increase of the body size and a complete disappearance of the barbels.

29. **Garra imberbis** (Vinciguerra)

(Plate XII Figs. 1-2)

1889/90. *Discognathus imberbis* Vinciguerra, *Ann. Mus. Genova*, Geneva, (2) **29**, p. 277, pl. 9, fig. 7 [Type-loc. : " Tao, karen Hills ", Burma, Type in BM ; one of the types].

1925. *Discognathus apogon* Norman, *Ann, Mag. Nat. Hist.*, London, (9) **15**, p. 570 [Type-loc.: 'Col des Nuages', Tongking. Type in BM].

1947. *Garra imberbis*, Nichols, *Natural History of Central Asia*, New York, **9** , p. 113, fig. 46.

Specimens examined.—Burma :—2, about 88·0 mm. each, from Mt. Carin.

Description.—Depth of body (5·85 5·83-5·87) in standard length, length of head 4·9 (4·88-5·03). Width of head 1·42 (1·25-1·39) in length of head, height of head 1·66 (1·65-1·67). Pupil of eye at or behind the middle of the length of head. Inter-orbital region slightly convex. Snout rounded, smooth, 1·81 (1·75-1·87) in length of head, diameter of eye 4·14 (3·50-4·78), inter-orbital width 2·05 (2·05-2·06). No barbels. 28 to 30 outer gill rakers on the lower part of the anterior arch. Length of disc 2·47 (2·26-2·69) in length of head, width 1·51 (1·48-1·55) in width of head ; length of disc 1·24 (1·10-1·38) in its own width. 44 to 45 scales in lateral line, 4·5 from the origin of dorsal to lateral line, 2·5 or 3 between this and pelvic. 16 scales on middorsal streak. Chest and belly scaled. Dorsal 111, 9 ; distance between the anterior origin of dorsal fin and tip of snout 2·24 (2·23-2·26) in standard length. Length of pectorals 1·08 (1·03-1·13) in length of head. Distance between anterior origins of pelvic and anal fins 1·89 (1·87-1·91) in that between anterior origin of pelvic and base of caudal fin. Anal 11, 5. Distance from vent to anal fin 1·52 (1·50-1·55) in that between anterior origins of pelvic and anal fins. Length of caudal peduncle 1·68 (1·13-2·23) in length of head, width 1·53 (1·52-1·55) in its own length.

Posterior chamber of air bladder, measured in 2 specimens 8·40 (7·14—9·66) per cent in standard length.

Coloration.—In alcohol, no well defined markings.

Distribution.—Asia : Burma : Karin Hills. Indo-China : North Tongking.

Relationships.—This form is most easily separated from its nearest relatives, *G. imberba* by the lesser number of scales along its lateral line (Text-fig. 22, Graph 1) and the smaller size, the biggest example I have examined being only 105·0 mm. standard length.

30. **Garra imberba** Garman

(Plate XII, Figs. 6-8)

1912. *Garra (Ageneiogarra) imberba* Garman, *Mem. Mus. Comp. Zool.*, Cambridge, U. S. A., **40**, p. 114 [Type-loc. : " Western Szechwan : Kiating, Min River "].

1929. *Garra pingi* Tchang, *Bull. Mus. Hist. Nat. Paris*, Paris, **1** (2), p. 241, fig. **3**. [Type-loc. : Kiating. Szechwan. Type in MHNP].

1933. *Garra piolanei* Petit & Tchang, *Bull. Mus. Hist. nat., Paris*, Paris, **5** (2), p. 189 [Type-loc. : Lung Van, Thanh Hoa Province, Annam. Type in MHNP].

1936. *Discognathus poilanei*, Pellegrin & Chevey, *Bull. Soc. Zool. Fr.*, Paris, **61**, p. 224.

1943. *Garra imberba*, Nichols, *Natural History of Central Asia*, New York, **9**, p. 113.

Specimens examined.—China : 11,141·0 to 305·0 mm., from Szechwan. Indo-China : 2, 94·5 and 112·0 mm., from Annam ; 1, 175 mm., from Tongking.

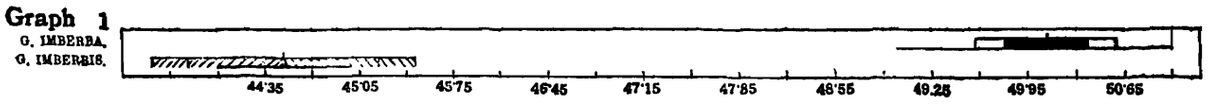
Description.—Depth of body 5·44 (4·78—6·00) in standard length, length of head 4·79 (4·49—5·49). Width of head 1·30 (1·20—1·40) in length of head, height of head 1·59 (1·44—1·72). Pupil of eye at or behind the middle of the length of head. Inter-orbital region convex. Snout rounded, smooth, scarcely tuberculated ; 1·64 (1·54—1·73) in length of head, diameter of eye 5·11 (3·82—5·90), inter-orbital width 2·02 (1·74—2·19). No barbels. 20 to 26 outer gill rakers on the lower part of the anterior arch. Length of disc 2·01 (2·47—3·00) in length of head, width 1·43 (1·28—1·64) in width of head ; length of disc 1·45 (1·30—1·67) in its own width. 48 to 52 scales in lateral line, 6·0, 6·5 or 7·0 from the origin of dorsal to lateral line, 3·5, 4·0 or 4·5 between this and pelvic. Scales on middorsal streak absent as a narrow streak from occiput to origin of dorsal fin. Chest and belly scaled. Dorsal 111, 9. Distance between the anterior origin of dorsal fin and tip of snout 2·24 (2·14—2·40) in standard length. Length of pectorals 1·04 (0·98—1·17) in length of head. Distance between anterior origins of pelvic and anal fins 1·93 (1·79—2·16) in that between anterior origin of pelvic and base of caudal fin. Anal 11, 5. Distance from vent to anal fin 1·46 (1·36—1·64) in that between anterior origins of pelvic and anal fins. Length of caudal 1·08 (0·93—1·20) in length of head, width 1·70 (—1·821·54) in its own length.

Posterior chamber of air bladder, measured in 4 specimens 2·73 (2·37—3·73) per cent in standard length.

Coloration.—In alcohol, no well defined markings.

Distribution.—Asia : China : Szechwan. Indo-China : Annam and Tonkgking.

Relationships.—This species is a member of the *imberbis* complex, being most closely related to *G. imberbis* as attested by a large scale count along lateral line, absence of barbels and a more anteriorly placed position of the vent. *G. imberba* is easily separated from *G. imberbis* by a larger scale—count along its lateral line (Text-fig. 22, Graph 1) and on the basis of its large size, this being the biggest species of *Garra* known the maximum size reaching up to about a foot in standard length.



TEXT-FIG. 22.—*Garra imberbis* compared with *G. imberba*.

Graph 1. Lateral line scales.

(c) The *Gotyla* group

This is a group of specialised species of *Garra* characterised by a well-developed proboscis on the top of the snout. It occurs from South China and Indo-China through the whole of India except Ceylon, to as far west as the western extremity of the great Himalayan range, the western most record being from the Swat River in Peshawar District. Itsr recop from Arabia (Hora, *op. cit.*) is considered erroneous (*vide infra*, p. 240).

This group appears to be related to the *lamta* complex, the closest being *lamta* itself and may have derived as an early offshoot of the *lamta* stock.

Included under this group are *gotyla gotyla*, *g. stenorhynchus*, *ryhnchota* and *nasutas*.

(i) The *Gotyla* complex

Garra gotyla gotyla, *G. g. stenorhynchus*, *G. rhynchota* and *G. nasuta* from the *gotyla* complex which is the only complex under the *gotyla*—group. The characteristics of the complex are, therefore, the same as given above for the group.

31. **Garra gotyla gotyla** (Gray)

(Plate XIII, Figs. 1-4.)

1832. *Cyprinus gotyla* Gray, *Ill. Ind. Zool.*, London, **1**, pl. 88, Figs. 3, 3*a*.

1839. *Garra bimaculatus* McClelland, *Asiatic Res.*, Calcutta, **19**, pp. 281, 374 [Type-loc. : " River. Laech at the foot of Mishmee mountains "].

1867. *Garra gotyla*, Steindachner, *Sitz. Ak. Wiss. Wien*, Vienna, **56** (1), p. 345, pl. 2, figs.

1872. *Discognathus lamta*, Day, *J. Asiat. Soc. Beng.*, Calcutta, **41** (2), p. 318.

1878. *Discognathus lamta*, Day (in part), *Fish India*, London, **2**, p. 527, pl. 123, fig. 1.

1889. *Discognathus lamta*, Day (in part), *Faun. Brit. Ind. Fish*, London, **1**, p. 346.

1889/90. *Discognathus lamta*, Vinciguerra, *Ann. Mus. stor. Nat. Genova*, Geneva, **29**, p. 275.

1919. *Garra kangrae* Prashad, *Rec. Indian Mus.*, Calcutta, **16**, p. 162, figs. 1, 1*a* [Type-loc. : Hill stream at Jaugal Khand, Kangra District, Punjab. Type in ZSI ; examined].

1919*a*. *Discongathus jerdoni* Var. *Kangrae* Annandale, *Rec. Indian Mus.*, Calcutta, **18**, p. 74.

1921. *Gara monti-salsa* Hora, *Rec. Indian Mus.*, Calcutta, **22**, p. 651 [Type-loc. : Nilwan ravine near the Shapur Salt Range, Punjab, Type in ZSI ; examined].

1921. *Garra lamta*, Hora (in part), *Rec. Indian Mus.*, Calcutta, **22**, p. 660.

1921. *Garra gotyla*, Hora, *Rec. Indian Mus.*, Calcutta, **22**, p. 653.

1936. *Garra gotyla*, Hora & Mukerji, *Rec. Indian Mus.*, Calcutta, **38**, p. 144.

1936. *Garra gotyla*, Hora, *Rec. Indian Mus.*, Calcutta, **38**, p. 318.

1937. *Garra gotyla*, Hora, *Rec. Indian Mus.*, Calcutta, **39**, p. 333.

1937*a*. *Garra gotyla*, Hora, *Rec. Indian Mus.*, Calcutta, **39**, p. 339.

1938. *Garra gotyla*, Hora, *Rec. Indian Mus.*, Calcutta, **40**, p. 176.

1941. *Garra gotyla*, Hora & Nair, *Rec Indian Mus.*, Calcutta, **43**, p. 369.

1949. *Garra gotyla*, Menon, *J. Bomb. Nat. Hist. Soc.*, Bombay, **48** (3), pp. 539, 541.

1950*a*. *Garra gotyla*, Menon, *Rec. Indian Mus.*, Calcutta, **47**, p. 299.

1950*b*. *Garra gotyla*, Menon, *Rec. Indian Mus.*, Calcutta, **47**, p. 233.

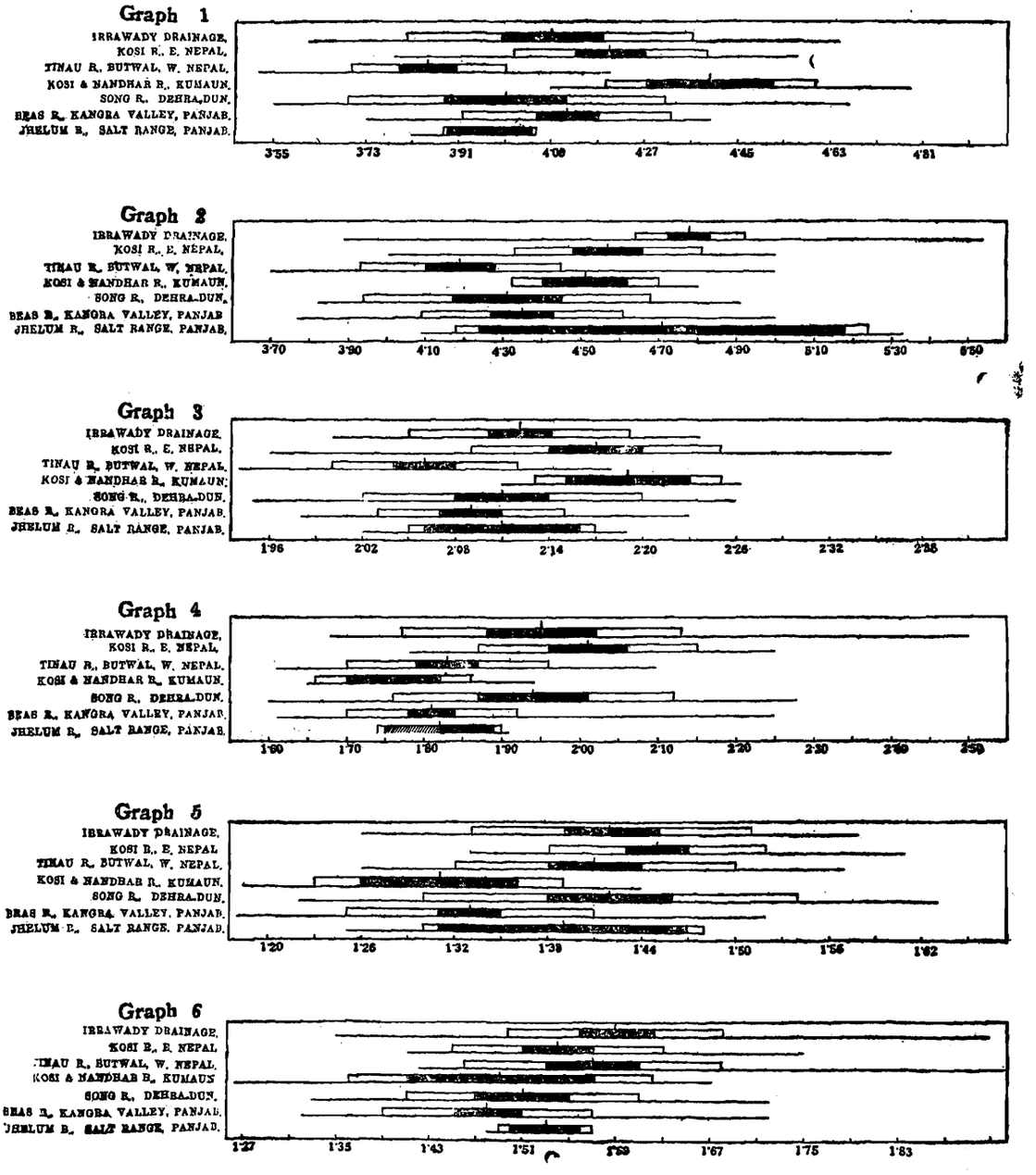
1954. *Garra gotyla*, Menon, *Proc. nat. Inst. Sci. India*, New Delhi, **22** (4), p. 480.

1955. *Garra gotyla*, Menon, *Rec. Indian Mus.*, Delhi, **52**, p. 22.

Specimens examined.—India : 26, 35·0 to 90·0 mm., from Manipur ; 3,50·0 to 127·0 mm. from Darjeeling ; 43, 35·0 to 142·5 mm., from Uttar Pradesh ; 84, 42·5 to 141·5 mm., from E. Punjab ; 56, 37·0 to 106·5 mm., from West Bengal ; 13, 52·0 to 99·0 mm., from Bihar. West Pakistan , 85·5 to 138·5 mm., from Peshwar. Nepal : 190, 26·0 to 61·5 from Kosi drainage, E. Nepal : 127, 38·5 to 90·5 mm., from Butwal ; 70, 35·0 to 57·0 mm., from Kerwani ; 4, 47·0 to 56·0 mm., from Bhaluri ; 21, 33·5 to 58·5 mm., from Nepalganj. Burma : 2, 90·5 to 115·0 mm., from Meekalan ; 2, 33·0 to 113·0 mm., from Myitkyina.

Description.—Depth of body 4·19 (3·70—5·00) in standard length, length of head 3·85 (3·52—4·20). Width of head 1·41 (1·26—1·57) in length of head, height of head 1·57 (1·42—1·92). Pupil of eye at or slightly behind the middle of the length of head. Inter-orbital region convex. Snout with a well-developed median proboscis and a transverse lobe at the tip. The free extremity of the proboscis, the transverse lobe and the lateral sides of of head in front of nostrils are covered with several large spiny tubercles, 1·83 (1·61—2·10)

in length of head, diameter of eye 4·49 (3·00—6·28), inter-orbital width 2·31 (2·06—2·62). Two pairs of barbels, the anterior as long as or shorter than diameter of eye, the posterior pair much smaller. 9 to 14 outer gill rakers on the lower part of the anterior arch. Length of disc 2·45 (2·22—2·87) in length of head, width 1·43 (1·15—1·67) in width of head ; length of disc 1·24 (1·00—1·43) in its own width. 32 to 35 scales in lateral line, 4·5 from the origin of dorsal to lateral line, 3·0 or 3·5 between this and pelvic, 9 to 10 scales on middorsal streak. Chest and belly scaled. 111, 7-8 ; distance between its anterior origin and tip of snout 2·06 (1·90—2·18) in standard length. Length of pectorals 1·18 (1·00—1·37) in length of head. Distance between anterior origins of pelvic and anal fins 1·89 (1·65—2·00) in that between anterior origin of pelvic and base of caudal fin. Anal 11, 5. Distance from vent to anal fin 5·16 (4·95—7·17) in that between anterior origins of pelvic and anal fins. Length



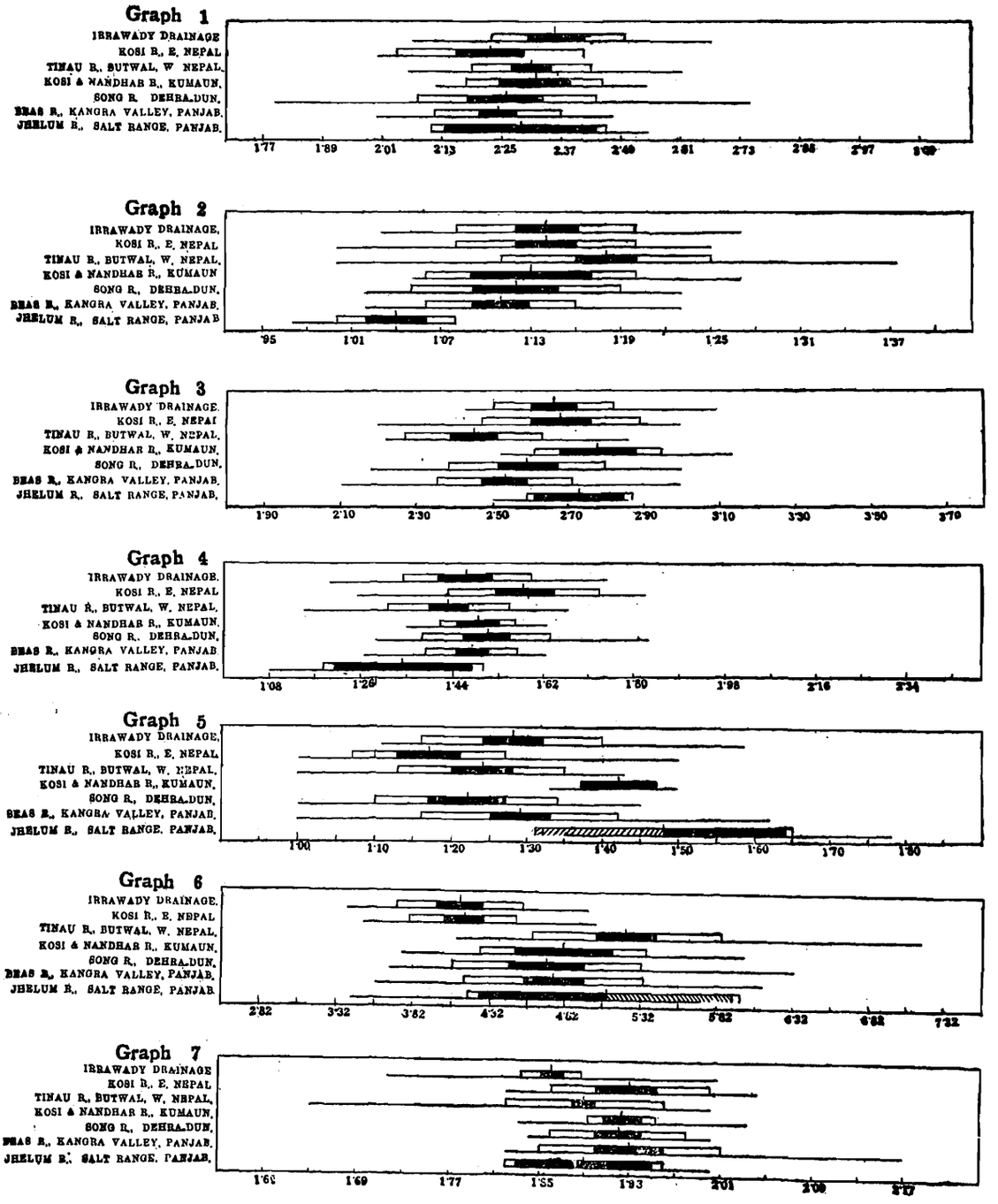
TEXT-FIG. 23.—Variations in different populations of *Garra gotyla* from the different drainages along the Himalayas.

Graph 1. Length of head in standard length. Graph 2. Depth of body in standard length. Graph 3. Distance between snout and dorsal fin in standard length. Graph 4. Length of snout in length of head. Graph 5. Width of head in length of head. Graph 6. Height of head in length of head.

of caudal peduncle 1·44 (1·28—1·75) in length of head, width 1·43 (1·20—1·70) in its own length.

Posterior chamber of air bladder, measured in 35 specimens 10·27 (4·51—22·07) per cent in standard length.

Coloration.—In alcohol, bluish grey above, yellowish beneath, a obscure mid lateral band in young specimens, a black spot behind the upper angle of the gill openings and a row of dark spots along the base of the dorsal fin.



TEXT-PIG. 24.—Variations in different populations of *Garra gotyla* from the different drainages along the Himalayas. (Continued).

Graph 1. Inter-orbital width in length of head. Graph 2. Length of pectoral in length of head. Graph 3. Length of disc in length of head. Graph 4. Width of disc in width of head. Graph 5. Length of disc in width of disc. Graph 6. Distance from vent to anal fin in distance between pelvic and anal fins. Graph 7. Distance between pelvic and anal fins in distance between pelvic and base of cauda].

Distribution.—Asia : India : Assam, all along the Himalayas, Chota-Nagpur plateau and the Vindhya-Satpura mountains of the Peninsula. Burma : Upper Burma West Pakistan : West Punjab to Peshawar.

Relationships.—This is evidently a very highly specialised species of *Garra* and can be easily distinguished by the presence of a well-developed median proboscis without any lateral lobes on the snout.

Remarks.—The proboscis on the snout exhibits considerable variation and on this account many different species were described in the past from the Himalayas. Having examined numerous specimens from the different drainages along the Himalayas and statistically compared them for the different taxonomic characters, I am convinced that they should all be referred to *G. gotyla gotyla.*

32. **Garra gotyla stenorhynchus** (Jerdon)

(Plate xiii, Figs. 5—10.)

1849. *Gonorhynchus stenorhynchus* Jerdon, *Madras J. Lit. Sci.*, Madras, **15**, p. 310 [Type-loc. : Bhawany River, Nilgiris].

1867. *Garra gotyla*, Day, *Proc. zool. Soc. Lond.*, London, p. 288.

1919. *Discognathus jerdoni*, Annandale (in part), *Rec. Indian Mus.*, Calcutta, **18**, p. 73, pl. 9, fig. 1 ; pl. 11, fig. 3.

1919. *Discognathus stenorhynchus*, Annandale, *Rec. Indian Mus.*, Calcutta, **18**, p. 74, pl. 9, fig. 3 ; pl. 11, fig. 4.

1919. *Discognathus gotyla*, Annandale, *Rec. Indian Mus.*, Calcutta, **18**, p. 75, pl. 10, fig. 1 ; pl. 11, fig. 6.

1920. *Garra jerdonia*, Rao, (in part), *Ann. Mag. Nat. Hist.*, London, (9) **6**, p. 53.

1920. *Garra stenorhynchus*, Rao, *Ann. Mag. Nat. Hist.*, London, (9) **6**, p. 53.

1921. *Garra stenorhynchus*, Hora (in part), *Rec. Indian Mus.*, Calcutta, **22**, p. 653.

1942. *Garra stenorhynchus*, Hora, *Rec. Indian Mus.*, Calcutta, **44**, p. 196.

1942. *Garra stenorhynchus*, Bhimachar, *Fisheries Bull. Dept. Agri. Mysore*, Bangalore, **1**, p. 38.

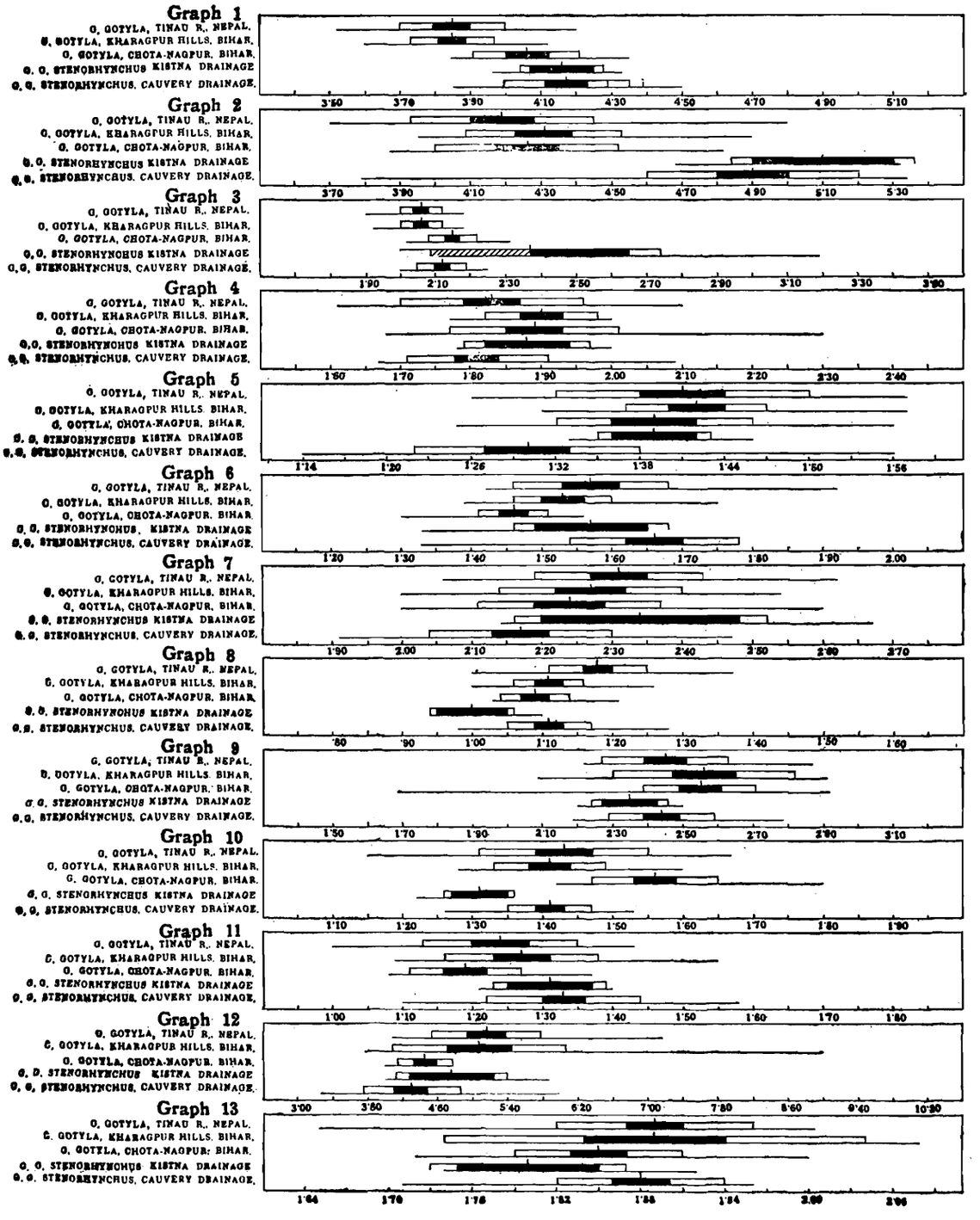
1955. *Garra stenorhynchus*, Rajan, *J. Bombay nat. Hist. Soc.*, Bombay, **53** (1), p. 45.

Specimens examined.—India : Madras State : 6, 85·5 to 155·0 mm., from Coimbatore District ; 49, 35·0 to 122·0 mm., from Nilgiri District ; Mysore State : 12, 77·0 to 108·5 mm., from Coorg ; Andhra State : 7, 47·0 to 85·5 mm., from Kurnool.

Description.—Depth of body 4·90 (3·79—5·34) in standard length, length of head, 4·17 (3·85—4·50). Width of head 1·30 (1·14—1·56) in length of head, height of head 1·66 (1·33—1·78). Pupil of eye at or slightly behind the middle of the length of head. Inter-orbital region convex. Snout with a well-developed median proboscis, and a transverse lobe at the tip. The free extremity of the proboscis, the transverse lobe and the lateral sides of head in front of nostrils are covered with several large horny tubercles 1·81 (1·67—2·09) in length of head, diameter of eye 4·51 (3·65—5·50), inter-orbital width 2·17 (1·91—2·47). Two pairs of barbels. the anterior pair as long as or shorter than diameter of eye, the posterior much shorter. 10 to 12 outer gill rakers on the lower part of the anterior arch. Length of disc 2·44 (2·19—2·79) in length of head, width 1·41 (1·26—1·53) in width of head ; length of disc 1·33 (1·10—1·58) in its own width. 32 to 35 scales in lateral line, 3·5 or 4·5 from the origin of dorsal to lateral line, 3·5 between this and pelvic 8 to 10 scales on middorsal streak. Chest and belly scaled. Dorsal 111, 7-8 ; distance between its anterior original and tip of snout 2·12 (2·00—2·25) in standard length. Length of pectorals 1·11 (0·98—1·28) in length of head. Distance between anterior origins of pelvic and anal fins 1·88 (1·71—1·96) in that between anterior origin of pelvic and base of caudal fin. Anal 11, 11, 5. Distance from vent to anal fin 4·31 (3·25—6·00) in that between anterior origins of pelvic and anal fins. Length of caudal peduncle 1·39 (1·16—1·77) in length of head, width 1·38 (1·21—1·52) in its own length.

Posterior chamber of air bladder, measured in 35 specimens 8·79 (3·66—17·58) per cent n standard length.

Coloration.—In alcohol, bluish grey above, paler beneath, a mid-lateral band in young specimens, a black spot placed anteriorly to the upper angle of the gill openings, and a row of well-defined dark spots at the base of the branched dorsal fin rays.



TEXT-FIG. 25.—Species of *Garra gotyla*. The Himalayan (Tinan River, Nepal) form is compared with populations from different drainages of the Peninsula.

Graph 1. Length of head in standard length. Graph 2. Depth of body in standard length. Graph 3. Distance betwen snout and dorsal fin in standard length. Graph 4. Length of snout in length of head. Graph 5. Width of head in length of head. Graph 6. Height of head in length of head. Graph 7. Inter-orbital width in length of head. Graph 8. Length of pectoral in length of head. Graph 9. Length of disc in length of head. Graph 10. Width of disc in width of head. Graph 11. Length of disc in width of disc. Graph 12. Distance from vent to anal fin in distance between pelvic and anal fins. Graph 13. Distance between pelvic and anal fins in distance between pelvic and base of caudal.

Distribution.—Asia : India : Cauvery and Kistna drainages, Western ghats.

Relationships.—This form is undoubtedly closely related to *G. gotyla* whose range extends all along the Himalayas and southwards as far as the Vindhya-Satpura mountains. It occurs in the Western-ghats south of the Vindhya-Satpura and is, therefore, most logically considered as a sub-species of *G. gotyla*. This form can, however, be easily separated from the typical *gotyla* by its more elongated body (Text-fig. 25, Graph 2).

Remarks.—The *gotyla* group seems to have crossed over the Garo-Rajmahal gap during a comparatively recent period and probably sufficient time has not lapsed for speciation to take place in the Peninsula ; further the members of the group are not found in Ceylon indicating that its spread southwards is of a recent period and that Ceylon had become a separate geographical entity before *gotyla* reached the Western-ghats (*vide infra*, p. 254).

33. **Garra rhynchota** Koller

1926. *Garra rhynchota* Koller, *Anz. Akad. Wiss. Mathnaturwiss*, Vienna, **13**, p. 121 [Type-loc. : Hai-nan Island, China].

1927. *Garra schismatorhyncha* Nichols & Pope, *Bull. Amer. Mus. nat. Hist.*, New York, **54**, p. 358, fig. 25 [Type-loc. : Hai-nan. Type in AMNH].

1927. *Garra lamta*, Koller, *Ann. Naturhist. Mus. Wien.*, Vienna, **41**, p. 32.

1943. *Garra rhynchota*, Nichols, *Natural History of Central Asia*, New York, **9**, p. 112, fig. 45.

Specimens examined.—China : 6, 84·0 to 159·0 mm., from Hai-nan.

Description.—Depth of body 4·22 (3·89—4·42) in standard length, length of head 4·36 (3·97—4·59). Width of head 1·31 (1·22—1·37) in length of head, height of head 1·36 (1·30—1·41). Pupil of eye almost in the middle of the length of head. Inter-orbital region convex. Snout with a prominent trilobed proboscis, the lateral lobes being small and in front of the nostrils and the tip of snout marked off by a deep transverse groove into a transverse lobe ; the free extremity of the proboscis, the transverse lobe and the lateral side of the head in front of nostrils are covered with several bony tubercles 1·84 (1·70—1·95) in length of head, diameter of eye 4·67 (4·33—5·36), inter-orbital width 2·46 (2·29—2·64). Two pairs of barbels, the anterior smaller than diameter of eye, while the posterior much smaller and hardly visible. 10 to 12 outer gill rakers on the lower part of the anterior arch. Length of disc 2·70 (1·40—1·60) in width of head ; length of disc 1·38 (1·25—1·54) in its own width. 33 to 34 scales in lateral line, 4·5 from the origin of dorsal to lateral line, 3·5 between this and pelvic 9 to 10 scales on middorsal streak. Chest and belly scaled. Dorsal iii, 7-8 ; distance between its anterior origin and tip of snout 2·12 (2·05—2·19) in standard length. Length of pectorals 1·06 (1·00—1·19) in length of head. Distance between anterior origins of pelvic and anal fins 1·98 (1·88—2·09) in that between anterior origin of pelvic and base of caudal fin. Anal ii, 5. Distance from vent to anal fin 5·82 (5·25—6·50) in that between anterior origins of pelvic and anal fins. Length of caudal peduncle 1·34 (1·30—1·37) in length of head, width 1·32 (1·28—1·36) in its own length.

Posterior chamber of air bladder, measured in 6 specimens 4·32 (3·18—5·43) per cent in standard length.

Coloration.—In alcohol, dark or brownish grey above, paler below, six longitudinal streaks of grey colour along the sides of the body, especially in the tail region, a black spot behind the upper angle of the gill openings and a row of very conspicuous dark spots along the base of the dorsal fin.

Distribution.—Asia : China : Hai-nan Island.

Relationships.—It is interesting to note that this island species is most closely related to *G. nasutus*. It is, however, easily separated from the mainland species by the position of its vent (Text-fig. 26). Judging from the more posterior position of the vent in *rhynchota* this species seems to be closer to the ancestral form which gave rise to these two species.

34. **Garra nasuta** (McClelland)

(Plate XIII, Figs. 11-12)

1838. *Platycarda nasuta* McClelland, *J. Asiat. Soc. Beng.*, Calcutta, **7**, (2), p. 947, pl. 55, figs. 2, 2*a*, 2*b* [Type-loc. : " Kasya mountains ", Assam.Type in USNM, probably a syntype or a topotype ; examined].

1839. *Platycarda nasuta* McClelland, *Asiatic Res*, **19**, p. 300, pl. 67, fig. 2.

1839. *Gonorhynchus caudatus* McClelland, *Asiatic Res.*, **19**, p. 375 [Type-loc. : 'Kasya mountains'].

1869. *Discognathus nasutus*, Gunther, *Cat. Brit. Mus. Fish.*, London, **7**, p. 70.

1925. *Garra orientalis* Nichols, *Amer. Mus. Novit.*, New York, **185**, p. 4 [Type-loc. : Fukien, S. China. Type in AMNH].

1928. *Discognathus bourreti* Pellegrin. *Bull. Soc. Zool. Fr.*, Paris, **53**, p. 340 [Type-loc, : River Claire, Tongking. Type in MHNP ; examined].

1934. *Garra fuliginosa* Fowler, *Proc. Acad. Nat. Sci. Phild.*, Philadelphia, **86**, p. 139, figs. 108, 109, 110 and 111 [Type-loc. : " Metang River, 35 miles north of Chieng Mai, North Siam " ; Type in ANSP].

1934. *Garra salweenica* Hora and Mukerji, *Rec. Indian Mus.*, Calcutta, **36**, p. 365, figs. 4, 5 [Type-loc, : " The Salween River at Takaw Kengtung State, southern Shan State, Burma ". Type in ZSI ; examined].

1943. *Garra orientalis*, Nichols, *Natural History of Central* Asia, New York, **9**, p. 111, fig. 44.

Specimens examined.—India : 1, 103·0 mm., from Assam. Burma : 2, 72·0 & 105·0 mm., from S. Shan States. 4, 101·0 to 108·0 mm., from Sittang system, China : 1, 61·0 mm., from Fukien ; 2, 73·0 to 88·0 mm., from Szechuan. Indo-China : 1, 146 mm., from Tongking.

Description.—Depth of body 4·37 (3·89—5·72) in standard length, length of head 4·35 (3·93—4·64). Width of head 1·29 (1·19—1·41) in length of head, height of head 1·41 (1·28—1·70). Pupil of eye slightly behind the middle of the length of head. Inter-orbital region convex. Snout with a prominent trilobed proboscis, the lateral lobes being small and in front of the nostrils and the tip of snout marked off into a transverse lobe ; the free extremity of the proboscis, the transverse lobe and the lateral sides of the head in front of nostrils are covered with several horny tubercles ; 1·74 (1·64—1·94) in length of head, diameter of eye 4·57 (3·20—6·25), inter-orbital width 2·39 (2·00—3·67). Two pairs of barbels, the anterior smaller than the diameter of eye, while the posterior much smaller and hardly visible. 10 to 12 outer gill rakers on the lower part of the anterior arch. Length of disc 2·47 (2·07—2·78) in length of head, width 1·52 (1·33—1·77) in width of head ; length of disc 1·26 (1·13—1·40) in its own width. 33 to 34 scales in lateral line, 4·5 from the origin of dorsal to lateral line, 3·5 between this and pelvic. 9 to 10 scales on middorsal streak. Chest and belly scaled. Dorsal 11, 8 ; distance between its anterior origin and tip of snout 2·16 (2·02—2·28) in standard length. Length of pectorals 1·07 (0·91—1·24) in length of head. Distance between anterior origins of pelvic and anal fins 1·86 (1·82—2·05) in that between anterior origin of pelvic and base of caudal fin. Anal 1-11, 5. Distance from vent to anal fin 4·42 (3·71—5·25) in that between anterior origins of pelvic and anal fins. Length of caudal peduncle 1·30 (1·14—1·55) in length of head, width 1·28 (1·14—1·41) in its own length.

Posterior chamber of air bladder, measured in 8 specimens 5·17 (2·86—6·93) per cent in standard length.

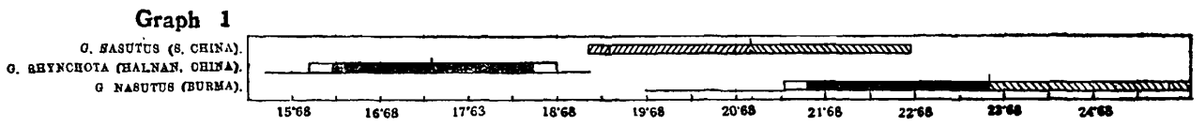
Coloration.—In alcohol, dark grey above, paler beneath, six longitudinal grey streaks along the sides of the body, especially in the tail region, a black spot behind the upper angle of the gill openings and a row of dark spots along the base of the dorsal fin.

Distribution.—Asia : Assam, Burma, S. China and Indo-China.

Relationships.—This species is outstanding due to the proboscis being trilobed in the way described above. The trilobed condition in *G. bicornuta* (*vide*, p. 120) is due to the development of two horn-like structures in front of the eyes and above the nostrils and

not in the way described for this species. The only other species in which the structure of the proboscis is similar to this species is *G. rhynchota*, but the two can be easily separated by the relative position of their vents. The vent is more anteriorly placed in this species than in *rhynchota* (Fig. 26).

Remarks.—*G. arabica* Hora (1921, p. 677) described from S. W. Arabia seems to be *G. nasutus* in every respect. I have examined the types of *G. arabica* and I have not been able to find any difference whatsoever between these two species. In this connection the following remarks made by Trewavas (1937, *l.c.*, p. 8) while discussing the affinities of the Arabian species of *Garra* is worth quoting : " *Garra arabica* Hora (1921 : 677, fig. 5) was described from specimens from Lahej (Wadi Tiban drainage system) presented to the Indian Museum by Dr. W. T. Blanford. Specimens presented to the British Museum by Dr. Blanford, from the same locality, are here included in *G. tibanica* and could not possibly be mistaken for *G. arabica*. Dr. Hora had kindly lent me a co-type of *G. arabica*, which is evidently closely related to *G. gotyla* (Gray) of the waters at the base of the Himalayas and to *G. stenorhynchus* (Jerdon) of Southern India. It is surprising that a member of this rather specialised Indian section of the genus should be found at Aden, and it is desirable that future collectors should search for it in the Wadi Tiban basin, so that its locality may be confirmed, if possible ". After examining all material of *Garra* from the Wadi Tiban drainage and after having failed to find a single specimen with a well-defined proboscis on the snout, I have come to the conclusion that probably it was due to some mistaken labelling that certain specimens of *G. nasutus* were happened to be described as *G. arabica*. I have, therefore, not considered *G. arabica* as a valid species.



TEXT-FIG. 26.—*Garra rhynchota* compared with *G. nasuta*.

Graph 1. Distance between pelvic and anal fins into distance from vent to anal fin in percents.

(d) *Spieces of doubtful relationships*

G. notata, *G. gravelyi* and *G. bicornuta* cannot be placed in any of the foregoing species complexes or groups ; their relationships are rather obscure. White *notata* can be placed in the *tibanica* complex of species and *gravelyi* and *bicornuta* in the *gotyla* group for purpose of convenience they have not been done so ; *G. notata* and *G. gravelyi* are, however, considered as hanging relicts (*vide*, Briggs, 1955, p. 150) while *bicornuta* a product of convergent evolution.

35. **Garra notata** (Blyth)

1860. *Platycara notata* Blyth *J. Asiat. Soc. Beng.*, Calcutta, **29**, p. 161 [Type-loc. : **Tenasserim**, Burma, Type in ZSI ; examined].

1921. *Garra notata*, Hora, *Rec. Indian Mus.*, Calcutta, **22**, p. 670.

Specimens examined.—Burma :—4, 45·5 to 53·5 mm., from Tenasserim.

Description.—Depth of body 4·06 (3·64—4·55) in standard length, length of head 4·10 (3·96—4·25). Width of head 1·39 (1·35—1·44) in length of head, height of head 1·62 (1·60—1·64). Pupil of eye at or slightly in front of the middle of the length of head. Inter-orbital region somewhat convex. Snout smooth, rounded, 2·43 (2·17—2·67) in length of head, diameter of eye 4·51 (4·33—4·80), inter-orbital width 2·41 (2·30—2·60) .Two pairs of barbels, the rostrals are longer than diameter of eye, while the maxillary much smaller and hardly visible. 9 to 10 outer gill rakers on the lower part of the anterior arch. Length of disc 3·24 (2·89—3·83) in length of head, width 1·88 (1·70—2·12) in width of head ; length of disc 1·23

(1·11—1·33) in its own width. 34 scales in lateral line, 5·0 or 5·5 from the origin of dorsal to lateral line, 4·5 between this and pelvic. 14 to 16 scales on middorsal streak. Chest and belly naked. Dorsal 11, 7—8 ; distance between its anterior origin and tip of snout 1·93 (1·88—1·96) in standard length. Length of pectorals 1·14 (1·08—1·18) in length of head. Distance between anterior origins of pelvic and anal fins 1·99 (1·83—2·18) in that between anterior origin of pelvic and base of caudal fin. Anal 11, 5. Distance from vent to anal fin 9·79 (7·33—12·00) in that between anterior origins of pelvic and anal fins. Length of caudal peduncle 1·50 (1·33—1·62) in length of head, width 1·29 (1·21—1·38) in its own length.

Posterior chamber of air bladder, measured in 2 specimens 23·00 (22·64—23·36) per cent in standard length.

Coloration.—In alcohol, dark brown above, whitish below, a black spot behind the upper angle of the gill openings and a series of black spots at the base of the dorsal fin-rays.

Distribution.—Asia : Burma, Tenasserim.

Relationships.—A relict species with no known close relatives.

36. **Garra gravelyi** (Annandale)

1889/90. *Discognathus lamta*, Viniciguerrra, *Ann. Mus. stor. nat. Genova*, Geneva, **29,** pp. 275, 279.

1918. *Garra lamta*, Annandale, *Rec. Indian Mus.*, Calcutta, **14,** p 45.

1919. *Discognathus gravelyi* Annandale, *Rec. Indian Mus.*, Calcutta, **16,** p. 133, pl. 2, figs, 3, *3a* [Type-loc. : He-Ho Stream, S. Shan State, Burma. Type in ZSI ; examined].

1921. *Garra gravelyi*, Hora, *Rec. Indian Mus.*, Calcutta, **22,** p. 654.

1952. *Garra gravelyi*, Satyamurthi, *J. Beng. nat. Hist. Soc.*, Darjeeling, **35,** p. 160.

Specimens examined.—Burma : 2, 86·5 and 95·0 mm., from S. Shan State., 2, 111·5 and 118·5 mm., from Lawksawk State ; 1, 90·0 mm., from Inle Lake.

Description.—Depth of body 4·22 (3·88—4·74) in standard length, length of head 4·78 (4·55—5·00). Width of head 1·44 (1·39—1·48) in length of head, height of head 1·36 (1·26—1·41). Pupil of eye at or slightly behind the middle of the length of head. Inter-orbital region somewhat convex. Snout somewhat pointed, a transverse groove at the tip and an incipient proboscis represented by a prominent squarish area in front of nostrils ; the transverse groove at the tip and an incipient proboscis represented by a prominent squarish area in front of nostrils; the transverse lobe at the tip of snout and the tip of the proboscis scarcely tuberculated ; 1·93 (1·78—2·17) in length of head, diameter of eye 4·11 (3·60—4·45), inter-orbital width 2·21 (1·95—2·45). Two pairs of barbels, subequal, shorter than diameter of eye. 12 to 14 outer gill rakers on the lower part of the anerior arch. 12 to 14 outer gill rakers on the lower part of the anterior arch. Length of disc 2·87 (2·53—3·54) in length of head, width 1·66 (1·43—2·15) in width of head ; length of disc 1·21 (1·08—1·29) in its own width. 32 to 34 scales in lateral line, 3·5, 4·0 or 4·5 from the origin of dorsal to lateral line, 3·5 between this and pelvic 8 to 9 scales on middorsal streak. Chest and belly scaled. Dorsal 11, 7 ; distance bteween its anterior origin and tip of snout 2·19 (2·11—2·31) in strandard length. Length of pectorals 0·99 (0·95—1·03) in length of head. Distance between anteior origins of pelvic and anal fins 1·91 (1·84—1·98) in that between anterior origin of pelvic and base of caudal fin. Anal 11, 5. Distance from vent to anal fin 4·08 (3·50—4·80) in that between anterior origins of pelvic and anal fins. Length of caudal peduncle 1·23 (1·15—1·33) in length of head, width 1·39 (1·24—1·50) in its own length.

Posterior chamber of air bladder, measured in 3 specimens 9·65 (5·83—17·22) per cent in standard length.

Coloration.—In alcohol, dark grey, pale white beneath, indistinct mid-lateral band with a few incomplete narrow longitudinal stripes above and below it especially on the sides

of the caudal peduncle, a black spot at the upper angle of the gill opening and a few indistinct black spots at the bases of the branched dorsal fin rays.

Distribution.—Asia : Burma, S. Shan State.

Relationships.—This species is not very closely related to any other *Garra*. The peculiar incipient proboscis on the snout is found only in this species and in this character it is probably a primitive form. I am, however, inclined to consider it as a relict species, from a Zoo-geographical point of view.

37. **Garra bicornuta** Rao

(Plate xiii Figs. 13-15)

1920. *Garra bicornuta* Rao, *Ann. Mag. Nat. Hist.*, London, (9) **6**, p. 57, pl. I, figs. 3, 3*a*, 3*b* [Type-loc. " River Tunga in Shimoga (Mysore State) ". Type in BM, " type and two co-types "; "ZSI three syntypes ", examined].

1921. *Garra bicornuta*, Hora, *Rec. Indian Mus.*, Calcutta, **22**, p. 651.

1942. *Garra bicornuta*, Hora, *Rec. Iniadn Mus.*, Calcutta, **44**, p. 196.

1941. *Garra bicornuta*, Bhimachar and Rao, *J. Mys. Univ.*, Bangalore, (N.S.) **1**(16), p. 146.

1942. *Garra bicornuta*, Bhimachar, *Fisheries Bull. Dept. Agri. Mysore*, Bangalore, **1**, p. 38.

Specimens examined.—India :—8, 73·0 to 100·5 mm., from Thunga system, Mysore.

Description.—Depth of body 4·10 (3·73—4·50) in standard length, length of head 4·67 (4·42—5·23). Width of head 1·34 (1·26—1·44) in length of head, height of head 1·37 (1·26—1·44). Pupil of eye at or slightly behind the middle of the length of head. Inter-orbital region convex. Snout with a well developed trilobed proboscis the lateral lobes arising above the nostrils and a transverse lobe at the tip of the anout ; the free extremity of the medium lobe, the transverse lobe and the lateral sides of the head in front of nostrils are covered with horny tubercles ; 1·76 (1·65—1·89) in length of head, diameter of eye 3·38 (3·00—3·80), inter-orbital width 2·15 (1·41—2·77). One pair of short rostral barbels. 11 to 12 outer gill rakers on the lower part of the anterior arch. Length of disc 2·71 (2·45—2·87) in length of head, width 1·70 (1·62—1·85) in width of head ; length of disc 1·19 (1·00—1·33) in its own width. 31 to 32 scales in lateral line, 3·5 from the origin of dorsal to lateral line, 2·5, 3·0 or 3·5 between this and pelvic, 8 to 9 scales on middorsal streak, the chest and abdomen scaled. Dorsal 11, 9 ; distance between the anterior origin of dorsal fin and tip of snout 2·18 (2·08—2·44) in standard length, Length of pectorals 0·95 (0·89—1·03) in length of head. Distance between anterior origins of pelvic and anal fin 1·89(1·80—2·05) in that between anterior origin of pelvic and base of caudal fin. Anal 1-11, 5. Distance from vent to anal fin 4·04 (3·30—4·91) in that between anterior origins of pelvic and anal fins. Length of caudal peduncle 1·35 (1·19—1·48) in length of head, width 1·21 (1·13—1·38) in its own length.

Posterior chamber of air bladder, measured in 2 specimens 19·29 (17·86—20·73) per cent in standard length.

Coloration.—In alcohol, dark brown above, pale yellowish below, an indistinct mid-lateral band from behind the gill openings to the base of caudal and a black spot at the upper angle of the gill openings.

Distribution.—Asia : India, Thunga system, Mysore.

Relationships.—This well-defined species is easily separated from the other member of the genus. It is so far known only from the Thunga River in Mysore and there is no known close relative to this species. It may have been derived from the *lamta* complex ; its resemblance to *gotyla* is due to convergent evolution and not due to its having evolved from a *gotyla-like* ancestor.

VII—ARTIFICIAL KEY TO THE SPECIES OF *Garra*

1a. Barbels absent.

2a. Scales in lateral line 44 to 45 ; gill rakers 28 to 30. Burma and Indo-china . . *imberbis*

2b. Scales in lateral line 48 to 52 ; gill rakers 22 to 26. South China and Indo-China *imbreba*

1b. Barbels present.

3a. A pair of barbels.

4a. Mental disc weakly developed without free posterior margin, barbels maxillary.

5a. Back, chest and abdomen scaled, origin of anal fins midway between origin of pelvic and base of caudal ; gill rakers 16 to 18. Syria & Iraq *variabilis*

5b. Back, chest and abdomen naked ; origin of anal fin distinctly nearer origin of pelvic than base of caudal ; gill rakers 9 to 11. E. Persia, Afghanistan and Beluchistan *rossica*

4b. Mental disc well defined with free posterior margin ; barbels rostral.

6a. Proboscis absent. Siam and Malaya .. .. *taeniata*

6b. A trilobed proboscis. Mysore .. .. .. *bicornuta*

3b. Two pairs of barbels.

7a. Proboscis absent.

8a. A series of dark spots at the base of the branched dorsal fin rays.

9a. Gill rakers 12 to 20 (a well defined dark lateral band with black pigmentation of considerable intensity in freshly preserved specimens).

10a. Head length 5 (4·50—6·00) times in standard length. Oman and Arabia .. .. *barreimia*

10b. Head length about 4·5 (3·60—5·07) times in standard length.

11a. Origin of anal fin nearer origin of pelvic than base of caudal. Syria and Palestine .. *rufa rufa*

11b. Origin of anal fin midway between origin of pelvic and base of caudal. Armenia, Iraq and Persia . *rufa obtusa*

9b. Gill rakers 9 to 11 (A pale lateral band with pigmentation of lesser intensity, well defined in young specimens, but merging with the upper grey in bigger examples).

12a. Vent located close to the base of anal fin ; distance of vent from base of anal fin more than 5 times in that between anterior origins of pelvic and anal fins.

13a. Scales in lateral line 31 to 36.

14a. Back naked. 31 to 34 scales in lateral line Eritrea *etheleynnae*

15a. Chest and belly naked ; scales in lateral line 34. Tenasserim, Burma *notata*

15b. Chest and belly scaled ; scales in lateral line 31 to 36. South-west Arabia and Somaliland *tibanica*

13b. Scales in lateral line 38 to 40. Abyssinia .. .. *makiensis*

12b. Vent located considerable distance in advance of base of anal fin ; distance of vent from base of anal fin 5 or less than 5 times in that between anterior origins of pelvic and anal fins.

16a. Distance of vent from base of anal fin 4 to 5 times in that between anterior origins of pelvic and anal fins

17a. Back fully scaled ; chest and belly scaled ; scales in lateral line 34 to 36. Abyssinia and Eritrea .. *quadrimaculata*

17b. Back not fully scaled (scales on middorsal streak absent), chest and belly naked; scales in lateral line 34 to 36 or 37. The Kahha and the Angrab streams, Abyssinia .. *ignesti*

16b. Distance of vent from base of anal fin 3 to 4 times in that between anterior origins of pelvic and anal fins.

18a. Depth of body less than 5 times in standard length. Scales in lateral line 36. Nigeria *trewavasi*

18b. Depth of body 5 or more than 5 times in standard length.

19a. Scales in lateral line 34 to 37 or 38. Belgium, Congo, French Equatorial Africa and French Guinea *ornata*

19b. Scales in lateral line 38 to 42. Eritrea, Abyssinia and Kenya *dembeensis*

8b. No such dark spot at base of branched dorsal rays.

20a. Scales in lateral line 34 or fewer.

21a. Tip of snout marked off by a deep transverse groove.

22a. A dark lateral band bordered above and below by light pale stripes especially in the posterior region.

23a. Distance of vent from base of anal fin less than 4 times in that between anterior origins of anal and pelvic fins.

24a. Length of head about 4 times in standard length.

25a. Inter-orbital width about 2 times in head length. Width of disc about 2 times in width of head. Peninsular India *mullya*

25b. Inter-orbital width more than 2 times in head length; width of disc less than 2 times in width of head. Ceylon. *Ceylonensis*

24b. Length of head less than 4 times in standard length. Gammaduwa *ceylonensis phillipsi*

23b. Distance of vent from base of anal fin more than 4 times in that between anterior origins of anal and pelvic fins. Himalayas, India *lamta*

21b. Tip of snout not marked off by a deep transverse groove.

22b. A pale lateral band without any lateral stripes.

26a. A light black bar across the dorsal and a broad, back W-shaped band across the caudal fins

27a. Back and post-pelvic regions scaled. Assam, India *lissorhynchus*

27b. Back and post-pelvic regions naked. Assam, India *rupecula*

26b. Dorsal and caudal without any markings.

28a. Distance of vent from base of anal fin about 3 times in that between anterior origin of pelvic and anal fins; scales in lateral line 33-34. Nepal and Darjeeling Himalayas, India *annandalvi*

28b. Distance of vent from base of anal fin 2·13 (1·89—2·45) times in that between anterior origins of pelvic and anal fins. Scales in lateral line 28-31. N. Borneo . *borneensis*

20b. Scales in lateral line 35-10.

29a. Vent located close to base of anal fin; distance of vent from the base of anal fin more than 5 times in that between anterior origins of pelvic and anal fins.

30a. Scales in lateral line 40. Yunnan, South China *yunnanensis*

30b. Scales in lateral line 36-38. Tongking, Indo-China *gracilis*

29b. Vent located considerable distance in advance of the base of anal fin; distance of vent from base of anal fin less than 5 times in that between anterior origins of pelvic and anal fins.

31a. Origin of dorsal distinclty nearer tip of snout than base of caudal. Canvery River, Western-ghats, Peninsular India *mcClellandi*

31b. Origin of dersal almost midway between tip of snout and base of caudal.

32a. Back scaled ; scales in lateral line 38-40.
33a. Vent situated almost midway between anterior origins of anal and ventral fins (distance of vent from base of anal fin 2·01 (1·83—2·20) times in that between the origins of pelvic and anal fins) Assam, India . . . . . *kempi*
33b. Vent not situated midway between anterior origins of anal and ventral fins. (Distance of vent from base of anal fin 2·49 (2·143·05) times in that between the origins of pelvic and anal fins. Assam, India . . . . . *naganensis*
32b. Back naked ; scales in lateral line 36-38. Kardamon and Palni Hills, Western Ghats . . . . . *hughi*

7b. Proboscis present.
34a. Proboscis trilobed.
35a. Distance of vent from base of anal fin 4·49 (4·00—5·25) times in that between origins of pelvic and anal fins. India (Khasi Hills), Burma, South China and Indo-China . . . . . *nasuta*
35b. Distance of vent from base of anal fin 5·82 (5·25—6·50) times in that between origins of pelvic and anal fins. Hainan . . *rhynchota*
34b. Proboscis a single projection without lateral lobes.
36a. Proboscis weakly developed without lateral tubercular area. South Shan States, Burma . . . . . *gravelyi*
36b. Proboscis well-developed with well-defined lateral tubercular area.
37a. Depth of body less than 5 times in standard length. Himalayas, Chota-Nagpur and Vindhya-Satpuras . . . *gotyla gotyla*
37b. Depth of body about 5 or more than 5 times in standard length. Western Ghats, Peninsular India . . . . *gotyla stenorhynchus*

VIII—EVOLUTION

The analysis of the major evolutionary trends in *Garra* is based on the following propositions :—

1. Development of a posterior free border to the suctorial disc is considered specialisation, the primitive structure being without a free posterior border.

2. Shifting of the vent forwards away from the base of the anal fin is considered a feature of great evolutionary significance within the genus. Hora (1930) has shown that the sucker is not an effective organ in torrential fish. In the case of torrential fish living on exposed surface of rocks it has been noticed that the fish orient themselves with the head against the current in an effort to prevent them from being lifted up from the substratum by water running beneath the fish. In such circumstances the tendency of the fish is to press the anterior part of the body more and more downwards in an effort to cling closer and closer to the bottom. This effort to utilise more and more the anterior part of the body for the purpose of adhesion is probably accompanied by a gradual flattening of the head and the anterior part of the body and certain changes in the disposition of the viceral organs. A careful study of the correlation of the position of the vent and the changes in the disposition of the viceral organs especially the intestine will be useful and is likely to yield interesting results. A gradual shifting forwards of the vent is, however, a most interesting feature of *Garra* and is considered of great systematic significance within the genus.

3. Reduction of the length of the air bladder accompanies specialisation. This is axiomatic as far as the evolution of torrential fish is concerned (Hora, *l.c.*, pp. 256-257). When a fish enters fast-flowing waters, buoyancy will be a disadvantage for the fish must tend to live near the bottom or in fact it must take to the ground habit of life.

4. Well-developed proboscis on the top of snout is considered specialisation for life in fierce currents. In turbulent waters a rounding off of the contours of the animals living there is generally considered a great necessity, since it helps them to offer less resistance to the current. But, Hora (1930, *l.c.*, p. 255) has adduced evidences to show how certain animals living in fiercest currents still possess spines on the surface. He explains the phenomenon by quoting Gibson (1923) who stated "that in some such bodies as spheres and cylinders the law of resistance may change widely with comparatively small alterations in the

conditions ; thus for example, at certain speeds the resistance of a sphere may actually be reduced by roughening the surface". The proboscis in *Garra* obstructs the current and probably makes it flow at a low velocity in the neighbourhood of the body.

With the foregoing propositions in mind it is now possible to place the various groups of species into their proper phylogenetic relationship.

The *variabilis*-group represents the most primitive known group of species within the genus. The adhesive apparatus is comparatively little differentiated in this group of species, the posterior free border being always absent. The posterior chamber of the air-bladder is cylindrical and well-developed, there is no proboscis on the snout and the vent is located close to the base of the anal fin.

Next is the *tilanica*-group differentiated by a well-developed suctorial disc and a smooth snout. Included in this group are *tibanica*, *rufa*, *lamta*, *lissorhynchus*, *taeniata*, *yunnanensis* and *imberbis* complexes. Of these, *tibanica* complex is the most primitive, *i.e.*, nearest to the *variabilis*-group, the air bladder being less specialised in this than in any other complex. *G. tibanica* characterised by the vent located close to the anal base is considered as the most primitive species within this complex. *Tibanica*, *quadrimaculata*, *ignesti*, *ornata* and *trewavasi* are all closely related species and in all probability evolved from the same stock. *Makiensis* and *dembeensis* show an increased lateral-line scale count and may have been derived from an early offshoot of the *tibanica*-stock. Of these two species, *makiensis* seems to be more primitive in that it has a vent position close to the anal base. *Ethelywynnae* is a small sized species with the vent situated close to anal base. It is considered as an offshoot of the *tibanica*-stock.

Tibanica—rufa—lamta complexes show certain features in common though they can be easily separated by the use of such characters as the colour pattern, the lateral line scale-count, the number of gill rakers and the nature of the snout. *Tibanica—rufa—lamta* complexes have no doubt originated from an ancestral *Garra* of a primitive type given off the *variabilis*-stock at an early period in the evolutionary history of the genus. I consider this stock as the main evolutionary stock with *tibanica* as the most primitive and *lamta* a specialised complex marked by such characters as a reduced air bladder, a reduced number of scales along the lateral line and a more limpet-like shape of the body.

Of the other complexes within the *tibanica*-group, *lissorhynchus* and *taeniata* complexes are very close to the *lamta* complex and have probably been evolved as a offshoot of the *lamta*-stock. *G. lamta* is a Himalayan species whereas the members of the *lissorhynchus* and *taeniata* complexes are found in the Assam and the Malayan regions respectively, where in isolation they have diverged from each other, however, retaining certain basic similarities between them.

The *yunnanensis* complex consists of a number of species whose principal characteristics are elongated body, an increased lateral line scale-count and a colour pattern devoid of any of the characteristic markings which distinguish the other complexes of this group. This complex in all probability may have been derived from a primitive survivor of the main evolutionary stock. Included in the *yunnanensis* complex are the following species : *yunnanensis*, *gracilis*, *naganensis*, *kempi*, *mcClellandi* and *hughi*. Of these, I consider *yunnanensis* as the most primitive in that it has the vent situated very close to the anal base. *Gracilis* is very little differentiated from *yunnanensis*, but the other species namely, *naganensis*, *kempi*, *mcClellandi* and *hughi* are all much specialised (*vide*, Fig. 21, Graph 5).

Imberbis complex characterised by a still larger number of scales along the lateral line and a more anteriorly placed position of the vent is considered as an early offshoot of the *yunnanensis*-stock.

The *gotyla* group represents an important step forward in the evolutionary history of the genus, the development of proboscis on the top of the snout being a highly adaptive modification for life in fiercest currents. The *gotyla*-group has, however, many similarities with the *lamta* and is therefore, considered as an early offshoot of the *lamta* complex

me of evolution of Garra

s French Guinea in West Africa. The geographical distribution of the known species of *Garra* is given in the following table.

ABLE 1.

the Known Species of Garra.

A			S				I					A				
th West Asia						South East Asia India						South East Asia				
							Peninsular India		Vindha, Satpura and Chota-Nagpur	Assam	Burma	S. China and Hainan	Indo China	Siam	Malaya	Borneo
Syria	Armenia	Iraq	Persia	Afghanis-than	Beluchis-than	Himalaya	Ceylon	W. Ghats								
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11

IX.—Zoogeograph

(a) *Place and time of evoluti*

The species of *Garra* are wide-spread, being distributed from South China and Borneo in the East to as far westwards as French Gui

Table 1.

Distributional Table of the Known

Species	A	F	R	I	C	A		A				
	West Africa		Central Africa	East Africa				South West Asia				
	French Guinea	Nigeria	French Equi-torial Africa	Belgian Congo	Kenya	Abyssinia	Eritrea Somali-land	S. W. Arabia	S. E. Arabia (Oman)	Pales-tine	Syria	Armen
The variabilis group												
The variabilis complex—												
1. *Garra variabilis* (Heckel)	—	—	—	—	—	—	—	—	—	—	+	—
2. *Garra rossica* (Wikolsky)	—	—	—	—	—	—	—	—	—	—	—	—
The tibanica group												
The tibanica complex—												
3 *Garra tibanica* Trewavas.	—	—	—	—	—	—	+	+	—	—	—	—
4 . *Garra quadrimaculata* (Rupell)	—	—	—	—	—	+	+	—	—	—	—	—
5. *Garra ignestii* (Gianferrari)	—	—	—	—	—	+	—	—	—	—	—	—
6. *Garra ornata* (Nichols and Griscar)	+	—	+	+	—	—	—	—	—	—	—	—
7. *Garra trewavasi* Monod	—	+	—	—	—	—	—	—	—	—	—	—
8. *Garra makiensis* (Boulenger)	—	—	—	—	—	+	—	—	—	—	—	—
9. *Garra dembeensis* (Rupell)	—	—	—	—	+	+	+	—	—	—	—	—
10. *Garra ethelwynnae* Menon	—	—	—	—	—	—	+	—	—	—	—	—
The rufus complex—												
11. *Garra rufa rufa* (Heckel)	—	—	—	—	—	—	—	—	—	+	—	—
12. *Grra obtusa* (Heckel)	—	—	—	—	—	—	—	—	—	—	—	—
13. *Garra barreimiae* Fowler and Steinitz	—	—	—	—	—	—	—	—	+	—	—	—
The lamta complex—												
14. *Garra lamta* Ham.	—	—	—	—	—	—	—	—	—	—	—	—
15. *Garra mullya* (Sykes)	—	—	—	—	—	—	—	—	—	—	—	—
16. *Garra ceylonensis ceylonensis* Bleeker	—	—	—	—	—	—	—	—	—	—		
17. *Garra c. phillipsi* Deraniyagala	—	—	—	—	—	—	—	—	—	—		
18. *Garra annandalei* Hora	—	—	—	—	—	—	—	—		—		

TABLE 1—*contd.*

Table of the Known Species of Garra—*contd.*

A		S								I		A					
South West Asia							South East Asia	India				South East Asia					
							Peninsular India			Assam							
Syria	Armenia	Iraq	Persia	Afghanistan	Beluchistan	Himalaya	Ceylon	W. Ghats	Vindha. Satpura and Chota-Nagpur		Burma	S. China and Hainan	Indo China	Siam	Malaya	Born	
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TABLE 1—

Distributional Table of the Kno

Species	A F R I C A								A				
	West Africa			Central Africa	East Africa				South West Asia				
	French Guinea	Nigeria	French Equi-torial Africa	Belgian Congo	Kenya	Abyssinia	Eritrea	Somal i-land	S. W. Arabia	S.-E. Arabia (Oman)	Pales-tine	Syria	Armenia
The lissorhynchus complex—													
19. *Garra lissorhynchus* (McClelland)	—	—	—	—	—	—	—	—	—	—	—	—	—
20. *Garra rupecula* (McClelland)	—	—	—	—	—	—	—	—	—	—	—	—	—
The taeniata complex—													
21. *Garra taeniata* Smith	—	—	—	—	—	—	—	—	—	—	—	—	—
22. *Garra borneensis* (Vaill.)	—	—	—	—	—	—	—	—	—	—	—	—	—
The yunnanensis Complex—													
23. *Garra yunnanensis* (Regan)	—	—	—	—	—	—	—	—	—	—	—	—	—
24. *Garra gracilis* (Pellegrin and Chevey)	—	—	—	—	—	—	—	—	—	—	—	—	—
25. *Garra naganensis* Hora	—	—	—	—	—	—	—	—	—	—	—	—	—
26. *Garra kempi* Hora	—	—	—	—	—	—	—	—	—	—	—	—	—
27. *Garra mcClellandi* (Jerdon)	—	—	—	—	—	—	—	—	—	—	—	—	—
28 *Garra hughi* Silas	—	—	—	—	—	—	—	—	—	—	—	—	—
The imberbis complex—													
29. *Garra imberbis* (Venciguerra)	—	—	—	—	—	—	—	—	—	—	—	—	—
30. *Garra imberba* Garman	—	—	—	—	—	—	—	—	—	—	—	—	—
The Gotyla group													
The gotyla complex—													
31. *Garra gotyla gotyla* Gray	—	—	—	—	—	—	—	—	—	—		—	
32. *Garra stenorhynchus* (Jerdon)	—	—	—	—	—	—	—	—	—	—	—		—
33. *Garra nasuta* (McClelland)		—	—	—	—	—	—	—	—	—	—	—	—
34. *Garra rhynchota* Koller	—	—	—	—	—	—	—	—		—	—	—	—
Species of doubtful relationships—													
35. *Garra notata* (Blyth)	—	—	—	—	—	—	—	—	—	—	—	—	
36. *Garra gravelyi* (Annandale)	—	—	—	—	—	—	—	—	—	—	—	—	
37. *Garra bicornuta* Rao	—	—	—	—	—	—	—	—	—	—	—	—	

The most important and striking facts that are evident from an analysis of the above table are :

1. That the most primitive and generalised species are found in West Asia and Africa.
2. That the highly specialised species appear in Southeast Asia.
3. That the greatest number of species are concentrated in Southwest China.

The above situations strongly indicate that Southwest China is the ancestral home of the genus. This region fulfills all the conditions laid down by Matthew (1915, p. 200) for a "Centre of dispersal" since it is inhabited by the most progressive species with the most primitive or generalised species occurring at the remote end of the area inhabited by the genus. Hora (1944) and Menon (1951*a* ; 1955) traced the centre of origin of the freshwater fish fauna of Southeast Asia to South China, particularly to the tableland of Yunnan and showed how this fauna spread to India and Africa on the one hand and to the other parts of the Southeast Asia on the other.

In considering the time of origin and evolution of any group of animals of which there is no fossil evidence, two main facts may be taken into consideration—firstly, the present-day ecological requirements of the animal and secondly, the geological history of the countries it inhabits. In the case of *Garra* the evolution of the adaptive characters for hill-stream life seems to be closely related to the evolution of the mountain systems of Southeast Asia. During the late Tertiaries, and particularly the Pleistocene, tectonic movements were very frequent and of a high magnitude. With the frequent upheaval of the Himalayas and associated ranges of mountains, the streams were being constantly rejuvenated thus subjecting the animals living in them to constant strains and stresses with the result that there was a rapid evolution of specialised hill-stream forms during a comparatively short period (Hora and Silas, 1952). This is what seems to have happened in the case of *Garra*. It seems most probable that the genus originated some time in the Middle or Upper Miocene, the most intensive movement which gave rise to the Himalayas being that of the Mid-Miocene period (Krishnan, 1953). The wide distribution of the genus at the present day also indicates a probable origin of the genus at such an early period as the Middle or Upper Miocene. The major evolutionary phases of the genus discussed in the previous chapter seem to be closely related to the geological history of the mountain system of Southeast Asia. The genus seems to have dispersed from Yunnan in a series of waves at such intervals as the tectonic movements of the Himalayas and the associated mountain ranges in Southeast Asia occurred.

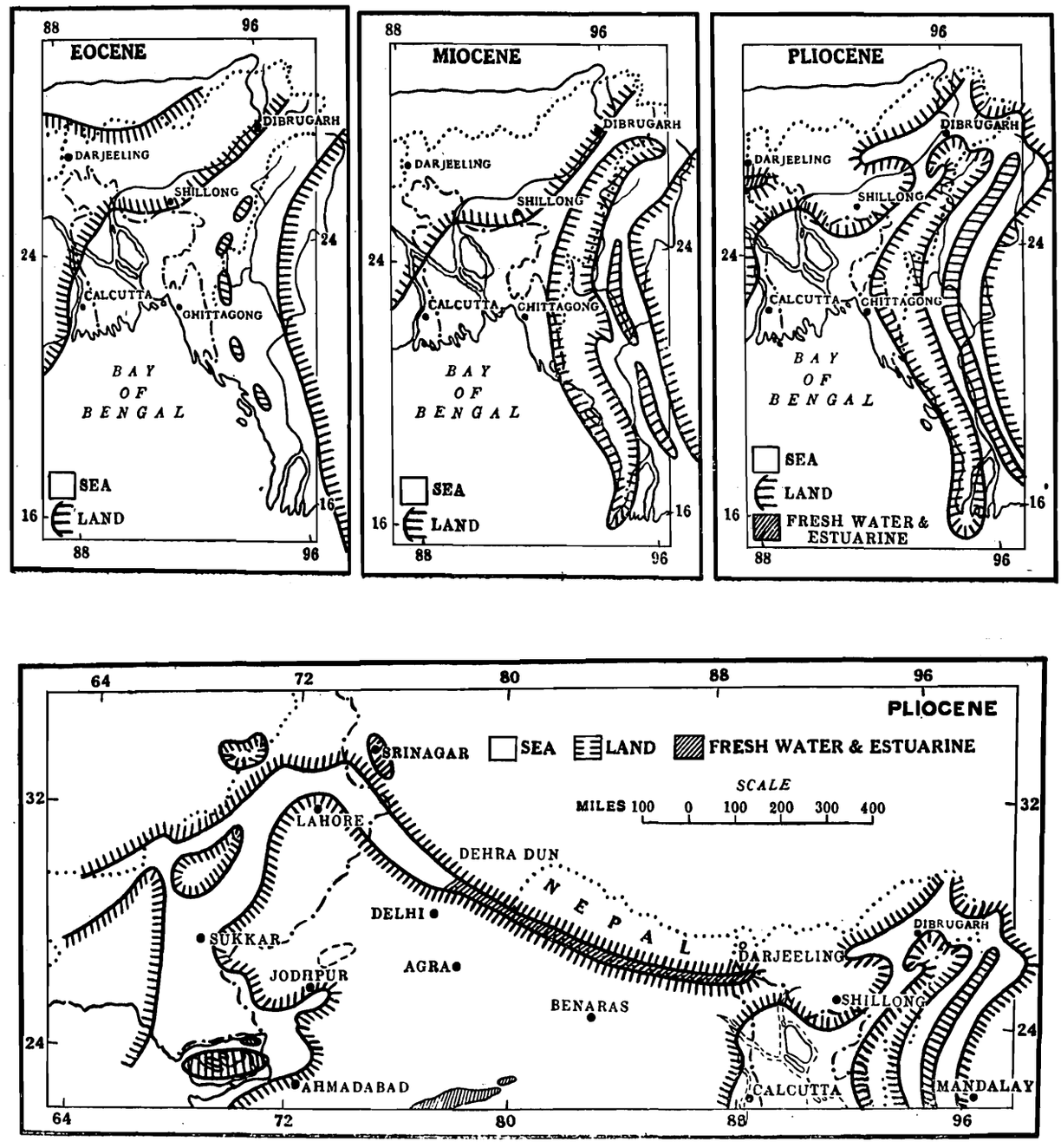
(b) *The route of dispersal of* Garra

The ecological requirements of *Garra* and their present-day distribution indicate that the Miocene and the later orogenic movements of the Himalayas (Burrard & Hayden, 1933, Krishnan, 1952) and the mountain systems of China and the Malay Archipelago (Gregory and Gregory, 1923) facilitated the dispersal of these fishes along certain mountain highways to far off places. Their distribution south-westwards to Peninsular India and Ceylon most probably effected in a series of waves which probably synchronised with the galciation periods of the Pleistocene when precipitation was higher and the rate of evaporation low thus giving rise to more perennial torrential streams in the hilly region.

(c) *Distribution of* Garra *during the Miocene-Pliocene*

Geologists have shown that a transgression of the Bay of Bengal during the Mid-Eocene cut off the land route between India and Burma and that it lasted the whole of the Miocene (Text-fig. 27). During this period no fresh-water fish seems to have migrated to India from South China (Hora and Menon, 1953). There is, however, evidence of fish-migration westwards along the "newly produced" lands of the eastern Tibet during the Miocene period (Hora, 1937). During the Miocene period *Garra* seems to have spread westwards along this route. This assumption is strengthened by the fact *Crossochilus*, a probable ancestor of *Garra* is to-day found in the Kashmir Valley, though *Garra* itself is not found there at the

present day. Recently in the summer of 1955 the late Dr. Hora made a thorough ichthyological survey of the Kashmir Valley and my conclusions are based on the results of this survey. The most primitive members—the *Variabilis*-group—must have had a wider distribution along the trans-Himalayas during the earlier epochs. It is, however, restricted to-day to Syria and Iraq with a related species, *rossica* in Seistan, Afghanistan and Baluchistan.

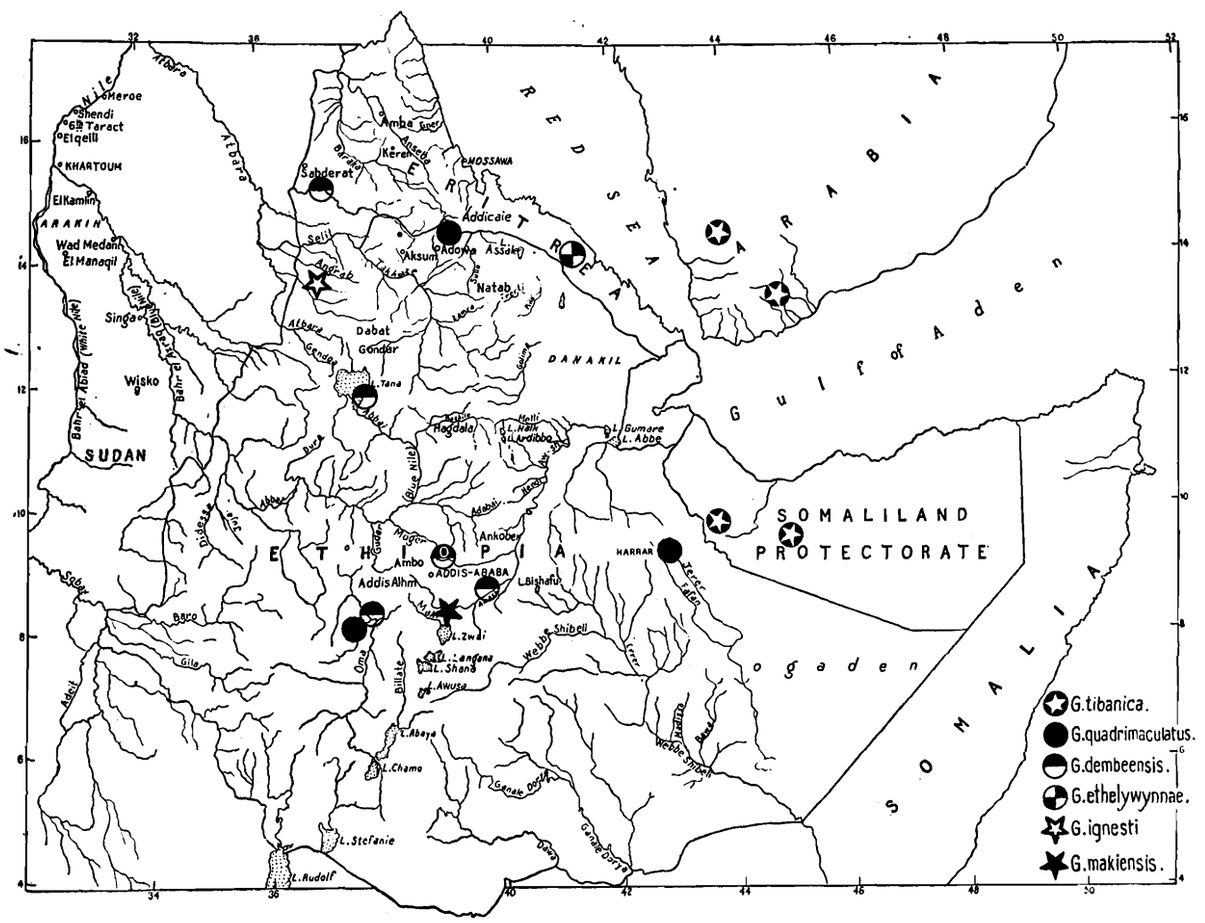


TEXT-FIG. 27.—Northward transgression of the Bay of Bengal during the Eocene, Miocene and Pliocene period which cut off land connections between India and the Far East. The Siwalik fore deep of the Pliocene period is shown in the lower figure. After Krishnan (*Bull. Nat. Inst. Sci. India*, pp. 26-28, 1952).

In the Pliocene the picture of the north-east part of India has, however, changed. The Pliocene upheaval seems to have rendered the arm of the sea that separated India and Burma shallow and may have cut it up into brackish water lakes and lagoons. With the advance of time, and concomitant with the Himalayan uplift movements, marshy conditions corresponding to those of the Siwaliks seem to have been established in the area and marsh-loving and sluggish water fishes could now migrate to India. We know definitely that they did so

from the occurrence of Bagrid fishes of the genera *Chrysichthys*, *Mystus* and *Rita*, Clariids of the genera *Clarias* and *Heterobranchus* and various Ophicephalids in the Siwalik rocks of India (Menon, 1954*b*). Low hills also made their appearance in the Pliocene. This is indicated by the occurrence of *Bagarius*, a characteristic hill-stream fish of the family Sisoridae in the Siwalik formations. It is found in South-west China, and is clearly a migrant from the Malayan region where it is known from the Tertiary beds of Padang in Sumatra (Sanders, 1934).

Thus, during the Pliocene the southern side of the Himalaya acted as a highway for the migration of *Garra* westwards. During this period the trans-Himalayan route does not seem to have played any part in the dispersal of Southeast Asian fish-fauna. The Pliocene tectonic movements seem to have uplifted the eastern part of the Tibetan plateau which was probably the first area to be lifted and raised above the neighbouring Chinese territory (Hora, *l.c.*, p. 247). The Central Asian drainage pattern of the Tertiary period also point to the same conclusion. During the Tertiaries the waters of the Central Asia may have flowed at first to the east, then towards the west and north before the present drainage pattern was established (De Terra, 1932).



TEXT-FIG. 28.—Distribution of *guadrimaculata, tibanica, dembeensis* (also found in Kenya), *ignestii, makiensis* and *ethelwynnae* indicated from specimens actually examined.

From India the dispersal to Africa seems to have taken place along Baluchistan, Persia Southern Arabia and Somaliland (Text-fig. 28). Recent investigations concerning the geological history of the floor of the Arabian Sea have revealed that :

"the floor of the north-western part of the Indian Ocean, as we know it to-day assumed its present form as a result of compression in Tertiary times, probably contemporaneously with the upheaval of the Alpine-Himalayan Mountain system and the arcs of the Malayan Archipelago and the formation of the Rift Valley. Consequently

in Pliocene or Post-Pliocene times the arc of land that once filled the triangle now bounded by the northern part of the East African coast and its continuation, the south-east coast of Arabia, the Baluchistan coast, and the west coast of India, became separated off by a series of faults and was submerged to its present depth" (Wiseman and Sewell, 1937).

TEXT-FIG. 29.—Bathymetric chart, showing the submerged ridges on the north-western coast of India, the Arabian coast and the northern part of the East African coast which faulted down during the Pleistocene. After Wiseman & Sewell (*Geol Mag.*, 74, p.230, 1937)

This submerged land mass (Text-fig. 29) would appear to have played a very great part in the dispersal of the *Garra* to Africa during the Pliocene. While discussing the origin and distribution of Clariid fishes to Africa (Menon, 1951*a*) it was pointed out that the Clariid fishes migrated to Africa during the Pliocene *via* Syria and Egypt. My conclusions were then mainly based on the occurrence of Clariids in the Lower Pliocene beds of the Siwalik Hills on the one hand and the Middle Pliocene beds of Egypt on the other with the present-day occurrence of *Clarias* in Syria. Clariid fishes may have spread to Africa *via* Syria and Egypt as well, these being marsh-loving fishes with a certain amount of salinity tolerance, but the case of *Garra* is quite different. Even though *Garra* occurs to-day in Syria and Palestine, it could not have spread to Africa along this route. The ecological requirements of *Garra* is in favour of a southern route *via* Yemen. The Yemen—Somaliland connection seems to have lasted up to the end of Pliocene or even a later period. The Red Sea was flooded from the north by the Mediterranean from the end of the Miocene period up to the end of the Pliocene. The Sinai connection seems to have arisen only with the breaking of the Yemen—Somaliland connection in late Pliocene or in the early Pleistocene and has continued in roughly the same shape to the present era of the Suez Canal (*vide*, Ripley, 1954).

(d) *Distribution of* Garra *during the Pleistocene and the Recent*

The uplift of the Yunnan plateau which took place probably in late Pleistocene or the Recent period seems to have enabled the specialised species of *Garra* to get radially distributed. This radial distribution of the specialised species of *Garra* strongly indicate a late Pleistocene or Recent uplift of the Yunnan plateau though there is a great deal of controversy among Geologists regarding the age of this uplift (Willis and Blackwelder,

1907 ; Depart, 1912 ; Gregory and Gregory, 1923). If Yunnan had been a high plateau even at an earlier period than the late Pleistocene it is most likely that instead of its being a "Centre of dispersal" animal life would have been totally perished in Yunnan during the severe glacial phases of the Pleistocene. *Garra*, on the other hand, seems to have flourished in Yunnan during the Pleistocene and with the recent uplift of the plateau got towards the west, along the Burmese arc to the south and along the Nan Shan trend to the east. The south-westward migration of *Garra* to Peninsular India appears to have taken place during the Pleistocene (*see* below).

(e) Conclusions

The probable sequence of the evolutionary waves of *Garra* is as follows :

Variabilis-wave.—The first wave of evolution of *Garra* from Yunnan can be termed the *variabilis*-wave. As pointed out it is a trans-Himalayan spreading from Yunnan to the Brahmaputra—Indus and thence to Afghanistan and westwards as far as Syria during the Miocene period.

Tibanica-wave.—The second wave of evolution of *Garra* from Yunnan that spread along the base of the Himalayas, Baluchistan, Persia, Arabia and Somaliland to Africa, is termed here the *tibanica*-wave. All the species of *Garra* found in Africa, West Asia (except members of the *variabilis*-wave) and *G. lamta* and *G. annandalei* are the products of this wave. As a consequence of the same wave, but probably after some time lag, we get the species, *G. mullya*, *G. ceylonensis* and *G. c. phillipsi*. The Garo-Rajmahal gap was under the sea during the Pliocene (Hora, 1951) and hence the *tibanica*-wave did not seem to have spread to Peninsular India till the end of that epoch. We have none of the primitive or less specialised species of *Garra* in the Peninsula. On the other hand, a secondary "brust of speciation" seems to have occurred in the Peninsula and we have to-day certain specialised species there. Only during the pluvial periods of the Pleistocene when the eustatic movements of the Bay of Bengal made the Garo-Rajmahal gap a dry land did *Garra* migrate South-wards to Peninsular India and thence to Ceylon (Hora, *l.c.*, p. 438). Ceylon seems to have retained its connection with the Peninsula during the whole of the Pleistocene, and that the final disruption of the island as a separate geographical entity did not take place until after the Upper Pleistocene (*vide*, Jacob, 1949). The inter-relationships of *G. mullya*, *G. ceylonensis* and *G. c. phillipsi* from an evolutionary point of view has already been discussed. *G. notata*, a species found to-day in Tenasserim, Burma is probably a product of the *tibanica*-wave.

Lissorhychus-taeniata-wave.—This spread south west-wards to Malaya and Borneo seems to have taken place subsequent to the uplift of the Yunnan plateau. Recent investigations of the structural history of the East Indies have revealed that :

"Between the basins of the north and east Sunda rivers there existed a divide from Sumatra, across Banka, Baliton and the Karimata Islands, to Borneo. This divide must, by its height, have offered great possibilities of migration to a number of animals and plants for which conditions of life were less favourable or insufficient in the extensive flat and low-lying area of the north and east Sunda rivers. Moreover, this land bridge between Sumatra and Borneo must have remained in existence to the very last during the rising of the sea level, whereas the lower areas must have submerged much sooner and the river systems dismembered" (Umgrove, 1949). *Garra* seems to have made use of this land route for its spread to North Borneo from Malaya probably during the Holocene glacial period which commenced 20,000 years ago and lasted up to 10,000 years ago (Zeuner, 1952).

Yunnanensis-wave.—This wave seems to have immediately followed *Lissorhynchus—taeniata*-wave. It had spread both south wards to the Assam Hills and southwestwards to the Western-ghats and eastwards to Tongking. This wave may have spread south-westwards earlier than 10,000 years ago for with the end of the Holocene Glaciation about 10,000 years ago, the Garo-Rajmahal gap must have become a barrier against their spread south-westwards (*vide*, Menon, 1954*c*, p. 491). The rapid evolution of species like

G. hughi, G. mcClellandi, G. bicornuta and *G. g. stenorhynchus* in the western-ghats is probably due to the recent orogenic movements and the consequent rejuvenation of the base level streams of the Western ghats (Menon, *l.c.*, p. 494).

The gotyla-wave.—The *gotyla*-wave seems to have followed the *Yunnanensis*-wave spreading eastwards as far as the Hainan-Island and westwards along the Himalayas and southwestwards along the Satpura—Vindhyas to the Indian Peninsula. *Gotyla*-wave also seems to have spread southwestwards during the Holocene Glacial epoch. Its spread southwards may have been accomplished not earlier than 10,000 years ago, the absence of members of the *gotyla*-group from Ceylon being taken as a probable indication of such a period for its southward migration (*vide*, Jacob, *l.c.*, p. 342).

The imberbis-wave.—This appears to have evolved from the *Yunnanensis*-stock last of all and is confined to Tongking, Szechwan and Burma.

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