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CYCLOPOIDES NOUVEAUX DU CONTINENT INDO-IRANIEN, I.

Par KNUT LINDBERG.

Cyclopetta orientalis, sp. nov.

Description.—Longueur de la femelle ovigère environ 700 μ ; offre l'aspect général d'un cycloptide, à tête parfaitement soudée au premier segment thoracique ; extrémité céphalique régulièrement arrondie, sans rostre apparent. Première antenne à 17 articles, rabattue elle atteint le tiers postérieur ou le bord postérieur du premier segment céphalothoracique. Un individu montrait une division incomplète du septième article. Deuxième antenne à 4 articles. Palpe mandibulaire à 2 branches. Abdomen assez étroit et allongé. Segment génital présentant

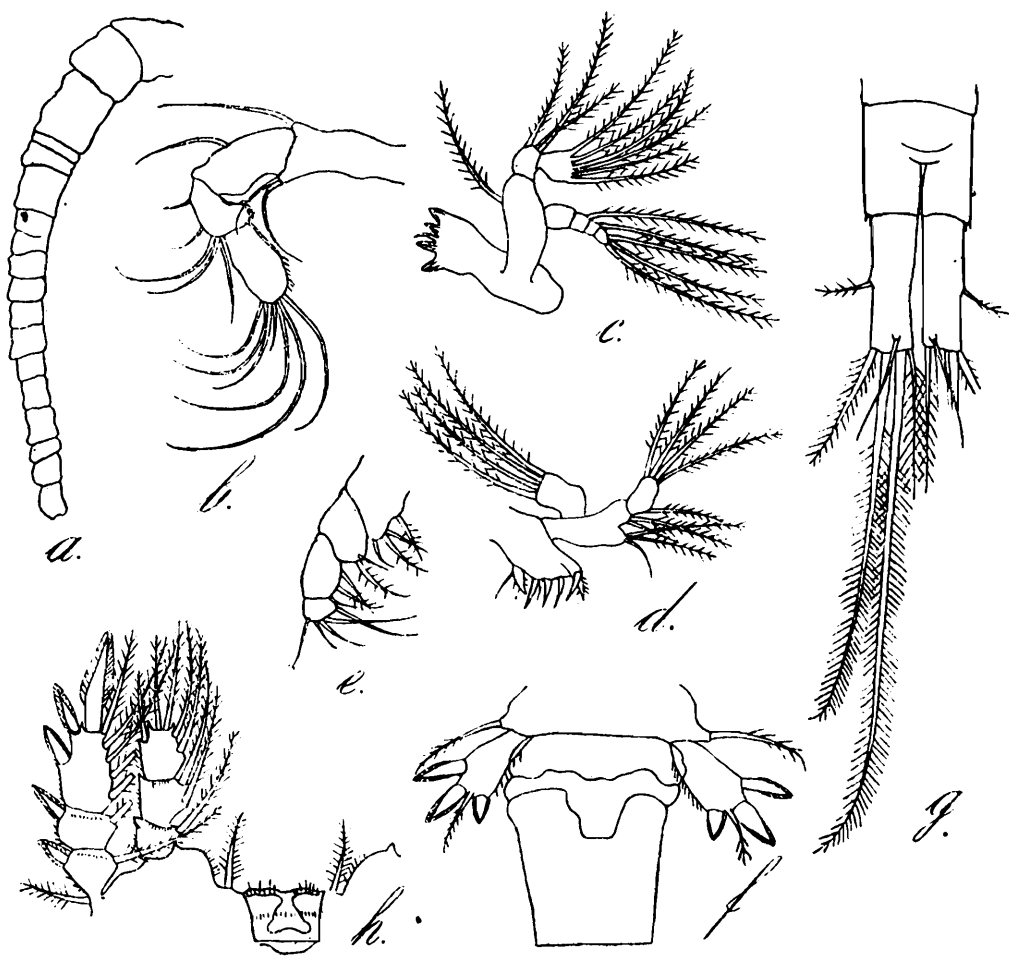


FIG. 1.—*Cyclopetta orientalis*, sp. nov. ♀

a. Première antenne ; b. Deuxième antenne ; c. Mandibule ; d. Maxille ; e. Deuxième maxillipède ; f. P 5 et segment génital, face ventrale ; g. Segment anal et furca, face dorsale ; h. P 4 et lamelle basale.

une échancrure dans son tiers antérieur ; il se rétrécit graduellement et légèrement dans sa partie distale. Segment anal plus long que le segment précédant. Opercule anal sans caractère distinctif. Furca

à branches parallèles, environ 4 fois aussi longues que larges. Soie latérale externe insérée un peu en avant du milieu de la branche. Soie apicale externe assez longue et très amincie ; elle est plus courte que la soie apicale interne. Soies apicales médianes à pennation légèrement hétéronyme. Pattes natatoires à branches tri-articulées. Formule des épines 4.4.4.3. Epines latérales et apicales des exopodites à structure lancéolée. Article terminal de l'enp. 4 court et trapu ; au lieu d'épines il porte deux soies apicales plus longues que l'article, la soie interne dépassant un peu en longueur celle de la soie externe. Lamelle basale de la quatrième paire de pattes munie de fines soies, à bord libre légèrement sinueux. P 5 formée d'un seul article, élargi en lamelle, portant 3 fortes épines ciliées et une mince soie. Bord latéral du cinquième segment thoracique pourvu d'une forte soie. Le réceptacle séminal semblait chez un des spécimens offrir l'aspect représenté sur la figure, mais les contours étaient très indistincts et il n'est pas certain que ce dessin donne une représentation correcte de sa structure. Ovisacs grands et allongés, écartés du corps ; ramenés vers l'abdomen ils atteignaient le tiers postérieur de la furca. Dans 3 ovisacs (chez deux individus) j'ai compté respectivement 25, 27 et 31 petits oeufs. Mâle inconnu.

Habitat.—J'ai récolté, au mois de décembre 1940, deux femelles ovigères dans des mares saumâtres peu profondes, près du bord de la mer à Pondichéry, et une jeune femelle dans une lagune à Oupalom, faubourg de Pondichéry, côte de Coromandel (Inde française).

Remarques.—La forme très remarquable qui vient d'être décrite appartient manifestement à la sous-famille des Cyclopininae de la famille des Cyclopinidae, puisqu'elle possède une deuxième antenne à 4 articles. Par suite de sa palpe mandibulaire à 2 branches et P 5 à un seul article, il convient de la ranger dans le genre de *Cyclopetta* de Sars, bien qu'elle diffère considérablement à plusieurs égards de l'espèce pour laquelle a été créé ce genre, espèce unique connue jusqu'à présent, pour autant que je le sache, le *Cyclopetta difficilis* de Sars.

Cyclopetta orientalis, sp. nov. ♀.

Longueur μ	Largeur μ	Long. 1	segm. 2 3	abdom. 4	Furca Long. : larg. :	Furca Soie dors.	Furca Soies apicales.	Enp. 4. Art. 3 Long. : larg.	Enp. 4. Art. 3 Soie ap. int. : soie ap. ext.
732	237	108	43 33	53	(30+33): 16=3.94:	1 ..	58 : 187 : 254 : 72	25 : 19=1.32 : 1	47 : 43=1.09 : 1
703	237	105	42 28	48	(32+33): 16=4.06:	1 58	63 : 192 : 259 : 70	26 : 20=1.30 : 1	42 : 37=1.13 : 1
627	237	108	37 27	47	(30+32): 16=3.87:	1 53	62 : 187 : 255 : 70	26 : 18=1.44 : 1	43 : 38=1.13 : 1

Eucyclops farsicus, sp. nov.

Description.—Longueur de la femelle ovigère environ 800 μ (de 769 à 836 μ). Ailes latérales du cinquième segment thoracique munies de fortes soies. Quelques individus ont montré les bords postérieurs des trois premiers segments abdominaux découpés sur la face ventrale en petites dents ; chez d'autres, cette caractéristique n'a pas été observée.

Rebord distal du quatrième segment abdominal portant sur la face ventrale la rangée usuelle de petites épines, qui s'étend aussi sur les parties latérales de la face dorsale. Echancrure anale pourvue de petits poils très fins. Branches de la furca le plus souvent bien divergentes, en moyenne de 3.74 fois aussi longues que larges. Serra très courte, composée de 2 à 7 petites spinules, placées à proximité de la soie latérale externe; les spinules les plus distales semblent parfois un peu plus longues que les autres. Soie dorsale de longueur intermédiaire entre celle de la soie apicale externe et celle de la soie apicale interne (longueur moyenne 54μ). Soie apicale externe assez forte et grosse, munie de cils

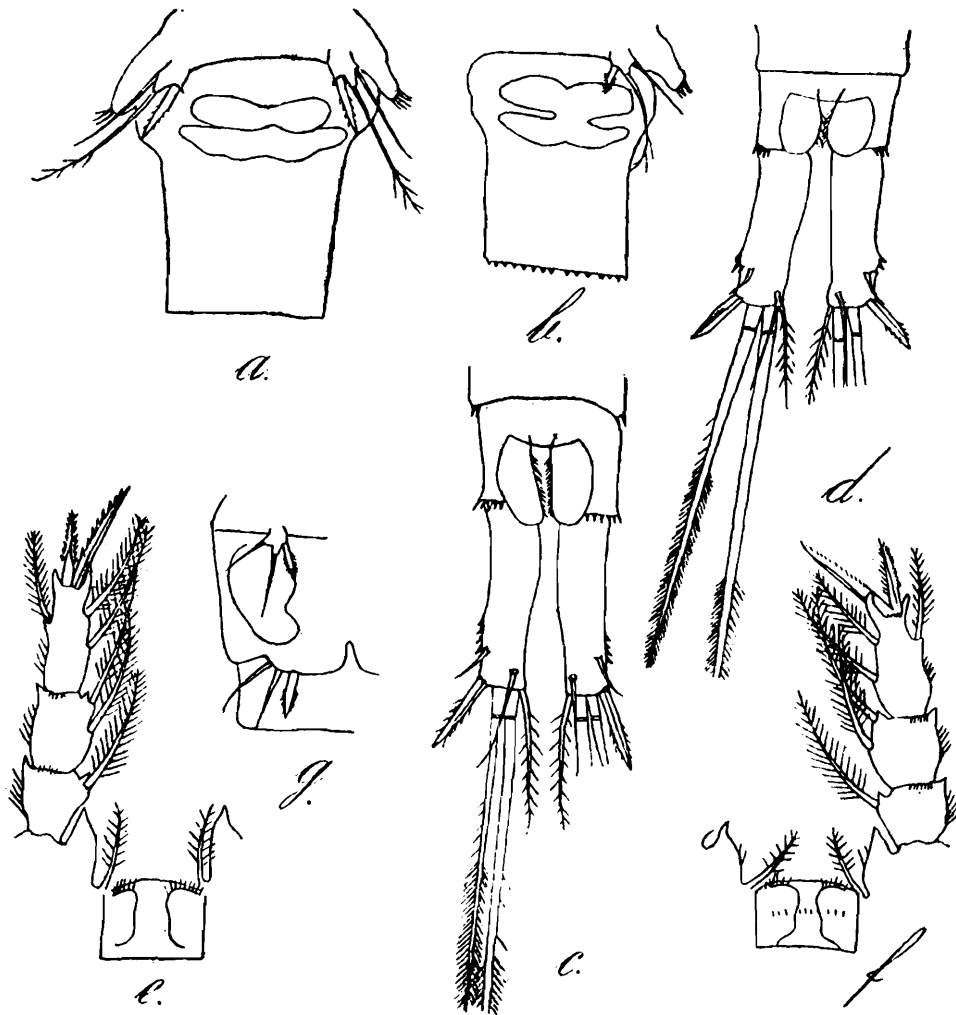


FIG. 2.—*Eucyclops farsicus*, sp. nov.

a. ♀ P 5 et segment génital, face ventrale; b. ♀ Do. Autre exemplaire; c. ♀ Segment anal et furca, face dorsale; d. ♀ Do. Autre exemplaire; e. ♀ Endopodite et lamelle basale P 4; f. ♀ Do. Autre exemplaire; g. ♂ P 5 et P 6.

courts; soie apicale interne considérablement plus longue que la soie apicale externe (rapport de 1.58: 1 à 2.03: 1, moyenne 1.79: 1). Les deux soies apicales médianes régulièrement pourvues de cils de longueur moyenne, très serrés sur les parties distales. Première antenne à 12 articles, rabattue elle atteint le milieu ou le tiers postérieur du deuxième segment thoracique. Sur les trois derniers articles se trouve une membrane hyaline étroite et entière. Formule des épines 3.4.4.3. Les

épines latérales et apicales des pattes natatoires montrent des bords amincis et étalés, structure décrite d'abord par Sars chez *E. euacanthus*. Article terminal de l'enp. 4 plus de deux fois aussi long que large (rapport moyen 2.24 : 1). Les deux épines apicales de cet article offrent aussi l'apparence en lancette déjà mentionnée, qui peut cependant être peu évidente chez l'épine apicale interne par suite de la torsion qu'elle présente le plus souvent. Cette épine est en général légèrement plus longue que l'article qui la porte (rapport moyen épine apicale interne : article 1.06 : 1), mais elle dépasse toujours considérablement en longueur celle de l'épine apicale externe (rapport moyen épine apicale interne : épine apicale externe 1.32 : 1). Lamelle basale de la quatrième paire de pattes pourvue des longues soies usuelles. P. 5 ressemble à celle d'*E. agiloides* ; la largeur de l'épine interne est environ deux fois celle de la soie médiane. Réceptacle séminal montrant le plan général usuel du groupe ; deux aspects différents sont représentés sur les figures. Ovisacs peu volumineux, très légèrement écartés du corps ; ramenés vers l'abdomen ils atteignent le plus souvent le tiers antérieur ou le milieu de la branche de la furca. Ils contiennent de 4 à 6 gros oeufs.

Mâle, longueur moyenne 642 μ . Branches de la furca parallèles, sans serra ; rapport moyen entre la longueur et la largeur de 3.47 : 1. P 6 formée d'une épine interne, forte mais courte, qui peut atteindre le bord postérieur du deuxième segment abdominal, d'une soie médiane, le plus souvent un peu plus longue que l'épine et d'une mince soie externe de direction oblique. Longueur moyenne de l'épine interne 28 μ .

Habitat.—Un étang d'eau douce à végétation abondante à Baba Hadji, localité située à 30 kilomètres au sud de Chiraz (province de Fars), à une altitude d'environ 1500 m. Récolté au mois de mars.

Remarques.—Pour autant qu'il me soit connu aucun *Eucyclops* n'a été présenté jusqu'à présent avec lequel l'espèce qui vient d'être décrite puisse être comparée. Kiefer a bien fait connaître un *Eucyclops* à serra très courte et possédant des épines de l'enp. 4 montrant un aspect en lancette l'*E. permixtus*, trouvé dans le Pendjab, et Kiefer dit avoir retrouvé cette même forme chez des animaux rapportés de 6 localités de l'Est de Java [d'après la figure No. 48 les épines en question ont cependant une apparence ordinaire, tandis que les autres sont très "lancéolées" sur la figure de la description originale (Kiefer 1928).] La structure de la furca et de ses appendices, celle de l'article 3 de l'enp. 4, celle de P 5 etc. montrent cependant qu'il s'agit d'une forme nettement distincte d'*E. farsicus*. Chez *E. permixtus* la première antenne est plus courte, l'article terminal de l'enp. 4 beaucoup moins allongé, l'épine apicale interne bien plus longue par rapport à l'article ; l'épine de P 5 considérablement plus longue et effilée. Une caractéristique très frappante qui permet au premier coup d'oeil et sans autre examen de distinguer l'*E. farsicus* non seulement du *E. permixtus* mais aussi de la forme suivante, c'est la structure de l'épine apicale externe de la furca ; courte, grosse et presque obtuse, à cils très courts chez *E. farsicus*, bien différente de l'épine apicale externe longue et amincie figurée par Kiefer chez *E. permixtus*.

Eucyclops farsicus, sp. nov.

Longueur μ	Furca Long. : larg.	Furca Soies apicales	Enp. 4. Art. 3 Long. : larg.	Enp. 4 Art. 3 Ep. ap. int. : ép. ap. ext.	Enp. 4. Art. 3 Ep. ap. int. : art.	P 5 Epine : soie (larg. approx.)	P 6 Epine : soie méd. : soie ext.
♀ 798	83 : 22=3·77 : 1	33 : 220 : 370 : 63	52 : 22=2·36 : 1	52 : 43=1·21 : 1	52 : 52=1 : 1	2 : 1	
836	87 : 23=3·78 : 1	37 : 220 : 374 : 67	52 : 23=2·26 : 1	58 : 43=1·35 : 1	58 : 52=1·12 : 1	2 : 1	
864	85 : 23=3·69 : 1	42 : 203 : 375 : 75	50 : 23=2·17 : 1	53 : 40=1·32 : 1	53 : 50=1·06 : 1	1·5 : 1	
769	80 : 22=3·63 : 1	38 : 217 : 370 : 60	50 : 23=2·17 : 1	55 : 42=1·31 : 1	55 : 50=1·10 : 1	2 : 1	
779	83 : 22=3·77 : 1	33 : 202 : X : 62	50 : 20=2·50 : 1	53 : 42=1·26 : 1	53 : 50=1·06 : 1	..	
817	90 : 23=3·91 : 1	38 : 214 : 347 : 67	52 : 23=2·26 : 1	55 : 40=1·37 : 1	55 : 52=1·06 : 1	2 : 1	
798	87 : 23=3·78 : 1	40 : 228 : X : 67	50 : 23=2·17 : 1	53 : 38=1·39 : 1	53 : 50=1·06 : 1	2 : 1	
788	83 : 22=3·77 : 1	37 : 203 : 340 : X	50 : 22=2·27 : 1	52 : 40=1·30 : 1	52 : 50=1·04 : 1	..	
..	78 : 22=3·54 : 1	33 : X : X : 67	45 : 22=2·04 : 1	48 : 35=1·37 : 1	48 : 45=1·06 : 1	1·8 : 1	
♂ 746	75 : 16=4·69 : 1	33 : X : X : 50	41 : 17=2·41 : 1	52 : 40=1·30 : 1	52 : 41=1·27 : 1	..	33 : 30 : 41
613	58 : 18=3·22 : 1	22 : 150 : X : 50	..	..	..	..	28 : 27 : 33
608	57 : 17=3·35 : 1	22 : 153 : 307 : 50	..	..	..	..	27 : 28 : 30
613	56 : 18=3·11 : 1	23 : 147 : X : 47	..	..	..	..	27 : 30 : 33
646	60 : 18=3·33 : 1	23 : 148 : X : 42	42 : 18=2·33 : 1	47 : 35=1·34 : 1	47 : 42=1·12 : 1	..	28 : 27 : 30
..	..	..	..	..	..	..	33 : 30 : 41
627	58 : 18=3·22 : 1	25 : 163 : 305 : 50	40 : 19=2·10 : 1	43 : 33=1·30 : 1	43 : 40=1·07 : 1	..	25 : 28 : 30

1941.]

K. LINDBERG : Cyclopoïdes nouveaux.

***Eucyclops ruttneri* forma *elburziensis*, nov.**

Description.—Longueur de la femelle adulte de 760 à 940 μ (moyenne de 8 individus 862 μ). Ailes latérales du cinquième segment thoracique portant de fortes soies. Une indentation du bord postérieur des trois premiers segments abdominaux a été observée chez quelques exemplaires, mais elle ne semble pas être constante. Quatrième segment abdominal muni sur la face ventrale du rebord postérieur d'une rangée de petites épines. De très fins poils s'aperçoivent au fort grossissement au niveau de l'échancrure anale. Branches de la furca plus ou moins divergentes, en moyenne de 3.63 fois aussi longues que larges. Serra rudimentaire, composée de 4 à 10 spinules, dont les plus distales sont en général légèrement plus longues que les autres. Soie dorsale (longueur moyenne 52 μ) le plus souvent plus courte que la soie apicale externe. Celle-ci assez longue et effilée (longueur moyenne 60 μ), portant de longs cils. Rapport moyen entre la longueur de la soie apicale interne et celle de la soie apicale externe de 1.35 : 1. Les deux soies apicales médianes munies de longs cils dont la disposition plus lâche que chez l'espèce précédente se voit sur la figure. Première antenne à 12 articles, rabattue elle atteint le bord postérieur du premier segment céphalothoracique et parfois le milieu du deuxième segment thoracique. Trois

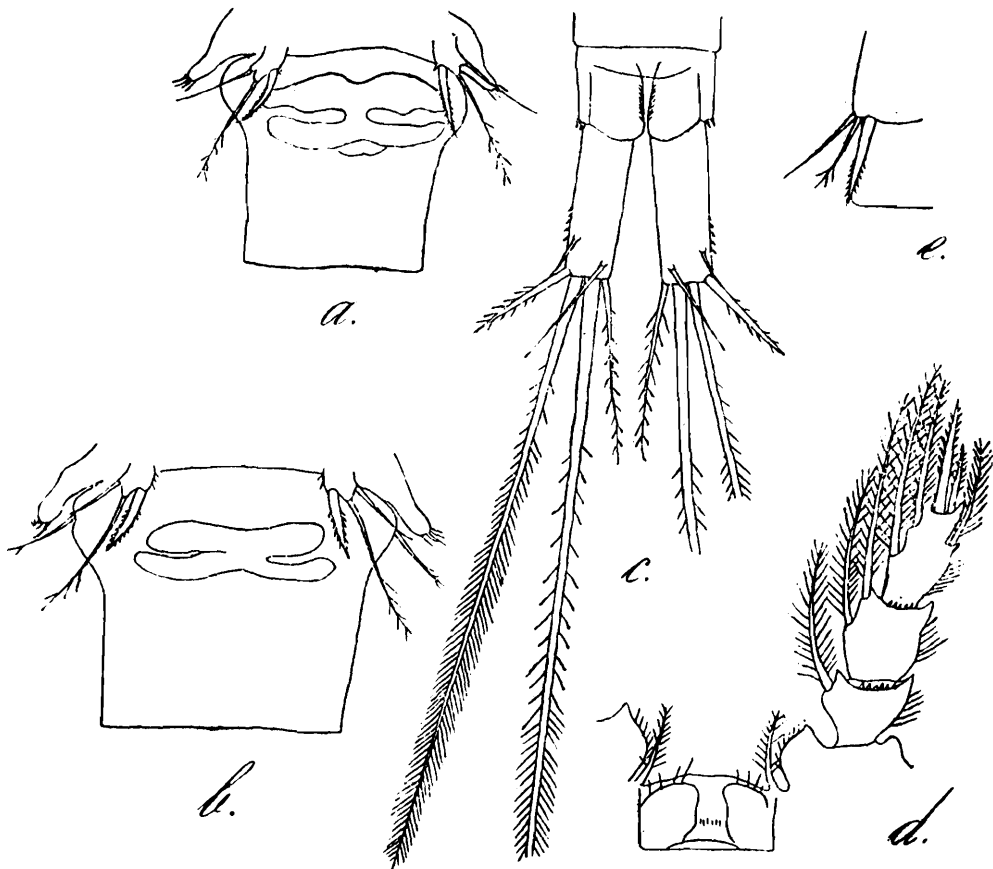


FIG. 3.—*Eucyclops ruttneri* forma *elburziensis*, nov.

a. ♀ P 5 et segment génital, face ventrale ; b. ♀ Do. Autre exemplaire ; c. ♀ Segment anal et furca, face dorsale ; d. ♀ Endopodite et lamelle basale P 4 ; e. ♂ P 6.

derniers articles pourvus d'une membrane hyaline étroite et entière. Les épines des branches des pattes natatoires ont toutes une structure ordinaire ; chez aucun des spécimens examinés je n'ai vu une apparence

lancéolée. Formule des épines 3.4.4.3. Article terminal de l'enp. 4 le plus souvent à peu près 2 fois aussi long que large (rapport moyen 1.98 : 1, mais amplitude de variation très grande allant de 1.68 : 1 à 2.40 : 1). Epine apicale interne toujours considérablement plus longue que l'article (rapport moyen épine apicale interne : article = 1.23 : 1) ; elle est aussi beaucoup plus longue que l'épine apicale externe (rapport moyen épine apicale interne : épine apicale externe = 1.71 : 1). Lamelle basale de la quatrième paire de patte munie de longues soies sans caractères distinctifs. P 5 ressemblant à celle de l'espèce précédente ; largeur de l'épine cependant parfois encore plus considérable, pouvant atteindre 2.5 fois celle de la soie médiane. Deux aspects un peu différents du réceptacle séminal ont été observés également chez cette espèce et ont été représentés sur les figures. Ovisacs plus volumineux que chez *E. farsicus*, légèrement écartés du corps ; ramenés vers l'abdomen ils dépassent souvent l'extrémité de la furca. J'ai compté de 4 à 15 oeufs dans chaque sac ; en moyenne il y en a eu de 7 à 8.

Mâle, longueur moyenne 722 μ . Branches de la furca parallèles ; 3 ou 4 petites spinules se trouvent placées à peu près sur le même niveau à proximité de l'insertion de la soie latérale externe. Les branches de la furca étaient chez les 3 individus examinés moins de 3 fois aussi longues que larges. P 6 composée d'une forte épine interne qui, chez les 3 spécimens, atteignait ou dépassait légèrement le rebord postérieur du deuxième segment abdominal ; d'une soie médiane plus courte que l'épine et d'une mince soie externe. Longueur moyenne de l'épine interne 43 μ .

Habitat.—Des mares de torrent dépourvues de végétation à Derbend (Chémiran, 14 kilomètres au nord de Téhéran) et à Pasqaléh (2 kilomètres plus au nord), ces deux localités se trouvant sur le versant sud du massif de l'Elbourz, à une altitude d'environ 1350 m. Récolté en petit nombre au mois d'octobre.

Remarques.—La forme dont il vient d'être question ressemble à certaines autres espèces peu connues, décrites d'après des spécimens uniques ou de nombre réduit et rapportées de localités isolées ou de régions circonscrites. Il s'agit d'animaux ressemblant beaucoup à de petits *E. serrulatus* (Fischer) mais possédant une serra se réduisant à un très petit nombre de spinules. Du *E. hadjebensis* (Kiefer), récolté au Maroc, notre espèce semble se différencier par la largeur moins grande de l'épine de P 5 et par l'épine ventrale plus longue de P 6 chez le mâle. *E. defectus* Lindberg, trouvé dans l'Inde centrale, possède aussi une épine de P 5 plus large et il a des branches de la furca plus longues. L'espèce qui lui ressemble le plus à juger d'après la description et les figures est *E. ruttneri* Kiefer, de Sumatra et de Java. Cependant il ne semble pas admissible de l'identifier avec celui-ci : la structure de la cinquième patte en diffère, notamment en ce qui concerne l'épine et aussi la configuration de l'article terminal de l'enp. 4, dont l'épine apicale interne est considérablement plus longue que l'article chez *elburziensis*, tandis que cette épine égale parfois en longueur celle de l'article ou ne la dépasse que légèrement chez *E. ruttneri*. Cependant, par suite des grandes analogies, il est présenté ici comme une forme d'*E. ruttneri*, mais cela à titre provisoire, à cause de l'impossibilité dans laquelle je me trouve à comparer les deux formes. Dans le cas d'une étude comparative de

Eucyclops ruttneri forma *elburziensis*, nov.

Localité	Longueur μ	Furca Long. : larg.	Furca Soies apicales.	Enp. 4. Art. 3 Long. : larg.	Enp. 4. Art. 3 Ep. ap. int. : ép. ap. ext.	Enp. 4. Art. 3 Ep. ap. int. : art.	P 5 Epine : soie larg. (approx.)	P 6 Epine : soie méd. : soie ext.
Derbend	♀ 798	82 : 24=3·42 : 1	60 : 284 : X : 73	44 : 22=2 : 1	55 : 30=1·83 : 1	55 : 44=1·25 : 1	2 : 1	
	804	85 : 24=3·54 : 1	58 : 287 : 446 : 73	47 : 22=2·14 : 1	58 : 33=1·76 : 1	58 : 47=1·23 : 1	2 : 1	
	760	70 : 23=3·04 : 1	47 : 217 : 417 : 65	42 : 21=2 : 1	53 : 30=1·77 : 1	53 : 42=1·26 : 1	2 : 1	
	931	97 : 26=3·73 : 1	62 : 295 : 466 : 82	47 : 25=1·88 : 1	60 : 37=1·62 : 1	60 : 47=1·28 : 1	2 : 1	
	931	108 : 27=4 : 1	73 : X : X : 88	50 : 26=1·92 : 1	58 : 37=1·57 : 1	58 : 50=1·16 : 1	2·5 : 1	
	883	97 : 27=3·59 : 1	53 : 290 : 459 : 108	47 : 28=1·68 : 1	63 : 35=1·80 : 1	63 : 47=1·34 : 1	1·8 : 1	
	940	102 : 28=3·64 : 1	70 : 314 : 514 : 85	53 : 27=1·96 : 1	62 : 38=1·63 : 1	62 : 53=1·17 : 1		
	♂ 675	57 : 20=2·85 : 1	42 : 208 : 384 : 77	35 : 20=1·75 : 1	47 : 27=1·74 : 1	47 : 35=1·34 : 1		43 : 30 : 38
	760	67 : 23=2·91 : 1	42 : 250 : 414 : 75	40 : 18=2·22 : 1	50 : 31=1·61 : 1	50 : 40=1·25 : 1		45 : 37 : 37
	731	63 : 22=2·86 : 1	43 : X : X : 80	..				42 : 37 : 43
Pasqaléh	♀ 855	92 : 23=4 : 1	60 : 250 : 424 : 78	53 : 22=2·40 : 1	62 : 35=1·77 : 1	62 : 53=1·17 : 1		

matériel suffisant il faut évidemment admettre aussi la possibilité d'arriver à la conclusion, soit, que les deux formes sont identiques, soit, qu'il convient de les séparer comme des espèces différentes ; et peut-être cette dernière éventualité sera-t-elle la plus probable. Les Cyclopoïdes de vastes régions de l'Inde sont maintenant assez bien connus, mais jusqu'à présent je n'ai trouvé nulle part dans l'Inde un *Eucyclops* ressemblant à *E. ruttneri*. Conséquemment l'agent de liaison géographique, pour ainsi dire, semble manquer entre les animaux des deux régions respectives, les îles de la Sonde sous l'équateur et le Nord du plateau de l'Iran dans la latitude 36°, régions de caractères bien opposés. Du reste, ce ne sera bien entendu que le jour quand nous connaîtrons complètement les nombreux *Eucyclops* du globe entier qu'il sera possible d'assigner leur place réelle aux divers *Eucyclops* à serra rudimentaire qui ont été mentionnés ici.

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SILUROID FISHES OF INDIA, BURMA AND CEYLON

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XI. FISHES OF THE SCHILBEID GENERA *SILONOPANGASIUS* HORA, *PSEUDEUTROPIUS* BLEEKER, *PROEUTROPIICHTHYS* HORA, AND *AILIA* GRAY.

As the family Schilbeidae is represented by several genera in the Ethiopian and Oriental zoogeographical regions, it was my¹ intention to give a comprehensive account of the classification, distribution, ecology and evolution of these fishes, but considerable difficulty was experienced in carrying out this plan, partly owing to the great confusion that prevailed in the taxonomy of the Indian genera and species of this family, and partly because of the absence of African material in the collection of the Indian Museum for comparison with the Indian forms. Accordingly, the Indian genera have now been revised one by one and the generic limits of *Eutropiichthys* Bleeker² [*E. goongwaree* (Sykes), *E. vacha* (Hamilton) and *E. murius* (Hamilton)], *Clupisoma* Swainson³ [*C. garua* (Hamilton), *C. prateri* Hora and *C. montana* Hora], *Silonia* Swainson⁴ [*S. silondia* (Hamilton)], *Pangasius* Cuvier and Valenciennes⁵ [*Pangasius pangasius* (Ham.)]; *Helicophagus* Bleeker⁶ and *Platytrapius* Hora⁷ have already been elucidated. The taxonomy of the Indian species included in these genera has also been dealt with. This article deals with a systematic account of the remaining Indian genera of the Schilbeidae.

Key to the Indian genera of Schilbeidae.

- I. Two barbels (maxillary); teeth caniniform; air-bladder⁸ greatly reduced *Silonia* Swainson.
- II. Four or eight barbels.
 - A. Four barbels; one pair maxillary, one pair mandibular.
 1. Caniniform teeth in jaws; air-bladder greatly reduced, without any caecum at the posterior end *Silonopangasius* Hora.
 2. Small, villiform teeth in jaws; air-bladder⁹ large or of moderate size, usually with a caecum at the posterior end *Pangasius* Cuv. & Val.

¹ Hora, S. L., *Cur. Sci.* V, pp. 352, 353 (1937).

² Hora, S. L., *Journ. Bombay Nat. Hist. Soc.* XXXIX, pp. 431-446 (1937).

³ Hora, S. L., *ibid.* XXXIX, pp. 659-678 (1937).

⁴ Hora, S. L., *ibid.* XL, pp. 137-147 (1938).

⁵ Hora, S. L., *ibid.* XL, pp. 355-366 (1938).

⁶ Hora, S. L., *Rec. Ind. Mus.* XXXIX, pp. 235-240 (1937).

⁷ Hora, S. L., *Journ. Siam. Soc. Nat. Hist. Suppl.* XI, pp. 39-46 (1937).

⁸ Nair, K. K., *Rec. Ind. Mus.* XI, pp. 5-11 (1938.)

⁹ Nair, K. K., *ibid.* XXXIX, pp. 117-124 (1937).

B. Eight barbels; one pair maxillary, two pairs mandibular, one pair nasal.

1. Teeth on palate in two small widely separated patches, sometimes connected by a linear series.

a. Rayed dorsal present; air-bladder large, forming blister-like areas above pectorals.

Pseudeutropius Blkr.

b. Rayed dorsal present; air-bladder¹ greatly reduced, tubular, partly covered by bone

Ailia Gray.

2. Teeth on palate in four distinct contiguous patches or in a broad band sometimes interrupted in the middle.

a. Teeth on palate in four distinct patches; air-bladder of moderate size

Proeutropiichthys Hora.

b. Teeth on palate in two extensive patches separated in the middle or in a continuous horse-shoe-shaped band.

i. Maxillary and palatine teeth greatly produced backwards at the sides; air-bladder² greatly reduced, tubular

Eutropiichthys Blkr.

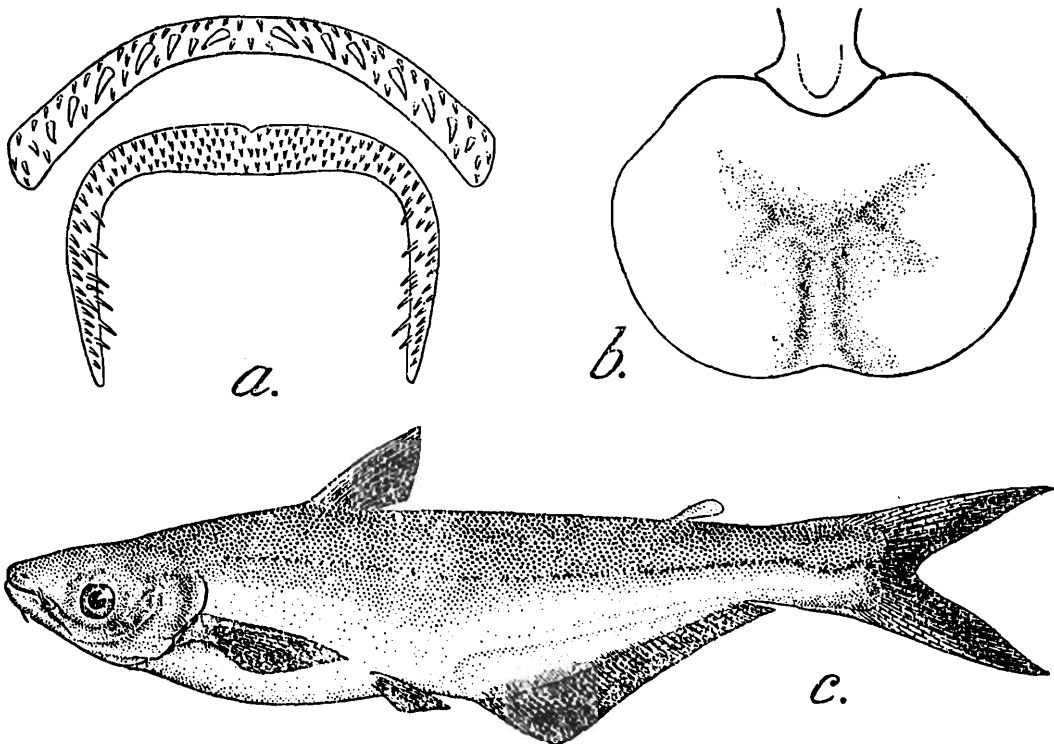
ii. Maxillary and palatine teeth not produced backwards; air-bladder³ greatly reduced, but not tubular

Clupisoma Swainson.

***Silonopangasius* Hora.**

1937. *Silonopangasius*, Hora, *Cur. Sci.* V, p. 352.

The genus *Silonopangasius* was proposed for *Ageneiosus childreni* Sykes.⁴ This species, as I understand it, possesses caniniform teeth in the jaws and a pointed lower jaw, as in *Silonia*, and four barbels—one



Text-fig. 1.—*Silonopangasius childreni* (Sykes).

a. Dentition: $\times 3$; b. Air-bladder: $\times 3$; Lateral view of a specimen from the Bhavani River: $\times \frac{2}{3}$.

¹ Nair, K. K., *Rec. Ind. Mus.* XL, pp. 185, 186 (1938).

² Nair, K. K., *ibid.* XL, pp. 183-185 (1938).

³ Nair, K. K., *ibid.* XL, pp. 186, 187 (1938).

⁴ Sykes, W. H., *Trans. Zool. Soc. London* II, p. 375 (1841).

pair maxillary and one pair mandibular—as in *Pangasius*. The air-bladder, though small and somewhat thick-walled, is considerably larger than that of *Silonia*; it is oval in outline with the longer axis transversely disposed. On account of the structure of the air-bladder and the presence of a pair of mandibular barbels this species cannot be referred to *Silonia* or to *Pangasius* and has accordingly been placed in a separate genus.

Ageneiosus childreni was characterised by Sykes as follows :

“ An *Ageneiosus*, without *cirri*; with the first ray of the dorsal and pectoral fins serrated on the anterior edge only : with eight rays in the dorsal and 42 in the anal fin ; with two sharp lobes to the tail, the upper being somewhat the smallest .”

Sykes mentioned the length of his specimen as 18 inches and remarked “ flesh sweet and juicy, but not firm ” As regards the affinities of his species he stated.

“ A comparison of my drawing with the description of *Ageneiosus mino* of Dr. Hamilton's ‘ Fishes of the Ganges ’, will show how many features there are in common between it and the *Parree*; but its height and compressed body, and the extent of the anal fin, at once fix the latter as a distinct species. Found in the Mota Mola river, at Poona. *Pimelodus silorida* (*sic*) of Buchanan Hamilton (Tab. VII, fig. 50) is also an *Ageneiosus*.”

The serrations along the anterior borders of the dorsal and the pectoral fins are obviously incorrectly shown in the figure of the species which most probably served for Sykes' description. Serrations are invariably present in Siluroid fishes along the inner borders of the spines, and the outer border may be smooth or serrated.

Jerdon,¹ who included this species in his list of fishes of Southern India, referred it to the genus *Silundia* and remarked :

“ I have very little doubt that this is a true *Silundia*, and perhaps the *S. Gangetica* though Sykes says there are no *cirri*, for it appears that the two small *cirri* which are present in that fish are made out sometimes with difficulty.”

Günther² included Sykes' species in the synonymy of *Silundia gangetica* without any comments; while Day³, when describing *Silundia sykesii*, made the following observations regarding this species :

“ Sykes states that this fish is termed *Purree Mahr.* and *Sillun* in the Deccan, that it is *without cirri*, and also that the first bony ray is ‘ serrated ’ on the anterior edge”, such being also shown in the figure. This last observation leads me to believe that he described from the drawing, which seems to have maxillary barbels indistinctly marked.

“ The long maxillary barbels of this species [*S. sykesii*] at once serve to distinguish it from the *S. gangetica*, C. V.”

The air-bladder of *S. sykesii* is described as “ transverse, not enclosed in bone.”

Day also referred to the presence of the mandibular barbels in *S. sykesii* and their absence in *S. gangetica* and came to the conclusion that no generic importance should be attached to this character. The generic distinction between the two species, however, rests mainly on the character of the air-bladder.

I have examined several examples of *Silonopangasius childreni* (Sykes). Three specimens (Nos. 1230, 1285, 8903) were purchased from Day and two out of these are labelled in Day's handwriting as *Silundia sykesii*; these are 123 mm., 180 mm., and 200 mm. in standard length

¹ Jerdon, T. C., *Madras Journ. Litt. & Sci.* XV, p. 340 (1849).

² Günther, A., *Cat. Fish. Brit. Mus.* V, p. 65 (1864).

³ Day, F., *Journ. Linn. Soc. Zool.* XII, p. 569 (1876).

respectively. Recently 3 adult specimens were received from the Mota Mola river, the type-locality, and in 1918 the late Dr. N. Annandale had collected a large number of young specimens from the edge of the Godavari river at Rajahmundry in the Madras Presidency. So far as is known at present, the species is found in Deccan only.

As a result of the examination of the above noted material I am fully convinced that Day's *Silundia sykesii* is synonymous with Sykes's *Ageneiosus childreni*. The following table of measurements gives some idea of the range in variation of proportions, etc.

Measurements in millimetres.

	Bhavani R.		Goda- vari R.	Madras.		Deccan.		Poona.		
Total length	256.0	165.0	81.0	..	220.0	332.0	..	338.0	323.0	300.0
Standard length ..	199.0	133.0	61.5	197.0	179.0	271.5	123.5	271.5	255.0	235.0
Length of head ..	50.0	31.0	16.0	45.0	42.0	63.0	28.8	64.0	57.0	55.0
Width of head ..	31.0	18.0	11.0	25.0	23.0	40.0	15.0	35.3	31.0	29.0
Width of body. ..	26.0	14.0	7.5	20.0	17.0	30.0	11.0	38.0	30.0	25.0
Height of body ..	49.0	30.0	13.5	40.0	37.0	57.0	21.5	62.0	57.0	55.0
Diameter of eye ..	13.2	9.5	5.5	13.0	12.5	17.0	9.0	17.0	16.0	14.8
Interorbital width ..	21.0	10.0	5.5	15.5	13.0	21.0	10.0	21.6	19.0	18.0
Length of snout ..	17.0	12.0	5.5	15.0	14.5	21.0	9.0	23.0	20.0	19.0
Length of maxillary barbel ..	12.0	11.0	12.0	16.0	15.5	28.0	15.5	31.0	26.0	25.0
Length of mandibular barbel ..	1.0	1.2	5.5	4.0	5.0	6.0	5.0	9.0	7.0	6.5
Length of dorsal spine ..	32.0	20.0	9.0	D.	D.	38.0	19.0	38.0	D.	D.
Length of pectoral spine ..	36.0	22.0	11.0	35.0	33.0	49.0	21.0	52.0	48.0	45.0
Least height of caudal peduncle.	18.0	11.0	5.0	16.0	15.5	20.0	10.5	25.0	20.0	20.0

***Pseudeutropius* Bleeker.**

The genus *Pseudeutropius* was proposed by Bleeker¹ in the group *Pangasii* to accommodate *Eutropius brachypterus* Blkr. and was characterised as follows :

“Cirri 8, nasales 2, supramaxillares 2, inframaxillares 4. Dentes maxillis pluriseriati. Dentes vomerini in vittam transversam dispositi, palatini distincti nulli. Cirri inframaxillares omnes margini maxillae anteriori valde approximati. B. 10.”

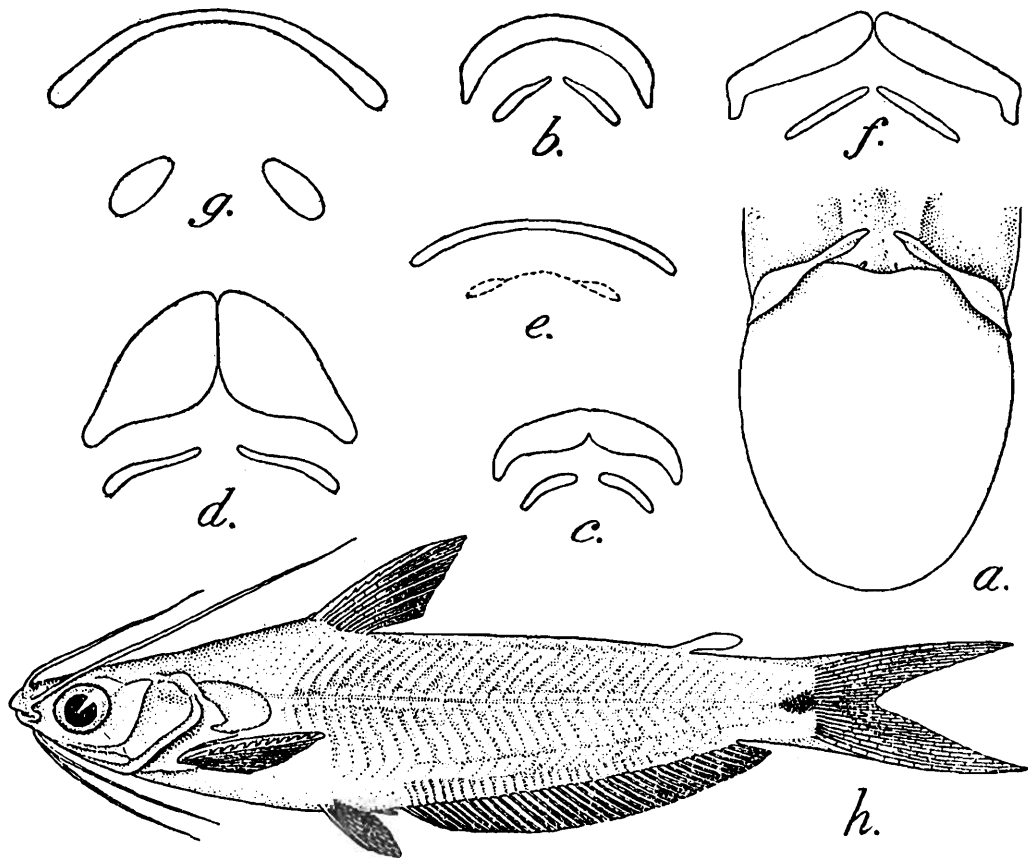
A year later Bleeker² revised this definition and stated “Dentes vomero-palatini in vittam transversam indivisam dispositi.”

The chief points of differences between *Eutropius* and *Pseudeutropius* are : (i) The mandibular barbels are situated at a considerable distance from the anterior margin of the lower jaw in *Eutropius* and close to the margin in *Pseudeutropius*. (ii) In *Eutropius* the mandibular barbels are placed one pair behind the other, whereas in *Pseudeutropius* both the pairs are in a more or less straight line. (iii) The vomerine and palatine patches of teeth are distinct, though contiguous, in *Eutropius* ; while in *Pseudeutropius* the vomero-palatine patches are transversely disposed and the vomerine teeth are indistinguishable from the palatine teeth.

¹ Bleeker, P., *Versl. Akad. Amsterdam* XIV, p. 398 (1862).

² Bleeker, P., *Ned. Tijdschr. Dierk.* I, p. 106 (1863).

A study of the descriptions of the species included by Günther¹ and Day² under *Pseudeutropius* shows that they paid little attention to the limits proposed by Bleeker for this genus with regard to the dentition of its members. For instance, in the six species referred by Günther to this genus the vomerine teeth are stated to "form a very narrow band, which is angularly bent, and continuous with the palatine teeth" in *P. brachypterus*, the type of the genus and of which Günther had a typical specimen from Bleeker's collection; while the dentition of *P. atherinoides*, *P. mitchelli* and *P. goongwaree* is not described. In



Text-fig. 2.—*Pseudeutropius* Bleeker.

a. Air-bladder of *P. atherinoides* (Bloch), from a specimen 53 mm. in standard length : $\times 4\frac{2}{3}$; b., c. and d. Dentition of three specimens of *P. atherinoides* (Bloch), 57 mm., 74 mm. and 100 mm. in standard length respectively : b : $\times 6$; c : and d : $\times 4$; e. Dentition of type-specimen of *P. brachypterus* (Bleeker) after a sketch by Mr. J. R. Norman; f. Dentition of *P. mitchelli* Günther after a sketch by Mr. J. R. Norman; g. Dentition of a specimen (No. 430) of *P. mitchelli* Günther, 96 mm. in standard length; h. Lateral view of a specimen (Cat. No. 502) of *P. atherinoides* (Bloch).

P. megalops, the teeth of the vomer form two quadrangular patches, which are separated from each other by a linear groove; the palatine teeth form a cuneiform band which is subcontinuous with the vomerine teeth." In *P. longimanus*, "the vomerine band is interrupted in the middle, each half being subcontinuous with the palatine band." Taking into consideration the character of dentition it is clear that whereas there is considerable similarity between *P. megalops* and *P. longimanus*, both of these differ from *P. brachypterus*, and should not be included under *Pseudeutropius* (*sensu stricto*).

¹ Günther, A., *Cat. Fish. Brit. Mus.* V, pp. 58-61 (1864).

² Day, F., *Fish. India*, pp. 470-474 (1877).

Day in his "Fishes of India" included seven species under *Pseudeutropius*; of all of these I have examined specimens determined by him. Though there are inaccuracies in his descriptions and figures of the dentition of the various species, I shall, for the point under discussion, refer to the account as given by him. In *P. goongwaree*, the teeth are "in a wide pyriform band wider than those in the jaws, the vomerine and palatine groups touching, but the two vomerine patches having a short interspace between them." In *P. taakree*, the vomerine and palatine teeth are in distinct patches. In *P. acutirostris*, the teeth are "in two minute patches on the vomer, and of the same character on the palatines, which are not continuous with those on the vomer." In *P. murius*, the teeth "on the vomer and palate form an almost uninterrupted semilunar band." The teeth on the palate of *P. sykesi* are "in two distinct patches." In *P. atherinoides*, there is "a narrow, uninterrupted, crescentic band across the palate," while in *P. garua* the teeth are "in a semilunar band across the palate, those of the vomer contiguous to those of the palatines, and each patch being semicircular internally: sometimes the two vomerine patches have an interspace between them." The great variation in the dentition of these species clearly shows that *Pseudeutropius*, as recognised by Day, is a composite genus.

It is also clear from the above that dentition alone is not sufficient for the proper differentiation of the genus *Pseudeutropius*. I have, however, found that if this feature is coupled with the nature of air-bladder, it is possible to differentiate and define more precisely this and the allied Schilbeid genera occurring in India.

For determining the precise limits of the genus *Pseudeutropius*, I requested Mr. J. R. Norman to examine the type-specimen of *Pseudeutropius brachypterus*, the type of the genus. He sent me a sketch of its dentition (Text-fig. 2e), and remarked that the specimen is in a poor condition and, in consequence, he had great difficulty in making out the outlines of the tooth-bands. According to Weber and de Beaufort¹ the dentition of *P. brachypterus* consists of "Minute teeth in narrow bands on the jaws; on the vomer in two small patches connected by an angular line of teeth." Unfortunately no account has so far been published of the air-bladder in this species, but it seems probable that it is a large, thin-walled structure which laterally comes in contact with the skin and forms translucent, blister-like areas above the pectoral fins. Weber and de Beaufort (*op. cit.*) described another species of *Pseudeutropius*—*P. moolenburghae*—from Sumatra in which they found "Teeth minute, in the jaws in a narrow band, on the vomer in two widely separate elliptic patches." Its figure shows the translucent area above the pectoral fin, though there is no reference to the nature of the air-bladder in the description.

As judged from the material in the collection of the Indian Museum, it seems that *Pseudeutropius* is represented in the Indian waters by *P. atherinoides* (Bloch)² and *P. mitchelli* Günther³; both the species possess vomerine teeth in two distinct patches which may be small or

¹ Weber M. and Beaufort, L. F. de, *Fish. Indo-Austral. Archipel* II, p. 249 (1913).

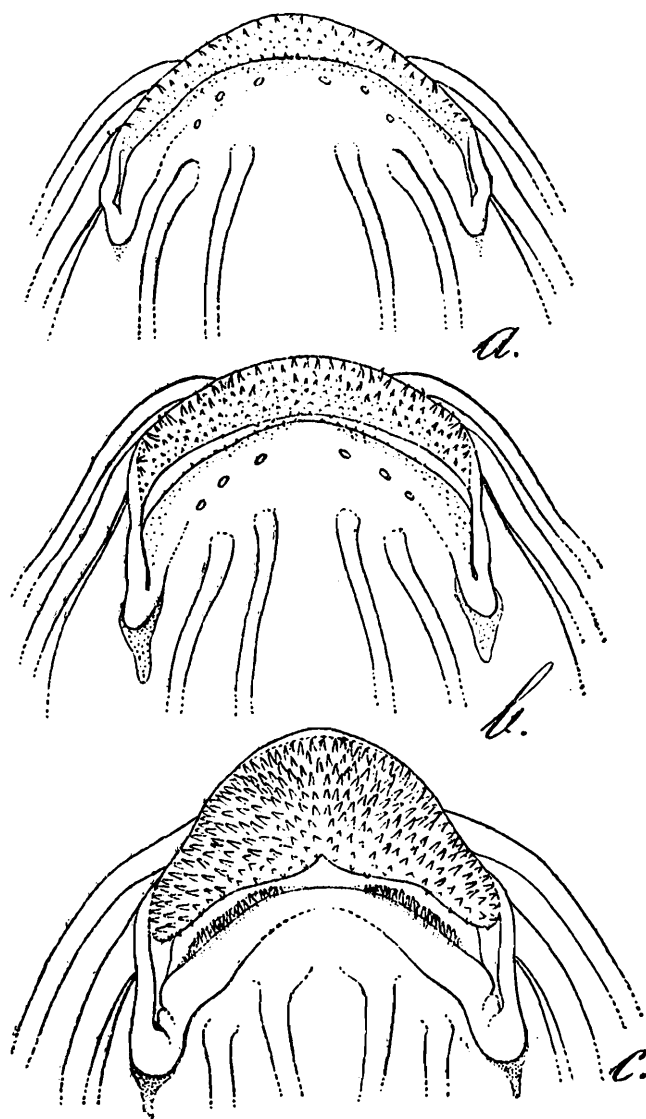
² Bloch, M. E., *Naturges. Ausland. Fische* VIII, p. 48 (1794).

³ Günther, A., *Cat. Fish. Brit. Mus.* V, p. 59 (1864).

extensive but are always narrow, and a large air-bladder free in the abdominal cavity (Text-fig. 2a). As there appears to be a considerable confusion regarding the specific limits of the two species I give below their brief history and chief taxonomic features.

***Pseudeutropius atherinoides* (Bloch.)**

P. atherinoides was described from Tranquebar, but later Hamilton¹ described two species from Bengal—*Pimelodus urua* and *P. angius*—which have rightly been regarded as synonymous with Bloch's species. Hamilton himself pointed out the close affinity between *P. urua* and *P. atherinoides*. *P. angius*, with brilliant colour markings, is only a colour form of *P. atherinoides*. Valenciennes's² *Bagrus exodon* is undoubtedly the same as Day's *Pseudeutropius acutirostris*.³ The former was



Text-fig. 3.—Ventral surface of the anterior part of head of three specimens of *Pseudeutropius atherinoides* (Bloch), showing stages in the prolongation of the upper jaw and the development of teeth.

a. Standard length of specimen 59 mm. : $\times 10$; b. Standard length of specimen 64 mm. : $\times 8$; c. Standard length of specimen 100 mm. : $\times 5\frac{1}{2}$.

¹ Hamilton, F., *Fish. Ganges*, pp. 177, 180, 377 (1822).

² Valenciennes, A., in *Belanger Voyage Ind. Orient. Zool.*, p. 385 (1834).

³ Day, F., *Proc. Zool. Soc. London*, p. 618 (1869).

described from Bengal whereas the latter is stated to be common in the Irrawaddy and other large Burmese rivers. The differences in dentition and colouration noticed among individuals of this species seem to indicate sexual dimorphism but the material is insufficient for a proper elucidation of this problem. In the collection of the Indian Museum there are specimens showing various stages in the elongation of the upper jaw and in one example from the Sunderbans typical *acutirostris*-condition of the snout is present. Though the figure of *Bagrus exodon* is rather poor for the determination of the species, the description of the dentition leaves no doubt about its identity. It runs as :

“ Nous lui donnons cette épithète d'*Exodon*, qui veut dire hors dents, parce qu'elle caractérise notablement les dents inter-maxillaires adhérentes à de larges plaques au bout du museau, de manière à dépasser entièrement la mâchoire inférieure.”

Chaudhuri¹ described a new variety of *P. atherinoides* from young specimens with the characteristic colour bands. “ A narrow spiral corrugation on chest ” in the variety *walkeri* is an artifact due to the action of the preservative used. The eyes are never subcutaneous in this species, and Chaudhuri's description is inaccurate on this point also.

***Pseudeutropius mitchelli* Günther.**

Pseudeutropius mitchelli was described by Günther² from two young specimens, “ Three and a half inches long ”, collected in the Madras Presidency. Unfortunately no specific locality is mentioned. In 1865, Day³ regarded it as a synonym of *P. sykesi* (Jerdon) and remarked :

“ By no means rare in the rivers of Malabar. In two specimens the adipose fin was absent, perhaps lost by some accident ; probably from some such deformed specimen Dr. Jerdon described the *Schilbe sykesii*. ”

In his *Fishes of Malabar*, he reaffirmed this view and stated that the species grows to above eight inches in length. Günther in the *Zoological Record* for the same year (p. 199) made the following observation under *Pseudeutropius mitchelli* :

“ Although Mr. Day states (*Fish. Malabar*, p. 192) that he has no doubt Mr. Jerdon described his *Schilbe sykesii* from an example without adipose fin, it must, even in that case, appear doubtful whether the fish is identical with *P. mitchelli*. If he cannot verify his assertion by the examination of the typical specimen, he has no right to exchange the name of a well-determined species for that of a doubtful one. ”

Day's reply to the above is contained in a footnote on p. 423 of his *Fishes of India* where after referring to Günther's observations he remarks : “ Jerdon had described the species fifteen years before Dr. Günther, and sufficiently well for my recognizing it at a locality where he found it ”

Jerdon's description⁴ of *Schilbe sykesii* is of a generalised nature and insufficient for the determination of the species. Jerdon's examples,

¹ Chaudhuri, B. L., *Rec. Ind. Mus.* VII, p. 444 (1912).

² Günther, A., *Cat. Fish. Brit. Mus.* V, p. 59 (1864).

³ Day, F., *Proc. Zool. Soc. London*, p. 289 (1865).

⁴ Jerdon's description of *Schilbe sykesii* (*Madras Journ. Litt. Sci.* XV, p. 335, 1849) is as follows :

“ Head one-fifth of whole length of body ; much compressed, its width being about half its length ; eye large, being $3\frac{1}{2}$ times in the head ; maxillary cirri reach the ventral fin, all the other (6) cirri longer than the head ; dorsal and pectoral spines serrated ; the latter strongly so ; anal fin about one-third of length of body—D. 1-6 ; A. 36—colour greenish above, silvery on the sides and beneath.”

about 6 inches in length, were obtained from the Cauvery. Recently I have got a large collection of fish from the same river made by Prof. C. R. Narayan Rao. There is a specimen in this collection which I refer to Jerdon's species. A thorough examination of this specimen and its comparison with others have shown that it undoubtedly belongs to *P. sykesi* which has proved to be identical with Sykes' *Hypophthalmus taakree*¹. Of the latter I have received a large number of fresh specimens from the Western Ghats, so there can be no doubt about its true identity.

The three specimens in the collection of the Indian Museum referred by Day to *P. sykesi* are about 5 inches in length without the caudal fin. The vomerine teeth in these specimens are in two distinct patches and the air-bladder is moderately extensive and lies free in the abdominal cavity; it also forms blister-like translucent areas above the pectoral fins. Mr. Norman very kindly examined the types of *P. mitchelli* and sent me a sketch of its upper dentition. He also observed that the "blister-like translucent area above the pectoral fin is indicated in the types of this species." The difference in the extent of the vomerine teeth of *P. mitchelli* and *P. sykesi* (Day nec Jerdon), as figured above, is probably due to the relative age of the specimens. I have noticed this in the case of *P. atherinoides* also; in the young the bands on the palate are more extensive and become somewhat reduced as the fish grows in size. From the above it is clear that Day was right in regarding *P. mitchelli* as identical with his *P. sykesi*, but unfortunately his *P. sykesi* is not the same as *P. sykesi* (Jerdon) which has now to be regarded as a synonym of *P. taakree* (Sykes). Thus *P. mitchelli* stands as a valid species.

Superficially *P. mitchelli* and *P. atherinoides* are very similar, but Mr. Norman informs me that the former has a smaller head, with the nape distinctly less elevated. These differences are also present in the specimens before me. In the adult specimens of *P. atherinoides* the snout is usually produced and bears teeth on the ventral surface.

Günther states that in his *P. mitchelli* the pectoral spine does not extend backwards to the vertical from the dorsal spine. This is not so in three specimens I refer to this species wherein the pectoral spine extends beyond the base of the dorsal spine.

Proeutropiichthys Hora.

1937. *Proeutropiichthys*, Hora, *Cur. Sci.* V, p. 353.

The genus *Proeutropiichthys* was proposed for such species of *Pseudeutropius*-like fishes in which the vomerine and palatine teeth form four distinct patches; these may be contiguous, slightly separated or widely apart from one another. The air-bladder is not extensive and thin-walled as in *Pseudeutropius*, but is of moderate size and lies free in the abdominal cavity.

Eutropius macrophthalmus Blyth was designated as the genotype of *Proeutropiichthys*, but an examination of fresh material from various

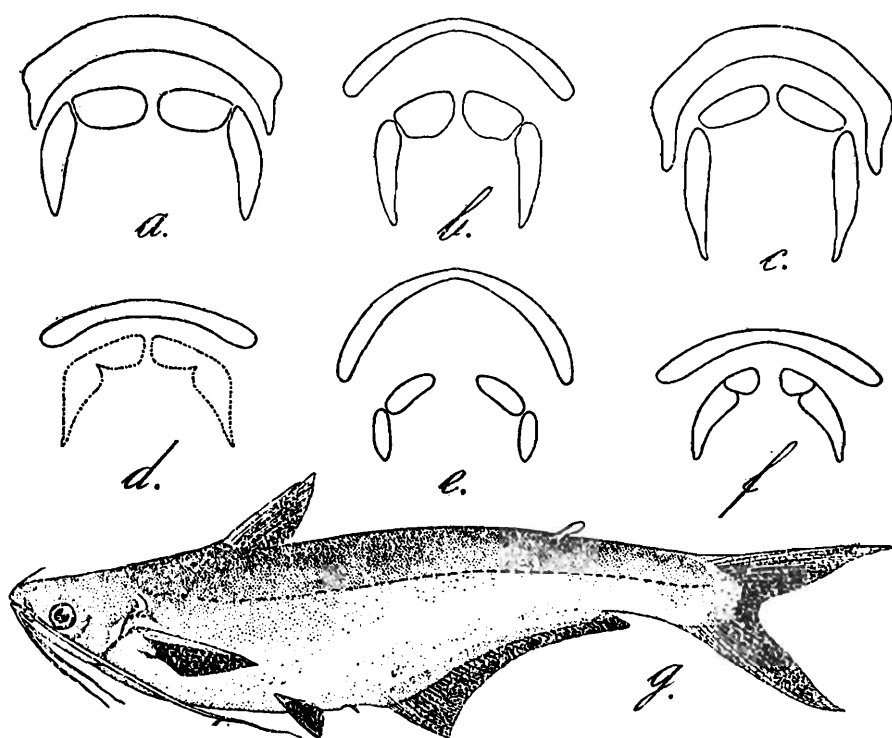
¹ Sykes, W. H., *Trans. Zool. Soc. London* II, p. 369 (1841).

localities in Peninsular India has shown that it is synonymous with *Hypophthalmus taakree* Sykes. As indicated below, this genus seems to be monotypic.

***Proeutropiichthys taakree* (Sykes).**

1841. *Hypophthalmus taakree*, Sykes, *Trans. Zool. Soc. London* II, p. 369, pl. lxxiv, fig. 4.
 1849. *Schilbe Sykesii*, Jerdon, *Madras Journ. Litt. Sci.* XV, p. 335.
 1849. *Bagrus taakree*, Jerdon, *ibid.*, p. 336.
 1853. *Bagrus taakree*, Bleeker, *Verh. Bat. Gen.* XXV, p. 56.
 1860. *Eutropius macrophthalmus*, Blyth, *Journ. As. Soc. Bengal* XXIX, p. 156.
 1864. *Pseudeutropius megalops*, Günther, *Cat. Fish. Brit. Mus.* V, p. 60.
 1864. *Pseudeutropius longimanus*, Günther, *ibid.*, p. 60.
 1867. *Eutropius taakree*, Day, *Proc. Zool. Soc. London*, p. 564.
 1869. *Pseudeutropius taakree*, Day, *ibid.*, p. 617.
 1877. *Pseudeutropius taakree*, Day, *Fish. India*, p. 471, pl. cix, fig. 4.
 1889. *Pseudeutropius taakree*, Day, *Faun. Brit. Ind. Fish.* I, p. 138.
 1890. *Pseudeutropius taakree*, Vinciguerra, *Ann. Mus. Civ. Stor. Nat. Genova* (2) IX, p. 205.
 1929. *Pseudeutropius taakree*, Prashad and Mukerji, *Rec. Ind. Mus.* XXXI, p. 478.

In view of the great taxonomic confusion that prevails regarding the specific limits of the various species included in the synonymy of *P. taakree*, I give below a short history of each and my reasons for making the nomenclatorial changes indicated above.



Text-fig. 4.—*Proeutropiichthys taakree* (Sykes).

- a. Upper dentition of a specimen from Burma, 126 mm. in total length : $\times 2\frac{3}{4}$;
 b. Upper dentition of a specimen from the Godavari River, 136 mm. in total length : $\times 3\frac{1}{2}$; c. Upper dentition of a specimen without history, 119 mm. in standard length : $\times 3$; d. Upper dentition of type-specimen of *Pseudeutropius longimanus* Günther. After a sketch by Mr. J. R. Norman ; e. Upper dentition of a specimen from Poona, 102 mm. in standard length : $\times 4\frac{1}{2}$; f. Upper dentition of type-specimen of *Pseudeutropius megalops* Günther. After a sketch by Mr. J. R. Norman ; g. Lateral view of a specimen (No. F. 12131/1) from Poona : $\times \frac{3}{8}$.

Sykes described his *Hypophthalmus taakree* from specimens collected in the "Beema river, near Pairgaon", and characterised it as follows :

"An *Hypophthalmus*, with 8 cirri, 2 of which reach to the ventral fins ; 2 very minute cirri near the nostrils, and 4 on the chin, nearly as long as the head ; with the first dorsal and pectoral rays serrated on the posterior edges, and with 8 rays in the dorsal and 50 in the anal fin."

From a perusal of the full description and figure of the species attention may be directed to the following other salient features of the fish :

- (i) "Eyes so much on the edge or side of the head as to be seen in half their diameter from below."
- (ii) "Tail being bent downwards from the end of the second dorsal and anal fins."¹
- (iii) "Snout nearly on a line with the level of the back, which is very slightly raised : belly more arched than the back"

Though as judged by modern standards, this species is insufficiently characterised, it is so common in the Deccan that there can be no doubt about its identity. I have examined large series of specimens of this species from Poona, Deolali, Hyderabad-Deccan, Godaveri, etc. There are, no doubt, marked variations in the number of rays in the anal fin and also in the development of dentition, but these are hardly of any specific value, especially when they intergrade. Being a variable species, it seems to have been described by later workers under several names.

Jerdon included this species in his list of the freshwater fishes of Southern India but gave a wrong diagnosis of the fish mentioning "Adipose fin long, anal fin short." In fact, the reverse of this was described by Sykes. *Schilbe sykesii* of Jerdon also appears to be synonymous with *P. taakree* as indicated above under *Pseudeutropius mitchelli* Günther (*vide supra*, p. 105).

Bleeker also recognised *P. taakree* as a valid species, but both Jerdon and Bleeker included it under *Bagrus*.

Blyth described *Eutropius macrophthalmus* from Tenasserim and characterised it as follows :

"Of the usual form of this genus, but with remarkably large eyes, that occupy more than half of the height of the head. Longer maxillary cirri reaching to the vent, the four inferior cirri to base of pectorals ; spines slender, the pectoral less so, and all minutely pectinated behind ; the dorsal also jagged in front for its basal half."

"D. 1-7.-A. 47 to 54."

"Colour bright silvery infuscated along the back, with a golden lustre on the gill covers. Soft rays of the dorsal and pectoral infuscated except at base ; also the median portion of the deeply forked caudal, while several outer rays of the caudal above and below are white throughout. Ventrals and anal white ; the slender adipose fin having minute dusky spots. Longest specimen 6½ in."

Günther² regarded this species as a doubtful form of *Pseudeutropius*, while Day³ considered it as a synonym of *P. goongwaree*⁴. I⁵ have already shown the precise specific limits of Sykes' *goongwaree* and its position in the genus *Eutropiichthys*. Though Blyth's description of

¹ This is an artifact. I have examined a specimen from Poona in which the back is arched as described by Sykes ; it is figured here as text-fig. 4g.

² Günther, A., *Cat. Fish. Brit. Mus.* V, p. 58 (1864).

³ Day, F., *Fish. India*, p. 471 (1877).

⁴ Sykes, W. H., *Trans. Zool. Soc. London* II, p. 369 (1841).

⁵ Hora, S. L., *Journ. Bombay Nat. Hist. Soc.* XXXIX, p. 435 (1937).

the species, especially on account of the absence of any reference to dentition of the fish, is insufficient for its precise determination I am convinced that this 'large-eyed *Eutropius*' could not be anything else except the form described by Day as *P. taakree* from Burma. Under *P. taakree* Day observed : "I have obtained in Burmah, as high as Mandalay, specimens which I am unable to separate from this species, except that in some the pectoral spine is slightly shorter, in other the adipose fin is almost or quite absent" I have examined specimens from Pegu and Mandalay referred by Day to *P. taakree* and also fresh specimens collected by Dr. B. N. Chopra in the Myitkyina District, Upper Burma. The latter specimens were reported upon by Prashad and Mukerji who remarked :

"The samples before us from Kamaing differ from Day's description mainly in their head being broader, the maxillary barbels shorter; the dorsal as well as the pectoral spines besides being denticulated posteriorly, are finely serrated anteriorly. Day 'obtained in Burma, as high as Mandalay', specimens apparently belonging to this species but with a shorter pectoral spine. It is quite possible that the Burmese specimens of *P. taakree* are distinct from the Indian."

The differences noted above are probably due to the large size of the Burmese examples in the collection studied by Prashad and Mukerji, for in larger specimens from Deccan the pectoral and dorsal spines are granulated along the anterior border. In smaller individuals these serrations are very fine and the outer border of the spine may appear as smooth. It is quite possible, however, that the Burmese race of the species may prove to be distinct but at the present the material from Burma is not sufficient to make such a detailed study.

Though Günther¹ doubtfully referred *Hypophthalmus taakree* Sykes to *Eutropius*, he described two species under *Pseudeutropius*, *P. megalops* and *P. longimanus*, which appear to be synonymous with Sykes' species. *P. megalops* was described from a single specimen "Six inches long. Godaveri at Mahadespur, Orissa. From the Collection of Messrs. V Schlagintweit." Day² included this species, with a query, under the synonymy of *P. murius*, and no other author appears to have commented on the specific limits of this species. In order to verify Day's contention I sent a sketch of the dentition of '*P. murius*' (I³ have included *murius* in the genus *Eutropiichthys*.) to Mr. J. R. Norman of the British Museum and requested him to compare it with the dentition of the type-specimen of *P. megalops*. He informed me that "The type of this species [*P. megalops*] has a dentition quite different to that shown in your sketch, so that I have given a rough sketch of this (Text-fig. 4 f). A second specimen in the British Museum identified as *P. megalops* (120 mm.) has a dentition agreeing exactly with your sketch." On further enquiry I learnt that the second specimen of *P. megalops* came from North East Bengal and formed part of the collection made by Jerdon.

The above information definitely clears up two points : (i) that *P. megalops* and '*P. murius*' are two distinct species and (ii) that Day may have been misled in his conclusion on account of the wrong identification of Jerdon's specimen in the British Museum.

¹ Günther, A., *Cat. Fish. Brit. Mus.* V, p. 52 (1864).

² Day, F., *Fish. India*, p. 472 (1877).

³ Hora, S. L., *Journ. Bombay Nat. Hist. Soc.* XXXIX, p. 435 (1937).

To bring out the differences between *P. megalops* and "*P. murius*" I requested Mr. Norman to compare the two specimens of *P. megalops* in the British Museum. He very kindly sent me the following note on this point.

"With regard to the two specimens of *Pseudeutropius megalops* of which the dentition is different these are certainly not of the same species and there is little doubt that Jerdon's specimen has been incorrectly named. In the type of *P. megalops* the depth of the body is $5\frac{1}{4}$ in the length without the caudal fin and the head 5, whereas in Jerdon's specimen the depth is 4 and the head $4\frac{3}{4}$. Further the maxillary barbel extends beyond the origin of the anal fin in the type and the caudal peduncle is longer than deep, whereas in Jerdon's specimen the barbel only reaches the first quarter of the pectoral spine and the caudal peduncle is about as deep as long. There are other minor differences but these are the more important."

In the collection of the Zoological Survey of India, there are 4 specimens from the Godavari River collected by Dr. N. Annandale at Rajahmundry which agree fairly closely with Günther's description of *P. megalops*, especially in the form of the dentition (Text-fig. 4 b). The proportions, length of barbels, etc. differ to a certain extent, but these differences cannot be regarded as specific. The number of anal rays varies from 42 to 49. I give below a table of measurements of these examples, which seem to me to belong to *P. taakree*.

Measurements in millimetres.

Standard length	..	..	108.5	103.0	65.0	55.0
Length of head ..	..	..	24.0	21.5	14.5	11.8
Width of head ..	..	..	13.5	12.0	7.8	6.0
Height of head at occiput ..	..	..	15.5	14.5	10.0	8.5
Length of mouth	..	..	5.0	4.0	3.0	2.5
Width of mouth	..	..	6.4	5.5	4.1	3.3
Diameter of eye	..	..	7.0	7.0	6.0	5.1
Length of snout	..	..	8.0	8.0	4.9	4.0
Interorbital width	..	..	7.5	7.2	4.5	4.0
Width of body ..	..	..	11.0	11.0	7.0	5.0
Height of body ..	..	..	20.0	18.0	12.5	9.0
Length of pectoral spine	..	..	20.4	19.0	11.0	D.
Length of dorsal spine	..	..	17.5	16.0	8.8	7.0
Length of nasal barbel ¹	..	..	10.5	10.0	7.0	4.5
Length of maxillary barbel ²	..	..	50.0	46.5	29.0	25.2
Length of outer mandibular barbel	..	..	25.0	24.0	12.0	10.0
Length of inner mandibular barbel	..	..	25.5	25.4	13.0	12.0
Length of caudal peduncle ..	..	..	16.0	14.0	7.5	6.5
Least height of caudal peduncle	..	..	9.0	8.5	5.0	4.0
Commencement of dorsal from tip of snout	..	..	34.0	31.5	20.5	16.5

P. longimanus was described from a "Skin : 6 inches long : not good state. India. From the Collection of the Zoological Society." The main difference from *P. megalops* seems to consist in the number of rays in the dorsal and anal fins (D. $1\frac{1}{6}$; A. 41 for *P. megalops* and D. $1\frac{1}{8}$; A. ca 54 for *P. longimanus*). I have referred above to the variation in the number of anal rays of *P. taakree* and after having examined large series of specimens it is not possible for me to recognise

¹ Reaching to the middle of the eye-diameter.

² The length of maxillary barbels is very variable ; usually they extend to the end of the pelvic fins but they may be shorter or longer.

the above differences as of any specific value. Accordingly, I agree with Day¹ that *P. longimanus* is synonymous with *P. taakree*. Day² was of the opinion that the type-specimen of *P. longimanus* was from the collection of Col. Sykes and may have been the original of his *P. taakree*.

At my request, Mr. J. R. Norman sent to me a sketch of the dentition of *P. longimanus* (Text-fig. 4 d) and it also shows that the species is identical with *P. taakree*. There are two old, poorly preserved specimens in the Indian Museum (Cat. No. 509) without any locality label or name of donor in which the number of fin-rays and dentition (Text-fig. 4 c) correspond with Günther's description of *P. longimanus*.

As noted in the case of several other Indian species, the distribution of *P. taakree* is also of zoogeographical interest; it is found in Deccan on the one hand and Burma on the other, and has not yet been recorded from the intermediate regions. There is one lot of 6 old specimens in the collection of the Indian Museum (No. Cat. 507) which is labelled to have been collected at Calcutta. This record seems to be rather doubtful.

Ailia Gray.

The generic name *Ailia* was proposed by Gray as a subgenus of *Malapterus* (*sic*) to accommodate his species '*Malapterus (Ailia) Bengalensis*' figured in the *Illustrations of Indian Zoology*. This figure is a copy of Hamilton's original drawing of *Malapterurus coila*. The definition of the genus is, however, given in the *Zoological Miscellany* (p. 8, 1831) and is as follows :

"Body compressed; fins all spineless; fat-fin very short and small over the end of the very long anal fin; ventral fins all nearly under the pectoral; tail forked. Most allied to *Melapterus* of Geoffroy."

At the same time Gray described the genus *Acanthonotus* for *A. hardwickii* which is also figured in the *Illustrations*. Both the figure and the description appear to be based on a badly preserved specimen of *Ailia coila* (Ham.) in which the neural spines projected beyond the dorsal profile giving the false appearance of "a series of small spines" before the spineless dorsal. Though the latter generic name has line priority over *Ailia*, it is not accepted here owing to its diagnosis being very defective.

The genus *Ailia* is remarkable in several respects and Bleeker³ constituted a separate group Ailianini in the sub-family Ailichthyoidei for its reception. Günther⁴, however, included it in his composite group Silurina, but Regan⁵ in his classification of the Siluroid fishes accommodated it in a separate subfamily—Ailiinae—of the Schilbeidae. The most salient features of *Ailia* are: (i) tubular, horse-shoe-shaped air-bladder, (ii) absence of rayed dorsal; (iii) presence of a small adipose dorsal, (iv) long anal fin; (v) eight well-developed barbels; (vi) forked caudal and (vii) fairly well marked dentition. Of these, great import-

¹ Day, F., *Proc. Zool. Soc. London*, p. 617 (1869).

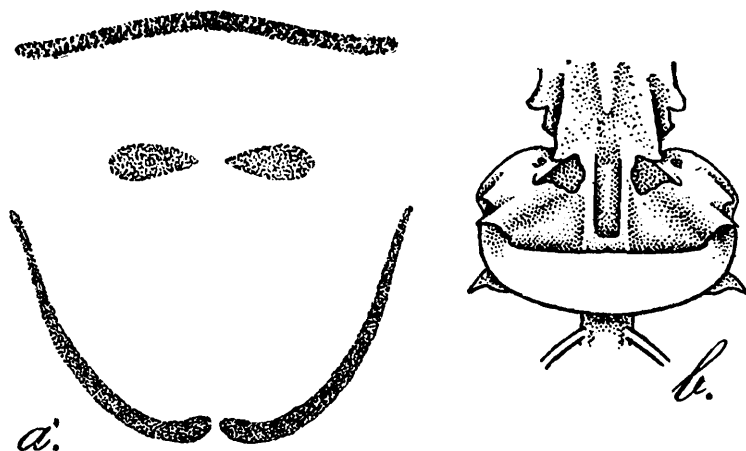
² Day, F., *Fish. India*, pp. iv (under Sykes), 471 (1877).

³ Bleeker, P., *Ichth. Arch. Ind. Prodr.* 1, Siluri, pp. ix, 248 (1858).

⁴ Günther, A., *Cat. Fish. Brit. Mus.* V, p. 55 (1864).

⁵ Regan, C. T., *Ann. Mag. Nat. Hist.* (8) VIII, p. 567 (1911).

ance has been attached to the structure of the air-bladder which has been described by Day¹, Bridge and Haddon² and Nair³.



Text-fig. 5.—Dentition and air-bladder of *Ailia coila* (Hamilton).
a. Dentition : $\times 8$; b. Air-bladder : $\times 5$.

In 1871, Day (*loc. cit.*) established the genus *Ailiichthys* for *A. punctata* found in "The Jumna, and southern rivers in the Punjab that are tributaries of the Indus, but not those on the hills," and characterised it as : "Differing from *Ailia* in that the ventral fins are entirely absent." In several cases I have previously referred to the absence of pelvic fins in fishes and shown that no reliance can be placed on this character for taxonomic purposes. In *Ailia*, for instance, the body is greatly compressed and almost leaf-like. The pelvic fins are very small and lie below the pectorals. In these circumstances their function is taken over by the pectorals, which are somewhat more elongated than usual, and in consequence the pelvics may be regarded as mere vestigial organs. It is no wonder, therefore, if under certain circumstances they do not make their appearance altogether. Similar cases of abnormality have been observed by a number of workers. Günther⁴ explained the absence of pelvics on the assumption that "The chief function of these fins is to balance the body of the fish whilst swimming ; and it is evident that, in fishes moving during a great part of their life over swampy ground, or through more or less consistent mud, this function of the ventral fins ceases, and that nature can readily dispense with these organs altogether." This is probably true in the case of such genera as *Channa-labes*, *Apua*, *Channa*, etc. which live in mud or vegetable débris, but *Ailia* is certainly not a bottom fish as is evident from its form and colouration. In the case of *Ailia* it seems probable that owing to the extension of the tail region and the compression of the head and body there remains very little space for the attachment of the pelvic fins. Moreover, the elongation of the pectorals as far back as the anal fin rendered the presence of pelvics as useless. In the economy of nature,

¹ Day, F., *Proc. Zool. Soc. London*, p. 712 (1871).

² Bridge, T. W. and Haddon, A. C., *Phil. Trans. Roy. Soc. London* (B) CLXXXIX, p. 208 (1894).

³ Nair, K. K., *Rec. Ind. Mus.* XL, pp. 185, 186 (1938).

⁴ Günther, A., *Ann. Mag. Nat. Hist.* (4) XII, p. 143 (1873).

therefore, these organs may sometime be totally absent. In view of what is stated above, I do not consider *Ailiichthys* as a separate genus from *Ailia*. In fact, my examination of the material in the collection of the Indian Museum shows that *Ailiichthys punctatus* Day is synonymous with *Ailia coila* (Ham.). Thus I am able to recognise only one species in this genus.

XII. A FURTHER NOTE ON FISHES OF THE GENUS *Clarias* GRONOVIVS.

In 1936, I¹ discussed the systematic position of the various forms of *Clarias* described from India, Burma and Ceylon, and concluded that only three species can be recognised from these regions, viz., *C. batrachus* (Linn.) (Ceylon, India, Burma, the Malay Archipelago and further east), *C. brachysoma* Günther (Ceylon) and *C. dayi* Hora (Wynaad Hills). Since then I have examined the Siluroid material preserved in the collections of the Bombay Natural History Society and the Government Museum, Madras, and among them found specimens (2 from Karkala, South Canara District and 7 from Goa), which, though closely allied to *C. brachysoma*, differ in certain respects from all the three species enumerated above. A similar specimen was also found in a collection of fishes sent by Prof. P. W. Gideon for determination; it was collected in a *nullah* near Belgaum. A close study of these specimens and literature has shown that they are referable to *C. dussumieri* Cuv. & Val.,² which was described from Malabar and Pondicherry from specimens 7 to 8 inches in length, and distinguished from *C. batrachus* (= *C. magur*) by the following characters:—

“ avec la tête lisse et large de la deuxième [*C. magur*], a les épines pectorales plus sensiblement dentées, et les dents de l'arc vomérien approchent plus de la forme de petits pavés que de celle de dents en velours ras.”

Though *C. dussumieri* was found by Jerdon³ “ in tanks and ditches in Malabar ”, Günther⁴ regarded it only as a *species inquirendum*. At the time of writing ‘ The Fishes of Malabar ’, Day⁵ had not examined any specimen of the species but later he⁶ found one example, 7 inches long, from the Wynaad which he assigned to *C. dussumieri*. This specimen, which is now preserved in the collection of the Indian Museum and is in a very poor state of preservation, was found by me (*loc. cit.*) to be abundantly distinct from all the known species of the genus and was accordingly made the type of a new species *C. dayi* Hora. In my previous note I regarded *C. dussumieri* as a synonym of the widely distributed Indian species, *C. batrachus*, but fresh material from the Malabar zone has convinced me that it is worthy of recognition as a distinct species. It is distinguished from *C. batrachus*, among other characters, by its greater distance between the occipital process and

¹ Hora, S. L., *Rec. Ind. Mus.* XXXVIII, pp. 347-351, text-figs. 1-5 (1936).

² Cuvier, G., and Valenciennes, A., *Hist. Nat. Poiss.* XV, p. 582 (1840).

³ Jerdon, T. C., *Madras Journ. Litt. & Sci.* XVI, p. 342 (1849).

⁴ Günther, A., *Cat. Fish. Brit. Mus.* V, p. 17 (1864).

⁵ Day, F., *Fishes of Malabar*, p. 197 (1865).

⁶ Day, F., *Fish. India*, p. 484 (1877).

commencement of the dorsal fin ; from *C. brachysoma* in having a more coarsely serrated pectoral spine, somewhat shorter barbels and more obtuse teeth on the palate and from *C. dayi* in having much longer nasal barbels, less molariform teeth and less strongly serrated pectoral spine. It is thus in several respects an intermediate form between *C. brachysoma* and *C. dayi*.

Specimens of *C. brachysoma* from Ceylon have usually been referred to *C. teysmanni* Bleeker (Java, Sumatra, Borneo and Malacca), but after an examination of the type material of both the species in the collection of the British Museum of Natural History, Mr. J. R. Norman (*vide* Hora, *loc. cit.*, p. 349) showed that the two forms are distinct. Generally speaking, there is no doubt regarding the very close similarity between the species typical of the Malabar zone and Ceylon on the one hand and of the Malay Archipelago on the other. Attention may here be directed to an error in my previous article on *Clarias* in the explanation of text-figure 2, *viz.*, text-figure 2a represents, after Norman, the vomerine tooth band of *C. brachysoma* and text-figure 2b that of *C. teysmanni* and not *vice versa* as was then described.

For facility of reference in future I give below full descriptions of *C. dussumieri* Cuv. & Val. For a detailed account of *C. dayi* Hora reference may be made to Day's descriptions of *C. dussumieri* both in the *Fishes of India* and in the *Fauna*.

***Clarias dussumieri* Cuvier and Valenciennes.**

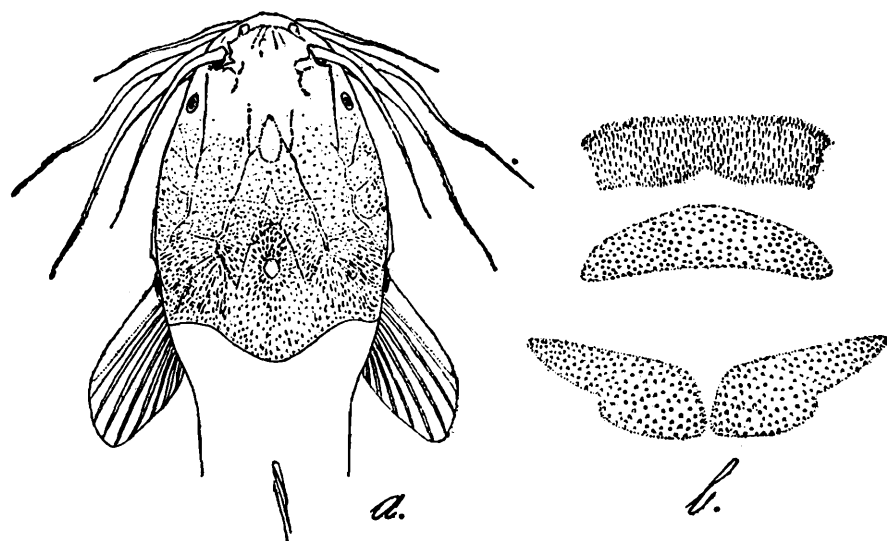
1840. *Clarias Dussumieri*, Cuvier and Valenciennes, *Hist. Nat. Poiss.* XV, p. 382.

D. 66-69 ; A. 45-59 ; P. 1/10-11 ; V 6.

Clarias dussumieri is an elongated fish in which the depth of the body is contained from 8.4 to 9.4 times, the length of head to end of gill-cover 6 times and to end of occipital process 4.5 times in the total length. The height of head is contained from 1.5 to 1.7 times in its length. The head is almost as broad as long. The diameter of the eye is contained from 8 to 10 times, the length of snout from 2.7 to 3.2 times and the interorbital width 1.8 times in the length of the head. The occipital process is broadly rounded ; its height is considerably less than half the length of its base. The distance between the origin of dorsal and occipital process is contained about 3 times in the length of the head to the end of the occipital process.

The dorsal surface of the head is roughened with ridges. The frontal fontanel is almost twice as long as broad and extends as far as the front border of the eye, while the occipital fontanel is oval and much shorter. The interorbital distance is greater than the width of the mouth and is almost equal to the postorbital part of the head. The nasal barbels extend as far as the occipital fontanel ; the maxillary barbels extend beyond the bases of the pectorals ; the outer mandibulars reach the bases of the pectorals while the inner mandibulars are shorter. There are villiform teeth in the jaws ; those in the upper jaw are in the

form of a continuous band one-fifth as broad as long; those in the lower jaw are grouped in two contiguous patches which are produced back-



Text-fig. 6.—*Clarias dussumieri* Cuvier and Valenciennes.

a. Dorsal surface of head and anterior part of body up to commencement of dorsal fin: $\times \frac{3}{4}$; b. Dentition: $\times 2\frac{1}{2}$.

wards at the sides. The vomerine teeth are conspicuously obtuse and are situated in a broad crescentic band.

The dorsal fin commences almost above the termination of the pectorals and is separated from the caudal by a distinct notch. The caudal fin is longer than the head and is roundly pointed at the end; it is not confluent with the anal and the dorsal fins. The pectoral fin is considerably shorter than the head; its spine is strong and conspicuously serrated along the outer border; along the inner border it is provided with a few small teeth in the middle. The pelvic fins extend beyond the commencement of the anal fin.

In the preserved specimens there are no distinct markings; the general colour is somewhat darker above and lighter below.

Variations.—The above description is based on two fine examples from Karkala in South Canara District. The seven specimens from Goa are in a poor state of preservation but generally agree in almost all particulars with the Karkala examples. The specimen from Belgaum is, however, stumpy and stout with the body considerably deeper, head somewhat broader and the paired fins shorter. The pectoral spine is relatively much shorter.

Distribution.—Along the Malabar Coast generally; it has been recorded from Pondicherry, Goa, South Canara and Belgaum.

Remarks.—Except for the differences in the nature of the pectoral spine and vomerine teeth, and the length of barbels *C. dussumieri* is closely related to *C. brachysoma* of Ceylon and *C. dayi* of the Wynaad. In the following Table I give measurements of 3 specimens of *C. dussumieri* and of 3 specimens of *C. brachysoma* for purposes of comparison.

Measurements in millimeters.

		<i>C. dussumieri</i>			<i>C. brachysoma</i>			
		Karkala.		Belgaum.	Ceylon.			
Total length	..	..	253.0	227.0	178.8 ¹	252.2 ²	236.0	206.0
Length of caudal	..	..	34.0	33.0	22.5	33.0	34.0	28.2
Depth of body	..	..	30.0	24.0	26.0	35.0	29.2	30.5
Length of head to end of opercle			41.2	38.0	34.2	44.0	40.0	33.0
Length of head to end of occipital process	..	..	54.3	49.6	43.4	54.2	50.5	44.5
Height of head	..	..	27.8	22.0	22.3	29.8	25.2	25.0
Width of head	..	..	38.0	34.5	33.0	39.5	37.5	31.8
Length of snout	..	..	14.3	13.8	10.5	15.2	14.0	10.5
Diameter of eye	..	..	5.0	3.9	3.0	4.2	4.2	3.5
Interorbital width	..	..	22.6	21.0	19.0	24.0	23.2	19.0
Length of pectoral spine	..	..	22.0	18.2	13.8	19.5	19.0	15.2
Length of pectoral	..	..	30.2	25.6	20.7	28.6	28.0	21.8
Length of pelvic	..	..	19.8	18.8	14.0	17.8	15.6	15.0
Length of nasal barbel	..	..	32.0	31.0	25.0	35.6	36.2	28.5
Distance between occipital process and dorsal fin	..	..	17.4	16.3	14.7	20.5	18.0	16.4

¹ The caudal fin is partly damaged in this specimen.² This is a mature female full of eggs.

LARVAL DEVELOPMENT OF *GARRA CEYLONENSIS* *CEYLONENSIS* (BLEEKER).

By S. JONES, M.Sc., Central Research Institute, University of Travancore,
Trivandrum.

In a previous paper (Jones, 1938a) the external features in the embryonic development of *Garra ceylonensis ceylonensis* (Bleeker) were given, and the present paper deals with the post-embryonic development of this form till the attainment of adult features. A week after the specimens hatched out, they were brought down from Demodera (Ceylon) to Colombo, and from there to Tambaram, Madras. It is of interest to note that the larvae stood the journey well and readily adapted themselves to a very hot climate from a comparatively mild one, and to Tambaram water which is well known for the high percentage of dissolved calcium salts.

Newly hatched larva.—It is 5 mm. in length and usually remains attached to algae by the lower side of the mouth, though how this is done is not understood, as no adhesive organ of any kind was noticed. Due to the presence of functional pectoral fins the larva has greater control over its movements than other newly hatched Cyprinids. When disturbed it darts off at great speed, but hangs on to the algae after some time (for further details see Jones, 1938a).

Second day.—The mouth opening is larger, yolk is reduced to half and the notochord at the caudal end is bent slightly upwards (Text-fig. 1a). A rudiment of the air-bladder is visible. The larva has a golden yellow colour under the microscope and actively swims about in water.

Third day.—The eyes begin to shine, the air-bladder shows a distinct bubble of air, gall bladder becomes visible, small papillary projections appear on the sides of the head, chromatophores increase on the dorsal side and the animal moves about very actively.

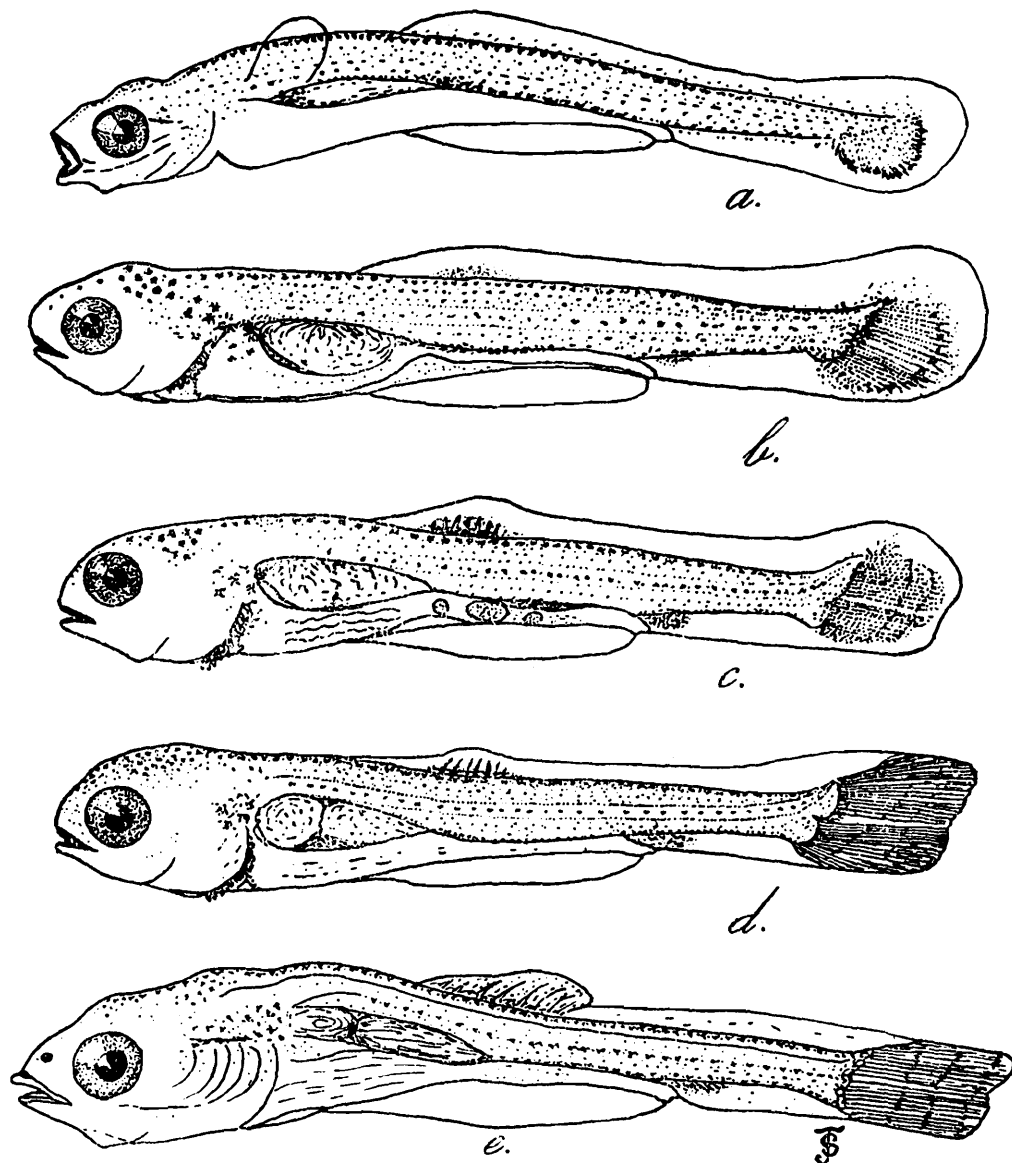
Fifth day. (Text-fig. 1b).—The mouth has well developed lips. All the yolk is absorbed, and the liver and the gut as a straight tube can be distinguished. External gills, which are mere filamentous elongations of the internal gill lamellae, are very well developed. The notochord at the posterior end is turned distinctly upwards and the caudal fin has rudimentary fin-rays. Chromatophores appear on the fins and the median fin-fold is broader at the position of the future dorsal fin. The papillary outgrowths on the head increase in number.

Seventh day. (Text-fig. 1c).—The chromatophores become more dense. About 18 fin-rays are formed in the caudal fin which develops a notch in the middle transforming it into the homocercal type, and rudiments of the dorsal fin-rays are developed. The animal feeds on algae.

Eighth day.—The air-bladder, which was simple at first, becomes constricted in the middle.

Ninth day. (Text-fig. 1d).—The constriction in the air-bladder becomes deeper showing two distinct regions, a rounded anterior and a conical posterior region.

Fourteenth day.—The caudal fin has a fringed edge, and is well supplied with blood vessels. Minute wart-like projections, perhaps the rudiments of rostral tubercles, are found on the snout.



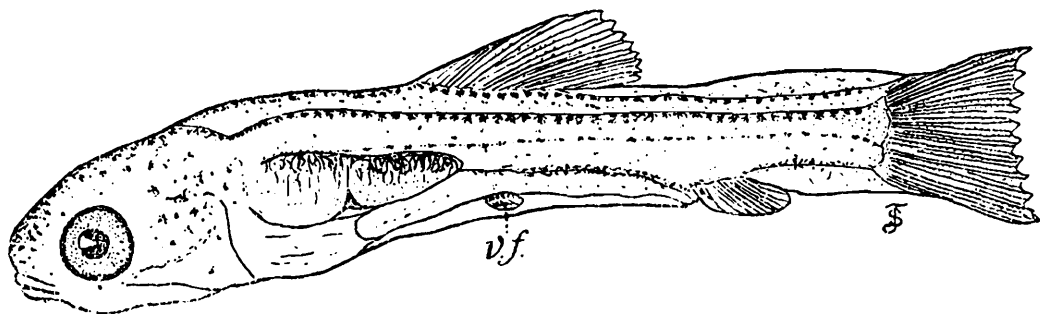
TEXT-FIG. 1.—Larval stages of *Garra ceylonensis ceylonensis* (Bleeker).

a. Second day: $\times 20$; b. Fifth day: $\times 20$; c. Seventh day: $\times 20$; d. Ninth day: $\times 20$; e. Twentieth day: $\times 14$.

Twentieth day. (Text-fig. 1e).—Length 7.5 mm. There are seven or eight fin-rays in the dorsal fin and the caudal fin is almost homocercal, but the dorsal half is a little larger. The position of the anal fin is marked by a broader portion in the marginal fin behind the anus. The number of chromatophores have considerably increased in the body, and the animal appears light grey to the naked eye. The mouth is inferior in position. The animals display cannibalistic tendencies, the larger and stronger ones attacking and devouring the smaller and the weaker.

One month old. (Text-fig. 2).—Length 8.8 mm. The anal fin with distinct fin-rays is developed, though the fin-fold connecting it to the

caudal still persists, and the ventrals are seen as small buds in front of the anus. The gut develops a loop in the middle, and the barbels



TEXT-FIG. 2.—One month old larval stage of *Garra ceylonensis ceylonensis* (Bleeker)
: $\times$ ca 11.

become visible. The young fish devour everything from bread and rice to frog meat and mussel flesh, and browse on the algal growth on the sides of the aquarium.

One and a half months old.—The young fish is 13.3 mm. long and has attained most of the external characters of the adult except the ventral sucker which is only rudimentary. The mouth is antero-ventral in position. There is only a single surviving specimen which grows stout with the ventral side getting flattened.

When the fish is about 2 months old the mouth becomes ventral in position and the sucker is developed. It is omnivorous in its diet, greatly relishing chopped meat and flesh. Since the development of the sucker the animal continually feeds on the algae growing on the sides of the aquarium.

The author's idea of working out the development of the ventral sucker had to be given up owing to the lack of specimens belonging to the later stages. About 40 living specimens were brought from Ceylon, and of these only two survived after a month and a half. One of them grew to a length of one and a half inches when three months old. In November 1937, the author had to leave Tambaram for Trivandrum and the specimen was also taken there where it was living till the end of February 1938, when it died in the absence of the author from the place. After it was brought to Trivandrum it could not be properly attended to and it did not grow to any appreciable extent. It was a chubby little fish resembling very much its congener, *Garra ceylonensis phillipsi* Deraniyagala.

The influence of the environment on eggs is well illustrated in *Garra*, which in the course of evolution has developed a comparatively large-sized egg resulting in the precocious development of the early larva. A comparison with the eggs and early larvae of other Cyprinids, whose development is known, is of interest (Khan, 1926, and Jones, 1938). Recently the author has been able to work out the development of two other South Indian Cyprinids¹ which provides additional evidence concerning the highly evolved nature of the egg and early larva of *Garra*.

The young *Garra* that was being reared used to come near the surface,

¹ The results have not yet been published.

especially in the evenings, and produce bubbles of air which accumulated as patches of sticky foam near the sides of the aquarium. Fraser (1937, p. 705) has recorded this habit in a number of Cyprinid fishes of Deolali, Nasik. As Hora says in a footnote (Fraser, *op. cit.*), the sticky nature of the bubbles may be caused by the slime taken up by the air as it passes over the gills.

About *Garra mullya* which was able to live for a short period of four days only in the aquarium, showing all the time respiratory difficulties due to lack of oxygen, Fraser (*op. cit.*, p. 691) says. "They periodically and frequently rose to the surface and by muscular action alone maintained themselves perpendicularly suspended, but not by their lips, for 30 to 35 seconds. While thus engaged, they create a froth of bubbles" Mr. S. J. Silas of Demodera (Ceylon) had a small fish-pond and I was able to notice adult specimens of *Garra* showing a similar behaviour whenever they were introduced into it. None of the specimens survived for more than a couple of days except a juvenile specimen about 4 inches long that lived for some months.

During a visit to the Peerumedu Hills in Travancore in February 1938, the author caught a young *Garra* from one of the hill streams there at a height of about 3,500 ft. This was brought to Trivandrum where it lived in a small glass vessel for 4½ months. This had the habit of making bubbles of froth regularly in the evenings.

The few experiments that I performed to test the adhesive capacity of the mental disc of an adult *Garra* were too crude and unsatisfactory to be relied on. The young specimen that the author was rearing did not at any stage exhibit any tendency to use the ventral disc as an adhesive organ. Whenever an artificial current was produced, it either swiftly darted against it or was helplessly carried along with it.

The condition was different in the case of the young *Garra* from Travancore. Whenever an artificial current was produced, it fixed itself to the bottom by the paired fins, especially the pectorals, and lowered its head bringing the ventral side into close contact with the bottom preventing the flow of water through the underside of the head. The animal remained in this position at one place for only a moment. It quickly darted forwards and effected fresh attachments. In still water it was noticed on a few occasions attempting to stick to the sides of the aquarium; but it was never found capable of effecting a permanent grip.

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LIFE-HISTORY AND BIONOMICS OF THE SPINY EEL, *MASTACEMBELUS PANCALUS* (HAMILTON), WITH NOTES ON THE SYSTEMATICS OF THE MASTACEMBELIDAE.

By T. J. JOB, M.Sc., *Lady Tata Memorial Research Scholar.*

(From the Laboratories of the Zoological Survey of India, Calcutta.)

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INTRODUCTION.

In the course of field studies on larvicidal fishes at Ulubaria, in the Howrah District, the author found numerous specimens of *Mastacembelus pancalus* (Hamilton), both adult and young, thriving in the large borrow pit extending between Telegraph-posts 19/6 and 19/10 down, between Ulubaria and Fuleshwar. Examination of the gut-contents of the fish showed that in the young stages the species sometimes consumes mosquito larvae and cyclops besides other aquatic micro-organisms. The presence of young fish naturally suggested the possibility of the species breeding in the borrow pit. Hence a search was made for the eggs of the species with a view to study its life-history, which would be of interest, for the development of no member of the Mastacembelidae, which is a family of uncertain relationships, is as yet known. After several weeks of unsuccessful attempts, eggs were discovered on the 12th of July, 1940 ; these consisted of 21 eggs forming a more or less loose mass entangled in a thick mesh of the submerged portion of a floating tuft of algae consisting mainly of *Spirogyra*. The eggs, with portions of the associated algae were carefully removed to the Malaria Inspector's Laboratory near-by, and the development followed in the water from the same borrow pit in conditions similar to those described for *Aplocheilichthys panchax* (*vide* Job, 1940, p. 57). Subsequently on several

occasions eggs in smaller numbers were found similarly attached up to the month of November. Larvae and post-larvae of different stages were also collected and examined for comparison with identical stages among those that lived in the laboratory. The bionomics of the species was studied both in an aquarium and in the natural habitat. In connection with the relationships of the Mastacembelidae the collection of Percomorphi in the Zoological Survey of India was examined.

ACKNOWLEDGMENTS.

I am very grateful to Dr. Bains Prashad, Director, Zoological Survey of India, for various facilities afforded to me in conducting this study and for his helpful criticism. The work was done under the kind direction of Rai Bahadur Dr. S. L. Hora, and my heartfelt thanks are due to him for constant guidance and encouragement. I am also thankful to Dr. Albert W. C. T. Herre of the Stanford University, California, for his instructive discussions on the systematics of the Mastacembelidae. I am indebted to Mr. A. Duncan, Agent and General Manager, and Mr. R. Senior-White, Malariologist, Bengal Nagpur Railway, for the travelling and field facilities very kindly afforded to me. To the Lady Tata Memorial Trust I am thankful for the award of a scholarship, which enabled me to make this study along with other researches on larvicidal fishes.

LIFE-HISTORY OF THE SPINY EEL.

General.—*Mastacembelus pancalus*, popularly known as the Spiny Eel, is distinguished by its compressed, eel-like shape; elongated, non-protractile snout; upper jaw terminating in a moveable appendage with a trilobed tip; long, spiny dorsal and anal fins; distinct, rounded caudal fin; absence of ventrals; and characteristic colouration. It is olive green along the back, lighter olivaceous on the sides, grading into yellowish white ventrally, with numerous irregularly scattered greyish white spots over the sides and small dark grey transverse blotches scattered along the mid-dorsal surface and extending downwards as irregularly vertical stripes along the sides; there are a few dark spots and blotches over the operculum and snout with a conspicuous dark grey band on either side from the tip of the snout to the eye and behind it over the opercle. The cheeks are golden and the nostrils bluish. The fins have a greenish yellow ground colour with many dark spots and blotches, the latter being comparatively more conspicuous in the median fins. Usually the colouration is brighter in the young. It becomes duller with age, and the vertical stripes often fade, except in the posterior third or so.

Day (1889, p. 334) has recorded the species from the large rivers of India, but says that he has not seen it along the Coromandel Coast south of the Kistna. Sundara Raj (1916, p. 290), however, has observed the fish thriving in tanks all over Madras and in the Cooum. Its local names are *Pangkai*, *Gochi*, *Gaugr-Gongli*, Bengali; *Tu-rah*, Assamese; *Turi*, *Bahru*, Ooriah; *Chen-du-la*, *Gurchee*, *Gro-age*, Punjabi; *Ju-gar*, pashtu; *Bamni*, Urdu; *Par-pa-ral*, Telugu; and *Pil Aral*, Tamil.

Breeding.—Young specimens of *Mastacembelus pancalus* measuring about 30 mm. were found in the Spur Tank,¹ Madras, in the month of February by Sundara Raj (*op. cit.*, p. 290), and he surmised that the species “breeds during the cold weather” D’Abreu (1925, p. 30), obtained 28 mm. fry from the Ambajheri Tank at Nagpur in April, while Prashad and Mukerji (1930, p. 16) found 50 mm. specimens in the Manchar Lake, Sind, in November. In the Railway borrow pits at Ulubaria the fish breeds from May to November², with the peak period at the commencement of the monsoon.

The mature female of *M. pancalus* is, as a rule, stouter, but less brightly coloured than the male. The ovaries are paired, elongated, strap-shaped sacs, of which the right one is slightly longer than the left. They hold an enormous number of ova in various stages of growth. The ovaries unite posteriorly into a short common oviduct which leads out through a slit-like opening situated on an elevated urinogenital papilla behind the anus, just in front of the anal fin.

The fish builds no true nest; but at spawning time it selects a sheltered portion of some algal mass below the surface, where proper aeration and sunshine would be ensured. There it lays a varying number of eggs, usually ten to twenty at a time, which are fertilised by the male as they are being laid. The eggs are demersal, and left to themselves would sink to the bottom. But being laid on algal meshes they remain suspended on them (text-fig. 1a), though on shaking violently, the eggs get detached and drop to the bottom. No parent was ever seen to guard the eggs.

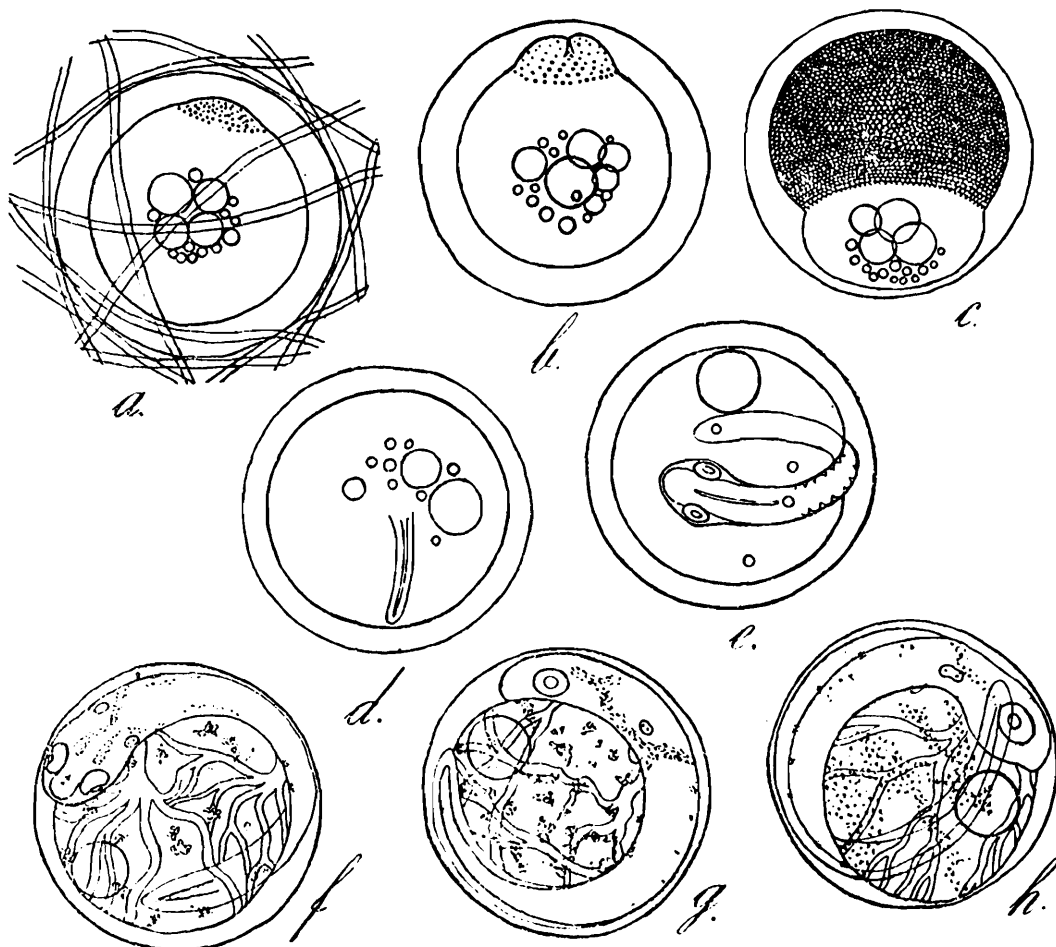
Egg and Embryonic Development.—The newly laid egg is more or less spherical and transparent; its diameter varies from 1.3 mm. to 1.35 mm. It is highly yolk-laden, and in general appearance resembles the egg of *Aplocheilichthys panchax* (Job, 1940, p. 57-59); but the cluster of adhesive threads so conspicuous in the egg of *A. panchax* is absent here. The egg membrane, however, bears certain irregular striations, which probably contribute towards making the egg stick to the algal tuft by friction. As in the case of *A. panchax* the egg is heavy, though provided with conspicuous oil globules of varying number and size in the yolk. The protoplasm in the fertilised egg stands out as a convex granular blastodisc. The early stages of cleavage (text-fig. 1b) and embryonic development are typically teleostean. It is, however, noteworthy that despite the presence of a large amount of yolk, the embryonic development is short, the eggs usually hatching a day and a half after they are laid. Text-fig. 1c shows an egg six hours after fertilisation. The blastoderm has spread over more than two-thirds of the transparent yolk, the uncovered portion of which remains protruding out as it were beyond the blastoderm rim, and encloses four large and several small oil globules.

¹ The Spur Tank has since been reclaimed.

² Eggs of the species were collected for the first time in July; but the presence of 18 mm. fry noticed in the month of June showed that breeding had commenced in May.

Nine hours old egg.

In a nine hours old egg (text-fig. 1d) the embryo has begun to be differentiated. The number of the oil globules is reduced, but one of them increases in size.



TEXT-FIG. 1.—*Mastacembelus pancalus* (Hamilton), segmentation of the egg and embryonic development: $\times$ ca. 22.

a. Unsegmented egg; b. Two-celled stage; c. About six hours after fertilisation; d. Nine hours after fertilisation; e. Twelve hours after fertilisation; f. Twenty-four hours after fertilisation; g. Thirty hours after fertilisation; h. Thirty-five hours after fertilisation.

Half a day old egg.

In another three hours the embryo (text-fig. 1e) is well differentiated with clearly marked optic vesicles. The yolk contains a single large oil globule and four to six tiny ones. The embryo is not yet free, but remains partly embedded in the yolk.

A day old egg.

In the course of the next twelve hours the embryo (text-fig. 1f) grows larger at the expense of a portion of the yolk. Circulation is established; chromatophores appear on the yolk and on the embryo, the chief pigment patches being a pair of irregular, elongated bands behind the eyes. The single large oil globule is conspicuous, while a few tiny ones are scattered about in the yolk. The auditory vesicles have appeared.

A day and a quarter old egg.

In a thirty hours old egg (text-fig. 1g) the pectoral fin buds begin to appear; the embryo grows larger, pigmentation increases, and the

median fin-fold makes its appearance. The hind region of the embryo gets freed from the yolk-sac, and at intervals the embryo twists and turns along with the yolk. The otoliths are quite clear. The circulation is active ; the heart beats about 160 times per minute. The chromatophores on the yolk form conspicuous patches. The body also is more pigmented. The pigment bands behind the eyes converge posteriorly towards the mid-dorsal side. The large oil globule remains while the others have been absorbed.

Hatching.

The egg hatches when about 36 hours old, the hatching taking place usually in the evening of the second day after the egg is laid. Text-fig. 1*h* shows an egg which is just about to hatch. Hatching is a quick process, the tail coming out first, and the larva smartly wriggling itself out of the egg membrane. This first energetic act apparently exhausts the larva which is burdened with a massive yolk-sac, and hence it reaches a near-by mesh and rests there in any pose, horizontal or inclined, generally with the belly turned upwards.

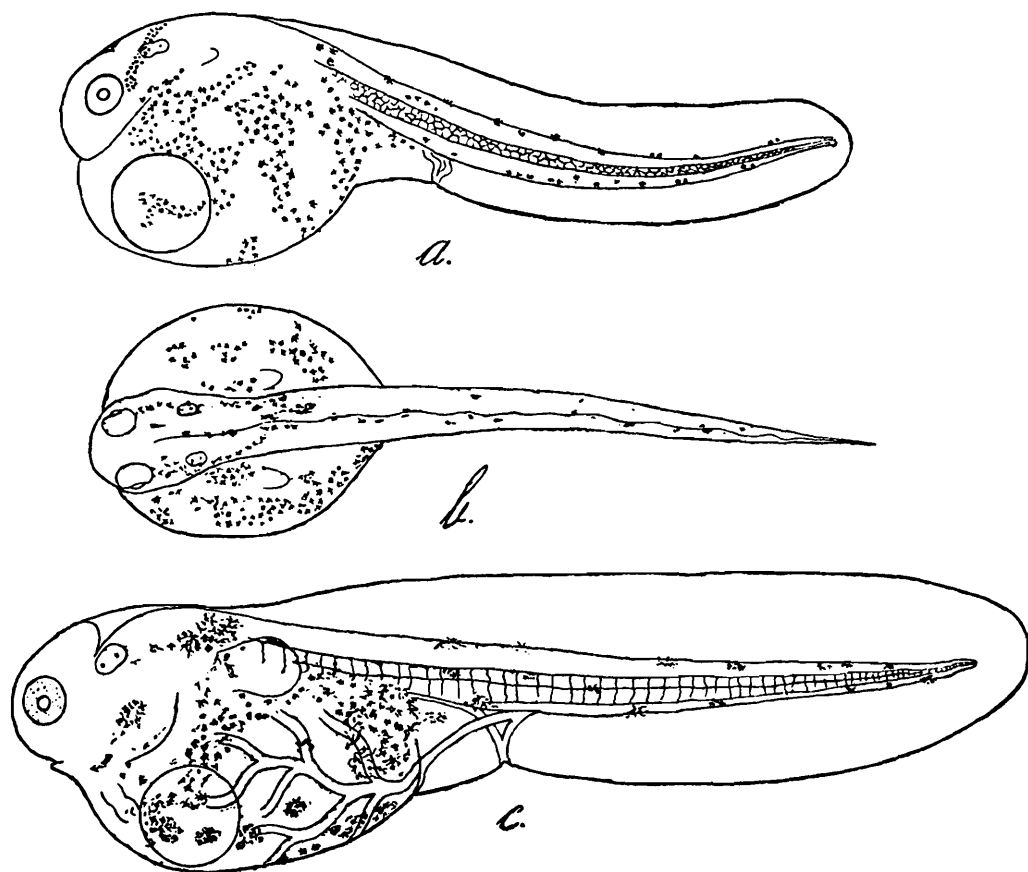
Newly Hatched Larva.—The newly hatched larva (text-fig. 2 *a, b*) is about 3.4 mm. long, and looks very much like a tiny tadpole. It is transparent and delicate, with well developed dark grey pigmentation. The pigment is disposed in an irregular patchy network on the large, projecting, rounded yolk-sac and on the head. It also extends in the form of small, sparingly scattered patches to the tapering body, especially towards its dorsal and ventral aspects. The head has a depressed appearance, and remains adpressed to the yolk. The body is slender, and narrows posteriorly into a straight tail. There is a wide, delicate, median fin-fold which commences at the nape and extends over the back and round the tail right up to the yolk-sac below. Against the anal region the fin-fold is marked by a very faint notch at its margin and a loop of a blood vessel through its width. The pectoral fin buds are laterally disposed, and stand out in the thoracic region over the yolk-sac. The notochord is simple and unsegmented. Occasionally the larva moves about briskly by quick, side to side movements of its wide tail to short distances, but soon resumes its motionless posture.

Metamorphosis.—As described above, the larva is remarkably different from the adult. Metamorphosis has been found to be a prolonged process, and it takes about a month for the characters of the young adult to be established. However, as the period of embryonic development inside the egg is short, the early larval development of the hatchling is fairly quick.

Twelve hours old larva.

In the course of twelve hours after hatching a fair portion of the yolk is absorbed, though much of it still projects (text-fig. 2*c*) as a pear-shaped structure on the ventral side. The head is distinct from the yolk-sac, and the small mouth appears as a crescentic pit on its ventral aspect. The opercular flaps also get differentiated. The pectoral buds grow out into broad fins, which though without rays, are very active, and keep on flapping even when the larva is stationary. The pigmentation

on the body becomes denser; paired lateral patches make their appearance. The eyes begin to grow dark. The notochord becomes



TEXT-FIG. 2.—*Mastacembelus pancalus* (Hamilton), early larval forms.

a. Lateral view of a newly hatched larva: $\times$ ca. 24; b. Dorsal view of the same; c. Lateral view of a larva twelve hours old: ca. 28.

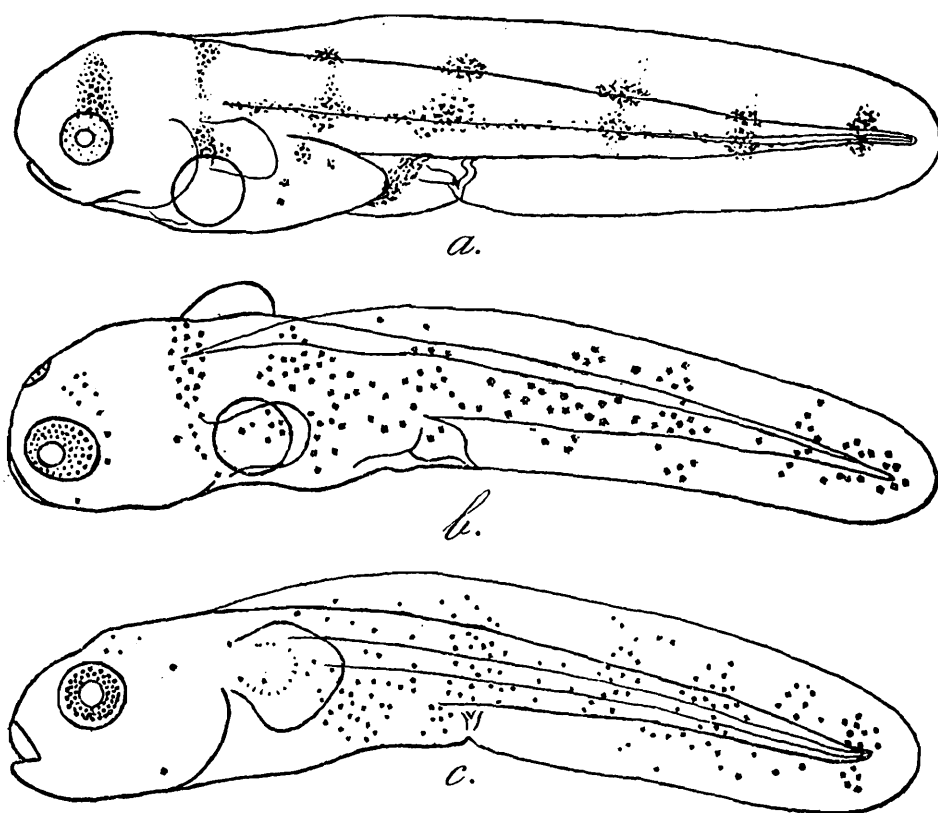
segmented, and rudiments of vertebrae begin to appear. The heart beats about 175 times a minute. The larva continues to be of inactive habits, resting on the algal mesh or lying on its back or side at the bottom for long intervals. When disturbed, or sometimes even of its own accord, it suddenly darts up and briskly jerks about for a short while.

Two days old larva.

A two days old larva (text-fig. 3a) is 4.8 mm. long, with the yolk further reduced, but with the oil globule still present. The head is quite pronounced, being stout and nearly truncate, dorsally sloping backwards. The mouth is well formed and subterminal in position. The mandibles are clearly marked off from the buccal floor. The operculum is well differentiated. The heart-beats are 175 per minute. The eyes are only slightly darker than before. In the median fin-fold there is not much change except that the portion in front of the anal region is slightly reduced. The pectorals are firmer, though still without rays. The pigment patches are conspicuous on the body. They are concentrated in dark areas above the eyes, at intervals on the body, especially towards the dorsal and to a less extent on the lateral aspect of the body, and on the abdomen. Some of the patches extend slightly to the fin-fold also. The larva is more agile than before, and at intervals, between periods of rest, it lashes about briskly.

Four days old larva.

A four days old larva (text-fig. 3b) is 5.1 mm. long. Most of the yolk is absorbed. The pre-anal fin-fold is reduced. The pectoral fins are larger. The chromatophores are more scattered in their arrangement; but in some areas they are in fairly dense patches, one occipital, one thoracic, one abdominal and five caudal—all extending to the median fin-fold.



TEXT-FIG. 3.—*Mastacembelus pancalus* (Hamilton), larval forms in the early stages of metamorphosis.

a. Two days old larva: $\times$ ca. $19\frac{1}{2}$; b. Four days old larva: $\times$ ca. $18\frac{1}{2}$; c. One week old larva: $\times$ ca. $16\frac{3}{4}$.

A week old larva.

By the seventh day the larva (text-fig. 3c) grows to 5.7 mm. in length. The contour of the head begins for the first time to show a slight indication of the future conical snout. The yolk is completely absorbed, and with the well formed mouth which is now terminal, the larva starts feeding on microplankton in the water. The eyes are well developed and look black with a beautiful brownish yellow ring around the central black area. The operculum appears ribbed owing to the formation of branchiostegals. The hyaline looking body of the larva begins to assume a faint yellowish opacity, which is due to (1) development of denser musculature, (2) more blood vessels and (3) the chromatophores scattered as lighter specks all over the body. The pre-anal part of the fin-fold has been completely absorbed, and the hind portion of the abdomen reaches up to the anus, which is fairly posterior in position. The posterior vertebrae of the long tapering tail are slightly upturned at this stage. The pectoral fins are large and firm with a basal cartilage. Radiating folds from the basal cartilage give a false appearance of rays, but true rays

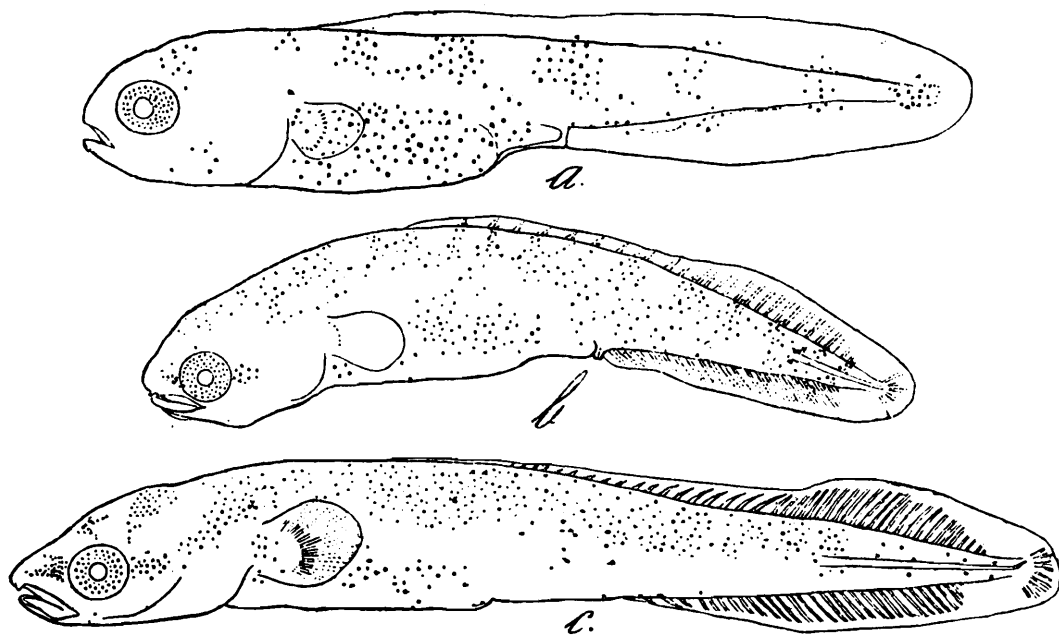
are yet absent. Though stronger than before, the larva still exhibits only intermittent activity, and indulges in frequent periods of rest in various postures in the algal mesh. Sometimes, when at the bottom, it creeps about or shoots smoothly forward and glides with its crest-like median fin-fold erect, the body being slightly arched as shown in the figure.

Ten days old specimen.

By the tenth day (text-fig. 4a) the length increases to 7.4 mm. The snout begins to assume a definitely conical shape. The body grows stouter. The median fin-fold in the anterior region of the back gets narrower. The pigmentation retains more or less the earlier pattern. The eyes, which had been flush with the general surface of the head, now stand out from it. A lip-fold appears and grows thick and fleshy at the angles of the mouth.

Twelve days old specimen.

The length is 10 mm. by the twelfth day (text-fig. 4b). The lip fold becomes more pronounced. The trilobed tip of the adult snout makes its first indication as the result of the growth of a pair of tiny lateral buds from the sides of the extreme tip of the snout. The anterior nostrils are carried at the ends of these buds. The median fin-fold gets narrower,



TEXT-FIG. 4.—*Mastacembelus pancalus* (Hamilton), intermediate stages of metamorphosis.

a. Ten days old specimen : $\times$ ca. $12\frac{1}{2}$; b. Twelve days old specimen : $\times$ ca. 8 ; c. Two weeks old specimen : $\times$ ca. $8\frac{1}{2}$.

as the body including the tail grows stouter. The future spinous portion of the dorsal fin gets markedly narrower than the rest of the fin-fold in which rays begin to make their appearance. Eighteen true rays appear in the region of the soft dorsal, twenty-one in that of the soft anal and five in that of the caudal. All the three spines in the anterior part of the anal and ten spines in that of the dorsal also begin to appear. The pectorals are larger, but still devoid of true rays. The anus becomes

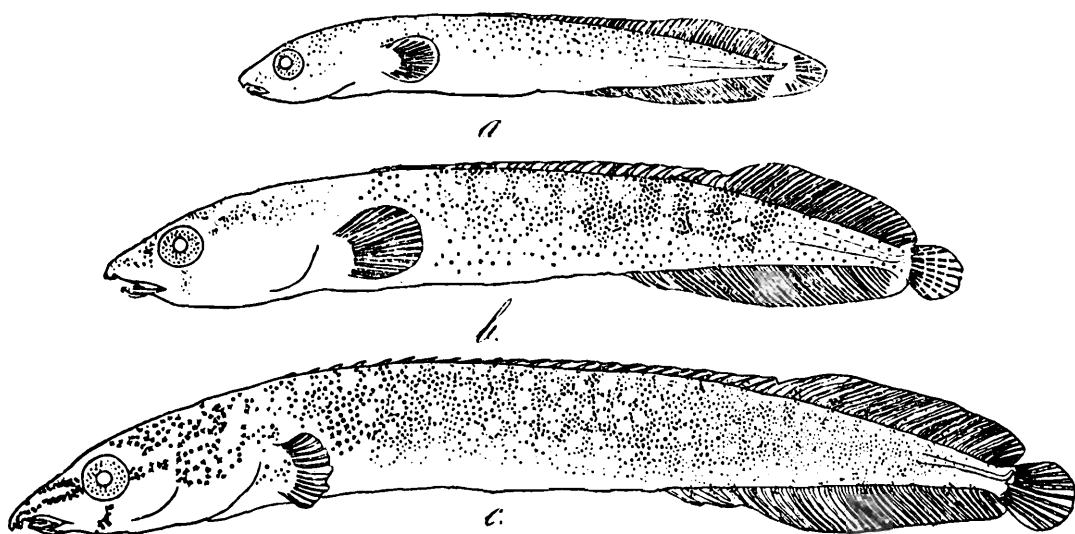
more posteriorly placed as the abdomen elongates. The pigmentation begins to show for the first time slight indications of the adult bands. Along the back the chromatophores are arranged in the form of irregular bands leaving large ovoid pigmentless patches of which there are about ten to be seen on each side of the body. On the head the adult ocular band is indicated as a discontinuous band in front of and behind each eye.

Two weeks old specimen.

When two weeks old, the specimen (text-fig. 4c) is 12.9 mm. long. The snout is more conical, and the terminal lobes of the upper jaw grow out making the mouth sub-terminal. The fleshy lip-folds at the angles of the mouth are more conspicuous. The preopercle can now be distinguished. The three anal spines are well formed, the second being the longest. Twenty-five rays are developed in the soft dorsal, twenty-seven in the soft anal and nine in the caudal, which last, however, is still confluent with the rest of the fin-fold. Indications of about twelve true rays are present in the pectoral. Eighteen spines of increasing length from front backwards appear in the anterior part of the dorsal fin-fold. The latter becomes narrower and the anteriormost part of it is absorbed. The faint pigment spots on the body begin to spread, leaving small, clear, circular patches, which are fore-runners of the greyish white spots of the adult fish. The ocular band of pigment becomes more extensive and darker.

Two and a half weeks old specimen.

By the middle of the third week the length reaches 15.2 mm. (text-fig. 5a). The pigmentation gets deeper in shade on the dorsal aspect.



TEXT-FIG. 5.—*Mastacembelus pancalus* (Hamilton), juvenile forms in the final stages of metamorphosis.

a. Two and a half weeks old specimen : $\times$ ca. 4 ; b. Three weeks old specimen : $\times$ ca. $4\frac{3}{4}$; c. One month old specimen : $\times$ ca. 5.

The anterior part of the dorsal fin is narrower and has twenty spines. The number of rays increases in the fins. The portions of the vertical fin-fold just in front of the caudal, above and below, are devoid of rays, and begin to show signs of atrophy.

Three weeks old specimen.

By the end of the third week the length becomes 18 mm. (text-fig. 5b). The snout gets elongated with well pronounced lobes at the tip. The posterior nostrils are now distinctly marked. Twenty-three spines are well marked in the anterior part of the dorsal fin; the interspinous membrane nearly stops short of the ends of the spines. The portions of the fin-fold immediately in front of the caudal have been absorbed and as a result the caudal is quite separate from the dorsal and the anal. There are thirty-two soft rays in the dorsal, thirty-five in the anal, eleven in the caudal and sixteen in the pectoral.

A month old specimen.

Metamorphosis is practically complete by the end of the first month. The length reaches about 22 mm. (text-fig. 5c). The snout, though still proportionately shorter than in the adult, assumes more or less the characteristic shape of the adult with a well defined, mobile, trilobed tip. Twenty-five spines are seen in the spinous dorsal, the anterior spines being short, sharp and devoid of any interspinous membrane. Thirty-three rays are present in the dorsal and thirty-seven in the anal. The caudal fin is rounded and has twelve rays. The pectoral has eighteen rays. The colouration, though not fully developed, is bright and approaches the adult pattern, the bands being well indicated and extending even to the dorsal and anal fins. Thus in a month's time the fish practically becomes a young adult.

As the fish grows the full adult features are gradually assumed. When ten months old the fish¹ reaches a length of 96 mm., and the gonads begin to mature. Evidently, as suggested by D'Abreu (*loc. cit.*), the species attains sexual maturity in the course of a year.

BIONOMICS.

Habits.—*Mastacembelus pancalus* lives in clear as well as muddy fresh waters of tanks, rivers, lakes, borrow pits, etc., but is an occasional immigrant to slightly brackish waters. It prefers a bottom of soft mud in which it can easily burrow, for which purpose its body is admirably adapted. In the natural habitat the young often glide about among algae and fine-leaved water plants, while the adults frequent the loose mud or lurk in narrow crevices near the banks. In the aquarium the fish spends most of the day time buried in the sand, part of the head alone usually protruding out. In this position, especially when silt accumulates on the exposed part of the head it easily escapes notice. This habit provides a perfect camouflage for both attacking its prey and escaping from its natural enemies. At night, however, it freely swims about, mostly at the bottom. But like other nocturnal fishes it can be trained to eat in day time, though, as soon as it has had its meal, it quickly returns to its shelter below. The act of burrowing was closely observed on several occasions. The fish glides about the bottom, nosing the substratum with its mobile, trilobed, sensitive snout and, selecting

¹ This description is based on those specimens which developed from the 18 mm. larvae collected in June.

a suitable spot, wriggles itself into the substratum by a brisk side to side and forward movement, until most of the body and tail are concealed. Sometimes the tail sticks out as also the tip of the head. On being disturbed from its burrow, it darts about for a while, and selecting another spot, makes a fresh burrow or sometimes returns to its original burrow. Half buried reeds and hollows are often its favourite resorts and this accounts for its habit of lurking about in cracks and crevices near the banks. Hence a common method of catching the fish is by leaving old, cast-off pipes or hollow bamboos here and there in pools and lifting them out along with the fish in them. The fish, however, is sometimes caught on rod and line, and villagers capture it also by raking the mud with a bent trident.

Hibernation and Aestivation.—Being capable of aerial respiration¹, the Spiny Eels burrow in the soil when the waters dry up. Specimens of *Rhynchobdella aculeata* have been exhumed (Day, 1877, p. 214) from the dried beds of ponds. A pair of *M. pancalus* were found deep under the mud in a drying pool at Ulubaria. In the cold winter months even in the presence of water in the aquarium *M. pancalus* was often noticed to bury the greater portion of its body including its snout in the mud and remain inactive for longer or shorter periods, the opercular flaps, when visible, being seen to exhibit no respiratory movement. The fish thus appears to be capable of resorting to longer or shorter periods of hibernation during which even the breathing movements are suspended.

Food.—The gut-contents of seventy specimens of the fish, ranging from 1 cm. to 14.5 cm. were studied more or less along the lines of those of the Perches and of the Killifish (Job, 1940, pp. 293-295 ; 1941). In the young stages the fish is found to subsist mainly on Entomostracan Crustacea, the items in the order of preponderance being Daphnids, like *Macrothrix orientalis*, Ostracods and traces of Cyclops, and larvae of insects such as *Ceratopogon* sp. and other Chironomids, Coleopterans and occasionally larvae of mosquitoes and other Dipterans. As the fish grows larger the proportion of insect larvae increases, and larger Crustacea begin to form a fair portion of the diet. Only in one instance were Teleostean remains noted among the gut-contents ; these consisted of a single egg and part of a fin.

ECONOMIC IMPORTANCE.

Like the true eels, the Spiny Eels are regarded by many as excellent for the table. One of the congeners, *Mastacembelus armatus*, grows to three feet, and D'Abreu (*op. cit.*, p. 32) lists it as the most important food fish after the murels in the Ambajheri tank at Nagpur. Hamid Khan (1934, p. 667) notes that its flesh is firm and tough, and said to be invigorating, but adds that in the Punjab, the Spiny Eels are shunned like snakes and are eaten mostly by low caste and poor people. More or less the same may be said about true eels as well ; for, while considered a delicacy by many, they are equally shunned in several districts

¹ For details of aerial respiration in the Spiny Eels, see Dobson, 1874, p. 312 ; Day, 1889, p. 332 ; Deraniyagala, 1932, p. 266 ; Ghosh, 1934, pp. 328, 329 ; and Hora, 1935, p. 8.

owing to popular prejudice due to their snake-like shape¹. *M. pancalus* grows only to seven inches, and though edible, is of less market value than its congeners. As fish remains were found only in one out of the seventy specimens of *M. pancalus* examined, the species does not appear to be so piscivorous as *M. armatus*, which has been noted (Hamid Khan, *loc. cit.*) to be "very destructive to eggs and fry of other fish."

The proportion of mosquito larvae in the gut-contents of the fish is insignificant and hence it is clear that though to a small extent the fish may help to reduce the numbers of larvae in marshy pools, it is not of any cognizable value in the control of mosquitoes. Again, as explained elsewhere (Job, 1941a), the proportion of Cyclops met with in the food of the species is too small to have any significance in the control of guinea-worm.

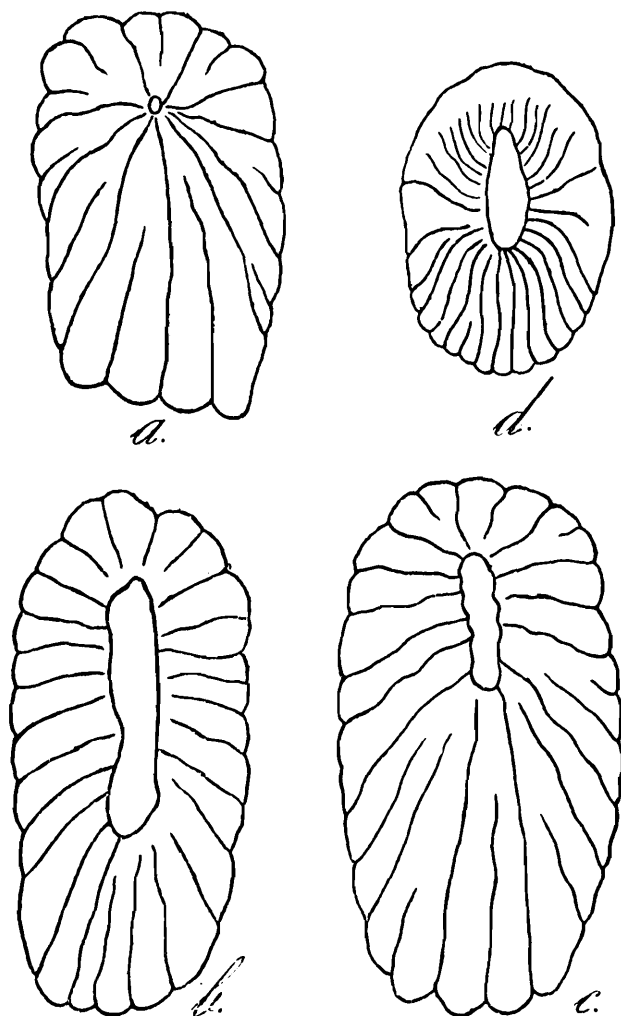
As far as parasites are concerned, while Rahimulla and Das (1935, p. 34), who studied collections of the fish from Hyderabad, report that "no parasites have been found" in the specimens examined by them, in several adult specimens from Ulubaria examined by the writer, numerous Trematodes and Nematodes, free as well as encysted, were observed. No parasites were seen in the younger stages of the fish.

SYSTEMATICS OF THE MASTACEMBELIDAE.

Günther (1861, p. 539) writes, "The structure of the mouth (not of the bones of the upper jaw) and of the gill-apparatus, the separation of the humeral arch from the skull, the absence of ventral fins, the anatomy of the internal parts, and the whole habit, afford ample proof that these fishes are eels, in which a part of the dorsal fin is spinous" He, however, mentions the presence of the air-bladder and pyloric appendages in the Mastacembelidae, while they are absent in the true eels. Besides, as Deraniyagala (*op. cit.*, p. 265) states, "the presence of dorsal and anal spines, normal ovisacs, oviducts and spawning in fresh-water" exclude these fishes of uncertain relationship from the Apodes. Again, whereas the eels are considered to be of ancient origin, being represented not only in all fresh waters and seas of the temperate and tropical zones of modern times, but also in fossils like those of Monte Bolca, Aix and Oeningen (*vide* Günther, 1880, p. 670), the Mastacembelidae are comparatively less ancient, being specialised for life in muddy bottom ecology, and, as mentioned by Meek (1916, p. 314), not known to be represented as fossils. It is believed (*vide* Chaudhuri, 1916, pp. 12, 13) that the Mastacembelidae evolved originally in India and spread over to China in the east and to Africa in the west, as "the most primitive forms are found only in this country and the extreme forms in China and Africa, with the intermediate forms in the intervening countries." From the external characters and the indications of the skeleton, Regan (1912, p. 218) concludes that "these fishes are related to, but more specialized than, the Percomorphi", though he could not trace their affinity to any particular group of Percomorph fishes. The general percoid

¹ Hamilton (1822, p. 27), has however, stated, "The fishes of the *Macrogathus* [*Mastacembelus*] genus have less of a disgusting appearance than those called *Muraena*, and are more sought after by the natives; the highest of whom in Bengal make no scruple of eating them; and by Europeans they are esteemed the best of the eel kind".

appearance, so marked in the early larvae of *M. pancalus*, lends support to Regan's surmise. Further, the similarity in distribution, the presence of dorsal and anal spines, and the similarity in the scale pattern seem to indicate that the Mastacembelidae might have originated from a Percoid fish remotely allied to Nandidae. The scales of Mastacembelidae are longer than broad, with basal, apical and lateral radii as in those of *Plesiops* Cuvier, a genus of Nandidae. While the nuclear area is very



TEXT-FIG. 6.—Outline diagrams of typical scales from the broad sides of fishes of the Mastacembelidae and *Plesiops* Cuvier (Nandidae).

a. *Mastacembelus pancalus* (Hamilton); b. *Mastacembelus armatus* (Lacép.); c. *Rhynchobdella aculeata* (Bloch); d. *Plesiops nigricans* Rüpp. (a, b and c are magnified about 32 times and d about 4½ times. The circuli are not represented).

small and narrow in *M. pancalus*, it is wider in *M. armatus* and *Rhynchobdella aculeata*, and very wide in *Plesiops* (text-fig. 6). The margins of the scales of all these are scalloped in varying degrees. The narrow nature of the scales of the Mastacembelidae may be a modification necessitated by their burrowing habits. The modification of the pelvic fins, which are absent in *Mastacembelus*, is also apparent in *Plesiops*, where there are fewer rays in the pelvics. The general resemblance of the twelve days old larva of *M. pancalus* to *Plesiops* is again striking. In the absence of a detailed knowledge of the anatomy of the Mastacembelidae and the Nandidae it is not possible, however, to arrive at any more precise conclusions in regard to their relationships. The above is merely a tentative suggestion.

SUMMARY.

The life-history of *Mastacembelus pancalus* (Hamilton) was worked out by following the development of its eggs collected from a Railway borrow pit between Ulubaria and Fuleshwar in the Howrah District, where the fish breeds from May to November with the peak period during the pre-monsoon rains. The fairly large eggs are laid, scattered in groups among algal meshes. Though the egg is heavily yolk-laden, the embryonic development is very short, and hatching takes place a day and a half after laying. The hatchling looks very different from the adult, and resembles a tiny tadpole. Being still heavily yolk-laden, it seldom moves about, but usually rests belly up for long intervals on the algal mesh. The early larval development is fairly rapid. Metamorphosis, however, is prolonged over a month. The yolk gets fully absorbed in the first week, and the larva begins to feed on microplankton, though active movement is still intermittent. In the course of the next two weeks the conical snout with its trilobed tip is developed, the median fins get differentiated with spines and rays, which latter appear in the pectorals also, and active swimming and wriggling movements commence. By the end of the first month there develops the 22 mm. long young adult with full complement of fin-rays and other characters of the adult fish. Maturity is attained in about one year.

Normally a nocturnal fish, *M. pancalus* usually spends the day time lurking in narrow crevices or in temporary burrows, which it makes in the soft substratum. In the young stage the fish feeds mostly on Entomostracan Crustaceans and certain insect larvae. The ratio of piscine elements in the food is negligible. In very cold and dry seasons the fish hibernates for longer or shorter periods.

Though small in size, and shunned by some owing to the snake-like shape, the fish is regarded good eating by many. Unlike *M. armatus*, *M. pancalus* is not very destructive to eggs and fry of other fishes. Its value in the control of mosquitoes and Cyclops is insignificant. The fish is frequently subject to parasitism by Helminths.

Regarding systematics, the general Percoid appearance of the early larvae of *M. pancalus*, the similarity in distribution, the presence of dorsal and anal spines, the similarity in the scale pattern, the modification of pelvic fins, and the general resemblance of the twelve days old larva of *M. pancalus* to *Plesiops* seem to indicate that the Mastacembelidae might have originated from a Percoid fish remotely allied to Nandidae.

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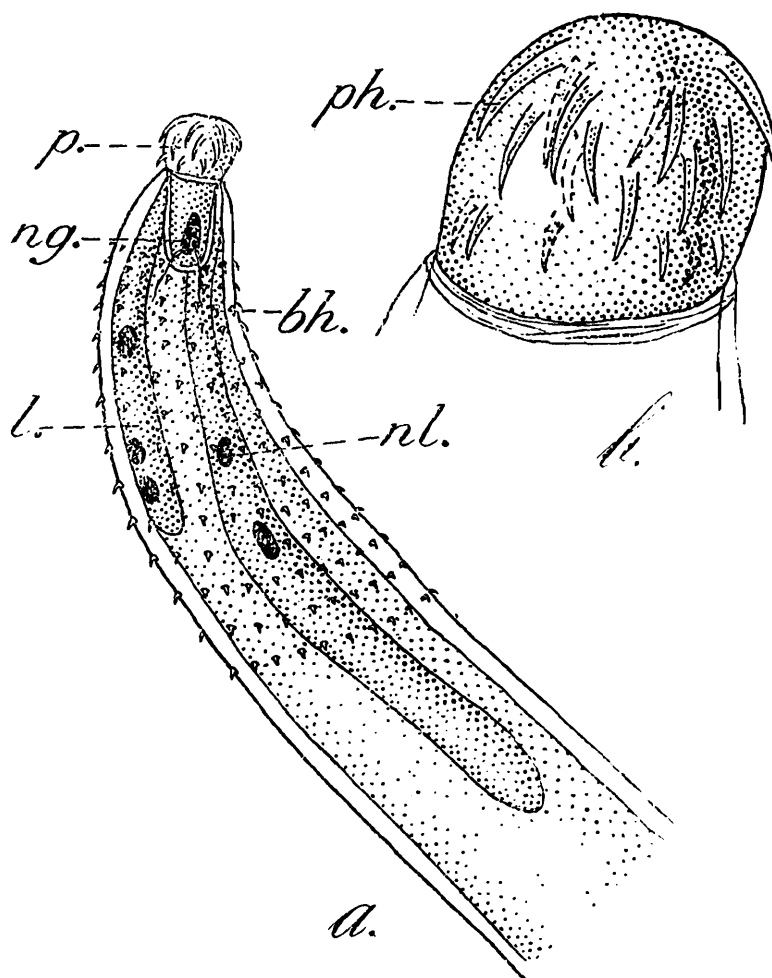
ON A NEW ACANTHOCEPHALA, *ACANTHOSENTIS SIRCARI*,
SP. NOV., FROM A CALCUTTA FISH, *RASBORA ELANGA* (HAM.).

By T. N. PODDER, M.Sc., M.B., Professor of Zoology, Carmichael Medical
College, Calcutta.

In the course of my investigations on the parasitic infections of various fishes of Bengal and other provinces available in the Calcutta markets, I found a new acanthocephalan parasite in the intestine of *Rasbora elanga* (Ham.). This fish is known in Bengal as "Elang bata", and is generally available in the local markets from September to March. I found that nearly 60 per cent of the fishes were infected with these parasites and the highest number of parasites in one specimen was 8-10; all the parasites were found in the intestine of the host. This worm is described below as *Acanthosentis sircari*¹, sp. nov.

***Acanthosentis sircari*, sp. nov.**

The body is usually cylindrical with a broad anterior end, while the posterior portion tapers a little towards the extremity. Sexual dimor-



TEXT-FIG. 1.—Anterior portion of *Acanthosentis sircari*, sp. nov.

bh., body hooks; l., lemnisci; ng., central nerve ganglion; nl., nucleus of the lemnisci; p., proboscis; ph., proboscis hooks.

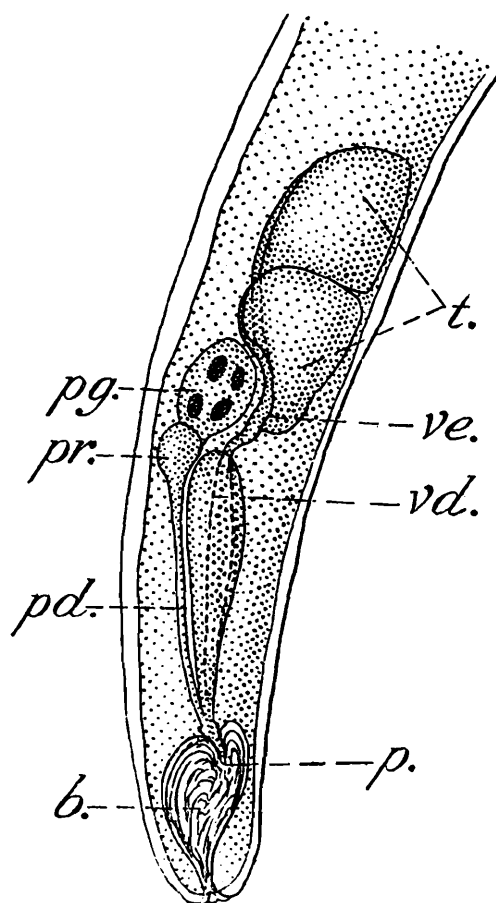
¹ The species has been named after Sir Nilratan Sircar, M.A., M.D., D.Sc., as a mark of gratitude for his keen interest in this line of research.

phism is well marked, the females being much larger than the males. The colour of fresh specimens is creamy-white.

The proboscis is globular with 3 rows of 6 hooks each. The hooks of the first and second rows are much larger than those of the third row. There is no definite neck, but in fully stretched specimens a comparatively small space, devoid of spines, corresponding to the neck can be distinguished.

The anterior half of the body is armed with circular rows of curved spines. In the anterior region these spines are closely set, but the rows near the middle are wide apart. In the body-wall there are a few giant sub-cuticular nuclei, five on the dorsal and two in the ventral aspect of the body, some branched nuclei are also present. The lacunar system is well developed. The transverse canals are very prominent, their course in the body-wall corresponds to the circles of cuticular spines and suggests a pseudosegmentation of the body.

The proboscis sheath is a single-layered, thin walled muscular sac, hanging down from the middle region of the proboscis. The central nerve ganglion is situated at the posterior extremity of the proboscis sheath.



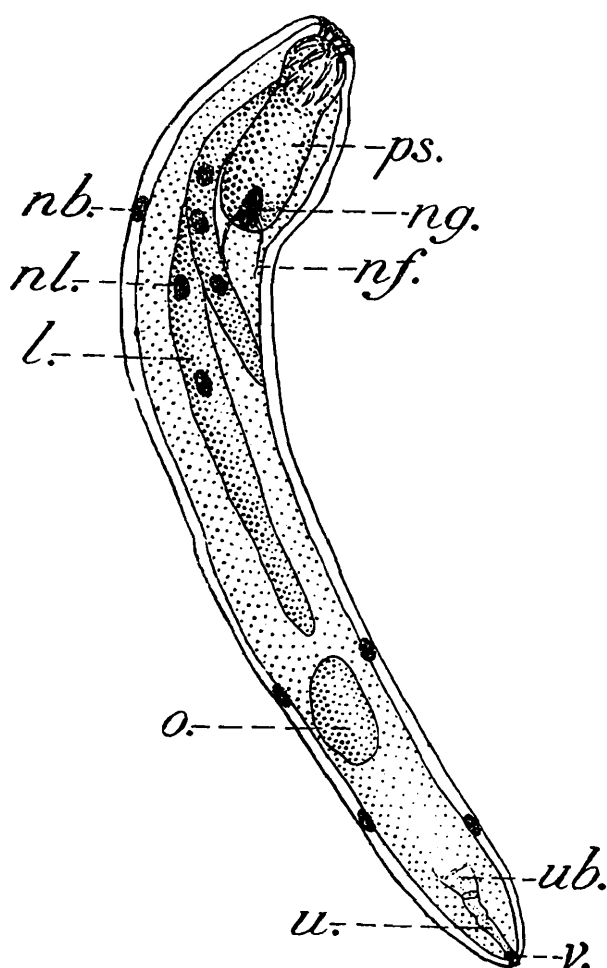
TEXT-FIG. 2.—Posterior portion of male *Acanthosentis sircari*, sp. nov.

b., bursa; p., penis; pd. prostatic duct; pg., Prostatic glands; pr., Prostatic reservoir; t., testes; vd., vas deferens; ve., vasa efferentia.

The two lemnisci are situated normally on either side of the proboscis sheath. One of the lemnisci is much longer than the other, being

nearly twice its length. This is a constant feature in all the specimens examined. There are three nuclei in the shorter lemniscus, and two in the longer.

The male genitalia consist of two ovoid testes situated closely apposed to each other. The vasa efferentia join one another near the prostatic reservoir to form a thick and elongated vas deferens which ends in the penis. The prostatic gland is a single syncytial mass with 6 to 8 nuclei embedded in it. It lies closely behind the posterior testis. The prostatic reservoir is a rounded organ which is continued as a narrow prostatic duct opening at the base of the penis. The seminal vesicle is a long balloon-shaped sac which also opens near the opening of the vas deferens into the penis. The penis is a conical muscular organ which ends at the top of the eversible bursa. The bursa is a funnel-shaped structure which, in most cases, is retracted within the body.

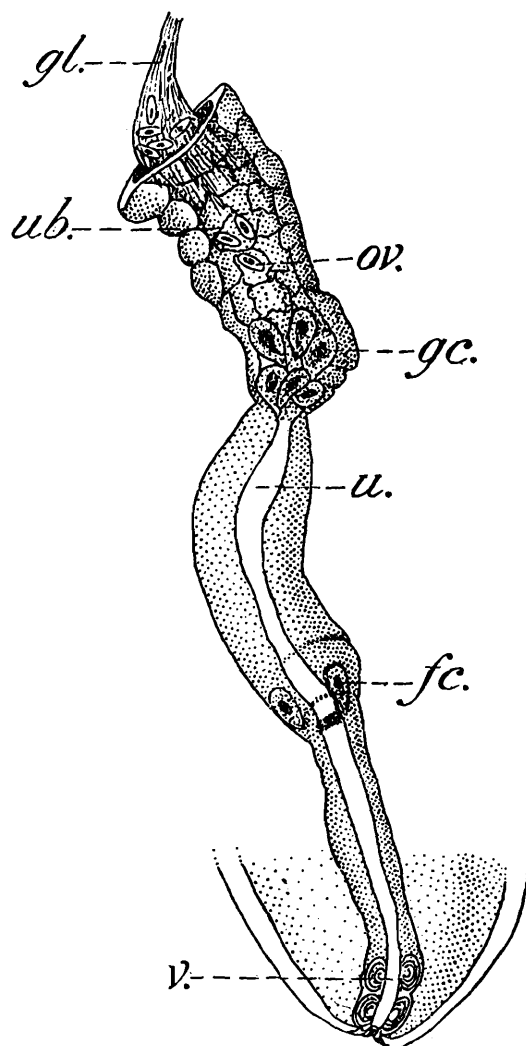


TEXT-FIG. 3.—Young female *A. sircari*, sp. nov. showing developing ovary.

l., lemnisci; *nb.*, body nucleus; *nf.*, nerve retinaculi; *ng.*, central nerve ganglion; *o.*, ovary; *ps.*, proboscis sheath; *u.*, uterus; *ub.*, uterine bell; *v.*, vagina.

The female genitalia consist of a thick walled uterine-bell which at its posterior end is continued as a long, tubular uterus. At the posterior extremity of the uterine-bell just near its opening into the uterus there are 5 to 6 giant cells, the "guard cells" which control the passage of the mature ova into the uterus. The wall of the uterus is thick, its posterior half is very muscular, and its lumen is much narrower posteriorly than anteriorly. At the junction of the anterior and posterior portions

of the uterus there are two giant cells situated within the uterine wall; these are the flask cells (Verma & Datta). The uterus leads into the thick and muscular vagina, which is situated at the postero-ventral end of the worm.



TEXT-FIG. 4.—Female genitalia of *A. sircari* sp. nov.

fc. flask cell; gc., guard cell; gl., genital ligament; ov., ova; u., uterus; ub., uterine bell; v., vagina.

Measurements.—Males 3.11–4.76mm. $\times$ 0.48–0.67mm.; females 2.94–11.89mm. $\times$ 0.39–1.01mm.; proboscis 0.138 $\times$ 0.115mm.; proboscis hooks, row (i) 0.055mm. long, row (ii) 0.048mm. long, row (iii) 0.018mm. long; proboscis sheath 0.265 $\times$ 0.150mm.; lemnisci (i) 0.920 $\times$ 0.104mm., (ii) 1.932 $\times$ 0.161mm.; testis, anterior 0.391 $\times$ 0.345 mm., posterior 0.379 $\times$ 0.322mm.; prostatic gland 0.253 $\times$ 0.207mm.; vas deferens 0.667mm. long; prostatic reservoir 0.161 $\times$ 0.104mm.; prostatic duct 0.598mm. long; bursa 0.437mm. long; uterine bell 0.115mm. long; uterus 0.133mm. long; vagina 0.161mm. long. Ova not liberated.

In the new species the males are generally much smaller than the females. The lemnisci are much longer than the proboscis sheath and one of the lemnisci is nearly double in length of the other. There are 3 nuclei in the shorter and 2 in the longer lemnisci. The wall of the proboscis sheath is single layered. The central nerve ganglion is situated

TABLE I.

Showing measurements of closely related species.

Name of species.	Sex.	Dimensions.	Proboscis.	Prob. Sheath.	Lemnisci.	Terminal Hooks.	Sub-cuticular nuclei.
<i>A. antspinus</i> Verma & Datta	♂	1.0-1.25 × 0.25-0.2 mm.	0.04-0.17 × 0.04-0.05 mm.	0.17-0.38 × 0.04-0.13 mm.	0.04-0.17 × 0.04-0.07 mm. both equal.	3 rows of 6 hooks. (i) 72μ (ii) 54μ (iii) 48μ	few oval & branched.
	♀	2.0-3.0 × 0.75-1.0 mm.					
<i>A. holospinus</i> Sen	♂	0.9-2.4 × 0.2-0.4 mm.	0.1 × 0.05 mm.	0.3 × 0.08 mm.	Slender and little longer than the proboscis sheath.		4 dorsal & 2 ventral.
	♀	1.6-9.4 × 0.2-0.7 mm.					
<i>A. dattai</i> Podder	♂	1.34-3.34 × 0.24-0.42 mm.	0.12 × 0.055 mm.	0.42 × 0.12 mm.	(i) 0.68 × 0.055 mm. (ii) 0.59 × 0.055 mm. Slightly longer than the proboscis sheath.	(i) 0.05 mm. (ii) 0.03 mm. (iii) 0.026 mm.	4-6 dorsal & 2 ventral
	♀	1.67-9.46 × 0.44-0.9 mm.					
<i>A. sarcari</i> , sp. nov. ..	♂	3.11-4.76 × 0.48-0.67 mm.	0.138 × 0.115 mm.	0.265 × 0.150 mm.	Much longer than the proboscis sheath, one nearly double the length of the other.	(i) 0.055 mm. (ii) 0.048 mm. (iii) 0.018 mm.	5 dorsal & 2 ventral.
	♀	2.94-11.89 × 0.39-1.01 mm.			(i) 0.920 × 0.104 mm. (ii) 1.932 × 0.161 mm.		

near the posterior extremity of the proboscis sheath. The prostatic gland is a single, syncitial mass, with 6-8 nuclei and the lacunar system is well developed.

Host.—*Rasbora elanga* (Ham.)

Location.—Intestine.

Locality.—Calcutta, India.

Type specimens.—(Reg. No. W3445/1) Deposited in the collections of the Zoological Survey of India (*Ind. Mus.*), Calcutta.

In conclusion, I have to express my hearty thanks to Dr. Bains Prashad, Director, Zoological Survey of India, Calcutta, for giving me facilities to consult the literature in the library and to Mr. M. N. Datta of the same department for his valuable suggestions.

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SOME ASPECTS OF THE CRANIAL MORPHOLOGY OF *URAEOTYPHLUS NARAYANI* SESHACHAR (APODA).

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(Plates IV—VI.)

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INTRODUCTION.

The genus *Uraeotyphlus* was originally included under *Caecilia* (part) Dum. & Bibr. until it was shown by Peters (1879) how *Uraeotyphlus* differed from the other genera; Peters, therefore, erected the new genus *Uraeotyphlus* to accommodate the three species known at the time. Nieden (1913), who followed Peters, included the three species of *Caecilia*,—*C. malabaricus*, *C. oxyuris* and *C. seraphini* under *Uraeotyphlus*; but the last species of *Uraeotyphlus* has subsequently been shown to belong to *Geotrypetes* by Parker (1927). Two more species were added later, namely, *U. menoni* and *U. narayani*, making in all four Oriental species. The last one was recently described by Seshachar (1939).

The important difference between the commonly occurring South Indian genera *Ichthyophis* and *Uraeotyphlus* in the arrangement of cranial bones is that in the former the parietal and squamosal approximate together dorsally (stegokrotaphy) while in the latter, a gap separates them (zygokrotaphy). The genera *Dermophis*, *Hypogeophis*, *Caecilia*, *Cryptopsophis*, *Amphiumophis*, *Herpele*, *Gymnopsis*, *Typhlonectes*, *Siphonops*, *Boulengerula* and *Gegenophis* are related to *Ichthyophis* in regard to the arrangement of the parietal and squamosal while the remaining genera *Rhinatrema*, *Geotrypetes*, *Praslinia*, *Bdellophis*,¹ *Chthonerpeton* and *Scolecormorphus* conform to the *Uraeotyphlus* plan. Recently Parker (1936) described a new genus from Cameroon, South Africa,—*Idiocranium*; in this also the parietal is not separated from the squamosal by a wide gap.

Wiedersheim (1879) having examined a single specimen of *Caecilia oxyura* (*U. oxyurus*) came to the conclusion that anatomically it was not very different from *C. lumbricoides* (*C. gracilis*) and *C. rostrata* (*Hypogeophis rostratus*), and remarked that the latter two species could very well be treated together. I reproduce his sentence (p. 27) here, for it chiefly concerns the genus *Uraeotyphlus* which is discussed in the present paper:

“*Caecilia lumbricoides* und *Caecilia rostrata*. Beide Arten zeigen nur so geringe Abweichungen dass sie fuglich zusammen abgehandelt werden konnen. Dasselbe gilt auch *C. oxyura*, insoweit er mit gelungen ist, an dem einem mir zu gebote stehenden Exemplare ins klare zu kommen.”

The cranial morphology of a large number of Apodan members was described by Wiedersheim, viz., *I. glutinosus*, *C. lumbricoidea* (*C. gracilis*), *C. rostrata* (*H. rostratus*), *C. oxyura* (*U. oxyurus*), *Siphonops annulatus*, *Siphonops indistinctum* (*Chthonerpeton indistinctum*); of these the accounts of the skull, hyoid apparatus, olfactory and auditory organs, the tentacle, the brain and its nerves chiefly concern us. It should be noted, however, that he described a species of *Uraeotyphlus* (*U. oxyurus*) as belonging to the genus *Caecilia* and similarly his two other examples *C. rostrata* and *S. indistinctum* are now regarded as species of the genera *Hypogeophis* and *Chthonerpeton* respectively.

¹ *Bdellophis* is merged with *Scolecormorphus*, see Barbour and Loveridge, 1928,

Peters (1881) noted that the skull of *Uraeotyphlus* closely resembled that of *Ichthyophis*, and, therefore, both differed considerably from that in the other genera. He described the gross morphology of the skull of *U. oxyurus*, having studied two specimens and remarked that the founding of the genus was definitely established. Describing the skull of *U. oxyurus*, he recorded the occurrence of separate intermaxillaria (premaxilla), a side piece on either side of the nasal (septomaxilla), a prefrontal, an orbital (postfrontal) and a pterygoid. The skull of *Uraeotyphlus* closely resembles that of *Ichthyophis* both coming from the same locality (South India)¹ except that the prefrontal does not reach the detached nasale (septomaxilla), and there is a gap between the squamosal (squamosojugale of Peters) and parietal. It is, however, significantly pointed out by Peters that these features may be individual variations or due to differences in age.

My object has been to describe in detail the morphology of the head of *U. narayani* and try to compare the anatomical details of this species with what has been described for other genera and finally to decide whether the erection of the new genus is justifiable.

MATERIAL AND METHODS.

The heads of larval and adult specimens of *I. glutinosus* and *U. narayani* secured from the Western Ghats were fixed in suitable fixatives (Bouin, Formol) and decalcified in a mixture of 70 per cent. alcohol containing 3 per cent. con. nitric acid (with phloroglucin). Alizarin transparencies of larval and adult animals were made for checking the skull preparations obtained by maceration. Sections were stained in Haematoxylin-eosin, Pasini, boraxcarmine-picro-indigocarmine and mucicarmine.

The entire lengths of the larval forms of *I. glutinosus* and of a juvenile specimen of *U. narayani* studied were as follows :

I. glutinosus : 3·8 (embryo), 7·0, 8·3, 10·0 and 12·7 cm.

U. narayani : 9·0 cm.

A single adult head of *Ichthyophis monochrous* was also sectioned for comparison. Heads of *Dermophis gregorii* Blgr., *Herpele ochrocephala* Cope, *Scolecormorphus uluguruensis* Barb. and Lov., and *Boulengerula boulengeri* Torn. were also sectioned and studied.

OBSERVATIONS.

The skull.—It is customary to study the skull by dividing it into regions, viz., frontal, parietal, occipital, palate and upper jaw, suspensorium and bones in association with the sense-capsules. But in the apodan skull where some of the bones fuse with adjacent ones, a

¹ Sarasins (1890) remark that one species of *Uraeotyphlus*, *U. africanus* (*U. seraphini*, Nieden 1913) is found in Africa, while there is not even a single record of the occurrence of an *Ichthyophis* from the Ethiopian Continent ; Parker (1927), however, correctly referred this species of *Uraeotyphlus* to *Geotrypetes* and thus removed a distributional anomaly.

narration based on this classification would entail a repetition of certain parts and therefore, I have adopted the following mode of description :

NASO-ETHMOID REGION :

The nasal } (bones in association with the olfactory
The septomaxilla } capsule).
The sphenethmoid.
The cartilages of the nasal region.

ORBITO-TEMPORAL REGION :

The frontal
The parietal
The pre- and post-frontal
(the frontal, pre- and post-frontals belong to the orbit ;
the parasphenoid and pleurosphenoid which belong to
this region are described under the occipito-auditory
region).

OCCIPITO-AUDITORY REGION :

The os Basale
The stapes.

THE UPPER JAW, PALATE AND SUSPENSORIUM :

The premaxilla
The maxillopalatine
The pterygoid
The prevomer
The squamosal
The quadrate

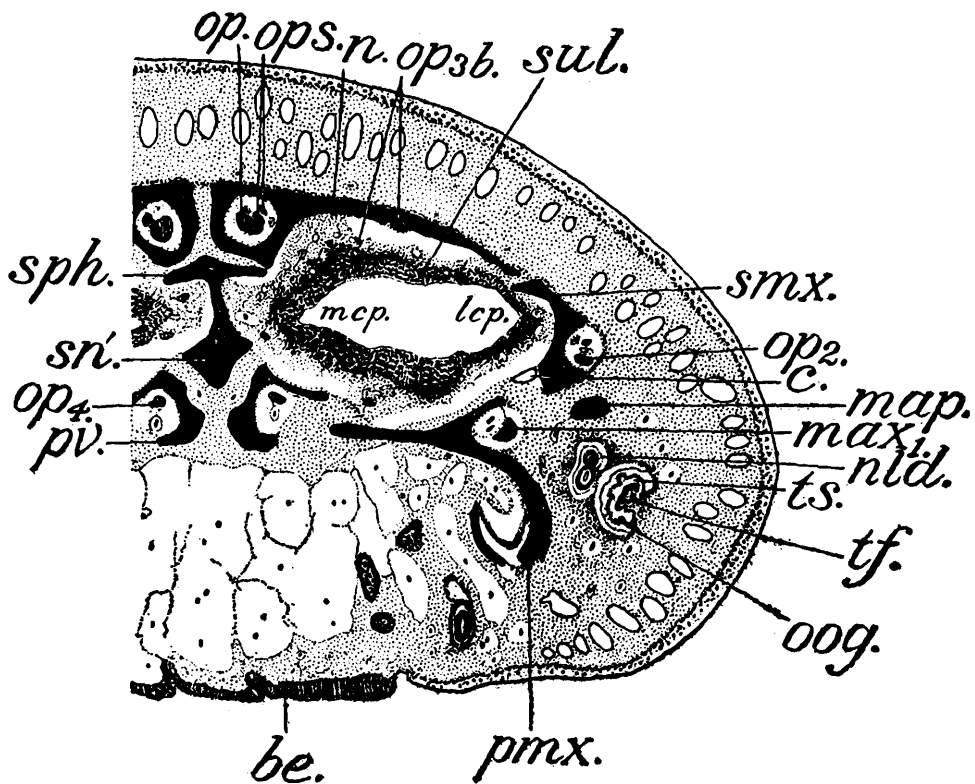
The only cartilage bones in the skull of Apoda are the os Basale, the stapes, and the quadrate.

Naso-ethmoid region.

The nasal (paired).—The nasals appear anteriorly as two vertical pieces of bone on either side of the prenasal prong. Posteriorly (*see* text-figs. 1, 8, 9, *n*) a horizontal piece is noticed dorsally to the olfactory chamber and the two (vertical and horizontal of each side) unite to enclose the main trunk of the ophthalmicus profundus nerve. This feature of the roofing bone (Pl. IV, fig. 1) is noticed till we reach the frontal which appears underneath the nasal and a few sections posteriorly the nasal disappear.

The septomaxilla (paired).—(*Nariale*, Marcus, Stimmelmayer and Porsch 1935). The septomaxilla (Pl. IV, fig. 1, text-fig. 1, *smx.*) which is noticed anteriorly to the appearance of the maxillopalatine in sectional views gives exit (through foramen epiphaniale ?) to a branch of the ophthalmicus profundus (*op*₂) nerve and is not united with the nasal (*n.*) above or with the premaxilla (*pmx.*) below. The contour of the bone in *Uraeotyphlus* differs slightly from that in *Ichthyophis*. A figure of a model of the septomaxilla is given by Sarasins (1890) where an upper, an external and an internal lamella are delineated. In *U. narayani* it appears posteriorly to the anterior naris as a small]-shaped

bone clasping the lateral portion of the olfactory sac ; the dorsal limb extends towards the nasal, while the lower limb is in contact with a cartilage (c). Anterior to the appearance of the prefrontal, the septo-



TEXT-FIG. 1.—*Uraeotyphlus narayani* Seshachar.

Transverse section in the septomaxilla region, posterior to fig. 8 : $\times 33$.

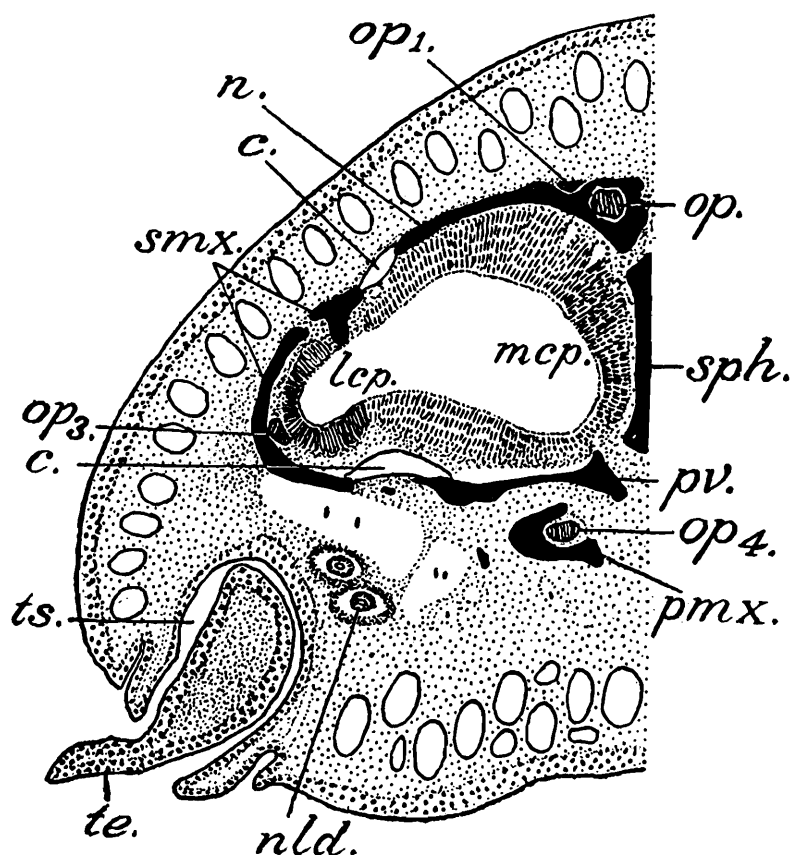
be., buccal epithelium ; c., nasal cartilage ; lcp., lateral cavum nasale principale ; map., maxilloplatine bone ; max₁., medial division of r. maxillaris V ; mcp., median cavum nasale principale ; n., nasal bone ; nld., nasolacrimal duct ; oog., opening of orbital gland ; op., r. ophthalmicus profundus V ; op₂., branch of r. ophthalmicus profundus ; op_{3b}., branches of op₃ ; op₄., branch of r. ophthalmicus profundus ; ops., branches of op to skin ; pmx., premaxilla ; pv., prevomer ; smx., septomaxilla ; sn', ossified septum nasi ; sph., sphenethmoid ; sul., sulcus ; tf., tentacular fold ; ts., tentacular sac.

maxilla disappears from sections. In the juvenile specimen of *Uraeotyphlus* that I have examined, the septomaxilla has not reached the maximum development noticed in the adult, but the adult configuration and the passage of the nerve (op₂) can be clearly made out.

In *Scolecormorphus* (text-fig. 2, smx.) anterior to the external naris the septomaxilla appears as a small piece of bone on the ventral aspect of the olfactory sac externally to the premaxilla ; in the plica which depends into the cavum nasale principale, a portion of the bone is noticed which however, in posterior sections, unites with the limb situated below the cavum nasale principale after the latter bone gives exit to a branch of the ophthalmicus profundus (op₃). The septomaxilla forms a horseshoe-shaped bone in the hollow of which the lateral part (lcp.) of the cavum nasale is located. The bone disappears in the region where the eye and prefrontal appear in sections.

The sphenethmoid.—This bone starts in the nasal septum (text-fig. 1, sph.) and invades the preoptic roots also. Anteriorly the bone appears as a median pillar and on the dorsolateral aspects of which the broad internal portion of each nasal rests. Ventrally the sphenethmoid

is slightly broadened with a cartilaginous tip (see cartilages of the nasal region). Posteriorly the sphenethmoid encloses the dorsal and ventral olfactory divisions of the nervous olfactorius (text-figs. 3, 9, *don*, *von*.)



TEXT-FIG. 2.—*Scolecomorphus uluguruensis* Barbour & Loveridge.

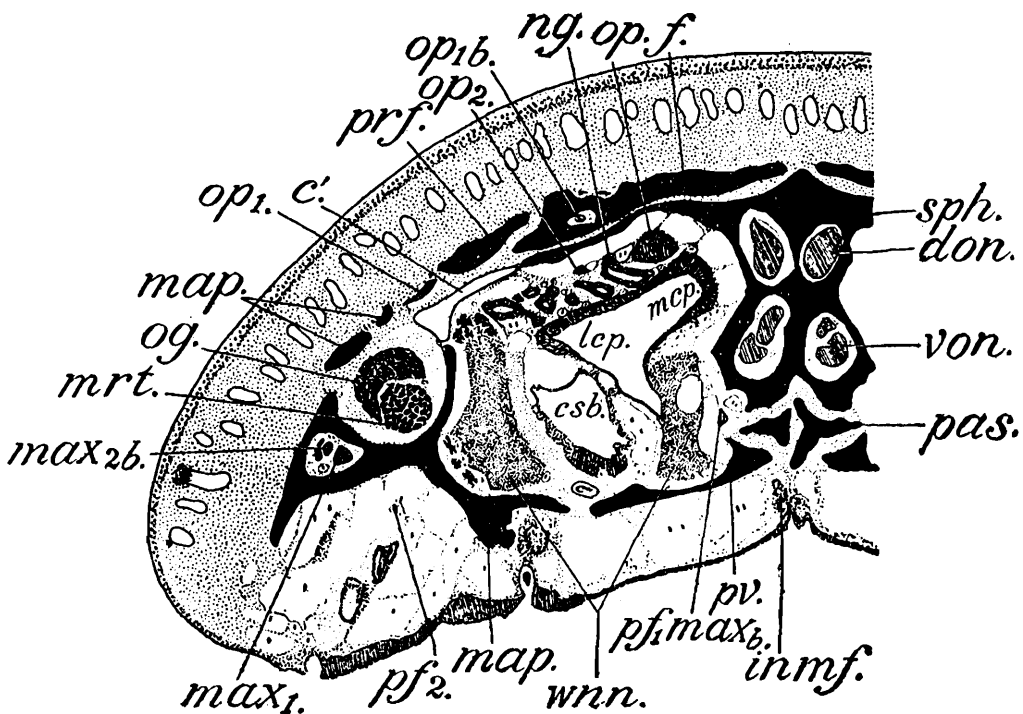
Transverse section in the septimaxilla region : $\times 55$.

c., nasal cartilage; *lcp.*, lateral cavum nasale principale; *mcp.*, median cavum nasale principale; *n.*, nasal bone; *nld.*, nasolacral duct; *op1*, *op2*, *op4*., branches of r. ophthalmicus profundus; *pmx.*, premaxilla; *pv.*, prevomer; *smx.*, septomaxilla; *sph.*, sphenethmoid; *te.*, tentacle; *ts.*, tentacular sac.

and in a slightly prechoanal region, five canals can be made out; two dorsal for the dorsal olfactory nerves, two ventral for the two ventral olfactory nerves and a median one (see text-fig. 9, *von*_b) in which a branch of the right ventral olfactory nerve runs. In text-fig. 3, a large bony extension running dorsally to the olfactory chamber on each side is given off and in this region, only four canals can be seen in the sphenethmoid. The gap between the lateral extension of the sphenethmoid and a dorsal limb of the maxillopalatine is bridged by a piece of cartilage (*c'*). In the region of the olfactory lobes, the sphenethmoid shows the typical girdle shape with the lateral extension still persisting. Dorsally an infrafrontal (interfrontale?) extension of the sphenethmoid is also noticed as described in *Hypogeophis* by Marcus, Stimmelmayer and Porsch (1935), and this point is indicated by these authors when they say that (p. 414):

Die bei *Siphonops* noch das Schädeldach bildende Deckplatte, die bei *Hypogeophis* von den Stirnbeinen verdeckt wird, wurde als Dermethmoidale bezeichnet und der dorsale ebenfalls der male Fortsatz des Processus interfrontalis.

The ophthalmicus profundus branch is enclosed in the dorsolateral wall of the sphenethmoid in posterior sectional views of *Uraeotyphlus*. In



TEXT-FIG. 3.—*Uraeotyphlus narayuni* Seshachar.

Transverse section, posterior to fig. 9 : $\times 30$.

c', c'', nasal cartilages; csb., "choanenschleimbeutel"; don., dorsal olfactory nerve; f., frontal bone; inmf., intermaxillary gland of Fahrenholz; lcp., lateral cavum nasale principale; map., maxillopalatine; max1., medial division of r. maxillaris V; max2b., branches of max2; mcp., median cavum nasale principale; mrt., m. retractor tentaculi; ng., nasal gland; og., orbital gland; op., r. ophthalmicus profundus V; op1, op2, branches of r. ophthalmicus profundus; op1b, branch of op1; pas., parasphenoid portion of os Basale; pf1maxb., palatinus facialis plus a branch of r. maxillaris V; pf2, lateral division of palatinus facialis; prf., prefrontal bone; pv., prevomer; sph., sphenethmoid; von., ventral olfactory nerve; wnn., wall of "Nebennase".

the optic region, the sphenethmoid becomes incomplete midventrally and forms only the ventrolateral boundary for the brain; further in this region the ophthalmicus profundus is not enclosed in a bony canal. The infrafrontal sphenethmoid persists. The foramen opticus (plus oculomotorius) appears and the sphenethmoid is noticed only dorsally and ventrally as rounded pieces of bone. However, posteriorly cartilage appears in these two portions representing the orbital (dorsal) and trabecular (ventral) cartilages.

In *Hypogeophis*, the ethmoidal region, which I have designated as the sphenethmoid following de Beer (1937), is composed of an anterior mesethmoid or presphenoid (arising in nasal septum), a dorsal dermethmoid and in the sides by the sphenethmoid (pleurethmoid plus sphenorbital) and a preethmoid (in connexion with the prevomer). However, de Beer considers that the sphenethmoid represents the presphenoid and orbitosphenoid bones.

The formation of an eminentia olfactoria (processus conchoïdes, Sarasins 1890) is characteristic of only some genera of Apoda. In *I. glutinosus* and *I. monochrous* an eminentia olfactoria is formed by the prevomer and sphenethmoid. A ventrolateral extension of the

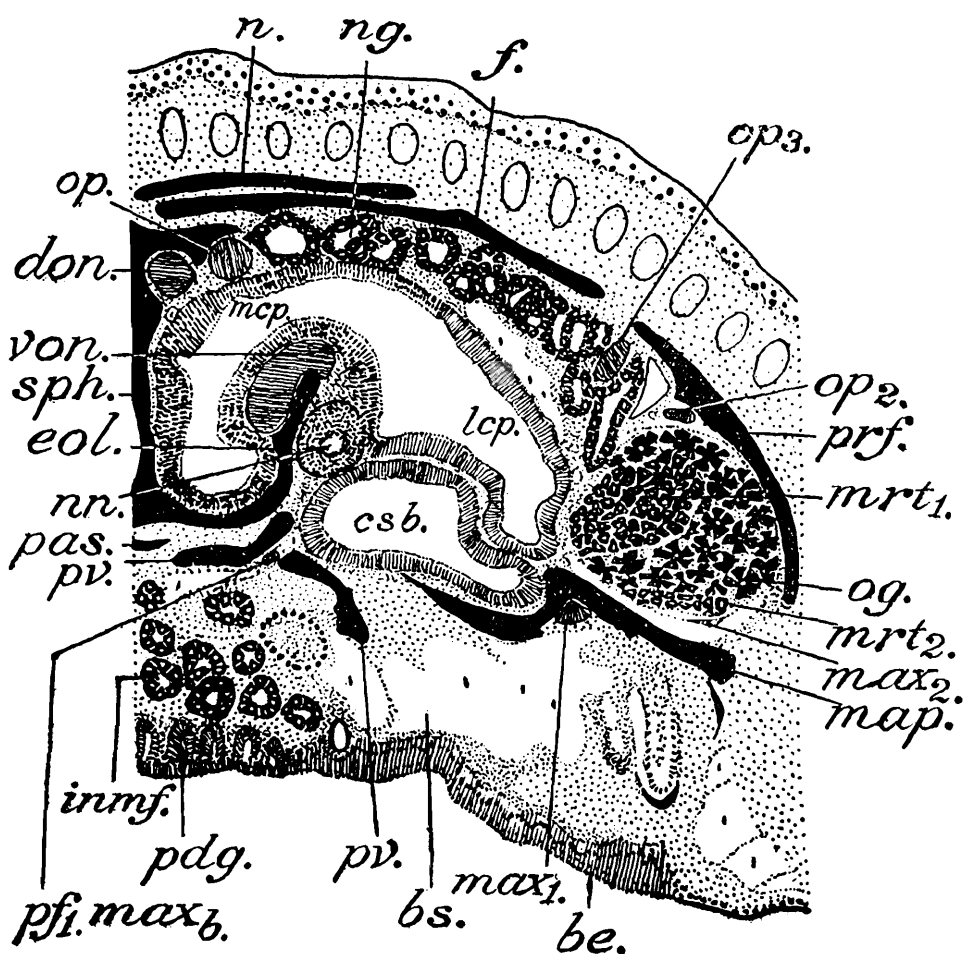
sphenethmoid projects into the nasal sac along with a portion of the prevomer so much so the cavity of the olfactory chamber is divided into a lateral and an inner (median) portion. A similar arrangement is also seen in *Geotrypetes* and *Dermophis* (Norris and Hughes 1918). However, in the latter animal the nasopremaxilla and the prevomer give rise to the elevation in the olfactory chamber anteriorly while in the posterior sections, the prevomer and the sphenethmoid contribute to it. Similarly in the case of *Ichthyophis*, the maxillopalatine sends a small projection on the external aspect of the prevomer. The formation of the eminentia olfactoria is totally wanting in *Herpele*, *Caecilia* and *Hypogeophis* (Wiedersheim 1879 ; Norris and Hughes 1918 ; Marcus, Stimmelmayer and Porsch 1935). In *U. narayani* also an eminentia olfactoria is absent and therefore a lateral chamber of the nasal sac, as described by Sarasins (1890) for *I. glutinosus*, is also absent.¹

In the investigated examples like *Boulengerula*, the degenerate eye is covered by squamosal while in *Caecilia* and *Herpele* the eye is covered by maxillopalatine and the eye muscles and eminentia olfactoria are absent, whereas in *Ichthyophis*, *Dermophis* and *Geotrypetes* an eminentia olfactoria is developed and the eye is not covered by bone. In *Scolecophorus* the eye is degenerate and is not covered by any bone, but an eminentia olfactoria is well developed. *U. narayani* forms a good link between *Boulengerula*, *Caecilia* and *Herpele* on the one hand and *Ichthyophis*, *Dermophis* and *Geotrypetes* on the other and it is noticed that the eye in *Uraeotyphlus* is not covered, the eye muscles are well developed with an optic nerve, but an eminentia is absent. It might be thought that there is a correlation between the degeneration of the eye consequent upon covered nature of it as in *Herpele* and *Boulengerula*, etc., and the absence of an eminentia, but the presence of a well developed eye and the absence of an eminentia in *Hypogeophis* and *Uraeotyphlus* and the presence of a degenerate eye and the possession of an eminentia in *Scolecophorus* (see text-fig. 4, *col.*) rules out any such relation.

The cartilages of the nasal region.—The prenasal prong appears as a thin cartilaginous structure between the premaxillae. In the region where the cartilaginous nasal septum (see text-fig. 8, *sn.*) which gives rise to the prong anteriorly widens to give rise to short tectal (*tn.*) and solum (*son.*) cartilages, it is noticed that the lateral sinus of the olfactory chamber (cavum nasale principale) is bounded externally by a crescentic cartilage (*cc.*) from which a short projection is noticed to enter the plica (*pl.*). In sections anterior to the nares, this crescentic cartilage forms a part of the roof and also the floor of the cavum nasale principale. The ventral cartilaginous limb of this in posterior sections lies between the lower limb of the septomaxilla and the premaxilla (text-fig. 1, *c.*) and further posteriorly is seen in between the inner portion of the maxillopalatine and prevomer and joins the bony solum of the sphenethmoid bone. Quite independently of the cartilages mentioned above, there appears a cartilage (see text-fig. 9, *c.*) between the prefrontal and frontal and spreads posteriorly between the maxillopalatine and the sphenethmoidal tectum (text-fig. 3, *c.*) and fuses with

¹ See The olfactory organ and associated glands.

the latter ; in other words it is an anterior cartilaginous extension from the tectum.



TEXT-FIG. 4.—*Scolecomorphus uluguruensis* Barbour & Loveridge.

Transverse section showing eminentia olfactoria : $\times 55$.

be., buccal epithelium ; bs., blood sinus ; csb., "choanenschleimbeutel" ; don., dorsal olfactory nerve ; eol., eminentia olfactoria ; f., frontal bone ; inmf., intermaxillary glands of Fahrenholz ; lcp., lateral cavum nasale principale ; map., maxillopalatine ; max₁., medial division of r. maxillaris V ; max₂., lateral division of r. maxillaris V ; mcp., median cavum nasale principale ; mrt₁., mrt₂., two parts of m. retractor tentaculi ; n., nasal bone ; ng., nasal gland ; nn., "Nebennase" ; og., orbital gland ; op., op₂., op₃., r. ophthalmicus profundus (op) and its branches ; pas., parasphenoid portion of os basale ; pdg., postdental gland ; pf. max., palatinus facialis plus a branch of r. maxillaris V ; prf., prefrontal ; pv., prevomer ; sph., sphenethmoid ; von., ventral olfactory nerve.

In the region where the anterior portion of the "Choanenschleimbeutel" (text-fig. 3, csb.) is noticed between the two portions of the "Nebennase", a horseshoe-shaped cartilage clasps the choanal chamber ; posteriorly a bit of this cartilage (c") is noticed dorsally to the maxillopalatine bone and this finally disappears.

ORBITO-TEMPORAL REGION.

The frontal (paired).—(text-figs. 3, 9, f.) The frontals meet each other in a close suture (Pl. IV, fig. 1) so that the sphenethmoid is not visible externally, a feature also noticed in *Gymnopsis* (Peters 1879), *Hypogeophis* (Marcus, Stimmelmayer and Porsch 1935), *Ichthyophis* and *Chthonerpeton*. In *Siphonops* (Wiedersheim 1879) between the nasopremaxilla, the frontals and parietals of either side, the sphenethmoid

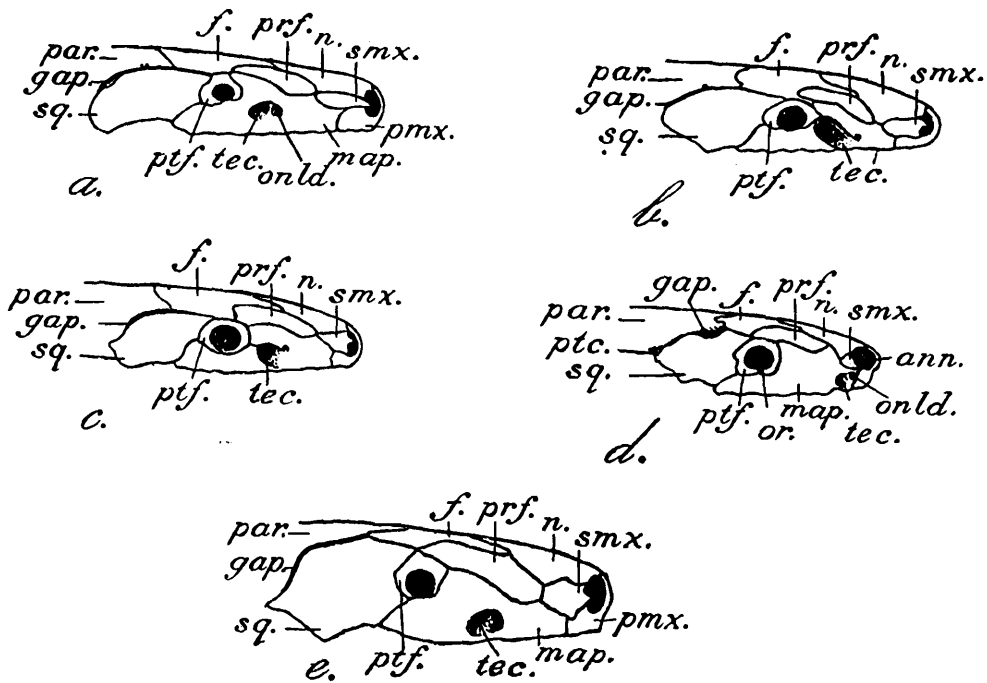
is visible as a diamond-shaped area ; in *Herpele squalostomum*, Peters (1879) shows the sphenethmoid in two areas, viz., between the nasopremaxilla and the frontals and between the latter bones and parietals. Parker (1936) who reproduced a figure of the same species of *Herpele* for purposes of comparison with *Idiocranium*, indicates the sphenethmoid as visible externally only between the nasopremaxilla and the frontals ; this probably is a variable feature. In *Scolecormorphus* (Peters 1895) the roofing bones approximate and, therefore, a part of the sphenethmoid is not visible externally, a point also confirmed by de Villiers (1938). In *Boulengerula* (Peter 1908), the bone is visible mainly between frontals. From the figures of Norris and Hughes (1918) it can be concluded that the sphenethmoid is visible dorsally owing to the incomplete approximation of the nasopremaxilla and the frontals in *Dermophis* and also in *Herpele*.

The parietal (paired).—(text-fig. 10, *par.*) They appear underneath the frontals and posteriorly form not only the roof but a part (dorsal) of the side, articulating with the os Basale (the pleurosphenoid, prootic and exoccipital parts).

The pre- and post-frontal (paired).—These two bones may be considered together. In *Ichthyophis* and *Uraeotyphlus* only these two bones are present, in all other Apoda they are absent, except in *Scolecormorphus* (Peter 1895, 1908) in which only a prefrontal is noticed (text-fig. 4, *prf.*). In the South Indian genera studied by me, the prefrontal (described as Preorbital by J. Müller) is bounded by the nasal and maxillopalatine anterolaterally and posterolaterally by the frontal and prefrontal. In the case of *I. glutinosus*, the figures of Sarasins (1890) show that the anterior tip of the prefrontal reaches the posterior border of the septomaxilla. In some of the skulls that I have examined this is not so, for the prefrontal is separated from the septomaxilla by the juxtaposed portions of the nasal and maxillopalatine. The sectional views of well grown adults of both *I. glutinosus* and *U. narayani* also exhibit the latter feature. A side view (see text-figs. 5a, 5c and 5e) depicts the condition enumerated above where the maxillopalatine and the nasal are not separated by the septomaxilla or prefrontal.

The exact contour of the postfrontal differs in individuals. In the case of *I. glutinosus*, Sarasins remarked that the bone was always 'half-moon'-shaped confirming the observation of J. Müller. Wiedersheim (1879) noted that the bone was ring-like normally and the crescentic nature of it was due to injury and Peters (1879) also remarked the same about the bone. In the figure drawn by Nieden (1913, p. 3), a ring-like postfrontal (see text-fig. 5c, *ptf.*) has been shown following Wiedersheim and Peters. In *U. narayani*, only one type is found, i.e., the circular. In one series of sections of a large animal the postfrontal is ring-like while in another (of a smaller size) it is crescentic with the gap towards the maxillopalatine. In the juvenile specimen of *U. narayani* (9 cm.), which I have studied, it is crescentic. The skulls of large specimens that have been prepared by maceration show a ring-like postfrontal. It is therefore abundantly clear that in *U. narayani*, the crescentic nature of the postfrontal is noticed in smaller animals while in the well grown adults, a ring-like postfrontal is present. In my figures

(Pl. IV, fig. 1 and text-fig. 5*d*) I have shown the bone ring-like. Having examined a large number of skulls of *I. glutinosus*, the crescentic post-



TEXT-FIG. 5.

Ichthyophis glutinosus (Linn.). Skull, lateral aspect.

a. (after Sarasins, 1890) : $\times 4.5$.

b. original : $\times 4.5$.

c. (after Nieden, 1913 modified) : $\times 4.5$.

Uraeotyphlus narayani Seshachar. Skull, lateral aspect, d. $\times 4.5$.

Ichthyophis monochrous (Bleek.). Skull, lateral aspect, e. $\times 4.5$.

ann., anterior nares ; f., frontal ; gap., fossa between squamosal and parietal ; map., maxillopalatine ; n., nasal ; onld., opening of nasolacrimal duct ; or., orbit ; par., parietal ; pmx., premaxilla ; prf., prefrontal ; ptc., pteroccipital cavity ; ptf., postfrontal ; smx., septomaxilla ; sq., squamosal ; tec., tentacular canal.

frontal is noticed in a majority of them while the presence of a circular one is not uncommon. In my preparations the ring-like postfrontal belongs to one which is easily the biggest among the macerated skulls and since Sarasins (1890) have shown a crescentic postfrontal in an equally large skull the shape of the bone is obviously subject to variation. On the other hand, in *U. narayani*, the shape of the postfrontal is always circular in well grown individuals. Peculiarly there is another feature of variation met with in these South Indian apodan genera to which reference has been made briefly already. In the figures by Sarasins (1890) of *I. glutinosus*, the septomaxilla and prefrontal (text-fig. 5*a*) meet each other ; in *I. monochrous* (text-fig. 5*e*) the topographical relationship of bones is exactly like that in *I. glutinosus*. But in the skulls of *I. glutinosus* studied by me, in some where the postfrontal is crescentic the prefrontal and septomaxilla are separated by the extension of nasal and maxillopalatine. The other type where the postfrontal is circular, the close apposition of the prefrontal and septomaxilla is also seen. I do not like to establish any correlation between the

shape of the postfrontal and the nature of approximation of prefrontal and septomaxilla without examining the other species, but it may be remarked that among all the skulls of *I. glutinosus* examined by me not one was noticed to possess a circular postfrontal and with prefrontal and septomaxilla separated from each other. In this connexion, the statement of Peters (1881) based on an examination of two skulls of *Caecilia oxyura* (*U. oxyurus*) that if the prefrontal reached the 'losge-losten nasale' (septomaxilla), it would closely approximate to the condition delineated for *I. glutinosus* is rather significant. This condition, *i.e.*, the separated prefrontal and septomaxilla particularly characterises all the skulls of *U. narayani* examined by me.

In *Scolecophorus kirkii* (Peter 1895, 1908) and in *S. uhuguruensis* (de Villiers 1938) there is a separate prefrontal but a postfrontal is absent; in *Hypogeophis* (Marcus, Stimmelmayer and Porsch 1935) a prefrontal appears in the larval stages but in the adult it fuses with the frontal and lachrymal and the composite bone is called a temporal.

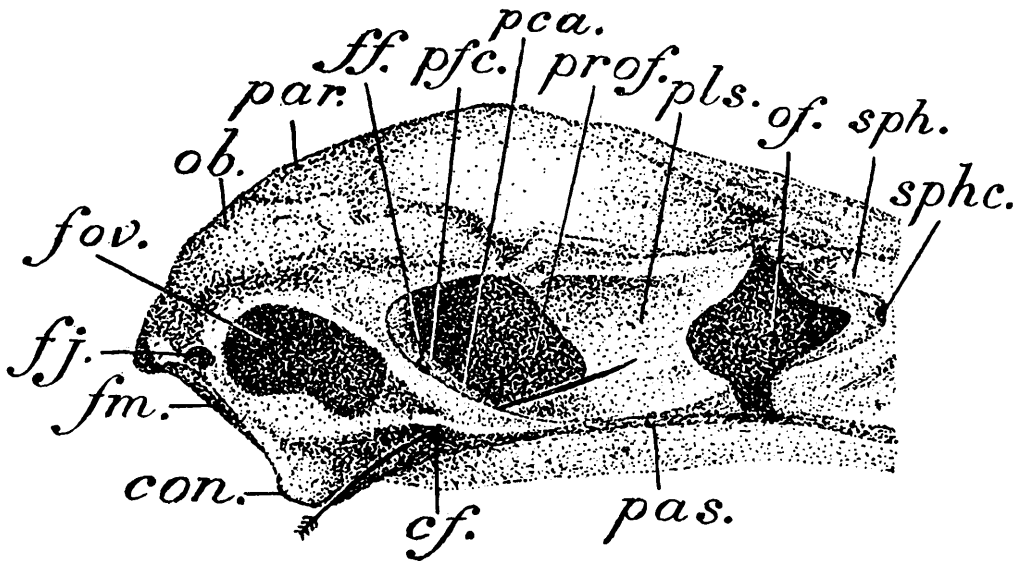
OCCIPITO-AUDITORY REGION.

The os Basale.—Under this term, Sarasins (1890) described the composite skeletal framework formed by the fusion of parasphenoid with its anterior rostrum (Pl. IV, fig. 2, *r.*) (called processus cultriformis in *Hypogeophis*) between the prevomers, basioccipital, supraoccipital and otic ossification and the pleurosphenoid,—the latter forming the lateral wall of the cranium posterior to the optic (*plus oculomotor*) foramen. According to Marcus, Stimmelmayer and Porsch (1935) the os Basale is contributed by nine different bones, *viz.*, basi-, pleuro-, supra-, and infra-occipitals, an epiotic, a pleurosphenoid, two parasphenoids and otic capsule.

A similar os Basale is also found in *U. narayani* and on its ventral face, orifices for the carotid artery (Pl. IV, fig. 2, *cf.*) and jugular foramina are located. In the lateral aspect of the cranium (text-fig. 6), the side wall reveals the optic (*plus oculomotor*) (*of.*), prootic (*prof.*) and facial (*ff.*) foramina. Roughly the position of some bones which have fused may be made out. Posterior to the optic (*plus oculomotor*) foramen is the pleurosphenoid bone (*pls.*) which commences from the anterior margin of the prootic foramen. The prootic (*prof.*) and facial (*ff.*) foramina are accommodated in the prootic region. A separate foramen for the oculomotor nerve is not seen, and in those forms where the third nerve is described in the adult, it enters the cranium along with the second nerve through the optic foramen. In the larval stages also there is no separate foramen in the cartilaginous wall and therefore, a pila metoptica is absent. As suggested by de Beer (1937) the cartilaginous wall which separates the optic and trigeminal foramina is a pila antotica produced far anteriorly. The trigeminal (*prof.*) and facial (*ff.*) foramina are separated by a bony bridge,—the prefacial commissure (*pf.c.*) both in *Ichthyophis* and *Uraeotyphlus*.

The parasphenoidal portion of the os Basale gives rise to the basipterygoid process (Pl. IV, fig. 2, *bp.*) with which the processus pterygoideus (*ppt.*) of the quadrate is united syndesmotically and since this

joint is identical with the basal articulation found in other Apoda being situated anteriorly to the facial nerve, it must be called a basal joint while in others it is a basal articulation of the cartilaginous facets of the processus pterygoideus and basiptyergoid process.



TEXT-FIG. 6.—*Uraeotyphlus narayani* Seshachar.

Side view of cranium showing nerve foramina : $\times 15$.

cf., carotid foramen; con., condyle; ff., facial foramen; fj., jugular foramen; fm., foramen magnum; fov., foramen ovale; ob., os Basale; of., optic plus oculomotor foramen; par., parietal; pas., parasphenoid portion of os Basale; pca., palatine canal; pfc., prefacial commissure; pls., pleurospenoid portion of os Basale; prof., protoic foramen; sph., sphenethmoid; sphc., sphenethmoidal canal for r. ophthalmicus profundus.

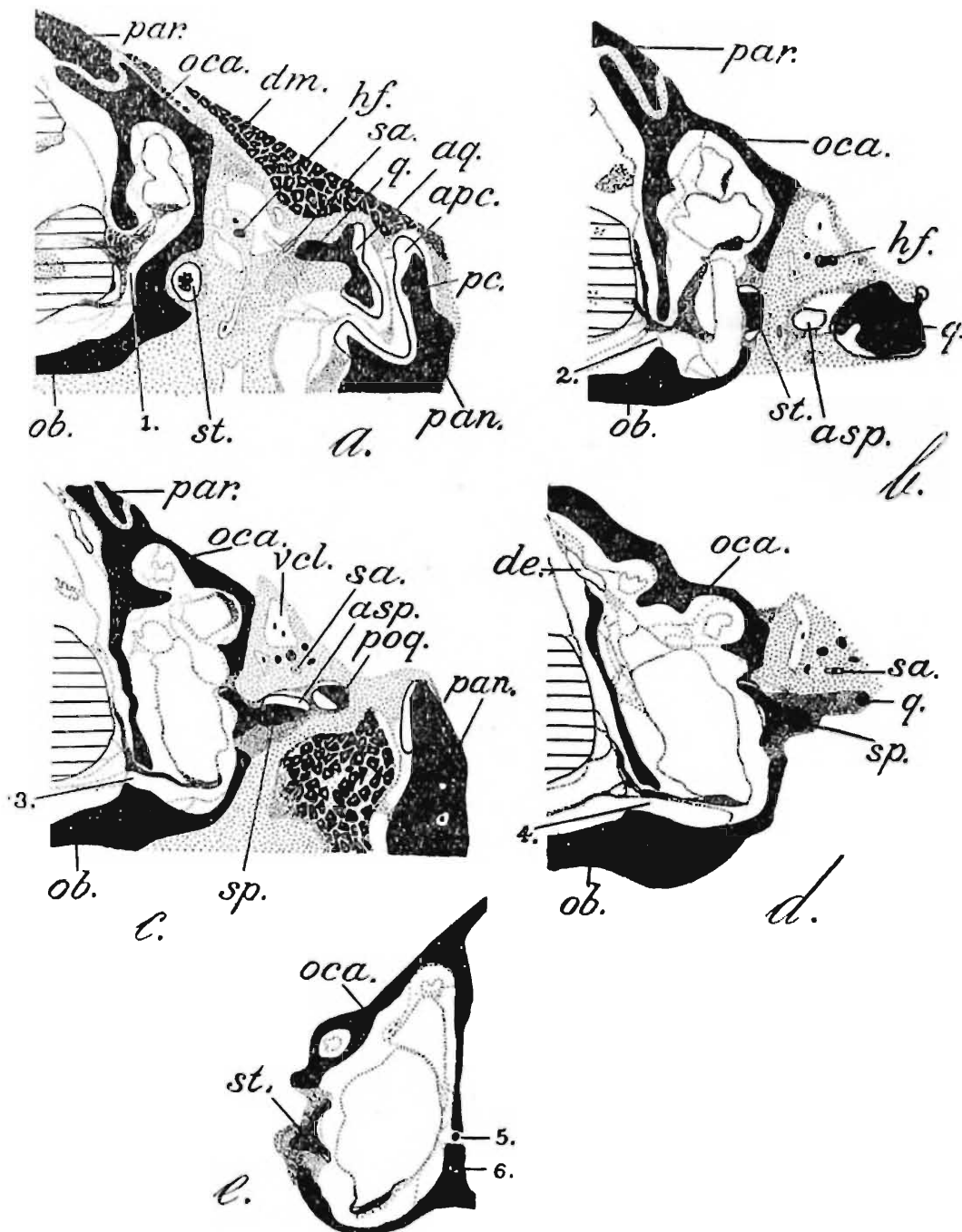
There is a well formed depression (sella turcica), in the os Basale for the accommodation of the pituitary body in *Uraeotyphlus*, *Dermophis*, *Scolecormorphus*, *Boulengerula* and *Herpele*, but in *Ichthyophis* it was not seen.

The stapes (text-fig. 7 a-d, st.).—(ossified operculum) with its stapedial process (sp.) is bony as in other Apoda and invariably the stapedial process articulates by its cartilaginous facet (asp.) with a similar facet of the processus oticus. The operculum is, however, stated to be absent by Wiedersheim (1879), Kingsley and Ruddick (1899), Kingsley (1900), M. Fürbringer (1922) and Stadtmüller (1936). The absence of the middle ear is ascribed to a borrowing mode of life by Versluys (1927, 1931). However, in *Scolecormorphus* (de Villiers 1938) there is no stapedial articulation since the stapes is absent (see page 19). In *Dermophis* (de Jager 1939) the stapedial process unites with the processus oticus which, however, is not seen in my preparations.

As in *Ichthyophis*, the stapedial artery in *Boulengerula* passes through a canal in the stapes before entering the cranioquadrate passage thus simulating the condition noticed in *Ranodon*, Geckones and mammals.

Marcus (1933) has pointed out that the stapes in *Hypogeophis* is in blastematous continuity with the hyoid in early stages of development and therefore it is a hyoid derivative. If this is proved for other

apodan genera also, then the suspension of the pterygoquadrate or quadrate is hyostylic.



TEXT-FIG. 7.—*Uraeotyphlus narayani* Seshachar.

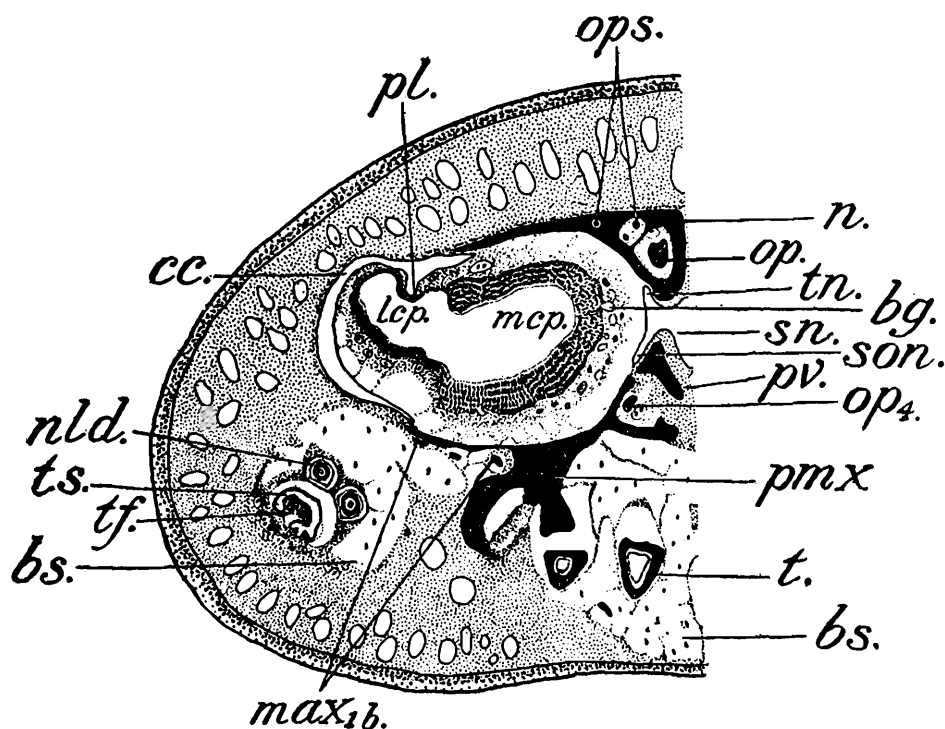
a—e., consecutive transverse sections in the auditory region: $\times 22$.

apc., articular facet of the processus condyloides; aq., articular facet of the quadrate; asp., articular process of stapes; de., ductus endolymphaticus; dm., M. depressor mandibulae; hf., r. hyomandibularis facialis; ob., os Basale; oca., otic capsule; pan., pseudoangular; par., parietal; pc., processus condyloides; poq., processus oticus of quadrate; q., quadrate; sa., stapedial artery; sp., stapedial process; st., stapes; vcl., vena capitis lateralis; 1., auditory orifice for the utricular nerve; 2, 3, 4, 5, 6., auditory orifices for the saccular nerves.

THE UPPER JAW, PALATE AND SUSPENSORIUM.

The premaxilla (paired).—The first bony structure one meets with in the sectional views of the anterior narial region is the premaxilla

(Pl. IV, figs. 1, 2 and text-fig. 8, *pmx.*). The premaxilla of either side is noticed to be pierced by blood vessels and branches of ophthalmicus profundus nerve. It is also seen that there is an oval cartilage of the sphenethmoid between the premaxillae of either side and in embryos, this cartilage projects as the prenasal prong (Peter 1898, de Beer 1937). Posteriorly, the premaxilla forms partly the internal boundary of the olfactory organ and a principal branch of ophthalmicus profundus (text-fig. 8, *op₄*) and a ramulus from the median branch of maxillary V run within it before gaining exit. In the region where the anterior portion of the "Nebennase"¹ is met with, the premaxilla disappears from sections.



TEXT-FIG. 8.—*Uraeotyphlus narayani* Seshachar.

Transverse section anterior to fig. 1 : $\times 33$.

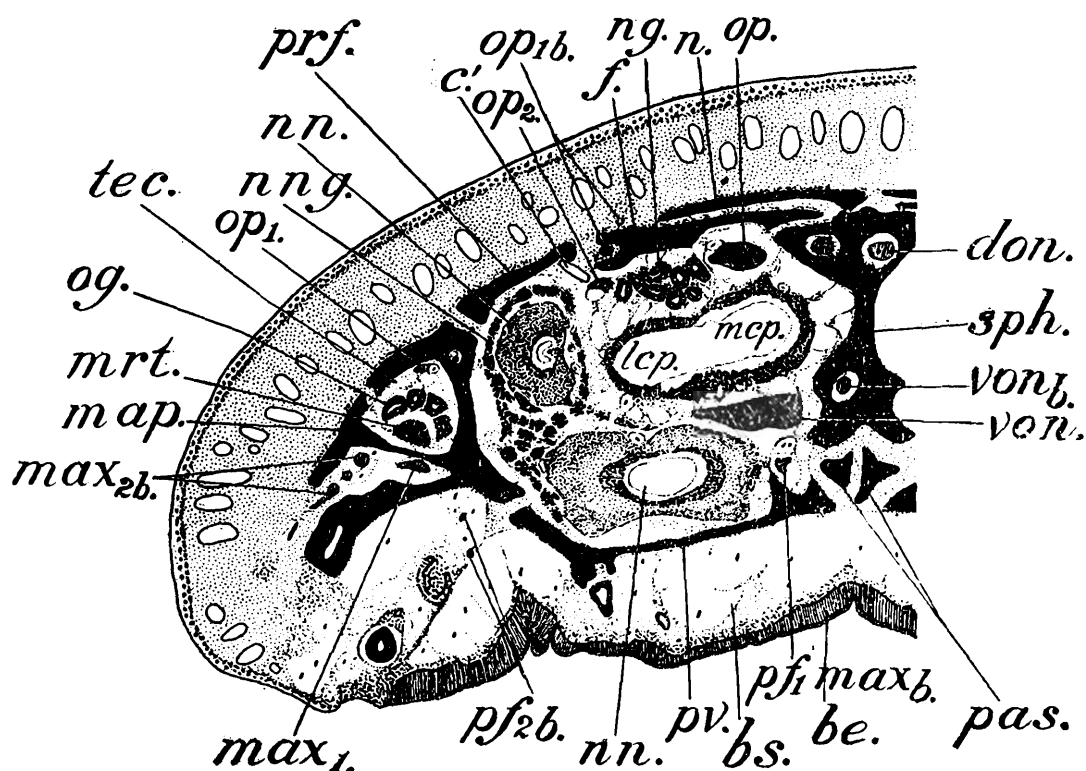
bg., Bowman's gland ; *bs.*, blood sinus ; *cc.*, crescentic cartilage ; *lcp.*, lateral cavum nasale principale ; *mcp.*, median cavum nasale principale ; *max_{1b.}*, branches of *max₁* ; *n.*, nasal ; *nld.*, nasolacrimal duct ; *op.*, *op₄.*, r. ophthalmicus profundus and branch respectively ; *ops.*, branches of *op* to skin ; *pl.*, plica ; *pmx.*, premaxilla ; *pv.*, prevomer ; *son.*, solum nasi ; *sn.*, septum nasi ; *t.*, tooth ; *tf.*, tentacular fold ; *tn.*, tectum nasi ; *ts.*, tentacular sac.

The fusion of the premaxilla with the nasal and septomaxilla to form a nasopremaxilla is a common feature of the apodan genera. In *Hypogeophis*, *Caecilia*, *Herpele*, *Gymnopsis*, *Chthonerpeton*, *Siphonops*, *Boulengerula* (Peter 1908), *Dermophis* (Norris and Hughes 1918, de Jager 1939), *Idiocranium* (Parker 1936) a fused nasopremaxilla is noticed. In *I. glutinosus*, *I. monochrous*, *U. narayani* and *Scolecormorphus* (Peter 1908) the nasals, premaxilla and septomaxilla are always separate though de Beer (1937) points out that these bones fuse in *I. glutinosus*.

The maxillopalatine (paired).—The anteriormost part of the maxillopalatine is met with in sections behind the anterior nares (Pl. IV

¹ See The olfactory organ and associated glands.

figs. 1, 2 and text-fig. 1, map.). In the region where the two nasolacrimal ducts enter into the "Nebennase" the outer portion of the maxillopalatine is seen as a horseshoe-shaped structure enclosing the "Nebennase". In the choanal region the lateral branch of the palatinus facialis passes through a foramen in this bone and runs ventrally to it. Further posteriorly where the tentacular canal (text-fig. 9, *tec.*) in the maxillopalatine (map.) is noticed dorsally, the lateral (max_{2b}) and medial (max_1) maxillary branches run ventrally in the bone separated from each other. Dorsally to the tentacular canal, the ophthalmicus profundus branch (op_2) runs in the maxillopalatine. In the optic region, the two passages for the maxillary ramuli are lost and post-optically, it is noticed that the anterior end of the pterygoid articulates with the posterior tip of the maxillopalatine by means of connective tissue (see text-fig. 10, *pt.*, map.).



TEXT-FIG. 9.—*Uraeotyphlus narayani* Seshachar.

Transverse section posterior to fig. 1 : $\times 33$.

be., buccal epithelium ; *bs.*, blood sinus ; *c'*., nasal cartilage ; *don.*, dorsal olfactory nerve ; *f.*, frontal ; *lcp.*, lateral cavum nasale principale ; *map.*, maxillopalatine ; *max1.*, medial division of r. maxillaris V ; *max2b.*, branches of max_2 ; *mcp.*, median cavum nasale principale ; *mrt.*, M. retractor tentaculi ; *n.*, nasal ; *ng.*, nasal gland ; *nn.*, "Nebennase" ; *nng.*, glands of "Nebennase" ; *og.*, orbital gland ; *op.*, *op1*, *op1b.*, *op2.*, r. ophthalmicus profundus and branches ; *pas.*, parasphenoid portion of os Basale ; *pf1maxb.*, palatinus facialis plus a branch of r. maxillaris V ; *pf2b.*, branch of the lateral division of palatinus facialis ; *prf.*, prefrontal ; *pv.*, prevomer ; *sph.*, sphenethmoid ; *tec.*, tentacular canal ; *von.*, ventral olfactory nerve ; *vonb.*, branch of *von.*

In *Boulengerula*, it is noticed by de Villiers (1938) that the suture between the posterior portion of the premaxilla of the nasopremaxilla and the maxillopalatine is lost and therefore the maxillopalatine also fuses with the anterior bones,—an instance of further consolidation of the bones of the maxillary segment.

In *Hypogeophis* (Marcus, Stimmelmayer and Porsch 1935) the maxillopalatine is formed by the fusion of maxilla, palatine and lachrymal and probably in *Ichthyophis*, the first two go to form the composite bone.

Two rows of teeth can be distinguished ; an outer and an inner. While the outer row is borne upon the premaxilla and the maxillopalatine, the inner row is carried by the prevomer and the maxillopalatine. Between the two rows of teeth, there is a large interdental area and glands occupy this region and these are described separately (see The glands of buccal cavity). However, the second row of maxillopalatine teeth may form an incomplete row. In *Scolecormorphus* and *Boulengerula* (Peter 1908) the teeth of the second row are absent near the choana, while anteriorly and posteriorly the prevomer and maxillopalatine are dentigerous.

The pterygoid (paired).—This bone (Pl. IV, fig. 2 and text-fig. 10, *pt.*) which is situated between the posterolateral aspect of the maxillopalatine and the basipterygoid process of the os Basale, does not fuse with the quadrate to form a pterygoquadrate in *I. glutinosus*, *I. monochrous* and *U. narayani*. The pterygoid (Pl. IV, fig. 2, *pt.*) and the os Basale are separated by a large vacuity,—the mediopalatinal cavity (*mpc.*) which is filled with connective tissue in the living animal. In posterior sectional views where the articular facet of the os Basale (basipterygoid process) is met with, the anterior portion of the processus pterygoideus of the quadrate is noticed dorsally to the pterygoid bone. In *Chthonerpeton* (Peters 1879), *Ichthyophis* (Sarasins 1890), *Idiocranium* (Parker 1936) and in *I. monochrous* and *Uraeotyphlus*¹ the pterygoid is an independent bone. In the other genera investigated a pterygoquadrate has been described, this is surmised to be formed by the fusion of the pterygoid and quadrate, though developmentally it is not substantiated. In *Boulengerula* (Peter 1908, de Villiers 1938), *Scolecormorphus* (de Villiers 1938), *Dermophis* (de Jager 1939), and also in *Herpele*, a pterygoquadrate is seen. Wiedersheim (1879) was not able to discover a pterygoid in *Siphonops*, *Chthonerpeton*, *Hypogeophis rostratus* and *Caecilia* and he referred the “doubtful bones” in between the maxillopalatine and the processus pterygoideus as Jugale (?) or postpalatine (?). Luther (1914) in his figures 4B and C shows a well marked pterygoid in *Siphonops* (dentigerous) while in *Caecilia*, a posterior portion of the maxillopalatine is shown as pterygoid. It is just possible that the processus pterygoideus of the pterygoquadrate reaches the maxillopalatine with no definite bone in between. In *Hypogeophis alternans* an independent quadrate or the formation of a pterygoquadrate is described by Marcus, Winsauer and Hueber (1933) and is depicted in their figures 3, 19 and 23.

The prevomer (paired).—The prevomer² (Pl. IV, fig. 2 and text-figs. 1, 3, 8, 9, *pv.*) which forms the roof of the palate anteriorly is bounded by the premaxilla or the premaxillary part of the nasopremaxilla anteriorly, the maxillopalatine laterally and the parasphenoidal rostrum

¹ Peter (1908) was not able to discover the nature of the pterygoid (united with quadrate or free) in *Uraeotyphlus* and *Scolecormorphus*.

² Parrington and Westoll (1939) remark that the term prevomer is synonymous with vomer and must be dropped.

of the os Basale mesially. This rostrum may or may not be visible externally in macerated skulls. In *Ichthyophis*, the prevomers of either side meet each other mesially, and only a very small portion of the rostrum is seen; the internal portion lies between the prevomers and the base of the sphenethmoid. In *U. narayani*, the prevomers are wide apart and between these bones the rostrum is seen. In one specimen of *U. narayani* whose sections are figured, the rostrum is double, but in the juvenile one and the other adults there is only a single one.

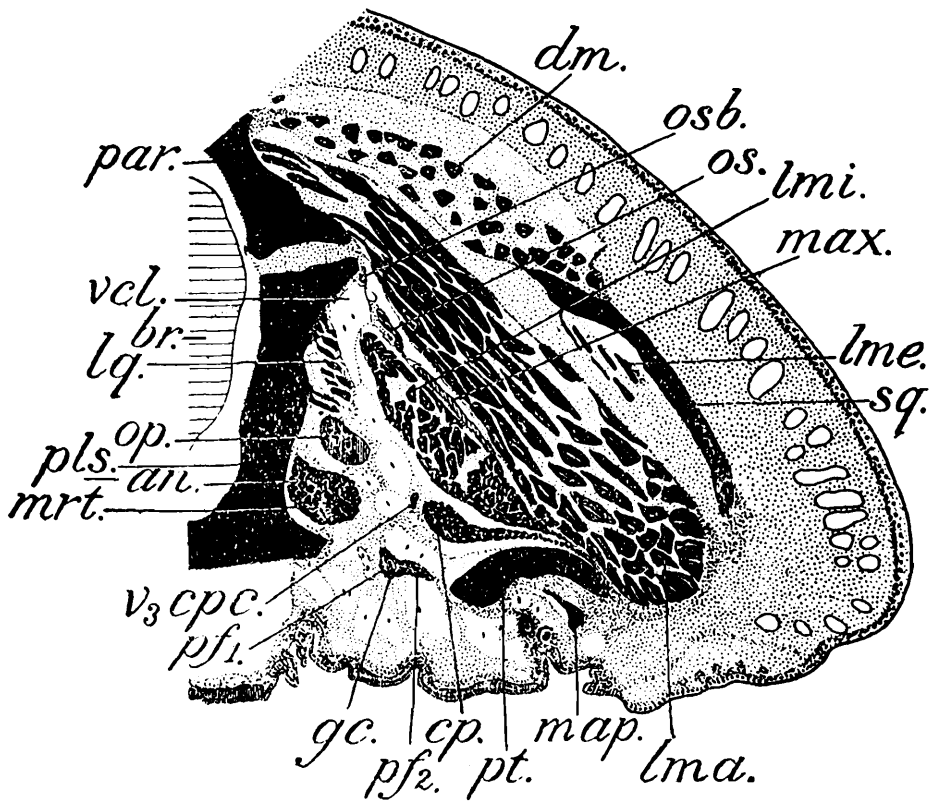
The second row of teeth belonging to the upper jaw is arranged as an arc of a circle on each prevomer. In the majority of cases the prevomer forms the anteromedian boundary of the choana (*Ichthyophis*, *Uraeotyphlus*, *Scolecormorphus*, etc.), while in *Dermophis* (*D. thomensis*, *D. seychellensis*, *D. mexicanus*, Parker 1936) and *Boulengerula* (Peter 1908) the prevomer lies far distant from the choanal opening. It has already been remarked that the prevomer contributes to the formation along with a limb of the sphenethmoid of an eminentia olfactoria, as in *I. glutinosus*, *I. monochrous*, *Dermophis* (Norris and Hughes 1918), *Geotrypetes* and *Scolecormorphus* (see Wiedersheim 1879, Figs. 32-34 and 37-40). The bone is pierced in *Uraeotyphlus* by the ventral ramulus of the ophthalmicus profundus nerve (op_4) anteriorly and posteriorly by the palatinus facialis (pf_1max_b) as in other Apoda. In the choanal region the prevomer articulates with the rostrum referred to above and the bone disappears a few sections posteriorly to the choana.

The squamosal (paired).—(*Paraquadrate* Gaupp., Peter., Marcus, Winsauer and Hueber., Marcus, Stimmelmayer and Porsch., *Jugale* Sarasins., *Squamosojugale* Peter., Peters).

It has already been remarked that the stegokrotaphic nature or zygokrotaphy of squamosal and parietal is utilised for purposes of taxonomy and the presence of a large gap between the parietal and squamosal in *Uraeotyphlus* (Pl. IV, fig. 1, *gap*.) separates it from its South Indian congener *Ichthyophis*. However, in *Ichthyophis*, a thin cleft is figured by Sarasins between the above named bones; but Wiedersheim (1879) does not show any cleft thereby making it a typically stegokrotaphic cranium. Peter (1908) refers to this feature as probably a variation. This is not an individual variation or due to differences in growth as Peters (1881) imagined it to be, for, having studied a large number of skulls of *Ichthyophis* and *Uraeotyphlus*, I notice a thin cleft in the former and a big one in *Uraeotyphlus*, and therefore the presence or absence of a cleft is certainly comparative.

In sectional views, the squamosal is noticed posteriorly to the post-frontal and is disposed laterally to the frontal and parietal, and in anterior sections dorsally to the maxillopalatine. In the posterior region of the optic (*plus* oculomotor) foramen the brain is covered over by the parietal and on the sides the anterior portion of the pleurosphenoid encloses the reminiscent orbital cartilage; the floor is formed by the os Basale (parasphenoid portion). Between the side wall of the cranium and the squamosal (Pl. IV, fig. 2 and text-fig. 10, *sq.*) in the lower temporal fossa (*lf.*), the MM. levator mandibular anterior (*lma.*), levator mandibular externus (*lme.*), levator mandibulae internus (*cp.*, *lmi.*), the ophthalmicus profundus (*op.*) and maxillary (*max.*) branches of

the trigeminal nerve and the head vein (*vcl.*) are noticed. Posteriorly the squamosal gives rise to a shelf-like projection towards the cranium (seen only in a few sections) free from any muscle insertions as in *Boulengerula*. Where the quadrate (Pl. IV, fig. 2, *q.*) appears as a bone closely applied to the inner face of the squamosal (*sq.*) separated by a thin connective tissue lamella, the insertion of the fibres of *M. levator mandibulae externus* is noticed on the former bone; the apposition of the bones persists in a large number of sections, and posteriorly to the trigeminal foramen, the squamosal disappears.



TEXT-FIG. 10.—*Uraeotyphlus narayani* Seshachar.

Transverse section in the squamosal region : $\times 33$.

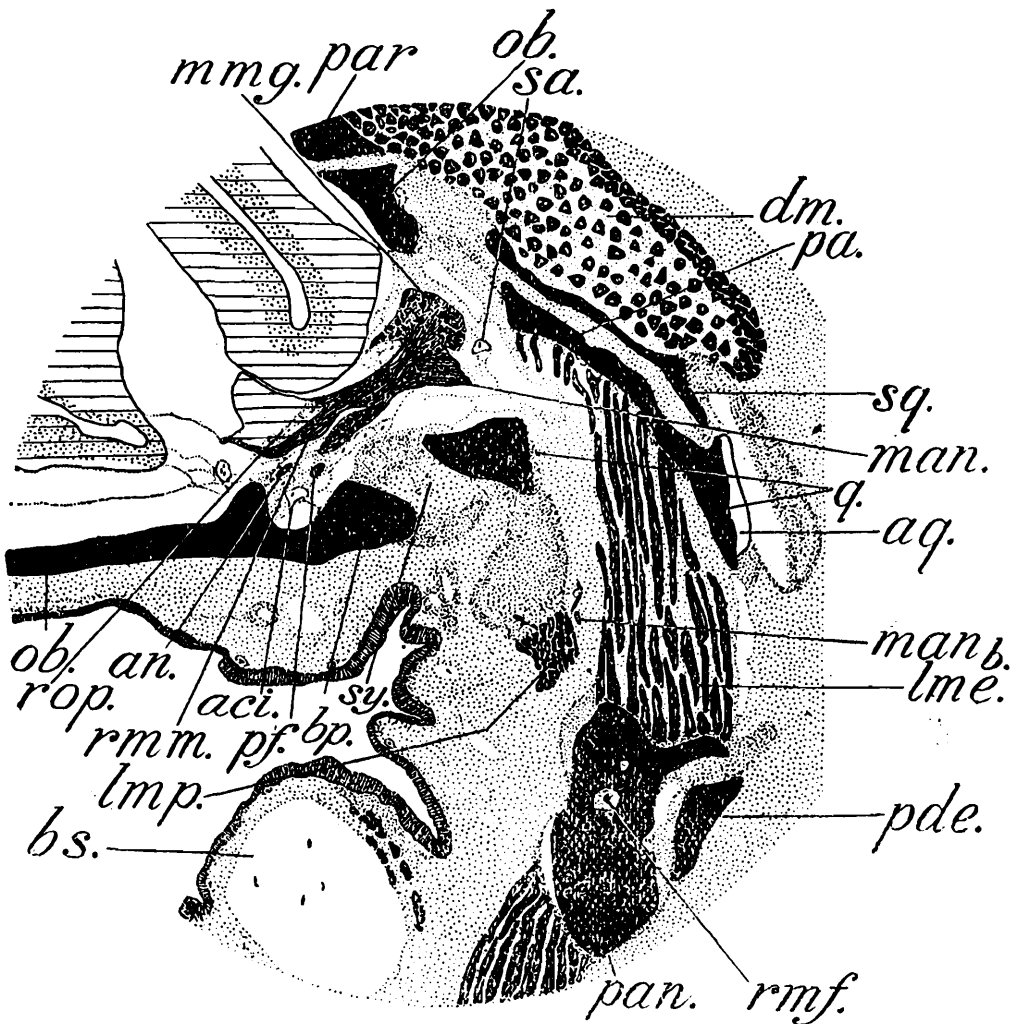
an., abducens nerve; *br.*, brain; *cp.*, "Caput preorbitale" of *M. l. m. internus*; *dm.*, *M. depressor mandibulae*; *gc.*, ganglion cell; *lma.*, *M. levator mandibulae anterior*; *lme.*, *M. levator mandibulae externus*; *lmi.*, *M. levator mandibulae internus*; *lq.*, *M. levator quadrati*; *map.*, maxillopalatine; *max.*, *r. maxillaris V*; *mrt.*, *M. retractor tentaculi*; *op.*, *r. ophthalmicus profundus V*; *os.*, *r. ophthalmicus superficialis VII*; *osb.*, branch of *r. ophthalmicus superficialis*; *par.*, parietal; *pls.*, pleurosphenoid portion of os Basale; *pf1.*, *pf2.*, median and lateral divisions of *r. palatinus facialis* respectively; *pt.*, pterygoid bone; *sq.*, squamosal; *vcl.*, vena capitis lateralis; *v3cpc.*, branch of *r. mandibularis V* to "Caput preorbitale" and *M. compressor orbitalis*.

[In figures 14, 15, 18, 20-25 and 28 Norris and Hughes (1918) label a bone in a precise topographical position of the squamosal as 'post-frontal'. The disposition of the bone and the muscular attachment conclusively prove when compared with other forms that it is a squamosal and not a post-frontal, for notice in figure 28, the post-frontal lying externally to the anterior portion of the 'pterygoquadrate', an anomalous position, and moreover, in the species examined by them, a post-frontal is absent.]

The quadrate (paired) or Suspensorium of Sarasins.

On the inner aspect of the squamosal appears the anterior portion of the quadrate (Pl. IV, fig. 2, *q.*) as an elongated bone separated by

some connective tissue. We can distinguish three processes given off anteriorly from the quadrate bone; a processus ascendens (processus



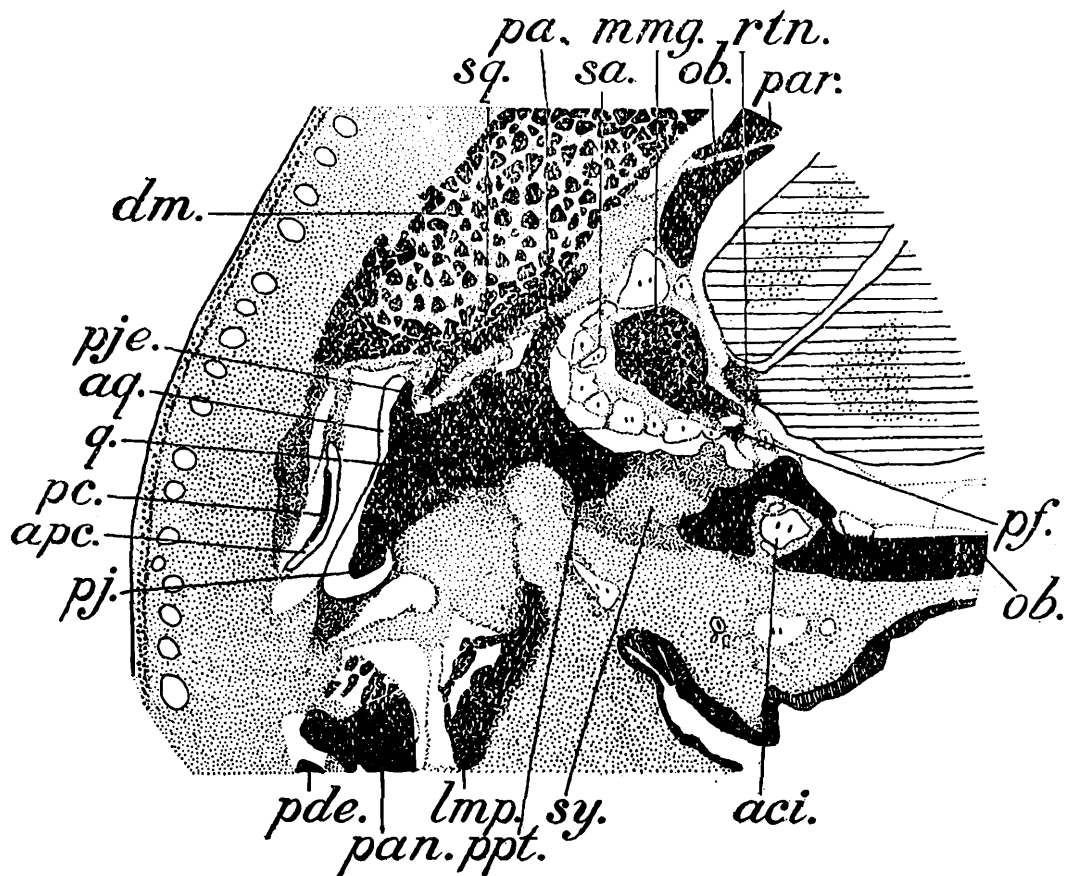
TEXT-FIG. 11.—*Uraeotyphlus narayani* Seshachar.

Transverse section in the region of gasserian ganglion: $\times 33$.

aci., arteria carotis interna; *an.*, abducens nerve; *aq.*, articular facet of the quadrate; *bp.*, basipterygoid process; *bs.*, blood sinus; *dm.*, M. depressor mandibulae; *lme.*, M. levator mandibulae externus; *lmp.*, M. levator mandibulae posterior; *man.*, r. mandibularis V; *manb.*, branch of r. mandibularis V; *mmg.*, maxillomandibular part of gasserian ganglion; *ob.*, os Basale; *pa.*, processus ascendens; *pan.*, pseudoangular; *par.*, parietal; *pde.*, pseudodentary; *pf.*, r. palatinus facialis; *q.*, quadrate; *rmf.*, ramulus mandibularis internus facialis (chorda tympani); *rmm.*, root of maxillomandibular nerve; *rop.*, root of ophthalmicus profundus nerve; *sa.*, stapedial artery; *sq.*, squamosal; *sy.*, syndesmotie connection.

squamosus, Sarasins 1890) (Pl. IV, fig. 2 and text-figs. 11, 12, *pa.*), a processus pterygoideus (Pl. IV, fig. 2 and text-fig. 12, *ppt.*) which articulates with the basipterygoid process (Pl. IV, fig. 2 and text-figs. 11, 12; *bp.*) of the os Basale by connective tissue (syndesmosis) (*sy.*), and a processus jugalis (text-fig. 12, *pj.*). Posteriorly, the quadrate gives rise to a fourth process,—the processus oticus (processus columellaris) (Pl. IV, fig. 2; see also text-fig. 7b, *poq.*) whose cartilaginous tip articulates with the cartilaginous portion of the stapedial process. From the external aspect of the short processus jugalis (text-fig. 12, *pj.*), a process is given off which articulates with the lower tip of the squamosal (*sq.*) by means of connective tissue. I have called this the processus

jugalis externus (text-fig. 12, *pje.*). In the region of the articulation of the lower jaw, the quadrate bears a processus articularis (Pl. IV, fig. 2 and text-fig. 12; see also text-fig. 7a., *aq.*) with which the pseudo-angular articulates.



TEXT-FIG. 12.—*Uraeotyphlus narayani* Seshachar.

Transverse section in the region of the Quadrate: $\times 33$.

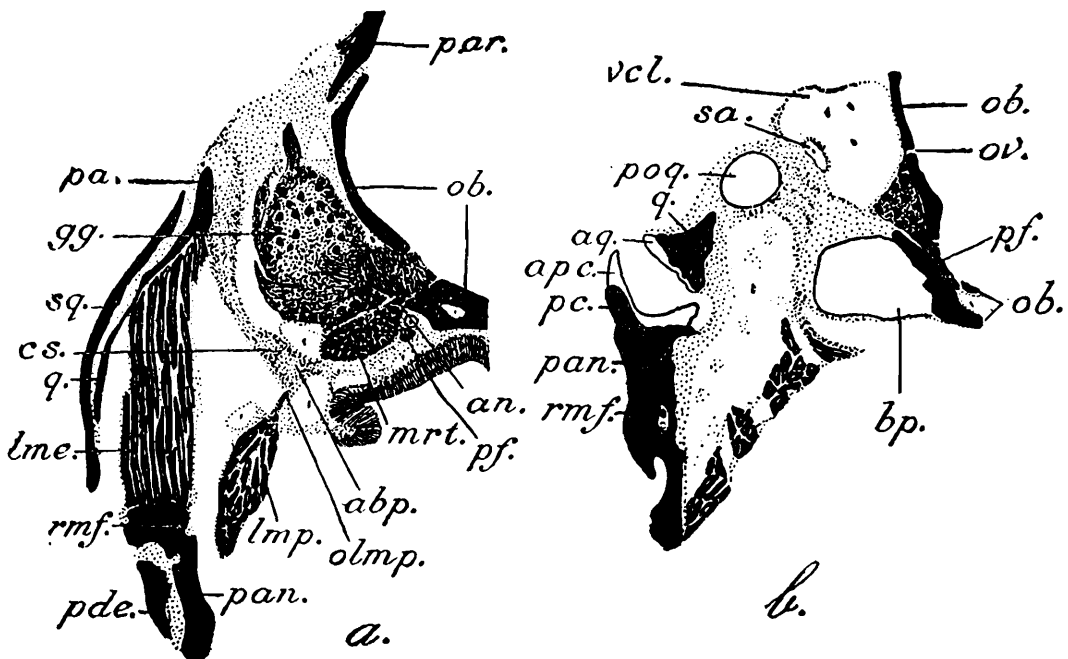
aci., arteria carotis interna; *apc.*, articular facet for the processus condyloides; *aq.*, articular facet of the quadrate; *dm.*, M. depressor mandibulae; *lmp.*, M. levator mandibulae posterior; *mmg.*, maxillomandibular part of gasserian ganglion; *ob.*, os Basale; *pa.*, processus ascendens; *pan.*, pseudoangular; *par.*, parietal; *pc.*, processus condyloides; *pde.*, pseudodentary; *pf.*, r. palatinus facialis; *pj.*, processus jugalis; *pje.*, processus jugalis externus; *ppt.*, processus pterygoideus; *q.*, quadrate; *rtn.*, root of trigeminal nerve; *sa.*, stapedia artery; *sq.*, squamosal; *sy.*, syndesmotie connection.

In *Ichthyophis*, the processus jugalis is longer than in *Uraeotyphlus* and Peter (1898) discovered a quadratojugal bone in it.

The articulation of the processus pterygoideus of the quadrate (or the pterygoquadrate where the pterygoid is not discoverable as an independent bone) with the basiptyergoid process of the os Basale is a characteristic feature of Apoda. In *Ichthyophis* and *Uraeotyphlus* the articulation is by syndesmosis; in the former even in the larval condition, the quadrate does not develop a basal process¹ and therefore the quadrate is syndesmotically connected with the basitrabecular or basiptyergoid process. This may apply also to *Uraeotyphlus*. In other forms that have been studied, *viz.*, *Dermophis* (Norris and Hughes

¹ However, Edgeworth (1925, p. 235) mentions in his table that 'basal process' forms a joint with the 'basal plate' in *Ichthyophis* and Peter (1898) also referred to a rudimentary processus basalis palatoquadrati.

1918, de Jager 1938, 1939), *Herpele* (Norris and Hughes 1918), *Boulengerula* (de Villiers 1936) the articulation is by the cartilaginous facets of the basipterygoid process and the processus pterygoideus of the quadrate. A basal process has been described in a *Siphonops braziliense* larva (7 cm. long), which is continuous with the basitrabecular process by Edgeworth (1925, 1935) but in the same sized larva, Goodrich (1930, Fig. 509) shows a joint. In *Hypogeophis* also (Marcus, Stimmelmayer and Porsch 1935) a basal process of the quadrate is formed which develops into the adult palatobasal articulation with the basipterygoid process. In *Scolecormorphus* (de Villiers 1938, p. 9) it is noted that "Although *Scolecormorphus* lacks a quadratostapedial articulation, it retains the pterygoquadratobasal one which is situated much more dorsally and much more closely to the side of the neurocranium than in *Boulengerula*", but again on page 11, the author states that "There is of course just a possibility of *Scolecormorphus* being neotenic in which case the absence of basopterygoquadrate and of a loose attachment of the outer wall of the otic capsule may not be due to degeneration at all" My own sections show that there is a connective tissue strand arising from the processus ascendens (text-fig. 13a, pa.) and proceeding towards the anterior portion of the basipterygoid process where the ligament of the M. 1. m. posterior (*lmp.*) is also inserted. However, in posterior sections (text-fig. 13b) arising from the processus pterygoi-



TEXT-FIG. 13.—*Scolecormorphus uluguruensis* Barbour & Loveridge.

a. Transverse section in the suspensorial region: $\times ca. 40$.

b. Transverse section posterior to a: $\times ca. 40$.

abp., anterior face of the basipterygoid process; *an.*, abducens nerve; *apc.*, articular facet of the processus condyloides; *aq.*, articular facet of the quadrate; *bp.*, basipterygoid process; *cs.*, connective tissue strand from ascending to basipterygoid process; *gg.*, gasserian ganglion; *lme.*, M. levator mandibulae externus; *lmp.*, M. levator mandibulae posterior; *mrt.*, M. retractor tentaculi; *ob.*, os Basale; *olmp.*, origin of M. levator mandibulae posterior; *ov.*, orifice for a branch of vena capitis lateralis in the wall; *pa.*, processus ascendens; *pan.*, pseudoangular; *par.*, parietal; *pc.*, processus condyloides; *pde.*, pseudodentary; *pf.*, r. palatinus facialis; *poq.*, processus oticus of quadrate; *q.*, quadrate; *rmf.*, ramulus mandibularis internus facialis; *sa.*, stapedial artery; *sq.*, squamosal; *vcl.*, vena capitis lateralis.

deus is a cartilaginous facet with which a similar facet of the basipterygoid process (*bp.*) articulates as in *Boulengerula*.

The processus oticus (processus columellaris of Marcus, Winsauer and Hueber 1933) articulation of the quadrate with the stapedia process is another characteristic feature of Apoda. In *Ichthyophis*, *Uraeotyphlus* (Pl. IV, fig. 2, *poq.*), *Boulengerula*, (de Villiers 1938) and in *Herpele*, it is present; in *Siphonops* and *Caecilia* a rudimentary one is recorded (Stadtmüller 1936) while in *Scolecophorus* (de Villiers 1938) it is absent along with the stapes.¹ In *Dermophis* (de Jager 1939) the processus oticus palatoquadrati is fused with the stapedia style and according to her this loss of quadratostapedial kinesis has taken place within recent times. It is of interest to note that in the case of *Hypogeophis* larva (Marcus, Stimmelmayer and Porsch 1935) the processus oticus of the quadrate enters into a temporary fusion with the stapedia process. In *Ichthyophis* embryo (Goodrich 1930) there is a processus oticus (rudimentary according to Stadtmüller 1936) which does not establish any connection dorsally while in *Siphonops* larva (Goodrich 1930, Fig. 509) the otic process establishes contact with the auditory capsule. Edgeworth (1925, 1935) however, differs from Goodrich; he does not find an otic process in his larva of *Ichthyophis* measuring 2.85 cm, but his Fig. 88 of *Siphonops* larva resembles exactly the reconstructed figure 509 of Goodrich where the otic process of the latter author corresponds with the processus ascendens articulating by means of a joint with the pleurospenoid region. Incidentally, it may be remarked here that the bone labelled by Goodrich in his figure as 'f' (frontal) should be read as parietal.

A brief reference may be made to the connection of the processus ascendens with the orbital cartilage (taenia marginalis). The connection of the processus ascendens with the orbital cartilage has been recorded by Winslow (1898) and Edgeworth (1925, 1935) in *I. glutinosus* embryos, but Peter (1898) who also studied early embryonic stages does not. While Edgeworth records the size of the embryo (2.85 cm.) the other two authors do not; Edgeworth, however, mentions that his embryo is slightly smaller than the one modelled by Peter. There is just a chance that the processus ascendens connection might have been formed previously and lost in Peter's stage. De Jager (1939a) refers to a similar connection (between pleurospenoid and processus ascendens cartilage) in a 11 cm. larva of *I. glutinosus*, and further remarks that had Peter examined a similar stage he would have discovered it since he did not study stages between 10 and 16 cm. in length, while Stadtmüller (1936) mentions only a partial connection in a 10 cm. larva of *I. glutinosus*. When I referred this point to Prof. Goodrich he informed me that this difference in the behaviour of the processus ascendens connection may be due to the fact that the authors were examining embryos of different species of *Ichthyophis*. This is not so, for, both Winslow and Peter secured their material from Dr. F. Sarasin, and unless it be that Sarasin's collection itself consisted of two races, it is difficult to reconcile the observations of Edgeworth and Winslow on the one hand and Peter on the other. De Jager's account may not

¹ Though de Villiers refers in the text to the absence of a stapes yet in his figure 4 (p. 14), a stapes is indicated.

be taken into consideration since she describes it in a larval form and also since the time of appearance of these cartilaginous structures varies. I have not been able to secure early embryonic stages, but in the stages examined by me of *I. glutinosus*, no connection was noticed. Therefore it may be that as suggested above, Edgeworth and Winslow were examining a stage where a connection is present and Peter, a slightly older one (as recorded by Edgeworth) where the connection is lost or if not, it is a case of variation.

THE GLANDS OF THE BUCCAL CAVITY.

Recently two memoirs have been published on buccal cavity glands ; one on Anura (Müller 1932) and another on Urodela (Seifert 1932). Leydig (1868) and Wiedersheim (1879) described the glands of the buccal cavity of some apodan genera. In *Ichthyophis glutinosus*, Sarasins (1890) described a set of glands between the two rows of teeth in the upper jaw and a set behind the second row of teeth. Both these are designated by them as the palatal glands (Gaumendrüse). Mang (1935) working on *Hypogeophis* labelled the glands present in between the dental rows as the "interdental" glands while those behind the second row of teeth as the "intermaxillary" glands. But Fahrenholz¹ (1934) described in *Uraeotyphlus menoni*, a few glands distributed almost mediolongitudinally starting slightly anteriorly to the choana as the intermaxillary glands comparable with those found in Anura and Urodela ; this set is obviously in addition to the set found in between the teeth rows and that behind them. He did not refer to the "Gaumendrüse" in *U. menoni* but suggested that an examination of the "zwischenkieferdrüse" in other apodan genera would be very desirable. In the case of *I. monochrous* and also in *I. glutinosus*, the intermaxillary glands as described by Fahrenholz for *Uraeotyphlus* are absent (Mahadevan 1936). In *U. narayani* (text-fig. 3, inmf.) and *U. menoni*, an extra set is added on in the palate which opens into the buccal cavity in a median groove as described in some Urodela (Seifert 1932). Mang (1935) however, did not refer to this gland in *Hypogeophis* and obviously it is absent and as already pointed out, the second set corresponding to the "Gaumendrüse" of Sarasins, is labelled by him in *Hypogeophis* as intermaxillary glands. The nomenclature I have adopted is as follows :

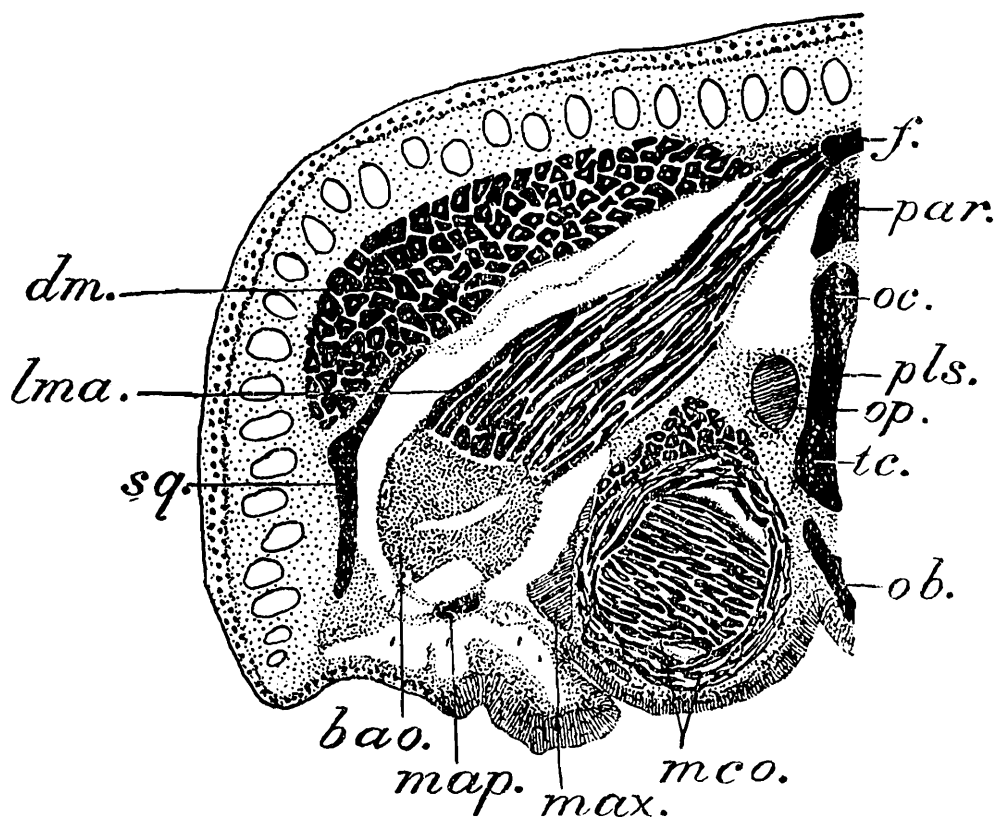
		Gaumendrüse 1. between teeth rows, upper jaw.	Gaumendrüse 2. behind second teeth row.	No intermaxillary of Fahrenholz.
<i>I. glutinosus</i> (Sarasins 1890).	..	..	..	..
<i>I. monochrous</i> (Mahadevan 1936).	..	Interdental glands	Intermaxillary glands	Absent.
<i>U. menoni</i> (Fahrenholz 1934).	..	No reference	No reference	Present.
<i>U. narayani</i> (Ramaswami).	..	Interdental glands	Postdental glands	Present.
<i>H. ochrocephala</i>	..	Ditto	Ditto	Absent.
<i>S. uluguruensis</i>	..	Ditto	Ditto	Present ; differs from that in <i>Uraeotyphlus</i> .
<i>B. bouengeri</i>	..	Ditto	Ditto	Absent.
<i>D. gregorii</i>	..	Ditto	Ditto	Absent.

¹ Fahrenholz does not unfortunately mention the source of his material, and if it was from South India, it is just possible that both of us have been dealing with the more commonly occurring species, *U. narayani* which for a long time the authorities of the Biological Supplies, Kottayam, S. India were supplying under the name of *U. menoni*.

Both the interdental and postdental glands resemble each other in histological details and the name suggested therefore is more for topographical convenience than for histological differentiation. However, the intermaxillary glands of *U. menoni* and *U. narayani* differ considerably from the other sets described above. A comparison of the interdental or postdental of *I. monochrous* or *U. narayani* (Pl. VI, fig. 1, *indg.*, *pdg.*) with the intermaxillary of *U. narayani* (see text-fig. 3, *inmf.*) reveals at once the points of difference. As in *U. menoni*, each gland in *U. narayani* also is composed of single layered glandular epithelium and opens into the buccal cavity by a convoluted duct. While in the younger specimen examined the duct is short and opens directly from the gland above into the mouth, in aged individuals the gland is enlarged and the duct follows an oblique course.

In *Scolecormorphus* (Pl. V, fig. 4 and text-fig. 4, *inmf.*) a well developed set of glands is present between the sphenethmoid region and the postdental glands (*pdg.*) resembling the dorsal glands (*ng.*). These open into the buccal cavity posteriorly and are topographically comparable with the intermaxillary glands of Fahrenholz, and I have therefore designated them as the intermaxillary glands.

The true palatal glands (*Palatinaldrüse* Mang 1935, *Rachendrüse* of Anura, Oppel 1900) described as occurring behind the choanae in *Hypogeophis* are absent in *I. glutinosus*, *I. monochrous* and *U. narayani*. No reference is made to these glands in *U. menoni* by Fahrenholz (1934).



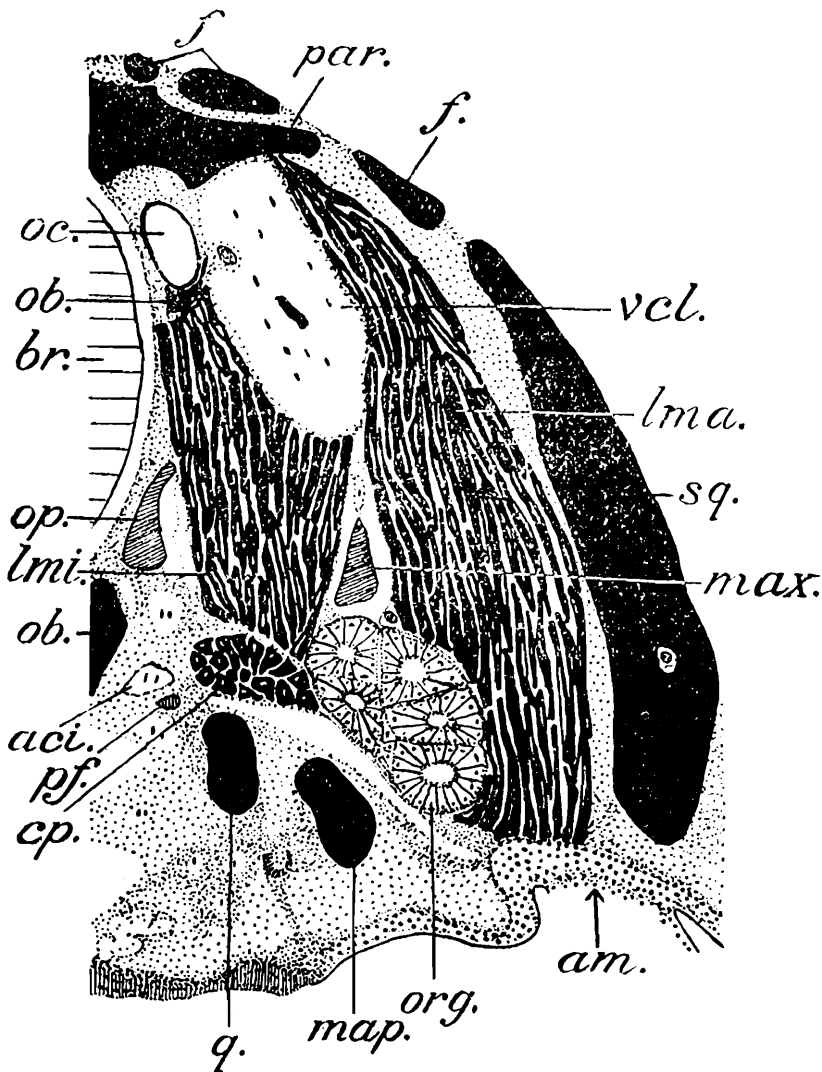
TEXT-FIG. 14.—*Scolecormorphus uluguruensis* Barbour & Loveridge.

Transverse section showing Bursa angularis oris: $\times 55$.

bao., Bursa angularis oris; *dm.*, M. depressor mandibulae; *f.*, frontal; *lma.*, M. levator mandibulae anterior; *map.*, maxillopalatine; *max.*, r. maxillaris V; *mco.*, M. constrictor orbitalis; *ob.*, os Basale; *oc.*, orbital cartilage; *op.*, r. ophthalmicus profundus V; *par.*, parietal; *pls.*, pleurosphenoid portion of os Basale; *sq.*, squamosal; *tc.*, trabecular cartilage.

The choanal glands (*Choanendrüse*, Sarasins 1890) in *U. narayani* (Pl. VI, fig. 6, *chg.*) open into the choana as in *I. glutinosus* and *I. monochrous*. Again no reference is made to this in *U. menoni* (Fahrenheit 1934). The presence of this gland is recorded by de Jager in *D. mexicanus* and not in *D. gregorii*. In *Herpele*, opening into the choana there are a few choanal glands; in *Scolecormorphus* the choanal glands are similar to the intermaxillary glands of Fahrenheit and open into the posterior portion of the choana and *Boulengerula* also possesses a set of choanal glands.

The dental and sublingual glands (*dentaldrüse*, *sublingualdrüse* Mang 1935) are disposed in *U. narayani* (Pl. VI, fig. 1, *slg.*) as in *Hypogeophis*.



TEXT-FIG. 15.—*Herpele ochrocephala* (Cope).

Transverse section showing oral mucous glands : $\times 55$.

aci., arteria carotis interna; *am.*, angle of mouth; *br.*, brain; *cp.*, "caput preorbitale" of *M. l. m. internus*; *f.*, frontal; *lma.*, *M. levator mandibulae anterior*; *lmi.*, *M. levator mandibulae internus*; *map.*, maxillopalatine; *max.*, *r. maxillaris V*; *ob.*, os Basale; *oc.*, orbital cartilage; *op.*, *r. ophthalmicus profundus V*; *org.*, oral gland; *par.*, parietal; *pf.*, *r. palatinus facialis*; *q.*, quadrata; *sq.*, squamosal; *vcl.*, vena capitis lateralis:

The bursa angularis oris (Fuchs 1931).—The occurrence of a *bursa angularis oris* has already been noted among Anura and in some am-

niote examples (Fuchs 1931). I have already noted (1934) that this structure is absent in *Ichthyophis* and *Uraeotyphlus*. In *Scolecomorphus* (text-fig. 14, *ba.*), however, it appears as a lymphocytic accumulation between the anterior end of the squamosal (*sq.*) and the compressor muscle of the orbital gland (*mco.*) and soon a cavity is noticed in it when the M. levator mandibulae anterior (*lma.*) is situated dorsally to it. The cavity of the gland (?) does not communicate with the buccal cavity as in anuran examples. Posteriorly, this structure disappears at the angle of the mouth.

In *Herpele*, a set of mucous glands appears in between the M. levator mandibulae internus (text-fig. 15, *lmi.*) and the "Caput preorbitale" (*cp.*) of the same and the M. levator mandibular anterior (*lma.*) just above the maxillopalatine bone (*map.*). Posteriorly they open into the buccal cavity. These are different histologically from the bursa angularis oris, but their anterior position and their opening into the buccal cavity are rather significant. These are obviously mucous glands of the skin which have migrated far internally.

THE TONGUE.

The apodan tongue is a padlike $\cap$ -shaped structure in the anterior portion of the floor of the mouth and is incapable of eversion as in Anura. The earliest reference made to the apodan lingual organ is by J. Müller (1831) where he referred to the bilobed papillae in *Ichthyophis*. Sentzen¹ described the tongue of *Caecilia tentaculata*, while Widersheim (1879) referred briefly to the elevated lateral portions of the tongue of *C. lumbricoides* (*C. gracilis*).

Teipel (1932) gave a complete account of the development of the tongue of *Hypogeophis* and also its adult structure. Both Marcus (1932) and Teipel remark that in a transverse sectional view the tongue of *Hypogeophis* is roughly divisible into lateral and median parts. The median part is highly vascular and glandular while the raised lateral parts are free from glands but the genioglossus muscle is inserted into them aiding the animal in respiratory activities.² This exclusive differentiation of the tongue into a median glandular and a lateral muscular part is disproved by Mang (1935) for he says (p. 304) :

Vier Querschnitte dieser Serie sind in der Zungenarbeit von Teipel in der Abb. 3 veröffentlicht. Auch in seiner Abb. 2 ist eine graphische Horizontalrekonstruktion der Zunge von dieser Serie gemacht, um zu zeigen, dass die mittlere Zunge nur vorn von Drüsen erfüllt ist, und wie sich die Drüsen erst weiter hinten und beim erwachsenen Tier auch auf die seitlichen Zungenteile erstrecken. Dabei muss diese Zeichnung für die Drüsen als unvollständig bezeichnet werden, da seitlich die Drüsen sich über die Zunge hinaus erstrecken.

However, it must be pointed out that the few scattered glands to which Mang refers appear only posteriorly to the insertion of the muscle in the lateral part.

¹ Quoted by Teipel (1932).

² Marcus has informed me (in. litt.) that he does not agree with the views of Kallius (1901) and Gegenbaur (1894) that the glandular activity was the primary cause of the muscularisation of the tongue.

In the case of *I. glutinosus*, *I. monochrous* (Mahadevan 1936), *U. menoni* (Chatterjee 1936) and *U. narayani*, the pad-like tongue observes the shape of an inverted U. Further, the tongue in *Ichthyophis* (Pl. V, fig. 3) and *Uraeotyphlus* (Pl. VI, fig. 2) is not divisible into median glandular and lateral muscular parts, but the two lateral limbs of the n-shaped tongue project posteriorly. The tongue proper is covered over by stratified epithelium (*se.*) on the surface of which open a large number of glands (Pl. V, figs. 2, 3, *lg.*) and the latter are not supplied with sphincter muscles as in *Hypogeophis* (Teipel 1932). The glands are larger and are more vertically elongated in *I. monochrous* (Pl. V, fig. 3, *lg.*) than in *I. glutinosus* and *U. narayani*. These tongue glands show quantities of mucus which can be stained by mucicarmine and obviously this secretion keeps the surface of the tongue moist, probably aiding the animal in deglutition. In *U. narayani*, the anterior tip reveals in sectional views (Pl. VI, fig. 1) a large number of blood vessels in the ventral aspect and a set of glands (*lg.*) dorsally; in the prechoanal portion, the lateral parts (Pl. VI, fig. 2, *lt.*) of the tongue are separated by the mesial ciliated pharyngeal portion. Buccal glands (*pg.*) occur in this middle portion (the postlingual glands of Mang) and thus a transverse section gives the spurious appearance of the tongue being divided into lateral muscular and mesial glandular parts. I do not consider this mesial section as a part of the tongue for, it correctly belongs to the pharyngeal region. Further, I am inclined to believe that the central glandular part described by Teipel (1932) in *Hypogeophis* tongue is really the pharyngeal part with its glands. Where the lingual muscle,—*M. genioglossus* appears (*M. hyoglossus* being absent from the tongue of Apoda so far examined), the major portion of this enters the lateral part as in *Hypogeophis* while a few fibres proceed to the median part also.

The mucous glands referred to above in the tongue make their appearance only in late larval life of *I. glutinosus*. Mang (1935) points out that in his preparations of stages 48 and 49 of *Hypogeophis* the tongue is lined by simple epithelium (single layered; he does not mention if it is ciliated as in *Ichthyophis*), but the epithelial cells are loaded with vitreous mucus. At any rate the glands seem to make their appearance in the next stage, 50 (7 cm. long larva),—a stage where the external gills are still persisting. According to him an invagination appears in the determined area and the cells commence to secrete mucus. In *I. glutinosus* on the other hand, it is the embryonic stage which is branchiate as already remarked, measures 6-7 cm. in length and obviously the time of development of the glands does not follow that in *Hypogeophis*. I have examined in this connection a young stage of *U. narayani* that I have with me (9 cm.), in this all the adult features have already made their appearance but only they have not grown to their maximum size. The tongue and the associated glands and the glands of the buccal cavity including the intermaxillary (though feebly) have made their appearance. *Uraeotyphlus* as compared to *Ichthyophis*, has a greatly abbreviated larval life, for the appearance of most of the characters like the tentacle, nasolacrimal ducts and the complete development of the eye muscles which only develop in late

larval life of *Ichthyophis*, are compressed into the very early larval life or they may even appear in the embryonic condition. I am inclined to believe that the embryonic life of *U. narayani* is very short and most of the characters enumerated above are heralded in this stage and when the larva is hatched, it is supplied with the full complements of an adult individual, only not so completely. This point can be confirmed only after examining embryos and as more material becomes available, I hope to study the early development of this interesting apodan type.

In *D. gregorii*, the lingual organ is well developed and in the choanal region (Pl. VI, fig. 3) the entrance of a few fibres of the genioglossus muscle into the central pharyngeal region can be made out. The glands are uniformly distributed in the tongue.

In *H. ochrocephala*, anterior sectional views reveal the presence of large sublingual glands and the tip of the tongue appears as a projection. Photomicrograph (Pl. VI, fig. 4) shows the lateral muscular portion (*lt.*) free from glands and the central ciliated pharyngeal region full of glands (*pg.*). It can also be seen that a few fibres of the genioglossus muscle enter the middle portion. Posteriorly, in the middle of the pharyngeal region, a groove appears into which the glands open.

In *Scolecormorphus*, since the second row of teeth is absent in the lower jaw, the anterior sections reveal a large number of sublingual glands extending between the jaws. The tongue no doubt observes the shape of an inverted U, but is not raised above the level of the jaw. The muscles (Pl. V, fig. 4) are inserted into the lateral aspect while the glands occupy the central ciliated area. In *Boulengerula* also (Pl. VI, fig. 7) the same features are noticed.

The study of the tongue in the Apoda reveals that the distribution of the lingual glands is rather interesting. In the tip (*i.e.*, at the anterior end of the $\cap$ -shaped tongue) a set of glands is always present. In the lateral portions of the tongue, the genioglossus muscle is predominantly noticed ; the absence of glands from this part is noticed in *Uraeotyphlus*, *Herpele*, *Scolecormorphus*, *Boulengerula* and *Ichthyophis*, while in *Dermophis* glands are also seen in the lateral parts.

According to Teipel (1932), three nerves enter into the tongue. The hypoglossal (XII) innervates the genioglossus muscle and the glosso-pharyngeal (IX) enters the median portion of the tongue. A ramulus from the united mandibular nerve (chorda tympani VII *plus* ramus mandibulari internus V) passes into the tongue as ramus lingualis. The lingual innervation by a branch of the chorda tympani is an important feature, for in this feature the Apoda simulate the higher tetrapodous forms (*see* Cranial nerves).

THE OLFACTORY ORGAN AND ASSOCIATED GLANDS.

The first cavity that we meet with in the anterior region of the olfactory organ is what Wiedersheim (1879) described as the cavum nasale principale. In the case of *I. glutinosus* (Wiedersheim 1879, Waldschmidt 1887, Sarasins 1890), *Geotrypetes* (Norris and Hughes 1918), *Dermophis* (Norris and Hughes 1918, de Jager 1939), *I. monochrous*

and *Scolecormorphus uluguruensis*, owing to the development of an eminentia olfactoria (processus conchoides, composed of projections from prevomer and sphenethmoid bones), the cavum nasale principale is incompletely divided into a median and a lateral chamber. According to Sarasins (1890), the lateral part is composed not only of a sensory part in which glands of Bowman are present, but also a ciliated respiratory part. Thus it is incorrect to say that the lateral part is purely respiratory, as de Jager (1939) has described. She noted that (p. 194) "The median olfactory part consists of olfactory cells which are absent from the lateral respiratory part with its cubical epithelium and mucous cells (Fig. 1). This typical division of the cavum nasale principale into two parts has been universally stressed" It should be noted here that the typical division of the cavum nasale principale is seen only in cases where an eminentia olfactoria is developed (see text-fig. 4, *mcp.*, *lcp.*) and in these the lateral portion is composed of not only respiratory but also olfactory epithelium. However, in an account of the olfactory organ of *H. rostratus*, Laubmann (1927) has not referred to a sensory or respiratory part but simply describes the cavum nasale principale (Hauptnase or chief nose) as formed of a lateral nose and a median one with a sulcus differentiating them. Marcus (1930) has also referred to the "Hauptnase" but does not allude to the physiological separation. This condition has also been noticed in *C. gracilis*, *U. oxyurus*, *Chthonerpeton indistinctum*, *S. annulatus* (Wiedersheim 1879) *Herpele* and *Caecilia* (Norris and Hughes 1918) and *U. narayani* (text-figs. 1, 3, 8, 9, *mcp.*, *lcp.*) and *B. boulengeri*.

A second cavity which we meet with in the sectional views of the apodan head in the narial region is the "Nebennase" of Wiedersheim (1879) or the organ of Jacobson (Sarasins 1890). Laubmann (1927) described this cavity as "Tastnase" or the organ of touch in the nose of *H. rostratus*. Marcus (1930) doubted the validity of this interpretation and therefore called this cavity as "Nebennase" (secondary nose), and I have followed the nomenclature employed by Wiedersheim and Marcus. The "Nebennase" opens into the tentacular sac by two ducts (text-figs. 1, 2, 8, 16, *nld.*) and internally, it (text-fig. 9, *nn.*) opens into the mesial or into the lateral part of the cavum nasale principale. As regards the internal opening, it is significantly pointed out by Norris and Hughes (1918) that "The development of a processus conchoides produces other modifications of the nasal topography. Jacobson's organ ["Nebennase"], which in *Herpele* and *Caecilia* (figs. 8, 9, 10) connects with the mesial portion of the nasal chamber, in the other type communicates with the lateral portion (figs. 6, 7, 10)"

The two ducts opening into the tentacular sac, called "Tranenröhrchen" (lacrymal ducts) by Sarasins, were first discovered by Leydig (1868) in *S. annulatus* and *C. gracilis* and were called by him "falschen Nasenöffnung" (pseudonasal opening). Wiedersheim (1879) described the two ducts of the "Nebennase" opening into the tentacular sac as tentacle canals for he thought that these emptied the secretion of the glands surrounding the "Nebennase" (which he therefore erroneously called the "tentakeldrüse") into the tentacle sac and Greeff (1884) working on *D. thomensis* confirmed the observations of Wieders-

sheim. Laubmann (1927) differed from these two authors and called these two ducts as "Tastnasenröhrchen" and ascribed a different function to the "Nebennase". On account of the constant exertion and withdrawal of the tentacle, a certain amount of air gets into the "Nebennase" through the "Tastnasenröhrchen" and the former is thus enabled to function as an "Organ of touch" and he therefore, called the "Nebennase" as "Tastnase" (the nose where the seat of touch is located). According to this author, then, the air that is taken in through the anterior nares and also through the tentacular nasolacrima ducts helps the animal in olfaction, in feeling and also in respiration.¹ Marcus cautiously remarks (1930, p. 662) :

Ob der Tentakel ein echter 'Tastfühler' sei, also erhebliche Tactile Reize vermittelt, lasse ich dahin gestellt.

and further notes that during borrowing, the anterior nares close up and air is led into the nose by the tentacular ducts ("Nebennasenröhrchen") for respiration and olfaction and when the latter close up, air enters through the anterior nares. This ingenious explanation will hold good in a form like *Hypogeophis* where the tentacle is far behind the anterior nares; but in those cases where the tentacle and, therefore, the openings of the nasolacrima ducts are below the anterior nares as in *Uraeotyphlus*, air cannot be led in during borrowing (provided these animals lead a subterranean life) for both inlets will be closed. In fact, *Ichthyophis* is not a borrower at all, for all the specimens collected so far are from under decaying vegetation or wood in moist surroundings. Therefore, these Apoda may be described as "surface cryptic" forms.

In *U. narayani*, the "Nebennase" (text-fig. 16, *nn.*) is elongated longitudinally and its two ducts (nasolacrima ducts, see text-figs. 1, 8, *nld.*) open into the tentacular sac as in other forms. The internal opening into the median part of the cavum nasale principale is situated by the side of the sphenethmoid.

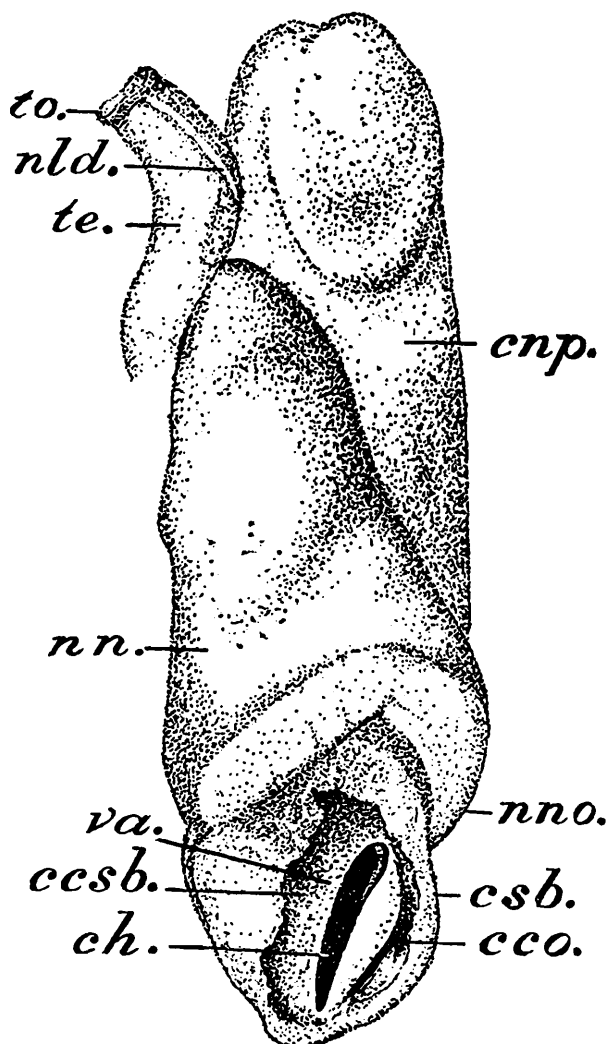
The organ of Jacobson is also described by Laubmann (1927) and Marcus (1930, Fig. 5) in *Hypogeophis*. This is a diverticulum (Laubmann, Figs. 9a, 9b and 9c) of the cavum nasale principale opening into the latter and in the same region the opening of the "Nebennase" can also be seen. According to this author, the Jacobson's organ is developed as a result of the mechanical rotation of the nasal organ. Such a structure is not noticed by me in *U. narayani* and also by other workers in the genera examined by them.

Sarasins (1890) described a third cavity which they called "Choanenschleimbeutel" and Wiedersheim (1879) also described this third cavity in association with "Nebennase". De Jager (1939) mentions that Laubmann (1927) does not refer to a "Choanenschleimbeutel"; however, we read in Laubmann that in the choanal region there is a cavity with a valve opening towards the choana. Marcus (1930) describing the same animal as Laubmann, noted that a posterior portion

¹ Sarasins (1890, p. 199) had already noted that the nasolacrima ducts led air into the nose, but could not ascribe any function to it.

of the olfactory sac could be homologised with Sarasins' "Choanenschleimbeutel" He says (p. 679).

Durch die eben beschriebene Falte im hinteren Nasengang (Choanenschleimbeutel der Vetter Sarasin) ist ein Mechanismus gegeben, der wie eine Ventilklappe die hauft bei der Ausatmung in jede der beiden Nasenteile dirigieren kann.



TEXT-FIG. 16.—*Uraeotyphlus narayani* Seshachar.

The olfactory organ from ventral aspect: the wall of the "Choanenschleimbeutel" is cut to show the cavities inside. Only one nasolactimal duct is visible: $\times 24$.

cco., cavity of the "Choanenschleimbeutel" into which choanal glands open; *ccsb.*, cavity of the "Choanenschleimbeutel"; *ch.*, choana; *cnp.*, cavum nasale principale; *csb.*, "Choanenschleimbeutel"; *nld.*, nasolacimal duct; *nn.*, "Nebennase"; *nno.*, the bend of "Nebennase" before it opens into "Choanenschleimbeutel"; *te.*, tentacle; *to.*, tentacular orifice; *va.*, valve.

The occurrence of this choanal chamber (text-figs. 3, 4, 16. *csb.*) with a valvular flap (*va.*) is a common feature among the apodan genera studied by me.

The nasal glands.—In addition to the glands of Bowman in the olfactory epithelium, two more sets of glands can be identified in the nasal region of Apoda generally. These are, (1) Nasal glands (Nasendrüse) situated dorsally or dorsolaterally (Pl. V, fig. 4 and text-figs. 3, 4, 9, *ng.*) in posterior sectional views to the cavum nasale principale

opening into the latter by ducts. These were first described by Wiedersheim (1879) in *S. annulatus*, *C. gracilis* and *H. rostratus*, *U. oxyurus* and *Chthonerpeton indistinctum*. The presence of the same was noticed by Sarasins (1890) in *I. glutinosus* and they have been designated as "dorsale Drüse" in *H. rostratus* by Laubmann (1927). In *Herpele*, Norris and Hughes (1918) delineate these glands in their fig. 8 and I have also observed them in my preparations. In *D. mexicanus*, Norris and Hughes represent them in their figs. 5, 6 and 7 and de Jager (1939) also confirms this both in *D. mexicanus* and *D. gregorii*; I have observed their presence in the latter species also. In *Boulengerula* and *Scolecomorphus*, my sectional views show well developed glands as also in *I. monochrous*. Obviously, the glands occur uniformly in the Apoda. (2) The glands of the "Nebennase" (Nebennasendrüse). Wiedersheim (1879) described the glands opening into the "Nebennase" as the "tentakeldrüse" for, the two ducts of the "Nebennase" were thought to arise from these glands and open into the tentacle sac. Sarasins (1890) described the glands opening into the "Nebennase" as the "Drüse der Jacobson'sche Organ". Norris and Hughes (1918) followed Sarasins's nomenclature. Laubmann (1927) described in *H. rostratus* "Tastnasendrüse" associated with the "Tastnase". De Jager (1939) noted that these glands open into the choanal chamber in *D. mexicanus* while in *D. gregorii*, few glands are embedded in the "ventrolateral wall of the choanenschleimbeutel into which they open", unlike what has been described by Wiedersheim, Sarasins and Laubmann, where the glands open into the secondary nose. In *U. narayani*, a large number of glands (text-figs. 3, 9, *nng.*) surround the lateral part of the "Nebennase" and open into it.

THE TENTACLE.

Englehardt (1924) and Laubmann (1927) put forward the view that the tentacle in the Apoda is an organ of touch ("Tast-organ"). But Marcus (1930) pertinently points out that it is a "Klopf-fühler" helping the cryptic animal in respiration and smelling. He says (p. 659).

Dagegen ist es sehr wahrscheinlich, das die Klopf-fühler der unter der Erde bohrenden Blindwühle des Atmen und Reichen durch die Nebennase erlauben, wenn die vorderen Narinen fest verschlossen sind, indem sie freien Atemraum schaffen.

Wiedersheim (1879) gives a dissected horizontal view of the M. retractor tentaculi in *C. (Uraeotyphlus) oxyurus*, where the tentacle enclosed in the tentacular canal into the tip of which the opening of nasolacrimal ducts, orbital glands and glands of the nasal region are shown. In the case of *Ichthyophis* (Sarasins 1890, Englehardt 1924), it has been noticed that the tentacular part (stopse) which projects beyond the skin is covered partially at its base by a fold of the same (tentakelfalte) which extends internally also; this tentacular fold to which the retractor muscle is attached moves up and down in the tentacular sac (tentakelsack). The tentacle is retracted by the M. retractor tentaculi. Sarasins (1890) ascribed the exertion of this to erection, but Marcus

(1930) in this connexion noted that the M. compressor glandulae oculi functioned not only as a compressor of the gland but also as a protractor of the tentacle.

In *Uraeotyphlus*, the external tentacular fold referred to above is absent and the tentacle itself is short and blunt, and I have not been able to detect any sensory innervation.¹

The homology of the retractor muscle which controls the activity of the tentacle has not been definitely settled. Sarasins (1890) was doubtful whether it was a part of the rectus internus or a modification of retractor bulbi. Marcus (1910) also believed in the retractor bulbi modification. Norris and Hughes (1918) described in the case of *Herpele* and *Caecilia* that the retractor muscle was a modified rectus externus muscle. Edgeworth (1935) considered it to be a modified retractor oculi. De Jager (1939) referred to the retractor muscle as a modified rectus externus. It is known in all these cases, that the abducens nerve innervates the rectus externus and also the retractor bulbi; it is natural therefore, to expect one of these muscles to be modified into a retractor tentaculi. In all the cases so far examined in *Ichthyophis* (Sarasins 1890, Norris and Hughes 1918, Englehardt 1924), *Dermophis* and *Geotrypetes* the M. rectus externus is present and the retractor bulbi is absent (*vide* Eye muscles, where I have shown that the retractor bulbi of Norris and Hughes, is a rectus medialis), and it can be surmised that the latter muscle is converted into the retractor tentaculi. But in those forms where the eye muscles are completely degenerate (*Herpele*, *Caecilia*, *Scolecormorphus*, *Boulengerula*) one of the two muscles innervated by the abducens may have been transformed. But in *Ichthyophis*, it has been shown by Englehardt (1924) that the retractor muscle is double, and is separated by a connective tissue layer (*see* also Norris and Hughes 1918, fig. 19) and therefore, finds comparison with the double retractor bulbi of *Triturus*. Such a double condition, I have also noticed in *Uraeotyphlus*, *I. monochrous*, *Scolecormorphus*, *Dermophis* and *Boulengerula*, suggesting thereby that in forms where the eye muscles are degenerate, the M. retractor tentaculi may be a modified retractor bulbi. As in *I. glutinosus*, the double nature of the retractor muscle becomes obvious when the rectus internus passes through the former in *I. monochrous*, *Dermophis* and *Uraeotyphlus*. In the latter the muscle ends in the region of the optic foramen as in *Dermophis*. In *Scolecormorphus*, a large M. retractor tentaculi (*see* text-fig. 4, *mrt*₁) is noticed and in addition to this, there arises one (*mrt*₂) from the tentacular fold which is separated from the retractor by orbital glands (*og.*). Postchoanally these two merge into each other and are surrounded by the compressor muscle. The retractor muscle is inserted on the os Basale ventrally to the trigeminal foramen. In *Boulengerula*, the retractor insertion into the tentacle is far anterior and in the choanal and postchoanal regions the muscle is noticed in two parts being separated by orbital glands. Posteriorly the double nature is retained and the muscles postoptically are inserted into the os Basale.

¹ I have not used any special stains for detecting sensory innervation,

THE EYE AND ITS MUSCLES.

It is well known that in the Apoda, the eye may be covered over completely or it may be visible externally. Structural degeneration naturally accompanies the condition where the eye is hidden as in *Herpele*, *Caecilia*, *Scolecormorphus*, etc.

Wiedersheim (1879) briefly referred to the eye of *Siphonops*.

While de Jager (1939) remarked that the eye was degenerate in *Dermophis*, I find that the eye is well developed with all its six muscles. Norris and Hughes (1918) clearly demonstrated this and I reproduce a photomicrograph (Pl. VI, fig. 5) to show a well developed eye and the associated structures like eye muscles (*em.*), orbital glands (*og.*), M. retractor tentaculi (*mrt.*) and optic nerve.

In *Boulengerula*, Nieden (1913) noted that the "Augen unter den Schädelknochen verborgen" and de Villiers (1938) also remarked that in *Boulengerula*, "The eye is totally degenerate and hidden beneath the paraquadrate as in *Scolecormorphus*" confirming the observations of Peter (1908, Fig. 8). Nieden made the same remark about *Scolecormorphus*, and obviously de Villiers follows that author in saying that the 'totally degenerate' eye is hidden below the paraquadrate (squamosal), which however, appears only posteriorly, nor is it hidden for that matter under any bone. The photomicrograph reproduced (Pl. V, fig. 1) shows that it (*e.*) is directed towards the lower jaw and is devoid of a lens, of eye muscles and nerves including the optic. Towards the maxillopalatine bone, the eye is partially surrounded by the tentacular sac into which the orbital glands (*og.*) open. After the eye disappears from sections, the M. retractor tentaculi appears attached to the wall of the tentacular sac.

In the case of *Herpele* examined by me, the eye is not only degenerate but is also hidden under the maxillopalatine bone.

In *U. narayani*, the eye is well developed both in the young and the adults examined as in *I. glutinosus* and *I. monochrous*. The photomicrograph (Pl. VI, fig. 6) passes through the optic nerve (*on.*) region and in the eye, a sclerotic, choroidea (pigment), iris, retina, cornea and lens (not seen in figure) can be clearly made out besides some of the eye muscles.

As early as 1868, Leydig described four eye muscles in *Siphonops*, but Wiedersheim (1879) does not refer to them. Sarasins (1890) described in *I. glutinosus* six eye muscles; four rectus and two oblique in association with a retractor tentaculi which probably is a modified M. retractor bulbi. Marcus (1910) found all the eye muscles in *Hypogeaphis* larva including a levator bulbi muscle (compressor muscle of the orbital gland). He also described a M. retractor tentaculi which he derived from the retractor bulbi (*c.f.* the tentacle). Norris and Hughes (1918) described in *Dermophis* six muscles; superior and inferior oblique (dorsal and ventral oblique), superior and inferior rectus (dorsal and ventral rectus), a rectus externus (*r. lateralis*) and a rudimentary retractor bulbi. A rectus internus (*r. medialis*) is absent, while a retractor tentaculi is present. According to the same authors in *Geotrypetes*, all the rectus and oblique muscles except *r. internus*, and a retractor bulbi and two retractor tentaculi muscles (a M. retractor

tentaculi and a M. retractor of the tentacular sheath,—the latter considered by them to be a modified r. internus) are present. In *Herpele* and *Caecilia* the eye muscles are absent; however, the tentacular muscle is described as a modified M. rectus externus.

Englehardt (1924) in his account of the tentacle and eye of *I. glutinosus*, records six eye muscles. While the obliquus superior is lost between the ethmoid cartilage and orbital gland, the inferior oblique is lost between the retractor (R2) and orbital gland ventrally. Of the rectus muscles, the medialis ends in the connective tissue between the retractor and orbital gland; the lateralis in between the orbital gland ducts an retractor; the superior and inferior end between the compressor and orbital gland ducts. According to the same author the oculomotor innervates the rectus and obliquus inferior muscles.

Edgeworth (1935) followed the works of Norris and Hughes (1918) and Englehardt (1924) and recorded that the ocular muscles and nerves were present in *Ichthyophis*, *Dermophis* and *Geotrypetes*, while “in *Caecilia* and *Herpele* the eye is partly or fully covered by maxilla and is rudimentary” A retractor tentaculi innervated by abducens nerve and homologised with the retractor bulbi (retractor oculi) of Urodela and Anura is also recorded.

de Jager (1939) reported (erroneously) that all the eye muscles have degenerated in *D. mexicanus* and *D. gregorii* except the r. externus which has become the M. retractor tentaculi.

Both in *I. monochrous* and *U. narayani*, all the eye muscles are present,—two oblique and four rectus muscles. Tracing the sections rostrocaudally, in *U. narayani*, it is noticed that the oblique muscles appear arising from the connective tissue covering the maxillopalatine towards the eye. While the insertion of the obliquus superior is noticed on the eye-ball in the anterior sections, that of the inferior appears more posteriorly. Between the o. superior and inferior and enclosed within the orbital glands, the rectus internus is seen. In a region where the rectus internus enters the m. retractor tentaculi, the insertion of the o. superior and inferior and the rectus inferior can be seen. Posteriorly, the r. superior and inferior enclosed within the orbital glands and the rectus externus inserted on the eye-ball can be made out. The rectus internus passes through the M. retractor tentaculi as in *I. glutinosus* (Englehardt 1924) and along with the rectus superior is lost between the orbital gland, M. retractor tentaculi and the compressor muscle. The rectus externus and inferior become so thinned out in the region between the connective tissue spanning the orbital and trabecular cartilages and the compressor muscle that it is difficult to trace them further. In both *Ichthyophis* and *Uraeotyphlus*, a retractor bulbi is absent as such and is modified into the tentacular muscle. However, according to Norris and Hughes (1918) in *Geotrypetes* and *Dermophis*, a rectus internus is absent and they note that in these two (p. 507) “a delicate muscle slip follows the optic nerve from the retractor tentaculi to the eye-ball, probably a retractor bulbi” Moreover, in the case of *Geotrypetes*, the retractor of the tentacular sheath is homologised with the rectus internus because of position and innervation. In *Ichthyophis*, the same authors state that the eye

muscles are as described by Sarasins (1890, Fig. 72, four rectus and 2 oblique). It is clear therefore, that Norris and Hughes have accepted the muscle passing through the retractor tentaculi to the eye-ball as rectus internus in *Ichthyophis* (see their Fig. 19) to which, however, they assign the name of a retractor bulbi in *Dermophis* and *Geotrypetes* and thus deny the presence of a rectus internus. Having examined *Dermophis*, *Ichthyophis* and *Uraeotyphlus*, I am convinced that the muscle designated as retractor bulbi by Norris and Hughes is actually the rectus internus which, as described by Englehardt passes through the retractor muscle and therefore, contrary to the observations of Norris and Hughes and de Jager, all the eye muscles are well developed in *Dermophis*.

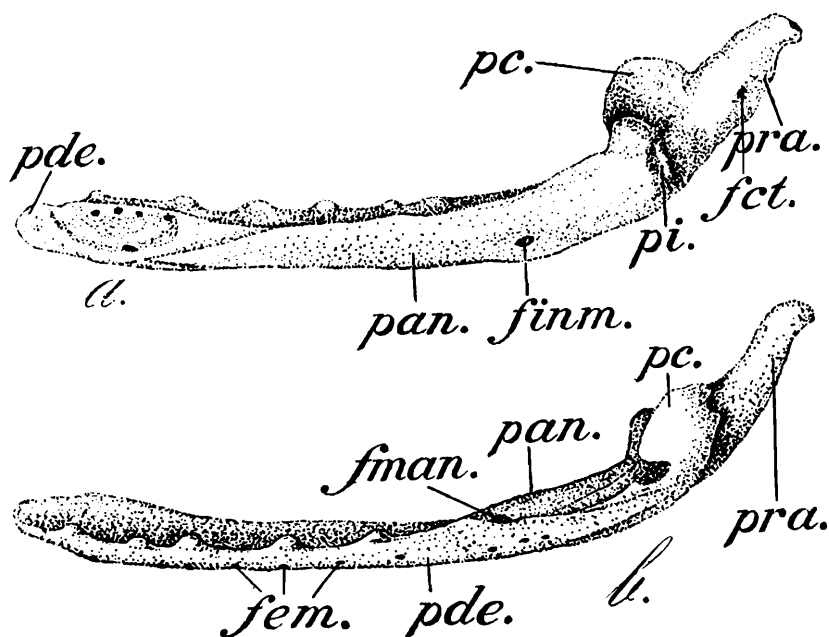
THE LOWER JAW.

Sarasins (1890) did not describe the lower jaw bones in detail but noted that it is composed of a dentary and an articular and that the inner tooth row belongs to the opercular (spleniale). Marcus, Winsauer and Hueber (1933) described in the case of *Hypogeophis*, a posterior gonial and an anterior dentary. The dentary carries the two rows of teeth. The gonial with which the articular fuses to form a gonioarticular, in the region of the suspension gives internally to a process,—the processus internus and laterovertically to a process—the processus condyloides (processus articularis mandibularis, Luther 1914), which articulates with the external aspect of the processus articularis of the quadrate and the jaw proceeds posteriorly as the processus retroarticularis mandibulae (Luther).

According to Eifertinger (1933) each ramus of the jaw consists of two composite bones, formed by the fusion of a number of elements during development. The posterior pseudoangular (gonioarticular) is composed of angular, gonial (prearticular, de Beer 1937), complimentary, and articular while the pseudodentary is formed by mentomandibular (mentomeckelian, de Beer 1937), dentary, splenial, coronoid and supraangular. The anterior portion of the dentary, the articular and the mentomeckelian are cartilage bones and the rest are membrane bones. This nomenclature of the fused bones in the lower jaw was accepted by Marcus (1933), but he pointed out that the pseudodentary is composed of dentary, mentomandibular, splenial and coronoid (no mention is made of supraangular) while the pseudoangular is formed by angular, gonial (complimentary ?) and the articular. In his fig. 6c Eifertinger (1933) describes in the posterior part a gonial and angular while in fig. 7a (44 mm. *Hypogeophis* larva) a gonioangular and extra element 'complimentare' are noted. Marcus (1933) however, while labelling a separate gonial and angular in his fig. 2b described (as gonial in fig. 2c), the region called by Eifertinger as 'complimentare'. He significantly mentions in this connexion that (pp. 181, 182)

In der Abb. 2c ist durch 4 Punkte, welche die Naht zwischen Dentale und Coronoid caudal fortsetzen angedeutet, dass im Goniale G oft die Spitze des Knochens selbständig verknöchert, und so vielleicht einem Complementare entspricht.

In *U. narayani*, as in *Hypogeophis*, two segments in each ramus of the lower jaw can be made out; a pseudodentary (text-fig. 17a, b, *pde.*) and pseudoangular (*pan.*). No exact differentiation into regions



TEXT-FIG. 17.—*Uraeotyphlus narayani* Seshachar.

a. the lower jaw from within : $\times 9$.

b. outer view, slightly inclined : $\times 9$.

fct., foramen for chorda tympani; *fem.*, foramina for the twigs of ramulus mandibularis externus V; *finm.*, foramen for ramulus intermandibularis; *fman.*, foramen for ramulus mandibularis V; *pan.*, pseudoangular; *pc.*, processus condyloides; *pde.*, pseudodentary; *pi.*, processus internus; *pra.*, processus retroarticularis.

where the original independent bones were present could be made out. A processus condyloides (*pc.*), a processus internus (*pi.*) and a posterior processus retroarticularis (*pra.*) are present. The orifices for the entry of ramus alveolaris VII (chorda tympani) (*fct.*) and the ramus mandibularis V (*fman.*) in the pseudoangular can also be seen. Anteriorly the pseudodentary of either side is united at the apex of the jaw into a symphysis by a reminiscent piece of cartilage. Two rows of teeth are borne upon this bone.

While the processus condyloides (see text-fig. 7a, *pc.*) is prominently developed in *Uraeotyphlus* [compared by Hueber (1933), with the 'Hammer, Hauptteil' of the mammalian ear] it is feebly developed in *Herpele* and *Dermophis* and *Scolecormorphus*, and is absent in *Boulengerula*.

THE JAW MUSCLES.

The latest account dealing with the development and disposition of adult arrangement of masticatory muscles is by Edgeworth (1925, 1935) who distinguishes four of them. I have employed the same nomenclature in describing the jaw muscles of adult *Uraeotyphlus* as Edgeworth.

Edgeworth (1925, 1935) considers the two muscles adductor mandibulae externus and adductor mandibulae internus (M. pseudotem-

poralis) of Hueber¹ as a single one since they arise singly in the early stages. He however, adds (Edgeworth 1935, p. 42) that "it separates into medial and lateral parts", and nerves pass through these two. But in [adult] *Ichthyophis* and *Siphonops*, according to the same author the muscle "persists as a whole". I have examined adult *Ichthyophis*, and it shows the separation of the muscle into two, as described by Luther (1914, p. 9, fig. 3) with its origin and insertions as in *Uraeotyphlus* (see below). Whatever the origin of these two parts of the muscle may be, it will facilitate description if we could give them distinct names and, therefore, I have called the M. pseudotemporalis as M. levator mandibulae internus and the M. adductor mandibulae externus (Hueber) as M. levator mandibulae anterior.

The four masticatory muscles are :—

- (1) M. levator mandibulae anterior (Edgeworth 1925, 1935) (Synonyms : M. Adductor mandibulae externus major *plus* M. pseudotemporalis. Luther 1914, Hueber 1933.
M. temporalis. Norris and Hughes 1918.
M. Masseter 1.
M. temporalis 1. Englehardt 1924.)
M. temporalis 2.
- (2) M. levator mandibulae externus (Edgeworth 1925, 1935) (Synonyms : M. Adductor mandibulae externus minor. Luther 1914.
M. masseter 2. Norris and Hughes 1918.
M. masseter. Englehardt 1924.
M. Adductor mandibulae posterior. Hueber 1933.)

Luther (1914) described no M. adductor mandibulae posterior in Apoda, but Hueber (1933) has since described the same in *Hypogeophis*.

- (3) M. levator mandibulae posterior (Edgeworth 1925, 1935) (Synonyms : M. pterygoideus *sic*. Luther 1914, Norris and Hughes 1918, Hueber 1933.)

According to Edgeworth (1925) this muscle is homologous with the same muscle in Anura and Urodela.

- (4) M. levator quadrati (Synonyms : *sic* Luther 1914, Norris and Hughes 1918, and Hueber 1933. M. pterygoideus Englehardt 1924.)

According to Edgeworth (1925, 1935) the opinion of Hueber that the M. levator quadrati is homologous with the M. constrictor dorsalis of fishes, is incorrect for, the latter did not adduce any embryological evidence in favour of his opinion.

In *Uraeotyphlus* (text-fig. 10, *lma.*), the M. levator mandibulae anterior arises from the frontal bone and is inserted on the pseudoangular of the lower jaw. Internally to this muscle, the M. levator mandibulae internus (*lmi.*) is noticed along with the "Caput preorbitale" (*cp.*) (see Luther 1914, p. 69) and the origin of the latter is described below. Both these muscles (*l. m. internus* and the "Caput

¹ See Marcus, Winsauer and Hueber, p. 171, 1933.

preorbitale" portion) are inserted on the pseudoangular by a common tendon while the *M. levator mandibulae internus* arises from the dorso-lateral aspect of the pleurosphenoid.

The *M. levator mandibulae externus* (text-figs. 10, 11, *lme.*) arises principally from the processus ascendens of the quadrate bone and is also inserted into the pseudoangular of the lower jaw.

The *M. levator mandibulae posterior* (text-figs. 11, 12, *lmp.*) arises from the ventral aspect of the processus pterygoideus of the quadrate and the insertion is on the retroarticular process of the pseudoangular. In *Scolecormorphus* (text-figs. 13a, b), it is noticed that the *M. levator mandibulae posterior* has a separate origin instead of from the ventral aspect of the processus pterygoideus as in other Apoda. This process is very small and the *M. l. m. posterior* arises from the anterior face of the basipterygoid process where the connective tissue strand (*cs.*) from the processus ascendens (*pa.*) comes and meets it.

The *M. levator quadrati* (text-fig. 10, *lq.*) arises from the lower aspect of the pleurosphenoid bone and is inserted into the processus pterygoideus of the quadrate dorsally.

I describe here the "Caput preorbitale" mentioned above and in this connexion describe the compressor muscle of the orbital glands also. In *Uraeotyphlus*, the compressor muscle makes its appearance as one attached on the internal aspect of the upper portion of the pre-frontal and posterior sections reveal the compressor muscle as an internal (circular) and an outer (obliquely longitudinal) portion. A part of this outer portion becomes separated in the region of the optic (*plus oculomotor*) foramen and runs with the *M. l. m. internus* into the lower jaw where it is inserted. This is the one described by Luther (1914) as "Caput preorbitale" Such a muscle has been noticed in *Ichthyophis* (and also in *Dermophis* according to Norris and Hughes 1918) while in *Caecilia* (Norris and Hughes 1918), the muscle appears to be inserted on the sheath of the compressor muscle or on the lateral wall of the skull. In my sections of *Dermophis gregorii*, the condition is as the one described for *Caecilia*.

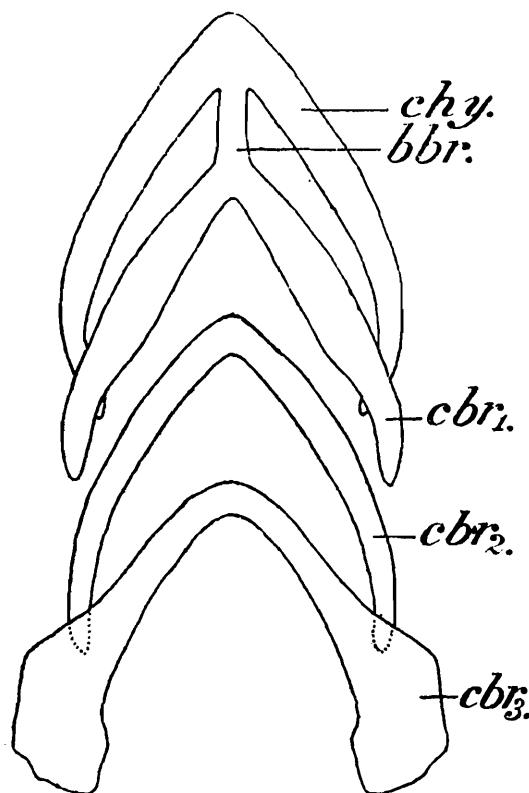
The *M. compressor orbitalis* has been found in all the Apoda so far studied and the development of the muscle in each case is one of degree; the muscle is extraordinarily well developed in *Herpele*, it is fairly well developed in *Ichthyophis*, *Uraeotyphlus* and *Dermophis* and it is poorly formed in *Scolecormorphus* and *Boulengerula*. The tendon of this muscle arises from the connective tissue covering the optic (*plus oculomotor*) foramen and surrounds the orbital glands. According to Luther (1914) and Edgeworth (1925) the muscle is a modified levator bulbi.

The *M. levator mandibulae internus* is not noticed uniformly among Apoda. While the muscle is well developed in *Ichthyophis*, *Uraeotyphlus*, *Dermophis*, and *Herpele*, it is absent in *Boulengerula*, *Scolecormorphus* (de Villiers 1938, 1939) and *Geotrypetes* (Norris and Hughes 1918). Consequent on this the path of the maxillary and mandibular branches of the trigeminal also differs. In *Hypogeophis*, *Ichthyophis*, *Uraeotyphlus* and *Herpele*, the maxillary branch runs between the *M. l. m. anterior* and *M. l. m. internus* in the region of these muscles, and in *Boulengerula*,

the nerve passes between the M. l. quadrati and the M. l. m. anterior since the M. l. m. internus is absent, while in *Scolecormorphus* where a M. l. quadrati is also absent the ramus maxillaris passes between the M. compressor orbitalis and the M. l. m. anterior. In *Dermophis gregorii*, the same nerve runs internally to the M. l. m. internus portion (i.e., between it and the connective tissue covering of the optic (plus oculomotor foramen) which is in close apposition with the M. l. m. anterior and is separated dorsally by a blood vessel. The two muscles cannot be clearly differentiated as in *Ichthyophis*. Probably on account of this fact de Jager (1939) remarks that a M. pseudotemporalis is absent in *D. gregorii* while it is prominently present in *D. mexicanus*.

THE HYOBANCHIAL SKELETON.

In the adult *Ichthyophis* (Sarasins 1890, M. Fürbringer 1922, de Beer 1937) we notice that in the hyobranchial skeleton, the ceratohyal of either side is fused and is connected with the similarly united ceratobranchial by the first basibranchial, the larval basihyal and second basibranchial having disappeared. [In larval *Ichthyophis* (Sarasins 1890), *C. tentaculata* (Henle 1839) and *C. hypocyanea* (J. Müller 1835), the fourth ceratobranchial arises as an independent arch and then fuses with the third.] Edgeworth (1935) however, mentions a basibranchial in the hyobranchial skeleton of the larvae of Apoda and also notes the absence of a basihyal in *Siphonops* and *Hypogeophis*. In *Ichthyophis*, there are four ceratobranchials in the adult. In *Hypogeophis* (Gewolf 1923) the ceratohyal of either side is connected by a U-shaped



TEXT-FIG. 18.—*Uraeotyphlus narayani* Seshachar.

The hyobranchial skeleton *in situ*, ventral view : $\times 9$.

bbr., basibranchial ; cbr₁, cbr₂, cbr₃., ceratobranchials 1, 2, and 3 ; chy., ceratohyal.

basibranchial which meets and fuses with the first pair of ceratobranchials, [Edgeworth (1935) shows the first pair of ceratobranchials disunited ventrally], and with the third ceratobranchial, the fourth and fifth have fused. In *Boulengerula* Peter (1908) draws a figure (Fig. 8) in which the united ceratohyal is mesially in contact with the first ceratobranchial. But my sections show that the ceratohyal and ceratobranchial are united mesially by a basibranchial. In *Uraeotyphlus* (text-fig. 18), *Scolecomorphus*, *Herpele* and *Dermophis*, as in *Boulengerula* and *Ichthyophis*, the ceratohyal (*chy.*) is connected with the ceratobranchial (*cbr*₁.) by a basibranchial (*bbr.*) cartilage and there are only three pairs of ceratobranchials (*cbr*₁, *cbr*₂, *cbr*₃.) in all these examples. As in *Ichthyophis*, the ventral ends are mesially united and the dorsal end of the third shows a thickening which probably represents the fused third and fourth. Whether there are one or two basibranchials (copulae 2 and 3) and a single basihyal (copula 1) during developmental stages of *Uraeotyphlus* as in *Ichthyophis*, can only be settled when early developmental stages are procured. The 9 cm. young specimen of *Uraeotyphlus* discloses all the characters of the adult hyobranchial skeleton.

THE CRANIAL NERVES.

The cranial nerves¹ have been described by various authors in several Apodan genera. I have not had access to Fischer's (1843) paper.

Wedersheim (1879) gave a good account of the nerves of *I. glutinosus* and *S. annulatus*. He recorded the following nerves :—

- (a) Each olfactory nerve is double and comparable with the two roots of a spinal nerve.
- (b) The optic nerves are vestigial.
- (c) No mention is made of eye muscle nerves (III, IV and VI).
- (d) The ophthalmicus profundus V arises independently and an anastomosis between it and ramus maxillaris V is described.
- (e) There is no ramus palatinus VII, probably it is united with trigeminus. An anastomosis between the facial nerve and gasserian ganglion is recorded.
- (f) The auditory nerve is well developed and arises by four roots.

Waldschmidt (1887) disagreed with Wiedersheim (1879) in the spinal nerve homology of the olfactory nerve. In *S. annulatus*, he described (Figs. 32 and 33) the following :—

- (a) The oculomotor sends a branch to compressor muscle and another to the ramus maxillaris V
- (b) The trochlear and abducens are absent.
- (c) A nerve arising from gasserian ganglion is shown to correspond with the ophthalmicus superficialis VII.
- (d) A nerve considered to be palatinus facialis is described.

Sarasins (1890) mention the double nature of the olfactory nerve and the supply to the organ of Jacobson from the ventral part. The auditory nerve enters the internal ear by five or six orifices.

¹ I am not describing the IX and X nerves for I hope to study these in connexion with the sympathetic system.

Burckhardt (1891) in describing the eye muscles and nerves in *Ichthyophis* noted the absence of the trochlear and abducens nerves like Waldschmidt and Wiedersheim. The organ of Jacobson is innervated by the ventral olfactory nerve and the VIII, IX and X nerves arise by more than one root.

Marcus (1910) described in *Hypogeophis* the presence of all the three eye muscle nerves. The embryo has a lateral line complement, viz., ophthalmicus superficialis, ramus buccalis and ramus mandibularis externus (?). A recurrens VII joins the sympathetic.

By far the most complete account of cranial, spinal and sympathetic nerves was given by Norris and Hughes (1918), we are concerned here with the Section on the cranial nerves only—

- (a) The olfactory nerves are double; the olfactory glomeruli are arranged in a posterolateral group and an anterior medial and lateral group.
- (b) The oculomotor, trochlear and abducens nerves are present in *Dermophis*, *Geotrypetes*, *Ichthyophis* (the adult *Ichthyophis* is devoid of a trochlearis). In *Herpele* and *Caecilia*, the nerves have completely disappeared.
- (c) Describing the trigeminal nerve of *Herpele*, a separate profundus ganglion is recorded. The ramus mandibularis gives rise to three branches, (1) a ramulus intermandibularis entering the lower jaw through the pseudoangular, (2) a ramus alveolaris (r. mandibularis internus) which unites with a similarly named nerve of VII and innervates the teeth and the lateral epithelium of the floor of the mouth, and (3) a ramus mandibularis externus which running in the lower jaw innervates the skin. Smaller ramuli from the r. mandibularis V enter into the MM. levator mandibulae anterior, l. m. externus, l. m. posterior, and compressor orbitalis.

The ramus maxillaris after passing through the jaw muscles divides into medial and lateral branches. The medial branch sends a commissure to lateral ramus palatinus facialis (temporary union) and also one to medial r. palatinus. While the lateral r. maxillaris supplies the skin at the side of the head, the medial goes to the sheath of the tentacle and the skin of the ventral and ventrolateral surfaces of the snout. In *Geotrypetes*, the r. maxillaris does not divide into lateral and medial branches but there is a branch given off which unites with palatinus VII.

The ramus ophthalmicus profundus arising from the ophthalmic ganglion runs anteriorly and at the level of the choana, a large branch is given off. This branch (op1) supplies the head and the tentacular sheath. A few fibres of this commingle with those of r. maxillaris. A second branch (op3) possibly supplies the Jacobson's gland and primarily the skin on the head. A third branch (op2v) arises from the ventral side of the ophthalmicus profundus (op2) and supplies the ventral epithelium of the snout after some

anastomoses with the branches of medial maxillary V. The principal nerve (op2) goes to the skin of the ventral side of the tip of the snout.

Besides these, a somatic sensory arising from the gasserian ganglion and another sensory (Vd) called the 'dorsal fifth' are also described.

- (d) The geniculate ganglion though connected with the gasserian can be easily differentiated; four groups of fibres arise from it. The ramus palatinus, after leaving the ganglion and traversing a short distance divides into a medial and lateral branch. The connexions with the r. maxillaris V are described above. The hyomandibular nerve gives rise to a motor branch which enters the depressor mandibular muscle and a visceral sensory which entering the lower jaw as the r. mandibularis internus VII (chorda tympani) unites with the similar branch of the trigeminal and runs to the symphysial region. The r. jugularis proceeds posteriorly after giving off branches to muscles (*viz.*, interhyoideus, constrictor colli). In *Dermophis* and *Geotrypetes* the distribution is the same.

The ramus ophthalmicus superficialis VII arising from the geniculate ganglion courses through the gasserian, anastomosing peripherally with the branches of the r. ophthalmicus profundus and goes to the skin. This is noticed in *Dermophis*, *Herpele* and is absent from *Geotrypetes*.

- (e) The auditory nerve arises by five roots, four going to the sacculus and the one dorsal to the macula neglecta.

Kuhlenbeck (1922) described the brain of *Ichthyophis*, *Siphonops* and *Hypogeophis*. A rudimentary oculomotorius and double olfactory were recorded.

Englehardt (1924) gave an account of the distribution of the nerves of *Ichthyophis*, but he does not refer to the papers of Norris and Hughes (1918) and Marcus (1910).

- (a) The trochlear is absent and the rudimentary oculomotor proceeds to rectus and obliquus inferior eye muscles and the abducens to the retractor tentaculi muscle.
- (b) Of the trigeminal, the ramus nasalis (ophthalmicus profundus) innervates the skin and tentacle sac; the ramus maxillaris innervates the compressor muscle, tentacle and upper jaw. A branch also unites with the facial nerve. The r. mandibularis supplies the masseter, the major and minor temporal muscles and the lower jaw.

The hyomandibularis branch of facial proceeds to the depressor muscle and lower jaw muscles; the fate of r. buccalis is not mentioned and from the r. nasalis (palatinus facialis) a twig joins the gasserian ganglion and another unites with r. maxillaris V. No mention is made of r. mandibularis internus.

de Villiers (1938) described the trigeminal, facial and abducens nerves in *Boulengerula* and *Scolecormorphus*.

- (a) An abducens is absent from *Boulengerula* but prominently present in *Scolecormorphus*.
- (b) In *Boulengerula*, there is a commissure connecting the trigeminal and facial ganglia which is absent from *Scolecormorphus*; only in *Boulengerula*, the ophthalmicus profundus ganglion is separated from maxillo-mandibular ganglion.
- (c) The palatinus facialis stops short at the sensory ganglion of trigeminal in *Boulengerula* and in *Scolecormorphus* the r. palatinus which runs anteriorly receives a branch from maxillary V; the distribution of hyomandibularis VII is not described and in both genera, a chorda tympani is wanting.

de Jager (1939) did not add anything new to what has already been described by Norris and Hughes (1918) but differed in certain important points. She recorded in *D. mexicanus* the following:—

- (a) The geniculate and gasserian ganglia overlap but do not fuse.
- (b) There are two prootic foramina,—a dorsal for r. maxillo-mandibularis and a ventral for ophthalmic branch. The r. ophthalmicus profundus has its own ganglion.
- (c) A temporary anastomosis of r. palatinus with ophthalmicus profundus in the profundus ganglion is recorded on one side.
- (d) The presence of an anastomosis between maxillary V and palatinus facialis is noted.
- (e) An abducens is absent; no mention is made of oculomotor and trochlear nerves.
- (f) A branch from maxillary V innervates the compressor muscle of the orbital gland.

The olfactory nerve.—The double nature of the nerve has been noticed from a long time. The ventral division is the shorter of the two and we may briefly examine the passage of these nerves in *U. narayani*. Arising from the olfactory lobe, each pair (right dorsal and ventral, and left dorsal and ventral) traverses independently in a canal in the sphenethmoid bone and soon however, the right ventral gives rise to a ramulus which passes craniad in a separate canal. Anteriorly the larger ventral olfactory nerve emerges from the bony canal (text-fig. 9, *von.*) and proceeds to innervate the medial and lateral divisions of the “Nebennase” (see Olfactory organ) and also its glands. At the region the innervation of the “Nebennase” is noticed, the median unpaired ramulus (*von_b.*) of the right olfactory nerve also gains exit and proceeds to the right side to innervate the ventral olfactory epithelium. In all the series of the head of *Uraeotyphlus*, this feature is noticed.

The dorsal olfactory nerve also gains exit from the sphenethmoidal bony canal and runs in close approximation with the ophthalmicus profundus V (with no anastomoses) and distributes itself over the olfactory epithelium.

In *Herpele*, my slides show the right and left ventral olfactory before entering the ventral canals in the sphenethmoidal septum, each gives rise to a small and a large ramulus respectively. These also run in independent canals in the septum and emerge in the region of the "Nebennase" to supply the right and left olfactory epithelium. This feature however, is not recorded by Norris and Hughes (1918). In *Dermophis* the supply of the "Organ of Jacobson" and "olfactory epithelium covering the convexity of the ridge on the floor of the olfactory chamber" by the ventral olfactory nerve as recorded by Norris and Hughes is corroborated by me. The extra branch seen in *Uraeotyphlus* and *Herpele* is not present.

The optic and eye muscle nerves.—There is considerable difference of opinion with regard to the optic and eye muscle nerves among Apoda. Norris and Hughes review the previous literature on the subject like that of Waldschmidt (1887) on *S. annulatus*, Burckhardt (1891) on *I. glutinosus* and Marcus (1910) on *H. rostratus*. The observations of Norris and Hughes (1918) may briefly be summarised as follows:—

- (a) An optic nerve is noticed in *Dermophis*, *Geotrypetes* and in the adult *Ichthyophis*.
- (b) Of the eye muscle nerves, oculomotorius is noticed in *Dermophis* (vestigial), *Geotrypetes* and *Ichthyophis* (very vestigial), a trochlear is present in *Dermophis* (vestigial), *Geotrypetes* (vestigial) and absent from *Ichthyophis*; an abducens is noticed in *Dermophis* (large), *Geotrypetes* and *Ichthyophis*. It innervates the tentacular muscle. In *Herpele* and *Caecilia*, these nerves are absent except the abducens which innervates the M. retractor tentaculi.

Englehardt (1924) in describing the tentacle and eye of *I. glutinosus* confirmed the presence of an abducens nerve (going to the tentacle), of an oculomotor (innervating the rectus and obliquus inferior) and the absence of a trochlear.

de Villiers (1938) noted the presence of an abducens in *Scolecophorus* while its absence was recorded in *Boulengerula*.

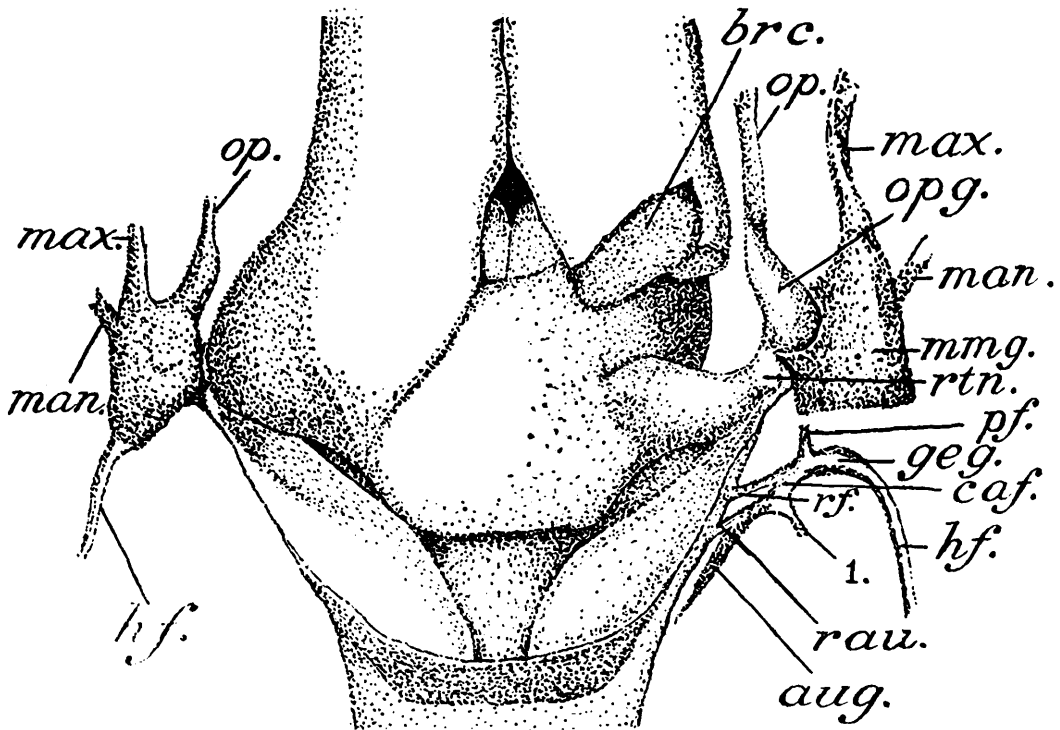
de Jager (1939) working on *D. mexicanus* and *D. gregorii* recorded that "All the eyemuscles and nerves have degenerated, except the M. rectus externus" and that an abducens was not recognizable.

In *U. narayani*, the optic nerve is well developed. The photomicrograph (Pl. VI, fig. 6) shows the optic nerve. Both in the juvenile and in the adult, the oculomotor is so vestigial that it could be found only with difficulty. The trochlear is definitely absent. The abducens is a powerful nerve and innervates the M. retractor tentaculi.

The trigeminal nerve.—As the descriptions of later authors like Englehardt (1924), de Villiers (1938) and de Jager (1939) vary considerably from those of Norris and Hughes (1918), I propose to describe in brief the passage and division of these nerves making relevant references to the above authors where necessary. It will be noticed that the observations of Norris and Hughes are almost completely borne out by my studies.

The gasserian ganglion (text-fig. 19) in *U. narayani* is seen externally to the os Basale (prootic region) and while the posterior part of

the ganglion (*mmg.*) gives rise to the maxillary (*max.*) and the mandibular (*man.*) branches, the anterior portion (*opg.*) gives rise to the oph-



TEXT-FIG. 19.—*Uraeotyphlus narayani* Seshachar.

A part of brain showing the origin of trigeminal, facial and auditory nerves. On the right side a portion of the hemisphere is cut and the structures are stretched a little : $\times 24$.

aug., auditory ganglion ; *brc.*, brain cut to show the root of trigeminal nerve ; *caf.*, commissure between auditory and facial nerves ; *geg.*, geniculate ganglion ; *hf.*, r. hypo-mandibularis facialis ; *man.*, r. mandibularis V ; *max.*, r. maxillaris V ; *mmg.*, maxillo-mandibular part of gasserian ganglion ; *op.*, r. ophthalmicus profundus V ; *opg.*, ophthalmicus profundus part of gasserian ganglion ; *pf.*, r. palatinus facialis ; *rau.*, root of auditory nerve ; *rf.*, root of facial nerve ; *rtn.*, root of trigeminal nerve ; *1.*, utricular nerve.

thalmicus profundus (*op.*) nerve. The ophthalmicus profundus ganglion is separate from the maxillo-mandibular part though closely apposed to it.

The ramus mandibularis V.—The disposition of the mandibular branch of the trigeminal in *Uraeotyphlus* follows the description given for the same by Norris and Hughes (1918). Arising from the maxillo-mandibular part of the gasserian ganglion (text-fig. 19, *mmg.*) it passes through a notch in the quadrate bone and then internally to M. levator mandibulae externus into the lower jaw through a foramen in the pseudo-angular bone. In the jaw, three branches can be followed. A branch,—ramulus intermandibularis to supply the intermandibular muscle and the skin, a r. mandibularis internus (alveolaris) which unites with a similarly named nerve of the facial, and a main branch,—r. mandibularis externus (composed of two divisions) which run between the pseudo-angular and the pseudodentary and then in a canal in the latter to the symphyseal region. Further, before proceeding to the lower jaw the r. mandibularis gives off small twigs which innervate the lateral skin passing through squamosal (Pl. V, fig. 5, *v₃ls.*) and the MM. l. m. anterior, l. m. externus (*v₃me.*), l. m. posterior and the compressor

orbitalis (*v₃cpc.*). The united mandibulae internus nerve (mandibulae internus V *plus* chorda tympani) also runs anteriorly; a ramulus of this is noticed to enter the region near the sublingual glands but not into the tongue as de Jager (1939) records in *Dermophis* where the nerve leaves the symphysial region to supply the epithelium of the floor of the mouth and the muscles of the tongue as in the higher tetrapodous forms and the latter point is also not recorded by Norris and Hughes (1918). Branches of the external mandibular enter the skin. I have examined the young specimen of *Uraeotyphlus* also and the above description drawn from this and the adults closely corresponds with that of Norris and Hughes.

In *Ichthyophis* larvae however, as described by Norris and Hughes (1918), the r. mandibularis externus runs externally to the jaw along with the r. mentalis externus VII. Englehardt (1924) recorded that the r. mandibularis innervated the masseter (Vc1), temporalis major (Vc2), temporalis minor and the lower jaw (Vc3). No mention is made of the branches that enter into the lower jaw.

The ramus maxillaris V.—Leaving the maxillomandibular part of the gasserian ganglion (text-fig. 19, *mmg.*), the nerve is first noticed associated dorsally with a branch (Pl. V, fig. 5, *os.*) between the MM. l. quadrati and l. m. anterior. More anteriorly the maxillary branch separates itself from this ramulus and runs between the MM. l. m. internus and l. m. anterior. Before running between these two muscles, and while through them, small ramuli are given off, the first of which unites anteriorly below the M. compressor orbitalis with the medial branch of palatinus facialis. This anastomosis is anterior to the temporary one between the lateral palatinus facialis and maxillary V. The principal maxillary branch now divides into two (text-figs. 3, 9, *max₁.*, *max_{2b}.*) which are enclosed anteriorly in a canal in the maxillopalatine bone (text-fig. 3, *map.*). Below the tentacular canal, the two branches of the maxillary are still enclosed in the bone but far apart in individual canals. The lateral branch (text-fig. 9, *max_{2b}.*) distributes itself to the side while the bigger inner branch running anteriorly (text-fig. 8, *max_{1b}.*) supplies the tentacular region.

In *Ichthyophis*, the maxillary branch has its lateral ramus (*max₂*) as its main component, while the median (*max₁*) unites with the median palatine (*pal₁*) branch. A lateral palatine branch (*pal₂*) unites temporarily, a feature also noticed in *Herpele* (Norris and Hughes 1918). In *Dermophis* (Norris and Hughes 1918) the arrangement of the maxillary nerve is as in *Herpele*. In *Geotrypetes* the maxillary does not divide into medial and lateral branches but a branch from it joins palatinus facialis. A double anastomosis of palatine and maxillary occurs. A united branch from maxillary and mandibular passes to the M. compressor orbitalis. Englehardt (1924) noted in *Ichthyophis* that the maxillary V innervated the compressor muscle (Vb4), skin (Vb1, Vb2), tentacle (Vb6) and upper jaw (Vb6); an anastomosis with r. buccalis facialis (Vb3 *plus* VIIa2) and a branch (Vb5) to r. nasalis facialis are also recorded. De Jager (1939) described a twig from the maxillary V to the compressor muscle in *Dermophis*, a point also corroborated by me.

The ramus ophthalmicus profundus V.—Having differentiated (text-figs. 11, 19, *rop. op.*) from the inner aspect of the profundus ganglion (text-fig. 19, *opg.*), it runs anteriorly surrounded by the ganglion, a few fibres of which enter the r. palatinus facialis. Running by the side of the pleurospenoid more towards the orbital cartilage, it gives off a branch (*op₁*), and in the choanal region the main branch (*op.*) is enclosed in a canal (see text-fig. 6, *sphc.*), then in a groove in the sphenethmoid bone while the branch (*op₁*) occupies a dorsal position. It (*op₁*) runs anteriorly after giving off a large branch which enclosed in the frontal bone (see text-figs. 3, 9, *op_{1b}*) supplies the dorsal skin and this does not establish any connexion with ophthalmicus superficialis VII as described by Norris and Hughes (1918); the other is then enclosed in the dorsal part of the tentacular canal in the maxillopalatine bone (text-fig. 9, *op₁*) and supplies the tentacular region. This ramulus (*op₁*) closely corresponds with (*op₁*) of Norris and Hughes. A second branch (*op₂*) arises from the ophthalmicus profundus during its passage in the canal and the main branch (see text-figs. 3, 9, *op.*) and the second (see text-figs. 1, 3, 9, *op₂*) run below the sphenethmoid roof-like extension. This latter ramulus runs in the roof of the nasal chamber near the “Nebennase” but does not supply any fibres to the glands of the latter (though Norris and Hughes describe so) but proceeds to innervate the side after passing through a foramen (f. epiphaniale ?) in the septomaxilla. The branch (*op₃*) of Norris and Hughes’s description tallies with this. A third (*op₃*) and a fourth (*op₄*) branches are given off from the ophthalmicus profundus. These two branches lie near the dorsal olfactory nerve. Branch (*op₃*) (see text-fig. 1, *op_{3b}*) runs for a short distance below the nasal bone and then passes through it for the dorsal skin. The fourth branch (see text-figs. 1, 8, *op₄*) passes downwards by the side of the septum nasi and then through the prevomer for the innervation of the floor of the upper jaw and this branch is comparable with (*op2v*) of Norris and Hughes. The principal branch (*op.*) runs in a canal in the nasal bone and proceeds after passing through a foramen (f. apicale ?) in the premaxilla for the innervation of the snout region giving off during its course a large number of twigs dorsally (see text-fig. 1, *ops.*).

Englehardt (1924) described the ophthalmicus profundus V in *Ichthyophis* as r. nasalis trigeminus from which branches proceeded to skin (Va1), tentacle sac (Va2) and to the snout (Va3, Va4).

In Urodela, the ophthalmicus profundus divides into a minor, a ventral, a lateral and a median branch and the latter two gain exit through the foramina epiphaniale and apicale respectively for the innervation of the snout region. However, it is difficult to recognise similar branches clearly in Apoda and at any rate, in their figure 7q, Marcus, Stimmelmayer and Porsch (1935) indicate the two foramina apparently believing them to be for the two branches of the profundus nerve. Norris and Hughes (1918) while making no mention of the probable comparison with the Urodelan median (nasalis internus) branch, notes that their (*op2v*) and (*op1* partly) are comparable with the ventral and lateral Urodelan branches respectively. However, it is just possible that the branches (*op₁*, partly), (*op.*), (*op₂*) and (*op₄*) of

Uraeotyphlus may find comparison with the ophthalmicus profundus minor, nasalis internus, nasalis externus and ventral branches of Urodela.

The facial nerve.—The facial nerve takes its exit through a separate foramen,—the facial foramen (see text-fig. 6, *ff.*) in the lateral wall, i.e., the prootic portion of the os Basale. The prootic (*prof.*) and facial foramina are separated by a bony prefacial commissure (*pfc.*). The geniculate ganglion (text-fig. 19, *geg.*) is small and extracranial and is separate from gasserian ganglion in the adult¹ while in the young stage examined, the ganglia are united.

No connexion between the gasserian and geniculate ganglia has been shown by Englehardt (1924) in *Ichthyophis*.

The ramus palatinus VII.—The palatine branch arising from the geniculate ganglion enters through the palatine foramen, the palatine canal² (see text-fig. 6, *pca.*) and then runs in association with the carotid artery in the carotid canal and emerges finally with the carotid artery into the cranioquadrate passage from the carotico-palatine foramen (in fig. 6, the bristle enters through the carotid foramen and comes out through the carotico-palatine foramen). The palatine nerve occupies a position below the profundus ganglion which is situated anteriorly and this is maintained till the ophthalmicus profundus is differentiated when a few fibres from the latter enter into the palatine (Pl. V., fig. 5). This anastomosis is an important feature for in no apodan form studied so far, a nervous connexion between the two is described, though de Jager (1939) makes mention of such an anastomosis in *Dermophis* on one side only. In Urodela and Anura, this anastomosis commonly occurs. In the region of the tentacular muscle, the ramus palatinus in *Uraeotyphlus* is separated from the ophthalmic branch by this muscle. The palatine anteriorly divides into a median (see text-fig. 10, *pf*₁.) and a lateral branch (*pf*₂.). A small twig arising from the maxillary branch of trigeminal meets temporarily the lateral palatine branch; more anteriorly, another division of maxillary fuses with the median palatine. The composite palatine branch (*pf*₁*max*_b.) runs in the choana region while the lateral palatine (*pf*₂.) runs dorsally and then ventrally to the maxillopalatine (see text-figs. 3, 9, *pf*₂.) to the anterior region. The anastomoses between the palatinus facialis and maxillary V are noticed only in Anura. The further distribution of the ramuli of these is as described by Norris and Hughes (1918) i.e., (*pf*₂.) to choanal epithelium and maxillary teeth and (*pf*₁*max*_b.) to medial wall of choana, roof of mouth and vomerine teeth.

In *Ichthyophis*, *Scolecormorphus*, *Boulengerula* and *Herpele* the palatine nerve first runs in the palatine canal of os Basale and then assumes the usual condition. This feature of the passage of the palatine in the os Basale for a short distance is not noticed in other examples viz., *Dermophis*, *Caecilia* and *Geotrypetes* (Norris and Hughes 1918).

A minute ganglion at the junction of the lateral branch of the palatine with the maxillary V is described in *Dermophis*, larva of *Ichthyo-*

¹ This seems to be a variable factor, for in an adult individual while on one side there is a connection between the extracranial facial and gasserian ganglia, no connection is noticed on the other side.

² This may be a canal or a groove in *Uraeotyphlus*; further the palatine branch on one side does not enter the palatine canal in one of the specimens studied.

phis and *Herpele*. I have not been able to detect a similar ganglion in adult *Uraeotyphlus* and in *Geotrypetes* it is apparently absent according to Norris and Hughes (1918). In the young stage of *Uraeotyphlus* that I have examined, it is noticed that the lateral branch (*pf*₂) before it receives a branch from the maxillary V (*max*_b) enlarges into a ganglion,—the palatine ganglion. Obviously this is purely a larval feature for, in both *Ichthyophis* and *Uraeotyphlus* larvae the ganglion is noticed while in the adult it has disappeared. The same is probably the case in *Geotrypetes* where the adult lacks one.

Englehardt (1924) noted that a twig (VIIa1) connected ramus palatinus with gasserian ganglion; the division of the palatine was not noticed. A connexion with maxillary V (Vb3 plus VIIa2) by ramus buccalis facialis and the more anterior union of r. nasalis facialis (palatinus facialis) with a branch of maxillary (Vb5) have also been recorded.

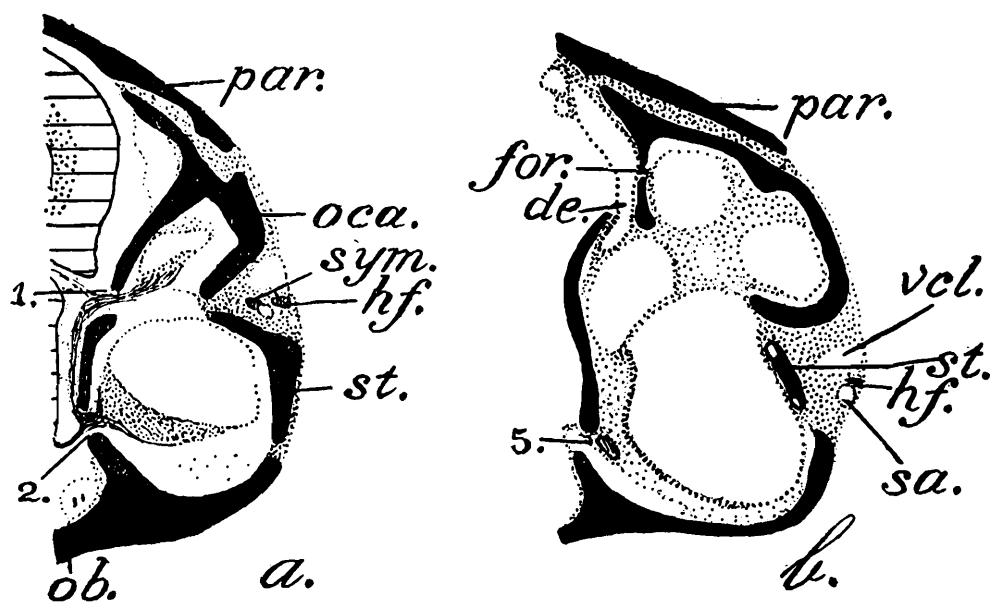
The ramus hyomandibularis VII.—After the separation of the palatine branch, the ramus hyomandibularis (text-fig. 19, *hf*.) arises from the geniculate ganglion (*geg*.) and runs posteriorly and dorsally to the stapes (see text-figs. 7a, b, *hf*.). The first branch given off from the geniculate ganglion uniting with the sympathetic fibres of the gasserian runs posteriorly by the side of the otic capsule in association with the r. hyomandibularis. A slender nerve is now given off from the r. hyomandibularis which running between the MM. depressor mandibulae and l. m. posterior enters a canal in the lower jaw as the ramus alveolaris (chorda tympani) in association with the r. mandibularis internus V. A bigger third proceeds to innervate the M. depressor mandibulae. The main branch,—r. jugularis runs posteriorly supplying the muscles in its course.

In *Ichthyophis* larva a mentalis externus, a jugularis and a third branch which divides into mentalis internus and an alveolaris are described by Norris and Hughes (1918). In the adult, the r. alveolaris arises independently. The origin therefore, of the chorda tympani from the hyomandibular branch in *Uraeotyphlus* differs from that in *Ichthyophis*. In *Dermophis* and *Herpele* (Norris and Hughes 1918), a ramus jugularis is described and it innervates the interhyoideus and constrictor colli muscles as in *Ichthyophis* and *Uraeotyphlus*. In *Geotrypetes* also there is a jugular branch. However, in the descriptions of the cranial nerves of *Dermophis* (*D. mexicanus* and *D. gregorii*) the fate of the hyomandibular is differently described by de Jager (1939). After giving off the r. alveolaris, the hyomandibular divides into three ramuli; the first innervates the M. depressor mandibulae (M. cephalodorsomaxillaris) while the other two are “ultimately lost amongst the branches of IX and X.” No reference is made to the jugularis branch. Englehardt (1924) described three branches (VIIb1, VIIb2, VIIb3) of the hyomandibular but their destination has been incompletely noted as MM. depressor and mylohyoideus.

The ramus ophthalmicus superficialis VII.—At the region of the differentiation of r. mandibularis V, the fibres of the ramus which in its topographical disposition corresponds with what has been described as “ophthalmicus superficialis” by Norris and Hughes (1918) can be made out in the maxillomandibular part of the gasserian ganglion.

Anteriorly, this nerve is disposed dorsally to the maxillary branch (Pl. V, fig. 5, *max.*) and is located between the MM. l. quadrati and l. m. anterior and more anteriorly between the MM. l. m. internus and l. m. anterior (*os.*). It divides into two: the dorsal branch ends in the M. l. m. anterior while the ventral passes dorsally to the muscle and supplies the skin. No motor branch is described by Norris and Hughes (1918) and the anastomosis between branch (*op₁.*) of ophthalmicus profundus and ophthalmicus superficialis VII is also not seen by me.

The auditory nerve.—In *Uraeotyphlus* posterior to the prefacial commissure, the auditory nerve is met with, a part of which is in union with the fibres of the seventh nerve (text-fig. 19, *caf.*). The auditory ganglion (*aug.*) is rather thin and from it ramuli run into the internal ear through the bony septum. The number of ramuli may vary in the same individual as, *e.g.*, in *Ichthyophis* and *Uraeotyphlus*, it may be five or six. In all the Apoda so far examined, the first ramulus supplies the utricular part (text-fig. 19, 1) while the remaining innervate the saccular portion. In *Uraeotyphlus*, the fourth ramulus enters the saccular part (*see* text-fig. 7*d*, 4) in the region of the endolymphatic foramen which is situated dorsally. Figure 7*e* is posterior to the endolymphatic foramen. Two figures (20*a* and 20*b*) are drawn for *Dermophis* to show two ramuli entering in at the same region to the utri-



TEXT-FIG. 20.—*Dermophis gregorii* Boulenger.

Two consecutive transverse sections in the auditory region: $\times 33$.

de., ductus endolymphaticus; *for.*, foramen in the bony septum; *hf.*, r. hyomandibularis facialis; *ob.*, os Basale; *oca.*, otic capsule; *par.*, parietal; *sa.*, stapedial artery; *st.*, stapes; *sym.*, sympathetic nerve; *vcl.*, vena capitis lateralis; 1, 2, 5., auditory orifice for the utricular (1) and saccular nerves.

cular and saccular portions (Fig. 20*a*, 1, 2) respectively and further, foramen 5 (text-fig. 20*b*, 5) is noticed along with the dorsal endolymphatic foramen. While de Jager (1939) has recorded only four ramuli in *Dermophis*, I notice five, of which four innervate the saccular portion. There is one other interesting point in the endolymphatic region of the ear of *Dermophis*. There is a foramen (text-fig. 20*b*, *for.*) in the

septum dorsally to the endolymphatic foramen through which the epithelium of the endolymphatic canal is in contact with the semi-circular canal of the internal ear. I am unable to say at present what exactly is the significance of this. In *Scolecormorphus*, four or five ramuli are noticed. In *Boulengerula*, there are again five and the endolymphatic foramen is between the third and fourth. In *Siphonops*, Wiedersheim (1879) recorded only four foramina.

THE CRANIAL NERVES OF *BOULENGERULA* AND *SCOLECOMORPHUS*.

I shall consider the cranial nerves of the two African genera *Boulengerula* and *Scolecormorphus* together and remark only on the salient features noticed in them.

The intracranial connexion between the geniculate and the gasserian ganglia and in the latter the separate existence of ophthalmicus profundus and maxillo-mandibular parts are known in *Boulengerula*; in *Scolecormorphus* the two ganglia (trigeminal and facial) are connected extracranially and the gasserian ganglion is a composite one.

In Figs. 6a, 6b and 6c drawn by de Villiers (1938) for *Scolecormorphus*, the origin of the trigeminal nerve is clearly shown. However, I have not been able to make out a "ganglion palatinum" in my sections of *Scolecormorphus*.

The first branch to separate itself off from the gasserian ganglion is the ramus mandibularis in *Scolecormorphus* and *Boulengerula*. A ramus mandibularis internus enters the lower jaw and unites with the chorda tympani where a few ganglion cells are noticed (*Boulengerula*). However, de Villiers (1938) denied the existence of a chorda tympani in these two genera. The united branch supplies the skin and tongue muscles in *Boulengerula*. Peculiarly in *Boulengerula* a ramus mandibularis externus is absent, while in *Scolecormorphus* it is prominently present.

There is a ramulus going to the compressor muscle from the ramus maxillaris in both genera; in *Boulengerula*, the r. maxillaris divides into a lateral and a larger medial one and from the latter there is a palatine commissure. In *Scolecormorphus*, the r. maxillaris sends first a palatine commissure and then a small ramulus to innervate the side (comparable with the lateral palatine branch) and the principal branch becomes ventrally disposed to the maxillopalatine and proceeds to the tentacular region.

There are only three branches of the ophthalmicus profundus in *Boulengerula*. The first, running for a short distance in the frontal bone supplies the dorsal skin; a second branch running lateroventrally and gaining exit through the nasopremaxilla-maxillopalatine supplies the anterior skin. The third or the principal branch is enclosed in the nasal portion and distributes itself to the snout. In *Scolecormorphus*, the first branch passes through the frontal as in *Boulengerula*; the second running dorsally to the orbital glands gets exit through the prefrontal; a third innervates the lateral and the tentacular region after passing through the septomaxilla. The fourth running by the side of the septum passes through the prevomer and premaxilla to the snout. The principal branch also innervates the snout.

The facial nerve.—A bony prefacial commissure is present in both genera. The r. palatinus runs for a short distance in the palatine canal in *Boulengerula* and anteriorly the r. palatinus is situated below the ophthalmicus profundus ganglion as in Fig. 8 drawn by de Villiers (1936, p. 237) though his labellings 'em' and 'bV1' should be read as M. retractor tentaculi (instead of eye muscle) and palatinus facialis (instead of branch of ophthalmicus profundus) respectively. The palatine nerve does not divide into lateral and medial branches but however, receives a branch from the r. maxillaris V. De Villiers denied the presence of a palatine branch in *Boulengerula* and in a later paper also he (1938, p. 19) recorded that "The palatine of VII stops short at the sensory ganglion of V in all the four sides available for comparison", and shew no palatine in Fig. 8 (1936, p. 237) or in Fig. 3 (1938, p. 11) and reaffirmed this on page 24 (1938) by saying that the facial has only one branch and, i.e.,—the hyomandibular. In *Scolecormorphus*, there is only one maxillo-palatine anastomosis and the undivided r. palatinus proceeds through the prevomer to the snout.

It must be remarked here that no anastomosis between the ophthalmicus profundus V and r. palatinus occurs in *Scolecormorphus*, though the profundus ganglion is not distinct from the gasserian ganglion.

KINETISM.

I only review in brief the problem of kinetism in Apoda here. The autostylic and mostly monimostylic condition of the cranium noticed in Amphibia was considered primary by K. Fürbringer (1904) who derived it from a Dipnoan one. Later Versluys (1912) who discovered the M. levator quadrati in Apoda described the streptostylic condition among the members of this group as primitive and Luther developed this line. The latter author (1914, p. 12) in homologising the M. l. quadrati with the M. constrictor dorsalis I of fishes came to the same conclusion as Versluys and if however, this condition is derived from the monimostylic Urodela, then the presence of M. l. quadrati becomes questionable.

Edgeworth (1925) after studying a few developmental stages of *I. glutinosus* and a *Siphonops* larva added that the processus ascendens of the quadrate is fused with the orbital cartilage in early stages in *I. glutinosus* and in *Siphonops* "there is a cartilaginous continuity between the quadrate and the lateral process of the basal plate" besides mentioning other points of contact between the chondrocranium and quadrate. Thus he comes to the conclusion that (p. 237) "These phenomena suggest that the streptostylic condition of adult Gymnophiona is not primary, but secondary to an original monimostylic one. The contrary opinion fails to explain the above described structures" It has been pointed out by de Beer (1937) in this connexion that the terms streptostylism and monimostylism are applicable to adult and not larval crania. Obviously, Edgeworth does not take into consideration the observation of Peter¹ (1898) where no processus ascendens connection with orbital cartilage is reported.

¹ Edgeworth mentions that his embryo is younger than the one modelled by Peter and therefore if the latter author had studied the same stage as Edgeworth, it may be surmised that the connection might have been discovered.

According to Marcus, the streptostyly of the Apoda is an ancestral acquisition and in this connexion Marcus, Stimmelmayer and Porsch (1935, pp. 418, 419) point out :—

Heute bin ich überzeugt, dass dem Chondrocranium keine ausschlaggebende Bedeutung für derartig weitgehende Hypothesen zuzusprechen ist, da temporäre Verwachsungen vorkommen, die wieder gelöst werden, so dass jeder sich aussuchen kann, was er für seine Hypothese braucht.

Hueber (1933) described the kinesis in the skull of *Hypogeophis* in detail while pointing out at the same time the primary or secondary nature of the stylism has not engaged his attention. It is recorded that the two segments,—the basal composed of the os Basale and the quadrate comprising the other bones move on each other ; the skull is, therefore, amphikinetic. But Luther (1914) and Lakjer (1927) consider the Apodan skull to be mesokinetic. De Beer (1937) while accepting that the skull of *Hypogeophis* is kinetic in Versluys's sense and is "capable of certain amount of internal movement although the quadrate is fixed to the squamosal" pointed out that the skull must be classified as monimostylic on Stannius's scheme. No doubt the quadrate is firmly bound to the internal aspect of the squamosal, but is certainly capable of some movement and is always separated by a certain amount of connective tissue. The quadrate is never *fused* with squamosal, contrary to what de Beer (p. 426) mentions in the case of *Hypogeophis*. In fact, no Apodan example so far studied is typically monimostylic, all of them being strictly streptostylic. Marcus, Stimmelmayer and Porsch (1935) confirm this when they say (p. 417) that in *Hypogeophis* 'Der Schädel ist hyostyl und streptostyl' Luther (1914) also mentions that the movement of the quadrate is considerably lessened but is not completely lost.

Hueber (1933) while mentioning that the connective tissue between the bones acts as a cushion during burrowing noted however, that since the bones are so closely bound the movement between the bones in a streptostylic sense may not be possible thus implying a functional monimostyly. Stadtmüller (1936) also noted that since the Apodan quadrate was united with squamosal (syndesmotically) or pterygoid, it exhibited "sympektische monimostyly" De Villiers (1938) also mentioned that no movement was possible between quadrate and squamosal and therefore, the quadrate was monimostylic. In all these cases, it is difficult to say if no movement is possible between the quadrate and squamosal ; so long as they are not *fused*, a certain mobility can be expected and as Luther remarks it is only a question of degree. Thus according to me, it is correct to assume that there is not even functional monimostyly and therefore, they are typically streptostylic and kinetic unlike what de Beer (1937) shows in his table on page 426.

According to Hueber (1933) in *Hypogeophis*, the movements of the quadrate and basal segments are possible at these four points :

- (1) processus columellaris (processus oticus) of the quadrate and the stapes (columella),
- (2) processus cultriformis (rostrum) of the os Basale and the pre-vomers,

- (3) processus pterygoideus of the quadrate and the basipterygoid process, and
- (4) os Basale and the parietals.

Of the Apodan genera examined by me none possesses all these four kinetic points. In *Ichthyophis* and *Uraeotyphlus*, the processus pterygoideus of the quadrate and the basipterygoid process are syndesmotically united; in *Scolecomorphus*, a stapes is wanting and therefore, a quadratostapedial articulation is lost though there is a processus oticus; in *Dermophis* (de Jager), the processus oticus and stapedial process are united and therefore, the movement is lost. The significance of the loss of kinetism is that the Apodan skull is slowly becoming akinetic.

SUMMARY AND CONCLUSION.

Summary.—The study of cranial morphology of *Uraeotyphlus* shows certain features in which it differs from its South Indian congener *Ichthyophis*, thereby amply supporting Peters's treatment of *Uraeotyphlus* as a separate genus. The anterior disposition of the tentacle, the absence of an external tentacular fold and the zygokrotaphic condition of the cranium have already been noticed by Peters and other workers.

The new facts which the present study reveals are largely a set of negative features by which *Uraeotyphlus* could be differentiated from *Ichthyophis* and they are :

- (1) The absence of an eminentia olfactoria in *Uraeotyphlus* and therefore the opening of the secondary nose ("Nebennase") more towards the nasal septum.
- (2) The absence of a passage in the stapes of *Uraeotyphlus* for the stapedial artery.
- (3) The absence of a buccal branch of facial nerve in *Uraeotyphlus* and in the young stage examined, the r. mentalis externus VII and r. mandibularis externus V do not run outside the jaw. The origin of the chorda tympani (r. alveolaris VII) is different; while it arises independently from the ganglion in *Ichthyophis*, it is a branch from the hyomandibular nerve in *Uraeotyphlus*.
- (4) The uniform occurrence of an anastomosis between the ophthalmicus profundus ganglion and the r. palatinus facialis in *Uraeotyphlus*. This is an important feature for Norris and Hughes describe that in all Caeciliae, on account of the distinctness of the profundus ganglion from the rest of the gasserian, the palatine anastomosis is transferred from the profundus to the maxillary branch. In *Uraeotyphlus*, the profundus is no doubt a distinct ganglion but possesses both palatino-profundus and palatino-maxillary anastomoses.
- (5) The highly abbreviated embryonic and larval periods and the appearance of adult characters very early in larval life if not in the embryos of *Uraeotyphlus*.
- (6) The shape of the skull; triangular in both *Ichthyophis* and *Uraeotyphlus* but in the latter the apex is more pointed than in *Uraeotyphlus*.

Now, the other important points in the study of the cranial morphology of *Scolecormorphus*, *Boulengerula*, *Dermophis*, *Herpele* and *Uraeotyphlus* may be recounted :

- (1) In *Ichthyophis* and *Uraeotyphlus*, there is a syndesmotic connexion between the basipterygoid process and processus pterygoideus of the quadrate. In *Scolecormorphus* anterior to the palatobasal articulation there is a thick connective tissue strand running from the processus ascendens of the quadrate to the cartilaginous facet of the basipterygoid process; from the same cartilaginous facet arises the M. levator mandibulae posterior instead of from the ventral aspect of the processus pterygoideus. Thus in *Scolecormorphus*, while one kinetic muscle (l. quadrati) is absent, the other (l. m. posterior) extends between the basipterygoid process and the lower jaw instead of between the processus pterygoideus and the lower jaw.
- (2) In *Boulengerula*, the stapedia artery passes through a passage in the stapes.
- (3) In *Scolecormorphus*, there is a well developed eminentia olfactoria and *Uraeotyphlus* and *Boulengerula* lack it.
- (4) *Ichthyophis* skulls exhibit both crescentic and circular postfrontals; while in those with crescentic postfrontal, the prefrontal and septomaxilla may be separated by the approximation of nasal and maxillopalatine, in those with circular postfrontals, the prefrontal and septomaxilla are always apposed. In *Uraeotyphlus*, the circular postfrontal characterises the adult and the prefrontal and septomaxilla are always separated.
- (5) The number of acoustic foramina range from four to six; in *Boulengerula*, *Scolecormorphus* and *Dermophis*, it may be four or five (de Jager describes only four in *Dermophis*) and in *Uraeotyphlus*, it may be five or six. While the stapes with its footplate is well developed in Apoda, *Scolecormorphus* is the only one to lack it. It is thought (Versluys) that the squamoso-quadrate complex transmits vibrations to the internal ear through the stapes, in which case *Scolecormorphus* even with four or five acoustic innervation, is probably deaf.
- (6) The processus condyloides of the lower jaw is well developed in *Ichthyophis* and *Uraeotyphlus*, feeble in *Herpele*, *Dermophis* and *Scolecormorphus* and absent from *Boulengerula*.
- (7) The degenerate eye is hidden under the squamosal in *Boulengerula* while in *Scolecormorphus* it is directed towards the lower jaw and is not hidden contrary to the descriptions of Nieden and de Villiers.
- (8) Eye muscles are absent in *Boulengerula* and *Scolecormorphus*. In *Dermophis*, eye muscles and optic nerve are well developed contrary to the observations of de Jager. A M. rectus internus is described in *Dermophis* which was denied by Norris and Hughes.

- (9) The double appearance of retractor tentaculi muscle is noticed in *I. monochrous*, *Dermophis*, *Uraeotyphlus* and *Boulengerula*. In *Scolecormorphus* anteriorly the retractor is partly inserted into the tentacle and partly into the tentacular fold.
- (10) There is only genioglossus muscle in the tongue of *Scolecormorphus*, *Ichthyophis*, *Hypogeophis*, *Uraeotyphlus*, *Dermophis*, *Herpele* and *Boulengerula*.
- (11) The intermaxillary glands of Fahrenholz (zwischenkieferdrüse) are present in *Uraeotyphlus* and absent from *Herpele*, *Boulengerula*, *Dermophis*, *Ichthyophis* and *Hypogeophis*. In *Scolecormorphus*, there is a set of postdental glands and dorsally to this, a set of glands resembling very much the dorsal glands is seen. Since topographically this resembles the intermaxillary of *Uraeotyphlus*, this has also been called intermaxillary gland.
- (12) The presence of a Bursa angularis oris in *Scolecormorphus* and a set of oral glands in *Herpele* are recorded.
- (13) In *Scolecormorphus* even though the profundus is not separate from the remaining gasserian ganglion, there is no profundus-palatinus anastomosis contrary to the observations of Norris and Hughes.
- (14) A palatinus facialis is prominently present in *Boulengerula* contrary to the descriptions of de Villiers.
- (15) The dorsal olfactory nerve runs undivided for a long distance in the bony canal of the sphenethmoid in *Boulengerula*.
- (16) The ramus mandibularis externus V is absent as an independent nerve in *Scolecormorphus* and *Boulengerula*.
- (17) The ramus mandibularis internus VII (chorda tympani) is present in *Scolecormorphus* and *Boulengerula* contrary to the findings of de Villiers.
- (18) While Laubmann characterises the tentacle as a "Tastfühler", Marcus regards it as a "Klopffühler" aiding the animal during burrowing in respiration and olfaction. When the anterior nares close up air is led into the olfactory chamber through the nasolacrima ducts. This explanation is applicable in all those cases where the tentacle is not situated directly below the anterior nares but behind it as in *Ichthyophis* and *Hypogeophis*. In *Uraeotyphlus* the tentacle is below the naris and during the act of burrowing (if the surface cryptic life can be described so) when the anterior nares close up the tentacle also cannot function and therefore, no air can be led into the "Nebennase"

Conclusion.—Whether the Apodan skull is primitive and, therefore, bears close resemblance to stegocephalian ancestors or the compactness of the cranium has been acquired secondarily due to a burrowing mode of life is a difficult question to answer. Stadtmüller (1936) mentions in this connection that the ossification of the skull depends upon the use of the head as a borer, but it has already been pointed out that one of the South Indian members, *Ichthyophis*, is not a typical bur-

rower, not digging by the head to lead a subterranean life but lives under rotten vegetation where there is sufficient moisture ; this has been called a " surface cryptic " life. According to Cope (1871), Sarasins (1890), Gaupp (1895), Peter (1898), Luther (1914), Jaekel (1927), Goodrich (1930), Werner (1930-31), Versluys (1931), Edgeworth (1935) and de Beer (1937) the stegokrotaphy has been acquired secondarily. In discussing this question we have only to look for clues in the morphology of bones and not in the internal organs since it is impossible to know anything about the soft anatomy of Stegocephalia.

Marcus and his students following Broili, have come to the conclusion that the Apoda are the surviving members of Stegocephalia having come down to the present times in the tropics on account of their cryptic habits. Amongst other features of primitiveness, it is suggested that the possession of a periorbital ring of bones and an interparietal in *Hypogeophis* recalls the stegocephalian relationship. But the occurrence of an interparietal foramen and bone (Hueber 1933) is not accepted by other workers (Stadt Müller).

De Beer (1937, p. 192) in discussing the evolution of Apoda, remarks that " On the other hand, it is noticed that the postfrontal and supratemporal are lacking in Gymnophiona ; which they would hardly be if these forms were primitive, since these bones are regularly present in reptiles. The complete roofing in Gymnophiona is therefore probably secondarily developed in connexion with the burrowing habit." It is only the supratemporal that is lacking in Apoda and the postfrontal is noticed in the two genera *Ichthyophis* and *Uraeotyphlus*. Probably the supratemporal has been merged in the adjacent bones and such consolidation is not uncommon amongst Apodan examples.

Boas (1914) found fossae in the Apodan skull and compared them with similar ones in Stegocephalia. According to him, the posterior temporal fossa is lost on account of the fusion of the " temporal roof and paroccipital " part while a pteroccipital gap (seen above and below the stapes when viewed from behind) and lower temporal fossa are present. Thus while the presence of a periorbital ring of bones and fossae point towards stegocephalian ancestry, the absence of a separate supratemporal weights against it.

It is interesting to note that the possession of kinetism throws light on the evolution of these forms. De Beer (1937, p. 427) points out that " the very wide distribution among vertebrates of the basipterygoid process as an articulating facet against which the pterygoid bone can move, points towards the kinetic condition as being the primitive one for the bony skull." Thus the Apodan skull being typically kinetic, is necessarily primitive. Further de Beer (1937, p. 198) infers that " The importance of this case of kinetism is that it is associated with a completely roofed skull, thus showing that there is no intrinsic improbability in the view that the Stegocephalia may have been kinetic." The kinetic possibility has already been observed by workers in Stegocephalia (Stadt Müller, 1936, p. 587). With reference to Apoda, this may mean that the roofed skull possesses kinetic points all of which have been acquired from a stegocephalian ancestor or even, though the roofing is secondarily developed due to cryptic habits, yet

the kinetism is retained and therefore the similar stegocephalian skull may also have been kinetic, the latter view put forward by the adherents of the secondary consolidation theory. This naturally leads us to conclude that the kinetism is an ancestral acquisition provided it has not arisen *de novo* in Apoda. Similarly the temporal fossae referred to above.

While the Apoda show these three primitive characters, *viz.*, the possession of periorbital ring of bones, fossae and kinetism, it must also be noted that the cryptic habit is resulting towards greater consolidation of the roofing bones; the formation of a composite nasopremaxilla-maxillopalatine in *Boulengerula* may be cited as an instance. Further, the gradual loss of kinetism is also attributable to it. In *Ichthyophis* and *Uraeotyphlus*, the basipterygoid articulation is lost and is syndesmotomic; in *Scolecormorphus* the quadrato-stapedial articulation is lost since the stapes has disappeared. While one kinetic muscle (l. quadrati) is absent in this, the other (M. l. m. posterior) has changed its point of origin. The quadrate in all these is so firmly bound with the squamosal that the movement between the two is considerably lessened thereby heralding a monimostyly. In other words the primitive Apoda are gradually evolving from a kinetic to an akinetic condition.

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EXPLANATION OF PLATE IV

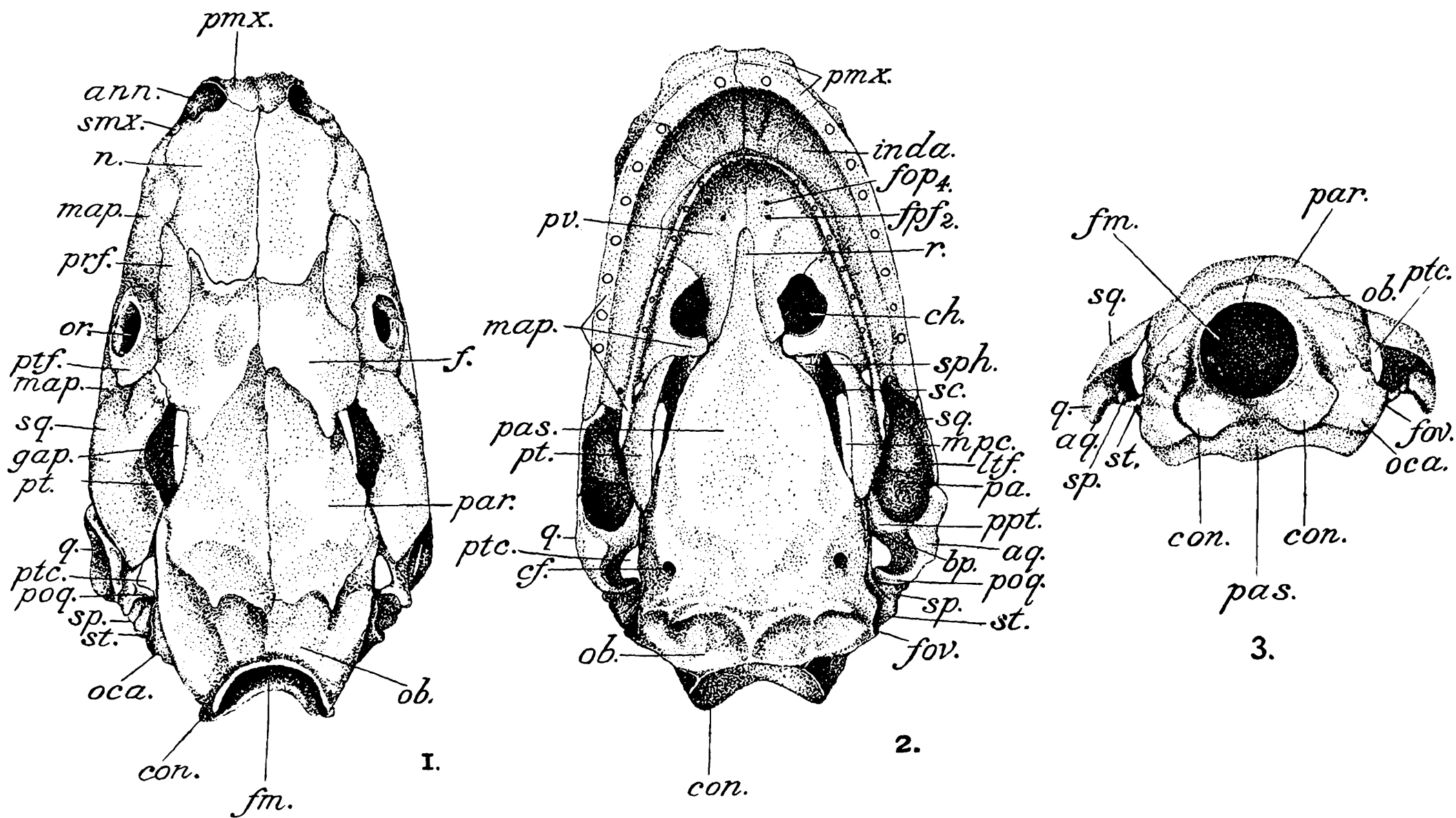
Skull of *Uraeotyphlus narayani* Seshachar.

FIG. 1.—Dorsal aspect : $\times 9$.

FIG. 2.—Ventral aspect : $\times 9$.

FIG. 3.—Posterior aspect : $\times 9$.

ann., anterior nares ; *aq.*, articular facet of the quadrate ; *bp.*, basipterygoid process ; *ch.*, choana ; *cf.*, carotid foramen ; *con.*, condyle ; *f.*, frontal ; *fm.*, foramen magnum ; *fop₄.*, foramen for *op₄.* branch of ophthalmicus profundus V ; *fov.*, foramen ovale ; *fpf₄.*, foramen for lateral palatinus facialis branch ; *gap.*, fossa between squamosal and parietal ; *inda.*, interdental area ; *ltf.*, lower temporal fossa ; *map.*, maxillopalatine ; *mpc.*, mediopalatal cavity ; *n.*, nasal ; *ob.*, os Basale ; *oca.*, otic capsule ; *or.*, orbit ; *pa.*, processus ascendens ; *par.*, parietal ; *pas.*, parasphenoid portion of os Basale ; *pmx.*, premaxilla ; *poq.*, processus oticus of quadrate ; *ppt.*, processus pterygoideus ; *prf.*, prefrontal ; *pt.*, pterygoid ; *ptc.*, pteroccipital cavity ; *ptf.*, postfrontal ; *pv.*, prevomer ; *q.*, quadrate ; *r.*, parasphenoidal rostrum of os Basale ; *sc.*, side of cranium ; *smx.*, septomaxilla ; *sp.*, stapedial process ; *sph.*, sphenethmoid ; *sq.*, squamosal ; *st.*, stapes.



Cranial Morphology of *Uraeotyphlus narayani*.

EXPLANATION OF PLATE V

FIG. 1.—Transverse section of *Scolecormorphus uluguruensis* Barbour & Loveridge in the region of eye : $\times$ ca. 19.

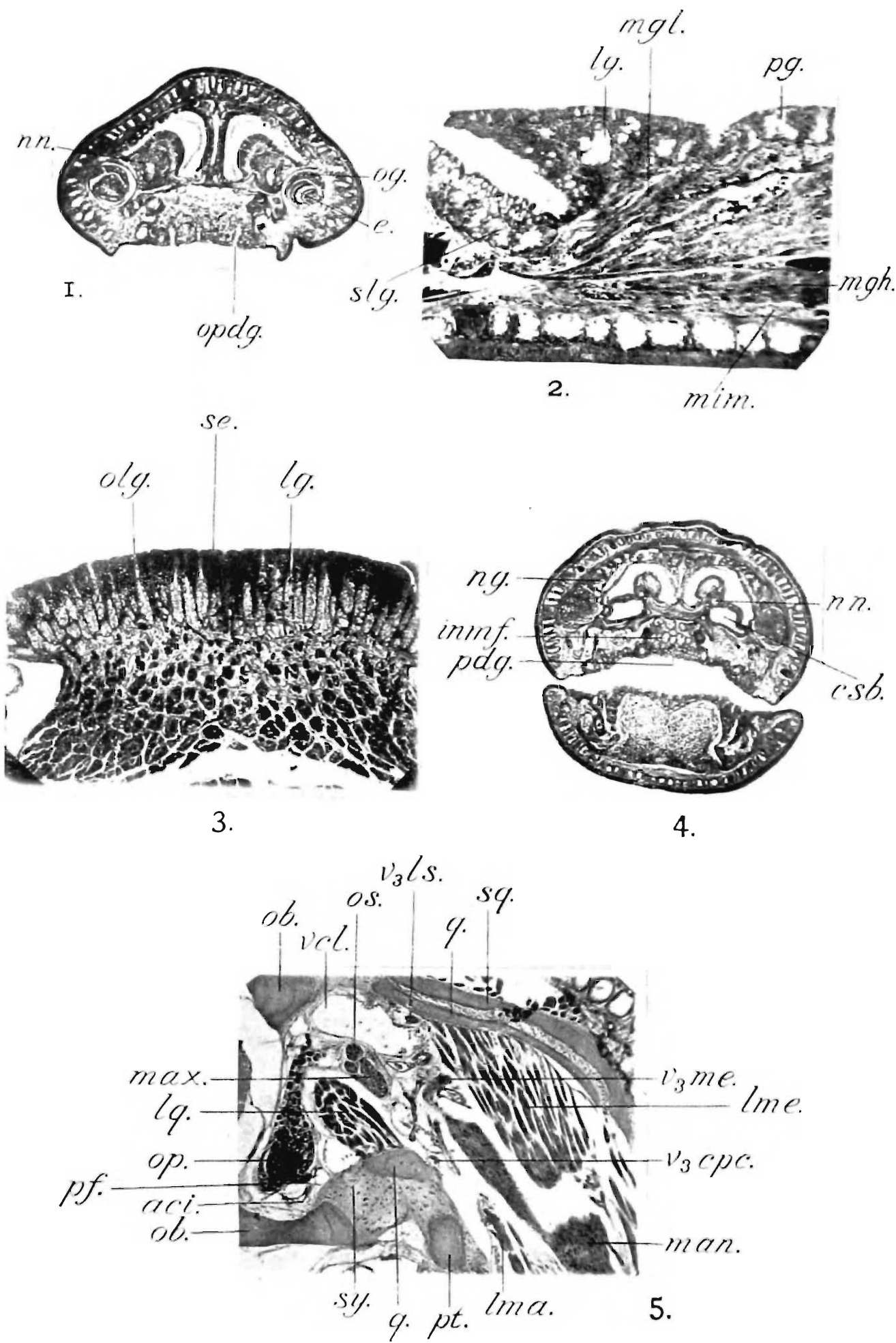
FIG. 2.—Longitudinal section of the tongue of *Ichthyophis glutinosus* (Linn.) : $\times 44\frac{1}{2}$.

FIG. 3.—Transverse section of the tongue of *Ichthyophis monochrous* (Bleek) : $\times$ ca. 14.

FIG. 4.—Transverse section of the head of *Scolecormorphus uluguruensis* Barbour & Loveridge in the eminentia region : $\times$ ca. 16.

FIG. 5.—Transverse section of *Uraeotyphlus narayani* Seshachar in the ophthalmicus profundus region : $\times$ ca. 53.

aci., arteria carotis interna ; *csb.*, "Choanenschleimbeutel" ; *e.*, eye ; *imf.*, intermaxillary gland of Fahrenholz ; *lg.*, lingual gland ; *lma.*, M. levator mandibulae anterior ; *lme.*, M. levator mandibulae externus ; *lq.*, M. levator quadrati ; *man.*, r. mandibularis V ; *max.*, r. maxillaris V ; *mgh.*, M. geniohyoideus ; *mgl.*, M. genioglossus ; *mim.*, M. intermandibularis ; *ng.*, nasal gland ; *nn.*, "Nebennase" ; *ob.*, os Basale ; *og.*, orbital gland ; *olg.*, opening of lingual gland ; *op.*, r. ophthalmicus profundus V ; *opdg.*, opening of postdental gland ; *os.*, r. ophthalmicus superficialis VII ; *pdg.*, postdental gland ; *pf.*, r. palatinus facialis ; *pg.*, pharyngeal gland ; *pt.*, pterygoid bone ; *q.*, quadrate ; *se.*, stratified epithelium ; *slg.*, sublingual gland ; *sq.*, squamosal ; *sy.*, syndesmotic connection ; *vcl.*, vena capitis lateralis ; *v₃cpc.*, branch of r. mandibularis V to "Caput pre-orbitale" and M. compressor orbitalis ; *V₃ls.*, branch of r. mandibularis V to lateral skin ; *V₃me.*, branch of r. mandibularis V to M. levator mandibulae externus.



Cranial Morphology of *Uraeotyphlus narayani*.

EXPLANATION OF PLATE VI.

FIG. 1.—Transverse section of *Uraeotyphlus narayani* Seshachar in the lingual region : $\times 15$.

FIG. 2.—Transverse section of the lower jaw of *Uraeotyphlus narayani* Seshachar : $\times ca. 13$.

FIG. 3.—Transverse section in the choanal region of *Dermophis gregorii* Boulgr. : $\times 15$.

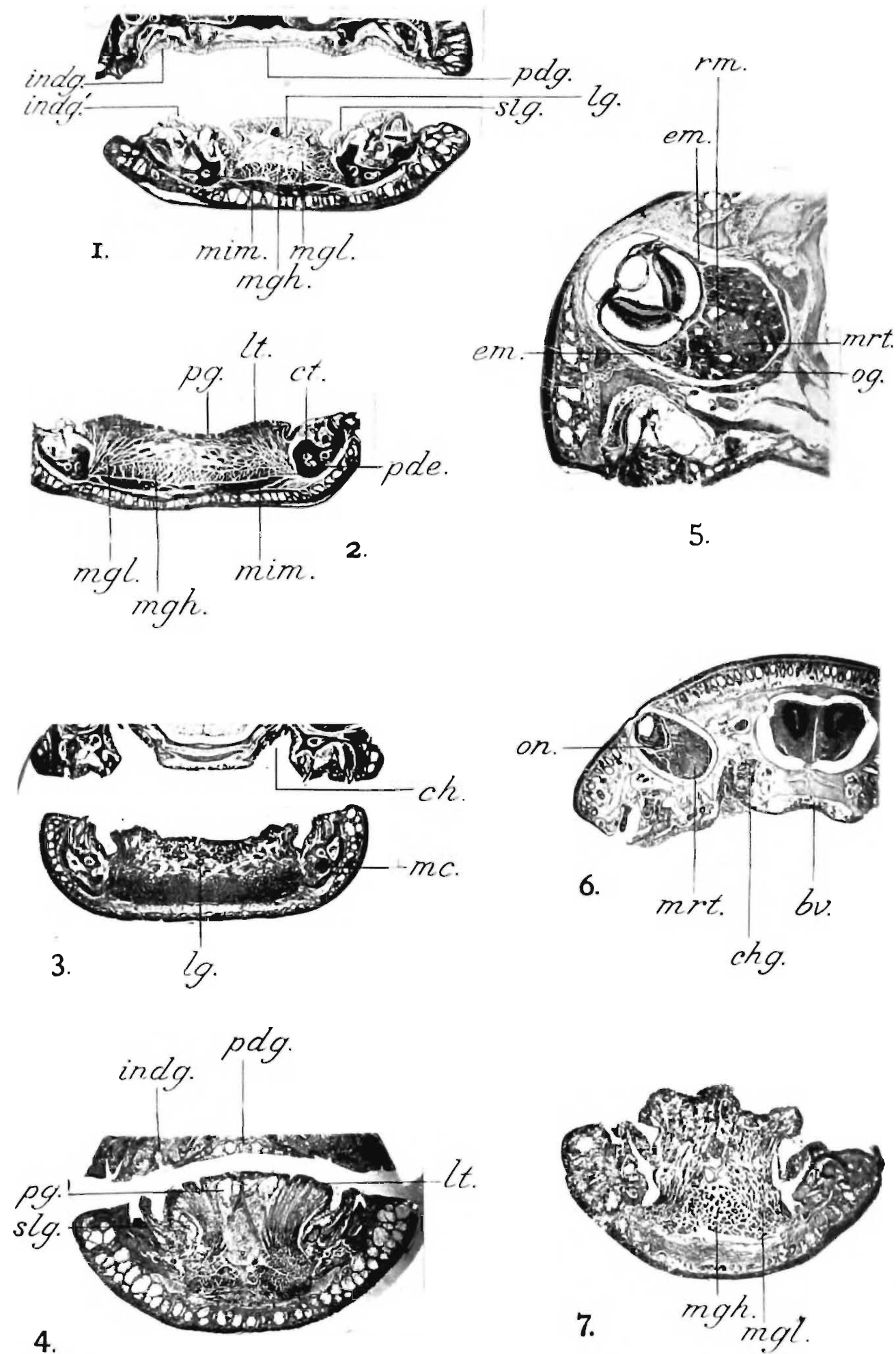
FIG. 4.—Transverse section of the tongue of *Herpele ochrocephala* (Cope) : $\times ca. 14$.

FIG. 5.—Transverse section in the region of eye of *Dermophis gregorii* Boulgr. : $\times 36$.

FIG. 6.—Transverse section in the region of eye of *Uraeotyphlus narayani* Seshachar : $\times 15$.

FIG. 7.—Transverse section in the region of tongue of *Boulengerula boulengeri* Tornier : $\times 24$.

bv., blood vessel ; *ch.*, choana ; *chg.*, choanal gland ; *ct.*, united rami mandibularis internus V and VII ; *em.*, eye muscle ; *indg.*, interdental glands of the upper jaw ; *indg'*, interdental glands of the lower jaw ; *lg.*, lingual gland ; *lt.*, lateral portion of the tongue ; *mc.*, Meckel's cartilage ; *mgh.*, M. geniohyoideus ; *mgl.*, M. genioglossus ; *mim.*, M. intermandibularis ; *mrt.*, M. retractor tentaculi ; *og.*, orbital gland ; *on.*, optic nerve ; *pde.*, pseudodentary ; *pdg.*, postdental gland ; *pg.*, pharyngeal gland ; *rm.*, M. rectus medialis ; *slg.*, sublingual gland.



Cranial Morphology of *Uraeotyphlus narayani*.

A NEW GENUS OF SCHIZOTHORACINE FISHES FROM TRAVANCORE, SOUTH INDIA.

By B. SUNDARA RAJ, *Diwan Bahadur, M.A., Ph.D.* (Liverpool).

(Plate VII)

In this paper a new genus of the Schizothoracine fishes is described from the Periyar Lake, which is an immense irrigation reservoir formed by the damming of the Periyar River, the largest and most important of the rivers of Travancore. It lies at an elevation of 2,709 feet above mean sea level. The Periyar rises in the Shivagiri Forest, on the Cardamom Hills, which form the north-eastern slope of the Western Ghats in Travancore, approximately in Lat. $9^{\circ} 10' N.$ and Long. $77^{\circ} 17' E.$ After a course of 10 miles in a northerly direction to Lat. $9^{\circ} 31' N.$ the river turns due west and flows over a sandy bed for a few miles to Peermade (Pirmed). It then resumes a northerly direction gradually trending westwards, and eventually crossing the Ghats reaches the sea near Cochin. The Periyar Dam is situated in its short east to west reach about 8 miles east of Peermade. The Lake at full supply level has a water spread of 232.80 square miles and a maximum depth of 176 feet. The discharge at the Dam is stated to be equal to half the average flow of Niagara. The Lake is surrounded by an impenetrable, evergreen tropical forest. The average rainfall in Peermade is 198.4 inches annually; it is the highest in all Travancore.

This is the first record¹ of a species of Schizothoracinae from the Tropics. The absence of this subfamily south of the Himalayas and the striking differences between the new genus and all the other known genera of Schizothoracinae might lead one to suspect that the South Indian fish is probably not a member of that subfamily. But the sheath of enlarged scales covering the vent and the base of the anal fin, which is the characteristic feature of that subfamily, and the serrated dorsal spine, the short anal fin and the general form of the fish prove that it is a true Schizothoracine species. The opinion of two leading ichthyologists, Professors L. F. de Beaufort and L. S. Berg, who were consulted, is quite definite. The latter, who is a specialist in the group and who examined a specimen, states :

“The Cyprinoid, as you correctly state, belongs undoubtedly to the Schizothoracinae as is demonstrated by the presence of a scaly sheath at the base of the anal fin and at the anal opening, by its serrated dorsal spine and short anal fin; but it differs from all the known Schizothoracinae in its peculiar scaling and from a lateral line forming a curve on the peduncle. The intestine is rather short and the peritoneum brown (not black). As far as I can judge this genus has affinity neither with *Cyprinus* nor with *Scaphiodon*, both those genera having no scaly sheath at the anal base. It is remotely allied to *Schizopygopsis*.”

¹ Dr. Hora has called my attention to a record in 1935 of an unidentified specimen of *Ptychobarbus* from Hyderabad State (Deccan) in the *Journ. Osmania University* III, p. 37. The occurrence of *Ptychobarbus* in plains is so improbable that the identification is open to serious doubt. Several enquiries made have not succeeded in either tracing the specimen or verifying the identification up to the time going to press.

Lepidopygopsis, gen. nov.

The new genus *Lepidopygopsis* is created to receive the South Indian form which differs from the rest of the Schizothoracinae in having a decurved lateral line on the caudal peduncle and in the arrangement and character of its scales and their number along the lateral line. It bears some resemblance to the genus *Schizopygopsis* Steindachner, from which it is readily distinguished by the presence of scales on the caudal portion of the body, a coarsely denticulated dorsal spine, four barbels and triserial pharyngeal teeth.

Genotype.—*Lepidopygopsis typus*, gen. et sp. nov.

Lepidopygopsis typus, gen. et sp. nov.

(Plate VII, figs. 1-4.)

Local name: “ Brahmana Kendai ” (Tamil).

B. iii; D. 4/7; A. 3/5; V 2/8; P. 1/14 (1/13)¹; C. 19; L. 1. 54-58 (54-60)+2; gill rakers 12 (10-12); Vert. 38.

The body is elongate and compressed. Its greatest depth, which is below the commencement of the dorsal fin, is contained 4.25 (4.1-4.65) times in the standard length. The dorsal profile ascends obliquely from the snout to the base of the dorsal fin almost in a straight line, whence it descends more gently also in a straight line to the base of the caudal fin. The ventral profile is curved up to the base of the anal fin but runs more or less straight along the caudal peduncle. The caudal peduncle is more than twice as long as broad at its narrowest part. The head is conical, moderately large and somewhat compressed; its length is contained 9.4 (4.4-4.9) times in the standard length; its width 1.7 (1.8-2) times and its height 1.4 times in its own length.

The eyes, which are moderately large, round and almost lateral in position, are situated more or less in the anterior half of the head. The diameter of the eye is contained 4.4 (2.8-4.4) times in the length of the head. The eyes are proportionately large in the young. The inter-orbital space is curved and is 1.8 (1.1-1.8) times the diameter of the eye.

The anterior and posterior nasal apertures are close together and are situated dorsally on either side of the snout midway between the tip of the snout and the anterior margin of the eye.

The snout, which is 1.25 (1.2-1.25) times as broad as long, is swollen, bluntly rounded, and overhangs the mouth. Its anterior border is sharp and entire and forms a deep rostral fold with small lateral lobes (Pl. VII, fig. 3). The large preorbitals extend on either side of the snout and end anteriorly in rounded, vertical borders concealing the lateral lobes of the snout. In one of the paratypes there are pearl organs on the snout. Two small rostral and two maxillary barbels are present; these are subequal, each measuring hardly 1.25 (1.12-1.25) of the diameter of the eye. The rostral barbels arise from the lateral lobes of the snout and the maxillary barbels are at the corners of the mouth.

¹ In the description the scale counts and measurements of the holotype, which is the largest complete specimen collected, are given; these are followed within brackets by the range of variation, if any, shown by the paratypes.

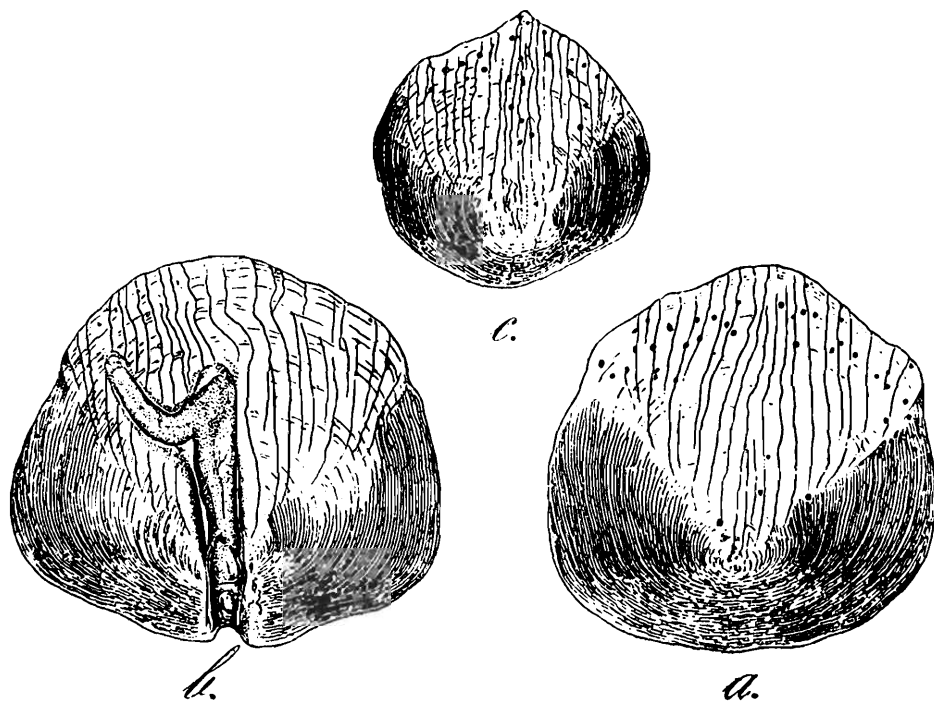
The mouth is inferior, moderately broad and transverse, but curved at the angles. Its cleft is shallow and nearly horizontal. The jaws are feebly protractile. The concealed maxillary does not reach below the anterior border of the eye (it does so in the young). The upper lip, which is thin and loosely invests the upper jaw, is continuous with the lower lip, which is developed only laterally at the curved corners of the mouth. The postlabial groove is broadly interrupted medially. The lower jaw is covered internally by the thin deciduous horny covering with a sharp anterior edge.

The gill opening is wide. It starts dorsally on a level with the upper border of the eye and extends forward ventrally to below the posterior margin of the preopercle. The gill membranes are confluent with the skin of the isthmus. The 10 to 12 short and pointed gill rakers are often curved and are hardly $\frac{1}{2}$ as long as the gill filaments which measure half the diameter of the eye. The pseudobranchiae are well developed and are provided with filaments.

The pharyngeal teeth (Pl. VII, fig. 4) are pointed and hooked and are in three rows 4-5.3.2—2.3.4-5. The anterior edentulous process of the pharyngeal is about $\frac{2}{3}$ as long as the posterior, and the pitted surface is moderately broad.

The alimentary canal is short, about 2.3 times as long as the standard length of the fish. The stomach contents in the specimen dissected consisted of insects, crustacea, diatoms and vegetable matter. The air bladder is of the usual Cyprinoid type and occupies almost the whole length of the body cavity. The peritoneum is brown in colour.

The scales are thin, cycloid, imbricate, and firmly adherent; their greatest diameter being that of the eye. There are no scales on the head, and only a few on the anterior part of the body consisting of a



Scales of *Lepidopygopsis typus*, gen. et sp. nov.

a. From scapular region; $\times 10\frac{1}{2}$; b. From lateral line; $\times 10\frac{1}{2}$; c. From caudal, peduncle; $\times 10\frac{1}{2}$.

patch on the scapular region extending as far as the 6th scale on the lateral line, a few scattered scales on the base of the dorsal spine, a continuous row of enlarged scales along the lateral line and another along the midventral line starting from the base of the ventral fins. This latter at the end of the ventral fins constitutes a row of elongated tile-like scales forming a sheath to the vent and the base of the anal fin. The caudal portion of the body behind the dorsal and ventral fins is completely covered by an even, longitudinal series of scales. There are 26 rows of scales round the caudal peduncle and 54-58 on the lateral line, with two more on the base of the caudal fin. The scales are oval, broader than long in the scapular region, more or less rounded on the caudal peduncle and elongate in the anal sheath. A typical scale from the scapular region is oval and has a broad gently convex base, rounded sides with obsolescent basilateral angles and an obtusely pointed apex. The focus is basal in position. Numerous fine circuli cover the whole scale. They are circular and are packed closely at the base, and more distinctly spaced and somewhat indistinct on the apical field. Unlike other Schizothoracinae only apical radii, about 28 in number, are present. They are fine, weak, and more or less parallel lines running up and causing the apical margin to be crenulate. Only a few radii reach the nucleus.

The lateral line is complete and decurved. It runs concurrently with the ventral profile as far as the middle of the caudal peduncle and thence in a straight line along the midlateral line of the body to the base of the caudal fin. The curvature of the lateral line on the caudal peduncle is a feature peculiar to this genus.

The dorsal fin is short and is situated opposite the ventral fin. The length of its base equals the length of the head without the snout. Its origin is closer to the tip of the snout than to the base of the caudal fin. Its free margin is concave. The last undivided dorsal ray, which is almost as high as the body, is osseous, stout, and strongly denticulated along the two sides of its posterior margin. When depressed the first branched ray, which is the longest, reaches well beyond the tips of the last ray and almost half way to the base of the caudal fin. The anal fin is also short; its base is only 0.75 as long as that of the dorsal fin, and has an obtusely straight free margin. It is inserted about midway between the bases of the ventral and caudal fins. The anal fin is shorter in young specimens. The pectoral fin is roughly falciform, nearly as long as the head (shorter in the young), and when depressed reaches three-quarters of the way to the base of the ventral fin which originates about midway between the bases of the pectoral and anal fins. The ventral fin has a slightly concave free margin and is shorter than the pectoral fin. When depressed it reaches about three-fourths of the way to the anal fin. The caudal fin is as long as the distance between the bases of the ventral and anal fins, and is deeply forked with subequal pointed lobes.

The anus is situated on a short papilla.

In fresh specimens the back is olive brown and the sides and ventral surface of the head and body silvery, the dorsal, the caudal, and the distal half of the anal fin olive green. The terminal half of the dorsal

fin has a broad, indistinct dusky band. The caudal lobes and the anterior margin of the anal fin are dusky. The pectoral and ventral fins are hyaline. The iris is silvery.

Relationships.—The exact position of the new genus among the known genera of the subfamily Schizothoracinae is somewhat obscure. It differs from the rest of the subfamily and approaches the Cyprininae more closely than any other genus of the Schizothoracinae in the absence of the basal radii on the scales, and in having fewer scales along the lateral line, which is decurved on the caudal peduncle. While in the character and number of rows of its pharyngeal teeth and in having the caudal portion of its body completely covered by imbricate scales it shows primitive characters; in the loss of scales on the anterior portion of its body it is specialised. Thus it seems to occupy an intermediate position between the primitive genera *Paratylognathus* and *Schizothorax* and the specialised genera *Schizopygopsis*, *Gymnocypris*, etc.

The new genus and species are described from 13 specimens collected in 1936 and half a dozen collected in 1939 from the Periyar Lake. The largest specimen measuring 170 millimetres in standard length has been selected as the holotype.

Holotype.—F13510/1, Zoological Survey of India (*Indian Museum*), Calcutta, from the Periyar Lake, Travancore.

Measurements in millimetres.

				Holotype.	Smallest paratype.
Standard length	..	..	..	170	75
Depth of body	..	..	..	40	18
Length of head	..	..	..	35	17
Width of head	..	..	..	21	8
Height of head	..	..	..	25	11
Diameter of eye	..	..	..	8	6
Interorbital space		..	..	15	6
Length of snout	..	..	..	12	5
Width of snout	..	..	..	15	6
Length of caudal peduncle		..	..	37	16
Least height of caudal peduncle		..	..	16	7
Length of dorsal fin	..	..	..	43	19
Length of pectoral fin	..	..	..	34	15
Length of ventral fin	..	..	..	30	14
Length of anal fin		..	..	36	13

Zoogeographical Remarks.—The occurrence so far south in tropical India of a solitary Schizothoracine genus related to *Schizopygopsis* of the Indus and Oxus Rivers to the north-west of India extends the known distribution of the Schizothoracinae very considerably. In the present state of our knowledge of Indian freshwater fish it is also one of the very remarkable instances of discontinuous distribution. A possible explanation for the presence of this trans-Himalayan fish on South Indian Hills is not however far to seek.

According to Jordan¹, while trout and white-fish in Canada and New England travel freely from one river basin to another by descending to

¹ Jordan, D. S., *Fishes*, p. 121 (London : 1925).

the lower reaches or the sea, such a passage of a mountain fish under existing climatic conditions is quite impossible further south, for instance, from the Potomac to the James, in Virginia. The conditions in the north, however, show that such a transfer is possible and will occur, provided climatic conditions favour it at any time. It is generally presumed that the glacial age at the close of the tertiary era in the Northern Hemisphere explains the occurrence of isolated Arctic types in the Lakes of Canada, Sweden, Finland, and in the Gulf of Bothnia, though a direct water communication is postulated. Whether peninsular India was subject to Pleistocene glaciation is doubtful, but geologists consider that sufficient evidence exists in the hilltop flora and fauna of the glacial cold of the north being felt on the plains of India¹.

W. T. Blanford, Medlicott and Oldham² state :

“On several isolated Hill ranges such as Nilgiris, Anamalai, Shevaroy and other isolated plateaux in Southern India, and on the mountains of Ceylon, there is found a temperate fauna and flora, which does not exist in the low plains of Southern India, but is closely allied to the temperate fauna and flora of the Himalayas, the Assam range (Garó, Khasi and Naga Hills), the Mountains of Malay Peninsula and of Java.....

“The animals inhabiting the Peninsular and Singalese hills belong, for the most part, to species distinct from those found in the Himalaya and Assam ranges. In some cases even genera are peculiar to the hills of Ceylon, and South India..... There are, however, numerous plants and a few animals inhabiting the hills of Southern India and Ceylon, which are identical with Himalayan and Assamese hill forms, but which are unknown throughout the plains of India.”

After discussing various agencies which might have effected such a distribution, the authors conclude, “The only remaining theory, to account for the existence of the same species of animals and plants on the Himalayas and the hills of Southern India, is depression of temperature.”

The occurrence, therefore, of this Himalayan and trans-Himalayan subfamily of fish in the Travancore Hills is in line with that of other northern types, such as the Nilgiri wild goat, and is explained by the glacial cold which rendered such a dispersal possible.

I wish to express here my great indebtedness to Dr. Baini Prashad and Dr. S. L. Hora of the Zoological Survey of India for their help in connection with this work. The illustrations were prepared under the supervision of Dr. Hora by Babu B. N. Bagchi.

¹ Wadia, D. N., *Geology of India*, pp. 242-246 (London : 1919).

² Medlicott, M. A. and Blanford, W. T., *A Manual of the Geology of India*, 2nd ed. (Revised by R. D. Oldham), pp. 13-16 (Calcutta : 1893).

EXPLANATION OF PLATE VII.

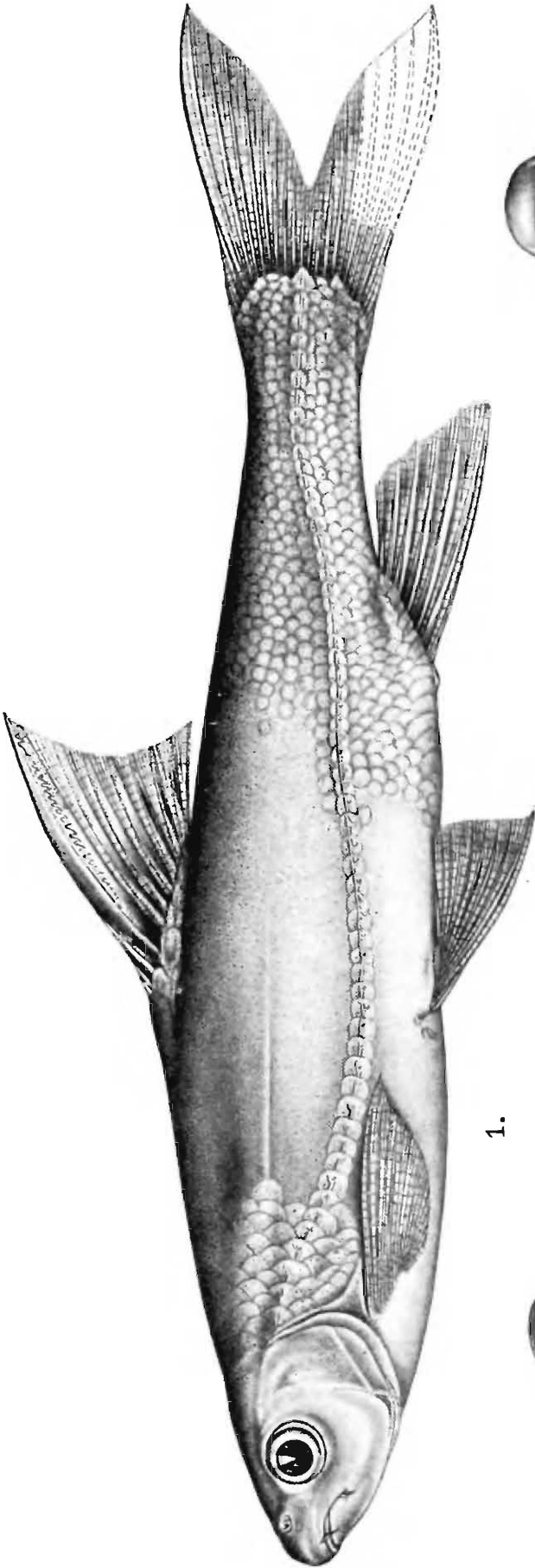
Lepidopygopsis typus, gen. et sp. nov.

FIG. 1.—Lateral view of the holotype : $\times \frac{7}{8}$.

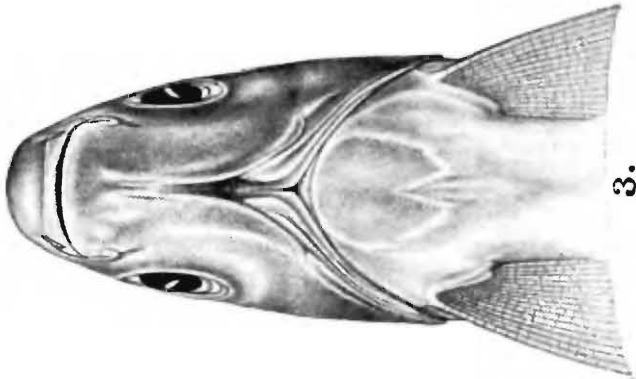
FIG. 2.—Dorsal view of head : $\times 1\frac{5}{16}$.

FIG. 3.—Ventral view of head : $\times 1\frac{5}{16}$.

FIG. 4.—Pharyngeal bones and teeth of a paratype : $\times 9\frac{5}{8}$.



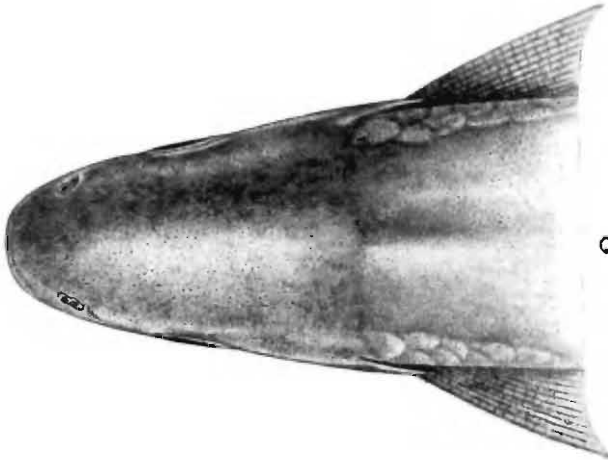
1.



3.



4.



2.

Lepidopygopsis typus, gen. et sp. nov.

E. N. Bagchi, del.

ON THE NATURAL HISTORY OF *KOWALA THORACATA* CUV. & VAL., WITH SPECIAL REFERENCE TO ITS GONADS AND EGGS.¹

By D. W. DEVANESAN, M.A., D.I.C., Ph.D. (London), and V. JOHN, B.A., Fisheries Section, Department of Industries and Commerce, Madras.

The beautiful sardine *Kowala thoracata* Cuv. & Val. yields an important seasonal fishery on the west coast of India, and has consequently been one of the subjects of study in the Marine Biological Station, West Hill, Calicut, since 1930. The species was first described by Cuvier and Valenciennes² under two names *Kowala thoracata* and *Meletta lile*, but Regan³ has shown that the two names refer to the same species for which he selected the name *Kowala thoracata* presumably on the basis of its page priority. Regan gives the range of distribution of this fish as "Kurrachee to New Guinea", while according to Fowler⁴ *Clupeoides lile* is found from "Western India to East Indies and Tahiti".

The fishery of this sardine commences on the West Coast in July and lasts till March. According to the statistics collected by the Department of Fisheries, Madras, on an average about 10,000 maunds valued at Rs. 17,000 are caught annually from the Malabar and South Kanara coasts. It is mostly consumed fresh, but the surplus in the case of heavy catches is salted and dried.

Food.—*Kowala thoracata* feeds on plankton. The following organisms have been found in its stomach-contents :

I.—*Zooplankton*.—(1) Copepods consisting chiefly of *Paracalanus* sp., *Acartia* sp., *Oithona* sp., (2) *Evadne* sp., (3) Crab-Zoea, (4) Larval bivalves, and (5) Fish-eggs.

II. *Phytoplankton*.—(1) Species of *Coscinodiscus*, such as *C. jonesianus*, *C. gigas* var. *dioramma*, and *C. oculus-iridis*, (2) *Fragilaria* sp., (3) *Chaetoceras lorenzianum*, (4) *Thalassiothrix nitzschoides*, (5) *Ceratium massiliense*, (6) *Peridinium depressum* and *P. ovatum*, (7) *Tintinnus* sp., (8) *Dinophysis homunculus*, and (9) *Biddulphia* sp.

Kowala thoracata appears to be destructive to fish-eggs and in one instance its food was found to consist mainly of eggs of the South Indian mackerel, *Scombrus microlepidotus*. It is very likely that it follows spawning shoals of fish and feeds on their eggs. This may be responsible for the natural fluctuations in the abundance of the fishes on whose eggs it feeds.

Size, Maturity and Spawning Season.—Specimens ranging from 60 mm. to 120 mm. in length have been collected. Day⁵ mentions that the species attains "about 4 inches in length". Young specimens less than 60 mm. have not been found in the commercial catches.

¹ Published with permission of the Director of Industries, Madras.

² Cuvier, G. and Valenciennes, A., *Hist. Nat. Poiss.* XX, p. 363, 378 (1847).

³ Regan, C. T. *Ann. Mag. Nat. Hist.* (9) X, p. 588 (1922).

⁴ Fowler, H. W., *The Fishes of Oceania, Mem. Bernice P. Bishop Mus.* X, p. 31 (1928).

⁵ Day, F., *Fishes of India*, pp. 638, 639, pl. clxii, fig. 1 (1878).

Fish measuring 100-110 mm. formed the bulk of the specimens sampled and examined. Sexual maturity is attained when the fish reach a length of about 90 mm.

Specimens partly or fully spent were seen in February 1936. In December 1938, female specimens with fully mature transparent ova were obtained. It may, therefore, be inferred that spawning season of this sardine roughly ranges between the months of November and February.

Reproductive organs and eggs.—The left ovary and the left testis only are functional. The right ovary and the right testis are vestigial, as sections showed neither oogonia nor spermatogonia respectively. One would expect this character to be included among the generic characters of the genus *Kowala*, but the fact that it has not been done indicates that this has not been noticed previously. A sinistorse emphasis in the organisation of animals is found in other groups as well, as for instance, in the survival and development of the organs on the left side of the Echinoderm larvae, the functioning of the left ovary and oviduct in Aves, and the functioning of the left ovary in Monotremes. In the last two cases the males are not affected, whereas in *Kowala thoracata* both sexes are affected. This phenomenon of sinistorse emphasis coupled with the dexteratropy either in one sex or in both sexes is not easy to explain. What factors were instrumental in the organs of one side in the ancestors of a bilaterally symmetrical animal becoming reduced and those of the other better developed, and why should the left have got the stress and not the right? These are problems for the animal physiologists and embryologists.

On 1st December, 1938, female specimens with mature transparent ova occurred in the catches. Artificial fertilisation resulted in the formation of the vitelline membrane indicating perhaps fertilisation. The fertilised egg is a typical clupeoid egg with vacuolated yolk and a large space between the egg-proper and the vitelline membrane. A number of yellow oil-globules are found in each egg, the number varying from four to eight. The entire egg including the perivitelline space measure about 0.8 mm. in diameter. The number of eggs on an average in a ripe female is about 8,000 which is a comparatively low figure for a clupeid. Even making allowance for the atrophy of the right ovary, the fecundity of this sardine is low when compared with that of the herring (*Clupea harengus*) and the pilchard (*Clupea pilchardus*) which lay about 30,000 and 60,000 eggs respectively.

A NEW GENUS AND SPECIES OF NEMATODES PARASITIC IN A "PIKA" FROM AFGHANISTAN.

By S. A. AKHTAR, *Professor of Biology, Faculty of Medicine, Kabul.*

A specimen of a rodent locally known as "pika" (*Ochotona* sp.) captured from a hill near Surchashma (a village at the source of Kabul river and about 60 miles south west of the city) was on dissection found to be heavily infected with small white nematode worms in its large intestine.

The worms belong to the family Oxyuridae Cobbold, 1864; and the subfamily Oxyurinae Hall, 1916. They exhibit affinities with the genus *Dermatoxys* Schneider, 1866; in having an oesophageal bulb, caudal alae in males and in the form of tail in the females and the shape of the eggs. They also resemble to some extent the genus *Protozoophaga* Travassos, 1923, in having a circumoral membrane supported by cephalic papillae. They, however, differ markedly from both the genera in the mouth being surrounded by six distinct, small, bilobed lips and in the absence of cervical alae, valvular apparatus and the wide oesophageal cavity. There are neither comb-like crests on the ventral surface nor a terminal process in the males. These differences are of sufficient importance for the creation of a new genus *Labiostomum* for these worms, which appears to be intermediate between the genera *Dermatoxys* and *Protozoophaga* referred to above.

Labiostomum, gen. nov.

Mouth hexagonal, surrounded by six bilobed lips, each supported by chitinous bars; cuticle of the head region inflated all round to form a well-defined cephalic bulb, supported by many cephalic papillae; oesophagus long, club-shaped, followed by a bulb, separated from the rest by a constriction, and without a valvular apparatus. *Male*: tail short, ending in a blunt point; caudal alae long and narrow, with a number of papillae close to the anus; spicule short, lightly chitinated; gubernaculum absent. *Female*: tail long, gradually tapering; vulva in front of the middle of the body; oviparous; eggs asymmetrical with rugose shells, and a plug at one pole.

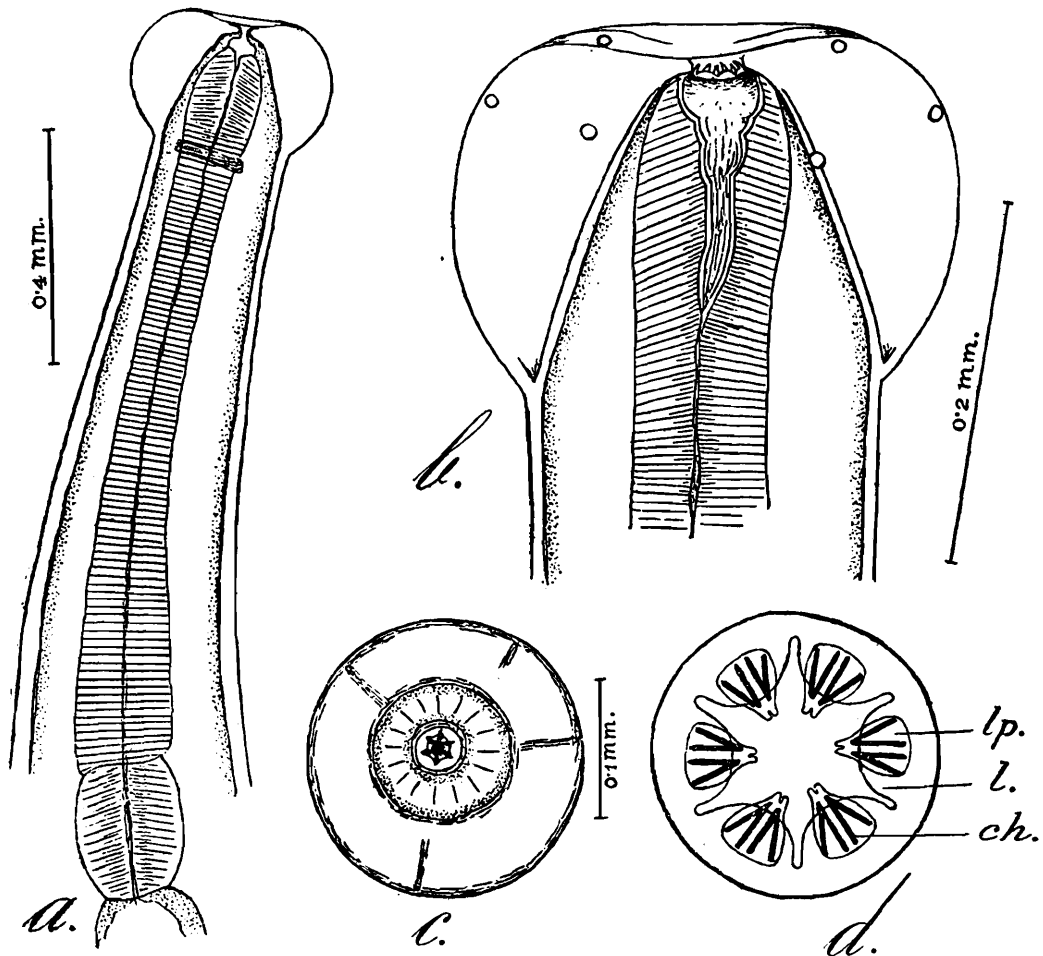
Genotype.—*Labiostomum naimi*, gen. et sp. nov.

Labiostomum naimi¹, gen. et sp. nov.

Body is cylindrical, finely striated transversely and with lateral alae. The cuticle of the head region is inflated to form a well-defined cephalic bulb, supported by about six cephalic papillae. Mouth hexagonal, surrounded by six small, conical and bilobed lips, each of which is supported by four chitinous bars, two placed laterally and two medially

¹ The species is named after H. E. Sardar Mohd. Naim Khan, Minister of Education, Afghanistan.

near each other. Buccal cavity present; oesophagus club-shaped with a distinct posterior bulb, separated from the rest by a constriction. The bulb is without a valvular apparatus, and the intestine is simple and straight. The nerve ring is situated a little above the termination of the cephalic bulb or near the beginning of the narrow lateral alae.



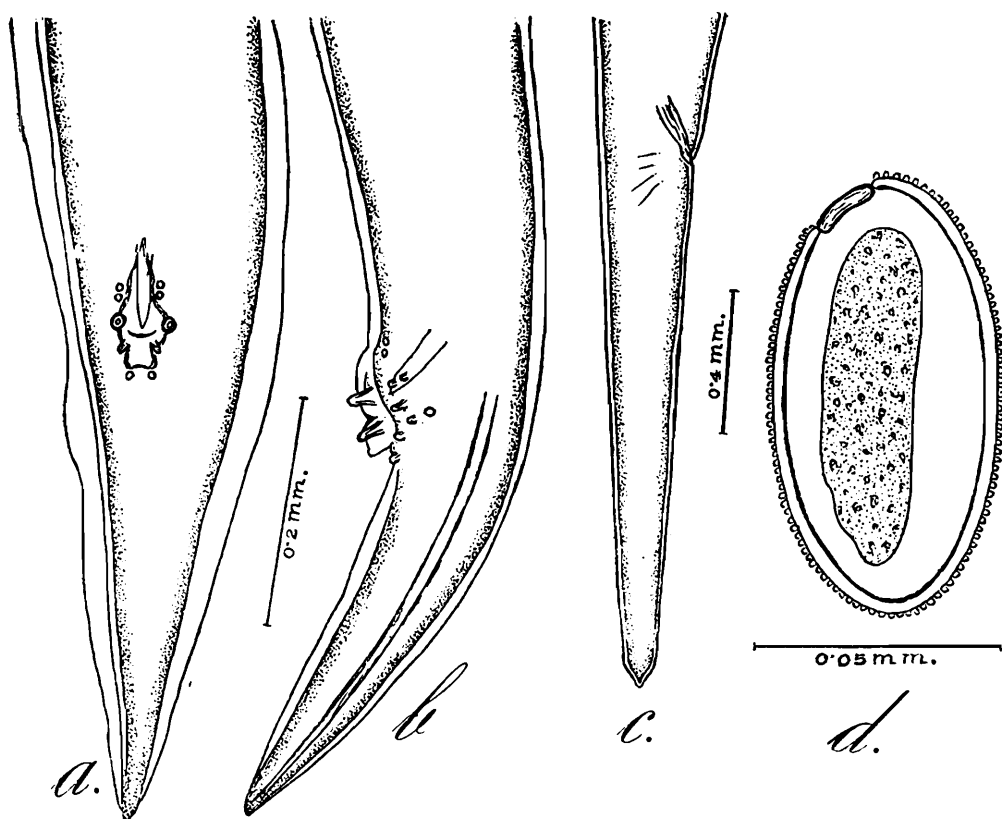
Text-fig. 1.—*Labiostomum naimi*, gen. et sp. nov.

a. Anterior extremity of female, lateral view; b. Anterior extremity of female, lateral view, more enlarged; c. Head, front view; d. Mouth, front view, diagrammatic.

ch., chitinous bar; l., ledge; lp., lip.

The male is smaller than the female; it is 3.397 mm. long and 0.283 mm. thick. The diameter of the cephalic bulb is 0.245 mm. The length of the vestibule is 0.020 mm. and that of the oesophagus 0.832 mm. The posterior bulb is 0.150 mm. in length and 0.130 mm. in diameter. The length of the tail is 0.436 mm. The tail is short, alate and incurved; it ends in a blunt point. The caudal alae are long and narrow. The spicule is short and lightly chitinised, it is 0.067 mm. long. The gubernaculum is absent. The caudal papillae are grouped in the vicinity of the cloaca where the cuticle is somewhat thicker. There are about eleven pairs of caudal papillae with the following arrangement:—Five pairs pre-anal, three pairs ventral and two pairs lateral; three pairs adanal, situated rather laterally; and three pairs post-anal, one pair

lateral and two pairs ventral. The papillae of the third pre-anal pair and the first post-anal pair are larger than others.



TEXT-FIG. 2.—*Labiostomum naimi*, gen. et sp. nov.

a. Posterior extremity of male, ventral view; b. Posterior extremity of male, lateral view; c. Posterior extremity of female, lateral view; d. Egg.

The female is 14.960 mm. long and 0.445 mm. thick. The cephalic bulb is 0.290 mm. in diameter. Narrow lateral alae extend posteriorly to the level of anus. The vestibule is 0.025 mm., and the oesophagus 1.333 mm. long. The posterior bulb is 0.183 mm. long and 0.143 mm. thick. The vulva is prominent and situated at a distance of 6.867 mm. from the anterior end of the body. The tail is long and ends into a short blunt cone. Its length is 1.240 mm. The eggs are asymmetrical with rugose shells and a plug at one pole, measuring 0.090 x 0.043 mm.

Type-specimen.—No. W 3443/1, Zoological Survey of India (*Ind. Mus.*), Calcutta.

HOMALOPTERID FISHES FROM PENINSULAR INDIA.

By SUNDER LAL HORA, D.Sc., F.R.S.E., F.N.I., Assistant Superintendent, Zoological Survey of India, Calcutta.

(Plate VIII.)

In 1920¹, attention was directed to the great confusion that prevailed in the taxonomy of the Indian species of the family Homalopteridae, and three distinct genera were recognised on the basis of the form of the pectoral fins and head, the nature of the lips and barbels, the general shape of the body and the number of rays in the pectoral fins. For the species found in Peninsular India, a new genus *Bhavanian* was proposed but unfortunately at that time no attention was paid to the nature of its gill-openings, which in *Bhavanian* are restricted above the bases of the pectorals, a feature unique among the Homalopterinae. In my² general revision of the Homalopteridae, *Bhavanian* was treated as a synonym of *Homaloptera* van Hass., for I had then examined several species of *Homaloptera* in various collections in which the head was broad and rounded like that of *Balitora* and approached the condition found in *Bhavanian*. However, in 1937³, when examining a series of well preserved specimens collected from a stream on the road-side between Kottigehar and Balehonnur, Western Ghats, Mysore State, the gill-opening was found to be very small and restricted above the base of the pectoral fin. The earlier material referred to *Bhavanian* was found to be of the same nature. This led me to revive the genus on this very important character.

Recently, Mr. S. Jones, at my request, sent me a small collection of freshwater fishes from Travancore, and in this lot, besides specimens of *Bhavanian*, a number of specimens with the gill-openings extending to the ventral surface for a short distance were also found. These examples are remarkable in several respects and for their reception a new genus *Travancoria* is proposed in this paper.

At my request, the Superintendent, Government Museum, Madras, sent me the only specimen of the Homalopteridae in the collection under his charge. The small specimen was collected by Dr. F. H. Gravely at Sivasamudram (alt. 1,500-2,000 ft.), Mysore, in May 1921, and belongs to *Balitora* Gray. In fact, it is closely allied to *B. brucei* Gray, a species of the Assam Hills and the Eastern Himalayas; but the head is more pointed, the body is not so flattened and the number of unbranched rays in the pectoral fins is less. In these respects, it agrees with the Burmese variety⁴ of the species, but till more material of this form becomes available for comparison I propose to describe it as a new variety of *B. brucei*.

¹ Hora, S. L., *Rec. Ind. Mus.* XIX, pp. 195-207 (1920).

² Hora, S. L., *Mem. Ind. Mus.* XII, pp. 274-277 (1932).

³ Hora, S. L., *Rec. Ind. Mus.* XXXIX, p. 11 (1937).

⁴ Hora, S. L., *Mem. Ind. Mus.* XII, p. 291, pl. xi, fig. 6 (1932).

In view of considerable fresh material having been obtained of *Bhavan*ia from several parts of Peninsular India, a complete definition of the genus and a revision of its species is also included. In order to define the systematic position of the three South Indian genera, a key to all the known genera of the Homalopterinae is given below.

Key to the genera of the Homalopterinae.

- I. Gill-opening small, situated entirely above base of pectoral. (Two anterior rays of pelvic fin simple.) *Bhavan*ia.
- II. Gill-opening of moderate size, extending to ventral surface for short distance.
 - A. Two anterior rays of pelvic fin simple.
 - 1. Rostral groove in front of mouth absent or very poorly developed; rostral fold absent or very slightly developed (Lips simple, continuous and without papillae). *Homaloptera*.
 - 2. Deep rostral groove in front of mouth present, overhung by rostral fold.
 - a. Seven or more rostral barbels arranged in two series; lips simple, continuous at angles of mouth; lower lip with a separate median portion followed by two prominent papillae. *Travancoria*.
 - b. Four rostral barbels in one row; lips, especially the upper strongly papillated; both lips continuous; lower lip not followed by medially situated papillae.
 - i. Two barbels at each angle of mouth; 7-8 anterior rays of pectoral simple; body sub-cylindrical with flattened ventral surface; snout pointed. *Sinohomaloptera*.
 - ii. One barbel at each angle of mouth; 9-10 anterior rays of pectoral simple; body greatly depressed and flattened; snout rounded and trenchant. *Balitora*.
 - B. Three or more anterior rays of pelvic fin simple.
 - 1. Pelvics free from each other, not united to form a disc-like structure.
 - a. Tail long and slender; least height of caudal peduncle less than diameter of eye; lips fimbriated; 3 barbels at each angle of mouth. *Lepturichthys*.
 - b. Tail stout and deep; least height of caudal peduncle greater than diameter of eye; lips papillated; 2 barbels at each angle of mouth. *Hemimyzon*.
 - 2. Pelvics united posteriorly to form a disc-like structure. *Sinogastromyzon*.

Of the three genera known from Peninsular India, *Bhavan*ia is more widely distributed along the Western Ghats having been recorded from the Malabar Hills, Wynaad, Nilgiris, Mysore and Travancore. *Travancoria* is so far known only from the Travancore Hills; it has been found in streams within a radius of about 5 miles of Pampadampara, Peerumedu Taluq, Travancore. *Balitora* is known from the Mysore State, besides north-east Bengal, Chittagong Hill Tract, Assam and Burma.

As a group, the Homalopteridae are extensively distributed in the hills of south-eastern Asia, but in India proper they are found in the hills of Assam and Chittagong, in the Eastern Himalayas as far as the

Tista River System, and in the hills of Peninsular India. In 1932, I (*loc. cit.*, p. 288) was unable to explain how the Homalopteridae spread from the Assam Hills to the Western Ghats, but since then I have adduced evidence to show that the torrential fauna of the north-east spread along the Satpura Trend to south-west. The discovery of another new genus of Homalopterid fishes from South India and the extension of the range of *Balitora* to Peninsular India lend additional support to a large-scale migration of the hill-stream fauna along the route stated above.

In describing a remarkable new genus of Schizothoracine fishes from the Periyar Lake, Travancore, Sundara Raj² made remarks on the zoogeographical significance of his discovery. He has followed the views of Medlicott, Blanford and Oldham³ and their conclusion that "The only remaining theory, to account for the existence of the same species of animals and plants on the Himalayas and the Hills of Southern India, is depression of temperature." The glacial cold may have helped in the dispersal of the terrestrial fauna from the north to the south, but without direct water communications between the two areas it is difficult to believe that mere depression of temperature could influence the dispersal of aquatic fauna to such distant places as the Himalayas and the hills of Travancore. Moreover, for the dispersal of the torrential Homalopteridae we not only require direct water communication between the Eastern Himalayas (Homalopteridae are not found to the west of the Tista Drainage) and the southern portion of the Western Ghats, but also torrential waters between these two areas, for which one has to postulate a connected chain of hills. This condition is fully satisfied by the Satpura Trend theory advanced by me in recent years and referred to above.

Both *Bhavanina* and *Travancoria* are *Balitora*-like in their general facies, nature of paired fins, and the characters associated with the mouth, such as rostral groove, rostral fold, etc. There would thus appear to be a close association of the South Indian forms, and it is probable that these three genera developed along independent lines from a common *Homaloptera*-like ancestral form. The isolation of the Peninsular forms from the main stock of the family for a sufficiently long time seems to have induced in some of them characters which are not found in any other member of the Homalopterinae but are only paralleled among the Gastromyzoninae, which spread more towards east and south from the central highlands of south-eastern Asia.

I wish to express my great indebtedness to Mr. S. Jones, Dr. C. C. John, Prof. A. Subba Rau and Mr. B. S. Bhimachar for their kindness in making collections of freshwater fish for me in Travancore and Mysore. Besides enriching the national collection at the Indian Museum; these have enabled me to describe several new and little known forms from among them. I am also grateful to the Superintendent, Government Museum, Madras, for the presentation of the specimen from

¹ Hora, S. L., *Proc. Nat. Inst. Sci. India* IV, p. 405 (1938).

² Raj, B. Sundara, *Rec. Ind. Mus.* XLIII, pp. 213, 214 (1941).

³ Medlicott, M. A. and Blanford, W. T., *A Manual of the Geology of India*, 2nd ed. (Revised by R. D. Oldham), pp. 13-16 (Calcutta: 1893).

Sivasamudram to the Indian Museum. My thanks are also due to Mr. K. K. Nair for drawing up the tables of measurements and to Messrs. R. Bagchi and B. N. Bagchi for preparing the illustrations.

Bhavana Hora.

1848. *Platyca*, Jerdon (*nec* McClelland), *Madras Journ. Litt. Sci.* XV, p. 333.
 1868. *Homaloptera*, Günther (in part), *Cat. Fish. Brit. Mus.* VII, p. 340.
 1872. *Homaloptera*, Day (in part), *Journ. As. Soc. Bengal* XLI, p. 28.
 1877. *Homaloptera*, Day (in part), *Fish. India*, p. 525.
 1889. *Homaloptera*, Day (in part), *Faun. Brit. Ind. Fish.* I, p. 242.
 1920. *Bhavana*, Hora, *Rec. Ind. Mus.* XIX, p. 202.
 1931. *Homaloptera*, Hora (in part), *Rec. Ind. Mus.* XXXIII, p. 68.
 1932. *Homaloptera*, Hora (in part), *Mem. Ind. Mus.* XII, p. 274.
 1937. *Bhavana*, Hora, *Rec. Ind. Mus.* XXXIX, p. 11.

The head and the anterior part of the body are greatly depressed, while the tail region is compressed from side to side. The ventral surface up to the anal opening is flattened. The snout is broadly pointed and is provided with more or less trenchant margins. The eyes are dorso-lateral, are provided with free orbital margins and are not visible from the ventral surface. The mouth is small, considerably less than half the width of the head, inferior, transverse and lunate. The lips are fleshy and leave the jaw free and partly uncovered; they are continuous at the angles of the mouth but the lower lip is divided into one central and two lateral portions; the middle part is followed by two prominent papillae. In front of the mouth, there is a narrow groove overhung by the rostral fold, from the front margin of which, forming indentations, arise four rostral barbels. Two lappets of the rostral fold curve inwards between the rostral and the maxillary barbels. The rostral groove is continuous with the grooves at the angles of the mouth. The jaws are sharp and covered with a horny substance. The gill-openings are small and restricted to the dorsal surface considerably above the bases of the pectoral fins. The body is covered with small scales which are absent on the ventral surface in front of the anal opening. The scales are provided with short, pointed keels which are continued on the head as series of tubercles. The dorsal and the anal fins are short; the former commences slightly behind the pelvis. The paired fins are horizontal and extensive; the pectoral commences slightly behind the eye and extends to the base of the pelvic which extends beyond the anal opening. Between the bases of the pectoral and ventral fins, the body extends outwards and is broadest in front of the bases of the ventrals. The pectoral is provided with 19 rays, of which 6-8 anterior rays are simple. The ventral is provided with 9 rays of which two are simple. The caudal fin is slightly emarginate and some of the outer rays are fused to form oar-like solid structures.

Genotype.—*Platyca australis* Jerdon (= *Bhavana annandalei* Hora).

Relationships.—Among the Homalopterinae, *Bhavana* is the only genus in which the gill-openings are restricted to the dorsal surface of the head and in this respect its development seems to be parallel to several genera of the Gastromyzoninae, such as *Protomyzon*, *Paraprotomyzon*, *Pseudogastromyzon*, *Sewellia*, *Beaufortia*, *Neogastromyzon* and *Gastromyzon*.

Bhavana australis (Jerdon).

Plate VIII, figs. 1-3.

1848. *Platycaura Australis*, Jerdon, *Madras Journ. Litt. Sci.* XV, p. 333 (Walliar).
 1867. *Homaloptera brucei*, Day (nec Gray), *Proc. Zool. Soc. London*, p. 348 (Wynaad).
 1868. *Homaloptera brucei*, Günther (nec Gray), *Cat. Fish, Brit. Mus.* V, p. 340 (Wynaad : Mr. Day's Collection).
 1872. *Homaloptera brucei*, Day (nec Gray), *Journ. As. Soc. Bengal* XLI, p. 28 (Wynaad).
 1877. *Homaloptera maculata*, Day (nec Gray), *Fish. India*, p. 526, pl. cxxii, fig. 2 (Wynaad specimen figured).
 1889. *Homaloptera maculata*, Day (nec Gray), *Faun. Brit. Ind. Fish.* 1, p. 243 (Wynaad, Nilgiris).
 1909. *Homaloptera maculata*, Jenkins (nec Gray), *Rec. Ind. Mus.* III, p. 289 (Tenmalai, Western Ghats).
 1920. *Bhavana annandalei*, Hora, *Rec. Ind. Mus.* XIX, p. 203, pl. x, figs. 1-3 ; pl. xi, figs. 5-7 (Travancore, Nilgiris and Malabar).
 1920. *Bhavana australis*, Hora, *ibid.*, p. 205, pl. x, figs. 4-6, pl. xi, fig. 8.
 1929. *Homaloptera maculata*, Pillay (nec Gray), *Journ. Bombay Nat. Hist. Soc.* XXXIII, p. 356.
 1936. *Homaloptera maculata*, John (nec Gray), *ibid.*, XXXVIII, p. 710.
 1937. *Bhavana annandalei*, Hora, *ibid.*, XXXIX, p. 11, text-fig. 4 (Western Ghats, Mysore State).

In 1867, Day recorded *Homaloptera brucei* from the Wynaad hills and assigned *Platycaura australis* Jerdon to its synonymy. One of Day's specimens from the Wynaad later served for Günther's description of *H. brucei*¹. However, in 1877, when Day² had obtained specimens of the real *Balitora brucei* Gray from the Darjeeling Himalayas and the hills of Assam, he regarded the Wynaad examples as *H. maculata*, but at the same time included all his earlier references, based on the Wynaad specimens, to *H. brucei* in the synonymy of the real *H. brucei*. Thus a great confusion was created by him in the systematic position and the geographical distribution of the Homalopterid fishes known from the Eastern Himalayas and Peninsular India respectively.

Vinciguerra³ found considerable difficulty in determining his Burmese examples of *H. brucei*, for he found great discrepancies in Day's earlier and later descriptions of the species and pointed out that the specimens found in the Nilgiri Hills must be regarded as specifically different from the specimens described by Day in the *Fishes of India* as *H. brucei*. In 1920, it was shown by me⁴ that Vinciguerra was correct in his analysis of Day's descriptions and a new genus *Bhavana* was proposed for the South Indian forms. Relying mainly on immature specimens, I recognised two species in this genus, but examination of further material has convinced me that the two species are identical, and the earlier name *australis* must, therefore, be used for them.

Unfortunately Jerdon's description of *Platycaura australis* is rather vague and applicable to more than one species. He stated : —

"Muzzle depressed, snout somewhat pointed ; eyes approximated ; body greenish with irregular spots and blotches of brown and red, and a series of white spots along the sides ; fins greenish, tinged with sienna red and spotted ; caudal with the lobes pointed lower one much the longest ; 4 minute cirri at end of snout, and 2 somewhat fleshy short cirri, one in front of and the other behind the mouth. Length about 2½ inches—D.7, A. 6."

¹ Günther's *Homaloptera maculata* from Assam is in reality *Balitora brucei* Gray.

² Day, F., *Fish India*, p. 526, pl. cxxii, fig. 1 (1877).

³ Vinciguerra, D., *Ann. Mus. Civ. Stor. Nat. Genova* XXIX, pp. 320-335 (1890).

⁴ Hora, S. L., *Rec. Ind. Mus.* XIX, pp. 195-207 (1920).

The nature of the barbels is the only character in the above description which enables this species to be distinguished from the new species described below, for the colouration is more or less similar in the two forms.

In view of considerable fresh material having been obtained from different parts of Peninsular India, the species may now be redescribed as follows :—

D. 2/7-9 ; A. 1/5-6 ; P. 6-8/9-11 ; V. 2/7-8 ; C. 17-18.

Bhavana australis is a *Balitora*-like fish in which the head and the anterior part of the body up to the anal opening are greatly depressed and the ventral surface is flat and horizontal. The tail is broad and compressed from side to side. The dorsal profile is gently arched, the greatest height of the body being in front of the dorsal fin. The head is broad, rounded and almost trenchant ; it is covered with series of short, hard, spine-like growths. The length of the head is contained from 4.37 to 5.42 times in the standard length and from 5.15 to 6.46 times in the total length ; the head is proportionately larger in smaller individuals. The head is almost as broad as long ; its breadth is contained from 1.05 to 1.28 times in its length. The eyes are of moderate size, approximated dorsally and situated in the posterior half of the head ; they are not visible from the ventral surface. The diameter of the eye is contained from 3.88 to 5.59 times in the length of the head, from 1.94 to 3.19 times in the length of the snout and from 1.38 to 2.00 times in the inter-orbital width ; the eyes are proportionately larger in smaller individuals. The nostrils are situated close to the anterior border of the eye ; the anterior nostril is situated in a flap which covers the posterior nostril. The mouth is small, inferior, semicircular and horizontal ; the gape of the mouth is about one-fifth of the width of the head. The lips are well developed and free from the jaws and leave a considerable portion of the jaws uncovered. Both the lips are continuous at the angles of the mouth but the median part of the posterior lip is separated off from the lateral parts and is followed by two prominent barbel-like papillae. The jaws are hard and covered by a horny substance ; the posterior jaw is rounded and shovel-like. Between the anterior lip and the rostral fold, there is a deep groove which is bifurcated near the origin of the maxillary barbel ; the inner branch is continued round the angles of the mouth while the outer branch is continued outwards and backwards. There are 6 short, stumpy barbels, 4 rostral and 2 maxillary. In between the rostral barbels, the rostral fold is produced into lobes and at the sides lappets are formed which cover parts of the rostral groove. The gill-openings are small, spout-like apertures which are restricted above the base of the pectoral fin. The gill-membranes are broad and thick.

The depth of the body is contained from 6.45 to 9.34 times in the standard length and from 8 to 11 times in the total length ; the body is proportionately more elevated in larger specimens. Between the bases of the pectoral and pelvic fins the body becomes broader posteriorly and is almost as wide as the width of the head. The caudal peduncle is well formed ; its least height is contained from 1.55 to 2.28 times in its length. The body is covered with small scales which are absent

Measurements in millimetres.

				Kottigehar, Mysore.	Sethumadai Hills, Mysore.				Kallar Stream, South Travancore.				Pampadampara, North Travancore.	
Standard length	..	..	..	27.1	38.1	46.2	71.0	71.6	67.4	71.8	74.2	77.9	54.9	84.2
Length of caudal	..	..	..	4.8	8.1	D.	D.	D.	14.9	16.2	16.2	16.6	D.	17.2
Length of head	..		..	6.2	8.4	9.4	13.1	14.1	14.0	14.8	15.1	14.9	11.2	15.7
Width of head	..	..		4.9	6.6	8.0	12.0	12.8	12.1	11.6	13.1	13.8	9.2	14.9
Height of head	..	..	..	3.0	3.9	4.8	7.1	6.7	7.1	6.9	6.8	7.4	5.1	8.0
Length of snout	..	..	..	3.1	4.0	5.2	7.8	7.5	7.9	7.9	8.6	8.4	6.2	9.0
Diameter of eye	..	..	..	1.6	1.9	2.0	2.9	2.9	2.6	2.5	2.7	3.0	2.4	3.1
Interorbital width	..	..	..	2.2	2.8	3.0	5.0	5.1	5.0	5.0	5.2	5.5	3.6	5.6
Depth of body	..	..	..	2.9	4.2	6.1	11.0	10.0	9.1	9.2	9.0	10.2	6.0	10.3
Width of body	..	..	..	4.0	5.6	7.9	13.2	12.4	12.9	10.9	12.3	13.1	9.1	13.9
Length of caudal peduncle		..	..	3.1	6.4	8.0	10.3	10.6	11.5	10.8	12.8	11.0	9.0	12.7
Least height of caudal peduncle		..	..	2.0	2.8	4.1	7.0	6.1	6.0	6.4	7.1	7.4	4.5	6.8
Length of pectoral	..	..	..	7.1	9.7	11.0	16.3	18.7	18.6	19.8	20.0	18.8	14.5	21.6
Length of ventral	..	..	..	4.2	8.2	9.0	15.2	15.9	16.0	17.7	17.8	16.1	12.1	19.3
Longest ray of dorsal	..	..	..	5.4	7.6	9.0	13.0	14.7	13.1	13.9	14.4	14.4	10.7	17.5
Longest ray of anal	..	..	..	3.6	5.6	5.9	9.8	10.0	9.6	10.0	10.8	11.5	8.6	12.4

on the head and on the ventral surface as far as the anal opening. There are about 70 to 75 scales along the lateral line. In some specimens, the scales in the anterior region are slightly keeled. The number of predorsal scales is about 30 and there are about 12 to 15 rows of scales above the lateral line and 9 to 10 below it to the base of the pelvic fins. The anal opening is situated in a shallow groove which runs in the mid-ventral line between the bases of the pelvic and anal fins.

The dorsal fin is short and commences slightly behind the pelvics; it is considerably higher than the depth of the body. The commencement of the dorsal fin is nearer to the tip of the snout than to the base of the caudal fin. The anal is similar to the dorsal and commences nearer to the base of the caudal than to that of the pelvic. The paired fins are broad, wing-like and horizontal. The pectorals commence just behind the eyes, are longer than the head and extend almost to the bases of the pelvics. The pelvic fins are similar to the pectorals and, except in very young specimens, are longer than the head; they may or may not extend as far as the anal opening but are separated from the anal fin by a considerable distance. The caudal fin is forked with the lower lobe considerably longer than the upper; except in the young examples, it is longer than the head.

The basipterygium (Pl. VIII, fig. 2) conforms to the Homalopterinae type; it is devoid of lateral horns and is provided with a lateral foramen. The pharyngeal teeth (Pl. VIII, fig. 3) are uniserial, those in the middle of the slender bone are larger. There are about 13 teeth.

The body and the fins are covered with spots which are irregularly distributed on the body while they form regular rows on the fins. In most of the specimens the dorsal surface is dark so the black spots do not show off well, but in the three specimens from Kallar Stream near Trivandrum the ground colour is considerably lighter and in consequence the spots are very prominent.

Distribution.—In the synonymy, localities from which this species has so far been recorded are given. I have now examined more specimens from the Sethumudai Hills, Mysore; Kallar Stream, near Trivandrum, Travancore, and from streams within a radius of 5 miles of Pampadampara, Travancore. It would thus appear that the species is so far known from the hills in the extreme south of Peninsular India.

Travancoria, gen. nov.

The head and the anterior part of the body are greatly depressed and the ventral surface in front of the anal fin is flattened. The snout is narrowly rounded in front and the fishes resemble the narrow-headed forms of *Balitora brucei* Gray described by me¹ from Burma. The eyes are small, dorso-lateral in position and are provided with free orbital margins; they are not visible from the ventral surface. The mouth is small, inferior, transverse and greatly arched. The lips are full, plain and continuous round the angles of the mouth; the middle part of the posterior lip is separated from the two lateral parts and is followed by two well-developed papillae which may appear as short barbels in

¹ Hora, S. L., *Mem. Ind. Mus.* XII, p. 291, pl. x, fig. 6; pl. xi, fig. 6 (1932).

certain specimens. The anterior jaw is covered by the lip, but the posterior jaw is naked, shovel-like, sharp, strong and covered with a horny substance. In front of the mouth there is a deep groove which is bordered anteriorly by the rostral fold and is continued backwards round the angles of the mouth as well as laterally to the sides of the head ; the portion of the groove between the maxillary barbel and the side of the head is partly covered by a hood-like extension of the rostral fold. There are four short and stumpy rostral barbels, and in between these the rostral fold is produced into 3 barbel-like projections. However, the form and arrangement of the barbel-like projections of the rostral fold varies considerably in the specimens examined by me. A pair of similar barbels (maxillary barbels) is situated at the angles of the mouth. The gill-opening is oblique and extends in front of the base of the pectoral fin to the ventral surface for a short distance. The body is covered with small scales which are absent on the head and on the ventral surface in front of the anal fin ; some of the anterior scales on the dorsal surface are provided with simple short keels which are continued forwards on the head as series of tubercles. The dorsal and the anal fins are short ; the former is almost opposite to the pelvic fins. The paired fins are broad and horizontal. The pectoral fin is pedunculate and commences considerably behind the eyes ; it almost reaches the pelvic which extends considerably beyond the anal opening. The body becomes broader posteriorly from behind the bases of the pectorals and is broadest just in front of the pelvics. The pectoral is provided with 15-16 rays of which 6 anterior rays are simple. The pelvic possesses 8-9 rays, of which 2 are simple. The caudal peduncle is well formed. The caudal fin is forked with the lower lobe considerably longer than the upper.

Genotype.—*Travancoria jonesi*, gen. et sp. nov.

Relationships.—This remarkable genus is intermediate in certain characters between *Homaloptera* van Hass. and *Balitora* Gray, while it has special features of its own which distinguish it from all the other genera of the Homalopterinae. In the form of the body it resembles certain varieties of *Balitora*, but fewer simple rays in the pectoral fins, simple lips, form of the rostral groove and the barbel-like projections on the anterior rostral fold help to distinguish the two genera. From *Homaloptera*, it differs in the possession of a rostral groove and the additional 3 barbels on the rostral fold. In having a posteriorly forked rostral groove, the new genus resembles *Parhomaloptera* Vaillant which belongs to the Gastromyzoninae. The only other genus of the Homalopterinae in which the pelvic fins are provided with two simple rays is *Sinohomaloptera* Fang ; it possesses a rostral groove but its lips are papillated, there are two barbels at each angle of the mouth and the pectoral fins are provided with 7-8 simple anterior rays. In the new genus, the structure of the lips, especially of the lower, the form of the rostral groove, lepidosis, tubercles on the head, and the presence of two papillae behind the lower lip are suggestive of *Bhavana* Hora, but in the latter the gill-openings are restricted above the bases of the pectoral fins, whereas in *Travancoria* they extend in front of the pectoral fin to the ventral surface for a short distance.

Travancoria jonesi, gen. et sp. nov.

Plate VIII, figs. 5-9.

D. 2/7-8 ; A. 1/4-5 ; P. 6/9-10 ; V 2/6-7 ; C. 17 ; L.l. 75-77.

Travancoria jonesi is a well-built loach of moderate size in which the head and the greater part of the body are depressed while the tail is somewhat compressed from side to side. The ventral surface is greatly flattened up to the commencement of the anal fin and thereafter the ventral profile rises gradually to the base of the caudal fin. The dorsal profile is gently arched, the greatest height of the body being in front of the dorsal fin. The head is broadly pointed anteriorly, and is covered with series of short, hard, spine-like growths ; its length is contained from 5.0 to 5.83 times in the standard length and from 5.93 to 6.83 times in the total length. The width of the head is contained from 1.09 to 1.33 times and its height at the occiput from 1.71 to 1.88 times in its length. The eyes are of moderate size, approximated dorsally and situated in the posterior half of the head ; they are not visible from the ventral surface. The diameter of the eye is contained from 4.13 to 5.00 times in the length of the head, from 2.42 to 2.68 times in the length of the snout and from 1.42 to 1.50 times in the interorbital width. The nostrils are situated close to the anterior border of the eye ; the anterior nostril is situated in a flap which covers the posterior nostril. The mouth is small, inferior, semicircular and horizontal ; the gape of the mouth is about one-fifth of the width of the head. The lips are well developed and free from the jaws ; the anterior lip covers the jaw while the posterior lip leaves a considerable part of the jaw bare. Both the lips are continuous at the angles of the mouth, but the median part of the posterior lip is pinched off and is followed by two prominent papillae. The jaws are hard and covered with a horny substance ; the posterior jaw is rounded and shovel-like. Between the anterior lip and the rostral fold there is a deep groove which becomes bifurcated near the base of the maxillary barbel ; the inner branch is continued round the corner of the mouth while the outer branch extends to the side of the head. There are 6 short stumpy barbels, 4 rostral and 2 maxillary, but in between the bases of the rostral barbels the rostral fold is produced into three barbel-like processes. At the side of the maxillary barbel, the rostral fold forms a lappet which is indented or crenulated. The gill-openings are small but extend to the ventral surface for a short distance ; the part of the gill-opening above the base of the pectoral fin is provided with a broad and thick gill-membrane.

The depth of the body is contained from 8.33 to 8.70 times in the standard length and from 9.87 to 10.15 times in the total length. The body is broadest in front of the pelvic fins where it is almost as broad as or somewhat broader than the width of the head. The caudal peduncle is strong and whip-like ; its least height is contained from 2.27 to 2.72 times in its length. The body is covered with small scales which are absent on the head and on the ventral surface as far as the anal opening. There are about 75-77 scales along the lateral line, 9 rows above it to the base of the dorsal fin and 9 rows of somewhat smaller scales below it to the base of the pelvic fin. There are about 20 predor-

sal scales. The dorsal and lateral scales in the anterior region are slightly keeled in the middle; the keels become less prominent posteriorly. The anal opening is situated in a shallow groove which runs in the midventral line between the bases of the pelvic and anal fins.

The dorsal fin is short and commences almost opposite or slightly behind the pelvics; it is considerably higher than the depth of the body. The commencement of the dorsal fin is considerably nearer to the tip of the snout than to the base of the caudal fin. The anal fin is similar to the dorsal and commences somewhat nearer to the base of the caudal fin than to that of the pelvic. The paired fins are broad, wing-like and horizontal; the pectorals commence behind the eyes and are longer than the head; they miss the bases of the pelvics by a short distance; the pelvics are similar to the pectorals and are almost as long as the head; they extend considerably beyond the anal-opening but are separated from the anal fin by a considerable distance. The caudal fin is almost as long as the head and is forked in the posterior third of its length; both the lobes are rounded and the lower lobe is better developed and longer than the upper.

The form and structure of the basipterygium (Pl. VIII, fig. 8) and nature of the pharyngeal bone and teeth (Pl. VIII, fig. 9) are similar to those described above for *Bhavana australis*.

The body is dark above and pale below in the flattened part. Along the dorsal surface there is a series of 8-10 broad, saddle-shaped spots, while the head and the sides of the body are mottled with black spots of different sizes and pattern, some of which form a black band along the lateral line. All the fins are provided with series of spots, especially along the middle.

Type-specimen.—F. 13507/1, Zoological Survey of India (*Ind. Mus.*), Calcutta.

Locality.—Streams within a radius of 5 miles of Pampadampara, Peerumedu Taluq, Travancore.

I have great pleasure in associating the name of this remarkable new loach with that of Mr. S. Jones, who sent a fine collection of fish from Travancore to the Zoological Survey of India.

Measurements in millimetres.

Standard length	..	..	59.1	62.9	70.0	75.0	87.0
Length of caudal	..	..	10.6	11.1	12.0	14.0	14.5
Length of head	..	..	11.2	12.2	12.0	15.0	16.0
Width of head		..	9.4	9.6	11.0	13.0	12.0
Height of head	..	..	6.8	6.6	7.0	8.0	8.5
Length of snout	..	..	6.3	6.9	7.8	8.0	8.5
Diameter of eye	..	..	2.2	2.6	2.9	3.0	3.5
Interorbital width	..	..	3.6	3.9	4.2	4.5	5.0
Depth of body		..	7.0	7.9	8.3	9.0	10.0
Width of body	..	..	8.6	10.2	11.0	13.0	14.0
Length of caudal peduncle	..	..	10.1	11.0	12.1	12.5	15.0
Least height of caudal peduncle		..	3.8	4.1	4.6	5.5	5.5
Length of pectoral	..	..	12.2	14.6	14.2	16.5	19.0
Length of ventral	..	..	11.5	11.6	12.1	14.5	15.0
Longest ray of dorsal	..	..	10.9	11.9	12.3	12.5	14.0
Longest ray of anal		..	8.1	8.7	10.1	10.0	11.0

Balitora brucei var. **mysorensis**, nov.

Plate VIII, fig. 4.

D.3/9 ; A.2/5 ; P.9/12 ; V.2/9 ; C.19.

The new variety of *Balitora brucei* from the Mysore State is represented by a single specimen about 2 inches in length. In its slender body and more elongate head it shows great affinity to *B. brucei* var. *burmanicus* Hora¹, but as the material of the new variety is inadequate it is not possible to institute a detailed comparison between the two varieties. On geographical grounds alone, it has been considered advisable to keep the variety from Peninsular India separate from that of Burma, at least for the time being.

The head is contained 4.36 times in the standard length and 5.64 times in the total length. The width of the head is contained 1.41 times and its height at occiput 2.23 times in its length. The diameter of the eye is contained 5.56 times in the length of the head, 3.44 times in the length of the snout and 1.81 times in the interorbital width. The depth of the body is contained 7.61 times in the standard length and 9.84 times in the total length. The caudal peduncle is almost 3 times as long as high.

In general facies, lepidosis, form of fins, mouth, lips, etc. this variety agrees with the *forma typica* and other varieties of the species.

The colour in spirit is olivaceous above with a series of 7 short, broad, saddle-shaped bands of gray colour along the back. On the head between the eyes and the occiput there is a pear-shaped dark mark. Along the lateral line there is a diffuse gray band. The ventral surface is dirty white.

Locality.—Sivasamudram (alt. 1,500—2,000 ft.), Mysore State.

Type-specimen.—F. 13512/1, Zoological Survey of India (*Ind. Mus.*), Calcutta.

Measurements in millimetres.

Standard length	..	..	..	..	..	38.8
Length of caudal	..		..	..	..	11.4
Length of head	..	..	..	..	..	8.9
Width of head					..	6.3
Height of head		..	..	..	..	4.0
Length of snout	..	..	..	..	..	5.5
Diameter of eye		..	..		..	1.6
Interorbital width		..	..	..	..	2.9
Depth of body	..	..	..	..	..	5.1
Width of body	..	..	..	..	..	6.2
Length of caudal peduncle			..		..	6.2
Least height of caudal peduncle			..	..	..	2.1
Length of pectoral	..	..	..	..	..	10.2
Length of ventral	..		..	..	..	8.9
Longest ray of dorsal		..	..	..	..	8.0
Longest ray of anal	..	..	..	..	..	7.0

¹ Hora, S. L., *Mem. Ind. Mus.* XII, p. 291, pl. xi, fig. 6 (1932).

EXPLANATION OF PLATE VIII.

Homalopterid Fishes from Peninsular India.

Bhavana australis (Jerdon).

FIG. 1.—Ventral surface of head : $\times 4$.

FIG. 2.—Basipterygium : $\times 3\frac{3}{4}$.

FIG. 3.—Pharyngeal bone and teeth : $\times 13$.

Balitora brucei var. *mysorensis*, nov.

FIG. 4.—Ventral surface of head : $\times 7\frac{1}{2}$.

Travancoria jonesi, gen. et sp. nov.

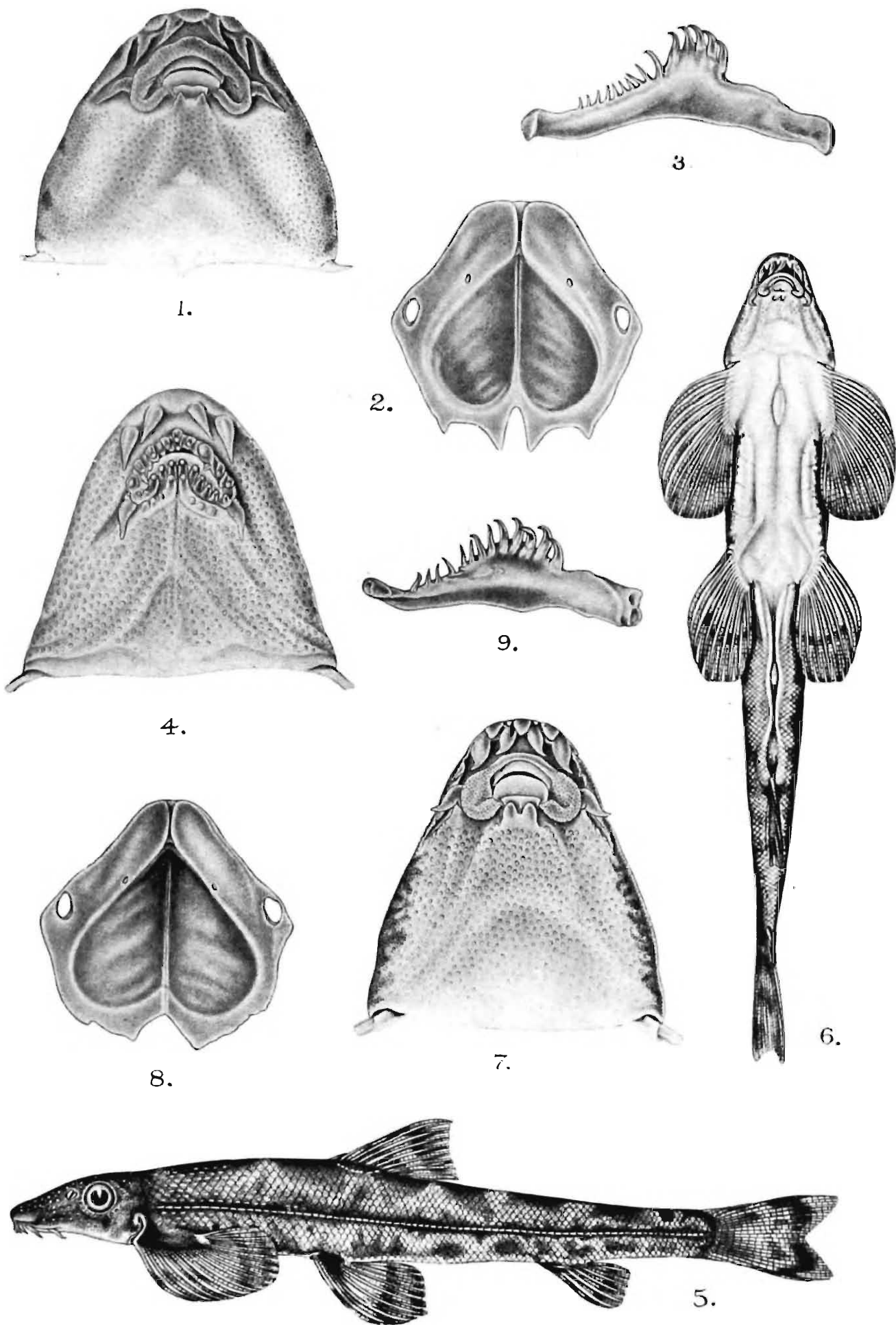
FIG. 5.—Lateral view : $\times 1\frac{7}{8}$.

FIG. 6.—Ventral view : $\times 1\frac{7}{8}$.

FIG. 7.—Ventral surface of head : $\times ca. 4\frac{3}{4}$.

FIG. 8.—Basipterygium : $\times 3\frac{3}{4}$.

FIG. 9.—Pharyngeal bone and teeth : $\times 13$.



R. Bagchi &
B. N. Bagchi, del.

Homalopterid Fishes from Peninsular India.

THE FRESHWATER FISH OF TRAVANCORE.

By SUNDER LAL HORA, *D.Sc., F.R.S.E., F.N.I., Assistant Superintendent, Zoological Survey of India, Calcutta, and* NIRMAL CHANDRA LAW, *M.Sc.*

(Plate IX.)

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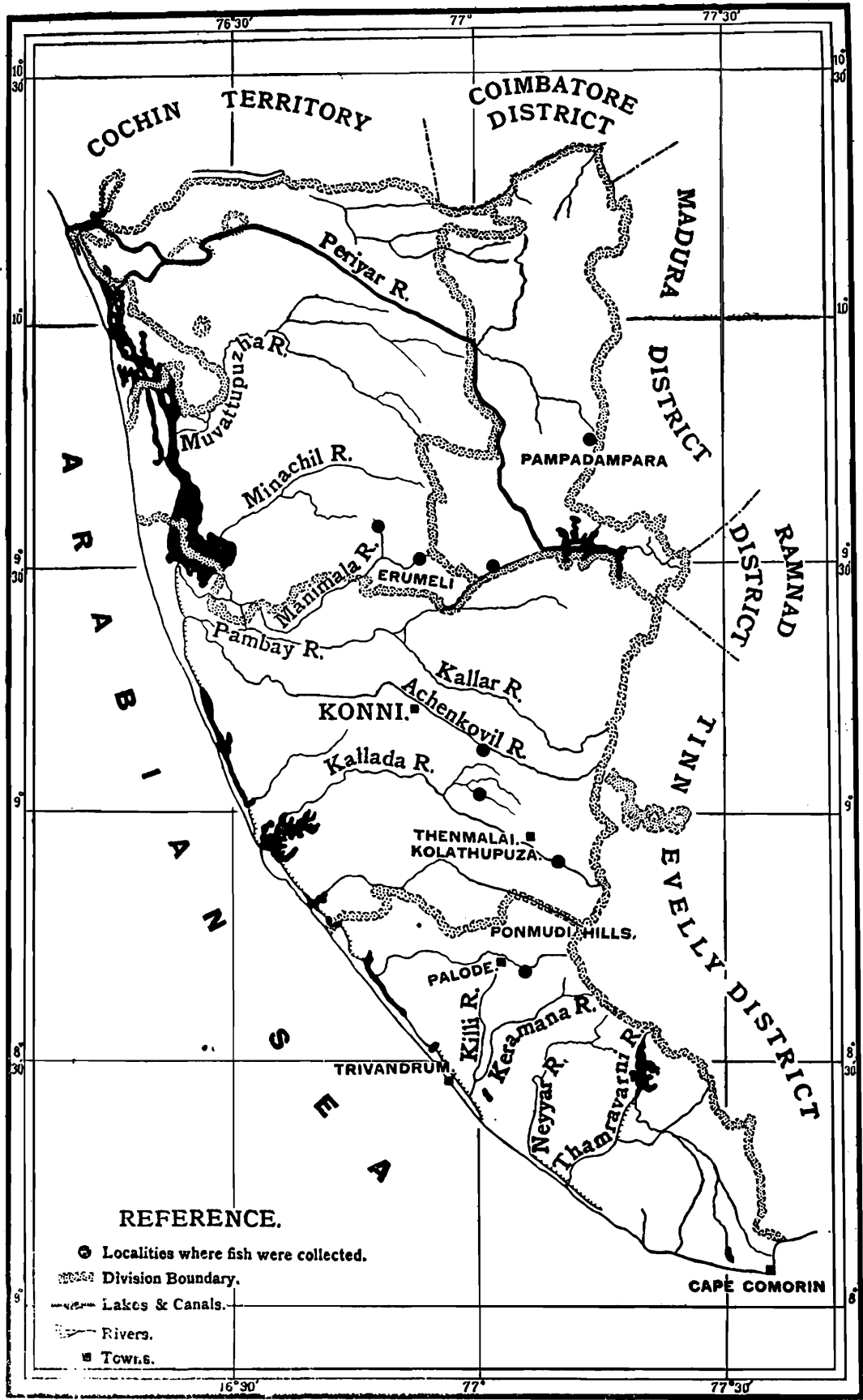
INTRODUCTION.

The freshwater fish of Travancore are particularly interesting on account of the zoogeographical peculiarities of some of the forms. An account of the geography of the country, in so far as it affects the aquatic fauna, will be found in John's¹ account of ' Freshwater Fish and Fisheries of Travancore ' It may be well, however, to reiterate here that Travancore lies in the extreme southwest of Peninsular India between 8° 4' and 10° 21' N. and 76° 14' and 77° 73' E., and that its eastern boundary is formed by a continuous range of hills. The total area of the State is 7,625 square miles, of which 3,547 square miles comprise the up-country reaching an altitude ranging from 4,000 to 8,000 feet above sea level, 2,707 square miles comprise mid-country and the remaining 1,371 square miles constitute the low-country. The hill ranges of Travancore are in reality spurs of the Western Ghats and as they stand like a wall behind the narrow coastal plains they obstruct the south-west monsoon and in consequence the rainfall is heavy between the months of May and August. There is a certain amount of rainfall during the north-east monsoon also. The maximum annual rainfall is about 200 inches.

Owing to the mountainous character of the country and the heavy rainfall, both during the summer and winter months, there is a large number of perennial torrential streams harbouring remarkable forms adapted for life in swift currents. With a view to study the fish-fauna of such waters, one of us requested Mr. S. Jones and Dr. C. C. John to collect for the Zoological Survey of India a representative lot of hill-stream fishes from different parts of the State. They very kindly undertook the work and the collection under report was made by them from the following localities :—

1. Pampadampara Tank, North Travancore.
2. Streams within a radius of about 5 miles round Pampadampara, North Travancore.
3. Dhobikana, a small stream close to Pampadampara, North Travancore.
4. Sannyasa-ode, near Pampadampara, North Travancore.

¹ John, C. C., *Journ. Bombay Nat. Hist. Soc.* XXXVIII, pp. 702-733 (1936).



TEXT-FIG. 1.—Map of Travancore showing localities in which the fish were collected by Mr. S. Jones and Dr. C. C. John,

5. Manimala R., near Kangirappally, Central Travancore.
6. A tributary of Manimala R., Erumeli, Central Travancore.
7. Pool at the foot of the largest fall of Peruntenuvi, a tributary of Pamba R., at Edakadathy, Central Travancore.
8. Achenkovil R., 7 miles south-east of Konni, Central Travancore.
9. Near the source of Kallada R., 4 miles east of Thenmalai, Central Travancore
10. Kulathupuzha, a tributary of Kallada R., Central Travancore.
11. Kallar stream at the foot of Ponmudi Hills, South Travancore.
12. Chittar stream at Palode, South Travancore.
13. Trivandrum, South Travancore.

With the exception of the Kallar stream, Mr. Jones's collection was made from streams in North Travancore, while Dr. John sent the material from the southern and central parts of the State. The collection under report is, therefore, fairly representative of the hill-stream fish-fauna of the State. Further search is, however, likely to reveal more forms from similar habitats. As one new genus and two new species have been found in the material collected by Mr. Jones and Dr. John there is every likelihood of more new species being found among the smaller forms that live under rocks and stones in torrential streams. Attention may also be directed to the fact that recently Raj¹ has described a new genus of Schizothoracine fishes from the Periyar Lake, Travancore.

The material is in an excellent state of preservation which shows that great care must have been taken in handling the specimens in the field. We wish to express here our great indebtedness to Mr. S. Jones and Dr. C. C. John for making the collection and presenting it to the Zoological Survey of India. A duplicate set of the material has been sent to the Government Museum, Trivandrum.

In January 1941, Dr. A. W. C. T. Herre of the Stanford University, California, visited Travancore and made a collection of fish. He presented to the Zoological Survey of India a few specimens obtained by him from the Kallar stream, 30 miles north-east of Trivandrum. The following species are represented in this lot:—

- | | |
|---|---|
| 1. <i>Barilius galensis</i> (Cuv. & Val.). | 4. <i>Garra mullya</i> (Sykes). |
| 2. <i>Barbus (Puntius) amphibius</i> (Cuv. & Val.). | 5. <i>Bhavania australis</i> (Jerdon). |
| 3. <i>Barbus (Puntius) melanampyx</i> (Day). | 6. <i>Nemachilus triangularis</i> (Day). |
| | 7. <i>Mastacembelus armatus</i> (Lacép.). |

The first comprehensive list of 369 species of the fishes of Travancore was published by Pillay², but he remarked that the list would probably be greatly augmented if the marine, brackish and fresh waters of the State could be systematically investigated. His list contains 72 freshwater species. John (*loc. cit.*) gave a list of 73 species but though he had included practically all the freshwater fishes listed by Pillay, he omitted to include, without comments, *Barilius bakeri*, *Barbus malabaricus* and *B. wynaadensis* which had already been recorded by Pillay from Travancore. However, he added to the previous list *Anguilla vulgaris*, *Barbus filamentosus*, *B. punctatus* and *B. sarana*. We have not been able to find any reference to the first of these species and presumably the author has confused his determination with the marine

¹ Raj, B. Sundara, *Rec. Ind. Mus.* XLIII, pp. 209-214 (1941).

² Pillay, R. S. N., *Journ. Bombay Nat. Hist. Soc.* XXXIII, pp. 347-379 (1929).

fish *Conger vulgaris* Cuvier which is a synonym of *Conger conger* (Linn.). Leaving this species out of consideration and combining the two lists, we have in all 75 species of freshwater fishes recorded from Travancore. Of these *Barbus filamentosus* and *B. mahecola* are synonymous¹ as they represent male and female sexes respectively of the same species (*vide infra*, p. 245). Similarly, *Haplochilus lineatus* and *H. rubrostigma* represent the two sexes of the same species. One of us² has shown that *Callichrous malabaricus* is a synonym of *C. bimaculatus*. *Rasbora nilgheriensis*, as noted by Day,³ is only a colour variety of the widely distributed *R. daniconius*. Thus the total number of freshwater species is reduced to 71. Of these, *Megalops cyprinoides*, *Hemirhamphus xanthopterus*, *Ambassis gymnocephalus*, *Gerres limbatus* and *Gobius striatus* (= *Awaous stamineus*) are mainly marine and brackish water species, though they may frequent fresh waters also. For this reason, it is advisable to exclude them from a list of purely freshwater fishes, the number of which will thus be reduced to 66.

We⁴ have described from Dr. John's collection a new Catfish, *Batasio travancoria*, from Central and Southern Travancore, while Raj⁵ has more recently described a small-scaled Barbel, *Lepidopygopsis typus*, from the Periyar Lake, and Hora⁶ has described from Mr. Jones's collection a Homalopterid loach, *Travancoria jonesi*, from Northern Travancore. Among the material under report we have further found representatives of the following species which were not recorded by Pillay and John: *Barilius gatensis*, *Danio aequipinnatus*, *Rasbora rasbora*, *Barbus mussullah*, *Barbus ticto*, *Garra mullya*, *Lepidocephalus thermalis*, *Nemachilus evezardi*, *N. guentheri*, *Bhavana australis*, *Mystus cavasius* and *Glyptothorax madraspaianus*. Of these, *B. mussullah* probably corresponds to *B. tor* of the lists of Pillay and John; *D. aequipinnatus* to *D. malabaricus*; *B. ticto* to *B. punctatus*; *G. mullya* to *Discoganthus lamta* and *B. australis* to *Homaloptera maculata*. Thus, excluding these five species, only 7 additional species are added to the list as a result of our present study. The total number of species now known from the fresh waters of Travancore is 76. As the nomenclature of a number of species is changed, we give below a complete systematic list of the freshwater fishes of Travancore with their up-to-date scientific names and geographical range. For vernacular names reference may be made to the lists published by Pillay and John respectively.

LIST OF THE FRESHWATER FISH OF TRAVANCORE WITH THEIR GEOGRAPHICAL RANGE.

The general classification of fishes adopted in the list is that proposed by Dr. C. Tate Regan, F.R.S., in his article on 'Fishes' in the Fourteenth Edition of the *Encyclopaedia Britannica* (1929). The genera under their respective families and the species under each genus are alpha-

¹ Hora, S. L., *Rec. Ind. Mus.* XXXIX, p. 22 (1937).

² Hora, S. L., *Rec. Ind. Mus.* XXXVIII, pp. 356-361 (1936).

³ Day, F., *Fish. India*, p. 584 (1878).

⁴ Hora, S. L., and Law N. C., *Rec. Ind. Mus.* XLIII, pp. 40-42 (1941).

⁵ Raj, B. Sundara, *Rec. Ind. Mus.* XLIII, p. 209 (1941).

⁶ Hora, S. L., *Rec. Ind. Mus.* XLIII, p. 230 (1941).

betically arranged. The species whose name is marked with an asterisk (*) is represented in the collection under report.

List of Species.

Geographical Range.

Order : OSTARIOPHYSI.

Suborder : CYPRINOIDEA.

Family : CYPRINIDAE.

Subfamily : ABRAMADINAE.

- | | |
|-------------------------------------|--------------------------------------|
| 1. <i>Chela boopis</i> Day .. | .. Travancore and South Canara. |
| 2. <i>Laubuca laubuca</i> (Ham.) .. | .. Ceylon, India, Burma and Sumatra. |

Subfamily : BASBORINAE.

- | | |
|--|---|
| 3. <i>Barilius bakeri</i> Day .. | .. Travancore. |
| *4. <i>Barilius gatensis</i> (C. V.) .. | .. Western Ghats, Nilgiris and Coorg. |
| *5. <i>Danio aequipinnatus</i> (McClell.) .. | .. Ceylon, India, Burma and Siam. |
| *6. <i>Rasbora daniconius</i> (Ham.) .. | .. Ceylon, India, Burma, Siam, Malaya, etc. |
| *7. <i>Rasbora rasbora</i> (Ham.) .. | .. India, Burma, Siam and Malaya. |

Subfamily : CYPRININAE.

- | | |
|---|---|
| 8. <i>Amblypharyngodon melettina</i> (C. V.) | Ceylon, Peninsular India and Deccan. |
| 9. <i>Amblypharyngodon microlepis</i> (Blkr.) | Peninsular India, through Orissa to Hooghly. |
| 10. <i>Amblypharyngodon mola</i> (Ham.) .. | India and Burma. |
| *11. <i>Barbus (Puntius) amphibius</i> (C. V.) | Ceylon and Peninsular India. |
| 12. <i>Barbus (Puntius) arulius</i> (Jerd.) .. | Peninsular India. |
| 13. <i>Barbus (Puntius) burmanicus</i> (Day) | Travancore, Burma and Malaya. |
| 14. <i>Barbus (Puntius) conchoni</i> Ham. | India (generally Northern India). |
| *15. <i>Barbus (Puntius) curmuca</i> (Ham.) | Western Ghats. |
| 16. <i>Barbus (Puntius) denisoni</i> (Day) | Travancore. |
| *17. <i>Barbus (Puntius) filamentosus</i> (C. V.) | Ceylon and Peninsular India. |
| 18. <i>Barbus (Puntius) lithopidos</i> Day | Travancore, South Canara and Coorg. |
| 19. <i>Barbus (Tor) malabaricus</i> Jerd. | Travancore and South Canara. |
| *20. <i>Barbus (Puntius) melanampyx</i> (Day) | Peninsular India. |
| 21. <i>Barbus (Puntius) melanostigma</i> (Day) | Travancore, Wynaad and Nilgiris. |
| *22. <i>Barbus (Tor) mussullah</i> Sykes .. | Peninsular India, and Deccan. |
| 23. <i>Barbus (Puntius) parrah</i> (Day) .. | Peninsular India. |
| *24. <i>Barbus (Puntius) pinnauratus</i> (Day) | Ceylon, Peninsular India, Satpuras, Burma and Siam. |
| 25. <i>Barbus (Puntius) sarana</i> (Ham.) .. | India and Burma. |
| 26. <i>Barbus (Puntius) sophore</i> Ham. ¹ | India, Burma and Yunnan. |
| *27. <i>Barbus (Puntius) ticto</i> Ham. .. | Ceylon, India, Burma and Siam. |
| 28. <i>Barbus (Puntius) vittatus</i> (Day) .. | Ceylon, Peninsular India and Cutch. |
| 29. <i>Barbus (Puntius) wynaadensis</i> Day | Travancore and Wynaad. |
| 30. <i>Garra jerdoni</i> (Day) .. | Peninsular India. |
| *31. <i>Garra mullya</i> (Sykes) .. | Peninsular India, Satpuras and Kathiawar. |
| 32. <i>Labeo dussumieri</i> (C. V.) .. | Ceylon, Peninsular India and Gujarat. |
| 33. <i>Rohitee bakeri</i> Day .. | .. Travancore. |

Subfamily : SCHIZOTHORACINAE.

- | | |
|--------------------------------------|----------------|
| 34. <i>Lepidopygopsis typus</i> Raj. | .. Travancore. |
|--------------------------------------|----------------|

¹This is the same species as *Barbus stigma* (Cuv. & Val.) of the earlier lists. For nomenclatorial change see Chaudhuri, *Mem. Ind. Mus.* V, p. 436 (1916).

List of Species.	Geographical Range.
Family : HOMALOPTERIDAE.	
Subfamily : HOMALOPTERINAE.	
*35. <i>Bhavana australis</i> (Jerd.)	.. Travancore, Nilgiris, Wynaad and Mysore.
*36. <i>Travancoria jonesi</i> Hora	.. Travancore.
Family : COBITIDAE.	
*37. <i>Lepidocephalus thermalis</i> (C. V.)	.. Ceylon and Peninsular India.
38. <i>Nemachilus botia</i> (Ham.)	.. Ceylon, India and Burma.
*39. <i>Nemachilus evezardi</i> Day	.. Peninsular India and Deccan.
*40. <i>Nemachilus guentheri</i> Day	.. Travancore and Nilgiri Hills.
*41. <i>Nemachilus triangularis</i> Day	.. Travancore.
Suborder : SILUROIDEA.	
Family : CLARIIDAE.	
42. <i>Clarias batrachus</i> (Linn.)	.. India, Burma, Siam, Malaya and further east.
Family : HETEROPNEUSTIDAE.	
43. <i>Heteropneustes fossilis</i> (Bloch)	.. Ceylon, India, Burma, Siam and Cochin-China.
Family : SILURIDAE.	
*44. <i>Callichrous bimaculatus</i> (Bloch)	.. Ceylon, India, Burma and further east.
45. <i>Wallagonia attu</i> (Bloch)	.. Ceylon, India, Burma, Siam, Malay Peninsula and Western Yunnan.
Family : SCHILBEIDAE.	
46. <i>Pseudeutropius sykesi</i> (Jerd.)	.. Peninsular India.
Family : BAGRIDAE.	
*47. <i>Batasio travancoria</i> Hora & Law	.. Travancore.
*48. <i>Mystus cavasius</i> (Ham.)	.. India, Burma and Siam.
49. <i>Mystus chryseus</i> (Day)	.. Travancore, Canara and Malabar.
50. <i>Mystus gulio</i> (Ham.)	.. Ceylon, India, Burma and Malaya.
*51. <i>Mystus malabaricus</i> (Jerd.)	.. Travancore, Malabar and Wynaad.
52. <i>Mystus montanus</i> (Jerd.)	.. Travancore, Wynaad and Cauvery R.
53. <i>Mystus oculatus</i> (C. V.)	.. Travancore, Malabar and Nilgiris.
54. <i>Mystus vittatus</i> (Bloch)	.. Ceylon, India, Burma and Siam.
Family : SISORIDAE.	
*55. <i>Glyptothorax madraspatanus</i> (Day)	Travancore, Nilgiris, and Mysore.
Order : APODES.	
Family : ANGUILLIDAE.	
56. <i>Anguilla bicolor</i> McClelland	.. Africa, India and further east.
Order : SYNENTOGNATHI.	
Suborder : SCOMBRESOCOIDEA.	
Family : XENENTODONTIDAE or BELONIDAE.	
*57. <i>Xenentodon cancila</i> (Ham.)	.. Ceylon, India, Burma, Malaya and Siam.
Order : MICROCYPRINI.	
Family : CYPRINODONTIDAE.	
58. <i>Aplochilus lineatus</i> (C. V.)	.. Ceylon, Peninsular India and Deccan.
Order : PERCOMORPHI.	
Suborder : PERCOIDEA.	
Family : AMBASSIDAE.	
59. <i>Ambassis dayi</i> Blkr.	.. Travancore and Malabar.
60. <i>Ambassis nalu</i> (Ham.)	.. Travancore, Malabar, Calcutta, Andamans and Malay Archipelago.
61. <i>Ambassis thomassi</i> Day	.. Travancore, Malabar, Siam and Malaya.

List of Species.	Geographical Range.
Family : NANDIDAE.	
62. <i>Nandus nandus</i> (Ham.)	.. India, Burma, Siam and Malaya.
Family : PRISTOLEPIDAE.	
63. <i>Pristolepis fasciata</i> (Blkr.)	.. Travancore, Burma, Siam, Malay Archipelago and Cochin-China.
64. <i>Pristolepis malabarica</i> (Gthr.)	.. Southern part of Western Ghats.
Family : CICHLIDAE.	
65. <i>Etroplus maculatus</i> (Bloch)	.. Ceylon and Peninsular India.
66. <i>Etroplus suratensis</i> (Bloch)	.. Ceylon, Peninsular India and Deccan.
Suborder : GOBIOIDEA.	
Family : GOBIIDAE.	
67. <i>Glossogobius giuris</i> (Ham.)	.. Ceylon, India, Burma and further east.
Suborder : ANABANTOIDEA.	
Family : ANABANTIDAE.	
68. <i>Anabas testudineus</i> (Bloch)	.. Ceylon, India, Burma and further east.
Family : POLYCANTHIDAE.	
69. <i>Macropodus cupanus</i> C. V.	.. South India, Malay Peninsula and Sumatra.
Suborder : OPHICEPHALOIDEA.	
Family : OPHICEPHALIDAE.	
*70. <i>Ophicephalus gachua</i> Ham.	.. Ceylon, India, Burma and further east.
71. <i>Ophicephalus leucopunctatus</i> Sykes	Peninsular India and Deccan.
72. <i>Ophicephalus marulius</i> Ham.	.. Ceylon, India, Burma to China.
73. <i>Ophicephalus micropeltes</i> (K. & V. Hass.) C. V.	.. Western Coast of India, Malay Archipelago, Siam and Indo-China.
74. <i>Ophicephalus striatus</i> Bloch	.. Ceylon, India, Burma and further east.
Order : OPISTHOMI.	
Family : MASTACEMBELIDAE.	
*75. <i>Mastacembelus armatus</i> (Lacép.)	.. Ceylon, India, Burma and further east.
76. <i>Mastacembelus guentheri</i> Day	.. Travancore, Malabar and Malaya.

As is to be expected, a great majority of the species belong to the Ostariophysi, 41 to the Suborder Cyprinoidea and 14 to the Suborder Siluroidea. Of the remaining 21 species, 1 belongs to Apodes (Anguillidae), 1 to Syntognathi (Belonidae), 1 to Microcyprini (Cyprinodontidae), 16 to Percomorpha (Ambassidae 3; Nandidae 1; Pristolepidae 2; Cichlidae 2; Gobiidae 1; Anabantidae 1; Polycanthidae 1; Ophicephalidae 5) and 2 to Opisthomi (Mastacembelidae).

ZOOGEOGRAPHICAL REMARKS.

With the exception of the Cichlidae, which are confined to Peninsular India and Ceylon, the remaining families listed above are widely distributed in the Oriental Region and even further afield. The Cichlidae represent the Ethiopian element in the fish-fauna of India¹. The Schizothoracinae, which are the dominant fish of the streams, marshes and lakes of the high plateau of Central Asia, represent the Palaearctic

¹ Hora, S. L., *Curr. Sci.* V, p. 354 (1937).

element in the fauna of Peninsular India. Two genera of the Schizothoracinae, *Schizothorax* Heckel and *Oreinus* McClelland, are found in torrential streams along the southern slopes of the Himalayas, but nowhere else in India. The occurrence of *Lepidopygopsis* in the Periyar Lake is, therefore, of special zoogeographical significance. Similarly the Homalopteridae, which are represented in Travancore by two genera of the Homalopterinae are of particular interest. The Homalopteridae are represented by a number of genera in south-eastern Asia and in India proper their range extends up to the hill ranges of Assam and Chittagong, and the Eastern Himalayas; they are absent from the rest of India with the exception of the southern parts of the Western Ghats. The same can be said with regard to the distribution of *Batasio* Blyth. The genera *Macropodus* Lacépède and *Pristolepis* Jerdon are either found in Peninsular India or in the Far East. There are species in the fauna of Travancore, such as *Mastacembelus guentheri*, *Barbus* (*Puntius*) *burmanicus*, *Ambassis thomassi*, and *Ophicephalus micropeltes*, which show a similar discontinuity in the respective ranges of their distribution. Even if individuals of a single species are considered, we find that specimens of *Barbus* (*Puntius*) *ticto* with the lateral line complete are either found in Peninsular India or in Burma and Siam. There is thus a great deal of evidence to show the close relationship of the Malayan fauna with that of Peninsular India.

The freshwater fish-fauna of Travancore can be divided into the following groups from a zoogeographical point of view :

Group I.—*Species distributed throughout India, Burma and further east.*

- | | |
|---|--|
| 1. <i>Laubuca laubuca</i> (Ham.). | 14. <i>Wallagonia attu</i> (Bloch). |
| 2. <i>Danio aequipinnatus</i> (McClell.). | 15. <i>Mystus cavasius</i> (Ham.). |
| 3. <i>Rasbora daniconius</i> (Ham.). | 16. <i>Mystus gulio</i> (Ham.). |
| 4. <i>Rasbora rasbora</i> (Ham.). | 17. <i>Mystus vittatus</i> (Bloch). |
| 5. <i>Amblypharyngodon mola</i> (Ham.). | 18. <i>Anguilla bicolor</i> McClell. |
| 6. <i>Barbus</i> (<i>Puntius</i>) <i>pinnauratus</i> (Day). | 19. <i>Xenentodon cancila</i> (Ham.). |
| 7. <i>Barbus</i> (<i>Puntius</i>) <i>sarana</i> (Ham.). | 20. <i>Ambassis nalua</i> (Ham.). |
| 8. <i>Barbus</i> (<i>Puntius</i>) <i>sophore</i> Ham. | 21. <i>Nandus nandus</i> (Ham.). |
| 9. <i>Barbus</i> (<i>Puntius</i>) <i>ticto</i> Ham. | 22. <i>Anabas testudineus</i> (Bloch). |
| 10. <i>Nemachilus botia</i> (Ham.). | 23. <i>Glossogobius giuris</i> (Ham.). |
| 11. <i>Clarias batrachus</i> (Linn.). | 24. <i>Ophicephalus gachua</i> Ham. |
| 12. <i>Heteropneustes fossilis</i> (Bloch). | 25. <i>Ophicephalus marulius</i> Ham. |
| 13. <i>Callichrous bimaculatus</i> (Bloch). | 26. <i>Ophicephalus striatus</i> Bloch. |
| | 27. <i>Mastacembelus armatus</i> (Lacép.). |

Group II.—*Species distributed in Peninsular India, Malay Peninsula etc.*

- | | |
|--|---|
| 1. <i>Barbus</i> (<i>Puntius</i>) <i>burmanicus</i> Day. | 4. <i>Pristolepis fasciata</i> (Blkr.). |
| 2. <i>Ambassis thomassi</i> Day. | 5. <i>Macropodus cupanus</i> C. V. |
| 3. <i>Ophicephalus micropeltes</i> C. V. | 6. <i>Mastacembelus guentheri</i> Day. |

Group III.—*Species distributed throughout India.*

1. *Barbus* (*Puntius*) *conchoni* Ham.

Group IV.—*Species with restricted distribution in India.*

- | | |
|--|---|
| 1. <i>Amblypharyngodon microlepis</i> (Blkr.). | 2. <i>Barbus</i> (<i>Tor</i>) <i>mussullah</i> Sykes. |
| 3. <i>Garra mullya</i> (Sykes). | 4. <i>Nemachilus evezardi</i> Day. |

Group V.—*Species common to Peninsular India and Ceylon.*

- | | |
|--|---|
| 1. <i>Amblypharyngodon melettina</i> (C. V.). | 5. <i>Labeo dussumieri</i> (C. V.). |
| 2. <i>Barbus</i> (<i>Puntius</i>) <i>amphibius</i> (C. V.). | 6. <i>Lepidocephalus thermalis</i> (C. V.). |
| 3. <i>Barbus</i> (<i>Puntius</i>) <i>filamentosus</i> (C. V.). | 7. <i>Aplochilus lineatus</i> (C. V.). |
| 4. <i>Barbus</i> (<i>Puntius</i>) <i>vittatus</i> (Day). | 8. <i>Etroplus maculatus</i> (Bloch). |
| 9. <i>Etroplus suratensis</i> (Bloch). | |

Group VI.—*Species distributed throughout Peninsular India.*

- | | |
|--|--|
| 1. <i>Barbus</i> (<i>Puntius</i>) <i>arulius</i> (Jerd.). | 4. <i>Garra jerdoni</i> (Day). |
| 2. <i>Barbus</i> (<i>Puntius</i>) <i>melanampyx</i> (Day). | 5. <i>Pseudeutropius sykesi</i> (Jerd.). |
| 3. <i>Barbus</i> (<i>Puntius</i>) <i>parrah</i> (Day). | 6. <i>Ophicephalus leucopunctatus</i> Sykes. |

Group VII.—*Species found in the Western Ghats and associated hills.*

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| 1. <i>Chela boopis</i> Day. | 9. <i>Nemachilus guentheri</i> Day. |
| 2. <i>Barilius gatensis</i> (C. V.). | 10. <i>Mystus chryseus</i> (Day). |
| 3. <i>Barbus</i> (<i>Puntius</i>) <i>curmuca</i> (Ham.). | 11. <i>Mystus malabaricus</i> (Jerd.). |
| 4. <i>Barbus</i> (<i>Puntius</i>) <i>lithopidos</i> Day. | 12. <i>Mystus montanus</i> (Jerd.). |
| 5. <i>Barbus</i> (<i>Tor</i>) <i>malabaricus</i> Jerd. | 13. <i>Mystus oculatus</i> (C. V.). |
| 6. <i>Barbus</i> (<i>Puntius</i>) <i>melanostigma</i> (Day). | 14. <i>Glyptothorax madraspatanus</i> (Day). |
| 7. <i>Barbus</i> (<i>Puntius</i>) <i>wynaadensis</i> Day. | 15. <i>Ambassis dayi</i> Blkr. |
| 8. <i>Bhavana australis</i> (Jerd.). | 16. <i>Pristolepis malabarica</i> (Gthr.). |

Group VIII.—*Species endemic in Travancore.*

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| 1. <i>Barilius bakeri</i> Day. | 4. <i>Lepidopygopsis typus</i> Raj. |
| 2. <i>Barbus</i> (<i>Puntius</i>) <i>denisoni</i> Day. | 5. <i>Travancoria jonesi</i> Hora. |
| 3. <i>Rohtee bakeri</i> Day. | 6. <i>Nemachilus triangularis</i> Day. |
| 7. <i>Batasio travancoria</i> Hora & Law. | |

Of the 76 species listed above, 27 are widely distributed in India, Burma and further east; 6 are found in Peninsular India on the one hand and in Burma and further east on the other, but nowhere else in India; 1 is distributed all over India proper but is not found in Burma; 4 have a restricted distribution in India, mainly in Peninsular India and along the Satpura Trend of mountains; 9 are found in Peninsular India and Ceylon, while the remaining 29 are restricted to Peninsular India and of these 7 are endemic in Travancore. Of the 29 species only known from Peninsular India, as many as 23 are found only in the Western Ghats and the associated hills. If Ceylon and Peninsular India be regarded as one zoogeographical region and the forms, which are found either in Peninsular India or further east but not in other parts of India, be grouped along with the species restricted to Ceylon and Peninsular India, it becomes apparent that about 60 per cent of the species are peculiar to Southern India and are found nowhere else in India proper. This high endemism of the fauna of this region has been noticed by previous workers also in the case of other groups of animals.

From a zoogeographical point of view, the freshwater fish-fauna of Travancore presents two special features, the marked Malayan element

and the preponderance of endemic forms. The former, according to Blanford¹, dates in India from the Miocene times. We have indicated above the occurrence of the Homalopteridae and of the genus *Batasio* in the hills of Assam and the Eastern Himalayas which indicates the probable route along which the Malayan fauna migrated to Peninsular India. Regarding the Himalayan fauna, Blanford stated that :

“ The Indo-Malay element in the fauna is very richly represented in the Eastern Himalayas, and gradually diminishes to the westward, until in Kashmir and further west it ceases to be the principal constituent. Almost all the Indo-Malay genera, and a very large proportion of the species, are identical with Assamese or Burmese forms. These facts are consistent with the theory that the Indo-Malay part of the Himalayan fauna, or the greater portion of it, has migrated into the mountains from the eastward at a comparatively recent period. *It is an important fact that this migration appears to have been from Assam and not from the Peninsula of India.*” (Italics are ours.)

One of us² has explained the presence of the Indo-Malayan element in the fauna of the Eastern Himalayas and Peninsular India by postulating that the uplift movement of the Himalayas was probably most active in the region of the Assam Himalayas as practically all the highest peaks are clustered round this area. It was argued that

“ This differential movement, which probably occurred late in the Miocene period, must have obliterated all traces of the eastward extension of the Indobrahm and also acted as a barrier between the eastern and western Himalayan fishes. The new stocks of specialised hill-stream fishes from the east, not finding means to cross this barrier, were deflected towards south-west along the Satpura Trend which probably at this period stretched across India as a pronounced range from Gujarat to the Assam Himalayas. From Gujarat the hill-stream fauna migrated towards the south along the Western Ghats and spread to the hills of the Peninsula in the extreme south.”

To account for the anomalies of distribution referred to above, Blanford (*loc. cit.*, p. 435) postulated the diminution of temperature as the cause for the dispersal of animals from the north to the south and stated :

“ Unless the temperature of India and Burma generally underwent a considerable diminution, it is not easy to understand how plants and animals of temperate Himalayan types succeeded in reaching the hills of Southern India and Ceylon, as well as those of Burma and Malay Peninsula.”

Temperature is undoubtedly a great factor in the dispersal of animals and probably has very great influence on the terrestrial fauna but in the case of aquatic animals the presence of water connections is also an important factor. Moreover, in the case of torrential fishes, such as the Homalopteridae, a rocky substratum and a swift current are also essential for their very existence. In view of these ecological considerations, it seems probable that the Satpura Trend may have acted as a highway for the migration of this fauna from the late Miocene period to the time of formation of the Rajmahal-Garro Hill gap. This movement may have been facilitated by the diminution of temperature if the earth movements of the glacial period provided necessary water connections for the transference of the fauna from the north-east to the south-west.

The high endemism of the Travancore fauna is an evidence of its antiquity and long isolation from the fauna of the mainland of India and of the adjacent countries. After migrating from north-east to

¹ Blanford, W. T., *Phil. Trans. Roy. Soc. London* (B) CXCIV, pp. 433, 434 (1921).

² Hora, S. L., *Rec. Ind. Mus.* XXXIX, p. 255 (1937).

south-west, the fauna came to a blind end in the Peninsular region and when, with the formation of the Rajmahal-Garo Hill gap and due to other causes, it became isolated, it had sufficient time to blossom out into distinct species, while still retaining its family affinities with the parent stock.

SYSTEMATIC ACCOUNT.

Barilius gatensis (Cuv. & Val.).

1878. *Barilius gatensis*, Day, *Fish. India*, p. 592, pl. cxlix, fig. 2.

- 4 specimens, 52 to 108 mm. in length. Streams within a radius of about 5 miles of Pampadampara, Western Ghats, North Travancore. S. Jones, April 1941.
- 3 specimens, 30 to 39 mm. in length. Manimala R., near Kangirappally, Central Travancore. C. C. John, 26.iii.1940.
- 2 specimens, 78 and 97 mm. in length respectively. Pool at the foot of the largest fall of Peruntenuvi, a tributary of Pamba R., at Edakadathy, Central Travancore. C. C. John, 11.ii.1940.
- 1 specimen, 72 mm. long. Chittar stream at Palode, South Travancore. C. C. John, 10.ii.1940.

According to Day, *Barilius gatensis* is known from "Western Ghats of Malabar and Neilgherry hills", but since then its range has been extended to other parts of the Western Ghats also. In some of the specimens under report, the lateral bars are short and form a series of oblong spots along the sides. On the whole it is a brightly coloured species.

Danio aequipinnatus (McClelland).

1878. *Danio aequipinnatus*, Day, *Fish. India*, p. 596, pl. cl, fig. 6.

- 19 specimens, 28 to 101 mm. in length. Streams within a radius of about 5 miles round Pampadampara, Western Ghats, North Travancore. S. Jones, 12.iv.1940 and April 1941.
- 2 specimens, 45 and 80 mm. in length. Sannyasa-ode, near Pampadampara, Western Ghats, North Travancore. S. Jones, April 1940.
- 2 specimens, 44 and 59 mm. in length. Manimala R., near Kangirappally, Central Travancore. C. C. John, 26.iii.1940.
- 2 specimens, 68 and 75 mm. in length. A tributary of Manimala R., Erumeli, Central Travancore. C. C. John, 20.ii.1940.
- 1 specimen, 91 mm. long. Pool at the foot of the largest fall of Peruntenuvi, a tributary of Pamba R., at Edakadathy, Central Travancore. C. C. John, 11.ii.1940.
- 19 specimens, 18 to 74 mm. in length. Achenkovil R., 7 miles south-east of Konni, Central Travancore. C. C. John, 17.ii.1940.
- 2 specimens, 66 and 68 mm. in length. Kulathupuzha, a tributary of Kallada R., Central Travancore. (Collected from a pond-like accumulation of water surrounded by big boulders.) C. C. John, 14.ii.1940.
- 3 specimens, 46 to 67 mm. in length. Chittar stream at Palode, South Travancore. C. C. John, 9.ii.1940.

The large number of young, half-grown and adult specimens referred by us to *Danio aequipinnatus* show variation in colouration and scale counts. It seems to us probable that *D. malabaricus* (Jerdon) of Peninsular India and Ceylon, and *D. strigillifer* Myers of North Burma and Peninsular India are synonymous with the North Indian *D. aequipinnatus*. The three forms, as known at present, are rather difficult to distinguish from one another and the material under report helps to bridge over the differences between them.

Rasbora daniconius (Ham.).

1878. *Rasbora daniconius*, Day, *Fish. India*, P. 584, pl. cxlvi, figs. 2, 3.

7 specimens, 33 to 82 mm. in standard length. Pampadampara Tank, Western Ghats, North Travancore. S. Jones, September 1938 and March 1940.

42 specimens, 21 to 102 mm. in length. Streams within a radius of about 5 miles round Pampadampara, Western Ghats, North Travancore. S. Jones, 12.iv.1940, and April 1941.

2 specimens, longer one 78 mm. in length. Manimala R., near Kangirappally, Central Travancore. C. C. John, 26.iii.1940.

The specimens of *Rasbora daniconius* correspond with Day's variety *neilgherriensis* which is stated to grow to a large size and to possess 34 scales along the lateral line. In all the specimens the lateral band is broad and well marked.

Rasbora rasbora (Ham.).

1878. *Rasbora buechanani*, Day, *Fish. India*, p. 584, pl. cxlv, fig. 10.

2 specimens, 77 and 83 mm. in length. Streams within a radius of about 5 miles round Pampadampara, Western Ghats, North Travancore. S. Jones, April 1941.

2 specimens, 50 and 65 mm. A tributary of Manimala R., Erumeli, Central Travancore. C. C. John, 20.ii.1940.

2 specimens, 82 and 94 mm. in length. Kulathupuzha, a tributary of Kallada R., Central Travancore. (Collected from a pond-like accumulation of water surrounded by big boulders.) C. C. John, 14.ii.1940.

1 specimen, 84 mm. long. Chittar stream at Palode, South Travancore. C. C. John, 10.ii.1940.

Rasbora rasbora is represented by a number of badly preserved specimens in which the scales have fallen off. The species is widely distributed in India and Burma, though in the fauna of South India it is less common than *R. daniconius*.

Barbus (Puntius) amphibius (Cuv. & Val.).

1878. *Barbus amphibius*, Day, *Fish. India*, p. 574, pl. cxlii, fig. 8.

2 specimens, 36 and 77 mm. in length. Manimala R., near Kangirappally, Central Travancore. C. C. John, 26.iii.1940.

8 specimens, 62 to 70 mm. in length. A tributary of Manimala R., Erumeli, Central Travancore. C. C. John, 20.ii.1940.

1 specimen, 88 mm. long. Pool at the foot of the largest fall of Peruntenuaruvu, a tributary of Pamba R., at Edakadathy, Central Travancore. C. C. John, 11.ii.1940.

3 specimens, 60 to 80 mm. in length. Near the source of Kallada R., 4 miles east of Thenmalai, Central Travancore. C. C. John, 9.ii.1940.

4 specimens, 57 to 74 mm. in length. Kulathupuzha, a tributary of Kallada R., Central Travancore. (Collected from a pond-like accumulation of water surrounded by big boulders.) C. C. John, 14.ii.1940.

4 specimens, 59 to 70 mm. in length. Chittar stream at Palode, South Travancore. C. C. John, 10.ii.1940.

All the specimens of *Barbus amphibius* listed above are characterised by the possession of a large, well-marked black spot before the base of the caudal fin; in this respect they agree with Day's description of the Malabar examples. According to Day, this species is found in "Central India, Deccan, Bombay and the Western coast of India, Madras and up to the coast as high as Orissa."

B. amphibius is liable to be confused with *B. dorsalis*¹ but the prominent caudal spot and the absence of dorsal and anal spots in *B. amphibius* enable the two species to be distinguished from each other.

***Barbus (Puntius) curmuca* (Hamilton).**

(Plate IX, fig. 1.)

1878. *Barbus curmuca*, Day, *Fish. India*, p. 566, pl. cxli, fig. 1.

3 specimens, 37 to 97 mm. in length. A tributary of Manimala R., Erumeli, Central Travancore. C. C. John, 20.ii.1940.

1 specimen, 148 mm. long. Pool at the foot of the largest fall of Peruntenuvuvu, a tributary of Pamba R., at Edakadathy, Central Travancore. C. C. John, 11.ii.1940.

3 specimens, 89 to 110 mm. in length. Near the source of Kallada R., 4 miles east of Thenmalai, Central Travancore. C. C. John, 9.ii.1940.

2 specimens, 106 and 113 mm. in length. Kulathupuzha, a tributary of Kallada R., Central Travancore. (Collected from a pond-like accumulation of water surrounded by big boulders.) C. C. John, 14.ii.1940.

Barbus curmuca is represented in the collection by a number of young, and half-grown specimens. In the largest example under report, the tips of the caudal fin are deep black in colour and proximal to them there are areas of a light colour. The rest of the fin is somewhat grayish. There is a deep black bar behind the gill-opening and in the dorsal half of the body the scales are grayish with lighter margins. The bases of the scales above and below the lateral line are provided with dark spots. The ventral surface is pale olivaceous.

***Barbus (Puntius) filamentosus* (Cuv. & Val.).**

1937. *Barbus filamentosus*, Hora, *Rec. Ind. Mus.* XXXIX, pp. 22-24, text-figs. 8, 9.

6 specimens, 65 to 87 mm. in length. A tributary of Manimala R., Erumeli, Central Travancore. C. C. John, 20.ii.1940.

12 specimens, 77 to 109 mm. in length. Pool at the foot of the largest fall of Peruntenuvuvu, a tributary of Pamba R., at Edakadathy, Central Travancore. C. C. John, 11.ii.1940.

4 specimens, 63 to 84 mm. in length. Near the source of Kallada R., 4 miles east of Thenmalai, Central Travancore. C. C. John, 9.ii.1940.

3 specimens, 75 to 128 mm. in length. Kulathupuzha, a tributary of Kallada R., Central Travancore. C. C. John, 20.ii.1940.

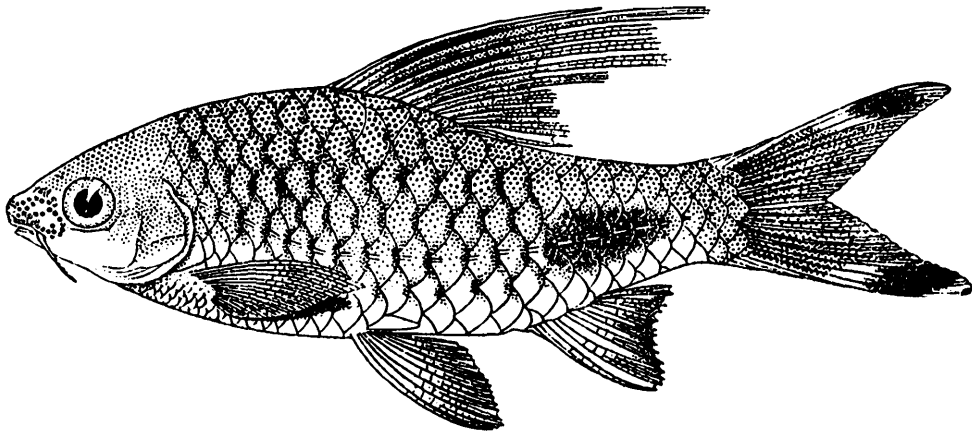
4 specimens, 70 to 82 mm. in length. Chittar stream at Palode, South Travancore. C. C. John, 10.ii.1940.

Of the 29 specimens of *Barbus filamentosus* collected by Dr. C. C. John from different localities in Travancore as listed above, there are only 6 fully developed males while the remaining examples are either females or juveniles. In the males the number of prolonged filiform rays varies from 3 to 5 and in one specimen the last unbranched ray is also greatly elongated (text-fig. 2). All the males are provided with patches of large tubercles on either side of the snout. These secondary sexual characters are very characteristic features of the species.

As already pointed out by one of us, considerable importance has been attached to the presence or absence of barbels in the individuals of this species. Small barbels, sometimes hidden in the grooves round

¹ Hora, S. L., *Rec. Ind. Mus.* XXXVIII, pp. 2-5 (1936).

the corners of the mouth, are invariably present in all the specimens, but they seem to vary considerably in length. In smaller individuals



TEXT-FIG. 2.—Lateral view of a mature male specimen of *Barbus (Puntius) filamentosus* (Cuv. & Val.), showing secondary sexual characters. Nat. Size.

they are relatively larger. In one of the male specimens (text-fig. 2) the barbels extend as far back as the posterior border of the eye. In one of the female specimens also the barbels are of the same length, while in two others they extend up to the middle of the eye. One specimen is still more remarkable, for in it the barbel of one side reaches the posterior border of the orbit while that of the other side is very small.

The colour varies considerably with age. In the young specimens the colour marks are not so prominent; the large lateral blotch is, however, fairly well marked and the fins are somewhat dusky. Some of the outer rays of the caudal fin in both the lobes are dark in colour. The bases of the scales are also faintly marked with dark spots. In larger specimens the lateral blotches as also the caudal blotches are intensely black and are surrounded by whitish areas. The black spots at the bases of the scales become somewhat darker, and in males (text-fig. 2) these markings become very prominent. Usually in the males a dark mark is also present behind the gill-opening. The last undivided ray is white in the males and the filamentous prolongations of the rays are somewhat dusky.

Barbus filamentosus is a South Indian species, having been recorded so far from "Canara down the Western coast and along the base of the Neilgherries, and Travancore hills, also Ceylon." It is said to attain at least 6 inches in length.

***Barbus (Puntius) melanampyx* (Day).**

1938. *Barbus melanampyx*, Misra, *Rec. Ind. Mus.* XL, pp. 258-260, 1 text-fig.

30 specimens, 23 to 57 mm. in length. Pampadampara Tank, Western Ghats, North Travancore. S. Jones, September 1938 and March 1940.

52 specimens, 19 to 64 mm. in length. Streams within a radius of about 5 miles round Pampadampara, Western Ghats, North Travancore. S. Jones, 12.iv.1940 and April 1941.

4 specimens, 21 to 37 mm. in length. Manimala R., near Kangirappally, Central Travancore. C. C. John, 26.iii.1940.

1 specimen, 52 mm. long. A tributary of Manimala R., Erumeli, Central Travancore, C. C. John, 20.ii.1940.

- 20 specimens, 22 to 45 mm. in length. Achenkovil R., 7 miles south-east of Konni, Central Travancore. C. C. John, 17.ii.1940.
 1 specimen, 58 mm. long. Kulathupuzha, a tributary of Kallada R., Central Travancore. (Collected from a pond-like accumulation of water surrounded by big boulders.) C. C. John, 14.ii.1940.
 6 specimens, 25 to 57 mm. in length. Chittar stream at Palode, South Travancore. C. C. John, 10.ii.1940.

Misra (*loc. cit.*) showed that the sexes of *Barbus melanampyx* can be distinguished by their respective colouration. From the large series of fresh specimens examined by us from Travancore we are able to confirm Misra's account, but find that the colouration of the sexes varies to a certain extent. In some of the female specimens the dorsal fin is not stained with black while in some of the smaller examples the three lateral bands are only faintly marked. In a number of male specimens the entire body is dark so that the two broad lateral bands cannot be differentiated from each other. The tips of the caudal fin may be devoid of the usual black colour, and in certain examples the opercular spot is also indistinguishable. In fully mature specimens the tubercles on the snout extend in a broad patch all round the front border of the snout.

***Barbus (Tor) mussullah* Sykes.**

1841. *Barbus mussullah*, Sykes, *Trans. Zool. Soc. London* II, p. 356, pl. lxi, fig 4.
 11 specimens, 60 to 260 mm. in length. Streams within a radius of 5 miles round Pampadampara, Western Ghats, North Travancore. S. Jones, 12.iv.1940 and April 1941.
 2 specimens, 42 and 53 mm. in length. Kallar stream at the foot of Ponmudi Hills, Western Ghats, South Travancore. S. Jones, April 1939.

Though Hora in his series of articles on the Game Fishes of India has not yet dealt with the Large-scaled Barbels of Peninsular India, the number of young and half-grown specimens under report seem to belong to *Barbus mussullah*. From a preliminary examination of the material from Peninsular India, Hora has found that this is the commonest species of these parts and that its range extends along the Satpura Trend to the Central Provinces.

***Barbus (Puntius) pinnauratus* (Day).**

1877. *Barbus pinnauratus*, Day, *Fish. India*, p. 561, pl. cxxxix, fig. 3.
 1936. *Barbus pinnauratus*, John, *Journ. Bombay Nat. Hist. Soc.* XXXVIII, p. 711.
 1937. *Barbus pinnauratus*, Hora, *Rec. Ind. Mus.* XXXIX, p. 336.
 1938. *Barbus pinnauratus*, Hora, *Rec. Ind. Mus.* XL, p. 239.
 1939. *Barbus pinnauratus*, Das, *Rec. Ind. Mus.* XLI, pp. 440, 441.
 1 specimen, 85 mm. long. Kulathupuzha, a tributary of Kallada R., Central Travancore. (Collected from a pond-like accumulation of water surrounded by big boulders.) C. C. John, 14.ii.1940.
 1 specimen, 111 mm. long. Chittar stream at Palode, South Travancore. C. C. John, 10.ii.1940.

In his recent publications, Hora has referred to the remarkable distribution of *Barbus pinnauratus* and indicated its close similarity to several species known from India and Burma. The specimens under report possess the characteristic colouration of the species and in other respects also represent the typical form,

Barbus (Puntius) ticto Hamilton.

1939. *Barbus (Puntius) ticto*, Hora, Misra & Malik, *Rec. Ind. Mus.* XLI, pp. 263-279.

1 specimen, 32 mm. long. Achenkovil R., 7 miles south-east of Konni, Central Travancore. C. C. John, 17.ii.1940.

In the paper referred to above, Hora, Misra and Malik adduced evidence to show that Day's *Barbus punctatus* from Peninsular India, characterized by the possession of a complete lateral line, is synonymous with *B. ticto*. In the specimen under report, the lateral line is more or less complete. It is worthwhile to mention here once again that examples of *B. ticto* with complete lateral line have so far been found both in Burma and Siam and in Peninsular India.

Garra mullya (Sykes).

1921. *Garra mullya*, Hora, *Rec. Ind. Mus.* XXII, pp. 658-660.

28 specimens, 63 to 186 mm. in length. Streams within a radius of about 5 miles round Pampadampara, Western Ghats, North Travancore. S. Jones, 12.iv.1940 and April 1941.

10 specimens, 61 to 121 mm. in length. A tributary of Manimala R., Erumeli, Central Travancore. C. C. John, 20.ii.1940.

2 specimens, 77 and 87 mm. in length. Pool at the foot of the largest fall of Peruntenuvi, a tributary of Pamba R., at Edakadathy, Central Travancore. C. C. John, 11.ii.1940.

1 specimen, 45 mm. long. Achenkovil R., 7 miles south-east of Konni, Central Travancore. C. C. John, 17.ii.1940.

12 specimens, 72 to 114 mm. in length. Near the source of Kallada R., 4 miles east of Thenmalai, Central Travancore. C. C. John, 9.ii.1940.

9 specimens, 71 to 105 mm. in length. Kulathupuzha, a tributary of Kallada R., Central Travancore. (Collected from a pond-like accumulation of water surrounded by big boulders.) C. C. John, 14.ii.1940.

2 specimens, 43 and 55 mm. in length. Kallar stream at the foot of Ponmudi Hills, Western Ghats, South Travancore. S. Jones, April 1939.

Garra mullya is the most widely distributed hill-stream fish of the Western Ghats and is represented by a large number of young, half-grown and adult specimens in the collection under report. It has been found to be equally abundant along the western portion of the Satpura Trend of mountains. The species can readily be distinguished by the absence of a proboscis on the snout, by the presence of tubercular areas, and by the fact that the tip of the snout is marked off by two short lateral grooves. In certain examples the tubercles are few and not well marked.

Bhavana australis (Jerdon).

1941. *Bhavana australis*, Hora, *Rec. Ind. Mus.* XLIII, p. 225, pl. viii, figs. 1-3.

12 specimens, 40 to 111 mm. in length. Streams within a radius of about 5 miles round Pampadampara, Western Ghats, North Travancore. S. Jones, 12.iv.1940 and April 1941.

1 specimen, 94.5 mm. long. Kallar stream at the foot of Ponmudi Hills, Western Ghats, South Travancore. S. Jones, April 1939.

Hora (*loc. cit.*) has given a detailed account of *Bhavana australis* and discussed its affinities with other genera of the Homalopterinae. The species seems to be fairly common in the southern portion of the Western Ghats.

Travancoria jonesi Hora.

1941. *Travancoria jonesi*, Hora, *Rec. Ind. Mus.* XLIII, p. 230, pl. viii, figs. 5-9.

20 specimens, 22 to 100 mm. in length. Streams within a radius of about 5 miles round Pampadampara, Western Ghats, North Travancore. S. Jones, 12.iv.1940 and April 1941.

An account of *Travancoria jonesi* was recently published by Hora (*loc. cit.*) in his paper on the Homalopterid fishes from Peninsular India. The genus *Travancoria* is very closely allied to *Bhavana*, but differs in having more extensive gill-openings and a larger number of rostral barbels. The species is known only from Travancore.

Lepidocephalus thermalis (Cuv. & Val.).

1878. *Lepidocephalichthys thermalis*, Day, *Fish. India*, p. 610, pl. clv, fig. 3.

20 specimens, 29 to 33 mm. in length. Pampadampara Tank, Western Ghats, North Travancore. S. Jones, March 1940.

42 specimens, 33.5 to 70 mm. in length. Streams within a radius of about 5 miles round Pampadampara, Western Ghats, North Travancore. S. Jones, 12.iv.1940 and April 1941.

Lepidocephalus thermalis is known from Peninsular India and Ceylon. In general facies, it is closely allied to *L. guntea* of northern India, but Day distinguished the two species by the size of the head and the number of transverse rows of scales on the body. It is likely that when large series of specimens from different localities are carefully examined, the two forms may prove to be local races of the same species.

Nemachilus evezardi Day.

1878. *Nemachilus evezardi*, Day, *Fish India*, p. 613, pl. cliii, fig. 11.

1919. *Nemachilus evezardi*, Annandale, *Rec. Ind. Mus.* XVI, p. 126, pl. i, figs. 2, 2a.

1938. *Nemachilus evezardi*, Hora, *Rec. Ind. Mus.* XL, p. 241.

42 specimens, about 25 mm. in length. Streams within a radius of about 5 miles round Pampadampara, Western Ghats, North Travancore. S. Jones, April 1941.

43 specimens, 13 to 56 mm. long. Dhobikana, a small stream close to Pampadampara, Western Ghats, North Travancore. S. Jones, March 1940.

8 specimens, 31 to 41 mm. in length. Sannyasa-ode, near Pampadampara, Western Ghats, North Travancore. S. Jones, April 1940.

Nemachilus evezardi was hitherto known from the Western Ghats, near Bombay, the Pachmarhi hills, Central Provinces, and the Bailadila range, Bastar State, Central Provinces. It is recorded here from the Travancore hills for the first time. The distribution of the species is of some interest as indicating the continuity of these hills at some earlier period.

N. evezardi is readily distinguished from other Indian species of the genus by the possession of well-marked nasal barbels. The colouration is very variable, but is quite characteristic of the species.

Nemachilus guentheri Day.

(Plate IX, figs. 2-5.)

1867. *Nemacheilus guentheri*, Day, *Proc. Zool. Soc. London*, p. 285.
1868. *Nemachilus guentheri*, Günther, *Cat. Fish. Brit. Mus.* VII, p. 361.
1872. *Nemacheilus guentheri*, Day, *Journ. As. Soc. Bengal* XLI, p. 195.
1878. *Nemacheilus guentheri*, Day, *Fish. India*, p. 615, pl. clvi, fig. 10.
1889. *Nemachilus guentheri*, Day, *Faun. Brit. Ind. Fish.* I, p. 228.

2 specimens, 27 and 51.2 mm. in length. Streams within a radius of 5 miles round Pampadampara Western Ghats, North Travancore. S. Jones, April 1941.

Since the discovery of *Nemachilus guentheri* by Day about 74 years ago in the "Rivers along the lower slopes and base of the Neilgherry hills", no other worker seems to have collected further material of this species. Günther's description is based on a typical specimen from Day's collection. Besides the two specimens collected by Mr. S. Jones as noted above, we have examined 3 specimens from the Dhoni forest in South Malabar collected by Mr. E. Burnes in May 1923, and 8 specimens collected by the late Dr. N. Annandale from the Nierolay stream, a tributary of the Bhavani river at the base of the Nilgiri Hills. These records show that the species is distributed probably all over the southern parts of the Western Ghats and the associated hill ranges.

In the specimens under report, the length of the head is contained from 5.10 to 5.69 times in the total length and from 4.16 to 4.49 times in the standard length. The head is broader than its height; its width is contained from 1.56 to 1.86 times and its height from 1.80 to 2.04 times in its length. The eyes are situated almost in the middle of the head or slightly nearer to the tip of the snout than to the end of the opercular border; the diameter of the eye is contained from 3.90 to 5.30 times in the length of the head, from 1.43 to 2.25 times in the length of the snout and from 0.83 to 1.40 times in the interorbital width. The head and the anterior part of the body are somewhat flattened while the tail is compressed from side to side. The depth of the body is contained from 8.68 to 9.79 times in the total length and from 6.85 to 7.72 times in the standard length. The caudal peduncle is almost as long as high or may be slightly longer.

From the material before us, it seems that the colouration is very variable. In a specimen from the Dhoni forest, the dorsal surface is uniformly dark with faint indications of the pale bands in the tail region. As pointed out by Day, there are usually three rows of pale spots (Pl. IX, fig. 2) but their extent varies practically with each individual. A black mark is invariably present in the axil of the pectoral fin and the caudal fin is provided with three W-shaped bands across it. There is a deep, short, vertical bar at the base of the caudal fin.

The specimens from the Nierolay stream (Pl. IX, fig. 4) and Pampadampara are much lighter in colour. The general colour of the body is pale olivaceous; the dorsal surface of the head is grayish, while the entire ventral surface is much lighter. The body is marked with 3 rows of spots of different sizes and form; they impart a very characteristic appearance to the species.

Measurements in millimetres.

			Dhoni Forest, S. Malabar.		Pampadam- para.		Nierolay Stream, Nilgiris.	
Total length ..	..	..	45.6	51.8	52.0	51.2	40.8	56.8
Length of caudal ..	..	..	9.1	10.6	10.4	10.8	7.2	12.0
Length of head ..	..	..	8.2	9.5	10.0	9.0	8.0	10.6
Height of head ..	..	..	4.1	4.9	4.9	5.0	4.0	5.5
Width of head ..	..	..	5.2	5.1	5.8	5.3	5.0	6.8
Depth of body ..	..	..	5.2	5.6	5.9	5.9	4.9	5.8
Diameter of eye ..	..	..	2.1	2.1	2.4	2.0	1.8	2.0
Length of snout ..	..	..	3.0	3.4	3.9	3.9	2.6	4.5
Interorbital distance ..	..	..	2.0	2.5	2.6	2.4	1.5	2.8
Length of dorsal ..	..	..	7.2	9.0	9.8	8.0	7.0	8.5
Length of pectoral ..	..	..	7.2	9.1	9.9	8.9	7.8	10.0
Length of ventral ..	..	..	6.7	8.1	9.0	7.7	6.0	8.9
Length of anal ..	..	..	6.1	7.2	8.1	7.0	5.2	7.7
Length of caudal peduncle ..	..	..	4.6	5.8	5.5	5.0	4.2	5.0
Least height of caudal peduncle ..	..	..	4.6	5.0	5.5	4.6	3.8	5.0

***Nemachilus triangularis* Day.**

1865. *Nemacheilus triangularis*, Day, *Proc. Zool. Soc. London*, p. 295.
 1865. *Nemacheilus triangularis*, Day, *Fish. Malabar*, p. 203, pl. xiv, fig. 1.
 1868. *Nemachilus triangularis*, Günther, *Cat. Fish. Brit. Mus.* VII, p. 352.
 1872. *Nemacheilus triangularis*, Day, *Journ. As. Soc. Bengal* XLI, p. 194.
 1878. *Nemacheilus triangularis*, Day, *Fish. India*, p. 619, pl. cliii, fig. 10.
 1889. *Nemachilus triangularis*, Day, *Faun. Brit. Ind. Fish.* I, p. 234.
 1909. *Nemachilus triangularis*, Jenkins, *Rec. Ind. Mus.* III, p. 289.
 1929. *Nemachilus triangularis*, Pillay, *Journ. Bombay Nat. Hist. Soc.* XXXIII, p. 710.
 1936. *Nemachilus triangularis*, John, *Journ. Bombay Nat. Hist. Soc.* XXXVIII, p. 710.
 6 specimens, 45 to 73 mm. in length. Streams within a radius of about 5 miles round Pampadampara, Western Ghats, North Travancore. S. Jones, 12.iv.1940, and April 1941.
 4 specimens, 42 to 49 mm. in length. Manimala R., near Kangirappally, Central Travancore. C. C. John, 26.iii.1940.
 6 specimens, 38 to 56 mm. in length. Achenkovil R., 7 miles south-east of Konni, Central Travancore. C. C. John, 17.ii.1940.
 1 specimen, 52 mm. long. Kulathupuzha, a tributary of Kallada R., Central Travancore. C. C. John, 14.ii.1940.
 8 specimens, 42 to 64 mm. in length. Kallar stream at the foot of Ponmudi Hills, Western Ghats, South Travancore. S. Jones, April 1939.

Day described *Nemachilus triangularis* from two specimens collected at Mundikyum, Travancore. The type-specimens are now preserved in the collection of the British Museum and, according to Day, the longer of the two is 2.1 inches in total length. There appears to be considerable inconsistency in Day's earlier and later accounts of the species regarding the proportions of the various parts of the body to the total length and, moreover, Day's illustration of the fish, as has already been pointed out by Günther, is not satisfactory. In view of this, we give below a complete description of the species and figures from fresh specimens.

D.2/8 ; A.2/5 ; P.11 ; V.8.

Nemachilus triangularis is a pretty loach with a very characteristic colouration ; it is almost subcylindrical with the head and anterior

part of body slightly depressed. The head is conical and bluntly pointed anteriorly ; its length is contained from 4.09 to 5.32 times in the standard length and from 5.13 to 7.11 times in the total length. The height of the head is contained from 1.45 to 1.88 times and its width from 1.28 to 1.55 times in its length. The eyes are of moderate size, are situated almost in the middle of the length of the head, and are not visible from below ; the diameter of the eye is contained from 3.60 to 5.00 times in the length of the head, from 1.33 to 2.14 times in the length of the snout and from 0.80 to 1.57 times in the interorbital width. In the males there is a small, obtuse projection of the preorbital below the anterior corner of the eye. The nostrils are situated considerably nearer to the anterior border of the eye than to the tip of the snout ; they are separated by a prominent flap. There are six moderately long barbels. The lips are thick, fimbriated and continuous at the angles of the mouth ; the lower lip is interrupted in the middle. The inter-maxillaries form a beak-shaped, median projection, which, when the mouth is closed, lies in front of the lower jaw.

The depth of the body is contained from 6.28 to 9.17 times in the total length and from 5.06 to 7.70 times in the standard length. The caudal peduncle is well formed and is generally somewhat higher than long. The body is covered with small distinct scales and the lateral line is fairly extensive and generally complete.

The dorsal fin originates slightly in advance of the pelvics and its commencement is almost equidistant from the tip of the snout and the base of the caudal fin. Its margin is straight and oblique, except at the anterior end where it is rounded. The pectoral is generally somewhat shorter than the head, but may be equal to it or even slightly longer ; it is broadly pointed in the middle and is separated from the pelvics by a distance equal to a third of its length. The pelvics are distinctly pointed in the middle and bear a fleshy appendage in the axil ; they do not extend as far as the anal opening. The caudal fin is deeply bifurcate.

The colour pattern varies considerably with age. In a young specimen, 35 mm. in total length, the ground colour is pale-olivaceous and there are about 7 dark bands descending from above to the sides ; they are angularly directed backwards and some of the anterior ones are united by narrow longitudinal streaks. Most of the bands are edged with madder brown, and rounded yellow spots are present in the angular parts of some of the anterior bands. There are four bands on the head, one on the snout, one below the eye and two behind it in the opercular region. The dorsal fin is provided with two bands and there are indications of two bands on the caudal. The anal and the pelvic fins are also provided with one band each. There is a black blotch at the base of the caudal.

Day¹ described the colouration of a specimen, 52.5 mm. in total length, as : " Yellowish-banded, each band being edged with black ; seven along the body, which pass backwards towards the lateral line, and consequently are disposed in a V-shaped manner ; one band passes over the operculum, a second through the eye and a third from the

¹ Day, F., *Proc. Zool. Soc. London*, p. 295 (1865).

orbit to the angle of the mouth. Dorsal with three irregular rows of black spots. Pectoral, ventral and anal unspotted, but darkest at their margins. Three black bands on the caudal, which has also a black base."

In a specimen, 72 mm. in total length, the colour pattern is still further modified. The ground colour of the head and the body is grayish and the pale bands on the body are broken up. There are seven bands, the anterior five are directed backwards, while the last two are vertical and are conspicuously edged with madder brown. There are a number of yellowish patches of different sizes and patterns above the lateral line. Five yellowish bands are present on the head and the colouration of the fins is similar to that described by Day.

Distribution.—Travancore. The specimens figured here were collected by the late Dr. N. Annandale at Courtallum, Travancore.

Measurements in millimetres.

	Pampadam- para.		Kallar Stream.			Achenkovil R.			Kula- thu- puzha.	Manimala R.		
Total length ..	55.0	70.5	42.0	57.0	67.5	38.5	53.2	56.5	51.5	42.5	48.0	49.2
Length of caudal ..	8.8	12.0	9.0	11.0	15.0	7.8	11.5	11.0	11.2	8.5	9.5	10.5
Length of head ..	9.0	11.0	7.0	9.0	11.5	7.5	10.0	10.0	9.0	7.8	8.5	8.0
Height of head ..	5.5	7.0	4.0	5.5	7.0	4.0	5.5	6.0	5.5	4.5	5.0	5.5
Width of head ..	6.5	8.0	5.0	7.0	8.0	5.0	7.0	7.0	6.5	5.5	5.5	5.8
Depth of body ..	6.0	8.0	5.0	7.0	9.0	5.0	7.5	9.0	6.5	5.8	6.0	6.0
Diameter of eye ..	2.0	2.5	1.4	2.5	2.5	1.8	2.2	2.5	2.0	2.0	2.2	2.2
Length of snout ..	3.5	4.2	3.0	3.5	4.5	2.4	4.0	4.0	3.5	3.2	3.5	3.2
Interorbital distance	2.5	3.8	2.2	2.5	3.0	2.0	2.5	2.0	2.5	2.0	2.0	2.0
Length of dorsal ..	8.5	10.0	5.8	9.0	9.5	5.8	8.0	9.0	7.8	7.2	7.5	7.5
Length of pectoral ..	8.5	11.2	6.5	9.0	12.0	7.0	9.0	9.0	8.0	7.0	9.0	8.0
Length of ventral ..	7.8	9.2	6.0	8.5	10.0	5.8	7.0	8.5	7.5	5.5	7.5	6.2
Length of anal ..	7.0	9.2	5.0	7.0	8.5	5.0	7.0	7.0	6.0	5.8	7.0	6.2
Length of caudal peduncle.	5.0	8.0	4.0	5.8	5.8	3.5	5.0	5.5	4.0	4.0	4.0	4.5
Least height of caudal peduncle.	5.0	7.0	4.5	6.5	8.0	4.0	6.5	6.0	5.0	5.0	5.0	5.2

***Callichrous bimaculatus* (Bloch).**

1936. *Callichrous bimaculatus*, Hora, *Rec. Ind. Mus.* XXXVIII, pp. 356-361.
2 specimens, 144 and 149 mm. in length. Near the source of Kallada R., 4 miles east of Thenmalai, Central Travancore. C. C. John, 9.ii.1940.

1 specimen, 162 mm. long. Kulathupuzha, a tributary of Kallada R., Central Travancore. C. C. John, 14.ii.1940.

Recently one of us (Hora, *loc. cit.*) discussed the specific limits of *Callichrous bimaculatus*, and referred to the great range of variation exhibited by the species. In the specimens under report, the colouration varies considerably; one of the specimens is very dark all over, while the others are much lighter.

***Batasio travancoria* Hora & Law.**

1941. *Batasio travancoria*, Hora and Law, *Rec. Ind. Mus.* XLIII, pp. 40-42, pl. ii, figs. 7-9, text-fig. 3.

1 specimen, 95 mm. long. Pool at the foot of the largest fall of Peruntenuaruvu, a tributary of Pamba R., at Edakadathy, Central Travancore. C. C. John, 11.ii.1940.

1 specimen, 85 mm. long. Near the source of Kallada R., 4 miles east of Thenmalai, Central Travancore. C. C. John, 9.ii.1940.

2 specimens, 78 and 105 mm. in length. Kulathupuzha, a tributary of Kallada R., Central Travancore. C. C. John, 14.ii.1940.

1 specimen, 75 mm. long. Chittar Stream at Palode, South Travancore. C. C. John, 10.ii.1940.

Batasio travancoria was recently described by us and remarks were made on the remarkable discontinuous distribution of the genus. It is known so far from the central and southern parts of Travancore.

***Mystus cavasius* (Ham.).**

1877. *Macrones cavasius*, Day, *Fish. India*, p. 447, pl. c, fig. 1.

1 specimen, 103 mm. long. Kulathupuzha, a tributary of Kallada R., Central Travancore. (Collected from a pond-like accumulation of water surrounded by big boulders.) C. C. John, 14.ii.1940.

Mystus cavasius is widely distributed in the fresh waters of India and Burma. The specimen under report is a male with a well-developed urinogenital papilla; the free portion of the papilla being almost as long as the diameter of the eye. The testes are lobulated as in *M. malabaricus* (*vide infra*, p. 255).

***Mystus malabaricus* (Jerdon).**

1877. *Macrones malabaricus*, Day, *Fish. India*, p. 450, pl. ci, fig. 2.

1936. *Macrones malabaricus*, John, *Journ. Bombay Nat. Hist. Soc.* XXXVIII, p. 709.

2 specimens, 89 and 111 mm. in length. A tributary of Manimala R., Erumeli, Central Travancore. C. C. John, 20.ii.1940.

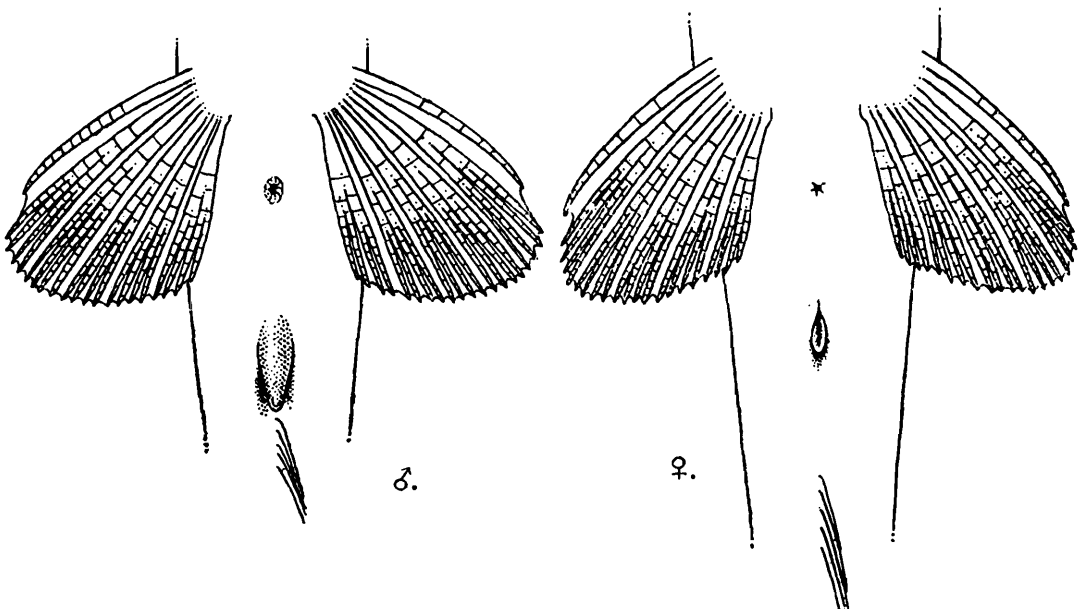
6 specimens, 95 to 119 mm. in length. Kulathupuzha, a tributary of Kallada R., Central Travancore. (Collected from a pond-like accumulation of water surrounded by big boulders.) C. C. John, 14.ii.1940.

1 specimen, 117 mm. long. Achenkovil R., 7 miles south-east of Konni, Central Travancore. C. C. John, 17.ii.1940.

3 specimens, 99 to 118 mm. in length. Near the source of Kallada R., 4 miles east of Thenmalai, Central Travancore. C. C. John, 9.ii.1940.

3 specimens, 91 to 113 mm. in length. Chittar stream at Palode, South Travancore. C. C. John, 10.ii.1940.

In Dr. C. C. John's collection there are 15 male specimens from 5 localities, as listed above, which we refer to *Mystus malabaricus* (Jerdon).



TEXT-FIG. 3.—External urinogenital structures in the male and female of *Mystus malabaricus* (Jerdon). Male: $\times 2$; Female: $\times 2\frac{1}{2}$.

The males are provided with a urinogenital papilla, the size of which depends upon the sexual maturity of the individual irrespective of its

length. In immature specimens the testes are ribbon-like structures but become greatly enlarged and highly lobulated in adult males. The urinogenital duct opens at the extremity of the papilla. In the females the urinogenital opening is a slit-like aperture bordered by thickened lips. On account of these secondary sexual characters, the males and females can be distinguished readily. The anal opening is situated at a considerable distance in front of the urinogenital opening.

The presence of a urinogenital papilla is a fairly common occurrence among Siluroid fishes. Mukerji¹ recorded it in the case of *Glyptosternum reticulatum* McClelland. Day (*loc. cit.*, pp. 449, 450) referred to the presence of an anal papilla (=urinogenital papilla) in the case of two species of *Macrones* described and figured by him, viz., *M. keletius* (Cuv. & Val.) and *M. armatus* Day. From among the specimens referred by Day to *M. malabaricus*, two are now preserved in the collection of Indian Museum; one (No. 721) is a male with a well developed papilla and the second is a female (No. 504). The former is the original of his figure in the *Fishes of India* and it seems that the presence of the papilla was overlooked. *M. malabaricus* differs from *M. keletius* and *M. armatus* by its smooth head and other characters of minor importance.

Recently Mookerjee, Mazumdar and Das Gupta² described similar urinogenital structures in *Mystus gulio* (Ham.), but used for them anthropomorphic terms and by implication assumed for them copulatory functions without giving reasons for their views. We found similar organs in all the species of *Gagata* and *Batasio* studied by us³.

M. malabaricus is known from the Malabar Coast, Wynaad Hills and the hill ranges of Travancore.

***Glyptothorax madraspatanus* (Day).**

1938. *Glyptothorax madraspatanus*, Hora, *Rec. Ind. Mus.* XL, p. 370.

- 1 specimen, 101 mm. long. Pampadampara, Western Ghats, North Travancore. S. Jones, 12.iv.1940.
- 2 specimens, 67 and 110 mm. in length. Streams within a radius of 5 miles round Pampadampara, Western Ghats, North Travancore. S. Jones, April 1941.
- 1 specimen, 173 mm. long. Pool at the foot of the largest fall of Peruntenuvi, a tributary of Pamba R., at Edakadathy, Central Travancore. C. C. John, 11.ii.1940.

In his key to the Indian species of the genus *Glyptothorax*, Hora⁴ included *G. madraspatanus* in the group in which the ventral surface of the outer rays of the paired fins is not plaited. In the larger specimen under report, the skin on the ventral surface of the pectoral spine and that of the two outer rays of the pelvic fins form an adhesive pad of longitudinal grooves and ridges similar to those of the thoracic adhesive apparatus. It seems probable that this character, which is directly correlated with the rapidity of the current, is of little taxonomic value.

¹ Mukerji, D. D., *Mem. Conn. Acad.* X, art. xviii, p. 329 (1936).

² Mookerjee, H. K., Mazumdar, S. R. and Das Gupta, B., *Ind. Journ. Vet. Sci. Animal Husb.* X, p. 295 (1940).

³ Hora, S. L. and Law, N. C., *Rec. Ind. Mus.* XLIII, pp. 9-42 (1941).

⁴ Hora, S. L., *Rec. Ind. Mus.* XXV, p. 12 (1923).

The lower lobe of the caudal fin of the larger specimen is abnormal ; it is rounded instead of being pointed and has a Y-shaped whitish area in its distal portion.

***Xenentodon cancila* (Ham.).**

1877. *Belone cancila*, Day, *Fish. India*, p. 511, pl. cxviii, fig. 5.

1 specimen, 222 mm. long. Pool at the foot of the largest fall of Peruntenaruvi, a tributary of Pamba R., at Edakadathy, Central Travancore. C. C. John, 11.ii.1940.

Xenentodon cancila is widely distributed in the fresh waters of India and on account of its characteristic beak can be readily distinguished from other kinds of fish.

***Ophicephalus gachua* Ham.**

1876. *Ophiocephalus gachua*, Day, *Fish. India*, p. 367.

5 specimens, 82 to 123 mm. in length. Streams within a radius of about 5 miles round Pampadampara, Western Ghats, North Travancore. S. Jones, 12.iv.1940 and April 1941.

1 specimen, 18 mm. long. Manimala R., near Kangirappally, Central Travancore. C. C. John, 26.iii.1940.

6 specimens, 36 to 51 mm. in length. Achenkovil R., 7 miles south-east of Konni, Central Travancore. C. C. John, 17.ii.1940.

1 specimen, 47 mm. long. Kulathupuzha, a tributary of Kallada R., Central Travancore. (Collected from a pond-like accumulation of water surrounded by big boulders.) C. C. John, 14.ii.1940.

Ophicephalus gachua is represented in the collection by several young and half-grown specimens. This species is widely distributed throughout the Oriental Region.

***Mastacembelus armatus* (Lacép.).**

1876. *Mastacembelus armatus*, Day, *Fish. India*, p. 340, pl. lxxiii, fig. 2.

1 specimen, 225 mm. long. Pool at the foot of the largest fall of Peruntenaruvi, a tributary of Pamba R., at Edakadathy, Central Travancore. C. C. John, 11.ii.1940.

2 specimens, 64 and 257 mm. in length. Achenkovil R., 7 miles south-east of Konni, Central Travancore. C. C. John, 17.ii.1940.

Mastacembelus armatus is a widely distributed Indian fish ; its range extends as far as China. As has already been noted by Day and other workers, the colouration of the species varies considerably with growth, and very young specimens¹ of about 2 to 3 inches in length look quite different from the adult.

¹ Hora, S. L. and Mukerji, D. D., *Rec. Ind. Mus.* XXXVIII, p. 145 (1936).

EXPLANATION OF PLATE IX.

THE FRESHWATER FISH OF TRAVANCORE.

Barbus (Puntius) curmuca (Hamilton).

FIG. 1.—Lateral view of a specimen showing the black-tipped caudal and tubercles on the side of the head : $\times \frac{7}{8}$.

Nemachilus guentheri Day.

FIG. 2.—Lateral view of a female specimen from Dhoni forest, S. Malabar : $\times ca. 2\frac{1}{4}$.

FIG. 3.—Ventral surface of head and anterior part of body of same : $\times ca. 2\frac{1}{4}$.

FIG. 4.—Lateral view of a male specimen from Nierolay stream, Nilgiri Hills : $\times ca. 2$.

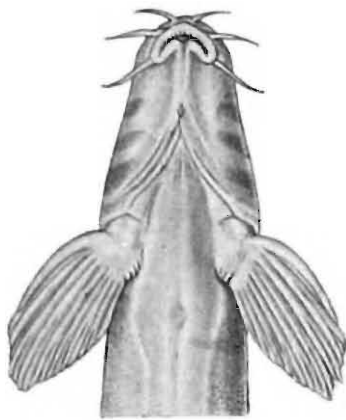
FIG. 5.—Ventral surface of head and anterior part of body of same : $\times ca. 2$.

Nemachilus triangularis Day.

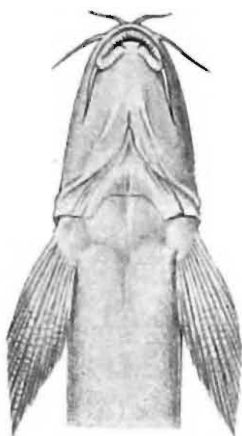
FIG. 6.—Lateral view of a juvenile specimen from Courtallum, Travancore : $\times ca. 3$.

FIG. 7.—Ventral surface of head and anterior part of body of same : $\times ca. 3$.

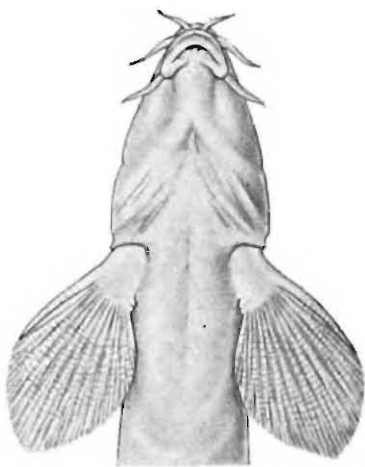
FIG. 8.—Lateral view of an adult specimen from Courtallum, Travancore, showing characteristic colouration of the species : $\times ca. 1\frac{2}{3}$.



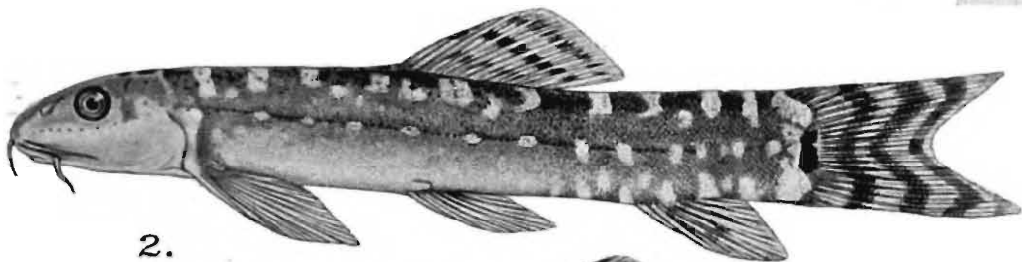
7.



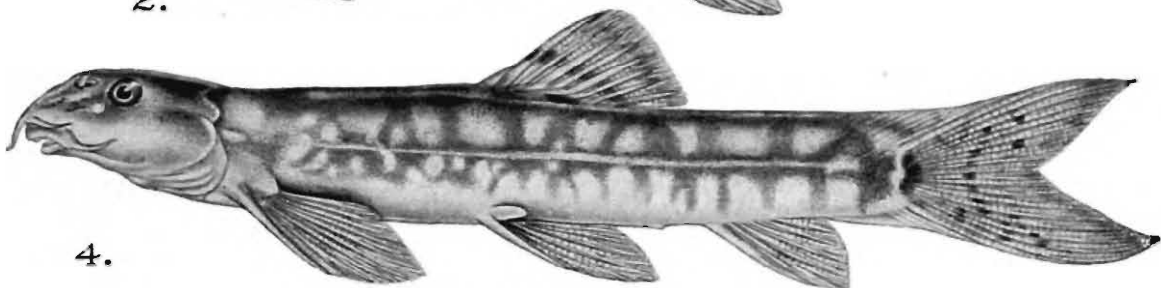
3.



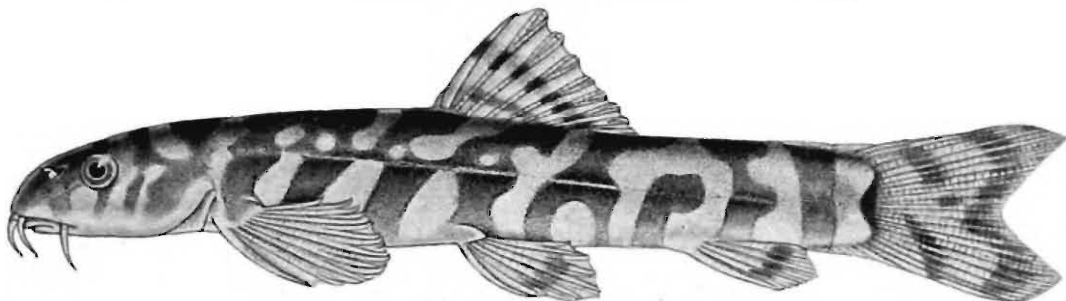
5.



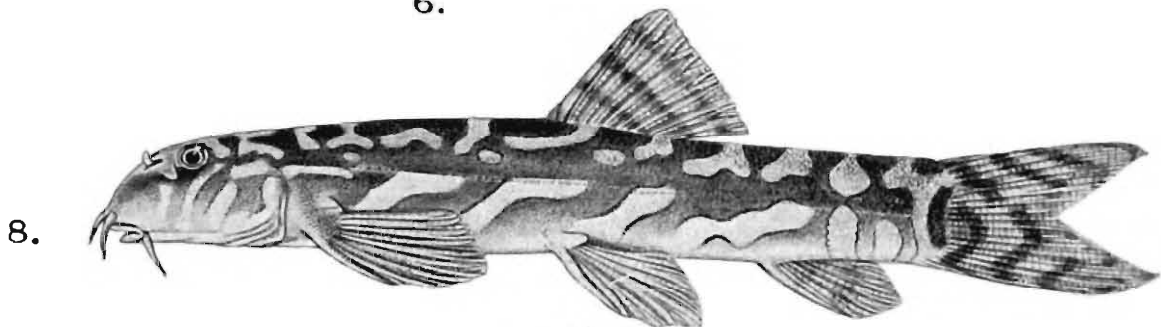
2.



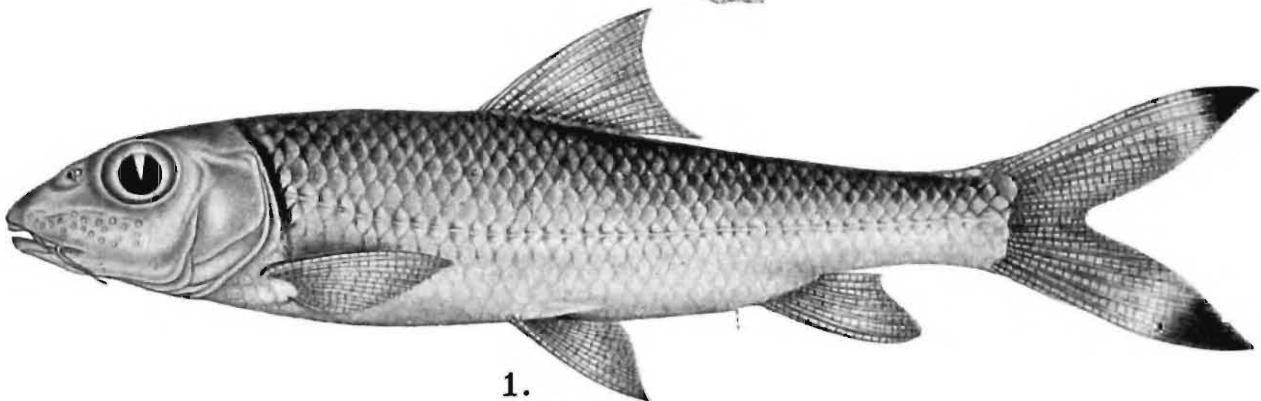
4.



6.



8.



1.

TWO NEW SPECIES OF *OBEREA* FROM MADRAS (COLEOPTERA : CERAMBYCIDAE).

By J. C. M. GARDNER, *Forest Research Institute, Dehra Dun, U. P.*

***Oberea artocarpi*, sp. nov.**

Ochraceous, except eyes, antennae, distal two-thirds of elytra and of wings and distal segment of abdomen (above and below) which are black. Pubescence very short uniformly corresponding in colour with the derm ; there are a few longer hairs on head, pronotum and base of elytra. Body elongate.

Head and pronotum with rather coarse but shallow and not very distinct punctures ; front in male a little wider than an eye (as seen in frontal view), distinctly wider in female ; lower lobe of eye slightly wider than high, separated from mandible by about one-third its own height. Antennae reaching to about the elytral apex, the scape very finely rugulose, the third segment slightly longer than fourth. Prothorax wider than long, very slightly constricted anteriorly and posteriorly. Elytra a little wider than prothorax and slightly attenuated in the middle region, with two feeble costae behind the shoulder which do not reach the apex, the disc depressed ; punctures mostly serially arranged, rather coarse basally, absent at apex ; apex of elytron somewhat narrowed, truncate and slightly concave, the outer angle with a rather stronger angulation, the inner with a small point. Posterior femora reaching a little beyond second abdominal segment. Last sternite of female with a fine median line, of male with a shallow longitudinal depression. Length 12 mm. to 15 mm. Elytra about five times as long as prothorax.

Holotype (male) and four paratypes reared from green twigs of *Artocarpus integrifolia* sent to Dehra Dun from Palghat, Madras. Emergences from 31st March, 1941 to 4th April, 1941.

The new species has much in common with *O. clara* Pasc. (= *O. armata* Gah.) but has no median process on the first abdominal sternite and the colour is quite different.

***Oberea mangalorensis*, sp. nov.**

Head, prothorax and underside (except last abdominal sternum) and legs fulvous ; last abdominal segment black except a narrow space at base ; antennae black ; elytra fulvous on about the basal third, infuscated beyond that. Body form elongate.

Head closely and rather coarsely punctured on frons and above ; frontal area higher than wide in male, wider in female ; lower lobe of eye about as high as wide, reaching to near mandible. Antennae extending a little beyond elytra in male ; third segment longer than fourth. Prothorax parallel sided, slightly longer than wide in male, about as long as wide in female ; distinctly and rather closely punctured. Elytra slender, somewhat narrowed in middle region, serially punctate ; the apices concave-truncate, the outer angle rather bluntly produced.

Posterior femora reaching to about middle of second abdominal segment. Abdomen with some larger punctures beneath. Last sternum of male with wide depression. Length 11 mm. to 14 mm.

Madras : South Mangalore, four specimens on foliage (J. C. M. Gardner). Holotype (female), allotype (male) and one paratype in Forest Research Institute ; one paratype in Zoological Survey of India, Calcutta.

This species resembles *posticata* Gahan structurally but is distinguished by the black posterior segment of the abdomen and the posteriorly infuscated elytra.