

VARIATIONS SAISONNIÈRES DES CYCLOPIDES DANS DES PUITS DU DECCAN (INDE).

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Le travail présent a été entrepris pour voir si l'étude des mouvements des populations dans les puits de l'hôte intermédiaire du ver de Médine (*Dracunculus medinensis*) est susceptible d'offrir une solution au problème de l'incidence saisonnière de la draconculose. En ce qui concerne l'Inde, où le maximum d'infestation humaine a lieu pendant la saison la plus chaude de l'année, l'hypothèse généralement admise pour expliquer ce fait c'est que le niveau de l'eau dans les puits est le plus bas pendant la saison chaude, qui aux Indes est celle précédant l'arrivée des pluies. Cette théorie repose sur l'observation que les cyclopes sont plus nombreux au fond des puits qu'à la surface et de ce fait la conclusion a apparemment été tirée que le nombre de cyclopes avalés par les indigènes doit être d'autant plus grand que la hauteur de l'eau est plus basse.

Par des numérations des cyclopes, répétées plusieurs fois par mois pendant une année entière dans des puits différents d'une région endémique, je me suis attendu à obtenir des renseignements sur la densité comparative de ces animaux à la surface et au fond des puits et sur les variations saisonnières des populations. A part des faits de cet ordre l'étude présente a fourni des données sur la proportion des formes de développement des Cyclopidés en question et d'une façon tant qualitative que quantitative, sur les diverses espèces habitant ces puits.

Méthode d'examen.

Deux puits ont été choisis ; l'un, puits G., à escalier de descente condamné au public, l'autre, puits B., à escalier ouvert, en usage commun. Les pêches ont toujours été faites par moi-même dans les mêmes conditions, entre 4 et 6 heures de l'après-midi, quand les villageois viennent prendre leurs provisions d'eau. Les parties des puits où la densité des cyclopes a été particulièrement importante à connaître sont évidemment la surface et le fond. Cependant j'ai pensé intéressant à faire des prélèvements aussi à une profondeur de 30 cm., celle-ci correspondant à peu près à celle d'où une grande portion de l'eau est retirée par les indigènes quand ils remplissent leurs vaisseaux métalliques dans les puits. Pour la récolte de l'eau de surface un seul mouvement demicirculaire, toujours de la même amplitude et exécuté de la même vitesse, a été fait avec un filet de gaze à bluter portant au bout un gobelet en laiton d'une capacité de 20 cm³. Le procédé a été exactement le même en enfonçant le bâton du filet jusqu'à 30 cm. au-dessous de la surface. Quant au prélèvement de l'eau du fond le filet a été descendu verticalement jusqu'au contact de la boue, toujours au même endroit, et a été retiré lentement après une attente d'environ une minute. Les animaux ont ensuite été tués à la formaline au laboratoire et comptés dans les 6 échantillons, chacun de 20 cm³. Je me suis

d'abord servi d'une cellule de Kolkwitz, mais je l'ai bientôt remplacée par une chambre de 1 cm³. montée sur une lame, ce qui a grandement facilité les numérations. Quatre formes de développement ont été considérées : (1) les femelles à sacs ovigères, (2) les femelles adultes ne portant pas des ovisacs, (3) les mâles adultes, (4) tous les stades copépodites. Les nauplii n'ont pas été comptés par suite de la facilité par laquelle ils passent inaperçus. Pour la détermination rapide de l'état de maturité des femelles attention a surtout été portée au degré de développement du segment génital.

La capacité de filtration des filets a évidemment varié dans une certaine mesure par suite du colmatage graduel qui se produit toujours, mais pour que ces variations soient restées peu importantes j'ai renouvelé trois fois le gaze du filet pendant l'année de l'étude. Toutefois les sources d'erreurs ou plutôt les facteurs de variation inévitables ont certainement été nombreux et opérant d'une façon tout à fait irrégulière, tant en ce qui concerne les échantillons prélevés du fond des puits, qui naturellement par le procédé employé n'ont pas pu représenter uniquement la faune du fond, que ceux de la surface et de 30 cm. Aussi les fluctuations dans les comptes ont parfois été très fortes, sans qu'elles aient toujours dû tenir aux méthodes de prélèvement. Quand il s'agit d'un milieu naturel tel qu'un puits on ne peut évidemment s'attendre à aucune stabilité comme on en obtient dans des expériences de laboratoire, où tous les facteurs variables peuvent être contrôlés. D'une part il y a les accidents de toute ordre dont sont responsables les êtres humains, remuant l'eau près de l'escalier ou la puisant d'en haut ; les matériaux divers transportés par le vent au contact de l'eau, les mouvements incessants des poissons, des grenouilles, des tortues, ceux des insectes grands et petits, etc. ; d'autre part il y a toutes les causes influençant d'une façon momentanée la filtration à l'instant même de chaque prélèvement, les parcelles de bois, de feuilles, de sable, d'insectes morts, la faune changeante en quantité et en qualité des autres Copépodes, des Cladocères, des Ostracodes, des Rotifères ; la flore d'algues, etc. plus ou moins envahissante. Puis il y a la question des migrations diurnes des Copépodes du fond à la surface ou inversement. Autant que je sache il n'est cependant pas connu si des migrations conformes à des lois existent vraiment dans le cas des Cyclopidés en question, mais pour qu'elles ne s'aient pas fait sentir les récoltes ont toujours été exécutées à peu près à la même heure de la journée. Au cours de pêches nombreuses j'ai cependant été impressionné par la probabilité plus grande des Cyclopidés vivant et se déplaçant en bancs à un même niveau des puits plutôt que faisant des migrations verticales importantes. Enfin il faut faire entrer en ligne de compte tous les phénomènes naturels faisant varier la faune des eaux d'un moment à l'autre dont les causes nous échappent. Dans les conditions qui viennent d'être indiquées il m'a semblé inapproprié d'entreprendre une évaluation statistique des chiffres obtenus et j'ai simplement donné les nombres moyens par récolte. Pour obtenir des termes de comparaison il a évidemment fallu diviser l'année d'après les saisons naturelles et envisager séparément les récoltes faites pendant chaque saison. A Kurduvadi il a été facile d'obtenir des divisions assez tranchées. L'arrivée des pluies a eu lieu

dans la première quinzaine du mois de juin ; elles ont été finies vers la fin du mois de septembre ; la saison froide a commencé vers le milieu du mois d'octobre et la saison chaude a débuté au milieu du mois de février, cette dernière saison, pendant laquelle il n'a tombé qu'un peu d'eau au moment d'orages rapidement terminés, a duré jusqu'au début de la mousson, mi-juin. La hauteur des pluies à Kurduvadi pendant l'année de l'étude, 1938 à 1939, a été donnée sur le tableau I.

J'ai ajouté séparément des données de pourcentages des formes de développement obtenues d'un puits à Vangarvadi (village à 20 km. de Kurduvadi) où une étude quantitative n'a pas été faite mais qui a servi pour évaluer le taux d'infestation des Cyclopides. Comme les pourcentages de ce troisième puits ont montré des variations importantes pendant le début et la fin, tant de la saison chaude que de la saison des pluies, ces deux saisons ont été subdivisées et la même subdivision observée au sujet des pourcentages des deux puits à Kurduvadi.

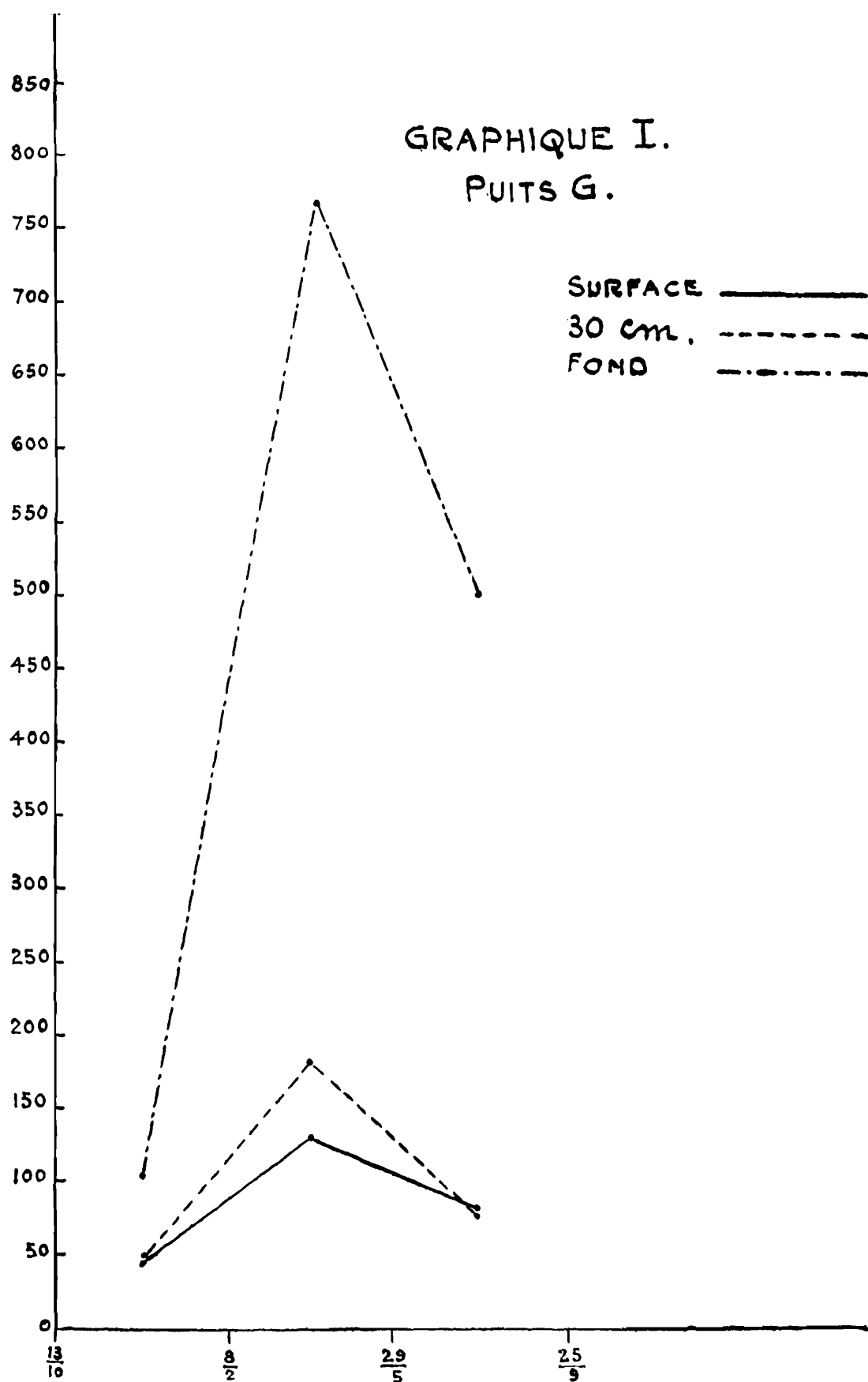
L'espèce de cyclope qui fait l'objet principal de ce travail est le *Mesocyclops vermifer* Lindberg, forme prépondérante dans la plupart des puits du Deccan et dont le rôle comme hôte intermédiaire du ver de Médine a été établi en 1935. Le *Mesocyclops leuckarti* (Claus), connu depuis longtemps comme hôte intermédiaire du *Dracunculus medinensis* dans des pays différents, s'est trouvé dans les trois puits en nombre tout à fait négligeable. Il en est de même du *Microcyclops varicans* Sars, de l'*Eucyclops agiloides* Sars et de l'*Ectocyclops medius* Kiefer ; de ce dernier un spécimen unique a été récolté et seulement d'un des trois puits. Le *Tropocyclops multicolor* Lindberg, qui est présent dans la plupart des puits de la région, n'a été trouvé en abondance que dans l'un des puits étudiés ici. Au cours d'expériences antérieures je n'ai pas observé de développement des embryons du *Dracunculus medinensis* dans ce cyclope et je n'ai jamais rencontré des individus à infestation naturelle. Il semble probable qu'il ne joue aucun rôle épidémiologique.

Résultats quantitatifs.

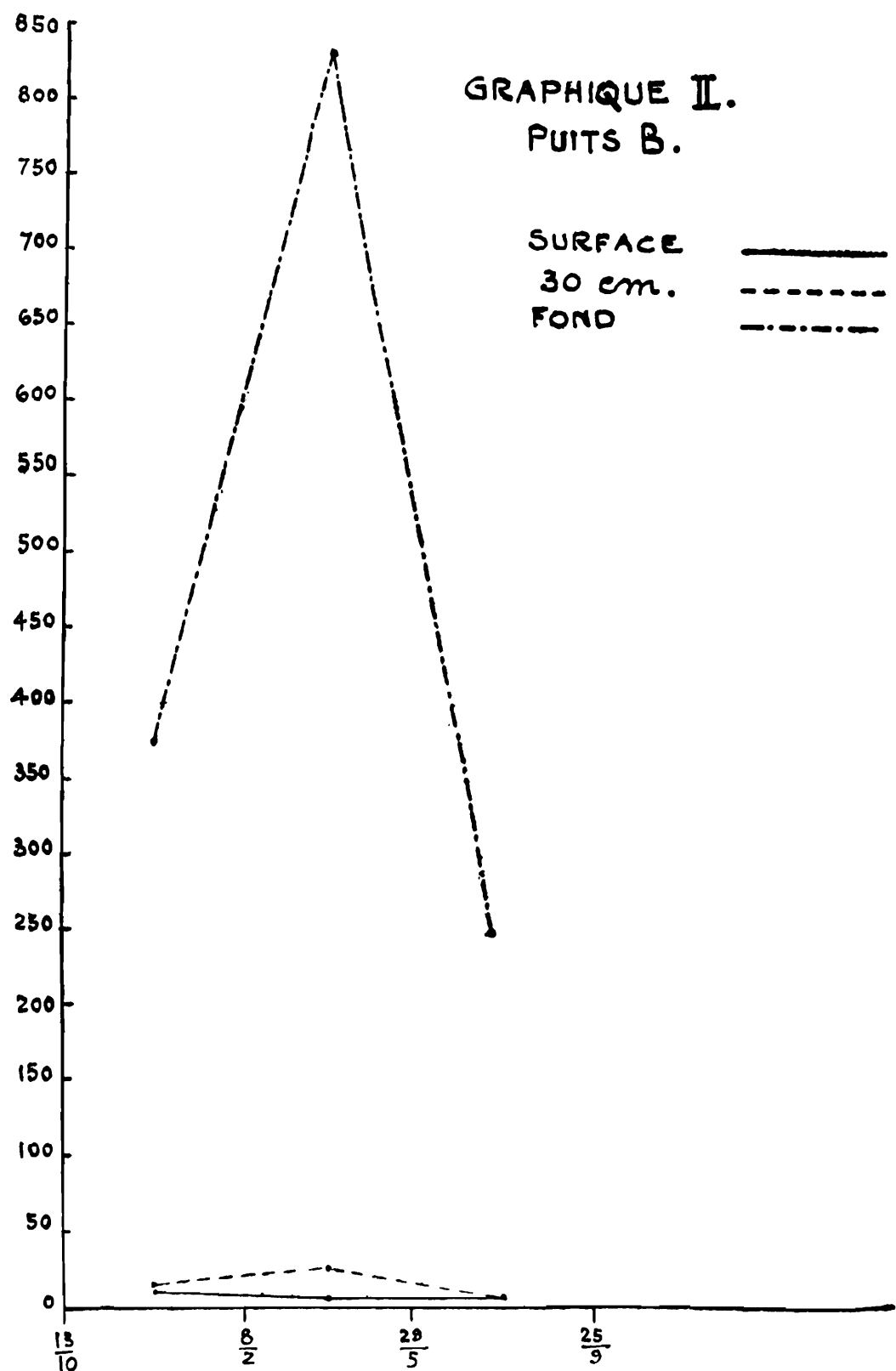
Sur le tableau II se voient les nombres moyens par récolte de *M. vermifer* pendant les 3 saisons de l'année et les mêmes chiffres sont représentés sur les graphiques I et II, où les nombres moyens sont pris en ordonnées et les saisons en abscisses.

Les données principales qui se dégagent de ce tableau et de ces graphiques sont les suivantes :—

- (1) Les cyclopes de l'espèce *M. vermifer* sont pendant toute l'année les plus nombreux au fond des puits.
- (2) Ils sont récoltés en plus grand nombre pendant la saison chaude que pendant l'hiver et la saison de la mousson, ceci peut-être par suite du moindre volume d'eau présent.
- (3) A la surface ils sont toujours peu nombreux aux endroits où l'eau est remuée par les indigènes (Puits B), mais leur nombre y est assez considérable dans le cas d'un puits d'où l'eau est puisée d'en haut, les prélèvements ayant été faits à quelque distance des parties agitées (Puits G).



GRAPHIQUE I.—Les données mentionnées sur le Tableau II(a) représentées graphiquement, les nombres moyens étant pris en ordonnées et les saisons en abscisses.



GRAPHIQUE II.—Les données mentionnées sur le Tableau II(b) représentées graphiquement de la même manière.

Incidence saisonnière de la draconculose.

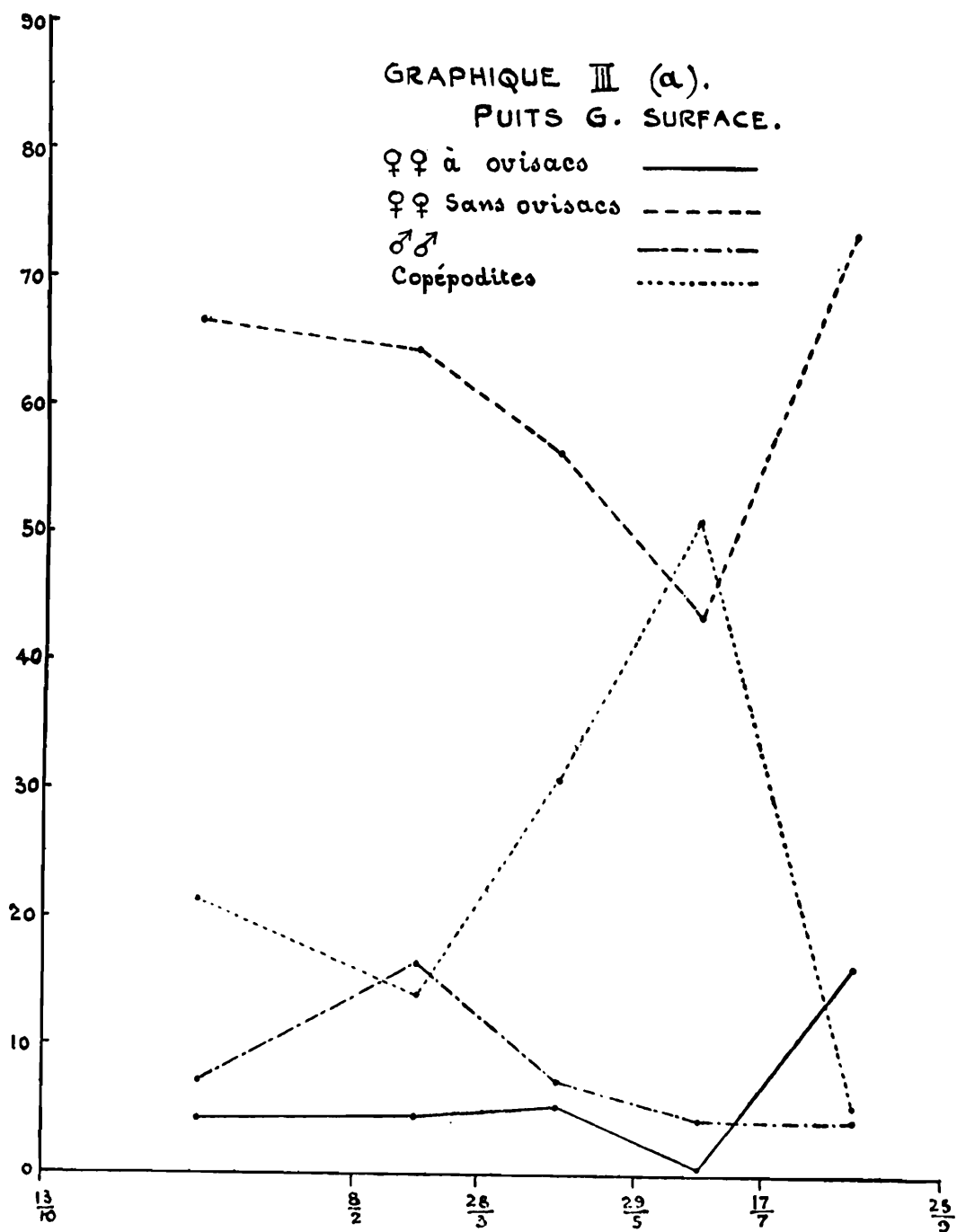
Les faits relatés viennent à l'appui de l'observation déjà mentionnée sur la prépondérance des cyclopes au fond des puits. Cependant il est évident qu'au cours d'années à hauteur de pluie normale l'eau ne descend pas dans bien de puits infestés à un niveau tellement bas que soit atteint les parties profondes où les cyclopes sont vraiment nombreux, et que la différence dans le nombre de cyclopes avalés par les indigènes pendant la saison chaude et pendant les autres saisons de l'année n'est probablement pas très grande. Du reste, d'après Mann, on rencontre même des puits dans le Deccan contenant plus d'eau en avril qu'en n'importe quelle autre époque de l'année (*Land and labour in a Deccan village*, No. 2, 1921, p. 28.). Il existe du reste des arguments sérieux venant à l'encontre de l'hypothèse expliquant l'incidence saisonnière par la faible hauteur de l'eau et le nombre plus grand des cyclopes qui en serait la conséquence. Si l'incidence saisonnière est uniquement fonction du nombre de cyclopes susceptibles d'être parasités et ingérés, des cas de draconculose devraient bien s'observer aussi aux autres saisons de l'année, puisque les cyclopes existent également en dehors de la saison chaude, bien qu'en nombre plus petit. Il est vrai qu'on peut rencontrer des cas de draconculose à n'importe quelle époque de l'année, mais en faisant une enquête dans ces cas, du reste exceptionnels, on trouve presque toujours, soit, que le début des symptômes remontait à la saison d'incidence ordinaire, soit qu'il s'agit de vers jeunes provoquant des accidents d'une façon anormale avant d'avoir atteint la maturité. D'autre part je n'ai jusqu'à présent trouvé aucun cyclope infesté en dehors de la saison d'incidence clinique, et, autant que je sache, une infestation naturelle de cyclopes hors saison, n'a jamais été rapportée par d'autres observateurs. Les constatations que j'ai faites à ce sujet feront l'objet d'une note séparée. Que des facteurs d'un tout autre ordre qu'une simple relation numérique soient à l'œuvre semble du reste se dégager des renseignements que j'ai recueillis dans le Laristan (Iran méridional) où l'infestation humaine n'a pas lieu à l'époque de la sécheresse, quand le niveau de l'eau dans les citernes est le plus bas, mais se fait, tout au contraire, pendant la saison qui suit l'arrivée des pluies.

Proportions saisonnières et verticales des sexes et des stades évolutifs.

Le nombre moyen par récolte des formes diverses de développement pendant les trois saisons de l'année, à la surface, à 30 cm. et au fond des puits G et B, a déjà été donné sur le tableau II. Sur les graphiques III, IV et V sont montrés les pourcentages des totaux pendant chaque saison, des femelles à ovisacs (trait continu), des femelles adultes sans ovisacs (ligne de traits), des mâles (trait pointillé) et des copépodites (pointillé fin), à la surface et au fond dans les puits G, B et V, les pourcentages étant pris en ordonnées et les saisons en abscisses.

En regardant ces graphiques le premier fait qui frappe c'est que le *M. vermifer* est un cyclope à reproduction polycyclique ou plutôt acyclique. Puis on voit qu'il y a certaines concordances entre les trois puits,

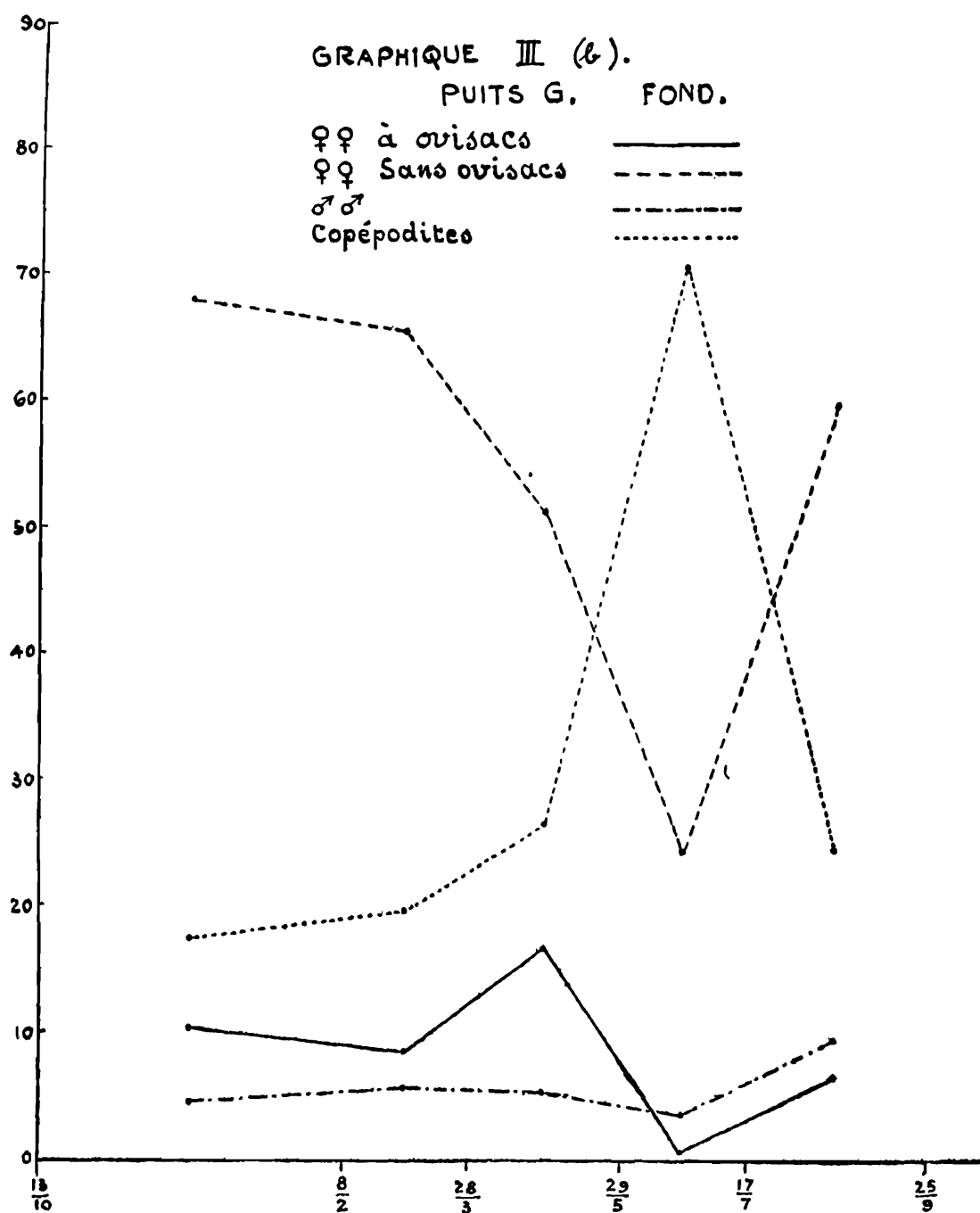
en ce qui concerne les proportions des divers stades aux saisons différentes, et qu'il existe aussi des divergences. Les *femelles à ovisacs* sont



GRAPHIQUE IIIa.—Pourcentages des totaux des stades évolutifs de *M. vermifer* pendant les différentes saisons de l'année dans le puits G à la surface et à 30 cm. pris ensemble.

dans les trois puits les plus nombreuses au fond à la fin de la saison chaude ; mais tandis que leur pourcentage n'atteint que 13 pour-cent

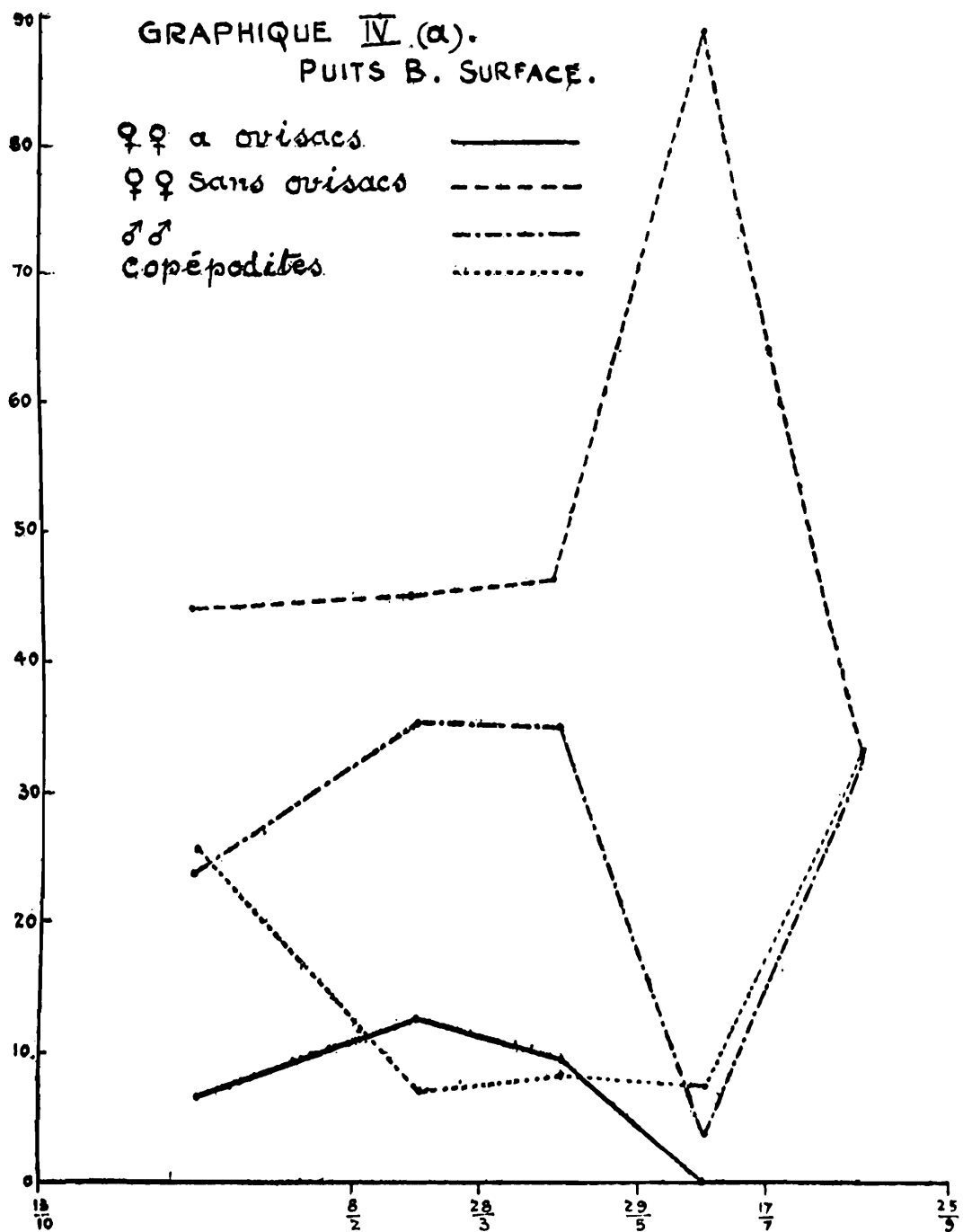
dans le puits B et 16.9 pour-cent dans le puits G, il monte jusqu'à 41 pour-cent dans le puits V C'est pendant la saison des pluies



GRAPHIQUE IIIb.—Les mêmes données au fond du puits G.

qu'elles sont les moins nombreuses dans les trois puits. Les *femelles sans ovisacs* représentent presque toujours la forme prépondérante. Dans le puits G elles le sont tant à la surface qu'au fond à chaque époque de l'année, sauf au fond au début de la mousson ; dans le

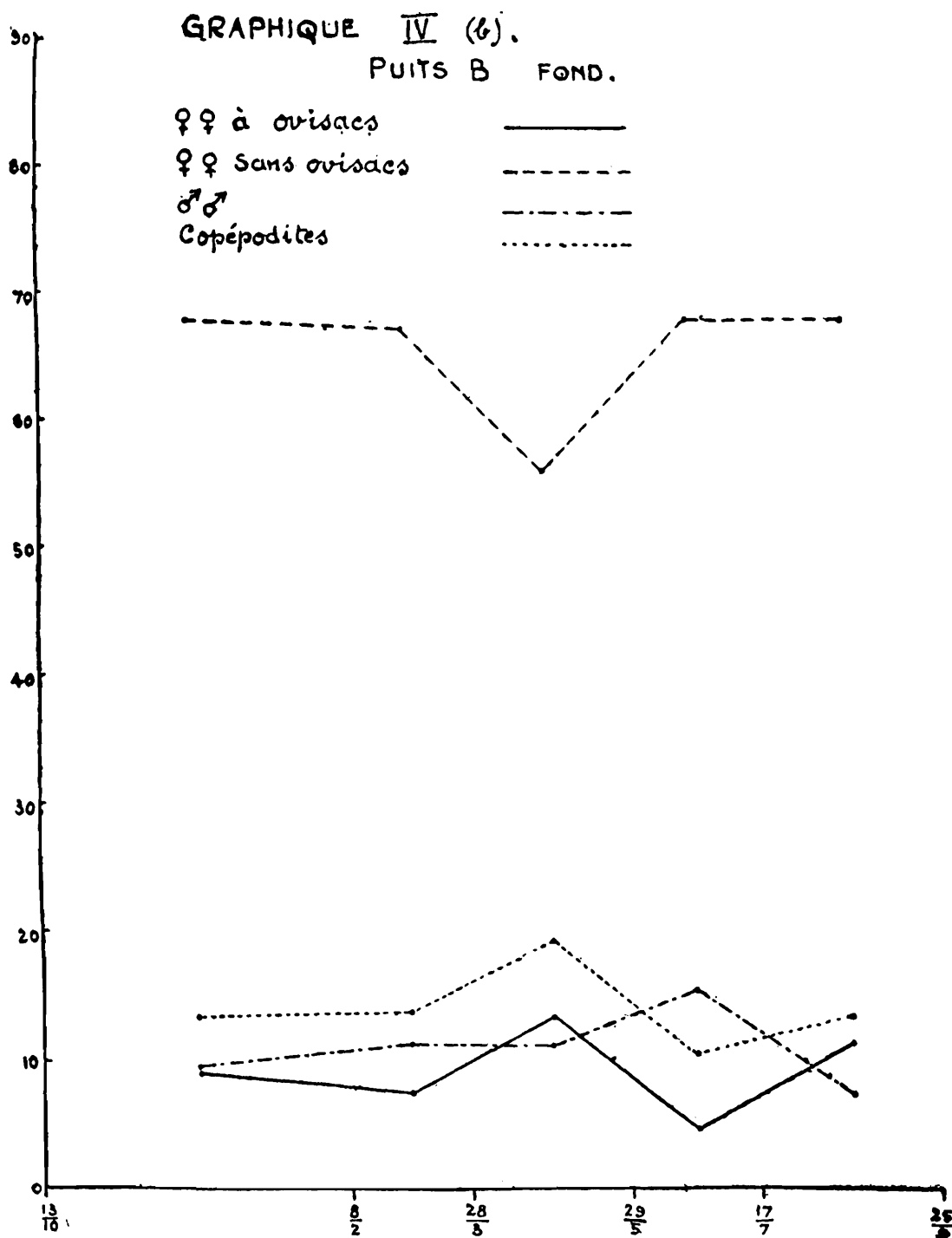
puits B elles sont également en majorité presque partout (Il faut remarquer que les récoltes faites dans ce puits à la surface et à 30 cm.



GRAPHIQUE IVa.—Pourcentages des totaux des stades évolutifs de *M. vermifer* pendant les différentes saisons de l'année dans le puits B à la surface et à 30 cm. pris ensemble.

pendant la fin de la saison pluvieuse n'ont donné que 3 cyclopes, les 3 de stades différents, et que par conséquent on ne peut aucunement

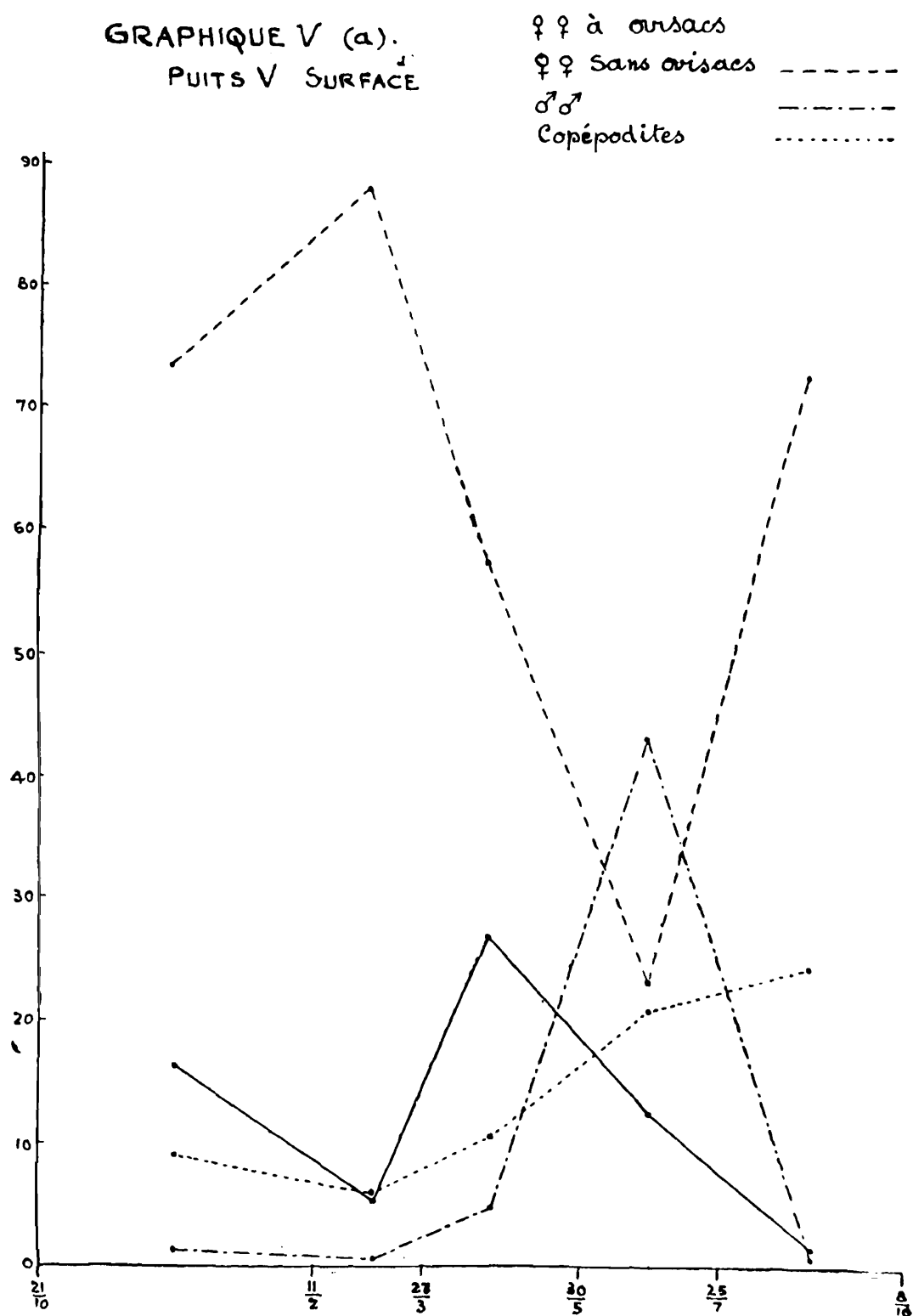
prendre en considération les 33·3 pour-cent obtenus, bien qu'il a fallu les faire entrer sur le graphique.) Dans le puits V les femelles sans



GRAPHIQUE IVb.—Les mêmes données au fond du puits B.

ovisacs prépondèrent aussi le plus souvent; elles y atteignent leur pourcentage le plus bas à la surface au debut de la mousson (23·5 pour-cent). Les mâles sont les plus nombreux à la surface pendant la saison chaude tant dans le puits G que dans le puits B (16·5 pour-cent et

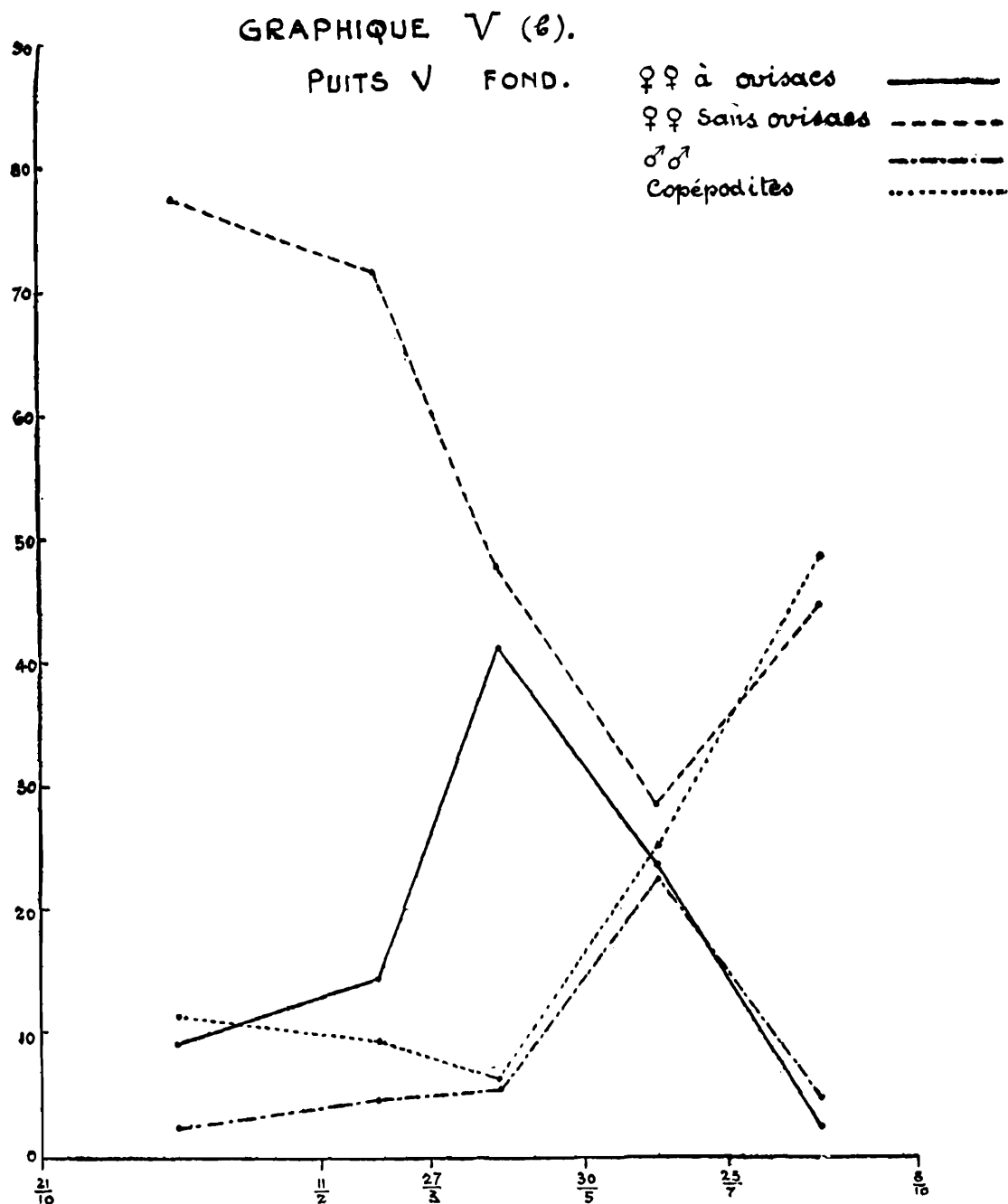
35.2 pour-cent). Dans le puits V c'est à la surface au debut de la saison des pluies que le pourcentage le plus élevé a été trouvé (43.1



GRAPHIQUE Va.—Pourcentages des stades évolutifs de *M. vermifer* pendant les saisons différentes de l'année dans le puits V à la surface.

pour-cent). Les *copépodites* ont dans le puits G été les plus nombreuses au fond au debut des pluies (70 pour-cent), leur maximum s'est trouvé à

la surface en hiver dans le puits B (25.4 pour-cent), et au fond à la fin des pluies dans le puits V (48.3 pour-cent). D'une façon générale les périodes de reproduction maximum paraissent correspondre à la fin de la saison chaude et au début de la saison pluvieuse, mais à d'autres égards



GRAPHIQUE Vb.—Les mêmes données au fond du puits V.

les populations de chaque puits semblent vivre soumises à des lois particulières ou subissant des influences agissant d'une façon différente dans chaque habitat.

Cyclopides d'autres espèces.

Comme il a déjà été dit les cyclopes d'espèces autres que le *M. vermifer* habitant les puits en question ne jouent probablement aucun rôle dans l'épidémiologie de la draconculose, soit par suite de leur extrême paucité, soit à cause d'inaptitude naturelle, comme c'est vraisemblablement le cas pour l'*E. (T.) multicolor*. Les récoltes de ces cyclopes dans les trois puits sont données ci-dessous.

PUITS G.

Mesocyclops leuckarti. (Total 43.)

	SAISON DES PLUIES.		HIVER.		SAISON CHAUDE.	
	Surface et 30 cm.	Fond.	Surface et 30 cm.	Fond.	Surface et 30 cm.	Fond.
♀♀ à ovisacs	0	0	0	1	0	0
♀♀ sans ovisacs	2	5	4	2	1	3
♂♂	0	0	0	2	2	5
Copépodites	0	0	6	2	5	3
TOTAL	2	5	10	7	8	11

Eucyclops (Tropocyclops) multicolor. (Total 1,290.)

♀♀ à ovisacs	21	0	283	0	255	9
♀♀ sans ovisacs	13	0	183	0	410	14
♂♂	4	0	21	0	29	1
Copépodites	3	0	36	0	8	0
TOTAL	41	0	523	0	702	24

Eucyclops agiloides. (Total 6.)

♀♀ à ovisacs	0	0	0	0	0	0
♀♀ sans ovisacs	0	0	2	1	1	0
♂♂	0	0	1	0	0	0
Copépodites	0	0	0	1	0	0
TOTAL	0	0	3	2	1	0

Microcyclops sp. (Total 1.)

Une copépodite en hiver, à la surface.

PUITS B.

Mesocyclops leuckarti. (Total 15).

♀♀ à ovisacs	1	0	0	0	1	0
♀♀ sans ovisacs	2	0	4	0	2	0
♂♂	0	0	0	0	0	0
Copépodites	0	0	0	1	1	3
TOTAL	3	0	4	1	4	3

PUITS B.—*contd.**Eucyclops (Tropocyclops) multicolor.* (Total 8.)

	SAISON DES PLUIES.		HIVER.		SAISON CHAUDE.	
	Surface. et 30 cm.	Fond.	Surface. et 30 cm.	Fond.	Surface. et 30 cm.	Fond.
♀♀ à ovisacs	0	0	1	0	0	0
♀♀ sans ovisacs	0	0	1	0	1	0
♂♂	1	0	2	0	0	0
Copépodites	0	0	2	0	0	0
TOTAL	1	0	6	0	1	0

Eucyclops agiloides. (Total 2.)

Une femelle sans ovisacs, en hiver, à la surface.

Un mâle, en hiver, à la surface.

Microcyclops varicans. (Total 3.)

Une femelle sans ovisacs, en hiver, à la surface.

Deux copépodites, saison chaude, à la surface.

PUITS V.

Mesocyclops leuckarti. (Total 26.)

	SAISON DES PLUIES.		HIVER.		SAISON CHAUDE.	
	Surface.	Fond.	Surface.	Fond.	Surface.	Fond.
♀♀ à ovisacs	0	0	0	0	0	0
♀♀ sans ovisacs	0	1	5	4	0	1
♂♂	0	0	0	1	1	0
Copépodites	2	5	3	2	0	1
TOTAL	2	6	8	7	1	2

PUITS V—contd.

Eucyclops (Tropocyclops) multicolor. (Total 87.)

	SAISON DES PLUIES.		HIVER.		SAISON CHAUDE.	
	Surface.	Fond.	Surface.	Fond.	Surface.	Fond.
♀♀ à ovisacs	0	0	42	1	0	0
♀♀ sans ovisacs	0	0	28	1	0	0
♂♂	0	0	9	0	0	0
Copépodites	0	0	6	0	0	0
TOTAL	0	0	85	2	0	0

Eucyclops agiloides. (Total 3.)

- Une femelle sans ovisacs, en hiver, à la surface.
- Une femelle sans ovisacs et un mâle, en hiver, au fond.

Microcyclops varicans. (Total 4.)

Deux femelles sans ovisacs, saison des pluies, au fond. Une copépodite en hiver, à la surface. Une femelle sans ovisacs, saison chaude, à la surface.

Ectocyclops medius. (Total 1.)

- Un mâle, saison chaude, à la surface.

TABLEAU I.

Hauteur des pluies à Kurduvadi, 1938-39.

						mm.
Juin	..	..	..	..	..	108·88
Juillet	..	..	..	..	..	218·79
Août	..	..	..	..	..	81·60
Septembre	..	..	..	..	..	188·70
Octobre	..	..	..	..	..	36·46
Novembre		..	..	..	..	0
Décembre	..	..	..	..	..	0
Janvier	..	..	..	..	..	0
Février	..	..	..	..	..	0
Mars	..	..	..	..	..	4·08
Avril	..	..	..	..	..	0
Mai	.,	..	..	..	..	1·02
TOTAL					..	639·53

TABLEAU IIa.

Nombre moyen par récolte à la surface, à 30 cm. et au fond de specimens de Mesocyclops vermifer dans le puits G pendant les 3 saisons de l'année, et variations saisonnières de la température, du niveau et du pH de l'eau de ce puits.

	Saison des pluies (Juin 11 à sept. 25). 7 prélèvements.			Hiver (Oct. 13 à févr. 8). 11 prélèvements.			Saison chaude (Févr. 18 à mai 29) 13 prélèvements.		
Température de l'eau (près de la surface).	26.5° C à 28° C			23.5° C à 26°C			27°C. à 28°C		
Niveau de l'eau	4.47 m. à 6.26 m.			4.24 m. à 6.52 m.			3.65 m. à 5.50 m.		
pH	7.5 à 8			6.6 à 7.5			7.2 à 7.5.		
	Surface, 30cm. Fond.			Surface. 30cm. Fond.			Surface. 30cm. Fond.		
Femelles à ovisacs	1.4	4.7	8.7	0.5	3.6	10.7	7.1	8.7	123.5
Femelles adultes, sans ovisacs.	37.1	45.4	126.8	27.4	35.8	71.9	68.5	109.9	405.4
Mâles	3.6	3.9	19.1	3.4	3.4	4.7	11.4	13.7	42.2
Copépodites	43.4	28	348.6	13.8	6.4	18.4	42.2	49.9	198.3
TOTAL	85.5	82	503.2	45.1	49.2	105.7	129.2	182.2	769.4

TABLEAU IIb.

Ces mêmes données pour le puits B.

	Saison des pluies (Juin 11 à sept. 25). 7 prélèvements.			Hiver (Oct. 13 à févr. 8). 11 prélèvements.			Saison chaude (févr. 18 à mai 29) 13 prélèvements.		
Température de l'eau (près de la surface).	26°C à 26.5°C			23° C à 25°C			26°C à 27°C		
Niveau de l'eau	4.60 m. à 7.50 m.			6.20 m. à 7.85 m.			5.35 m. à 7.08 m.		
pH	7.5			6.6 à 7.5			7.4 à 7.5		
	Surface. 30cm. Fond.			Surface. 30cm. Fond.			Surface. 30cm. Fond.		
Femelles à ovisacs	0	0	15.3	0.7	0.7	34.5	0	2.7	81.7
Femelles adultes sans ovisacs.	2.3	1.3	171.3	4.8	4.8	254.8	1.2	11.2	522.9
Mâles	0	0.3	36	2	3.2	35.4	0.1	9.4	93.6
Copépodites	0.1	0.3	28.7	3	2.4	50.4	0.2	2	133.1
TOTAL	2.4	1.9	251.3	10.5	11.1	375	1.5	25.3	831.3

TABLEAU IIIa.

Récoltes de *M. vermifer* à la surface, à 30 cm. et au fond dans le puits G pendant l'année 1938-39.

Date.	SURFACE.					30 cm.					FOND.				
	♀♀ à ovisacs.	♀♀ sans ovisacs.	♂♂	Copé-podites.	Total.	♀♀ à ovisacs.	♀♀ sans ovisacs.	♂♂	Copé-podites.	Total.	♀♀ à ovisacs.	♀♀ sans ovisacs.	♂♂	Copé-podites.	Total.
Juin 11	1	13	1	8	23	2	17	2	4	25	6	30	5	7	48
„ 22	2	173	22	296	493	2	141	17	176	336	48	771	122	2,413	3,354
Juil. 2	0	30	0	0	30	0	17	0	2	19	2	24	0	0	26
„ 17	0	14	0	0	14	0	13	0	2	15	0	19	0	2	21
Août 1	0	0	0	0	0	0	1	0	1	2	2	14	5	17	38
„ 31	0	3	1	0	4	1	22	2	1	26	2	21	2	1	26
Sept. 9	7	27	1	0	35	28	107	6	10	151	1	9	0	0	10
Oct. 13	2	56	4	41	103	8	104	16	38	166	6	40	4	21	71
Nov. 6	0	5	4	9	18	16	97	1	3	117	49	122	6	25	202
„ 13	3	23	0	2	28	1	16	0	0	17	1	8	0	4	13
„ 22	0	0	0	0	0	1	3	0	3	7	12	97	6	60	175
Déc. 1	0	120	6	39	165	0	28	0	5	33	4	216	6	37	263

TABLEAU IIIa—contd.

Récoltes de *M. vermifer* à la surface, à 30 cm. et au fond dans le puits G pendant l'année 1938-39—contd.

Date.	SURFACE.					30 cm.					FOND.				
	♀♀ à ovisacs.	♀♀ sans ovisacs.	♂♂	Copé-podites.	Total.	♀♀ à ovisacs.	♀♀ sans ovisacs.	♂♂	Copé-podites.	Total.	♀♀ à ovisacs.	♀♀ sans ovisacs.	♂♂	Copé-podites.	Total.
Déc. 18	0	8	3	0	11	8	53	5	14	80					
„ 22	0	6	0	0	6	0	3	0	0	3	10	36	(Perdu) 0	3	49
Janv. 11	0	9	2	3	14	0	12	0	0	12	2	121	6	0	129
„ 18	0	42	3	1	46	5	59	11	5	80	1	18	3	5	27
Févr. 8	1	33	16	57	107	1	16	5	2	24	8	54	13	22	97
Févr. 18	1	18	6	4	29	2	52	12	7	73	11	51	2	8	72
„ 28	3	11	7	8	29	1	13	10	13	37	9	70	15	33	127
Mars. 8	3	21	3	1	28	0	18	1	0	19	5	189	13	19	226
„ 17	3	12	1	2	18	2	3	2	0	7	51	298	22	136	507
„ 28	0	34	8	4	46	0	21	2	5	28	20	106	11	22	159
Avril 4	2	150	60	73	285	8	443	92	131	674	2	213	123	135	473
„ 6	0	30	1	2	33	1	22	0	2	25	1	24	0	2	27
„ 15	0	0	0	0	0	0	0	0	0	0	1	3	0	2	6
„ 28	18	94	23	74	209	12	75	12	23	122	70	238	65	345	718
„ 30	4	38	0	29	71	4	136	5	66	211	1	52	2	20	75
Mai. 8	19	220	23	279	541	5	140	17	289	451	268	628	143	1,182	2,221
„ 18	30	170	12	52	264	69	396	12	63	540	1,155	3,307	148	657	5,267
„ 29	10	93	4	21	128			(perdu)			12	92	5	17	126

TABLEAU IIIb.
Récoltes correspondantes faites dans le puits B.

Date.	SURFACE.					30 cm.					FOND.				
	♀♀ à ovisacs.	♀♀ sans ovisacs.	♂♂	Copé- podites.	Total.	♀♀ à ovisacs.	♀♀ sans ovisacs.	♂♂	Copé- podites.	Total.	♀♀ à ovisacs.	♀♀ sans ovisacs.	♂♂	Copé- podites.	Total.
Juin 11	0	0	0	0	0	0	1	1	1	3	12	63	30	29	134
„ 22	0	1	0	0	1	0	2	0	0	2	60	914	198	130	1,302
Juil. 2	0	15	0	0	15	0	5	0	0	5	0	5	0	0	5
„ 17	0	0	0	0	0	0	0	0	1	1	0	5	0	0	5
Août 1	0	0	0	1	1	0	0	0	0	0	5	20	3	12	40
„ 31	0	0	0	0	0	0	0	0	0	0	9	47	5	8	69
Sept. 25	0	0	0	0	0	0	1	1	0	2	21	145	16	22	204
Oct. 13	0	13	0	18	31	0	4	0	0	4	15	102	9	22	148
Nov. 6	0	0	0	0	0	0	0	0	4	4	45	481	23	149	698
„ 13	0	3	0	0	3	0	2	0	0	2	3	169	2	13	187
„ 22	8	35	20	16	79	8	43	32	22	105	183	446	85	63	777
Déc. 1	0	0	0	0	0	0	0	0	0	0	38	329	14	39	420
„ 18	0	1	1	0	2	0	0	0	0	0	19	139	35	19	212

TABLEAU IIIb—*contd.**Récoltes correspondantes faites dans le puits B—contd.*

Date.	SURFACE.					30 cm.					FOND.				
	♀♀ à ovisacs.	♀♀ sans ovisacs.	♂♂	Copé-podites.	Total.	♀♀ à ovisacs.	♀♀ sans ovisacs.	♂♂	Copé-podites.	Total.	♀♀ à ovisacs.	♀♀ sans ovisacs.	♂♂	Copé-podites.	Total.
Déc. 22	0	0	0	0	0	0	0	1	0	1	32	74	3	10	119
Janv. 11	0	1	0	0	1	0	4	2	0	6	18	746	131	133	1,028
„ 18	0	0	1	0	1	0	0	0	0	0	11	32	11	6	60
Févr. 1	0	0	0	0	0	0	0	0	0	0	10	209	48	50	317
„ 8	0	0	0	0	0	0	0	0	1	1	6	76	28	50	160
Févr. 18	0	0	0	0	0	2	10	19	5	36	59	483	74	115	731
„ 28	0	0	0	0	0	0	0	2	0	2	6	44	36	73	159
Mars 8	0	2	0	0	2	0	4	0	0	4	126	2,334	346	216	3,022
„ 17	0	6	0	0	6	2	5	0	0	7	122	805	173	397	1,497
„ 28	0	1	0	0	1	5	4	4	0	13	167	688	104	99	1,058
Avril 4	0	0	0	0	0	15	23	85	3	126	5	45	31	20	101
„ 6	0	1	0	0	1	4	63	1	14	82	14	62	0	15	91
„ 15	0	0	0	0	0	0	0	0	0	0	0	2	0	0	2
„ 28	0	1	0	0	1	0	4	0	0	4	192	219	56	115	582
„ 30	0	0	1	3	4			(perdu)			8	203	60	122	393
Mai 8	0	2	0	0	2	2	8	1	0	11	213	481	75	259	1,028
„ 18	0	2	0	0	2	3	11	0	2	16	81	890	101	147	1,219
„ 29	0	1	0	0	1	0	2	1	0	3	69	542	161	153	925

TABLEAU IVa.

Les nombres totaux et les pourcentages des stades évolutifs de *M. vermifer* récoltes pendant les différentes saisons de l'année, à la surface et à 30 cm. pris ensemble, et au fond, dans les puits G et B.

				DÉBUT SAISON DES PLUIES (11. vi—17. vii).				FIN SAISON DES PLUIES (1. viii—25. ix).				HIVER (13. x—8. ii).				DÉBUT SAISON CHAUDE (18. ii—28. iii).				FIN SAISON CHAUDE (4. iv—20. v).			
				Surface et 30 cm.		Fond.		Surface et 30 cm.		Fond.		Surface et 30 cm.		Fond.		Surface et 30 cm.		Fond.		Surface et 30 cm.		Fond.	
				Total.	Pour-cent.	Total.	Pour-cent.	Total.	Pour-cent.	Total.	Pour-cent.	Total.	Pour-cent.	Total.	Pour-cent.	Total.	Pour-cent.	Total.	Pour-cent.	Total.	Pour-cent.	Total.	Pour-cent.
PUITS G.																							
♀♀ à ovisacs	..	..		7	0.73	56	1.63	36	16.51	5	6.76	46	4.42	107	10.12	15	4.78	96	8.79	182	5.12	1,510	16.94
♀♀ sans ovisacs	..	..		418	43.87	844	24.47	160	73.39	44	59.46	696	66.86	719	68.02	203	64.65	714	65.45	2,007	56.47	4,557	51.13
♂♂	..	..		42	4.39	127	3.68	10	4.59	7	9.46	76	7.30	47	4.45	52	16.56	63	5.78	261	7.35	486	5.45
Copépodites	..	..		488	51.09	2,422	70.22	12	5.50	18	24.32	223	21.42	184	17.41	44	14.01	218	19.98	1,104	31.06	2,360	26.48
PUITS B.																							
♀♀ à ovisacs	..	..		0	0	72	4.98	0	0	35	11.18	16	6.67	380	9.21	9	12.68	480	7.42	24	9.49	582	13.47
♀♀ sans ovisacs	..	..		24	88.90	987	68.26	1	33.33	212	67.73	106	44.17	2,803	67.93	32	45.07	4,354	67.33	118	46.64	2,444	56.80
♂♂	..	..		1	3.70	228	15.77	1	33.33	24	7.67	57	23.75	389	9.43	25	35.21	733	11.33	89	35.18	484	11.15
Copépodites	..	..		2	7.40	159	10.99	1	33.33	42	13.42	61	25.41	554	13.43	5	7.04	900	13.92	22	8.69	831	19.14

TABLEAU IVb.

Les pourcentages des stades évolutifs de M. vermifer pendant les différentes saisons de l'année à la surface et au fond dans le puits V (Les chiffres des "nombre comptés" n'ont pas de signification proportionnelle.)

				DÉBUT SAISON DES PLUIES (8. vi—25. vii).				FIN SAISON DES PLUIES (3. viii—8. x).				HIVER (21. x—11. ii).				DÉBUT SAISON CHAUDE (18. ii—27. iii).				FIN SAISON CHAUDE (3. iv—30. v).			
				Surface.		Fond.		Surface.		Fond.		Surface.		Fond.		Surface.		Fond.		Surface.		Fond.	
				Nombre compté.	Pour-cent.	Nombre compté.	Pour-cent.	Nombre compté.	Pour-cent.	Nombre compté.	Pour-cent.	Nombre compté.	Pour-cent.	Nombre compté.	Pour-cent.	Nombre compté.	Pour-cent.	Nombre compté.	Pour-cent.	Nombre compté.	Pour-cent.	Nombre compté.	Pour-cent.
♀♀ à ovisacs	..	..	..	86	12.29	167	23.86	131	1.65	64	2.45	1,212	16.31	499	9.28	85	5.33	262	14.33	170	26.86	311	41.03
♀♀ sans ovisacs	..	..	..	165	23.57	199	28.43	5,775	72.58	1,156	44.29	5,445	73.29	4,148	77.13	1,406	88.21	1,303	71.28	364	57.50	36	47.63
♂♂	..	..	..	302	43.14	159	22.71	72	0.90	128	4.90	91	1.23	114	2.12	15	0.94	90	4.92	31	4.90	39	5.14
Copépodites	..	..	..	147	21	175	25	1,979	24.87	1,262	48.35	681	9.17	617	11.47	88	5.52	173	9.47	68	10.74	47	6.20

SOMMAIRE.

- (1) La présence quantitative des Cyclopides a été étudiée pendant une année entière dans deux puits, à la surface, à 30 cm. et au fond.
- (2) Dans trois puits une étude pareille a été faite des variations saisonnières et verticales des divers stades évolutifs des Cyclopides.
- (3) La portée des résultats sur la théorie courante aux Indes expliquant l'incidence saisonnière de la draconculose a été discutée brièvement.

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SUCCINEA SUSHUPTA, NOM. MUT.—A CORRECTION.

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In 1925¹ I described a curious little aestivating Succineid mollusc from the Western Ghats near Lonavla (Bombay Presidency) under the name *Succinea arboricola*. While going through the current literature received in the library of the Zoological Survey of India, I discovered that the specific name *arboricola* is preoccupied in the genus for a South African species described by Mousson as *S. arborea* and renamed by Connolly as *S. arboricola* on grounds of priority [*vide* Connolly, M. in *Ann. S. African Mus.* XI, p. 220 (1912) and in XXXIII, p. 446 (1939) of the same journal]. I, therefore, propose the new name *sushupta*² for the Western Ghats species.

¹ Rao, H.S., *Rec. Ind. Mus.* XXVII, pp. 394-400 (1925).

² From a Sanskrit word meaning deep sleep.

INDIAN EARTHWORMS.

XII. THE GENUS *HOPLOCHAETELLA*.

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INTRODUCTION.

The genus was established by Beddard in 1890, with the name *Hoplochaeta*, for *Perichaeta stuarti* Bourne 1886 which had been characterized very inadequately and, in part, erroneously. Beddard later (1895) became doubtful of his own genus and withdrew it. Michaelsen (1900) retained the genus but with a slight change in spelling (to *Hoplochaetella*, *Hoplochaeta* having been preoccupied) and later (1909) included in it, along with the single Indian species, certain forms from New Zealand. The latter were removed to a distinct genus (*Hoplochaetina*) in 1921. The status of the genotype and of the genus itself remained dubious until 1925. After study of a single specimen in poor condition from the type locality of the genotype, Michaelsen recognized some of the more important generic characteristics and the necessity of suppressing Stephenson's *Erythraeodrilus*. Michaelsen's account of his worm is however inadequate for present purposes so that a satisfactory characterization of the genotype is still impossible.

Eleven species have been erected, each of which has been known hitherto either from a single specimen (*bifoveata* and *inornata*), or from one or several very short series. Types of one species are non-existent, those

of several other species, even when first studied twenty to thirty years ago were in "bad" condition. Six species are known only from the type localities. With the exception of the types of three species, *khandalaensis*, *powelli* and *stuarti*, all of the type material has been re-examined.¹ Only five lots of new material (hitherto unstudied) have been secured in recent years and four of these are short series with all of the specimens in poor to very poor condition. Fortunately, through the kindness of Mr. S. H. Prater, a fairly long series of well preserved specimens of *khandalaensis* has been secured. As a result of the paucity of material and poor condition of so many important specimens the status of at least two species remains doubtful, diagnoses of other species are tentative or incomplete, while four or possibly five species must remain unnamed until well preserved material is procured.

In 1923 Stephenson reduced two species, *affinis* and *bifoveata*, to varieties because he had come to think that "variable genital markings were previously accorded undue weight". Possibly because of some such opinion Stephenson used genital markings only once in his key (1923) and then unsuccessfully as a result of an unfortunate choice of pairs of characteristics that vary according to the condition of the animal (actually surface convex or depressed, with or without a recognizable circumferential groove). In absence of long series a decision as to the value to be allotted to genital marking characteristics in any particular species rests on analogy with conditions in other species. A decision made in this way is however liable to be reversed, especially in connection with the structures now under consideration.

In one species, *khandalaensis*, a series of 108 specimens has been studied. In that series each worm, without exception, has one segmentally located genital marking which is invariably median and symmetrically placed with reference to the midventral line. On 103 specimens the single marking is post-setal on xix. Four of the 108 specimens have an additional, more anterior marking of the usual type. One worm lacks the marking on xix but has a characteristic marking in the anterior location. Variation with respect to symmetry and pairing is *nil*, as to number and location slight. Two other species have sausage-shaped genital marking glands similar to those of *khandalaensis*. In one of these, *powelli*, in ten specimens from two localities there is always a pair of symmetrical genital markings on 19/20 though additional markings may occasionally (two specimens) be present; paired behind 19/20, unpaired and asymmetrical or symmetrical anterior to 19/20. In this species the diagnostic characteristic seems to be presence of a pair of genital markings on 19/20 while the variation in symmetry of an occasional extra anterior marking does not appear to be of importance. In the third species, *mullani*, in a series of seven specimens, each worm has one genital marking which is always asymmetrically placed but which is found in one of two different locations. Here there is variation as to location but none as to symmetry and number.

Of the species with sessile genital marking glands, *affinis* can be distinguished from *suctoria*, and *kempi* from *bifoveata* in much the same

¹ Types of *powelli* are in the British Museum and cannot be borrowed. There are no types of *stuarti*.

way as the three species with sausage-shaped genital marking glands are distinguished from each other ; *affinis* and *suctoria* by the paired or unpaired genital markings, *bifoveata* and *kempi* by the symmetry or asymmetry in placement of the markings. In these circumstances *affinis* and *bifoveata* are both retained provisionally. Some slight support for the decision as to *affinis* is furnished by spermathecal characteristics.

With regard to *anomala* and the forms that must be considered in connection with it the situation is more difficult. Of the five clitellate types of *anomala* (as now restricted by exclusion of one type) two have no genital markings while each of two specimens has but one of the pair of markings present on xviii of the fifth worm which may represent the normal condition in this species. Of the two very short series to be considered in connection with *anomala*, four of the five clitellate specimens from Jog Falls have no genital markings, but the fifth has an unpaired median and symmetrical genital marking on 24/25, one of two specimens from Panchgani has no markings while the other has one or a pair (condition indeterminable) on 20/21. The argument from analogy with species having sausage-shaped genital marking glands is weakened here by the absence of genital markings on a large proportion of the specimens, but may be regarded as supported by the presence of other characteristics that appear to provide evidence for specific distinction of both series from *anomala*. The excluded type of *anomala*, distinguished from the types by genital marking characteristics, is similarly distinguished by additional characteristics that appear to be of taxonomic value.

In contrast to the variation just discussed, all species are rather uniform with respect to some characteristics often variable intragenetically. Thus the prostomium appears to be always epilobous in the quadriprostatic species, the condition in biprostatic species is uncertain. An anterior location of the first dorsal pore also seems to be characteristic. With but few exceptions, which may be only unimportant individual variations, the pore is on 4/5. Two of the apparent exceptions (location on 5/6 in *inornata*, on 6/7 in *kempi*) may be due to failure to recognize more anterior pores because of the poor condition of the material. All reproductive apertures are always minute. Excretory, circulatory and digestive systems are, so far as is known, uniform except for some slight intragenetic variation with regard to the hearts of xiii, the presence of fairly sharply demarcated intestinal caeca in one species, and possibly also some variation in segmental location of the gizzard.

Certain species, including *khandalaensis*, have been thought to be characterized by a brown colouration, a supposition which is very questionable in view of the fact that preservation in each case was alcoholic. Specimens of *khandalaensis*, preserved in formalin and examined very shortly after preservation, are always characterized by presence in the dorsum of a red pigment. It is quite possible that all quadriprostatic species at least are similarly characterized. In this connection it may be noted that all species of *Tonoscolex* are always unpigmented, a species of *Eutyphoeus* may be unpigmented or have a brown pigment with no intraspecific variation, while in *Pheretima* there is considerable intragenetic variation as to pigmentation.

Unpaired, lymph glands, have been found in all but three species, which are known only from softened specimens. In well preserved material the glands are present in a complete series from xv posteriorly. In some specimens, not so well preserved, the gland in xv has been seen, but from xvi posteriorly for some distance the glands are unrecognizable. Presumably this is due to disintegration in the middle region but confirmation is necessary. Similar lymph glands are known at present to occur only in *Pheretima*.

In eight quadriprostatic species septa 9/10-11/12 are closely crowded and united peripherally so as to reduce the coelomic cavities of x and xi to testis sacs of a rather peculiar type somewhat reminiscent of the condition of segment xi in certain species of *Eutyphoeus*. This type of testis sac may conveniently be referred to as septal. Stephenson does not refer to these septal sacs as testis sacs, and in using the general term in connection with *anomala* and *kinneari* he presumably intended to refer to a distinctly different type of structure. The characterization is however so vague that it is impossible to do more than suggest that the sacs of *kinneari* may be annular, U-shaped, or paired and vertical, while the sacs of *anomala* may be cylindrical. Characterization of the condition in *stuarti* is impossible. All three species, *anomala*, *kinneari* and *stuarti*, are known only from macerated specimens. Possibly presence of testis sacs of one sort or another is as characteristic of *Hoplochaetella* as of *Pheretima*.

In an emended diagnosis (Stephenson 1917, p. 358) *Hoplochaetella* is said to be apenisetal. There are, however, probably in each species, median to the ectal portion of each prostatic duct, chaetae that may for the present be referred to as penial. The number of follicles is unknown but at least one follicle is located on the median face of each prostatic duct, the usual location for at least one penisetal follicle, and another (or others?), in certain species, may be imbedded in glandular material. Whether or not these follicles open directly to the exterior is unknown. In spite of careful search external apertures have not been found though this was perhaps to be expected from the condition of most of the material studied. In the absence of discrete apertures, follicles must either open indirectly to the exterior through the male pores (combined openings of male deferent and prostatic ducts) or be closed off ectally from the exterior. In the latter eventuality the setae are presumably without function. Some slight support for this is perhaps provided by the deep location in the parietes and the size relative to that of the worms. Shafts are small, varying in size from 0.2-0.4 mm. in length and with a maximum thickness of ca. 0.010-0.012 mm. Modifications from ordinary type are present though slight,—the sigmoid shape has been lost and the shaft has become practically straight but sculpturing of the tip and ornamentation are slight or lacking. In the circumstances it is uncertain whether we have here an early stage of modification into a more effective type of penial setae or a reduction preliminary to ultimate disappearance of setae once more efficient. A study of late embryonic and young juvenile stages might yield interesting information in this connection.

In each species certain ventral setae of some of segments vii-ix are modified as the copulatory setae. Presence or absence of ornamentation on these setae at present appears to be specifically characteristic and of value in diagnosis but whether other characteristics are capable of similar use is not yet obvious.

The posterior termination of the male deferent ducts is of especial interest. Stephenson observed that in *anomala* the vasa deferentia of a side pass into a region behind the anterior prostatic duct (possibly xviii) where one turns anteriorly while the other is continued into xix, indicating that the species has two pairs of male pores, a most unusual condition. This peculiarity was supposed to be characteristic of *anomala* only and is presumably the reason for the specific name, since in all other species of the genus "vasa deferentia unite and open in common with the anterior prostate on the seventeenth segment" (Stephenson 1920, p. 226). It is obvious, however, from inspection of dissected types and figures that Stephenson did not actually trace the male deferent ducts in any species to an external aperture or even to a junction with a prostatic duct. (Note statements which are usually to the effect that the deferent ducts "end" behind the anterior prostatic duct, *i.e.*, become invisible in his dissections and also *vide* fig. 26. pl. x, 1920). Tracing the course of the vasa deferentia in most species of this genus is unusually difficult, in part as a result of the presence of masses of glandular material within which the ducts may be imbedded. Repeated attempts to trace the course of the male deferent ducts have been unsuccessful and in none of the worms was a single duct dissected out unbroken from one end to the other. However, no evidence has been found to indicate that the deferent ducts of a side unite posteriorly in any quadriprostatic species. On the contrary paired ducts (or structures that look like ducts) have always been found posteriorly in each species. One duct of a side, presumably that from the anterior male funnel, joins the anterior prostatic duct of xvii, while the other deferent duct continues posteriorly to join the prostatic duct of xix. Although the necessity for confirmation of this condition in several species is admitted, it is almost certain that all quadriprostatic species of *Hoplochaetella* have four male pores.

The origin of the biprostatic species (presumably by disappearance of a posterior pair of prostates) is accordingly not as simple as it appeared to be when it was thought that both the deferent ducts of most quadriprostatic species united with the anterior prostatic ducts. The biprostatic condition may have arisen in an acanthodrilin ancestral form prior to the union of posterior deferent and prostatic ducts, in which case *Hoplochaetella* is diphyletic, or the posterior deferent ducts have lost an ancestral junction with the prostatic ducts of xix and secondarily acquired a new junction with the anterior prostatic ducts. If the latter should be correct one might almost expect to find, on analogy with the passage of the anterior ducts into xviii before turning forwards, that the other ducts pass further posteriorly, perhaps even into xix before turning anteriorly. Unfortunately all biprostatic specimens are in such poor condition that a more favorable opportunity for study of the deferent ducts must be awaited.

The junction of a vas deferens with the anterior prostatic duct on the posterior face of the latter in this genus, as well as the passage of the vasa deferentia into the parietes just behind the prostatic duct of xvii in *Eutyphoeus*, certainly appear to be good evidence for a phylogenetic derivation of both genera from ancestral forms with male pores on xviii (acanthodrilin condition) and for Stephenson's attraction theory (1920, p. 226). Unfortunately nothing seems to be known of the ontogenetic development of the male deferent ducts in earthworms (so far as can be determined from the literature available locally), but an investigation of this problem in species of *Hoplochaetella* might yield interesting results. Presumably the vas deferens grows posteriorly from a male-funnel rudiment rather than anteriorly from a male pore rudiment or otherwise. (Note that in those aberrant specimens of species of *Pheretima* in which prostates, prostatic ducts and male genital terminalia fail to develop, the vasa deferentia may be continued posteriorly for varying distances behind the male pore segments as if "searching" for the missing organs.) In these circumstances why is the prostatic duct "attraction" for the male deferent duct not exerted when the latter first comes into the neighbourhood of the former rather than at a later period after the "unattracted" duct has been able to grow posteriorly into a region behind the prostatic duct?

In a number of species, glands of unknown function¹, referred to hereinafter as parietal glands, are protuberant more or less conspicuously into the coelomic cavities from the parietes in the prostatic region. These bodies must open either into the prostatic ducts within the parietes or directly to the exterior on the male porophores. No variation as to number or shape of these structures was found in the dissected specimens of *khandalaensis*. Hence it is assumed that the diverse confirmations found in other species are also characteristic.

The nature and relationships of the various structures in the region of the male pores, collectively referred to as the male genital terminalia, should be investigated from sections.

Hoplochaetella has been derived by Michaelsen (*vide* Stephenson 1915 and 1917) from the New Zealand genus, *Perieodrilus*², and by Stephenson (1917, 1923 and 1930) from the Madagascar-South Indian genus, *Howascolex*.³ Without referring again to the problems raised by the phyletic derivation of one genus from another when both are

¹ Stephenson refers to these structures as accessory glands, a term that he also applies to stalked glands associated with follicles of the copulatory setae.

² *Hoplochaetella* and *Octochaetus*, the only two genera common to India and New Zealand, formed the basis for the supposed land communication between the two areas independent of Australia. Indian species of *Octochaetus* are now recognized as generically distinct from the New Zealand forms (Gates 1933 and Michaelsen 1933) and the *Hoplochaetella*-*Perieodrilus* relationship needs no further consideration (*vide* Stephenson 1917, p. 358).

³ Three species of *Howascolex* are thought to be endemic in South India. All of these are small worms, 1-2 mm. thick, though fairly long (60-110 mm.) for slender earthworms. In view of the small size of the South Indian species, endemism in that region may be questioned. Occurrence of all three in South India may be the result of accidental or artificial importation. The only species known from Madagascar is fairly large, 120 mm. long and 6 mm. thick.

known only from extant and inadequately characterized species, certain points in connection with the supposed *Howascolex-Hoplochaetella* relationship should be noted.

In *Hoplochaetella*, the derived genus, calciferous glands are in x-xiii, while in *Howascolex*, the ancestral genus, the glands are in xvi with an occasional slight development in xv or xvii. Derivation of either of these conditions from the other appears to be improbable and further evolution in *Howascolex* would presumably be along the line of more definitely partitioning off from the gut, structures perhaps in the nature of stalked glands or sacs, as for instance in *Dichogaster*. In Indian species of *Howascolex* excretory organs are mega-nephridia only in the posteriormost portion of the body, micro-nephridia only anteriorly, while in *Hoplochaetella* micro- and mega-nephridia coexist from xx at least, if not xii-xiv, posteriorly. The micro-nephridial condition in the family Megascolecidae is thought to be the result of phylogenetic fragmentation of originally paired mega-nephridia, a process recapitulated in the ontogeny of certain forms. In accordance with this belief, mega-nephridial fission would be completed in anterior and middle portions of the body in Indian species of *Howascolex* while in the posteriormost segments the fission has not begun. In *Hoplochaetella* on the contrary fission presumably has only just begun in a region extending from segment xx to the hind end, for in that region there are paired mega-nephridia large enough to reach nearly to the mid-dorsal line. It should be noted, however, that micro-nephridia are fairly numerous even in the mega-nephridial segments of *Hoplochaetella*. If embryonic fission of mega-nephridia does take place in *Hoplochaetella*, it must be of such a nature that the original rudiment can still develop into a large mega-nephridium, a condition which can be derivative of that characteristic of the corresponding middle region in Indian species of *Howascolex* only by an evolutionary reversal so complete as to be extremely unlikely. In the Madagascar species of *Howascolex* mega-nephridia are presumably present throughout the body while micro-nephridia are present only in the region of xxxiv-lx and are few in number, two to fourteen per segment. From such a condition it is of course easier to derive the *Hoplochaetella* condition, yet it should be noted that a continuation of the process already begun in the Madagascar section of *Howascolex* should lead to the condition characteristic of the Indian section of *Howascolex* but not to that characteristic of *Hoplochaetella*. However it is doubtful if the excretory system of any species of *Howascolex* is sufficiently known to warrant further discussion of this matter, especially in view of the fact that slight maceration in specimens that are not very well preserved may prevent recognition of important characteristics of excretory systems if not of whole sets of organs. Development of the excretory organs in both *Howascolex* and *Hoplochaetella* is unknown.

The fact that the excretory systems are so different in the Indian and Madagascar sections of *Howascolex* is sufficient ground for suspecting that the genus (as recognized by Michaelsen and Stephenson) is not monophyletic, and such suspicion is further justified by differences

in the digestive and reproductive systems, the vascular system being practically unknown.

In spite of an awareness "that greater significance should perhaps be attached to the position and degree of development of the calciferous glands", Pickford has recently (1937, p. 605) transferred to *Howascolex* South American species of *Wegeneriella* and *Acanthodrilus*. The genus as now emended by Pickford has calciferous glands in xvi with or without some slight development in xv or xvii, in xiv-xv, and in viii-xi. It is most unlikely that in the evolution of any "monophyletic" genus the calciferous glands have 'jumped' around in any such manner. Furthermore *Howascolex*, in Pickford's sense, is now diagnosed as having true mega-nephridia accompanied by micro-nephridia. This is not definitive. Mega-nephridia and micro-nephridia are of so many different types that genera can no longer be defined merely by unrestricted use of the terms mega-nephridial and micro-nephridial. Leaving out of consideration a statement regarding the gizzard, Pickford's emended definition is so inclusive as to be capable of serving as a subfamily definition for all Indian genera of the former Octochaetinae except *Octochaetoides*. Without excepting the statement as to the gizzard, the emended diagnosis is broad enough to include several groups, probably of generic rank, of worms from such widely separated areas as India, Madagascar, Africa, and South America. To this group there would have to be added Stephenson's *Ramiella* which differs only in the complete absence of calciferous glands.

Hoplochaetella is one of the Indian genera formerly included in the obsolete Megascolecoid subfamily Octochaetinae. All of the Indian genera, with the single exception of *Octochaetoides*, have exonephric, parietal micro-nephridia together with paired mega-nephridia (provided with the usual preseptal funnels) in a posterior portion of the body of variable length. So far as is known, none of these genera has enteronephric nephridia, either micro- or mega-, behind the clitellar region. All have tubular prostates.

When the Diplocardiinae was broken up and distributed among other Megascolecoid subfamilies one genus, *Dichogaster*, was transferred to the Octochaetinae. The excretory systems of two Burmese species of *Dichogaster* have now been examined and in each of these species there are paired mega-nephridia provided with the usual preseptal funnels in the posteriormost segments. So far then as the combination of nephridial characteristics just mentioned above is concerned, *Dichogaster* can be included in a group along with *Howascolex*, *Hoplochaetella*, *Ramiella*, *Eutyphoeus*, *Scolioscolides*, *Barogaster*, *Eudichogaster*, *Lennogaster*, *Pellogaster*, *Rillogaster*, *Priodochaeta* and possibly also *Priodoscolex*. To avoid confusion attendant on use of the obsolescent term Octochaetinae this group of genera may be referred to as the *Hoplochaetella* group.

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SYSTEMATICS.

Genus **Hoplochaetella** Michaelsen.

1890. *Hoplochaeta*, (non *Oplocheta*, corr. *Hoplochaeta*, Rondani 1856, Dipt.)
Beddard, *Proc. Zool. Soc. London*, 1890, p. 57. (Genotype-*Perichaeta stuarti* Bourne 1886).
1900. *Hoplochaetella*, Michaelsen, *Das Tierreich* X, p. 321.
1909. *Hoplochaetella* (part), Michaelsen, *Mem. Ind. Mus.* I, pp. 202-203. (Excluding New Zealand species.)
1910. *Hoplochaetella* (part), Michaelsen, *Abh. Nat. Ver. Hamburg* XIX, (5), p. 25. (Excluding New Zealand species.)
1915. *Erythraeodrilus*, Stephenson, *Mem. Ind. Mus.* VI, p. 100. (Genotype *E. kinneari* Stephenson 1915.)
1917. *Hoplochaetella*+*Erythraeodrilus*, Stephenson, *Rec. Ind. Mus.* XIII, pp. 354, 359, 388 and 402.
1920. *Hoplochaetella*+*Erythraeodrilus*, Stephenson, *Mem. Ind. Mus.* VII, pp. 223 and 227.
1921. *Hoplochaetella*+*Erythraeodrilus*, Michaelsen, *Mitt. Mus. Hamburg* XXXIII, p. 38.
1923. *Hoplochaetella*+*Erythraeodrilus*, Stephenson, *Oligochaeta*, in *F. B. I.* pp. 467 and 457.
1925. *Hoplochaetella*, Michaelsen, *Zool. Jahrb. Syst.* LI, pp. 314-315.
1926. *Hoplochaetella*, Stephenson, *Rec. Ind. Mus.* XXVIII, pp. 250 and 265.
1930. *Hoplochaetella*, Stephenson, *The Oligochaeta*, p. 848.

Diagnosis.—Quadrithecal, each spermathecal pore at or near the centre of a transversely placed area of slight epidermal tumescence. Male pores (combined openings of male deferent ducts, prostatic ducts and penisetal follicles?) on small, paired porophores. Female pore median and presetal on xiv. Reproductive apertures all minute. Setae perichaetine; ventralmost setae of prostatic segments modified or lost, setae in vicinity of spermathecal pores modified (copulatory setae). On development of clitellar glandularity intersegmental furrows disappear and dorsal pores are occluded but setae are retained; clitellum annular, on xiii-xvi. First dorsal pore on (or on a furrow near to?) 4/5. Pigmentation red. Septa all present from 4/5 posteriorly (except in *anomala*?). Gizzard in (or belonging to?) one segment. Calciferous glands four pairs in x-xiii, antero-posteriorly flattened, reniform with concave faces mesially, opening through short stalks directly into oesophageal lumen ventro-laterally. Intestine begins in xvi. Typhlosole simple, beginning in xxii-xxv. Hearts of x-xiii latero-oesophageal. Extra-oesophageal trunks below the gut throughout¹, with branches to calciferous glands, joined in xiii by a vessel formed by a union in xiv of a posterior latero-parietal vessel and an anterior commissure from the dorsal trunk. Supra-oesophageal trunk present in ix-xiii². Excretory organs: closed(?), exonephric(?) parietal micro-nephridia from ii or iii posteriorly, closely crowded into paired vertical bands in ii-iii (or iii-iv?), especially numerous and nearly covering the parietes in xiv-xvi; closed(?), enteronephric(?) micro-nephridia in paired clusters on the anterior faces of 4/5-5/6; open, exonephric(?) mega-nephridia with preseptal funnels, one pair per segment from xii-xiv posteriorly, rather small in xii-xiv to xix. Holandric, testis sacs present; seminal vesicles in ix and xii. Prostates tubular; ducts slender entally, with

¹ Not on or adherent to the gut.

² A negative characteristic is the absence of a subneural trunk.

spindle-shaped muscular widening ectally, narrowed again within the parietes. Spermathecal ducts slender ectally, widened and muscular entally, diverticula joining duct entally. One copulatory setal follicle opening to the exterior in conjunction with each of a number of shortly stalked, tubular glands contained within membranous sacs protuberant into the coelomic cavity.

Distribution.—Yercaud, Salem district (Madras Presidency), Nundydroog, and Jog Falls (Mysore State), in South India, and in Western India from Goa, North Kanara and Belgaum north to Bombay, Andheri and Matheran. At present all species appear to be restricted to the lowlands¹.

Key to species of Hoplochaetella.

1 a.	Quadriprostatic	..	..	..	2
b.	Biprostatic	..	..	..	11
2 a.	All spermathecal pores on viii, (rarely posterior pores on 8/9)	..	..	..	3
b.	All spermathecal pores not on viii though segmental				9
3 a.	Three pairs of parietal glands median to prostatic ducts, middle pair in xviii	..			4
b.	Parietal glands lacking or not in three pairs and none in xviii	..	..	..	6
4 a.	No genital markings, ca. 85 setae on xii	..			<i>inornata</i> .
b.	Genital markings present, 50-66 setae on xii	..			5
5 a.	Genital markings paired	..			<i>powelli</i> .
b.	Genital markings unpaired and median	..			<i>khandalaensis</i> .
6 a.	Spermathecal diverticula paired or in two groups of 2-3	..	..	..	7
b.	Spermathecal diverticula in circles	..			8
7 a.	Genital markings unpaired and symmetrical	..			<i>bifoveata</i> .
b.	Genital markings unpaired but asymmetrical	..			<i>kempi</i> .
8 a.	Genital markings unpaired and median, circle of diverticula with one hiatus	..	..	..	<i>affinis</i> .
b.	Genital markings in part paired, circle of diverticula uninterrupted	..	..	..	<i>suctoria</i> .
9 a.	Spermathecal pores on vii and viii	..	..	..	<i>stuarti</i> .
b.	Spermathecal pores on viii and ix	..	..	..	10
10 a.	Genital markings with central aperture, glands sausage-shaped, last hearts in xiii	..	..	..	<i>mullani</i> .
b.	Genital markings when present without central aperture, glands sessile, last hearts in xii	..			<i>anomala</i> .
11 a.	All spermathecal pores on viii	..	..	..	<i>kinneari</i> .
b.	Anterior spermathecal pores on vii	..	..	..	<i>H. spp.</i>

A. QUADRIPROSTATIC SPECIES.

Prostomium epilobous. Ventralmost setae of xix modified or lost. Male pores two pairs on xvii or 17/18 and xix or 18/19, one male deferent duct on each side turning anteriorly in xviii to pass into the posterior face of an anterior prostatic duct, the other duct passing into the anterior face of the posterior prostatic duct.

¹ Elevation of Yercaud may be between 3,000 and 6,000 feet. No information is available as to level at which worms were secured. Absence of mention of elevation in most other cases may be taken perhaps as indicative of elevations not much above the sea level.

Hoplochaetella affinis Stephenson.

1917. *Hoplochaetella affinis* (part) Stephenson, *Rec. Ind. Mus.* XIII, p. 399. (Type locality—Mormugao Bay, Portuguese India. Types in Indian Museum. Excluding specimens from Vareeg Islet.)

1923. *Erythraeodrilus sutorius* var. *affinis* (part), Stephenson, *Oligochaeta*, in *F. B. I.*, p. 466. (Excluding specimens from Vareeg Islet.)

Material examined.—From the Indian Museum; 5 acitellate specimens labelled, "*Hoplochaetella affinis* Stephenson. Types. Mormugao Bay, Portuguese India (Donna Paula Bay and vicinity). Aug. 1916. Dr. S. W. Kemp. W 128/1.", and one acitellate, dissected specimen labelled, "*Hoplochaetella affinis* Stephenson. Small Bay on S. W. side of Mormugao Bay, Portuguese India. Sept. 1916. Dr. S. W. Kemp. W 127/1".

External characteristics.—The first dorsal pore is on 4/5 (2). Spermathecal pores are minute and superficial, each pore at the centre of a transversely placed area of slight epidermal thickening (?) and shortly elliptical outline, the posterior pores on 8/9 (2 specimens) or slightly in front of 8/9, the anterior pores in front of the setal circle and slightly nearer to the circle than to 7/8, all pores about *cd*. Anteriorly dislocated setae of viii may be on a transverse line with the anterior spermathecal pores or may be about equidistant from a transverse spermathecal pore line and 7/8. Dislocated setae of ix may be in a fairly straight transverse line and also nearer to the anterior intersegmental furrow than to the setal circle from which they have been displaced. Dislocations of setae are shown below. Except for those in the spermathecal porophores each displaced setal follicle opens to the exterior at the centre of a small area of epidermal thickening (?) circular in outline.

Dislocated Setae.

Specimen	vii	viii	ix	REMARKS
1	<i>a</i> of left side posteriorly.	<i>a</i> of both sides posteriorly, <i>b</i> of left side anteriorly.	<i>a-d</i> of both sides anteriorly.	Posterior genital marking asymmetrical. Posterior spermathecal pores in front of 8/9. Type.
2	<i>a</i> of right side posteriorly. ¹	<i>a-b</i> of both sides anteriorly and in addition one seta on left spermathecal porophore and three on right.	<i>a-d</i> of both sides anteriorly.	Posterior spermathecal pores almost exactly on 8/9.
3	..		<i>a-c</i> of left side and <i>a-b</i> of right side anteriorly.	Abnormal.
4	<i>a</i> of both sides posteriorly.	<i>a-b</i> of left side and <i>a</i> of right side anteriorly, and in addition one seta on left spermathecal porophore and two on right.	<i>a-d</i> of left side and <i>a-c</i> of right side anteriorly and nearer to 8/9 than setal circle.	Posterior spermathecal pores in front of 8/9.
5	<i>a</i> of both sides posteriorly.	<i>a</i> of both sides anteriorly.	<i>a-d</i> of both sides anteriorly.	Posterior spermathecal pores practically on 8/9 (left pore doubled?).
6	..	<i>a</i> of both sides anteriorly and in addition three setae, <i>b-d</i> , on each anterior spermathecal porophore.	<i>a-d</i> of both sides anteriorly, right <i>d</i> only slightly.	Posterior spermathecal pores in front of 8/9. W 127/1.

¹ This seta was removed. It lacks an ectal portion, but has the ental portion curved rather like the handle of a walking stick. Associated with this seta is a rudimentary gland.

Male pores are minute and superficial, each pore in region of *ce* (determined from *xx*) and towards the median margin of a transversely placed, greyish, translucent area of approximately elliptical outline and a width of about two intersetal intervals. Intersegmental furrows are lacking ventrally, but porophores are, so far as can be determined from these specimens, just anterior to site of 17/18 and just posterior to site of 18/19.

Genital markings are unpaired, median, transversely extended but not reaching on either side to the male pore lines, post-setal on *xvii* and *xix* on four specimens, each marking with a distinctly demarcated, translucent central portion, and an opaque, band-like, marginal rim. On one of these worms the posterior marking is slightly asymmetrical with relation to the male pore lines and on the left side reaches anterior to the setal circle of *xix* and in contact with the male porophore. A fifth specimen, with metameric abnormality in region of *viii-ix* has also two unpaired median markings, but the anterior marking appears to be mainly pre-setal, reaching in front to site of 16/17. On this specimen and on the worm with an asymmetrical posterior marking, a ventral region bearing the genital markings and the male porophores is rather deeply depressed. The anterior margin of a posterior marking or the posterior margin of an anterior marking may be concave, the marking being of a slightly crescentic shape.

Internal anatomy.—The gizzard is in *vi* (4). The intestine begins in *xvi* (4), a valve posteriorly in *xv* and anteriorly in *xvi*. The typhlosole begins in *xxiii*, and in an anterior portion is triangular in cross section.

Hearts of *x-xiii* are latero-oesophageal. The large commissures from the dorsal trunk in an anterior portion of *xiv* pass down to the level of the ventral face of the gut where each unites with a vessel of similar size, possibly from the parietes, and then passes through 13/14 to join the extra-oesophageal just as the latter turns laterally to pass to the posterior calciferous glands. Extra-oesophageals have been traced anteriorly only to 5/6. No subneural. Lateroparietal vessels were not found. Lymph glands are present, as in *khandalaensis*, and begin in *xv* (4). The anteriormost gland of one specimen contains two brown discs.

Excretory system has, as in *khandalaensis* the usual clusters on the parietes in *ii* and *iii* and on the anterior faces of septa 4/5 and 5/6.

Segments *x* and *xi* closed off as in *khandalaensis*. No seminal vesicles in *x*. Male deferent ducts not traced throughout, but duct-like cords in *xviii* pass to anterior faces of posterior prostatic ducts and posterior faces of anterior prostatic ducts. Parietal glands, at least of the *khandalaensis* type, are lacking. There may, however, be glandular material within the parietes around ectalmost portions of prostatic ducts with slight protuberances (?) into the coelomic cavities, or the matted tissues associated with the portions of the prostatic ducts just above parietal level may be wholly nephridial.

In the type, spermathecal diverticula are ventrally directed, digitiform and characterized by a brilliant spermatozoal iridescence, with the diverticula (9, 10, 11, and 12) in an incomplete circle, the hiatus on the posterior face of the duct and less than one quarter of the circle. One

spermatheca is about 4 mm. long, the slender and the thick portions of the duct each about 1 mm. long.

Glands of copulatory setae are in four coelomic sacs and are short, 1-2 mm. long. Copulatory setal follicles are on the anterior faces of the gland ducts, within the parietes, the ental ends of the follicles just recognizable above the parietes. Copulatory setae are ornamented.

Genital marking glands are large, almost in contact antero-posteriorly, and sessile on the parietes.

Remarks.—One specimen which had been dissected by Stephenson, must be regarded as the type. Two further specimens have now been dissected, the abnormal worm and another. The type, with the spermatozoal iridescence of spermathecal diverticula, is presumably a post-sexual acelitellate. Spermatozoal iridescence is lacking in the spermathecal diverticula of the other two specimens.

A sixth specimen, from a different locality in Mormugao Bay, has a label in Stephenson's handwriting, "*var. pallida*." On this worm the anterior genital marking which slightly transcends the male pore lines is on the probable site of 16/17, the margins about equidistant from setal circles of xvi and xvii. The posterior marking which is slightly shortened transversely appears to be about equidistant from setal circles of xix and xx and hence across 19/20. The typhlosole is at first triangular in section as in other species. None of the spermathecal diverticula is iridescent. One spermatheca, which was removed, has nine rather thickly digitiform and flattened diverticula in an incomplete circle with a posterior hiatus as in the types. On other spermathecae the hiatus in the diverticular circle is lacking or much smaller and inconspicuous.

Although reduced to the status of a variety of *suctor* by Stephenson in 1923, *affinis* seems for the present to be distinguished by the absence of paired markings.

Diagnosis.—Male pores just anterior and posterior to sites of 17/18 and 18/19, each pore towards median margin of a transversely placed, translucent area of shortly elliptical outline. Spermathecal pores in *cd*, anterior pores in front of setal circle, posterior pores on or slightly in front of 8/9. Genital markings transversely placed, unpaired and median, two, post-setal on xvii and xix, not reaching laterally to male pore lines. Setae: 72/v, 80/ix, 74/xii, 65/xix, viii/0-4, xvii/0, xviii/1-3, xix/0; *a* dislocated posteriorly on vii, *a* or *a-b* of viii and some or all of *a-d* of ix dislocated anteriorly, each follicle opening externally through a circular porophore, some or all of *b-d* of viii usually on the anterior spermathecal porophores. Pigmentation red? Length 140 mm. Diameter 7 mm.

Gizzard in vi. Last hearts in xiii. Unpaired lymph glands from xv posteriorly. Testis sacs formed by peripheral fusion of septa 9/10-11/12. Parietal glands (if present?) not protuberant into coelomic cavities. Genital marking glands sessile on the parietes. Spermathecal diverticula short and digitiform and ventrally directed, in one circle (of 9-12) with fairly wide posterior hiatus. Copulatory setae ornamented¹; short glands, in four coelomic sacs; an additional pair of sacs in vii.

Distribution.—Mormugao Bay, Portuguese India.

¹ Although penial setae are probably present no setae are visible externally on xvii and xix in the ventral region between the longitudinal male pore lines.

Hoplochaetella anomala Stephenson.

1920. *Hoplochaetella anomala* Stephenson, *Mem. Ind. Mus.* VII, p. 223. (Type locality—Belgaum, Bombay Presidency. Types in the Indian Museum.)
 1923. *Erythraeodrilus anomalus*, Stephenson, *Oligochaeta*, in *F. B. I.*, p. 458.

Material examined.—From the Indian Museum: 2 acitellate and 5 clitellate (2 dissected) specimens labelled, "*Hoplochaetella anomala* Stephenson. Types. Belgaum, Bombay Presidency. 5.6.1910. N. B. Kinneer. W 290/1"; and 4 clitellate, macerated specimens labelled, "Near the S. bank of the Sharavati River. Jog Falls, Mysore State. H. S. Rao. Nov. 1928". From the Bombay Natural History Society: 2 clitellate, macerated specimens labelled, "Panchgani, Satara district. Sept. 1939. C. McCann".

Notes on the types. External characteristics.—There are four chaetae in the setal circle of viii between the spermathecal pore lines and two to four on ix between the same lines, *i.e.*, ordinary setae in normal positions in setal circles and not on tumescences. On ix some of the setae lateral to *b* may be dislocated only very slightly. Setae are lacking ventrally on xvii and xix between the male pore lines but are present normally on xviii (*ca.* six to eight).

Male porophores are depressed. The minute male pores are clearly visible. There may be one or two further openings on each porophore close to the male pore but the epidermis is damaged and the pore-like appearances may be artefacts.

Two specimens have each an unpaired, post-setal genital marking on the left side of xviii, in line with and of about the same size as the male porophores. (Stephenson had one specimen with paired markings on xviii.) Markings in the region of 24/25 would be unrecognizable, if present, because of gelatinization in the post-prostatic region.

Internal anatomy.—Lymph glands if once present are now quite unrecognizable posteriorly as well as anteriorly.

Each specimen (3) has two, vertically placed parietal glands associated with each prostatic duct, one just median and one just lateral to the prostatic duct; the lateral gland is more conspicuously protuberant into the coelomic cavity. These glands must open to the exterior through the prostatic duct or by apertures on the male porophore, possibly the latter. Each gland is hollow and filled with a flocculent coagulum. The male deferent ducts of a side pass posteriorly between the anterior prostatic duct and the lateral gland. In xviii one duct turns back on itself and passes into the posterior face of the anterior prostatic duct, apparently without enlargement, to an ejaculatory bulb, though covered over with rather tough tissue close to the prostatic duct. The other duct passes straight to the anterior face of the posterior prostatic duct. Tracing the course of the vasa deferentia in these worms is remarkably easy because of their superficial location on the parietes. Penial setae are present on the median faces of both anterior and posterior prostatic ducts. Seminal vesicles of x (?) are large. In xi there is a pair of masses (of testicular coagulum?) exactly similar in appearance to the vesicles of x but without recognizable attachment to a septum. Possibly all of these supposed vesicles are merely masses of testicular coagulum.

A cuticular lining of the spermathecal duct is separated off from the duct wall to the ampulla. Paired spermathecal diverticula are ventrally directed, with very short stalks, each diverticulum with two

to five ellipsoidal masses of spermatozoa. The copulatory setal glands are in paired clusters (three to five) in viii and ix, passing to the parietes posteriorly round the spermathecal ducts. The glands are short. Coelomic sacs, if present, are unrecognizable. A copulatory setal follicle projects conspicuously into the coelomic cavity on the median face of each gland stalk.

Remarks.—The types were “In bad condition” in 1920 and the condition is certainly no better now.

Several specimens, including an undissected type, cannot now be referred with certainty to *anomala* as they differ from the majority of the types in characteristics that may prove to be of taxonomic value. The diagnosis is of course based on the type series, after exclusion of one specimen, but to facilitate comparison with the account given above the divergent worms are described herewith. In all of these forms, including the types of *anomala*, the gizzard certainly appears to be in vii but this location is determined by counting forwards from ix and a very delicate septum may have been ruptured in dissection so as to be unrecognizable. Septum 6/7 was not found or identified with certainty, two pre-gizzard septa characterized by the presence on their anterior faces of nephridial clusters are, presumably, to be regarded as 4/5 and 5/6. In these circumstances the segmental location of the gizzard requires confirmation.

According to Stephenson (1920, p. 226) *anomala* is more primitive than other species then known because of the segmental location of the male pores in the setal circles, and the greater separation of the spermathecal pores, possibly also because of the presence of testis sacs. Not mentioned but probably also to be regarded as primitive are the paired spermathecal diverticula. Testis sacs are presumably cylindrical or of the type found in *khandalaensis*, but in view of the condition of the types when studied by the author they must be described from properly preserved specimens.

The excluded type.—A small, short transversely placed genital marking of elliptical outline is present immediately lateral to each male porophore. Corresponding to each of these markings there is a fairly large gland on the parietes internally, strongly adherent to the lateral face of the prostatic duct. These glands are larger than either of the median or lateral glands in the other types. Parietal glands of the usual sort (*i.e.*, not opening externally on genital markings but associated with prostatic ducts or male porophores) are entirely lacking here.

Penisetal follicles are visible on the median faces of the prostatic ducts of xvii and xix without dissection (usually glandular tissue must be cleared away from the immediate vicinity of the ducts before the follicles become visible). Four penial setae from one side of xix were obtained. Discrete follicles are unrecognizable, two setae may be functional and two reserve. Shafts are nearly straight, the tips flattened on one side and convex on the opposite side, without ornamentation. Lengths : 0.13, 0.19, 0.21, and 0.30 mm.

The Mysore Specimens. External characteristics.—Length 65-90 mm. Diameter 4 mm. Pigmentation red, fairly dense but restricted

to the anterior and posterior ends, possibly leached out by alcohol elsewhere. The first dorsal pore is on 4/5 (3) or 5/6 (1).

Setae begin on ii on which segment there is a nearly complete circle. Mid-ventral gaps are small, mid-dorsal gaps much wider but variable, some of the dorsalmost setae possibly unrecognizable because of small size or deep retraction. Formula : 39/iii, 38/viii, 53/xii, 60/xx, viii/6, ix/8, xvii/0, xviii/14, xix/0.

The clitellum is annular and extends from just anterior to the setae of xiii to just behind the setae of xvi ; intersegmental furrows and dorsal pores lacking, setal circles present.

Quadrithecal, spermathecal pores minute and superficial, transversely slit-like pre-setal on viii and ix, each pore at or near the centre of a small, circular area delimited by a slight furrow, the posterior margins of the porophores just in front of the setal circle of viii or in or just behind the setal circle of ix. Apertures of the follicles of six copulatory setae form an irregular circle around each spermathecal pore. Postero-lateral and antero-median to each spermathecal porophore there is usually a tiny tubercle with a central aperture of the follicle of a copulatory seta.

The single female pore is median and pre-setal.

Male pores are minute, each pore at the tip of a very tiny, conical protuberance from a point slightly postero-median to the centre of a circular porophore with soft central region and tough peripheral portion. The porophores are fairly widely paired, on xvii and xix, a central portion more or less deeply but not regularly depressed, or the whole porophore may be nearly flat. In the latter case the median margin is marked off by a slight furrow while the lateral margin is protuberant.

One specimen has a transversely placed genital marking of elliptical outline on 24/25, left side, extending antero-posteriorly nearly to the setae of xxiv and xxv and latero-mesially between *f* and *a*. A fairly deep groove demarcates a peripheral rim from the convex central portion.

Internal anatomy.—Septa 9/10 and 11/12 are close to 10/11 and either apposed to it peripherally or connected with it by very short, cylindrical bands of delicate connective tissue, the condition of the specimens preventing a more exact characterization.

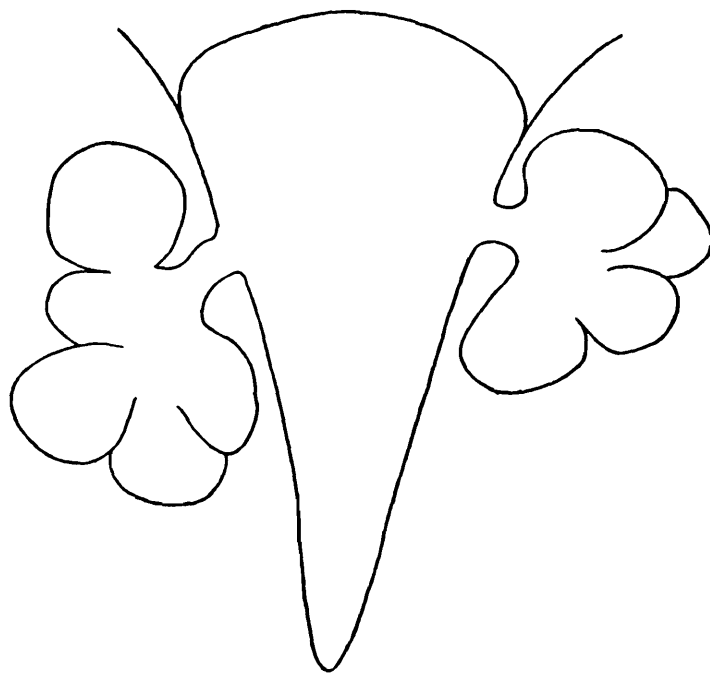
The large gizzard is in vii (2). No intestinal caeca. Typhlosole not noted, nor segment of intestinal origin.

The last pair of hearts is in xii (2). Paired commissures in the anterior portion of xiv pass ventrally and into extra-oesophageal trunks. Other portions of the circulatory systems were not in a satisfactory condition for study.

Seminal vesicles are paired in ix, x and xii, the vesicles of x being on the anterior face of 10/11. An ental portion of the prostatic duct is translucent, an ectal portion about 3 mm. long muscular and thickly spindle-shaped. Within the body wall and on the median face of each prostatic duct is a tiny cord of tissue containing five or six setae. In xix the setae are 0.38-0.40 mm. long, almost straight, the tip slightly more pointed than on the copulatory setae and without ornamentation.

Spermathecal ampullae, distended by a hard material, are four to six times as long as the duct. The latter is fairly wide entally, gradually narrowed ectally and very slender within the parietes, and opens into the

ampulla by a slit-like aperture. Diverticula are paired, median and lateral, each diverticulum with a very short stalk and three or more seminal chambers.



Hoplochaetella anomala ?—Spermathecal duct and diverticula of a specimen from Mysore State. $\times ca$ 47.

Associated with each spermatheca are five or six glands, each gland about 2 mm. long and with a slender duct about 1 mm. long which is slightly widened as it passes into the parietes. Associated with each gland and protuberant into the coelomic cavity is a muscular follicle containing a single copulatory seta. The shaft is nearly straight except for a slight curvature of the entalmost portion and a slight bend at the extreme tip, and tapers gradually at the ectal end to a rather bluntly rounded termination. Of two setae the tips are hollowed in a spoon-like fashion. An ectal region is ornamented with longitudinal rows of four to six transversely placed, jagged ridges, a light spot just in front of each ridge as if a bit of the shaft had been gouged out. Length : in viii, 0.65-0.73 mm. ; in ix, 0.64-0.70 mm.

The genital marking gland is sessile on the body wall.

Parasites.—Nematodes are present in the coelomic cavities of all dissected specimens. A much larger nematode was found in the gut of one specimen.

Remarks.—Efforts to trace the deferent male ducts in two of the specimens were failures. In a third worm the deferent ducts were traced into xviii from whence one was followed posteriorly into xix but junctions with prostatic ducts were not found. Laboratory notes on glands of the prostatic region are unsatisfactory but are presented for whatever they may be worth. "Associated with each prostate and passing into the body wall just in front of each prostatic duct is a conspicuous glandular mass flattened against the parietes of xvii-xviii of xix-xx or xxi, of variable shape, marginally incised by the septa, without recognizable duct, the wall of the coelomic portion delicate and easily ruptured releasing hard balls which look almost like sperm balls."

The Panchgani Specimens. External characteristics.—Length 28 and 50 mm. Diameter $2\frac{1}{2}$ and 3 mm. Pigmentation unrecognizable (alcoholic preservation). Prostomium epilobous, without transverse furrow at posterior end of tongue. First dorsal pore on 4/5 (2). The clitellum is annular, extending from just in front of the setae of xiii to just behind the setae of xvi; intersegmental furrows and dorsal pores lacking, setae present.

Setae are lacking ventrally on xvii and xix but there are six setae (2) on xviii between the male pore lines, *a* and *b* of both sides of viii and ix in normal positions (2) but *c-f* or *g* of viii are dislocated anteriorly in a transverse row about midway between the setal circle and 7/8 while the same setae of ix are arranged in circle around the posterior spermathecal pores.

Spermathecal pores are minute and superficial, on *c*, or in *cd*, the anterior pores midway between the displaced setae of viii and 7/8 and accordingly nearer to the intersegmental furrow than the setal circle, the posterior pores on or very close to the setal circle of ix.

The female pore is median and presetal (2).

The minute male pores are on *c* or just lateral to it, towards the median margins of small, transversely placed depressions of short elliptical to oval outline and appear to be very slightly behind the setal circles of xvii and xix. Each depression (male porophore) is within an indistinctly demarcated, whitish area of slight tumescence, the areas of a segment reaching nearly into contact mesially on one specimen, and perhaps in contact on the other worm.

A transversely placed area of whitish tumescence in *bb* (one worm only) extending from the setal circle of xx nearly to the setae of xxi is either a genital marking or a tumescence containing two markings (the latter, if present, unrecognizable).

Internal anatomy.—Two very delicate, transparent septa are attached to the gut anterior to the seminal vesicles of ix and presumably are 7/8-8/9. The next recognizable septum passes to the gut just in front of the gizzard and since it bears the posterior pair of vertically placed masses of nephridial tubules is presumably to be regarded as 5/6. No trace of 6/7 has been found. Septa 9/10, 10/11 and 11/12 apparently pass to the parietes normally.

The gizzard certainly appears to be in vii (2). The intestine begins in xvi (2). The typhlosole is simple and lamelliform, terminating six or seven segments in front of the hind end. The last hearts are in xii (2).

Seminal vesicles of ix and xii are large, x and xi filled with sticky material in which vesicles and membranes are unrecognizable. Male deferent ducts of a side pass into xviii between the anterior prostatic duct and the lateral parietal gland, one deferent duct continued into xix, the other turning back into xvii. The deferent ducts are probably not thickened prior to junction with the prostatic ducts though covered with soft (glandular?) tissue. Just median and lateral to each prostatic duct, and protuberant from the parietes into the coelomic cavity is a vertically placed, ellipsoidal, hollow gland with a thick but soft wall.

Genital marking glands are two short, low masses of elliptical outline, longitudinally placed, sessile on the parietes, separated from each other by the nerve cord.

The spermathecal ampullae are not bound down around the ental ends of the ducts. The lumen in the thickened ental portion of the duct is slit-like in transverse section. Each spermatheca has two diverticula, one median and one lateral, each diverticulum ventrally directed and with three to five shortly ellipsoidal to spheroidal, iridescent masses of spermatozoa. Each of these masses presumably represents a seminal chamber, all of the chambers of a side apparently opening into the duct through a common aperture. Two or three chambers of each diverticulum are always quite definitely smaller than the others and may occasionally lack spermatozoal iridescence.

Copulatory setal follicles are protuberant into the coelomic cavity. The major portion of the setal shaft is straight, an ental portion curved like the handle of a walking stick. The tip is convex on one side and flat or very slightly concave on the opposite side. Ornamentation is lacking (18 setae of one worm and 14 of the other). The glands are short, about 1 mm. long (not including the duct). Coelomic sacs, if present, are unrecognizable.

Remarks.—The specimens are in such poor condition that setal counts and recognition of certain external characteristics are impossible. The intestine is completely disintegrated behind the clitellum for a considerable distance, lymph glands (if present) quite unrecognizable throughout, nephridia (except for the clusters on the anterior faces of 4/5 and 5/6) unrecognizable, characteristics of testis sacs (if present) indeterminable. The circulatory system, however, with the exception of the absence of hearts of xiii, is as usual in the genus. Penial setae were not found though looked for carefully.

The Panchgani worms are distinguished from the types of *anomala* by the absence of genital markings on xviii, the presence (1) of more closely paired genital markings on 20/21, and the absence of ornamentation on copulatory setae and possibly also by absence of penial setae.

Absence of ornamentation on copulatory setae at present appears to be a useful criterion for specific distinction as this characteristic has been noted hitherto only in *H. stuarti* from which the present worms are obviously clearly distinct. The taxonomic value of the other differences from the types of *anomala* is unknown. In any case the erection of a new species is not to be considered as the specimens disintegrated during the course of examination so as to be useless as types.

Diagnosis.—Male pores in line with setal circles of xvii and xix, in *cd*, towards the median margins of transversely placed, short depressed porophores of elliptical outline in *bh*. Spermathecal pores pre-setal on viii (about midway between setal circle and 7/8?) and in or close to the setal circle of ix, on or close to *c*. Genital markings (when present) post-setal on xviii, in line with male porophores. Setae: 36-44/viii, 40-46/xii, viii/4, xvii/0, xviii/6-8, xix/0; some or all of *c-f* dislocated anteriorly on viii (and posteriorly on ix?). Pigmentation? Length 85 mm. Diameter 3 mm.

Gizzard in vii? Last hearts in xii. Lymph glands? Testis sacs? Seminal vesicles present in x. Ejaculatory bulbs? Parietal glands in xvii and xix, one median to and one lateral to each prostatic duct. Genital marking glands sessile. Spermathecal diverticula paired, with short stalks, ventrally directed, each diverticulum with 2-5 seminal chambers (?). Copulatory setae ornamented; glands short, in clusters of 2-5 behind each spermathecal duct (coelomic sacs?).

Distribution.—Known only from the type locality, Belgaum, Bombay Presidency.

Hoplochaetella bifeveata Stephenson.

1917. *Hoplochaetella bifeveata* Stephenson, *Rec. Ind. Mus.* XIII, p. 398. (Type locality—Talewadi, near Castle Rock, N. Kanara district, Bombay Presidency. Type in the Indian Museum.)

1922. *Erythraeodrilus kempfi* var. *bifeveatus*, Stephenson, *Rec. Ind. Mus.* XXIV, p. 437.

1923. *Erythraeodrilus kempfi* var. *bifeveatus*, Stephenson, *Oligochaeta*, in *F. B. I.*, p. 462.

Material examined.—From the Indian Museum: 1 clitellate dissected specimen labelled, "*Hoplochaetella bifeveata* Stephenson. Type. Talewadi near Castle Rock, N. Kanara district, Bombay Presidency. Oct. 1916. Dr. S. W. Kemp. W 129/1".

External characteristics.—Spermathecal pores are on porophores of the usual type, on viii, about in *bc*, the anterior pores about midway between the setal circle and 7/8, the posterior pores slightly in front of 8/9. Dislocated setae are as follows: on vii, apparently none; on viii, *a* of right side slightly anterior, within a discrete tubercle which is in contact with the spermathecal porophore, in addition three setae in each anterior spermathecal porophore (presumably *b-d* or *a-c*); on ix, *c-d* of left side and *b-c* or *c-d* of right side very slightly anterior to the circle and on a single area on each side of slight epidermal tumescence.

Male pores are minute and superficial, each pore towards the median margin of a small, transversely placed, translucent area of elliptical outline, the porophores just in front of and just behind the sites of 17/18 and 18/19.

Genital markings are unpaired, approximately median and symmetrical, transversely extended, reaching nearly to or slightly beyond the male pore lines, the anterior marking about equidistant from setal circles of xvi and xvii and accordingly across 16/17, the posterior marking pre-setal on xx, dislocating 19/20 anteriorly. Central and marginal areas demarcated as in *affinis*. A ventral area extending from the setae of xvi to 20/21 is smooth and with no intersegmental furrows. There are two ventral setae on xviii.

Internal anatomy.—Lymph glands of the *khandalaensis* type are probably present.

Glandular material is present around the ectal portion of each prostatic duct near the parietes, possibly in the form of a complete or incomplete annular collar.

Spermathecal diverticula lack spermatozoal iridescence and are small, short and digitiform, (ventrally directed?). The number is variable; a single diverticulum on each side of the duct, one diverticulum on one side of the duct and none on the other side, two diverticula on each side closely crowded together, two on one side of the duct and none on the other. Copulatory setal glands are short, $1\frac{1}{2}$ -2 mm. long, in three pairs of sacs, the anterior pair in vii. Copulatory setal follicles on the anterior or median faces of gland stalks are slightly protuberant above the parietal level. Copulatory setae are ornamented with short transverse rows of a few small teeth, a short ental portion of the shaft curved like the handle of a walking stick.

Remarks.—The epidermis is damaged in the spermathecal region and some of the internal structures are lacking, the gut in poor condition, and the glands around prostatic ducts fragmented. Genital markings are like those of *affinis* but the spermathecae are like those of *kempi*.

The species, if really distinct, is very close to *kempi*, and can be distinguished at present only by the symmetrical locations of the genital markings. If *bifoveata* is to be suppressed, the asymmetrical condition characteristic of the types of *kempi* is, presumably, a rather common abnormality.

***Hoplochaetella inornata* Stephenson.**

1917. *Hoplochaetella inornata* Stephenson, *Rec. Ind. Mus.* XIII, p. 395. (Type locality—Talewadi, near Castle Rock, North Kanara district, Bombay Presidency. Type in the Indian Museum.)

1923. *Erythraeodrilus inornatus*, Stephenson, *Oligochaeta*, in *F. B. I.*, p. 459.

Material examined.—From the Indian Museum: 1 clitellate specimen labelled, "*Hoplochaetella inornata* Stephenson. Type. Talewadi, near Castle Rock, N. Kanara district, Bombay Presidency. Oct. 1916. Dr. S. W. Kemp. W 130/1".

External characteristics.—On 4/5 at the mid-dorsal line there is a pore-like marking, possibly perforate, and a functional dorsal pore is certainly present on 5/6.

Ventral setae are lacking on xvii and xix, seven setae on xviii between male pore lines, no setae on viii in setal circle between spermathecal pore lines. No setae are dislocated on vii and ix, and tumescences as in *kempi* are lacking. On viii dislocated setae are as follows: on anterior left spermathecal porophore 1, right porophore 2, on posterior left spermathecal porophore 2, right porophore 3, *e* of the right side slightly posterior and at centre of a tiny tumescence of circular outline.

Spermathecal pores are minute and superficial, each pore at or near the centre of a small, transversely placed slightly tumescent short area of elliptical outline, the pores in *bd*, about equidistant from the setal circle, posterior pores a trifle more median than the anterior.

The single female pore is median and pre-setal.

The minute male pores are about in *ce*, each pore at the centre of a nearly circular abruptly depressed area. A marginal portion of each porophore is not depressed but slightly tumescent, forming a fairly

definite rim around the depression. One or more additional pores may be present on each porophore but are not definitely identifiable.

Internal anatomy.—The typhlosole is a simple lamella.

Extra-oesophageals, supra-oesophageal, dorsal trunk, commissures and hearts are, so far as can be determined, as in *khandalaensis*. No subneural. Latero-parietal vessels not seen. The kidney-shaped mass in xv mentioned by Stephenson is the first lymph gland much enlarged.

The usual clusters of nephridia are present on the anterior faces of 4/5 and 5/6, and probably also on the parietes in ii-iii.

The vasa deferentia of a side pass posteriorly in contact with each other, turning laterally to pass around the anterior prostatic duct and then mesially in xviii where one bends forward while the other continues posteriorly but first ventrally. The posteriormost portion of each duct is modified into a large, spheroidal (muscular?) bulb on the anterior face of the posterior prostatic duct and the posterior face of the anterior duct, the prostatic ducts much narrower ectal to the junction with the male deferent ducts. Penial setae are present in xix but were not found in xvii. The single seta removed is practically straight and unornamented.

The spermathecae are 4+ mm. long, the slender ectal portion of the duct 1 + mm., the thick portion of the duct about 1 mm. in length. The ampulla is bound down around the ental end of the duct so that the latter appears to be invaginated into the ampullary lumen as a rather conspicuous annulus. A layer of transparent material on the annulus and lining the duct probably is the cuticle. In the thickened portion of the duct the lumen is irregular as a result of the presence of several longitudinal and fairly high ridges. In the ectal portion of the duct the lumen is circular in section. There is but a single circle of diverticula on each spermatheca, an occasional diverticulum slightly more ectal than the others. The diverticula, characterized by spermatozoal iridescence, are short and ellipsoidal, ventrally directed, and without a recognizable stalk exterior to the duct. Twelve diverticula were counted on one spermatheca of which three are more or less deeply bifid ectally.

Copulatory setal glands are about 2 mm. long, the ducts 1 + mm. long in two coelomic sacs, with the wall of the sacs very thin and transparent. The bluntly rounded ental end of a copulatory setal follicle projects slightly above the parietes in front of each gland. One follicle was removed. The single copulatory seta is ornamented, an ental portion curved into an arc somewhat like that of the handle of a walking stick.

Remarks.—This species differs from both *khandalaensis* and *powelli* in the absence of genital markings and of seminal vesicles in x, in the larger setal numbers, and in the presence of male seta on xviii. Were it not for the setal differences one might be justified in raising a question as to the type being a slightly abnormal specimen of *khandalaensis* (or perhaps even *powelli*).

Diagnosis.—Male pores in *ce*, at or near centres of small porophores at the posterior margin of xvii and anterior margin of xix. Spermathecal

pores on viii, in *bd*, midway between the setal circle and furrows. Setae 84/v, 80/ix, 84/xii, 85/xx, viii/0,¹ xvii/0, xviii/7, xix/0; *a-c, d* or *e* of viii dislocated anteriorly and posteriorly onto spermathecal porophores. First dorsal pore on 4/5 (?). Pigmentation red? Length 101 (+?) mm. Diameter 6 mm.

Gizzard in vi. Last hearts in xiii. Unpaired lymph glands from xv posteriorly. Testis sacs formed by peripheral fusion of septa 9/10-11/12. Vasa deferentia just prior to junctions with prostatic ducts enlarged to form spheroidal ejaculatory bulbs. Parietal glands in xvii-xix, three on each side, just median to the prostatic ducts, largest in xviii. Spermathecal diverticula ventrally directed, short, ellipsoidal, occasionally bifid, 12 (more or less) in a single circle. Copulatory setae ornamented, glands short, in two coelomic sacs, in viii.

Distribution.—Known only from the type locality, Talewadi, in North Kanara district, Bombay Presidency.

Hoplochaetella kempi Stephenson.

1917. *Hoplochaetella kemp*i Stephenson, *Rec. Ind. Mus.* XIII, p. 392. (Type locality—Talewadi, near Castle Rock, North Kanara district, Bombay Presidency. Types in the Indian Museum.)

1923. *Erythraeodrilus kemp*i, (part), Stephenson, *Oligochaeta*, in *F. B. I.*, p. 460. (Excluding var. *bifoveata*.)

Material examined.—From the Indian Museum: 8 clitellate (1 dissected) specimens labelled, "*Hoplochaetella kemp*i Stephenson. Types. Talewadi, near Castle Rock, N. Kanara District, Bombay Presidency. Oct. 1916. Dr. S. W. Kemp. W 68/1".

External characteristics.—Two of the shortest specimens are probably incomplete posteriorly. Another specimen, apparently complete, is *ca.* 70 mm. long. Most of the worms are about 4 mm. thick. Pigmentation is now unrecognizable. Dorsal pores are unrecognizable anterior to the clitellum on most specimens but a pore is almost certainly present on 4/5 on two worms.

The clitellum is reddish brown, not protuberant or slightly constricted, intersegmental furrows lacking, sites of dorsal pores occasionally indicated by slight depressions but pores probably occluded, setae present; annular, extending posteriorly to 16/17 or to just behind the setae of xvi, and anteriorly to just in front of the setal circle of xiii. An anterior portion of xiii of variable length is white.

The single female pore (8) is median and slightly pre-setal.

Spermathecal pores are minute and superficial, all four pores open and clearly visible on every specimen, in *ac*, the anterior pores midway between the setal circle of viii and 7/8 or slightly nearer to the setal circle, the posterior pores slightly nearer to 8/9 than the anterior pores are to the setal circle. Spermathecal pores are located on transversely placed areas of slight tumescence and probably of shortly elliptical

¹ No setae in ventral portion of setal circle between longitudinal spermathecal pore lines.

outline, margins indistinctly demarcated. Dislocated setae are shown below.

Specimen	Setae associated with tumescences	Dislocated Setae		Male setae on
	vii	viii	ix	xviii
1	<i>a-c</i> of left side, <i>a</i> of right side.	left 3 right 2	<i>c-d</i> of left side, <i>c</i> of right side.	2
2	<i>a-b</i> both sides	left 3 right 3	Surface damaged	4
3	<i>a-b</i> both sides	left 3 right 3 <i>d</i> of each side slightly displaced anteriorly and on a tumescence.	<i>b</i> both sides	2
4	<i>a-c</i> of left side, <i>a-b</i> of right side.	left 4 right 3 <i>d</i> of right side on tumescence and slightly anteriorly.	<i>a-b</i> both sides	4
5	<i>a-b</i> both sides	left 3 right 3	<i>c</i> (?) of left side, <i>c-d</i> of right side, <i>a-b</i> follicles empty ?	4
6	<i>a-d</i> of left side, <i>a-b</i> of right side.	left 3 right 3	<i>a-c</i> both sides	0?
7	<i>a-b</i> both sides	left 3 right 3	<i>c-d</i> both sides, <i>b</i> of left side present, left <i>a</i> and right <i>a-b</i> follicles empty ?	4
8	<i>a-b</i> of left side, <i>a</i> of right side.	left 3 right 3	<i>b</i> of right side (?) damaged surface.	4

Several ventral setae are lacking on the left side of vii of every worm, the corresponding setae of the right side present.

Several (probably not as many as on vii) ventral setae are usually lacking on the right side of ix lateral to the setae on tumescences and occasionally fewer setae are also lacking on the left side.

Setae on tumescences of vii and ix may be dislocated anterior to the setal circle but usually so slightly that the displacement is scarcely recognizable.

Dislocated setae of viii are anterior, apertures of follicles on the spermathecal porophores.

Male porophores are small, transversely placed, translucent areas of short elliptical outline. On four specimens the porophores are definitely segmental, anterior to 17/18 or its site and posterior to 18/19 or its site. On two or three specimens the anterior porophores appear to be across sites of 17/18, the posterior porophores on xix. On another worm all of the porophores appear to be across the sites of the inter-segmental furrows. Male pores are minute, each pore at or very slightly median to the centre of a porophore, *ca* in *ac*.

Genital markings are transversely placed and shortly elliptical in outline. Each marking comprises a central portion and a marginal band, a considerable inner portion of the marginal band depressed and translucent while the central area is white and opaque. Markings are located as follows : (1) on 16/17 and pre-setal on xx, anterior marking

slightly asymmetrical towards the right side, the posterior marking on the left side and with centre lateral to the male pore line ; (2) pre-setal on xx only, right side, centre about on the male pore line ; (3) pre-setal on xvii and xx, anterior marking on the right side, posterior marking on the left side, centres lateral to the male pore lines ; (4) anterior marking practically symmetrical and mainly pre-setal on xvii, posterior marking pre-setal on left side of xx and with centre median to male pore line ; (5) pre-setal on xvii and xx, anterior marking on the right side, posterior marking on the left side, centres lateral to the male pore lines ; (6) as on 5 except that the centre of the posterior marking is about on the male pore line ; (7) as on 5 ; (8) as on 5 except that the markings appear to be equally across 16/17 and 19/20.

Internal anatomy.—The gizzard is in vi (2). The intestine begins in xvi (2), the oesophageal valve posteriorly in xv and just reaching into xvi. The typhlosole begins abruptly in xxii (2) and is a fairly high, simple lamella, very gradually decreasing in height posteriorly, ending abruptly in lxxv (specimen with 94 segments).

The dorsal blood vessel (single) is continued on to the pharyngeal bulb. A supra-oesophageal trunk is first visible in an anterior portion of ix and terminates posteriorly by dividing into two vessels passing to the posteriormost calciferous glands. Extra-oesophageals have been traced from 4/5 to the posteriormost calciferous glands. No subneural. A posterior latero-parietal vessel is present on each side in xv-xvi, completely concealed from view by nephridia, and unrecognizable posteriorly. Just in front of 14/15 the vessel rises from the parietes and after uniting with the commissure of xiv passes through 13/14 and joins the extra-oesophageal just as the latter turns laterally towards the calciferous glands. Commissures of xiv are large and join the dorsal trunk just behind 13/14. Hearts of x-xiii are latero-oesophageal, all commissures and hearts of viii-xiii passing into the ventral trunk, and paired vessels from dorsal trunk in v-vii not traced to ventral trunk. Lymph glands are present from xv (2) posteriorly, and are very small anteriorly, relatively quite large towards the hind end.

Mega-nephridia begin in xiv but in xiv-xix the loops (5) are about half the length of those behind xix. In another specimen (3) mega-nephridia of xiv-xix are, at least in part, or perhaps even wholly, lacking. In posterior segments the neck portion of a mega-nephridium is very slender and rather long so that the funnel is held out some distance in front of the septum. On the neck just behind or slightly behind the funnel there are usually two to four clusters of coelomic corpuscles. Each cluster of corpuscles is adherent to a funnel-shaped structure provided with filamentous processes resembling cilia and a short stalk passing to the neck. Cilia of the main funnel often project beyond the funnel margin and are usually in brush-like bunches, eight having been noted on several funnels. Micro-nephridia are numerous enough to cover practically the entire body wall in segments xiii-xvi. The usual clusters are present on the anterior faces of 4/5 and 5/6 and on the body wall in ii and iii.

No seminal vesicles in x. Male deferent ducts have not been successfully traced throughout, but they almost certainly pass into the anterior

faces of posterior prostatic ducts and the posterior faces of the anterior ducts. On the median face of each prostatic duct, sessile on the body wall and markedly protuberant into the coelomic cavity but concealed from view by micro-nephridia, is a gland shaped like a half collar with concave side laterally. On the lateral face of each prostatic duct is a smaller but also protuberant, vertically placed, rather flattened gland, likewise concealed by micro-nephridia, possibly continuous within the parietes with the other gland. In 3 specimens a single glandular collar surrounds the prostatic duct except for a small space postero-laterally. On the median face of each posterior prostatic duct are penial setae in two (or possibly three ?) follicles. Three setae dissected out from one side are 0.30-0.32 mm. long and practically straight. Two of these setae are ornamented near the tips by short, transverse serrate ridges. The other seta is unornamented. Only one seta was secured from the other side and this was also unornamented.

A pair of small, collapsed, sac-like structures on the posterior face of 13/14 are probably the rudiments of structures usually called ovisacs.

Spermathecae are about $2\frac{1}{2}$ mm. long, the ducts about 1 mm. long. The ampulla is bound down around the ental end of the duct which has the appearance of being invaginated into the ampullary lumen as a rather flattened annulus covered with a transparent layer of material that is possibly the cuticle. Diverticula are usually ventrally directed, with very short and slender stalks practically confined to the tissues of the duct and short ellipsoidal seminal chambers with spermatozoal iridescence,—in two groups as follows: 0+1, 1+1, 1+2, 1+2 (specimen 5); 2+3, 3+3 (2 with common stalk), 2+3 (2 with little or no iridescence), 2+3 (3); 2 or 3 in each group (1 and 2).

Follicles of copulatory setae are muscular, the bluntly rounded ental ends protuberant above the parietes on the median face of the glands but within the parietes the seta passes into the posterior face of the gland stalk. The gland is short, 1 mm. or a trifle longer and much thicker than the duct. There is one gland for each dislocated seta on viii as well as for each seta of the tumescences. Definite coelomic sacs have not been seen but thin bits of tissue adherent to the glands are possibly the fragments of coelomic sacs in which case there are probably three pairs, one each in vii-ix. Copulatory setae are ornamented.

Genital marking glands are sessile, flattened, though definitely protuberant into coelomic cavities, and are larger than the genital markings. One gland came easily out of the body wall, leaving a smooth margin in the parietes and with the opaque central portion of the genital marking on the ventral face of the glandular mass.

Remarks.—Dorsal pores are not recognizable or identifiable as patent apertures on some of the specimens, even after removal of the cuticle, posterior as well as anterior to the clitellum.

Although penial setae were not found in xvii it is impossible to conclude that they are lacking. The glandular tissues around the prostatic ducts are so brittle that dissection is difficult. The glands in the coelomic cavity associated with a prostatic duct may be merely lobes of a single gland forming an annulus around the duct within the parietes.

Distinction of hearts from commissures by colour appears to be impossible. In one specimen the commissures of xiv and of viii-ix are as white as the hearts of x-xiii.

Prior to removal of the cuticle only one aperture is recognizable on the male porophores. After removal of cuticle (1 specimen) one or two additional pit-like markings, possibly apertures, are visible. As the cuticle was slightly adherent to the porophores and required some slight force to lift it off, the pits may be the result of damage to the epidermis.

As the peculiar asymmetry in location of the genital markings (and in loss of certain ventral setae of vii) is constant in the type series, it may be a characteristic of the species, in which case *bifoveata* is distinct. However, if the asymmetry is merely a local or common variation *bifoveata* can probably be suppressed.

Diagnosis.—Male pores (on or) in front of 17/18 and behind 18/19, in *ac*, at or near centres of transversely placed, translucent areas of shortly elliptical outline. Spermathecal pores on viii, in *ac*, anterior pores in front of setal circle, posterior pores slightly nearer to 8/9 than the anterior pores are to the setal circle. Genital markings transversely placed and of elliptical outline, centres usually on or lateral to the male pore lines, pre-setal on xvii (or on 16/17) and xx (or on 19/20), anterior marking usually on right side, posterior marking on left side, two markings usually present. Setae 52/v, 56/x, 45/xx, viii/0, xviii/2-4; some or all of *a-d* of vii and ix on tumescences, three setae on each side of viii dislocated anteriorly on to spermathecal porophores close to spermathecal pores. First dorsal pore on 4/5 (?). Pigmentation red? Length 70-103 mm. Diameter 4-4½ mm.

Gizzard in vi. Last hearts in xiii. Unpaired lymph glands from xv posteriorly. Testis sacs formed by peripheral fusion of septa 9/10-11/12. Parietal glands; a half-collar on the median face of each prostatic duct, a smaller lobe on the lateral face. Genital marking glands sessile. Spermathecal diverticula with shortly ellipsoidal seminal chambers and very slender stalks almost confined to duct, (median and lateral ?) groups, usually of 2-3. Copulatory setae ornamented; glands short, in six coelomic sacs (?), in vii-ix.

Distribution.—Known only from the type locality, Talewadi, in North Kanara district, Bombay Presidency.

***Hoplochaetella khandalaensis* (Stephenson).**

1924. *Erythraeodrilus khandalaensis* Stephenson, *Rec. Ind. Mus.* XXVI, p. 350. (Type locality—Khandala, Bombay Presidency. Types in the Indian Museum.)

1925. *Erythraeodrilus khandalaensis*, Stephenson, *Proc. Zool. Soc. London*, 1925, p. 898.

1926. *Hoplochaetella khandalaensis*, Stephenson, *Rec. Ind. Mus.* XXVIII, p. 265.

Material examined.—From the Bombay Natural History Museum: 11 clitellate specimens labelled, "Andheri, Thana district. 10.10.38. C. McCann". 2 acitellate specimens labelled, "Andheri, Salsette Island. 14.8.38. C. McCann.", and 90 juvenile or acitellate specimens labelled, "Andheri, Salsette Island, Thana district. 13.8.38. C. McCann".

External characteristics.—Length 85-155 mm. Diameter 4-6 mm. Pigmentation red, restricted to the dorsum; gradually fading out

posteriorly; ventrum white. Pigment is lacking, invisible or scarcely recognizable on rather indefinite, mid-segmental stripes of irregular outline bearing the setae, the stripes of a segment not continuous mid-dorsally. The prostomium is epilobous, one half to three quarters; a transverse furrow at the posterior margin of tongue probably always lacking, an apparent transverse furrow occasionally visible, and having more the appearance of a fortuitous crease than of a definite furrow. The first dorsal pore is on 4/5 (8), 5/6 (1), or 6/7 (1). Definitely pore-like but apparently non-functional markings are often present anterior to the first definitely functional pore.

Setae begin on ii. A mid-ventral gap may be lacking on ii-iii or even iv, and is small on the remaining pre-clitellar segments as well as on segments just behind the clitellum, never large, usually no greater than 3*ab*. A mid-dorsal gap is usually present throughout (occasionally lacking on ii-iv), larger than the ventral gap and more variable in width. Setal numbers of several clitellate specimens are indicated in the table below. Ventral setae of vii and ix are not usually dislocated although *a* of ix is dislocated anteriorly on one side of one specimen. The ventralmost setae of viii are displaced, usually to positions surrounding the anterior spermathecal pores (8 clitellate specimens), but may be dislocated posteriorly only (1 specimen, with three setae close to each posterior spermathecal pore and no setae around anterior pores) or both anteriorly and posteriorly (2 specimens with one or two setae close to each spermathecal pore). Externally the ventralmost setae of xvii-xix appear to be lacking on clitellate as well as aclitellate specimens and most juvenile worms, but on two of the smallest juveniles there are visible, just median to each male pore, two tiny black dots, each doubtless the tip of a seta. The dots are not at the surface and follicular apertures are unrecognizable under best optical conditions. It appears as if the tip of the seta is covered over by cuticle and a very thin layer of epidermis. Internally (in both juvenile and clitellate specimens) there is on the median face of each prostatic duct, after removal of nephridia and glandular material, a pair of modified setae.

Setal formulae.

ii	iii	viii	xii	xx
32	44	51	56	53
28	47	49	60	50
39	49	53	60	62
40	47	50	57	54
38	48	49	66	52

The clitellum is annular, extending from 12/13 to 16/17 or nearly to, or towards, each of those furrows; intersegmental furrows and dorsal pores lacking, setae present. Thickening of epidermis anteriorly and posteriorly near 12/13 and 16/17 is recognizable at the mid-dorsal incision while it is almost unrecognizable externally.

Quadrithecal, spermathecal pores minute and superficial, pre-setal and post-setal on viii, about equidistant from the setal arc, slightly

nearer the arc than to the intersegmental furrows, in *ac* usually close to *b*. Each pore is located at or near the centre of a small, transversely placed marking of shortly elliptical outline with greyish translucent centre and a slightly raised, opaque, marginal band. Associated with each anterior spermathecal porophore (or as previously indicated) are minute apertures, the combined openings of follicles of copulatory setae and the accompanying stalked glands, the apertures on the centres or rims of the markings or more rarely external to the markings. Spermathecal and gland apertures, always open, are recognizable on juvenile and aclitellate as well as on clitellate specimens. The spermathecal openings can be distinguished from the other pores by the slightly larger size and the absence of a seta or of a black appearance within the parietes due to visibility of tip of seta through transparent tissues.

The single female pore (11) is median and pre-setal, at the centre of a whitened area of circular to short elliptical (and then transversely placed) outline.

Male pores (combined apertures of prostatic ducts, male deferent ducts and penisetal follicles?) are minute and superficial apertures, about on *b* or in *bc* (as of *xx*), always open, even on juveniles, each pore at or near the centre of a transversely placed, greyish, translucent area of short elliptical outline. Even with the best optical conditions further pores are unrecognizable but the epidermis of the porophores is very soft and easily ruptured. Exact location of the areas and pores is impossible, even on the juveniles as intersegmental furrows 17/18-18/19 are unrecognizable mid-ventrally. On some juveniles the pores appear to be quite definitely on sites of the furrows and are at least in line with the furrows when the latter are first visible laterally. On other juveniles the anterior pores appear to be just as definitely on *xvii* though only slightly in front of sites of 17/18. More rarely the posterior pores appear to be on the anterior margin of *xix*. On clitellate specimens each male porophore has a slightly raised, narrow, whitish marginal rim. A median area between setal circles of *xvii* and *xix*, bearing the male porophores is depressed in a regularly concave fashion.

The single genital marking (103 specimens) is median, in the region between the setae of *xix* and *xx*. Intersegmental furrow 19/20 is unrecognizable mid-ventrally on aclitellate and clitellate specimens but when first visible laterally is usually dislocated posteriorly by the genital marking. On the smallest juveniles the furrow is complete mid-ventrally and a rudiment of the genital marking with a distinct opening is definitely segmental and midway between the setae of *xix* and 19/20. On clitellate worms the genital marking is circular or nearly so, with a narrow, whitish and slightly raised, marginal band and a central area that is greyish or brownish, smooth and hard. Just in front of the centre of each marking is a small, transversely placed slit with whitened margins which may be smooth and firm or slightly tumescent, wrinkled and soft.

On nine of the clitellate specimens there is a median region of slight epidermal thickening, extending from 19/20 on to *xxvi*, *xxvii* or *xxviii* and laterally about to *c* on each side anteriorly, gradually narrowed posteriorly. On six of these worms there is a post-setal area of similar

appearance on vii, in cc. On two specimens there are visible, on these latter areas, numbers of dark dots which appear as quite minute pores.

Internal anatomy.—All septa are present, at least from 4/5 posteriorly, 4/5-8/9 funnel-shaped with oesophageal apices directed posteriorly; all septa membranous and transparent or slightly translucent; 9/10 and 11/12 in contact towards the periphery except ventrally with 10/11, the three septa presenting an appearance in the pinned out specimen as of a single muscular septum.

The gizzard is in vi (12). The cuticular lining of the gut is continued at least into vii and is thickened in the gizzard. The inner wall of the oesophagus is provided with low, white, longitudinal ridges; anterior to the gizzard the ridges are thicker while posterior to the gizzard ridges may be irregularly creased, interrupted or modified so as to present the appearance of short and thick villi or even of vertical ridges of variable length. Calciferous glands, four pairs in x-xiii (12), are antero-posteriorly flattened, reniform, with hilus mesially, in the posterior portions of the segments, reaching below the level of the ventral face of the gut but not reaching up to the level of the dorsal face of the gut. Each gland is provided with a rather short, but fairly thick stalk, which passes to the ventral face of the gut at the extreme lateral margin. Ducts open directly into the oesophageal lumen by small, circular pores. The intestine begins in xvi (12), the oesophageal valve at region of attachment of 15/16 or slightly behind. Intestinal caeca (dorsal, lateral or ventral) are lacking. The typhlosole begins rather abruptly in the region of xxiv-xxv (though continuous with a lower ridge that reaches into xvi) and is a low, simple, nearly straight lamella, at first triangular in cross section, decreasing in height posteriorly and unrecognizable behind cviii (in a worm with 122 segments) or in the last 12-16 mm. of worms that are 150 mm. long. There are no supra-intestinal glands.

The dorsal blood vessel (single) is continued on to the pharyngeal bulb. The large supra-oesophageal, not firmly adherent to the gut, is first recognizable just behind 8/9 and terminates in the posterior portion of xiii by dividing into two branches each of which passes latero-ventrally on to the posterior face of a calciferous gland just below the dorsal pole and is then continued nearly to the ventral pole. In each of segments x-xii large branches from the supra-oesophageal pass similarly on to the posterior faces of the calciferous glands. The ventral trunk is continued to the region of the sub-pharyngeal ganglia where it bifurcates, the branches passing laterally. Extra-oesophageal trunks are first recognizable laterally just behind the nephridial masses of ii or iii where they are formed by the union of two vessels from the body wall dorsally. Each trunk is continued postero-ventrally, apparently receiving in the region of iii or iv a single commissure from the ventral vessel and in v a large vessel from the pharyngeal bulb. Anteriorly on 4/5 the trunk passes up to the level of the ventral face of the gizzard from whence it is continued posteriorly at about the same level, giving off in x-xii short vertical branches to the ventral poles of the calciferous glands, turning up in xiii to pass into the ventral pole of the calciferous gland. A small, posterior, latero-parietal vessel, recognizable at least as far back as xxi, passes upwards in the coelomic cavity of xiv and after receiving a com-

missure from the dorsal trunk runs anteriorly to open into the extra-oesophageal just as the latter turns towards the calciferous gland. Commissures in xiv may be dark and red throughout, or white throughout, or dark in a ventral portion and white in a dorsal portion of variable length, each commissure emerging from the dorsal trunk just behind 13/14 and giving off one or two branches to the dorso-lateral aspect of the oesophagus. The thickness of the commissure may be approximately the same throughout or a ventral portion may be slenderer. No sub-neural.

The last pair of hearts is in xiii (12). Commissures of ix are about as large as the hearts of x-xiii, commissures of viii slightly smaller. All commissures or hearts of viii-xiii pass into the ventral trunk. Anterior to viii commissures between dorsal and ventral trunks are lacking or unrecognizable. Dorsally each heart of x-xiii bifurcates, the bifurcations unusually short, the posterior branch passing to the dorsal trunk, the still shorter anterior branch into the calciferous gland vessel of the supra-oesophageal trunk. Blood has been found in all of these bifurcations excepting only in the anterior branch of the heart of x which, accordingly, may not be a vascular tube. Posteriorly in xiv there is usually visible one or a pair of vessels passing from the dorsal trunk to the dorso-lateral aspect of the oesophagus.

Beginning from xv (12) there is in each segment, attached to the dorsal blood vessel and the anterior face of the septum, a transversely placed lymph gland. A median portion of the gland just over the dorsal blood vessel in posterior segments may be thin and translucent, in which case the appearance at first glance is that of a pair of glands. In six specimens the anteriormost gland (in xv) is filled with a brownish granular material closely packed into a fairly tough disc. In one of the worms slight manipulation of the gland was sufficient to rupture the very delicate wall and release the disc. Posteriorly similar brownish material is often present in the glands, usually in two small, discrete, lateral masses. Larger masses of brownish material may be lateral or median, usually only one in each gland.

Mega-nephridia are long loops, reaching in xx and posteriorly nearly to the mid-dorsal line, located on the parietes in the anterior halves of the segments or just behind the septa, the small pre-septal funnels close to the ventral parietes in the region of *ad*, the slender pre-septal neck regions rather long. Smaller and perhaps modified mega-nephridia are usually present in xiv-xix, the size increasing posteriorly, but are occasionally unrecognizable. On the anterior faces of 4/5 and 5/6 there are fairly large, paired, vertically placed clusters of micro-nephridial tubules. Ducts of the posterior clusters have not been traced beyond the parietes ventrally in v. In ii and iii or iii and iv there are paired transversely placed bands of closely crowded tubules on the parietes, the bands similar to those of species of *Eutyphoeus* though the tubules here are not so closely crowded. From iv or v to a post-prostatic region the parietal micro-nephridia are small, numerous, and rather uniformly distributed. In aclitellate worms the integument is visible but in clitellate specimens the tubules are thickened and slightly elongated and practically cover the coelomic face of the body wall. Posteriorly the tubules are also numerous but less uniformly distributed, in some

specimens at least more numerous and closely crowded dorsally. A definite arrangement appears to be lacking though there seems to be a tendency for the tubules to be attached in three or four transverse rows in each segment.

Coelomic cavities of x and xi are reduced by approximation and (except ventrally) peripheral fusion of septa to form a sort of testis sac which is usually filled with coagulum. Paired seminal vesicles are present in ix, x, and xii (10), the smaller, middle vesicles attached to the anterior face of 10/11, one of the vesicles of ix lacking in two specimens. Prostates are tubular and may reach as far back as xxxv. The glands are tubular, looped back and forth in a regularly zigzagged fashion, the lumen small and slit-like in transverse section. In juvenile worms the prostates are confined to xvii and xix but are also looped. An ental portion of the duct, 3-4 mm. (anterior prostates) or 5-6 mm. long (posterior prostates), is slender. In xvii and xix the ducts are thickened to form spindle-shaped, muscular bulbs with marked sheen, each bulb *ca.* 2 mm. long, the lumen in the bulb relatively very small and circular in transverse section. Within the body wall the duct is again slender and is imbedded in adherent glandular (?) material. On the posterior face of each anterior duct and the anterior face of each posterior duct, close to the ectal end of the spindle-shaped enlargement and within the parietes or covered over by glandular material, is a thick-walled, almost spheroidal muscular bulb. The male deferent ducts have not been traced throughout; posteriorly they are covered over by diagonal muscle fibres, nephridia and glandular material. Both ducts of a side pass lateral to the anterior prostatic ducts and, so far as can be determined, into xviii. Apparently one duct then turns forward to pass into the posterior face of the muscular bulb on the posterior face of the prostatic duct, the other deferent duct passing into the anterior face of the corresponding bulb on the posterior prostatic duct, the muscular bulbs probably ejaculatory and in the nature of local thickenings of the vasa deferentia. (Deferent ducts were broken, each time, in attempting to remove the glandular material in which they are imbedded. In one of the clitellate worms deferent ducts are characterized by a marked iridescence. From xviii, where the rupture usually occurs in the dissection, similar iridescent tubes pass anteriorly or posteriorly into the ejaculatory bulbs on the prostatic ducts. In a juvenile worm deferent ducts of both sides were traced from the posterior ejaculatory bulbs anteriorly into xvi, but the other duct was broken on each side though a short piece still remained continuous with the bulb.

Protuberant into the coelomic cavities just median to the ectal ends of the prostatic ducts, on each side, is a longitudinal row of three glandular bodies, one each in xvii-xix, those of xviii often much larger than the others (coelomic portion 3 mm. long). Each of these bodies is soft, the lumen filled with a loose coagulum, the three of a side apparently continuous with each other within or close to the parietes.

The spermathecal duct is shorter than the ampulla, circular in cross section, with muscular sheen, quite slender ectally, gradually widened entally and especially so near the ampulla from which it is clearly distinguished though not always obviously, as an ectal portion of the ampulla may be bound down around an ental part of the duct. Slightly

ectal to the ampulla and on the thickest portion of the duct there is a circle of 8-17 diverticula. Each diverticulum is usually elongate but sinuous in a rather zigzagged fashion, bound to the duct with the distal end ventrally. A major portion of each diverticulum is characterized by a spermatozoal iridescence that is lacking in a very slightly narrower proximal portion which might be regarded as a stalk. The connective tissue which binds the diverticula to the duct may conceal the stalk portions from view so that there is visible at first glance only a circle of small, apparently ovoidal to shortly ellipsoidal seminal chambers but the tissue can be dissected off without especial difficulty. In addition to these longer diverticula there may be two or three shortly ellipsoidal seminal chambers with stalks confined to the tissues of the spermathecal duct, or a diverticulum may be bifid distally. Thus one spermatheca has eight diverticula of which one is bifid and two are sessile seminal chambers. The lumen of the duct (relative to the thickness of the wall) is small, even in the thicker ental portion and is circular to slit-like in transverse section. A fairly large ball of densely packed spermatozoa may be present in an ectal portion of the ampulla, seated on the aperture into the duct, and smaller, softer masses of spermatozoa in shape similar to that of the diverticula may be present just beneath the ball. Occasionally the lumen of the thick ental portion of the duct is filled with spermatozoa and in this case the lumen is enlarged and irregular rather than slit-like.

Between the two spermathecae of a side there is a cluster of glands, usually enclosed in a single coelomic sac. Each gland is 3-5 mm. long, elliptical in cross section with (relatively) very small and eccentric lumen, transversely slit-like to circular in section. From each gland a slender duct 1-2 mm. long and with marked (muscular?) sheen passes into the parietes. On the anterior face of the stalk of each gland, within the parietes and opening into the duct is a shortly ellipsoidal to ovoidal, thick-walled (muscular) follicle, containing a single copulatory seta. The ental end of a follicle is just visible above the parietes. Behind each posterior spermatheca there is usually on the ventral parietes a mass of tissue that appears to be the wall of a small, collapsed, coelomic sac (*cf.* sacs of vii in *suctoria*).

On the median face of each prostatic duct and within the parietes, hence visible only after removal of the glandular material, there are two penial setae imbedded in a muscular (?) mass. It is not clear from the preparations that have been made whether there are two follicles each containing a single seta or one follicle containing two setae.

The sausage-shaped gland of the median genital marking is 12-13 mm. long, reaching as far back as xxviii when not bent anteriorly or curled up around the gut, and is nearly 2 mm. in diameter. A soft outer layer can be easily scraped off revealing a tough-walled (muscular?) capsule about 0.5 mm. in diameter, very slightly widened at extreme ental end, with central lumen slit-like in transverse section. There is no stalk or duct. Occasionally a gland can be pulled out from the parietes without rupture and in this case only a portion of the genital marking surrounding the aperture is removed from the epidermis.

On the posterior face of 13/14 there is usually present a pair of small vesicles presumably the same as those which Stephenson referred to

as ovisacs. The vesicles usually contain one or more aggregates of brown granules. An ordinary sigmoid seta is included in one of these masses of brown granules. The function of the organs is unknown but is possibly more like that of the pseudovesicles in certain species of *Pheretima*, than of an ovisac.

Remarks.—An aclitellate specimen, with a reddish discolouration of the clitellar segments and brilliant spermatozoal iridescence on the male funnels but no iridescence in the seminal chambers of the spermathecae is probably post-sexual.

Even with best optical conditions nephropores are unrecognizable.

Absence of mega-nephridia in xiv-xix of certain specimens may be the result of maceration.

Types of *khandalaensis* are not fully sexual, clitellum “hardly distinguishable” and with spermathecal ducts of the same length as the ampullae (a condition characterizing most aclitellate and juvenile specimens from Andheri).

Diagnosis.—Male pores on or close to sites of 17/18 and 18/19 about in *bc*, at or near centres of paired, transversely placed, translucent areas of shortly elliptical outline all of which are within a median depression reaching antero-posteriorly to levels of setal circles of xvii and xix. Spermathecal pores on viii, in *ac*, about equal distances before and behind the setal circle and slightly nearer the circle than to intersegmental furrows. Genital marking post-setal on xix but dislocating 19/20 posteriorly, with single slit-like pore (occasionally an extra marking on xvi). Setae: 28-40/ii, 44-49/iii, 49-53/viii, 56-66/xii, 50-62/xx, viii/0, xvii-xix/0; ventralmost setae of viii dislocated, usually anteriorly and in circles around spermathecal pores. Pigmentation red. Length 85-155 mm. Diameter 4-6 mm.

Gizzard in vi. Last hearts in xiii. Unpaired lymph glands from xv posteriorly. Testis sacs formed by peripheral fusion of septa 9/10-11/12. Seminal vesicles present in x. Vasa deferentia just prior to junctions with prostatic ducts enlarged to form spheroidal, ejaculatory bulbs. Parietal glands, in xvii-xix, three on each side, just median to the prostatic ducts. Genital marking gland tubular, sausage-shaped, 12-13 mm. long. Spermathecal diverticula ventrally directed, elongate and sinuous, occasionally bifid, 8-17 in a single circle. Copulatory setae ornamented; glands long, in two coelomic sacs in viii.

Distribution.—Bombay, Andheri, Lonavla, Khandala in the Bombay Presidency.

Forma **dichordarius** (Stephenson).

1924. *Erythraeodrilus khandalaensis* f. *dichordarius*, Stephenson, *Rec. Ind. Mus.* XXVI, p. 352.

1925. *Hoplochetella khandalaensis* f. *dichordarius*, Stephenson, *Rec. Ind. Mus.* XXVIII, p. 265.

Material examined.—From the Bombay Natural History Museum: 4 juvenile specimens labelled, “Andheri, Salsette Island, Thana district. 13.8.38. C. McCann”.

External characteristics.—Each of these worms has an additional genital marking, post-setal on xvi and midway between the setal circle and 16/17, the marking similar to that on xix. Combined apertures of copulatory setal follicles and stalked glands are around the anterior spermathecal pores only.

The anterior genital marking gland (sausage-shaped) is not quite as well developed as the posterior. Both glands are short.

Remarks.—Except as noted above the external characteristics and internal anatomy are the same as in juvenile specimens of the typical forms.

In addition to the specimens mentioned above, another worm from the same tube has an anterior, median genital marking but lacks the posterior marking.

Distribution.—Bombay, Andheri, and Mahableshwar in the Bombay Presidency.

Hoplochaetella mullani (Stephenson).

1924. *Erythraeodrilus mullani* Stephenson, *Rec. Ind. Mus.* XXVI, p. 348. (Type locality—Matheran, Bombay Presidency. Types in the Indian Museum.)

1926. *Hoplochaetella mullani*, Stephenson, *Rec. Ind. Mus.* XXVIII, p. 265.

Material examined.—From the Indian Museum: 7 clitellate (1 dissected) specimens labelled, "*Erythraeodrilus mullani* Stephenson. Types. Matheran near Bombay. Oct. 1921. Prof. J. P. Mullan. W 1136/1."

External characteristics.—Spermathecal pores are minute and superficial, in *ac*, probably on or close to *b*, each pore in the setal circle, at or near the centre of a rather indistinctly demarcated, transversely placed area of slight epidermal tumescence. The ventral setae of viii and ix are arranged in more or less regular circles around the spermathecal pores, the pore slightly nearer the two or three median setae of the circle than to the lateral setae. One or two additional setae may be more or less markedly displaced, the follicle aperture of each of these dislocated setae in a small, tumescence of circular outline.

Dislocated Setae.

Specimen.	On spermathecal porophores.		On individual, circular porophores.	Location of genital marking.	REMARKS.
	viii	ix			
1	2-4	4-3	<i>e-f</i> left side and <i>d-e</i> right side of ix anteriorly.	Presetal on xviii, left side.	Type.
2	5-4	5-5	<i>a</i> right side of viii, and both sides of ix anteriorly.	Presetal on xix, left side.	Complete dissection.
3	4-5	5-5	<i>f</i> right side of ix anteriorly.	Presetal on xix, left side.	
4'	5-5	5-5	<i>f</i> left side of viii posteriorly, <i>f</i> both sides of ix anteriorly.	Presetal on xix, left side.	Opened.
5	4-5	4-5	<i>f</i> right side of ix anteriorly.	Presetal on xix, left side.	
6	5-5	5-5	<i>f</i> both sides of ix anteriorly.	On 18/19 (?) left side.	
7	5 ^a -5	4-5	<i>e</i> left side and <i>f</i> right side of ix anteriorly.	Postsetal on xvii, right side.	

(1) On this specimen there are two apertures of copulatory setal follicles in which no setae are visible the spermathecal pores not certainly distinguishable from the follicle apertures on the left anterior spermathecal porophore. This is the first time that follicle apertures have been noted with no setae therein. Associated with this porophore there are five copulatory setal glands internally. The setae must be unusually deeply retracted or discharged.

(2) The first number of each couple in the second and third columns is of the left side.

The clitellum is annular.

Male porophores are paired as usual, each porophore small, circular or almost so in outline, depressed. The two porophores of a segment (and also a genital marking) may be contained within a common shallower depression or all four porophores as well as the genital marking may be included within a single shallow depression. In either case the porophores of a segment are separated from each other by a longitudinal median ridge. Male pores, clearly visible, are at or near the centres of the porophores. Additional pores have not been found. Ventral setae are lacking on xvii and xix, two to four (rarely six ?) setae present ventrally on xviii between the male pore lines.

Genital marking locations are shown in the table above. At the centre of each marking is a tiny, slit-like aperture, the margins of the aperture in contact so that traction on the skin is necessary to see the pore. One unusually large genital marking has a narrow opaque raised rim, a translucent, slightly depressed central portion, the margin of the aperture slightly tumescent, opaque and white. The genital marking may be in contact with a porophore but is never located on a porophore.

Internal anatomy.—The gizzard is in vi (2). The intestine begins in xvi (2). The typhlosole begins rather gradually in xxii (1), is continued anteriorly for a short distance as a very low ridge, triangular in cross section for a short distance, then lamelliform, decreasing gradually in height posteriorly, in a terminal region very low, apparently interrupted at the septal constrictions, unrecognizable behind cxiv (a specimen with 132 segments).

The circulatory system is as in *khandalaensis*, with latero-oesophageal hearts in x-xiii, commissures of xiv joining a latero-parietal vessel and then uniting with the extra-oesophageal just prior to passage on to the posterior calciferous glands, no subneural trunk. Lymph glands, unpaired are present (2) in xv and in the posteriormost portion but are unrecognizable elsewhere, the gland in xv of each specimen distended by brownish material.

Nephridia as usual, with vertically placed clusters on the anterior faces of 4/5 and 5/6, and on the parietes in ii-iii. Mega-nephridia behind xx have masses of the coelomic corpuscles on the preseptal necks immediately behind the funnels, but secondary funnels or funnel-like structures are unrecognizable.

Rudimentary seminal vesicles are present in x (1). Both vasa deferentia of a side pass into xviii lateral to the anterior prostatic duct, one continuing straight on into xix, the other turning on itself to pass anteriorly into xvii. A terminal portion of each duct is enlarged into an ovoidal ejaculatory bulb with a muscular sheen, adherent on the ectalmost portion of the spindle-shaped muscular region of the prostatic duct (the remainder of the prostatic duct ectally much slenderer, of a dull white appearance without sheen). On the median face of each prostatic duct and conspicuously protuberant into the coelomic cavity (3 specimens) there is a single parietal gland, usually somewhat collar-shaped and reaching around to the anterior and posterior faces of the duct. The gland appears to be solid but when broken off close to the parietes a circular aperture is seen just antero-median to the

prostatic duct. Penial setae are present in both xvii and xix in at least two follicles, one on the median face of the prostatic duct and one within glandular material. A penial seta from the follicle on the median face of a prostatic duct of xix is 0.28 mm. long, nearly straight, the tip flat on one side, convex on the other side and ornamented with several transversely placed, serrate ridges.

The genital marking gland is sausage-shaped, 5-6 mm. long, about 1 mm. thick. An outer layer of soft material, more than two-thirds of the thickness of the gland, is easily scraped away revealing a slender rod-like capsule of dull, opaque appearance. The lumen is transversely slit-like in section, small, extending almost to the ental end of the gland.

The anterior spermathecae are in vi, the posterior in ix (2). The spermathecal ampulla apparently is not bound down around the ental end of the duct, the interior of the ampulla and of the thickened portion of the duct filled with a sticky material that is very difficult to remove. The lumen in the ental portion of the duct is large, elliptical in cross section. In the thin, ectal portion of the duct an outer layer is dull white, a middle layer with brilliant (muscular?) sheen. Iridescent sperm masses are in ellipsoidal seminal chambers of various sizes, ventrally directed. There are always two groups of seminal chambers, the number of chambers in a group varying from two to six. The number of apertures opening into the spermatheca is less than the number of the seminal chambers, but the exact number of openings was not determined. In each of four spermathecae there are at least three openings. On each of the four spermathecae, in addition to the two groups of seminal chambers there is a single, isolated chamber.

Copulatory setal glands are contained in two pairs of coelomic sacs, in viii and ix. The glands are tubular, the lumen very small, the ducts much slenderer, short and almost confined to the parietes, the glands, *ca.* 1½ mm. long. On the median face of each gland stalk and rather conspicuously protuberant above the parietes there is a follicle of a copulatory seta. The setae are ornamented.

Diagnosis.—Male pores in line with setal circles of xvii and xix, at or near centres of rather closely paired porophores. Spermathecal pores in *ac*, usually on or close to *b*, in setal circles of viii and ix. Genital marking asymmetrically placed, pre-setal on xvii, xviii or xix, centre on or lateral to male pore lines, with tiny, central, slit-like aperture. Setae: 70/v, 77/x, 76/xii, 61/xix, xvii/0, xviii/2-4 (+?), xix/0; *a-d*, *e*, or *f* of each side of viii-ix in a more or less regular circle around each spermathecal pore or in discrete porophores. Pigmentation red? Length 110-120 mm. Diameter 7 mm.

Gizzard in vi. Last hearts in xiii. Unpaired lymph glands present from xv (?) posteriorly. Septa 9/10-11/12 united peripherally to form unpaired testis sacs. Seminal vesicles of x rudimentary. Vasa deferentia just prior to junctions with prostatic ducts enlarged to form ovoidal ejaculatory bulbs. Parietal glands half-collar-shaped, one on the median face of each prostatic duct. Genital marking gland tubular, sausage-shaped, 5-6 mm. long. Spermathecal diverticula two (?) groups of ventrally directed ellipsoidal seminal chambers and one (or more?)

isolated seminal chamber (s). Copulatory setae ornamented; glands short, in paired coelomic sacs in viii and ix.

Distribution.—Matheran, and Lonavla in the Bombay Presidency.

Hoplochaetella powelli (Stephenson).

1925. *Erythraeodrilus powelli* Stephenson, *Proc. Zool. Soc. London*, 1925, p. 898. (Type locality—Bombay. Types in British Museum.)

Material examined.—From the Bombay Natural History Society; 2 clitellate specimens labelled, "Panchgani, Satara district. September 1939, C. McCann."

External characteristics.—Length 102-108 mm. Diameter 6 mm. A slight pigmentation of brownish appearance (alcoholic preservation) is recognizable on the dorsum behind the clitellum. The prostomium is epilobous, *ca.* $\frac{1}{2}$, with no transverse furrow at the posterior end of the tongue. The first dorsal pore is on 4/5 (2) but one specimen has a pore-like, though apparently non-functional marking on 3/4. The clitellum is annular and extends from the setae of xiii to or nearly to 16/17; intersegmental furrows lacking, sites of dorsal pores indicated by slight depressions, setae present.

Setae begin on ii and are lacking ventrally on xvii and xix, probably also on xviii. On viii, setae *a-c* or *d* are dislocated anteriorly into arc-shaped rows (with concave sides anteriorly) behind the anterior spermathecal pores.

Spermathecal pores are minute and superficial, in *bc*, on viii, the posterior pores midway between 8/9 and the post-setal secondary furrow, the other pores slightly more anterior to the setal circle than the posterior pores are from 8/9. Each pore is at the centre of a rather indefinite transversely placed area of tumescence.

The single female pore is median and presetal (2).

The male pores are probably in or close to *cd*, each pore more or less on the site of an intersegmental furrow (17/18-18/19 not recognizable ventrally), at or close to the centre of a transversely placed, slightly depressed, opaque, white area of shortly elliptical outline. Removal of cuticle from the male genital area leaving the surfaces of the porophores in perfect condition, was possible on one specimen. No apertures, aside from the male pores, are recognizable. A ventral region surrounding the male porophores is characterized by a slight brownish discolouration.

Genital markings are paired, each marking transversely placed, of shortly elliptical outline¹. A central aperture, slightly larger than the male pores, appears to be on or close to the site of an intersegmental furrow and is within a flat, slightly depressed area which is surrounded by a thick, raised, marginal band. The markings are five to six inter-setal intervals wide, and the centres are usually lateral to the male pore lines. One specimen has three pairs of markings on 19/20-21/22, more closely paired posteriorly, the median margins of the posteriormost markings more or less on *a*. A single marking on 16/17 is asymmetrical

¹ Stephenson (1926, p. 265) mentions presence of paired genital markings on xviii, as well as asymmetrical markings on the same segments. Worms with these markings should be re-examined, as well as those with markings in the setal circles.

and with centre slightly to right of the midventral line. The other worm has paired markings on 19/20-20/21 and a single, symmetrically placed marking on 16/17 but the latter has two apertures which are median to the male pore lines.

Internal-anatomy.—The gizzard is in vi (2). The intestine begins in xvi (2). The typhlosole is simple, lamelliform and terminates about 8 mm. from the hind end, interrupted in the last four segments.

The last pair of hearts is in xiii (2). The circulatory system, so far as can be determined, is like that of *khandalaensis*. In xv there is a large, transversely placed, lymph gland (2) but further glands are not recognizable except in the posteriormost portion of the body.

The excretory organs are, so far as can be determined, as in *khandalaensis*. Mega-nephridia, however, have not been definitely identified anterior to xx or xxi.

Coelomic cavities of x and xi are reduced to testis sacs by approximation and peripheral apposition of septa 9/10-11/12. Seminal vesicles of ix and xii are large. None were found in x. Male deferent ducts have been traced into xviii where one turns anteriorly, the other continuing into xix. Just in front of each posterior prostatic duct and behind each anterior duct there is a translucent mass which is probably the gelatinized remnant of a rather spheroidal muscular enlargement of the terminal portion of a male deferent duct. In xvii-xix on the parietes on each side there is a longitudinally placed whitish mass into the anterior and posterior portions of which the prostatic ducts pass. In xviii a sausage-shaped protuberance from the mass is especially conspicuous, with shorter protuberances in xvii and xix, one just median to each prostatic duct. The posterior portions of the male deferent ducts and the penial setae are buried within the glandular mass.

Two or three penial setae are present just median to each prostatic duct but the number of follicles was not determined. The setal shafts are almost straight, or with a very slight curvature to one side at the extreme ental end, 0.33-0.37 mm. long, 0.015-0.020 mm. thick at a rather nodule-like region about midway between the ectal and ental ends. The tip may be bluntly rounded (worn) or pointed, one side convex, the opposite side flat or very slightly hollowed. Ornamentation is of a few, transversely placed, short rows of fine teeth.

Genital marking glands, are short sausage-shaped, 1.2-1.5 mm. long. The lumen is central and as in *khandalaensis* an outer glandular (?) layer comes easily away from a tough digitiform capsule. In the worm with a symmetrically placed genital marking on 16/17 there is a gland corresponding to each aperture.

The spermathecal ampulla is bound down around the ental end of the much shorter duct. The lumen in the widened ental portion of the duct is transversely slit-like in section. The diverticula are ectally directed, rather digitiform but sinuous, bound down to the duct, occasionally bifurcated or even trifid, closely crowded into a single circle, interrupted once, usually on the posterior face of the duct.

The copulatory setal glands, in paired coelomic sacs, are about 2 mm. long, approximately 0.5 mm. of the duct coelomic. The setal follicles are small, latero-mesially flattened, only slightly protuberant

above the parietes on the anterior faces of the gland ducts. Copulatory setae are 0.57-0.61 mm. long, the shafts nearly straight, except for slight arching of the entalmost portion. The tip may be bluntly rounded (worn ?) or sharp with one side convex and the opposite side flat or very slightly concave. Ornamentation consists of short transverse rows of fine teeth.

Posterior to the clitellum and in the body wall at the mid-dorsal line there is a conspicuous, red stripe.

Remarks.—Although these worms at first appeared to be well preserved the internal organs are so macerated that recognition of an anterior portion of the typhlosole, the anteriormost meganephridia and seminal vesicles of x is impossible. Accurate setal counts are also impossible. The muscular portions of the prostatic ducts are reduced to a yellowish slime, a spheroidal mass of somewhat similar appearance associated with each prostatic duct and imbedded in the opaque glandular mass of xvii-xix almost certainly indicating presence of muscular thickenings of the male deferent ducts. Curiously, non-muscular portions of the prostatic ducts are fairly well preserved.

H. powelli has been known hitherto only from the original account of a series of eight specimens which have not been available for study. The genital markings and their glands are like those of the Panchgani worms but in the type series there is only a single pair of markings constantly located on 19/20. Further differences from the present worms are : intestinal origin in xv, and the slightly smaller number of anteriorly displaced setae on viii. The latter does not appear to be of importance at present and the more anterior intestinal origin, in view of the uniformity elsewhere throughout the genus and the possibility of a mistake in determination, certainly requires confirmation. Further comparison between the present worms and the types is impossible because of gaps in our knowledge of the latter : nothing is known of the circulatory system except that the last hearts are in xiii, male deferent ducts were not traced to junction with the prostatic ducts, lymph glands and penial setae were not mentioned and copulatory setae were not examined. In these circumstances identification of the Panchgani specimens as *powelli* must be regarded as more or less tentative.

Diagnosis.—Male pores on or close to sites of 17/18 and 18/19, in region of *bd*, each pore at or near centre of a transversely placed, depressed porophore of shortly elliptical outline. Spermathecal pores on viii, in or near *bc*, slightly anterior to the setal circle and to 8/9. Genital markings paired, on (16/17) 19/20 (20/21-21/22), each with central aperture on or close to site of intersegmental furrow and on or lateral to male pore lines (except on 16/17). Setae : 42/v, 50/ix, 52/xii, 48/xx, xvii/0, xviii/?, xix/0, some or all of *a-c*, or *d* of viii dislocated anteriorly. Pigmentation red ? Length 102-120 mm. Diameter 5-6 mm.

Gizzard in vi. Intestine begins in xvi ? Last hearts in xiii. Lymph glands, unpaired, from xv posteriorly ? Testis sacs formed by peripheral fusion of septa 9/10-11/12. (Seminal vesicles of x rudimentary ?). Vasa deferentia just prior to junctions with prostatic ducts enlarged to form spheroidal ejaculatory bulbs. Parietal glands in xvii-xix as in *khandalaensis* ? Genital marking glands sausage-shaped, 1-2½ mm.

long. Spermathecal diverticula ventrally directed, elongate and sinuous, occasionally bi- or trifid, 10-12, in a circle with one hiatus. Copulatory setae ornamented, glands short, in two coelomic sacs in viii.

Distribution.—Bombay, Panchgani, (Satara district), in the Bombay Presidency.

Hoplochaetella stuarti (Bourne).

1886. *Perichaeta stuarti* Bourne, *Proc. Zool. Soc. London*, 1886, p. 667. (No types. Type locality—Yercaud, South India, at elevations of about 5,000 feet.)
 1889. *Perichaeta stuarti*, Bourne, *Journ. As. Soc. Bengal* LVIII, p. 110. (Salem record in previous paper mistaken.)
 1890. *Hoplochaeta stuarti*, Beddard, *Proc. Zool. Soc. London*, 1890, p. 57.
 1895. *Perichaeta stuarti*, Beddard, *Monog.* p. 368.
 1900. *Hoplochaetella stuarti*, Michaelsen, *Das Tierreich* X, p. 322.
 1903. *Hoplochaetella Stuarti*, Michaelsen, *Die geogr. Verbr. Olig.* Berlin, p. 108.
 1909. *Hoplochaetella stuarti*, Michaelsen, *Mem. Ind. Mus.* I. p. 111.
 1910. *Hoplochaetella stuarti*, Michaelsen, *Abh. Nat. Ver. Hamburg* XIX, (5), p. 12.
 1917. *Hoplochaetella stuarti*, Stephenson, *Rec. Ind. Mus.* XIII, p. 354.
 1921. *Hoplochaetella stuarti*, Michaelsen, *Mitt. Mus. Hamburg* XXXVIII, p. 34.
 1923. *Hoplochaetella stuarti*, Stephenson, *Oligochaeta*, in *F. B. I.*, p. 468.
 1925. *Hoplochaetella stuarti*, Michaelsen, *Zool. Jahrb. Syst.* LI, p. 305.

Material examined.—From Prof. C. R. Narayan Rao; 5 softened, clitellate specimens labelled, "Nandydroog, S. I."

External characteristics.—Length: 115, 118, 125 and 127 mm. Diameter, 4-5 mm. Prostomium epilobous but without transverse furrow at posterior end of tongue. Pigmentation unrecognizable, possibly leached out by preservative. The clitellum is dark red.

Setae begin on ii and are small, often definitely paired dorsally. Mid-dorsal gaps in the setal circles are usually larger than the mid-ventral gaps. Setal formulae are shown below. Setae are lacking mid-ventrally on xvii and xix between the male porophores, but are all present mid-ventrally on xviii. Setae *a* and *b* of vii-ix are usually present in normal positions but *c*, *d*, *e*, and occasionally *f* and *g* of vii-viii are displaced.

Setae.

ii	iii	viii	xii	xx	vii	viii	xviii
28	35	43	51	48	3	4	7
22	35	44	52	53	3	4	7
..	..	37	46	46	4	4	10
24	35	40	51	50	4	4	7
25	35	45	49	56	4	4	9

The first dorsal pore is on 3/4 (1), or 4/5 (4), but with a pore-like though apparently non-functional marking on 3/4 on two of the specimens.

The clitellum is annular and extends from just behind the setae of xiii to 16/17 or nearly to 16/17; intersegmental furrows and dorsal pores lacking, setae present.

Quadrithecal, spermathecal pores minute and superficial, post-setal on vii and viii, about in *df*. Each spermathecal pore is at or near the centre of an indistinctly demarcated, very slightly tumescent area of slight epidermal modification, the outline approximating to shortly

elliptical (transversely placed). The anterior margins of the porophores are at or very close to the setal circles while the posterior margins do not reach to the posterior intersegmental furrows. Accordingly the spermathecal pores are nearer to the setae than the furrows. On four specimens the displaced setae of vii and viii are posterior to the setal circle and in the neighbourhood of the spermathecal pores. On one of these worms four setae on the left side of ix are displaced; *b* and *c* anteriorly, *d* and *e* posteriorly. On the fifth worm a single seta on the right side of viii (*c* ?) is displaced anteriorly, the other displaced setae are behind the setal circle. Each anteriorly displaced seta is at the centre of a tiny tubercle of circular outline. The spermathecal apertures are a trifle larger than the other openings and more conspicuous, having a very slightly swollen and whitish marginal rim. Other apertures may be close to the spermathecal pores and on the spermathecal porophores or, rarely, one may be more distant and on its own area of slight epidermal modification.

The female pore is median and pre-setal (5).

Male pores, two pairs on xvii and xix in line with the setae of their segments and in *ce* or *f*, are minute, each pore at or near the centre of a translucent area of epidermal modification. Each of these porophores is rather deeply retracted into the parietes, producing an appearance as of an invagination with a fairly large and rather squarish aperture more or less in the region of *cg*. On one specimen the median and lateral margins of each anterior depression are nearly in contact with each other so as to produce the appearance of a secondary male aperture that is longitudinally slit-like. The male pores are open, short, and transversely elliptical in shape. With the best optical conditions there are visible on the porophores still smaller and circular markings which appear to be pores. Traction on the margins of the depressions or on the porophores themselves is necessary in order to recognize the pores and yet even slight traction ruptures the soft tissues of the porophores. On one worm pores are quite unrecognizable, the number of pores on the other specimens apparently variable as indicated below, the pores usually posterior to the male openings, occasionally antero-median. (Locations of male pores, as well as of spermathecal apertures, as determined externally, have been confirmed by dissecting prostatic and spermathecal ducts out of the parietes from the coelomic side.)

Gland pores on male porophores.

xvii.		xix.	
Left.	Right.	Left.	Right.
2	3	1	3
2	3	2	3
1	1	1	1
3	3	2	2

On re-examining these worms a year or so later these pores are unrecognizable. The epidermis of the porophores in most of the specimens has however been damaged.

Genital markings are lacking.

Internal anatomy.—Some of the septa anterior to 8/9 are either lacking, or rudimentary and represented only by slight shreds or cords, or else so fragile and macerated that they were destroyed in the course of opening and pinning out the specimens.

The gizzard probably belongs to segment vii or vi, the exact location not being determinable as a result of the softening and destruction of septa anterior to 8/9. Calciferous glands are four pairs in x-xiii (5), attached by short stalks to the oesophagus ventro-laterally. Glands may all be of about the same size or those in xii may be larger than the others, or the glands may decrease slightly in size from xiii anteriorly. The intestine begins in xvi (5). Dorso-laterally on the gut in the region of the posterior prostate, in each of three segments there is a pair of small, thin-walled caeca flattened against the intestine. The prostates are adherent to the gut in this region, the intestinal wall is considerably macerated, and the septa are so fragile that it has not been possible to locate the caeca segmentally. A fairly large typhlosole is present, beginning one or two segments in front of the anteriormost caeca.

The last pair of hearts is in xiii (5). Anterior to 8/9 four pairs of vessels are given off from the dorsal trunk but only the pair belonging to viii can be traced to the ventral vessel. Lymph glands have not been found even in the posteriormost segments.

Parietal micro-nephridia are unrecognizable behind xx, probably as a result of the maceration, and are only doubtfully recognizable in some of the pre-clitellar segments. Mega-nephridia, though also somewhat macerated, are quite obviously present from xx posteriorly, reaching on either side almost to the mid-dorsal line.

Male funnels are characterized by a brilliant spermatozoal iridescence. Testis sacs? Seminal vesicles are three pairs in ix, x and xii, the vesicles in x attached to the anterior face of 10/11 (5). The prostatic ducts are 5-9 mm. long, the ental portion of each duct slender and occasionally looped in a fairly regularly zigzagged fashion with the limbs of the loops short and in contact with each other. Ectally the duct is thickened and spindle-shaped, with a marked muscular sheen. The male deferent ducts of a side pass posteriorly in contact with each other but without uniting. From xvii the ducts are at least in part concealed from view by diagonal muscles, nephridia, blood vessels, etc., but this covering tissue, perhaps as a result of the maceration, can be removed more successfully than in *H. khandalaensis*. Both ducts of a side are lateral to the prostatic ducts of xvii and pass into xviii. Here one duct turns abruptly on itself and passes forwards into the posterior face of the anterior prostatic duct without enlargement. The other deferent duct may be looped in a rather regular fashion in xviii and xix and passes into the anterior face of the posterior prostatic duct, also without muscular enlargement. Four prostatic ducts were removed from the body wall, and after removal of connective and glandular tissue were cleared and examined microscopically to trace the course of the deferent ducts. Two of these preparations were successful. The vas deferens after penetrating the muscular wall of prostatic duct, turns ventrally for a short distance before opening into the lumen of the duct.

The ectalmost portion of the duct is lined with cuticle which appears to be thicker than the external cuticular layer and breaks off from the outer cuticle so as to leave a thickened rim at the end of the duct. The cuticular lining of the duct with this rim has a test-tube-like shape.

Protuberant rather conspicuously into the coelomic cavities of xvii and xix immediately lateral and median to each prostatic duct is a rather ovoidal, soft, thin-walled gland. Stalks are unrecognizable and the glands could not be traced through the parietes. Only slight manipulation is necessary to rupture the glands releasing from a fairly large lumen, white, loosely flocculent material. Presumably these glands open to the exterior through the male porophores by the pores mentioned above. Glands in xviii, as in *khandalaensis*, are lacking but the body wall of xviii is modified mid-ventrally.

On the median face of each prostatic duct and within the body wall are two or three setae, probably in two distinct follicles. These setae are 0.22-0.34 mm. long, slender and straight. Setae of xvii are rounded at the tips and without ornamentation, setae of xix with tips slightly hollowed out to produce a rather spoon-like concavity but without further ornamentation.

The spermathecal duct is nearly as long as or longer than the thin-walled ampulla from which it is clearly distinguished although this may not be immediately externally slender in the parietes, gradually widened entally and in the region of the diverticular junctions nearly as wide as the ampulla, with a marked muscular sheen, even in the slender ental portion. The lumen is wide in the region of the diverticular junctions and shortly elliptical to almost circular in section or somewhat irregular, slightly narrowed entally, gradually narrowed still further ectally and becoming slit-like in transverse section. The diverticula form a completely annular band about 1 mm. wide around the duct just below the ampulla. At first glance this band appears to consist of two circles of rather finger-shaped diverticula, an ental circle with the diverticula directed towards the ampulla, and an ectal circle with the diverticula directed ventrally, the components of both circles bound to the duct by delicate connective tissue. On scraping away the diverticula a single circle of apertures through the duct into the lumen becomes visible, the circle containing 15-22 openings. (The size of these openings varies and some of the smallest openings may have been missed out.) Considering the structure opening into the interior of the duct through one of these apertures as a single diverticulum it may then be described as follows: doubly glove-shaped with one group of irregularly and shortly digitiform seminal chambers (3-4) reaching upwards along the duct and another group of similar but usually very slightly longer chambers reaching downwards along the duct, both groups opening into the duct lumen by a common stalk. The seminal chambers are characterized by a brilliant spermatozoal iridescence which is lacking or markedly diminished proximally.

Associated with each spermatheca is a group of short-stalked, tubular glands, the stalks quite slender but with a marked muscular sheen. Each gland is $1\frac{1}{2}$ - $2\frac{1}{2}$ mm. long, with (relatively) small and central (or nearly so) lumen, circular in cross section. Each cluster of

glands is enclosed in a transparent, thin-walled sac. In a worm with dislocated setae in ix a cluster of glands is present in that segment.

Associated with each stalked gland is a spindle-shaped setal follicle that projects fairly conspicuously into the coelomic cavity. Each follicle has a thick wall and a slight muscular sheen. The common passage to the exterior from gland and follicle is lined with a tube of thickened cuticle which is widened for a short distance in an ental portion of the parietes. In this widened section of the tube is the tip of the copulatory seta. The tube has a thickened rim at its aperture and a test-tube-like appearance as in the case of the cuticular lining of the prostatic duct.

Copulatory setae are nearly straight, the shafts curved slightly to one side at the ental ends, gradually narrowed ectally but with rather bluntly rounded terminations (worn?). Setae of vii are 1.02-1.08 mm. long, while those of viii are 0.88-0.96 mm. long. No ornamentation is visible. One of the displaced follicles of segment ix contains two setae, 0.82 and 0.99 mm. long, similar in appearance to the copulatory setae.

Parasites.—Nematodes are present in the testis sacs of one specimen.

Remarks.—Except as may have been noted differently above, the external characteristics and internal anatomy are as in *khandalaensis*.

In the specimens of *khandalaensis* described on a previous page some softening has taken place and hence it is possible to strip off from the coelomic face of the body wall a peritoneal layer together with adherent blood vessels and nephridia and thus expose the longitudinal musculature. A quite similar appearance of the body wall in post-prostatic segments of the South Indian specimens just described is probably due to a more extensive maceration with consequent fragmentation and loss of part of the peritoneum and attached structures. This explains the inability to recognize micronephridia in posterior segments of the body.

Bourne's preliminary description of the species is incomplete as well as partly erroneous, and was not corrected or amplified. The status of the species, and also of the genus erected for it by Beddard in 1890, remained doubtful until fairly recently. Michaelsen, after examination of a single, damaged and previously dissected specimen from the type locality, concluded that his worm was referable to Bourne's species. Michaelsen's account is not as detailed as is now necessary, but his specimen apparently differs from those described above as follows: more posterior location of the first dorsal pore, on 7/8; location of male pores on tiny papillae borne on protuberant porophores; presence of hearts in xiv; small size of mega-nephridia, presence of post-clitellar micro-nephridia; shorter (relative to length of ampulla) spermathecal ducts¹. Although these differences, at least in part, appear at first to be of taxonomic importance, in reality they may not be so. The protuberant male porophores may represent only an everted condition of the rather deep depressions mentioned above. The hearts of xiv are probably anterior commissures from the dorsal trunk to the extra-oesophageal

¹ Possibly also by a more posterior location of the spermathecal pores. Michaelsen merely notes that the pores are "eine, deutliche, wenn auch kurze Strecke vor den Intersegmental-furchen" from which it might be concluded that the pores are nearer to the furrows than to the setal circles.

system—a similar mistake in identification of commissural vessels in xiv was made by Stephenson. The small size of the mega-nephridia is possibly to be explained as a result of maceration and consequent loss of portions of the tubules (nephridia were unrecognizable doubtless also as a result of maceration in all except a short postclitellar portion of Michaelsen's worm) as is the absence of micro-nephridia in postclitellar portions of the Nandydroog worms. Dorsal pores anterior to 7/8 may have been unrecognized. Relative shortness of spermathecal duct is probably not of taxonomic value. Exact location of the spermathecal pores in Michaelsen's worm is unknown. In view of the uncertainty as to these points the diagnosis below is based only on the Nandydroog worms.

Diagnosis.—Male pores in *cf*, in line with setal circles of xvii and xix, at or near centres of circular areas of greyish translucence located in region of *a-h*. Spermathecal pores post-setal on vii and viii, nearer to setal circles than intersegmental furrows, in *df*. Setae: 22-28/ii, 35/iii, 37-45/viii, 46-52/xii, 46-56/xx, vii/4, viii/4, xviii/7-10: *c-e* of vii-viii usually, *f* and *g* occasionally, dislocated posteriorly. Pigmentation? Length 115-127 mm. Diameter 4-5 mm.

Gizzard in vi? Intestinal caeca dorso-lateral, 3 pairs (in xxv or xxvi-xxviii?). Last hearts in xiii. Lymph glands? Testis sacs? Seminal vesicles present in x. Parietal glands in xvii and xix, one just median and one just lateral to each prostatic duct, opening to exterior by minute apertures on male porophores (?). Spermathecal diverticula doubly glove-shaped, 15-22, in a single circle; each diverticulum with 6-12 irregularly digitiform seminal chambers part of which are directed ectally and part entally. Copulatory setae unornamented; glands short, in four coelomic sacs, one in front of each spermatheca.

Distribution.—Yercaud, Salem district in the Madras Presidency; and Nandydroog, Mysore State, South India.

Hoplochaetella suctoria Stephenson.

1917. *Hoplochaetella suctoria* Stephenson, *Rec. Ind. Mus.* XIII, p. 388. (Type locality—Sanvordem, Portuguese India. Types in Indian Museum.)

1923. *Erythraeordrilus suctorius* (part), Stephenson, *Oligochaeta*, in *F. B. I.*, p. 464. (Excluding var. *affinis*.)

Material examined.—From the Indian Museum: 1 juvenile and 4 acitellate specimens labelled, "*Hoplochaetella suctoria* Steph. Types. Under stones near river subject to tidal influence, Sanvordem, Portuguese India. 11.ix.16. S. Kemp. W 67/1."

External characteristics.—The first dorsal pore is on 4/5 (3). Pigmentation now quite unrecognizable.

Some of the ventral setae of vii-ix are dislocated on each specimen as follows.—(1) posteriorly on vii, anteriorly on viii-ix, displaced setae removed in previous dissection; (2) *a* of both sides of vii posteriorly, *a* of both sides of viii anteriorly, *b-d* of left side and *b* of right side slightly anteriorly, *a-d* of left side, and *c-e* of right side of ix anteriorly; (3) *a-b* of both sides of viii anteriorly, *a-d* left side and *a-e* right side of ix anteriorly; (4) *a* of both sides of vii posteriorly, *a* of both sides of viii anteriorly, *b-c* of both sides slightly anteriorly, *d* of left side and *b-d* of right side of ix anteriorly; (5)—(juvenile) *a-b* of left side and *a* of

right side of vii posteriorly, *a-c* of both sides of viii anteriorly, *c-d* of both sides of ix anteriorly. Dislocated setae are usually in fairly straight transverse rows. Setae are lacking ventrally on xvii-xix (5).

Spermathecal pores are minute and superficial, of about the same size as the apertures of the setal follicles and distinguishable only by absence of setae. The anterior pores are just antero-lateral to *b*, just lateral to *b*, or just lateral to *c*, usually anterior to setal arc, the posterior pores on or close to *b*, definitely in front of 8/9 but nearer that furrow than to the post-setal secondary furrow.

Male pores are minute and superficial, towards the median margins of transversely placed areas of greyish translucence, more or less in line with 17/18 and 18/19 which are lacking ventrally on all specimens, xviii probably slightly shortened ventrally. Each male porophore may have a slightly raised opaque marginal band. On the juvenile specimen only three male pores are recognizable and immediately median to each of two pores is a black dot, presumably, the tip of a penial seta.

Genital markings are sharply demarcated, each with a greyish translucent central portion and a slightly raised, wide, opaque marginal band. The markings are located as follows: (1) anterior pair on xvii, extending from 17/18 nearly to 16/17, longitudinally placed or slightly diagonal, posterior marking on right side probably post-setal on xix dislocating 19/20 posteriorly, longitudinally placed; (2) paired markings on xvii not reaching levels of 16/17 or 17/18, transversely placed but so shortly elliptical as to be almost circular, posterior marking median, posterior margin mid-ventrally at level of setal circle, anterior margin definitely behind level of setal circle of xix, possibly pre-setal on xx (dislocating 19/20 anteriorly?); (3) anterior marking median, from 16/17 nearly to 17/18, posterior markings longitudinally or diagonally placed and equally on xix and xx (?); (4) paired markings on xvii, transversely placed, probably slightly more post-setal than pre-setal, posterior marking median and post-setal on xix (?); (5) lacking or unrecognizable. Centres of anterior paired markings are lateral to male pore lines, centres of posterior paired markings more or less on male pore lines. Mid-ventral interval between anterior paired markings *ca.* 1 mm. and between posterior paired markings *ca.* $\frac{1}{2}$ mm. Except in one specimen unpaired median markings are so shortly elliptical in outline as to be almost circular but on the exceptional individual the marking is transversely extended so as to approximate to the condition in *affinis*,—the marking is however slightly asymmetrical with relation to the male pore lines.

Internal anatomy.—The gizzard is in vi (2). The oesophagus is widened in ix, narrow in x-xv and with low, longitudinally placed, white ridges on the inner wall. Calciferous glands are rather reniform with concave sides mesially, a stalk passing from the hilus to the gut. Glands appear to be solid in section due to the close crowding of the vertical lamella. The intestine begins in xvi (2), the oesophageal valve posteriorly in xv and anteriorly in xvi.

The typhlosole begins in xxii-xxiv (1) and is unrecognizable behind cxviii (1 specimen with 145 segments), it is triangular in cross section anteriorly, lamelliform posteriorly, and gradually decreases in size still further posteriorly.

Hearts of x-xiii are latero-oesophageal as in *khandalaensis*. A fairly large vessel joins the dorsal trunk just behind 13/14 on each side and on the ventro-lateral aspect of the gut turns anteriorly to run towards the extra-oesophageal. Mid-segmentally in xiv a pair of slightly smaller vessels from the dorso-lateral aspect of the gut joins the dorsal trunk. A supra-oesophageal trunk is recognizable only in part and ends in xiii as in *khandalaensis*. A posterior latero-parietal vessel is present on the parietes lateral to the prostatic ducts in xix-xv or xiv but has not been traced to the gut. Extra-oesophageals are recognizable from 5/6 to xi. No subneural (2). An unpaired lymph gland lies across the dorsal trunk just in front of each septum from xv posteriorly (2). Towards the hind end the glands are bilobed.

Nephridia are as in *khandalaensis*, with large paired, vertically placed clusters of tubules on the anterior faces of 4/5 and 5/6. Nephridia of ii and iii appear to be closely crowded into paired, vertically placed, small bands on the parietes.

A pair of tough, small, vertically ovoidal bodies on the anterior face of 10/11 just below the calciferous glands of one specimen may be rudimentary seminal vesicles. Deferent male ducts were not traced throughout but are recognizable in xvii where they pass lateral to the anterior prostatic ducts. One deferent duct turns to pass into the posterior face of the anterior duct while the other passes into the anterior face of the posterior duct, in both cases just within the parietes and covered over by delicate tissue. On the median face of each prostatic duct there are two penisetal follicles, each containing one seta. Setae are nearly straight, without ornamentation and sculpturing of tips, the latter tapering but not to a sharp point. These setae are usually broken or crushed in removal but are about 0.2 mm. long and 0.01 mm. thick. Two follicles from the region of one prostatic duct were removed but without possibility of identification as an *a* or *b*. Of the two setae, one is slightly thicker in the middle portion than the other and resembles a nodule. There may be some glandular material in the parietes around prostatic ducts, but definite glands protuberant into coelomic cavities are lacking as in *khandalaensis*.

A fairly long, parietal portion of the spermathecal duct is slender and circular in cross section, the coelomic portion gradually widened entally but flattened on two sides so that the transverse section is elongately elliptical, the lumen is slit-like, and the wall thick. The ampulla is bound down around the ental portion of the spermathecal duct to the level of attachment of diverticula, and the entalmost portion of the duct protuberant into the ampullary lumen as a high, thick annulus. The inner wall of the spermathecal duct and the outer surface of the annular projection into the ampullary lumen have an unusually smooth appearance due to the presence of a transparent layer that looks like cuticle. The diverticula are shortly digitiform and are arranged in a single circle, with the free ends directed ventrally, eighteen were noted on one spermatheca. No spermatozoal iridescence.

Glands of the genital markings are low sessile masses on the parietes, with the longitudinal muscular layer interrupted (1). In another worm

glandular masses were only doubtfully recognized, and, if present, are not as well developed.

In each of segments vii, viii and ix there is a pair of sacs protuberant into the coelomic cavities, one on either side of the nerve cord. These sacs are flattened out on the parietes in both specimens, and may thus appear to be somewhat like enlarged nephridial tubules. Each sac, except in vii, contains the stalked, digitiform glands passing to the parietes along with the displaced setae. Several glands were removed, each with a setal follicle adherent to the duct of the gland, but the ectal portions were broken so that the manner of union was not observed. Sacs of vii are transversely placed over ventral portions of setal circles.

Remarks.—Two specimens had been dissected previously, one with considerable damage to the internal organs and the ventral surface in the spermathecal region. Dissection of the latter was completed so far as possible, the other (the type) was left intact, while a complete dissection was made of an anterior portion of a third specimen.

The “transversely elongated, almost linear” prostatic pores are merely porophores-areas of greyish translucence of the epidermis towards the median margin of which the minute real male pores are recognizable under favourable conditions. Discrete openings of peni-setal follicles, if present, are unrecognizable with even under the best optical conditions. The supposed spermathecal pores described and figured in the original account of the species are artefacts and quite unrecognizable after removal of the cuticle. Anterior pores are not on porophores (though these might be recognizable on clitellate specimens) but each of the posterior pores appears to be located at or near the centre of a transversely placed area of very slight epidermal thickening with shortly elliptical outline. There is no transverse groove on any of the specimens.

Although it seems fairly certain that the structures identified as male deferent ducts are actually so, this identification requires confirmation especially in view of Stephenson's failure to find connections with posterior prostatic ducts. Characteristics of parietal glands in the prostatic region, such as number, shape and location, appear at present to have taxonomic value. Absence of such glands, or perhaps of lobes or extensions into the coelomic cavities seems to be characteristic of *suctoria*, but in view of the immaturity of all of the types this requires confirmation from sexual material.

A diagnosis based on a short series of five immature specimens with considerable variation in important characteristics (*e.g.*, location of genital markings) will probably be rather unsatisfactory.

Diagnosis.—Male pores on or close to sites of 17/18 and 18/19, towards median margins of transversely placed, translucent areas of shortly elliptical outline. Spermathecal pores on viii, on or just lateral to *bc*, slightly anterior to the setal circle and 8/9. Genital markings on xvii and on region between setal circles of xix and xx, paired in one (or both ?) of these regions, centres of paired markings on or lateral to male pore lines. Setae: 66/v, 66/ix, 63/xii, 60/xxi, viii/0, xvii-xix/0; *a* dislocated posteriorly on vii, some or all of *a-e* dislocated anteriorly on viii and ix. Pigmentation red? Length 140 mm. Diameter 6 mm.

Gizzard in vi. Last hearts in xiii. Unpaired lymph glands from xv posteriorly. Testis sacs formed by peripheral fusion of septa 9/10-11/12. (Seminal vesicles present in x (Parietal glands, if present, not protuberant into coelomic cavities?). Genital marking glands sessile on the parietes. Spermathecal diverticula shortly digitiform, ventrally directed, 15-20 in one circle. Copulatory setae ornamented; glands (short ?) in four coelomic sacs, an additional pair of sacs in vii.

Distribution.—Known only from the type locality, Sanvordem in Portuguese India.

Hoplochaetella sp.

1917. *Hoplochaetella affinis* (part), Stephenson, *Rec. Ind. Mus.* XIII, p. 399. (Excluding all specimens except those from Vareeg Islet.)

1923. *Erythraedrillus sutorius* var. *affinis* (part), Stephenson, *Oligochaeta*, in F.B.I. p. 466. (Exclusions as above.)

Material examined.—From the Indian Museum; 1 acitellate, damaged but undissected specimen labelled, "*Hoplochaetella affinis* Stephenson. Vareeg Islet, S. side of Mormugao Bay, Portuguese India. August 16. Dr. S. W. Kemp. W 125/1."

External characteristics.—Spermathecal pores are on porophores of the usual type, on viii, in *cf*, the anterior pores very slightly in front of the setal circle, the posterior pores perhaps a bit further in front of 8/9. Dislocated setae are as follows: on vii, none; *a* on both sides of viii anteriorly, and in addition two or three setae on each side, presumably *bc* or *bd*, slightly displaced to the anterior spermathecal porophores; on ix *a-b* of both sides anteriorly.

Genital markings unpaired, median, transversely extended, pre-setal on xvii (or on 16/17) and xx.

Internal anatomy.—The gizzard is in vi. Calcareous crystals are present in the calciferous glands. The typhlosole terminates in xciii. The circulatory system is as in *khandalaensis*, lymph glands present posteriorly. Excretory system as usual with bands of tubules on parietes in ii-iii and clusters on the anterior faces of 4/5-5/6.

Male deferent ducts have not been traced but cords like deferent ducts pass into the anterior faces of the posterior prostatic ducts and the posterior faces of the anterior ducts within the parietes. Parietal glands in region of prostatic ducts not noticed. Genital marking glands sessile on the parietes, about 3 mm. in diameter.

Spermathecae are 5—6 mm. long, the thick portion of the duct *ca.* 1 mm. and the thin portion of the duct *ca.* 1½ mm. in length. Spermathecal diverticula are ventrally directed, shortly digitiform, and in two groups. Spermatozoal iridescence is lacking, and the diverticula could not be traced through the duct to discover if each digitiform structure opened into the duct by a discrete pore. In ix one spermatheca has two diverticula or a single bifid diverticulum on each side; the other spermatheca has three diverticula on one side and two on the other. In viii one spermatheca has one bifid diverticulum on one side, and a quadrifid diverticulum on the other which may have the appearance of four closely crowded diverticula; the other spermatheca has two diverticula on one side and three on the other.

Copulatory setal glands are in coelomic sacs passing to the parietes just behind each spermatheca, five in each anterior sac, two in each, posterior sac. No sacs in vii. The glands are 5-6 mm. long, the ducts about 1 mm. long.

Remarks.—The epidermis of the male genital region is roughened. At the time of killing the body wall had widely ruptured in a lateral region at xxv and again dorsally in region of xv-xvi, the gut completely lacking in a region from xv-lii, and the other structures less extensively damaged.

Except for size the specimen is more like the type of *biforeata* than that of *affinis*.

B. BIPOSTATIC SPECIES.

At least two, possibly three, biprostatic species will have to be recognized eventually. Unfortunately all of the biprostatic specimens that have been available for study are in poor condition, and no species can be satisfactorily characterized. In these circumstances it is impossible to ascertain if the biprostatic forms are closely related or whether the biprostatic condition has arisen independently. The entrance of the male deferent duct into the prostatic duct on the posterior face of the latter seems to indicate a derivation from a quadriprostatic condition with two pairs of male pores, but the presence of ventral setae normally on xviii and xix requires presumably an origin from some ancestral, quadriprostatic form prior to modifications of ventral setae of xviii and xix.

Hoplochaetella kinneari (Stephenson).

1915. *Erythraeodrilus kinneari* (part) Stephenson, *Mem. Ind. Mus.* VI, p. 100. (Excluding one type with widely paired spermathecal pores and genital marking on 16/17. Type locality—Castle Rock, North Kanara district, Bombay Presidency. Types in the Indian Museum.)
1917. *Erythraeodrilus kinneari* (part), Stephenson, *Rec. Ind. Mus.* XIII, p. 402. (Excluding dissected type with genital marking on 16/17 and Kemp's specimen.)
1923. *Erythraeodrilus kinneari* (part), Stephenson, *Oligochaeta*, in *F. B. I.*, p. 463. (Exclusions as above.)

Material examined.—2 (1 dissected) clitellate, macerated specimens labelled, "*Erythraeodrilus kinneari* Stephenson. Types. Castle Rock, N. Kanara District, Bombay Presidency Lt. Col. J. Stephenson. W 26/1."

External characteristics.—Each minute pore is at the centre of a protuberant, post-setal porophore of almost circular outline (possibly shortly elliptical and transversely placed), with centre about on *c*.

Genital markings, present on one specimen only, are paired, circular or almost so, post-setal on xviii, centres about on *c*, reaching mesially to *b*, a tiny central portion depressed and with the appearance of a pore.

Internal anatomy.—Septa 9/10-11/12 are not united peripherally.

The gizzard is in vi. Calciferous glands are small, even in xii-xiii. The intestine begins in xvi (1). The simple, lamelliform typhlosole begins in the region of xxii-xxiv.

The usual clusters of nephridia are present on the anterior faces of 4/5-5/6. The last hearts are in xii. Lymph glands, if once present, are now unrecognizable.

Seminal vesicles of x are large. The male deferent duct passes lateral to the prostatic duct in xvii, then turning mesially enlarges to form an ovoidal (muscular?) ejaculatory bulb opening into the posterior face of the prostatic duct. Penial setae are present on the median face of the prostatic duct. One seta is 0.25 mm. long, 0.012 mm. wide at region of greatest thickness approximately at middle of the shaft, nearly straight except for slight bends at the ectal and ental ends, both bends toward the same side, without ornamentation.

The spermathecal diverticula are paired, each diverticulum consisting of several closely crowded seminal chambers aggregated in such a way as to form a flat disc opening into the duct by a single short stalk, the chambers radiating peripherally like the spokes of a wheel. Two clusters of (2 and 3) short copulatory setal glands are present in iii, one cluster between each two spermathecae of a side. A copulatory setal follicle projects conspicuously into the coelomic cavity from in front of each gland. The single seta examined is ornamented.

Genital marking glands are sessile and only slightly protuberant into the coelomic cavity.

Remarks.—As a result of the maceration little can be learned from these specimens. The spermathecal pores are not definitely recognizable but may be located on viii in *bc*, the anterior pores slightly in front of the setal circle, the posterior pores a little further behind the circle. None of the setae of vii and ix appears to be dislocated or placed on tumescences. On the dissected type, *a* of each side of viii seems to be present and in normal position. Ventral setae appear to be lacking on xvii but present normally on xviii and xix.

*Diagnosis.*¹—Male pores midway between setal circle of xvii and 17/18, more or less on *c*, each pore at the centre of a protuberant circular porophore. Spermathecal pores on viii (in *bc* just in front of and slightly behind the setal circle?). Genital markings (when present) paired, post-setal on xviii, more or less in line with and as large as the male porophores. Setae: 46/vi, 53/ix, 40/xix, viii/2, xvii/0, (*b-c* or *d* dislocated on viii?). First dorsal pore on 3/4 (?). Pigmentation red? Prostomium prolobous? Length 120 mm. Diameter $3\frac{1}{2}$ mm.

Gizzard in vi. Last hearts in xii. Lymph glands? Unpaired, sub-oesophageal testis sacs in x and xi? Seminal vesicles of x large. Male deferent ducts just prior to junctions with prostatic ducts enlarged to form ovoidal ejaculatory bulbs. (Parietal glands?). Genital marking glands sessile on the parietes. Spermathecal diverticula paired, each a stalked, flat disc with (12) closely crowded, radially directed seminal chambers. Copulatory setae ornamented; glands short, 2-3 on each side of vii (in coelomic sacs?).

Distribution.—Known only from the type locality, Castle Rock, in N. Kanara district, Bombay Presidency.

¹ Certain statements are included in the diagnosis in view of the fact that the original description was based on the type with paired genital markings on xviii (Stephenson, 1917, p. 403.)

Hoplochaetella sp.

1915. *Erythraeodrilus kinneari* (part) Stephenson, *Mem. Ind. Mus.* VI, p. 100.
(Excluding all except the specimen with genital markings on 16/17.)
1917. *Erythraeodrilus kinneari* (part), Stephenson, *Rec. Ind. Mus.* XIII, p. 402. (Excluding all except the specimen with genital marking on 16/17.)
1923. *Erythraeodrilus kinneari* (part), Stephenson, *Oligochaeta*, in *F. B. I.*, p. 463. (Excluding all except the specimen with genital marking on 16/17.)

Material examined.—From the Indian Museum; 1 clitellate, dissected, macerated specimen labelled, "*Erythraeodrilus kinneari* Stephenson. Types. Castle Rock, N. Kanara District, Bombay Presidency. Lt. Col. J. Stephenson. W 26/1."

Remarks.—Spermathecal pores are widely separated, more or less in *de*, the anterior pores slightly in front of 7/8, the posterior pores probably in the setal circle of viii. There are no dislocated setae on vii-ix. Spermathecal porophores on vii, seen by Stephenson (who failed to recognize the spermathecal pores or the nature of the markings) are now practically unrecognizable.

Male porophores are similar to those of *kinneari* but are more widely separated, the male pores more or less in *df*. There are four setae on xvii, between the male pore lines, all ventral setae of xviii-xix probably present.

The single genital marking is on the left side, on 16/17, the centre of the marking slightly median to the male pore line. The gland is inconspicuous, sessile on the parietes.

Ejaculatory bulbs are lacking? The male funnels may be unpaired sub-oesophageal testis sacs.

There is no ornamentation on the single copulatory seta that was examined.

The location of the anterior spermathecal pores on vii seems to be sufficient justification for regarding this specimen as specifically distinct from the two types of *kinneari* considered above. The specimen is in very poor condition and, lacking several organs, is quite unfit to serve as the type of a new species.

Hoplochaetella sp.

1917. *Erythraeodrilus kinneari* (part) Stephenson, *Rec. Ind. Mus.* XIII, p. 402. (Excluding all except Kemp's specimen.)
1923. *Erythraeodrilus kinneari* (part), Stephenson, *Oligochaeta*, in *F. B. I.*, p. 463. (Excluding all except Kemp's specimen.)

Material examined.—From the Indian Museum; 1 clitellate, dissected specimen labelled, "*Erythraeodrilus kinneari* Stephenson. Castle Rock, N. Kanara District, Bombay Presidency. Dr. S. W. Kemp. W 65/1."

Remarks.—No setae are displaced on vii-ix, nor any located on tumescences. There are about seven setae on vii and ten setae on viii between the spermathecal pore lines. There are four setae on xvii between the male pore lines. All ventral setae of xviii-xix appear to be present.

The spermathecal pores are widely separated, the anterior pores on vii slightly in front of 7/8, the posterior pores in the setal circle of viii, the posterior pores being one setal and intersetal interval further laterally than the anterior pores.

The single genital marking is pre-setal, on the left side of xvii, of about the same size as the male porophores, the centre slightly median to the male pore lines.

Calciferous glands are present in xiii as usual.

The male deferent ducts appear to be slightly widened as they join the prostatic ducts on the posterior faces. The genital marking gland is inconspicuous, and sessile on the parietes.

Each spermatheca has two elongate diverticula, pendent ventrally, each diverticulum with two or three shortly ellipsoidal seminal chambers.

The location of the spermathecal pores is similar to that of the worm just considered above but the spermathecal diverticula are so different as to indicate specific distinction. Hearts of xiii are present according to Stephenson (though now quite unrecognizable as such) and this, if correct, would be further evidence of specific distinction. Unfortunately the specimen is in a very poor condition and quite unfit to serve as the type of a new species.

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ON A SMALL COLLECTION OF ANNELIDA POLYCHAETA OF THE INDIAN MUSEUM, CALCUTTA.

By PIERRE FAUVEL, *Professeur de Zoologie à l' Université Catholique d' Angers, France.*

The collection of Polychaeta under report consists of worms from two distinct regions. The majority are from the Andamans and the coasts or backwaters of Travancore and Cochin States, where they were found either in sea-water or in brackish waters of variable salinity.

More interesting are those collected from the tanks and cisterns of the Calcutta Waterworks at Pulta in, very likely, quite fresh water¹. These freshwater species are indeed, only four in number :

Dendronereides heteropoda Southern.

Lycastis indica Southern.

Nereis cricognatha Ehlers.

Nephtys oligobranchia Southern.

Of the first, only two specimens were found. Southern's type specimens came from brackish pools and salt lakes in Barantolla, near Calcutta. I have already recorded this species (1932, p. 87) from the bottom sand in an unfiltered water tank, Calcutta, and from Basra (Shat-el-Arab), 70 miles from the sea, in quite fresh water.

Lycastis indica Southern, like most species of *Lycastis*, is another fresh and brackish water species, though it appears also to live on the sea-shore like *Ly. ouanaryensis* Gravier, a very closely allied species from Guiana. The specimens from Pulta are smaller and not so numerous as those from the Travancore and Cochin backwaters, especially Kayamkulam Kāyal.

Nephtys oligobranchia Southern is another small euryhaline Polychaete living in fresh or brackish water and, occasionally, in the sea. It is very plentiful in the Pulta cisterns.

But the most common Polychaete of the Calcutta Waterworks seems to be *Nereis cricognatha* Ehlers; large numbers of this species were collected, most of them atokous, but with a few epitokous males and females. The occurrence of this species in fresh water is a little amazing, for, to my knowledge, it has been met with only in seawater, with perhaps the one exception of the record by Annandale on the shores of the Hooghly at Budge-Budge, in water of unstated salinity.²

¹I have no data as regards the salinity.

[During the monsoon months, June to September, the water in the tanks is certainly fresh, but from January onwards up to the end of May the salinity gradually rises approximately up to 4.0 to 6.0 at the lowest ebb and 8.0 at the highest flood. The salinity is expressed as chlorine figures in parts per 100,000 of Hooghly river water as per records for the years 1937 and 1938. Ed. R. I. M.]

²[Budge-Budge is within twenty miles below Calcutta and is, presumably, subject to the usual variations in salinity that occur in Calcutta, but there are no records of salinity for Budge-Budge. The range of variation might, if anything, be greater here because of the Rupnarain and Damodar rivers which empty their flood waters into the Hooghly below Calcutta. Ed. R. I. M.]

Most of the species mentioned in this note were described in my previous paper (1932), the only exceptions being : *Lepidasthenia microlepis* Potts, *Phyllochaetopterus ellioti* Crossland and *Sabella porifera* Grube already recorded from Krusadai (Fauvel, 1930), *Audouinia semicincta* Ehlers and *Sabella melanostigma* Schmarda, very likely new to India, the rare *Syllis okadai* Fauvel, from Japan and Annam, and, last but not the least, *Pista indica*, a very peculiar new species of this genus.

Family APHRODITIDAE Savigny.

Genus **Hermione** Blainville.

Hermione hystrix (Savigny).

Hermione hystrix, Fauvel, 1932, p. 10.

East coast of Port Bonington, Stewart Sound, Andamans. Two specimens.

Habitat.—Indian and Atlantic Oceans.

Genus **Iphione** Kinberg.

Iphione muricata (Savigny).

Iphione muricata, Fauvel, 1932, p. 12.

Port Bonington, Stewart Sound ; Port Blair (coral reef, in crevices amongst dead coral, between tide marks) ; Long Island and Sound I. (on coral rocks and under stones) in the Middle and North Andamans respectively. Several large and small specimens.

Habitat.—Indian and Pacific Oceans.

Genus **Harmothoe** Kinberg.

Harmothoe ampullifera (Grube).

Harmothoe ampullifera, Fauvel, 1932, p. 22.

Neendakara, Travancore (at the edge of the sand-bar away from the sea). A single fine specimen.

Habitat.—Indian Ocean.

Genus **Gastrolepidia** Schmarda.

Gastrolepidia clavigera Schmarda.

Gastrolepidia clavigera, Fauvel, 1932, p. 25.

East coast of Port Bonington, Stewart Sound, Andamans.

A very dark broken specimen without elytra and most of the appendages. The large and conspicuous ventral lamellae are characteristic, as well as the few curved and spinulose dorsal setae, and the large unidentate hooked ventral setae, with a few slenderer spinulose superior ones.

Habitat.—Indian and Pacific Oceans.

Genus **Lepidasthenia** Malmgren.**Lepidasthenia microlepis** Potts.*Lepidasthenia microlepis*, Potts, 1910, p. 343, pl. xix, fig. 17.*Lepidasthenia microlepis*, Horst, 1917, p. 85, pl. xix, fig. 9.*Lepidasthenia microlepis*, Fauvel, 1930, p. 510.

Ross I., Andamans (on coral stones).

This rather large specimen is broken into two parts and is incomplete behind. In the anterior part, two dark segments alternate with three or four paler ones, and further on one dark segment alternates with a paler one up to the 22nd segment. Behind, they are all dark with a thin transverse darker streak. The colouration is somewhat similar to that of *L. elegans* Grube. The ventral setae are unidentate, and there are no giant ones. Dorsal setae are lacking. The elytra are very small, hardly as broad as the elyrophore.

On a specimen from New Caledonia, I found a few bidentate setae in the feet. According to Potts and Seidler, they occur only on the anterior feet. There seems to exist some variation, perhaps in relation with age and size (?).

Habitat.—Maldives, Andamans, Malay Archipelago, Durban, and New Caledonia.

Family AMPHINOMIDAE Savigny.

Genus **Eurythoe** Kinberg.**Eurythoe complanata** (Pallas).*Eurythoe complanata*, Fauvel, 1932 p. 45.

Long I., Middle Andaman ; Between Blair Reef and Chatham Causeway, Ross I., Chatham I., Phoenix Bay, Viper Island, and Mithakhari, all the localities in Port Blair, Andamans.

Large and small specimens, some broken, others regenerated, represent this ubiquitous species of coral reefs.

Habitat.—Tropical, all over the world.

Genus **Chloeia** Savigny.**Chloeia flava** (Pallas).*Chloeia flava*, Fauvel, 1932, p. 55.

Phoenix Bay, Port Blair, S. Andaman.

The colour of the species is rather variable.

Habitat.—Indian and Pacific Oceans, and Japan.

Family PHYLLODOCIDAE Grube.

Genus **Phyllodoce** Savigny.**Phyllodoce tenuissima** Grube.*Phyllodoce tenuissima*, Fauvel, 1932, p. 70.

Between N. Bay and N. Corbyn's Cove, Port Blair, Andamans (among coral débris).

The body of this species is very long and slender. Specimens are 350 mm. long and more, with a width of 2-3 mm. only. The dorsal cirri are broadly lanceolate or ovate. The back is streaked with dark blue, iridescent, transverse lines.

Habitat.—Ceylon, Nicobars, Andamans, Philippine Islands, South Australia, and New Zealand.

Family SYLLIDAE Gube.

Genus **Syllis** Savigny.

Syllis exilis Gravier.

Syllis exilis, Fauvel, 1932, p. 77.

South Point, Port Blair, Andamans (from under stones at low tide).

Two fine specimens with stout arched back giving them an appearance somewhat like that of an *Eusyllis*. The dorsal cirri are alternating and have numerous well marked articles. The shaft of the lower setae is swollen and the simple hook is bent ; but none of these hooks is as large and curved as in *Syllis fusco-suturata* Augener, which I regard as only a variety of *S. exilis*.

Habitat.—Indian and Pacific Oceans.

Syllis closterobranchia Schmarda.

Syllis closterobranchia, Fauvel, 1932, p. 77.

South Corbyn's Cove, Port Blair, Andamans. One specimen.

Habitat.—Indian and Pacific Oceans.

Syllis okadai Fauvel.

Syllis okadai, Fauvel, 1934, p. 307, figs. 1-2.

South Corbyn's Cove, Port Blair, Andamans.

The coloration of this species which I first described from Seto (Japan) is strikingly characteristic, though somewhat variable. The dark ground color of the back is speckled with white dots. On the anterior part of the body, four pale contiguous segments form a broad white collar separated from a second white collar by three dark segments. On the Andaman specimen, this second white collar is wanting, but the pattern of the after-part of the body is normal. The tentacles and dorsal cirri are rather short, with distinct articles. The shaft of the setae is swollen under the terminal piece which is a broad, short, unidentate hook. Such bristles recall those in *S. exilis*.

In addition to the above mentioned, I have seen two other specimens from the Gulf of Siam (1939, p. 292).

Habitat.—Seto (Japan), Gulf of Siam, and Andamans.

Family NEREIDAE Johnston.

Genus *Lycastis* Savigny.*Lycastis indica* Southern.

Lycastis indica, Southern, 1921, p. 578, pl. xix, fig. 2.

Lycastis indica, Fauvel, 1932, p. 82, pl. ii, figs. 1-2.

? *Lycastis ouanaryensis*, Gravier, 1901, p. 359, figs. 1-10.

East and West Narakal, backwater between Ernakulam and Edappalli, Vypin and Cheriya Kadamakudi, all in Cochin State; Puttankari, Kayankulam Kayal, Veli Lake, Trivandrum, Quilon, and Vembanad Lake, all in Travancore State; Cisterns of Calcutta Waterworks at Pulta; Andamans.

The very large quantity of specimens whose size varies from 12 mm. to 50-60 mm., and even 140-150 mm., enabled me once more to verify the variability of a number of characters such as the disposition of the eyes more or less in a line and their size, the number of teeth in the jaws, and the length of the dorsal cirri, a variability which I had already remarked upon (1932).

One of the leading characters described by Southern is the absence of dorsal setae, though he had found one from the tenth foot backwards on two of the five specimens he examined.

In the material of the Zoological Survey of India, I occasionally found 1-2 slender dorsal setae on a small specimen from the Salt Lakes, near Calcutta. On the specimens 50-60 mm. long from a cistern at Pulta, the dorsal setae were missing on most of the feet except a few anterior ones which bore one or two. Large specimens from Kayankulam Kayal, 140-150 mm. long, 5 mm. broad, showed hardly one or two feet, irregularly distributed, and bearing a single dorsal seta. In the other hand, smaller specimens from other localities bore 1-2, rarely more, dorsal setae on many feet.

The size and shape of the dorsal cirri are liable to a rather wide range of variation. Though they are never as broad as the nearly heart-shaped cirri of *L. meraukensis*, their length varies materially. In large specimens the number of dorsal cirri of the posterior region is much increased, and the cirri are recurved on the back, giving to the Nereid the Phyllocid appearance already noticed by de Saint-Joseph.

In short, the likeness between *L. indica* and *L. ouanaryensis* is very striking. As the normal occurrence of a few dorsal setae in the anterior feet, at least, is confirmed, the gap between the two species is still less.

Both species partake of the same euryhaline behaviour. *L. indica* ranges from fresh water (Pulta Cisterns) to brackish water and probably sea water (Andamans). *L. ouanaryensis* lives in fresh water of marshes and in brackish water of estuaries, and between tide-marks at Cayenne. *Lycastis senegalensis* Saint-Joseph (1901, p. 217, pl. viii, figs. 1-7), another species with few dorsal setae and long narrow dorsal cirri, seems hardly distinct, as far as one can judge from the bad figures of the author.

A careful comparison of numerous specimens of the same size of these three species would be necessary to settle the question of their synonymy. If conspecific, the name *L. senegalensis* would have the priority.

Habitat.—India, Macassar, and Guiana (?).

Genus **Tylonereis** Fauvel.**Tylonereis bogoyawlenskyi** Fauvel.

Tylonereis bogoyawlenskyi, Fauvel, 1932, p. 83.

Neendakara Bar, and Veli Lake, Travancore.

The specimens from Veli Lake are plentiful, but unfortunately more or less soft. Nevertheless they are well characterised by their trilobed ventral setigerous lobe.

Habitat.—Persian Gulf, Gulf of Manaar, and Travancore.

Genus **Dendronereis** Peters.**Dendronereis aestuarina** Southern.

Dendronereis aestuarina, Fauvel, 1932, p. 86.

Kayankulam Kayal and Vembanad Lake, Travancore. Very numerous atokous specimens were collected, some with the proboscis extruded. They fit in well with Southern's description.

Habitat.—Gangetic Delta, Madras, Travancore, and Taleh Sap.

Genus **Dendronereides** Southern.**Dendronereides heteropoda** Southern.

Dendronereides heteropoda, Fauvel, 1932, p. 87, pl. ii, figs. 3-9.

Vallarpadam, a cochin Harbour; a cistern in Calcutta Waterworks at Pulta. On the shore at Vällarpādam only somewhat doubtful débris was seen. The two specimens from Pulta were typical ones.

Habitat.—Calcutta, Bombay, Vällarpādam in Cochin Harbour, Diamond Isles, and Shat-el-Arab.

Genus **Nereis** Cuvier.**Nereis jacksoni** Kinberg.

Nereis jacksoni, Fauvel, 1932, p. 97.

South Point, Port Blair, Andamans (from stones).

Only two small atokous specimens represent this widely distributed species of tropical seas.

Habitat.—Indian and Pacific Oceans.

Nereis chilkaensis Southern.

Nereis chilkaensis, Fauvel, 1932, p. 94.

Neendakara Bar, Travancore.

A few female specimens full of eggs, in an incipient state of epitoky, bear rudimentary lamellae on their feet.

Habitat.—Chilka Lake, Ennur Backwater, Madras, Pamban, and Travancore.

Nereis glandicincta Southern.

Nereis glandicincta, Fauvel, 1932, p. 92.

Kumbalam Island and Narakal, Cochin State.

The specimens are very numerous. On the everted proboscis of many of them, the denticles of the groups VI are missing altogether, as well as those of the groups VII-VIII, thus giving the worms the appearance of a *Ceratonereis*. On a few others, the denticles of groups VI are very small, translucent, and can only be detected by the use of a very strongly, slanting light and a rather high magnification.

Several females full of eggs, but still atokous, were "green in life" There was also an epitokous male specimen. The feet and bristles are typical.

Habitat.—India, Singapore, Gulf of Siam, and Pulo Kondor (South China Sea).

Nereis cricognatha Ehlers.

Nereis cricognatha, Fauvel, 1932, p. 91.

Pulta Survey, Calcutta Waterworks ; Andamans.

With the exception of a few specimens from the Andamans, a striking quantity of this species comes from the Calcutta Waterworks at Pulta, in the mud at the bottom of pre-settling tanks, among débris in the cisterns, in Sponges and among the colonies of *Modiola* growing in the water-mains.

Most of them are atokous, a few subepitokous, and still fewer males and females are fully epitokous. They show the usual variation in the number of the denticles of the groups I, V and VI.

This species, which shows a great likeness to *Nereis succinea*, is also euryhaline. Judging by its plentiful occurrence in the Calcutta Waterworks, where it appears to be the commonest Polychaete worm, it seems to thrive well equally in fresh- and brackish-water as in salt water of the sea.

The proboscis is very nearly alike in both species, but in *N. succinea* the dorsal cirri in the posterior part of the body are greatly enlarged.

Habitat.—New Zealand, Bass Straits, Philippine Islands, and India (Krusadai, Hooghly, Calcutta).

Genus Perinereis Kinberg.**Perinereis cultrifera** Grube.

Perinereis cultrifera, Fauvel, 1932, p. 104.

Neendakara Bar, Travancore.

Only one specimen belonging to the variety *perspicillata* Grube.

Habitat.—Cosmopolitan.

Perinereis aibuhitensis Grube.

Perinereis aibuhitensis, Fauvel, 1932, p. 106.

Shoal Bay Creek, Andamans.

A single atokous specimen.

Habitat.—Philippine Islands, Malay Archipelago, China, and India.

Perinereis nigro-punctata Horst.

Perinereis nigro-punctata, Fauvel, 1932, p. 107.

South Corbyn's Cove, Port Blair, Andamans.

The back of the specimen still retains the usual pattern of three transverse black spots across each segment. The proboscis shows a few anomalies, group V consists of a single large paragnath, and there are two flattened transverse teeth in one of the groups VI and only one in the other.

Habitat.—Malay Archipelago, India, and Australia.

Perinereis cavifrons Ehlers.

Perinereis cavifrons, Fauvel, 1932, p. 107.

Backwater between Ernakulam and Edappalli, Cochin ; Ashtamudi Kayal, Quilon, and Chevara in Travancore. One of the specimens from Chevara is an epitokous male, all the others are atokous.

Habitat.—Java, and India.

Perinereis neocaledonica Pruvot.

Perinereis neocaledonica, Fauvel, 1932, p. 107.

Near Jones Point, Sound I., N. Andaman (under stones).

The single specimen present is very large : 175 mm. long and 6 mm. broad. The everted proboscis bears two stout, smooth, black jaws. Group V consists of a large denticle and a small one. Groups I and II are missing, as in the specimens from the Arabian Sea and New-Hebrides, previously described. The tentacles and tentacular cirri are very short.

Habitat.—New-Caledonia, New-Hebrides, Andamans, and the Arabian Sea.

Genus **Pseudonereis** Kinberg.**Pseudonereis anomala** Gravier.

Pseudonereis anomala, Fauvel, 1932, p. 112.

South Point, Port Blair, Andamans (from stones).

There were three atokous worms and an epitokous male.

Habitat.—Indian Ocean, Madagascar, Malay Seas, and Australia.

Family NEPHTHYDIDAE Grube.

Genus **Nephtys** Cuvier.**Nephtys oligobranchia** Southern.

Nephtys oligobranchia, Fauvel, 1932, p. 119.

Cisterns at Pulta, Calcutta Waterworks.

The numerous specimens of this species are all from the Calcutta Waterworks, where it appears to thrive in large quantities. They are small, their average size ranging from 10 to 20 mm. in length.

This species lives in waters of variable salinity, that is, in fresh-brackish-, or even sea-water.

Habitat.—India, Mergui (Burma), and Gulf of Siam.

Family GLYCERIDAE Grube.

Genus **Glycera** Savigny.

Glycera alba Rathke.

Glycera alba, Fauvel, 1932, p. 133.

Vendurutti, Cochin State.

Only a small specimen.

Habitat.—Atlantic and Indian Oceans, Red Sea, India, and Annam.

Genus **Goniada** Aud.-Edw.

Goniada emerita Aud.-Edw.

Goniada emerita, Fauvel, 1932, p. 120.

Vendurutti, Cochin State.

A very small one, with stout acicular dorsal setae.

Habitat.—Atlantic Ocean, Mediterranean Sea, India, and Japan (?).

Family EUNICIDAE Grube.

Genus **Eunice** Cuvier.

Eunice aphroditois (Pallas).

Eunice aphroditois, Fauvel, 1932, p. 133.

S. W. of Long Island, M. Andaman (amidst coral rocks) ; South Point Port Blair, Andamans ; South of Long Island, M. Andaman.

The specimen from the first named locality was " Dark blue in life, parapodial lobes tipped white, yellowish brown spots " Though it is only 80 mm. long and 9 mm. broad, it is still entire, the back part being regenerated. There is no trace of a white collar on the now dark-chestnut back ground, which is spotted with faint transparent dots (in alcohol). It agrees with the young, blue-coloured (in life) form of the species.

Several large pieces from the last-named locality (fixed in Carnoy's fluid)—one anterior, two posterior and a middle part—belong to two big specimens whose body is now a grayish yellow, with dark spots, but without any trace of a collar. Another, from South Point, 112 cm. long and 15-20 mm. broad is yellowish, more or less speckled with dark spots, and without collar. On the other hand, three other large anterior fragments from the same locality show faint traces of a pale collar on segments 4-5. The first gill appears on the already branched 5th setigerous segment.

Habitat.—Atlantic, Indian, and Pacific Oceans, and the Mediterranean Sea.

Eunice antennata Savigny.

Eunice antennata, Fauvel, 1932, p. 138.

South Point (from stones) and Phoenix Bay, Port Blair, Andamans.
Several small specimens.

Habitat.—Indian and Pacific Oceans.

Genus **Marphysa** Quatrefages.**Marphysa sanguinea** (Montagu).

Marphysa sanguinea, Fauvel, 1932, p. 141.

East Narakal and backwater between Ernakulam and Edappalli, Cochin State ; Neendakara Bar, Kayankulam Kayal, Chevara, and Quilon in Travancore State.

The specimens from muddy ground are more slender and rounded than the others, as I have already noticed (1932).

Habitat.—Atlantic, Indian, and Pacific Oceans.

Marphysa stragulum (Grube).

Marphysa stragulum, Fauvel, 1932, p. 143.

Cheppanam, Cochin State.

A small worm bears both knife-like and falcigerous setae and gills only on a few anterior segments, which is characteristic of the species.

Habitat.—Philippine Islands, and India.

Genus **Diopatra** Aud.-Edw.

Munambam Bar, Travancore State.

A few very small specimens, some of them in a dried state, cannot be identified specifically.

Genus **Arabella** Grube.

In sandy pools between tide-marks midway from Blair Reef to Chatham Causeway, Port Blair.

A fragment without head, may belong to this genus.

Genus **Lumbriconereis** Blainville.**Lumbriconereis heteropoda** Marenzeller.

Lumbriconereis heteropoda, Fauvel, 1932, p. 153.

Neendakara Bar, Travancore.

Numerous fragments with long, erect ligules on the posterior feet and hooks.

Habitat.—Red Sea, India, Japan, and California.

Lumbriconereis pseudobifilaris Fauvel.

Lumbriconereis pseudobifilaris, Fauvel, 1932, p. 154, pl. vi, figs. 7-13.

West Narakal, Cochin State; Munambam Bar, Travancore State.

This species, first described from Akyab (Burma) is distinguished by the absence of hooks, all its setae being winged capillaries, and by the presence of very long ligules in the posterior feet.

Habitat.—Akyab (Burma), and India.

Family CHAETOPTERIDAE Aud.-Edw.

Genus **Phyllochaetopterus** Grube.(?) **Phyllochaetopterus elioti** Crossland.

(?) *Phyllochaetopterus elioti*, Fauvel, 1930a, p. 41.

"Tough leathery tubes buried in sand between Chatham Causeway and Blair Reef," Port Blair (Feb. 12, 1934, H. S. Rao).

From these horny tubes, coated with sand, I succeeded in extracting only the anterior part of the worm with big palps, two eyes and two small tentacles, which I refer somewhat doubtfully to *Ph. elioti*, a species which, with a very similar tube, was previously found at Krusadai.

Habitat.—Zanzibar, and India.

Family CIRRATULIDAE Carus.

Genus **Audouinia** Quatrefages.**Audouinia semicincta** Ehlers.

Audouinia semicincta, Fauvel, 1935, p. 339.

South Corbyn's Cove, Port Blair, Andamans.

Only one small black specimen with tentacular cirri ringed alternately black and white.

Habitat.—Pacific Ocean, Annam, India, and the Red Sea (?).

Family CHLORAEMIDAE Malmgren.

Genus **Stylarioides** Delle Chiaje.**Stylarioides parmatus** Grube.

Stylarioides parmatus, Fauvel, 1932, p. 179.

Between Blair Reef and Chatham Causeway, Port Blair. "In madreporarian coral mass."

The two specimens are provided with the characteristic oval shield coated with sand. The numerous, rather slender, gills are borne on a horse-shoe-like peduncle. The palps are stout.

Habitat.—Indian Ocean, and New Zealand.

Family OPHELIIDAE Grube.

Genus **Polyophthalmus** Quatrefages.**Polyophthalmus pictus** Dujardin.

Polyophthalmus pictus, Fauvel, 1932, p. 191.

South Point (from stones in low tide) and South Corbyn's Cove, Port Blair, Andamans.

The specimens in the collection are all very small and discoloured.

Habitat.—Atlantic, Indian, and Pacific Oceans.

Family TEREPELLIDAE Grube.

GENUS **Terebella** Linne.**Terebella ehrenbergi** Grube.

Terebella ehrenbergi, Fauvel, 1932, p. 226.

Near Jones Point, Sound I., Stewart Sound, North Andaman (under stones).

This discoloured specimen, nearly translucent, still bears its three pairs of gills.

Habitat.—Red Sea, India, Andamans, Annam, and Japan.

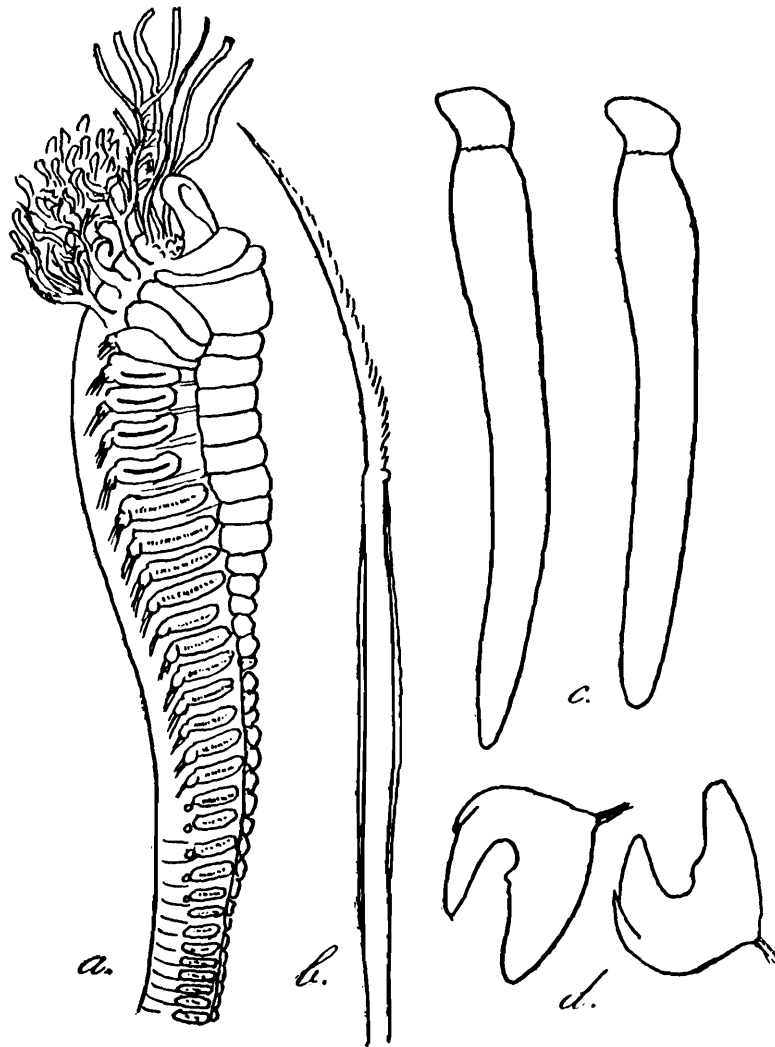
Genus **Pista** Malmgren.**Pista indica**, sp. nov.

West Narakal, Cheppanam, Chêriya Kadamakudi and backwater between Ernakulam and Edappalli—all in Cochin State.

Specific characters.—Body rather short and plump, abdomen cylindrical, with numerous short, crowded segments. 16 thoracic setigerous segments. Prostomium eyeless, with lobe bearing long and rather thick grooved tentacles. Buccal segment expanded into a dorsal arched lip. Obsolete lateral lobes on segments 2-3, 8 to 9 ventral scutes. Three pairs of bushy gills, all about the same size. Pygidium without papillae. Dorsal setae capillary, with narrow wings and a finely serrated tip. Uncini from the 2nd setigerous segment. The first four uncinigerous tori short, with a transverse row of big, long, brown hooks with a smooth tip. On the next two tori, a single row of small avicular uncini, the succeeding thoracic and abdominal segments bearing two alternating rows. Length of worm—15-30 mm. and, thorax 2-2.5 mm. broad. Colour lost in alcohol.

The 17 specimens of this curious Terebellid are all provided with 16 thoracic setigerous segments and three pairs of gills. In appearance they are much like *Terebelli lapidaria*, an equally short and stiff species. Their most striking feature, at first sight, is the presence of four

conspicuous brown streaks on each side of the thorax (text-fig. *a*). On closer examination, these brown streaks resolve into a transverse row of



Pista indica : *a.* Anterior part : $\times$ ca. 10. *b.* Thoracic bristle : $\times$ 400. *c.* Big thoracic hooks : $\times$ 160. *d.* Uncini : $\times$ 520.

very large blunt hooks, with a long and thick shaft. They recall those in *Trichobranchus* and in *Terebellides*, but are straighter and smooth at the tip (text-fig. *c*). On the 5th uncinigerous segment (6th setigerous) there is a sudden change from these big brown hooks to the usual avicular uncini. They are rather like those in *Polymnia*, with 1 to 2 slender teeth above the main fang, but very small compared to the big hooks (text-fig. *d*). They are set in a single transverse row on uncinigerous tori 5-6, which are materially longer than the four preceding ones. Next, these tori gradually decrease in length and bear two opposite alternating rows of uncini, nearly to the end of the body.

On the first abdominal segment, there is a small knob above the torus. Further back, the segments are short, densely crowded, and the tori nearly meet on the middle ventral line, without forming pinnules.

The dorsal setae are very peculiar for a *Pista*, for they are serrated at the tip, as in the genus *Amphitrite* (text-fig. *b*).

The ventral scutes are thick transverse pads up to the 9th setigerous segment. The buccal segment and the two following ones are more or less swollen. The side lobes of segments 2-3 are obsolete, reduced to a simple fold which is even wanting on swollen specimens. The gills, borne on a stout stalk, are large and bushy, all the three pairs being about the same size.

In spite of its dorsal setae with serrated tip, this species belongs to the genus *Pista*, for all its other characters agree with it. In *Pista*, the gills are branched and vary from one to three pairs, eyes are sometimes present and as often missing. Thoracic segments vary from 15 to 17. To my mind, the most striking feature of the genus is the difference between thoracic hooks, a number of the anterior ones being provided with an elongated basal process, differing thus, more or less markedly, from the usual type found in the following segments.

As I have already stated (1932, p. 232), the genus shows a tendency to form a descending series of forms, from those having the uncini with a huge chitinous shaft, as in *Pista robustiseta* and *P. mirabilis*, to those with only a slender and reduced process, with many intermediate stages.

The anterior hooks of *P. indica*, though more or less like those of *Pista mirabilis* and *P. robustiseta*, show a still more exaggerated condition of that peculiar feature with their broad shaft and their blunt tip without teeth at the vertex.

The serrated tip of the dorsal setae is unusual in the genus, but *P. polybranchiata* has dorsal setae with fine serrations seen only under a high magnification, and so also a few *Amphitrite*, in which the serration of the tip of the dorsal setae can only be detected under a very high magnification (*A. cirrata*, *A. alcicornis*).

In short, such a slight feature as the minute serrations of the tip of the dorsal setae can hardly be regarded as of generic value when in all other features the present species agrees with *Pista*.

Habitat.—India.

Family SABELLIDAE Malmgren.

Genus *Sabella* Linné.

Sabella melanostigma Schmarda.

Sabella melanostigma, Johansson, 1927, p. 121, (Synonymy).

Sabella melanostigma, Mesnil and Fauvel, 1939, p. 23.

Sabella bipunctata, Baird, Fauvel, 1914, p. 149, pl. vii, figs. 18-21.

Sabella guinensis, Augener, 1918, p. 565, pl. vi, figs. 149, pl. vii, figs. 247-249.

In sandy pools at low tide between Blair Reef and Chatham Causeway, Port Blair, Andamans.

This rather large *Sabella* has lost its branchial tuft. The ventral groove is missing or very obsolete, and then only on the posterior part. The pick-axe setae are very peculiar with their end very thin, translucent and shaped like a coal-scuttle.

Habitat.—Tropical Atlantic, Andamans, Malay Seas, and Japan.

Sabella porifera Grube.

Sabella porifera, Fauvel, 1930, p. 60.

South of Long I., Middle Andamans.

I have already recorded this species from Rameswaram.

It is easily identified by the four stout glandular pads at the base of the gills. The branchial lobes, though not coiled spirally, describe each a little more than a half circle. There are no eyes on the gills.

Habitat.—Red Sea, Indian Ocean, and Australia.

Genus **Dasychone** Sars.**Dasychone serratibranchis** Grube.

Dasychone serratibranchis, Fauvel, 1932, p. 236.

Between Jones and Mitchell Points, Sound I., North Andaman (between tide-marks).

Owing to the poor condition of the specimen, the discoloured eyes on the gills can hardly be detected and the dorsal stylodes are quite obsolete. The body is short, plump, and has lateral eye-spots.

Habitat.—India, Philippine Islands, New Zealand, and Australia.

Family SERPULIDAE Burmeister.

Genus **Ficopomatus** Southern.**Ficopomatus macrodon** Southern.

Ficopomatus macrodon, Fauvel, 1932, p. 248.

Cheppanam, Cochin State.

A small Pelecypod shell is coated with a colony of numerous tiny Serpulid tubes. These tubes are round, with a single dorsal ridge, more or less high and wavy in its distal part.

The operculum and setae of the worms are typical. Though the setae have a marked likeness to those of *Mercierella*, both operculum and tube are quite different.

Habitat.—Cochin State, Ennur backwater, Taleh-Sap, and Gulf of Siam.

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NOTES ON THE BREEDING HABITS AND EARLY DEVELOPMENT OF *MACROPODUS CUPANUS* (CUV. & VAL.), WITH SPECIAL REFERENCE TO THE CEMENT GLANDS OF THE EARLY LARVAE.

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INTRODUCTION.

Macropodus cupanus (Cuv. & Val.), originally included in the genus *Polyacanthus* (K. & v. H.) Cuv. & Val., is the only representative of the genus *Macropodus* Lacépède in Indian waters. It is a small-sized fish, common in tanks, lakes, ditches and streams, and is capable of living in foul waters which are very deficient in oxygen. Like the other members of the family Anabantidae, it is capable of breathing atmospheric air. It is a shy fish with peculiarly graceful movements, and hides by burrowing in the mud when frightened. It is considered a valuable mosquito larvivore. As our knowledge of the breeding and development of Indian Anabantoids is very meagre, it is hoped that this paper will be of some interest. The presence of cement glands in the early larvae, recorded here for the first time in the family, is of special significance.

BREEDING AND DEVELOPMENT.

Eggs of *M. cupanus* have been collected from a number of tanks in and around Trivandrum (Travancore) during the months of January, February, May, July, September, October and November. As the search for the eggs has never been continuous or exhaustive it is quite possible that the fish is a perennial breeder. Intensive breeding has been noticed during the advance monsoon rains when there are intervals of bright sunshine. According to Thomas (1870), in South Canara, its breeding season is May and June.

The nest¹ consists of a small clear space near the water edge, about 5" in diameter, devoid of all weeds and grasses, except a single stalk of a weed or grass in the middle, which serves as an anchorage for the floating egg mass. Egg masses have also been collected from the under surfaces of the leaves of water-lily and from fallen leaves in the water close to the margins of tanks.

The nest is always guarded by the male fish which remains just below the egg mass. The fins of the male are beautifully coloured and its eyes are red. There is no open communication between the nest and the main body of water except through the algae or decaying vegetable

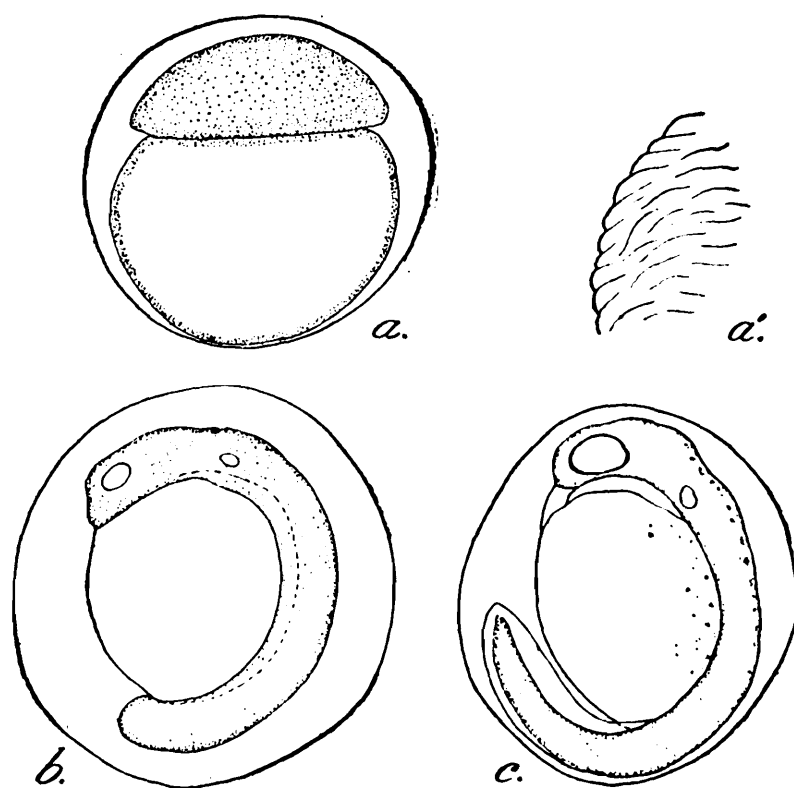
¹ In connection with the nest-building, mating and egg-laying habits of the "Labyrinth Bubble-nest Builders" reference may be made to Innes' excellent descriptions and figures in his "Exotic Aquarium Fishes" (pp. 338-361, Philadelphia: 1935) of fishes of the genera *Macropodus*, *Trichopsis*, *Betta*, *Colisa*, *Trichogaster*, *Osphronemus*, *Helostoma* and *Anabas*. His accounts are based on observations made in aquaria.

matter which presumably serve either as a place of hiding or the means of escape by the guardian fish when disturbed. The eggs are attached to the under side of a circular froth of air bubbles, which is about an inch and a half in diameter and is located in the middle of the clear space.

Mating and egg laying, which follow the preliminary acts of courtship and nest building, have been observed by the present writer under natural conditions. The breeding male, which is larger in size than the female, has its body and fins vividly coloured in different beautiful shades giving it a brilliancy seldom found under normal conditions. The female is less attractive and is of a dark dull colour. Eggs are laid in batches and during the intervals between the laying of the successive batches of eggs the female remains quietly in one place a few inches away, usually at the bottom, in a completely exhausted condition. The male is very active and busies himself with the work of substituting fresh bubbles of air in place of those lost from the bubble nest by taking occasional gulps of air and blowing it on to the under side of the nest. Once or twice it goes near the female and 'noses' it so as to create excitement. Finding no response from the female it goes under the nest and after making a brief survey inspects the mud for any egg that might have fallen down by accident. The exact procedure by which stray eggs at the bottom are brought up to the nest could not be clearly seen, though it was observed that the male remains at an angle at the bottom probing the mud for eggs. Probably the eggs are blown up. While the male is thus engaged the female begins to show signs of activity as if awakened from slumber and the male quickly noting the changed disposition of its mate approaches and touches it with confidence and the latter quickly responds to the invitation of the male and accompanies it to the under side of the nest where both make a few circles and exhibit some sort of a playful love chase for a few seconds. Suddenly the male bends round in an arch converting its body into a ring around the female which remains motionless and submissive. During this act the head of the male touches its tail, and the vent of the male comes into close apposition with that of the female. Simultaneously with this both turn over describing a semi-circle so that the female now remains with the ventral side up. They remain quiet in this condition for about 10 to 15 seconds. The beautifully coloured pelvic fins of the male stand erect in a conspicuous manner and the anterior portion of the dorsal fin shows some sign of movement. The male now relaxing its grip moves to one side and the female with the ventral side still up, before resuming the normal position, sends up a stream of about 10 to 15 eggs, which are shot up towards the mass of air bubbles by the force of the ejection and there they float with the other eggs. After this act the female steadies herself slowly with signs of complete exhaustion, just like a half dead fish that has lost its equilibrium. While the female rests at a side the male is busy looking after the nest and the eggs. This act is repeated a number of times till roughly about 300 eggs are laid. The combined weight of the eggs submerges a portion of the comparatively large mass of air bubbles, but the dorsal surface of the nest projects like a dome above the surface of water.

As indicated above, the actual nest building and mating prior to egg laying have not been observed by the present writer. Probably these actions are similar to those of the Indian Rainbow-Fish, *Colisa fasciata* (Bl. & Schn.) (= *Colisa vulgaris* Cuv. & Val.), more popularly known as the Striped Gourami, a graphic description of which was published by Carbonnier (1876). His observations were made at Paris where the temperature of the aquarium was kept at 23-25°C. (=73.4-77°F.). A large number of the Anabantoids are bubble-nest builders (Jones, 1939), whereas some have much different nesting habits. The Giant Gourami, *Osphronemus goramy* Lacépède, builds a nest of water plants (Raj, 1916 and Roxas & Umali, 1937), and *Betta picta* (Cuv. & Val.) and *B. brederi* Myers are oral brooders (Myers, 1939). In all cases parental solicitude is restricted to the male.

The eggs (text-fig. 1a) of *M. cupanus* are small, about 0.9 mm. in diameter, and the bubbles of air constituting the froth help them to



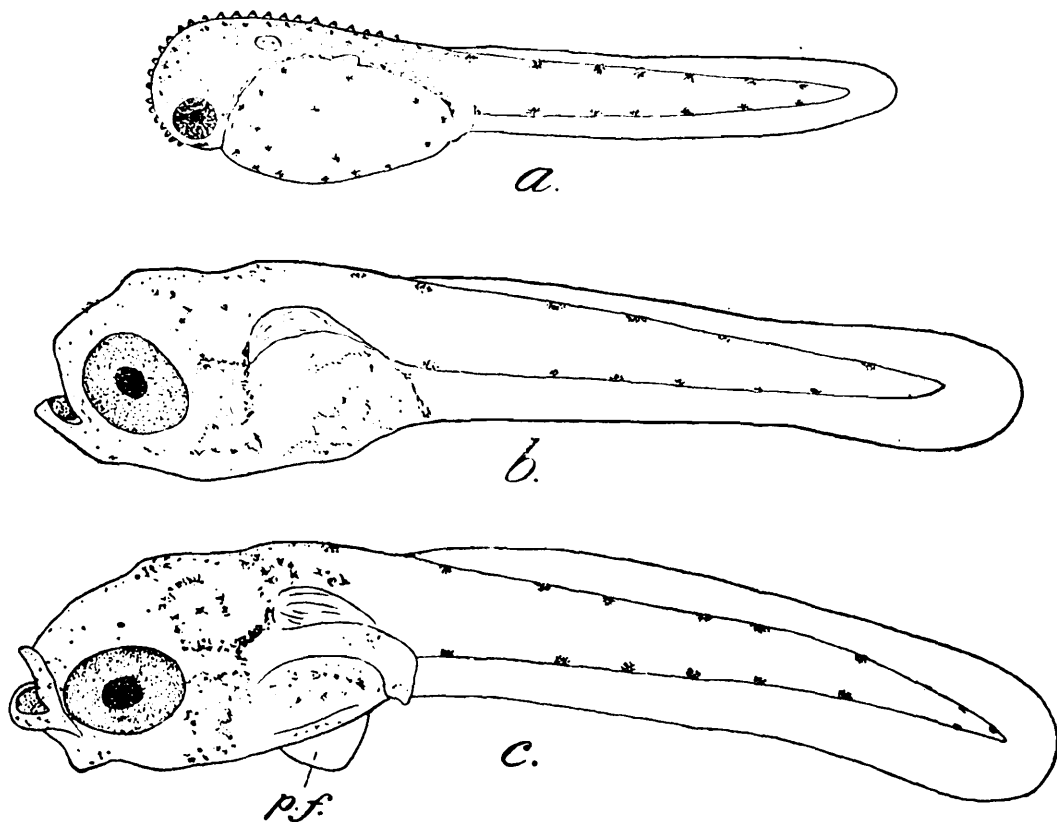
TEXT-FIG. 1.—Embryonic stages of *Macropodus cupanus* (Cuv. & Val.). All the figures are from preserved specimens.

a. Egg about 6 hours old, showing the blastoderm above and the yolk below: $\times 40$; a'. A portion of the egg-membrane highly magnified to show the surface ridges; b. Embryo 24 hours old: $\times 40$; c. Embryo 36 hours old: $\times 40$.

float. Unlike the eggs of many other Indian fishes, the egg-membrane in *M. cupanus* is not rigid, but is of a jelly-like consistency. The surface continues to be sticky for a long time and it is thrown into a series of folds or ridges (text-fig. 1a'). The eggs, though not lighter than water, are capable of floating as a result of the attached air bubbles and due to surface tension. The large mass of air bubbles constituting the froth is of a transitory nature and under natural conditions fresh bubbles are supplied by the guardian fish in place of those that have burst.

Though the large bubbles burst soon, a few small ones, which are discernible only under a microscope, remain attached to the egg membrane for a long time and they help the eggs to float. Some of these as a result of surface tension continue to float even after all the bubbles have burst, but a gentle shake wets the upper exposed surface and make them sink. Under laboratory conditions, it has been found that all floating eggs undergo healthy development, whereas most of the demersal eggs do not hatch out, probably due to lack of proper aeration.

Eggs showing early developmental stages have been usually collected in the morning, though egg laying has been observed in the afternoon also. The blastodisc which is found on one side of the yolk mass (text-fig. 1a) can easily be distinguished even with the naked eye by its white colour. The yolk is devoid of oil globules and the blastoderm completely envelopes it when about 16 hours old. In the 24 hours old eggs the embryo (text-fig. 1b) is visible with rudiments of the optic



TEXT-FIG. 2.—Larval stages of *Macropodus cupanus* (Cuv. & Val.). Figs. b. & c. are from preserved specimens.

a. Larva about 12 hours after hatching. $\times ca. 30$; b. Larva on the 3rd day (cement glands not shown). $\times ca. 32$; c. Larva on the 6th day. $\times ca. 32$.

p.f. Pectoral fin.

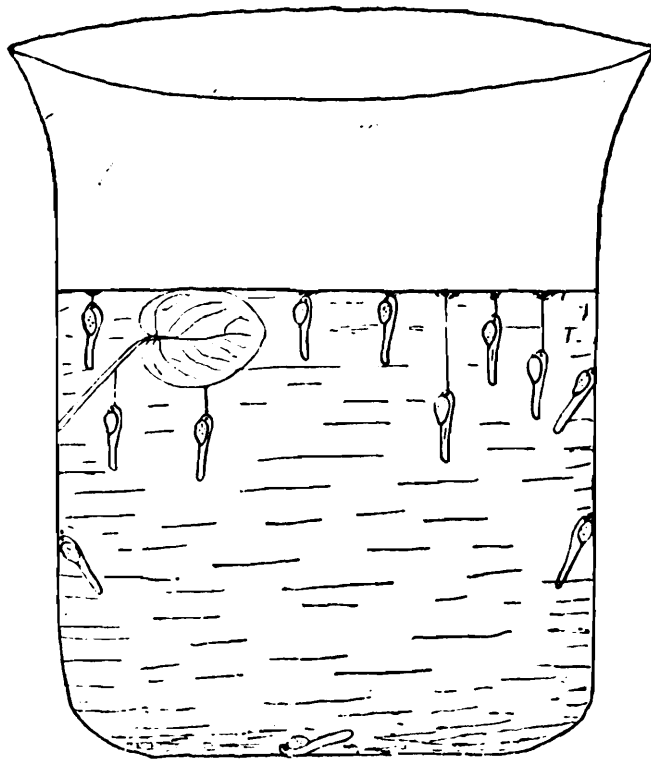
and auditory organs and the tail still attached to the yolk. Six hours later the tail is free from yolk and the heart begins to pulsate. When the embryo is about 36 hours old (text-fig. 1c) chromatophores are formed, the eyes develop the lens, the auditory vesicles have two concretions, the tail is long, the embryo wriggles inside and there is a slow blood circulation. The eyes are devoid of pigment and the median fin-fold is very narrow.

The newly hatched larva (text-fig. 2a) is 2.3 mm. in length with a large yolk mass to which the head is closely attached. The mouth,

anus and gill slits are absent at this stage. The yolk is devoid of any oil globule and the tail is protocercal. The eyes are lightly pigmented and the auditory organs have two concretions. The most interesting feature is the presence of a large number of minute cement glands all over the head and the nape which produce a mucous secretion by which the larva attaches itself to the surface film or water, to the sides of the aquarium or to floating objects in the water (text-fig. 3).

The mouth is formed on the second day, the number of chromatophores on the head increases, the eyes get darker and the larva continues to remain attached with the aid of the mucous secretion. When disturbed it darts about for some time, but reattaches itself almost immediately.

On the third day (text-fig. 2b)¹ more than half of the yolk is consumed, the gill slits are formed and the air-bladder is developed. The



TEXT-FIG. 3.—Larvae of *Macropodus cupanensis* (Cuv. & Val.) under laboratory conditions. Diagrammatic.

The larvae are suspended or attached by the mucous secretion of the cement glands. alimentary canal is still indistinct. The pectoral fins are larger but not functional at this stage.

On the fourth day, practically the whole of the yolk is absorbed, cement glands disappear, the pectorals develop and the larvae are able to move about. A small quantity of unconsumed yolk is present towards the right side and probably this is responsible for the air-bladder to be slightly disposed to the left side.

The alimentary canal could be seen on the 5th day. During the following 10 days no appreciable changes were observed. As the larvae

¹ The cement glands cannot be seen distinctly in preserved specimens though they can be distinguished without any difficulty in living specimens.

lived in captivity for about a fortnight only, further development could not be followed. The larvae at this stage can be distinguished by a dorsal and a corresponding ventral row of seven or eight chromatophores as shown in text-figure 2c. Raj (1916) refers to eight dark vertical bands in the young (17 mm. size) of *Anabas scandens* (Daldorff) [= *A. testudineus* (Bloch)] which fade away as the fish grows older. To the naked eye the chromatophores of *M. cupanus* appear as bands in the living specimens and it is probable that these may develop into definite bands in the older larvae as a larval character. There are no colour bands in the adult. Some Anabantoids, such as the Striped Gourami (*Colisa fasciata*), have colour bands in the adult also.

CEMENT GLANDS.

In a previous paper (Jones, 1938) dealing with the origin and development of the cement glands in *Etroplus maculatus* (Bloch) the author dealt with the different types of cement glands found in the different groups of vertebrates and also discussed the various views regarding their origin and homology. In conclusion it was stated that

“The origin of the cement organs as endodermal pouches in the Ganoidei has led Kerr (1906) to compare them with the pre-mandibular head cavities of other vertebrates. Reighard and Phelps (1908) are of opinion that these glands are homologous with the anterior gut pouches of Elasmobranchs, which in turn, have been homologized with the anterior gut pouches of Amphioxus, one of which, is converted into the ciliated organ (Neal, 1898 and van Wijhe, 1914). It is very doubtful if this view could be accepted from the fact that in the Teleostei, Dipnoi and Anura these organs are of ectodermal origin, though the condition in Ganoidei is in support of it. This would mean that the organ would have arisen independently in the different groups of vertebrates as suggested by Eycleshymer and Wilson (1908) who also support the suggestion of Balfour with regard to the origin of the barbels in Teleosts as seen from the fate of the cement organs in *Acipenser*. As against this view Kerr (1919) is of opinion that during ontogeny certain phases in the development of the organs have been slurred over or even omitted giving rise to a condition in Dipnoi and Anura where the organs were known to take their origin from the ectoderm. But instances, wherein different or intermediate conditions in origin within the same group, which would have gone in favour of this theory, are lacking. Still the fact that in Teleostei and Dipnoi, the two intermediate groups of vertebrates possessing cement organs, they are known to originate from the inner layer of ectoderm whereas in the more highly evolved Anura the secretory cells of the gland are derived from the superficial layer of ectoderm, cannot be without some phylogenetic significance. However, more work on the cement glands in fishes, especially of Teleosts, is required before this and the allied questions can be solved in a satisfactory way.”

Since the publication of the above paper, the author has recorded the presence of a cement gland in a Cyprinid, *Danio malabaricus* (Jerdon) [Jones, 1938a]. Here the gland is a large median structure situated just above the mouth and between the eyes; it is exactly like the one found in the African and South American Characids, *Sarcodaces odœ* (Budgett, 1901) and *Curimatus elegans* (Azevedo, Dias & Vietra, 1938) respectively. The origin of the cement gland in none of the above-mentioned forms has yet been worked out and hence little additional light can be thrown on the homology of this organ.

The cement glands of *Macropodus cupanus* are remarkable in that they are unlike those of any other previously recorded types, and their position (distribution) throws considerable light on the origin of the cement glands in the different groups of vertebrates. The cement organs of *M. cupanus* consist of numerous minute conical wart-like pro-

jections scattered all over the head and the nape, as far back as the origin of the dorsal median fin-fold. Their peculiar position shows that whatever may be their origin (ectodermal or endodermal) they can hardly be homologized with those found in the Ganoidei which have been regarded as homologous to the pre-mandibular head cavities of vertebrates. The apparently ectodermal origin, according to Kerr (1919), in the other groups of vertebrates is due to the slurring over or omission of certain phases in the development of the glands in the course of ontogenic development, giving rise to the present condition. If that is the explanation advanced for the origin of the different types of cement glands, how can the peculiar distribution of the glands in *Macropodus cupanus* be accounted for? It would be ridiculous to suggest that the glands of this fish had their origin in the anterior gut pouches, which in the course of early embryonic development were divided up and scattered throughout the head and the nape! Hence it is only reasonable to conclude that the cement glands in vertebrates are not homologous organs, but are only analogous and have arisen independently in the different groups for an identical function.

The above view of the author about the origin of these glands in vertebrates is further strengthened by the recent discovery of another very interesting type of cement gland, situated as a median cup-shaped organ on the ventral side of the yolk sac, in a Cyprinid. From whichever germ layer this gland may originate it is difficult to conceive a pre-mandibular origin for it. This point is being elaborated by the author elsewhere.

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¹ For a complete bibliography on the cement organs of vertebrates see Jones 1938, and for references on the breeding habits of Anabantoids Jones 1939.

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ON SOME EARLY STAGES IN THE DEVELOPMENT OF THE GANGETIC ANCHOVY, *ENGRAULIS TELARA* (HAM).

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INTRODUCTION.

In the course of biological investigations at the Calcutta Corporation's Water-works at Pulta, Dr. S. L. Hora made monthly collections of young fish from the *Pucca* Settling Tank No. 4 for a period of one year (Hora and Nair, 1940, p. 36) with a view to elucidate the breeding seasons and growth-rate of various fishes of the river Hooghly. These collections contained innumerable young specimens of *Engraulis telara* (Hamilton), and since the developmental stages of this important economic fish are not known, Dr. Hora very kindly suggested this work and handed over the material to me for study. It may here be mentioned that the sorting out of the collections made from the *Pucca* Settling Tank No. 4, which was entrusted to me, entailed a great deal of work as practically no accounts of the larval and post-larval forms of Indian fishes have so far been published. Even provisional identifications, therefore, involved a great deal of work and study of the various stages of growth from the youngest larvae to the post-larval forms in which adult characters were fully established.

The embryonic development of the European and Japanese Anchovies is worked out by Wenckebach (1887) and Nishikawa (1901) respectively, while Fage (1920) thoroughly studied the life-history, bionomics and the larval development of the Mediterranean Anchovy, *Engraulis encrassicholus* (Linn.). Delsman (1929) has described the spawning and the embryonic as well as the early post-embryonic stages of seven out of the ten species of *Engraulis* listed by Weber and de Beaufort (1913) from the Indo-Australian Archipelago. Hildebrand and Cable (1930), in their account of the "Development and Life-history of fourteen Teleostean fishes at Beaufort", have described the economic importance,

spawning, development and early stages of *Anchoviella epsetus* (Bonnaterre). Though unfortunately, no such investigation has so far been done for Indian Anchovies, Fage's work provides an excellent model for the study of the Indian forms.

Only two species of *Engraulis*, namely, *E. telara* (Ham.) and *E. hamiltonii* (Gray), are generally caught in the river Hooghly near Calcutta ; both the forms ascend the river during the breeding season which is not the same for the two species. From extensive collections made at Pulta, it has been ascertained that the peak-period of breeding of *E. telara* is February-March. At this season the fish is caught from the river Hooghly in large quantities, and, though it is regarded as of inferior quality on account of large number of bones, still it is of considerable economic importance.

Engraulis larvae can readily be distinguished by their greatly compressed and elongated body, wide and oblique mouth with prominent maxillaries, projecting upper jaw and wide nostrils ; while those of the two species, when sufficiently advanced, can be separated by the different vertebral counts ; *E. telara* has 57 vertebrae whereas *E. hamiltonii* has only 47. In earlier stages from a size of 10 mm. in length, when the anal fin is sufficiently developed to admit the enumeration of the rays, they can be distinguished by the number of rays in the anal fin which is 60-65 for *E. telara* even in earliest stages studied and 40-41 for adults of *E. hamiltonii*. The elongation of the outer ray of the pectoral fin, a characteristic feature of *E. telara*, becomes noticeable at a much later stage.

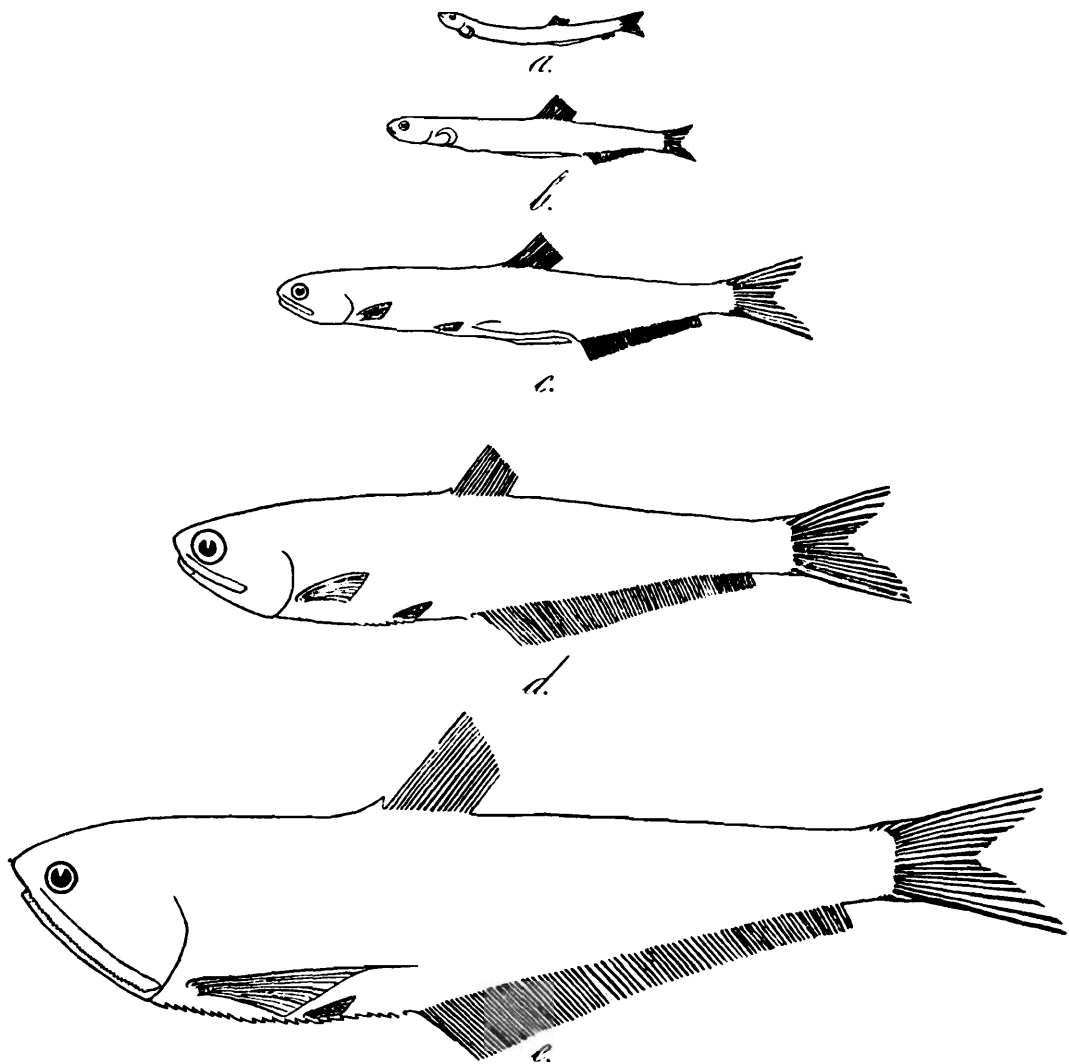
Since the number of vertebrae of fish larvae is taken as a good and reliable character in distinguishing species (Lebour 1921, p. 428), the young specimens described here were treated with caustic potash and stained with Alizarine so as to count the vertebrae without difficulty.

I take this opportunity to record my grateful thanks to Dr. Bains Prashad, Director, Zoological Survey of India, for affording me the necessary facilities for work in his department. I am highly indebted to Dr. S. L. Hora for the material, valuable suggestions and constant encouragement.

DESCRIPTION OF THE MATERIAL.

A 10 mm. larva (text-fig. 1a.) is slender, elongate, compressed and transparent without any trace of pigment. The body is of nearly uniform depth throughout. The mouth is terminal, and the prolonged maxilla can be made out clearly even at this early stage. The eye is large and black in the centre with a silver lining around it. The gill-cover is present, and, owing to its transparent nature, the gills are visible through it. The different bones of the gill-cover are very small and at this stage are not joined together to form a compact structure. The rudiments of the pectoral fins are present as rounded flaps, which, though membranous, are provided with firm basal plates and radiating thickenings. The pelvic fins are entirely absent. The anus is far behind the dorsal fin, which at this stage starts behind the middle of the total length. The anal fin is short and is connected with the caudal fin by a portion of the once continuous larval fin fold. The rays of the caudal

fin are better developed and are jointed ; this is the only properly formed fin at this very early stage. The alimentary canal is nearly straight



TEXT-FIG. 1.—Early stages of *Engraulis telara* (Ham.) from 10mm. to 50mm. in total length.

a. 10 mm. b. 15 mm. c. 25 mm. d. 35 mm. e. 50 mm.

and the intestine with the prominent folds of its mucosa can be clearly seen through the transparent abdomen. It may be observed that in the allied American Anchovy, *Anchoviella epsetus* (Bonnaterre), Hildebrand and Cable (1930, p. 391) have reported that the alimentary canal appears to lie outside the body wall to which it is joined by connective tissue. In *Engraulis telara*, at any rate, microtome sections reveal that even at this stage the gut lies entirely within the body wall. The extreme thinness and transparency of the body wall, however, gives the appearance as if the alimentary canal were lying separately from the rest of the body.

The body of 12 mm. larva is slightly broader, especially in the region of the dorsal fin. The pectoral flap is slightly larger, the anal fin is longer and has a few more rays ; the anus has shifted forward and now lies just below the posterior end of the dorsal fin, which, at this stage, commences almost in the centre of the larva.

In a specimen of 14 mm. in total length the body is still slender, though the larva has become slightly broader. The tail region is more

markedly narrow. The pelvic is still unrepresented. The dorsal fin has shifted further forward and commences slightly in advance of the middle of the larva. The vertebrae are well differentiated, and the first dorsal ray lies opposite the spine of the 22nd vertebra and the last that of the 29th. The anus is situated opposite the body of the 33rd vertebra. The head has grown proportionately bigger, the snout less pointed, while the mouth is directed somewhat obliquely upwards with a prominent maxilla.

In a larva of 16 mm., the dorsal fin has shifted further forward so that its first ray lies opposite the spine of the 21st vertebra while the last lies opposite that of the 29th. The pelvic fin has made its appearance much in advance of the dorsal fin and the anus is now situated between the 32nd and 33rd vertebrae. The mouth is terminal and oblique. The maxilla is prominent with its teeth, and reaches to about the anterior margin of the eye. The alimentary canal is still visible through the transparent abdomen.

The general shape of the body of a larva of 18 mm. in total length is similar to that of the 16 mm. size. The dorsal fin has shifted further forward and commences above the spine of the 20th vertebra and ends above that of the 28th. The pectorals are still represented by flaps with ray-like supports, while more rays have appeared in the anal fin. The anus lies opposite the 32nd vertebra. The upper jaw is slightly more prominent than the lower, and the maxilla reaches beyond the posterior margin of the eye.

In a larva of 20 mm. size the position of the dorsal fin is not changed but the anus has shifted slightly forward and lies between the 31st and 32nd vertebrae. A few chromatophores have made their appearance along the base of the anal fin. The basal plates of the pectoral flaps have decreased in size and the rays have become bigger and stronger. In all other respects it is similar to a larva of 18 mm. size.

The snout in a larva of 25 mm. in total length (text-fig. 1c) has assumed the typically Engraulid shape with a slightly longer upper jaw. The maxilla, which is quite prominent, with fairly well developed teeth, has grown considerably and now reaches to about the middle of the head. The basal plates of the pectoral flaps are greatly reduced and the fin assumes its typical form. The dorsal fin has shifted still further forward so that it commences above the spine of the 18th vertebra and ends above that of the 26th. The anus lies below the 31st vertebra. The abdomen is still smooth without any indication of scutes.

The dorsal fin and anus have shifted still further forward in a specimen of 30 mm. size; the former commences above the spine of the 16th and ends above that of the 25th vertebra while the anus lies below the body of the 27th. Mouth is terminal and obliquely turned upwards and the maxilla reaches up to the gill-cover, the different bones of which have come closer together. The body is deepest below the dorsal fin. The abdomen is still without scutes.

A 32 mm. specimen shows a considerable advance in development. The dorsal fin commences above the spine of the 15th vertebra and ends above that of the 24th, while the anus lies under the 25th vertebra. A small dorsal spine makes its appearance at this stage. The first scute

also has appeared just in front of the pelvic fins, while two or three projections of the body wall can be noticed in front of it.

The dorsal fin and anus have shifted still further forward in a specimen of 35 mm. size (text-fig. 1d). The dorsal fin commences above the spine of the 14th vertebra and ends above that of the 22nd. The maxilla has grown larger and reaches beyond the anterior margin of the gill-cover. At this stage there are altogether eight scutes in various stages of development. Six of these are in front of the pelvics and two behind them. The two scutes immediately in front of the pelvics are well developed while the four in front and the two behind the pelvics are just starting to project. The dorsal spine is very well marked at this stage.

A specimen 40 mm. long is not so slender, since the depth of the body has increased considerably. The pectoral fins are well developed. The outer ray of each pectoral fin is elongated and reaches the pelvic fin of the corresponding side. There are 13 scutes in front of the pelvics and three behind them. Out of the thirteen in front, eight are supported by ribs while the anterior five have no supports. The anus has shifted forward and lies at a point below the commencement of the dorsal fin.

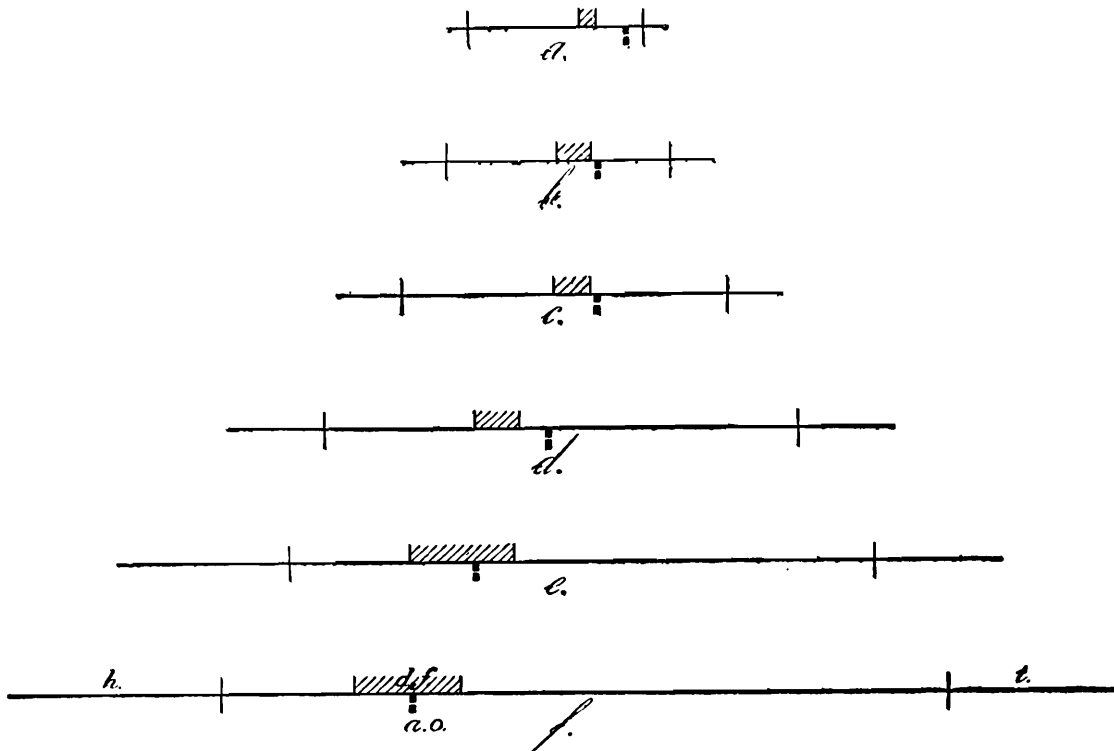
Nearly all the adult characteristics have appeared in a larva of 50 mm. in total length (text-fig. 1e). As in the adult, the dorsal fin is situated between the 13th and 21st vertebrae, the anus below the 19th vertebra, and all the 22 scutes are fully developed, 15 being in front of and seven behind the pelvic fins. The first seven scutes are in front of the first rib and hence they are not supported by ribs while the rest have rib supports. The maxilla reaches up to the posterior margin of the gill-cover. The outer ray of the pectoral fin has not yet attained the maximum length and is just within reach of the anal fin. The outer ray of the pectorals attains its full length in specimens of 82 mm. or upwards.

GENERAL OBSERVATIONS.

The chief interesting points to be noted in the stages described above are the forward migration of the dorsal fin and the anus, the development of the scutes and pectoral fin, and the gradual assumption of the relative proportions of the various parts of the body.

Forward movement of dorsal fin.—In very young specimens the position of the dorsal fin could not be noted in relation to the vertebrae since the latter did not stain with Alizarine up to 14 mm. size. Even in younger specimens the dorsal fin and anus were shifting forward as shown in text-figure 2. The dorsal fin shifts over about 9 vertebrae in its migration forward during the growth of the young from 14 mm. to 50 mm. in total length. In a specimen of 14 mm. it commences opposite the spine of the 22nd vertebra and ends with that of the 29th. During the growth of the larva, the dorsal fin travels gradually forwards and in a specimen of 50 mm., it commences opposite the spine of the 13th and ends with that of the 21st vertebra which is its permanent position in the adult fish. The first ray of the dorsal fin is converted into a spine while the last one is double but counted as one. The last double ray

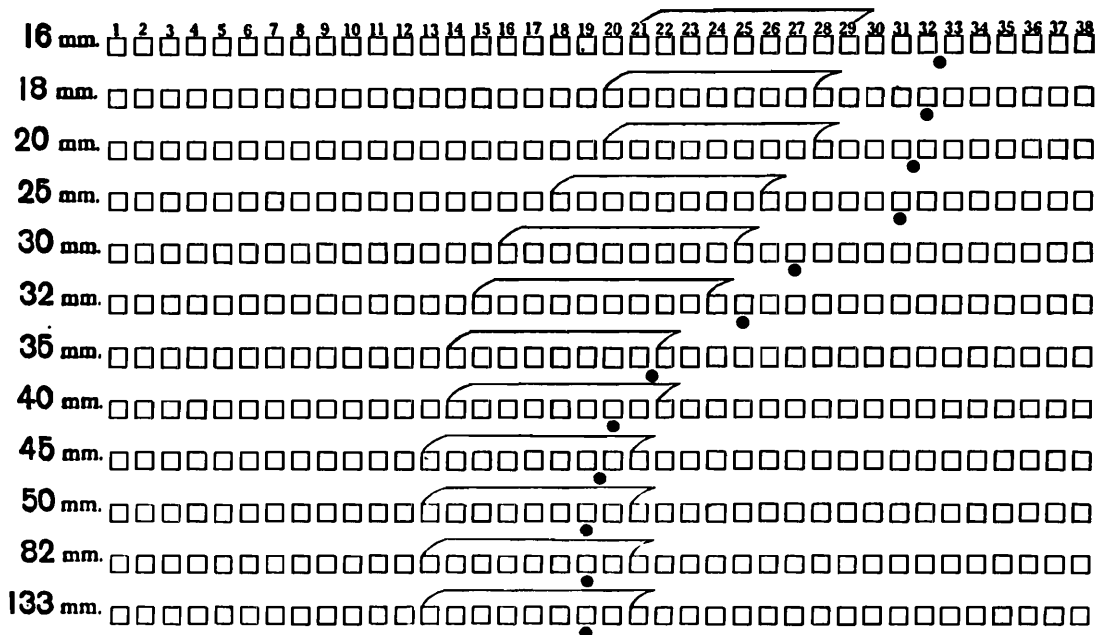
of the dorsal as well as of the anal fins are provided with smaller proximals.



TEXT-FIG. 2.—Diagrammatic construction to represent the phases of growth of the different parts of the body of the larvae of *Engraulis telara* of various sizes on the same scale.

a. 10 mm. b. 14 mm. c. 20 mm. d. 30 mm. e. 40 mm. f. 50 mm.
a.o., anal opening ; df., dorsal fin ; h., head ; t., tail.

Change in position of anus.—During the growth of *Engraulis telara*, the anus also begins to migrate forward as is already known in the case of Anchovies in the seas round Java (Delsman 1929, p. 276) and in the



TEXT-FIG. 3.—Diagram showing the positions of the dorsal fin and anus in relation to the vertebrae in *Engraulis telara* of various sizes ranging in length from 16mm. to 133mm. in total length. The squares indicate vertebrae, the black dots indicate the positions of anus during various stages of growth and the lines indicate the origin and extent of the dorsal fin. Only the first thirty-eight vertebrae are shown in the figure.

case of Pilchard, Sprat and Herring (Lebour 1921). This forward movement of the anus in relation to the vertebrae is clearly visible in Alizarine preparations. Text-figure 3 is a diagrammatic representation of the forward movements of the dorsal fin and anus in relation to the vertebrae of young *Engraulis telara* of various sizes. The anus moves over about 14 vertebrae (from 33rd to 19th) during the growth of the fish from 14 mm. to 50 mm. size. This migration may be due to an unequal growth of the posterior part of the body as suggested by Fage (1920, p. 14) and Lebour (1921, p. 429).

Development of scutes.—In an adult specimen there are 15 or 16 scutes in front of and 7 scutes behind the pelvic fins. All the scutes excepting the first seven, which are in front of the first rib, are supported by ribs. Rarely an additional scute appears in between the regular ones, and in such cases it is not supported by a rib. Such an odd scute may generally be found between the regular 15th and 16th. The development of the scutes is more or less similar to that of *Hilsa* (Nair 1939, pp. 414-415). In the case of *Engraulis telara* the first scute in front of the pelvic fins appears when the larva is 32 mm. in total length. Gradually more scutes are added until all of them are formed when the specimen reaches 50 mm. in total length.

Development of Pectoral fins.—The pectoral flaps appear very early. They are quite unlike the pectoral fins of the adult into which they become converted afterwards. To start with each pectoral flap consists of a rounded muscular basal plate, attached to the body of the larva behind the gill-opening, and provided with a thinner frill supported by slender ray-like projections arising from its outer margins. After some time this basal plate stops growing while the slender rays grow bigger and stronger to form the pectoral fins when the specimen attains 25 mm. in total length. For a time the rays of the pectoral fin grow uniformly but from the 40 mm. stage the outer rays begin to elongate. These rays outgrow the rest and reach the anal fin in a specimen of 50 mm. in total length. The elongated outer rays are jointed and attain their full length, reaching up to a third of the anal fin, when the specimen is 82 mm. long.

Relative proportions of different parts.—The forward shifting of the dorsal fin referred to above is also clear from the table of measurements and proportions given below. In a specimen of 19 mm. in total length the distance between the tip of snout and the commencement of the dorsal fin is contained about 1.7 times and the distance between the dorsal and caudal fins is contained about 4.8 times in the total length. With the forward movement of the fin the former distance is gradually reduced, so that in a specimen of 50 mm. in total length it is contained about 3.1 times in the total length, while the latter distance is contained about 2.3 times in the total length.

Text-figure 2 also shows that the growth of the different parts of the body is not equal; the diagram is so constructed as to represent the phases of growth of the different parts of the body of the larva of various sizes on the same scale. From this figure it is clear that the caudal region of the larva elongates more rapidly than the trunk, and, probably, as in the Mediterranean Anchovy (Fage 1920), that may be the reason for the forward migration of the anus and dorsal fin. In a larva of 10 mm. size the posterior region, that is the portion beyond the anus, is contained

five times in the total length of the larva while the anterior region, that is the portion in front of the anus, is $\frac{4}{5}$ of the total length. As the larva grows, these two regions also grow, but the former grows more quickly than the latter, so that in a specimen of 50 mm. size, the posterior region is about $\frac{2}{3}$ while the anterior is only $\frac{1}{3}$ the total length.

It has been indicated above that the body is very narrow in the early stages; this is borne out by the fact that the depth of the body in a specimen of 10 mm. is contained about 12.5 times in the total length while the same proportion is reduced to about 4.9 in a specimen of 50 mm. size. The height of the caudal peduncle also increases gradually along with the growth of the fish.

In the following table A. denotes the length of the base of the anal fin; AC., the distance between anal fin and caudal fin; C., the length of caudal; CP., the least height of the caudal peduncle; D., the length of base of dorsal; DB., the depth of body; DC., the distance between dorsal and caudal; H., the length of head; SA., the distance between tip of snout and anus; SD., the distance between tip of snout and the commencement of dorsal; T., the total length of the fish.

SUMMARY.

The material of young *Anchovy* described in this article was obtained from the Pulta Waterworks, Calcutta, and in determining the young forms reliance was placed on the number of vertebrae which is believed to be a constant character. For the counts of vertebrae specimens were cleared in caustic potash and stained with Alizarine. Twelve young stages of 10 mm. to 50 mm. in total length are described in detail and attention is directed to the changes in the relative proportions of the different parts of the fish during growth.

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¹ Not consulted by the author.

Table of measurements and relative proportions.

T.	C.	$\frac{T}{C.}$	DB.	$\frac{T}{DB.}$	H.	$\frac{T}{H.}$	CP.	$\frac{T}{CP.}$	D.	$\frac{T}{D.}$	A.	$\frac{T}{A.}$	SD.	$\frac{T}{SD.}$	DC.	$\frac{T}{DC.}$	AC.	$\frac{T}{AC.}$	SA.	$\frac{T}{SA.}$
mm.	mm.		mm.		mm.		mm.		mm.		mm.		mm.		mm.		mm.		mm.	
10	1.0	10.00	0.8	12.50	1.0	10.00	0.6	16.67	1.0	10.00	0.9	11.11	6.0	1.67	2.0	5.00	0.5	20.00	8.0	1.25
10	1.1	9.09	0.9	11.11	1.1	9.09	0.5	20.00	1.0	10.00	0.9	11.11	6.0	1.67	2.1	4.76	0.6	16.67	8.0	1.25
10	1.1	9.09	0.8	12.50	1.0	10.00	0.6	16.67	1.0	10.00	0.9	11.11	6.0	1.67	2.1	4.76	0.6	16.67	8.0	1.25
12	1.5	8.00	1.0	12.00	1.6	7.50	0.8	15.00	1.3	9.23	2.1	5.71	6.2	1.94	2.8	4.29	0.8	20.00	7.6	1.58
12	1.5	8.00	1.1	10.91	1.6	7.50	0.9	13.33	1.4	8.57	2.2	5.45	6.1	1.97	2.9	4.14	0.6	20.00	7.9	1.52
12	1.6	7.50	1.0	12.00	1.6	7.50	0.8	15.00	1.4	8.57	2.2	5.45	6.2	1.94	2.9	4.14	0.6	20.00	7.9	1.52
14	1.9	7.37	1.5	9.33	1.9	7.37	0.8	17.50	1.8	9.33	2.9	4.83	7.0	2.00	3.5	4.00	0.8	17.50	8.5	1.65
14	1.9	7.37	1.6	8.75	1.8	7.78	0.9	15.56	1.6	8.75	2.9	4.83	7.0	2.00	3.6	3.89	0.9	15.56	8.6	1.63
14	1.8	7.78	1.6	8.75	1.9	7.37	0.9	15.56	1.6	8.75	2.8	5.00	7.0	2.00	3.5	4.00	0.8	17.50	8.6	1.63
14	1.9	7.37	1.6	8.75	1.9	7.37	0.9	15.56	1.6	8.75	2.9	4.83	7.0	2.00	3.6	3.89	0.8	17.50	8.6	1.63
16	1.9	8.42	2.1	7.62	2.2	7.27	1.1	14.55	1.6	10.00	3.3	4.85	8.6	1.86	4.5	3.56	1.0	16.00	9.9	1.62
16	1.8	8.89	2.0	8.00	2.2	7.27	1.0	16.00	1.7	9.41	3.2	5.00	8.5	1.88	4.6	3.48	1.0	16.00	9.9	1.62
16	1.9	8.42	2.1	7.62	2.3	6.96	0.9	17.78	1.6	10.00	3.2	5.00	8.4	1.90	4.5	3.56	1.1	14.55	10.0	1.60
16	1.9	8.42	2.1	7.62	2.3	6.96	1.1	14.55	1.7	9.41	3.2	5.00	8.5	1.88	4.6	3.48	1.0	16.00	9.9	1.62

Table of measurements and relative proportions—contd.

T.	C.	$\frac{T}{C.}$	DB.	$\frac{T}{DB.}$	H.	$\frac{T}{H.}$	CP.	$\frac{T}{CP.}$	D.	$\frac{T}{D.}$	A.	$\frac{T}{A.}$	SD.	$\frac{T}{SD.}$	DC.	$\frac{T}{DC.}$	AC.	$\frac{T}{AC.}$	SA.	$\frac{T}{SA.}$
mm.	mm.		mm.		mm.		mm.		mm.		mm.		mm.		mm.		mm.		mm.	
18	2.0	9.00	2.7	6.67	2.8	6.43	1.2	15.00	1.8	10.00	3.5	5.14	9.0	2.00	5.8	3.10	1.2	15.00	11.6	1.55
18	2.1	8.57	2.7	6.67	2.9	6.21	1.1	16.36	1.9	9.47	3.5	5.14	9.1	1.98	5.8	3.10	1.1	16.36	11.5	1.57
18	1.9	9.47	2.6	6.92	2.8	6.43	1.1	16.36	1.8	10.00	3.4	5.29	9.0	2.00	5.8	3.10	1.2	15.00	11.6	1.55
18	2.0	9.00	2.8	6.43	2.8	6.43	1.1	16.36	1.8	10.00	3.5	5.14	9.0	2.00	5.9	3.05	1.2	15.00	11.5	1.57
20	2.3	8.69	2.8	7.14	2.9	6.90	1.4	14.29	1.9	10.53	4.5	4.44	9.8	2.04	6.8	2.94	1.4	14.29	12.1	1.65
20	2.2	9.09	2.9	6.90	2.8	7.14	1.6	12.50	1.9	10.53	4.8	4.17	9.8	2.04	6.9	2.89	1.4	14.29	12.1	1.65
20	2.4	8.33	2.9	6.90	3.0	6.67	1.5	13.33	1.8	11.11	4.9	4.08	9.9	2.02	7.2	2.78	1.5	13.33	12.0	1.67
20	2.4	8.33	2.8	7.14	3.1	6.45	1.4	14.29	1.9	10.53	5.0	4.00	10.0	2.00	7.2	2.78	1.4	14.29	12.1	1.65
25	2.5	10.00	3.0	8.33	3.2	7.81	2.0	12.50	2.0	12.50	6.0	4.17	11.2	2.23	9.3	2.69	1.7	14.71	14.3	1.75
25	2.6	9.62	3.0	8.33	3.2	7.81	2.1	11.90	2.0	12.50	6.1	4.10	11.1	2.25	9.4	2.66	1.7	14.71	14.2	1.76
25	2.4	10.42	3.1	8.06	3.3	7.58	2.1	11.90	2.1	11.90	6.1	4.10	11.0	2.27	9.3	2.69	1.7	14.71	14.3	1.75
25	2.5	10.00	3.0	8.33	3.2	7.81	2.0	12.50	2.0	12.50	6.0	4.17	11.2	2.23	9.3	2.69	1.7	14.71	14.3	1.75
30	4.2	7.14	3.9	7.69	4.4	6.82	2.0	15.00	2.8	11.07	8.8	3.41	11.0	2.73	12.6	2.38	2.0	15.00	14.5	2.07
30	4.2	7.14	3.9	7.69	4.4	6.82	2.0	15.00	2.9	10.34	8.7	3.45	11.3	2.65	12.5	2.40	2.0	15.00	14.6	2.05
30	4.0	7.50	3.8	7.89	4.5	6.67	2.1	14.29	2.7	11.11	8.8	3.41	11.3	2.65	12.6	2.38	2.0	15.00	14.5	2.07
30	4.1	7.32	3.8	7.89	4.4	6.82	2.1	14.29	2.7	11.11	8.8	3.41	11.3	2.65	12.6	2.38	2.0	15.00	14.5	2.07

1940.]

K. K. Nair: *Early Stages of Engraulis telara.*

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35	4.7	7.45	6.2	5.65	6.0	5.92	2.5	14.00	3.0	11.67	12.3	2.85	12.5	2.80	14.8	2.36	3.0	11.67	15.0	2.33
35	4.7	7.45	6.1	5.74	6.1	5.74	2.4	14.58	3.1	11.29	12.2	2.87	12.3	2.85	14.9	2.35	3.1	11.29	15.1	2.32
35	4.8	7.29	6.2	5.65	6.1	5.74	2.5	14.00	3.0	11.67	12.3	2.85	12.4	2.82	14.7	2.38	3.1	11.29	15.0	2.33
35	4.7	7.45	6.1	5.74	6.1	5.74	2.5	14.00	3.0	11.67	12.2	2.87	12.5	2.80	14.8	2.36	3.1	11.29	15.0	2.33
40	5.8	6.90	7.0	5.71	7.9	5.06	2.9	13.79	4.1	9.76	15.2	2.63	13.5	2.96	16.2	2.47	2.9	13.79	16.0	2.50
40	5.7	7.02	7.0	5.71	7.8	5.13	2.8	14.29	4.1	9.76	15.2	2.63	13.4	2.99	16.3	2.45	2.9	13.79	16.1	2.48
40	5.7	7.02	7.1	5.63	7.9	5.06	2.8	14.29	4.1	9.76	15.3	2.61	13.3	3.01	16.3	2.45	2.9	13.79	16.1	2.48
40	5.7	7.02	7.0	5.71	7.9	5.06	2.8	14.29	4.1	9.76	15.2	2.63	13.4	2.99	16.3	2.45	2.9	13.79	16.2	2.47
45	6.5	6.92	9.0	5.00	8.5	5.29	3.8	11.84	4.1	10.98	18.0	2.50	14.2	3.17	20.2	2.23	3.1	14.52	17.0	2.65
45	6.3	7.14	8.9	5.06	8.4	5.36	3.8	11.84	4.2	10.71	18.5	2.48	14.1	3.19	20.3	2.22	3.0	15.00	17.2	2.62
45	6.4	7.03	8.9	5.06	8.4	5.36	3.7	12.16	4.2	10.71	18.4	2.45	14.1	3.19	20.3	2.22	3.1	14.52	17.1	2.63
45	6.5	6.92	8.9	5.06	8.5	5.29	3.8	11.84	4.2	10.71	18.4	2.45	14.1	3.19	20.3	2.22	3.1	14.52	17.0	2.65
50	7.3	6.85	10.1	4.95	9.6	5.21	4.2	11.90	4.5	11.11	20.2	2.48	16.0	3.13	22.2	2.25	3.4	14.70	18.1	2.75
50	7.3	6.85	10.0	5.00	9.5	5.27	4.2	11.90	4.4	11.36	20.1	2.49	16.0	3.13	22.3	2.24	3.5	14.29	18.0	2.78
50	7.4	6.76	10.1	4.95	9.6	5.21	4.2	11.90	4.4	11.36	20.3	2.46	16.0	3.13	22.2	2.25	3.5	14.29	18.3	2.73
50	7.5	6.67	10.1	4.95	9.6	5.21	4.2	11.90	4.5	11.11	20.5	2.44	16.0	3.13	22.1	2.26	3.5	14.29	18.3	2.73

AN INVESTIGATION ON THE NUTRITION OF THE PERCHES OF THE MADRAS COAST.

By T. J. JOB, *M.Sc.*

(Conducted at the University Zoological Research Laboratory, Madras.)

(Plates V, VI.)

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INTRODUCTION.

Despite the great importance of the question of the food of fishes, with its varied bearings on feeding adaptations, migration and allied topics of considerable scientific interest, and economic issues connected with the development of fisheries and the biological control of human diseases, very little attention has so far been devoted to the subject. As Sim (1883) observes, pond owners seem to have been content to throw a few handfuls of oats occasionally into their ponds, while others "considered themselves more 'knowing' when, before putting the oats they had it steeped for a time in ale" The study of the food of fishes began to attract the attention of scientific men only towards the close of the last century, and since then several ichthyologists have tackled the subject both in the New and the Old World. As the nature of the food depends to a great extent upon the nature of the environment, the problem is interesting from specific as also ecological viewpoints. In India very little is known about the nutrition of the fishes of our waters. But for stray remarks on the stomach-contents of certain fishes and more or less detailed papers on the food of *Sardinella longiceps* (Hornell and Nayudu, 1923), of *Sardinella gibbosa* (Devanesen, 1932), of certain marine fishes from Ceylon (Southwell, 1913), of certain larvicidal fishes (Sen, 1937; Hora and Nair, 1938; Roy, 1938; Job, 1940a) and of the Mountain Barbel (Malik, 1940), no detailed information is available regarding the food and feeding habits of the great variety of fishes which are found in the Indian waters.

Professor R. Gopala Aiyar, Director, University Zoological Research Laboratory, Madras, suggested to me that an investigation on the food and feeding habits of the perches would be of great value, since many of them are highly prized as food-fishes in different parts of the country. In the present paper an attempt is made to record the food of the perches of the tropical waters in an analytical manner.

The work was conducted in the course of two years, 1936-1938, under the supervision of Professor R. Gopala Aiyer, at the University Zoological Research Laboratory, Madras, and I am thankful to him for his kind encouragement and constant help, especially in the identification of the Polychaete food items. I am grateful to Dr. Baini Prashad, Director, and Rai Bahadur Dr. S. L. Hora, Assistant Superintendent, Zoological Survey of India, Calcutta, for kindly going through the manuscript and for their helpful suggestions. My thanks are also due to Dr. F. H. Gravely for enabling me to check some of the identifications of Crustaceans with the help of the collections in the Madras Government Museum, to Diwan Bahadur Dr. B. Sundara Raj, Director of Fisheries, Madras, for facilities for observations on the feeding activities of fishes in the Madras Marine Aquarium, to Mr. N. D. Sundararama Sastri, Head of the Department of Statistics, Madras University, for examining the statistical part of the paper and to Mr. R. Velappan Nair for his kind help in the preparation of the diagrams. I am grateful to the University of Madras for the award of a Research Studentship which enabled me to carry out this detailed study.

GENERAL OBSERVATIONS.

The perches form a large and world-wide group of Acanthopterygian Teleosts embracing forms ranging from the smallest spiny-rayed fishes like *Microperca punctulata* and species of *Ambassis* up to the gigantic sea-perches such as *Epinephelus tauvina* recorded to grow to as much as seven feet in length and in weight to about three hundred pounds. They are cosmopolitan in their habits, thriving in the sea, brackish and fresh waters of the temperate and tropical regions. Many of the Indian species are marine, and are regarded (Nayudu, 1939) as "deep-sea prime fishes". Several of them enter estuaries and bodies of brackish water up to the tidal limit, while some like the 'cock up', *Lates calcarifer*, even migrate to fresh waters to prey upon their weaker neighbours. Many of them are hardy and wholesome food-fishes, esteemed in coastal regions as well as in the inland districts, and some of them yield valuable bye-products such as isinglass. Along the Madras Coast several genera occur almost all the year round.

Perches are of immense economic importance. Moses (1922) in his statistics of the fish supply of Madras, has shown that for the year from July 1921 to July 1922, 75,118 pounds of sea-perches worth more than eleven thousand rupees were caught from the Madras Coast besides 21,511 pounds of 'cock up' worth about six thousand rupees. The fishery of these fishes depends not a little upon the nature and regular supply of their food, both as regards its quality and quantity, and a study of their food and feeding habits, therefore, constitutes one of the first steps in the ways and means to be adopted for conserving and increasing their numbers,

Very little systematic information is available regarding the food of the perches and all that is known is confined mainly to the freshwater forms. Speaking about *Lucioperca*, Günther (1880) says that "like all its congeners it is stated to be voracious and destructive to smaller fish", and about the British bass, *Labrax lupus*, he adds that with its large stomach and voracious appetite it had won for itself the appellation 'lumpus' from ancient Romans. In the XXIst volume of Encyclopedia Britannica mention is made of *Perca fluviatilis* occurring in lakes as deep as fifty fathoms, but ascending to four thousand feet, being strictly carnivorous and most voracious, and of its wandering about in small shoals within a certain district playing sad havoc among small fishes and hence not to be tolerated in waters where fry of valuable fish are to be cultivated. O'Donoghue and Boyd (1934) studying the stomach-contents of nine specimens of the same species caught from the West Loch near St. Abbs, say that they fed on practically the same food as the trout, and observe that they are serious competitors in this way, though the extent of the menace depends upon the number of perches present and the amount of food available. Jordan (1907) speaks of the darters or 'dwark perches', Etheostominae of America, as carnivorous, voraciously feeding on larvae of Diptera. Referring to the Sacramento perch, *Archoplites interruptus*, the same writer cites Green describing how upon the introduction of catfish into the Sacramento, the perch fed on young catfish and died as the catfish erected their spines and tore the stomach walls. Pearse and Achtenberg (1918), dealing with the habits of the yellow perch in Wisconsin lakes, observe that it is a versatile feeder, usually feeding on or near the bottom. They analysed the diet and determined the percentages of the constituents by volume, noting the seasonal variation in the same. They found that it feeds mainly on larvae of Crustaceans and insects, on Entomostraca, small Teleosts and a few Oligochaetes. Lebour (1919) in her study of the food of young fish states that of the two young specimens of *Morone labrax* measuring 6 mm. obtained from the region of the Panther Buoy in May and June, the stomach of one contained Copepod remains, while that of the other was empty. In India no systematic work on the food of perches has so far been carried out.

MATERIAL AND METHODS OF STUDY.

Six hundred and forty-one specimens of fish belonging to eighteen species referable to eight genera, as detailed in the following statement, were examined—

Order PERCOMORPHI¹

Sub-order PERCOIDEA

Division Perciformes

Family APOGONIDAE

Genus *Apogon* Lacépède.

Apogon nigripinnis Cuv. & Val.

Genus *Ambassis* Cuvier and Valenciennes.

Ambassis gymnocephalus (Lacép.).

¹ The classification adopted by Weber and Beaufort (1929; 1931; 1930) has been followed.

Family SERRANIDAE

Sub-family EPINEPHELINAE

Genus *Epinephelus* Bloch.*Epinephelus boenack* (Bl.).*Epinephelus undulosus* (Q. & G.).*Epinephelus maculatus* (Bl.).*Epinephelus tauvina* (Forsk.).*Epinephelus lanceolatus* (Bl.).

Family THERAPONIDAE

Genus *Therapon* Cuvier.*Therapon puta* Cuv. & Val.*Therapon jarbua* (Forsk.).Genus *Pelates* Cuvier and Valenciennes.*Pelates quadrilineatus* (Bl.).

Family LEIOGNATHIDAE

Genus *Gerres* Cuvier.*Gerres punctatus* Cuv. & Val.

Family LUTIANIDAE

Sub-family LUTIANINAE

Genus *Lutianus* Bloch.*Lutianus johnii* (Bl.).*Lutianus lutianus* Bl.*Lutianus lineolatus* (Rüpp.).*Lutianus sanguineus* (Cuv. & Val.).*Lutianus vaigiensis* (Q. & G.).

Sub-family POMADASYANAE

Genus *Pomadasys* Lacépède.*Pomadasys maculatus* (Bl.).*Pomadasys olivaceous* (Day).

The investigation was directed towards determining the details of the natural diet of these fishes since what is eaten in captivity is never a reliable criterion of their natural tastes. Again different species show specific preferences, and only by examining the contents of stomachs of the various species caught from their natural environment can the details of their diet be determined, and as Knauthe (1907) says, "the value of food must be determined biologically even more than phenologically or chemically"

The limits of the present study are indicated in the title of the paper, the observations being mainly confined to specimens obtained from catamarans returning from the sea, from the Chintadripet Market and from catches of fishermen from the rivers Cooum and Adyar, while in a few cases they extended to collections from the Buckingham canal and the Fort St. George moat. Except in the cases of the catches from the Adyar, the Cooum, the Buckingham Canal and the Fort St. George moat it was not possible to study the environmental conditions directly; for, in the absence of a sea-going boat, the statements of the fishermen returning from the sea had to be relied upon (of course these have to be taken with some reserve), while in the case of specimens purchased from the market, even this was not available. In all cases whenever possible

the approximate time of catch was noted with a view to determining the amount of feeding activity during different hours, as early in the morning, late in the forenoon, early in the afternoon and towards evening and nightfall. The specimens usually reached the laboratory dead. They were identified and labelled. The length of each specimen from the extreme anterior end of the snout to the end of the caudal fin was taken, the animal being held straight on a measuring tape. The fish was then cut open and the extent of feeding was recorded by noting the state of distention of the stomach and the amount of food contained in it. The following symbols are used in the account given :— 1 represents a full stomach, while 1+ represents a stomach gorged with food ; 0.8 represents pretty full, 0.6 about half full, 0.4 containing appreciable amount of food, 0.2 a little, 0.1 very little and 0.0 an empty stomach. Since the amount of food present in the stomach may depend, among other factors, upon the interval between the actual time of feeding and the capture of the fish and upon the stage of digestion and the passage of digested stuff into the intestine, this method of estimating the stomach contents is only a rough one, but this was the only practical method that could be adopted for getting an approximate idea of the extent of feeding under natural conditions.

The stomach-contents were carefully removed and examined immediately whenever time permitted it, or stored in 5 per cent. formalin in tubes to be examined later. The maturity of the specimens was determined from the condition of the gonads, that of the females from the nature of the ovaries and of the males from the presence or absence of fully formed sperms in the genital ducts. Often the size and colour of the gonads were useful indications for determining the state of their development.

In the analysis of the food-contents, the larger elements were identified with the help of a hand-lens. To distinguish the smaller organisms the gut-contents were transferred part by part to slides. After the addition of a little water they were spread out under a binocular microscope, and when this was not sufficient, the elements were teased out and examined under cover-slips with a compound microscope. After separating the different constituents of the food, their volumes in percentages were roughly estimated and recorded. From individual tabulations thus made, monthly lists were prepared. The food was often more or less mixed with mucus and it was not always possible actually to measure the volumes of the different components, and so Pearse's method (Pearse, 1915—cited by Breder and Crawford, 1922) was adopted for the estimation of the quantities of the various items of food. " Briefly in this method the contents of each sample is considered as unity, the various items being expressed in terms of percentage by volume as estimated by inspection " Obviously a rough estimate alone can be obtained by such a method ; but none other was feasible. It has to be noted that frequently only small quantities of food such as the ceratophores of a Polychaete or the scales of a fish would be found ; yet in the absence of evidence of other food having been eaten, such contents had to be listed as 100 per cent. Polychaete or Teleostean remains as the case might be. However, as Breder and Crawford (*op. cit.*) explain,

“these errors would be naturally compensating rather than cumulative”, and in the tables presented here, giving the averages for the different months and for the total number of fish examined, these do not appear to be very significant.

The exact determination of the food of the species under consideration presented several difficulties. The fishes did not always have food in the stomachs. It is significant, as Aflalo and Marston (1904) explain, that many fishes have the habit of throwing their last meal when captured, and “whether they do so in pain, in terror or in some hope of throwing over ballast when struggling for life and liberty, we can only surmise, but the habit is very familiar to fishermen and anglers.” Hardy (1924) more or less agrees with these observations as far as the young herring is concerned. Many of the perches in the present study were caught in the immediate presence of the writer. But none of them showed any direct evidence in support of such a view and as Ogilvie (1927) observes in the case of post-larval herrings “even the shock of capture” never seemed “to have induced any attempt to get rid of” the food-contents. Regurgitation or sudden ejection of food-contents was never seen, except when live specimens were suddenly thrown into the preserving fluid. However, several of the fishes examined were found with empty stomachs. While in the case of gravid females, ripe males and spent up individuals this may partly be explained as being due to a retardation of the food capturing activity in the breeding season, in other cases this explanation does not hold good. More or less long intervals of complete or partial starvation are not infrequent among fishes. Thus Pearse and Achtenberg (*op. cit.*) observe that perches in the Wingra and Mendota lakes have periods when little or no food is eaten. Again Devanesen (*op. cit.*) remarks that *Sardinella gibbosa* refrains from feeding at intervals. It is only reasonable to suppose that in cold blooded forms nutriment is mainly employed for growth, hardly any being required for the maintenance of body temperature. While the abstinence from feeding may in some cases be for the purpose of giving rest to the stomach (Devanesen, *op. cit.*), in others it may be due to the lack of hunting for food.

The perches studied, excepting the species of *Epinephelus*, seem to digest their food fairly rapidly; for the stomach-contents were very often seen to be in a more or less advanced stage of digestion. Regarding the items of diet themselves, it was not always easy to identify them. The larval forms of many species are by no means well known. Sometimes the food consists partly or wholly of these or other delicate organisms, and when these have been submitted to the strong solvent action of the gastric juice, it is often difficult, if not impossible, to determine precisely the species or even the genus to which the organisms belong. But since a fish usually takes whatever edible material the water within its range contains and which its peculiar alimentary apparatus enables it to appropriate, it is apparent that the exact identification of the food elements is usually of little importance when carried beyond a certain point.

In the case of the Crustaceans¹, identification was comparatively easy, the chitinous test, especially of the smaller forms, being fairly tough and flexible and often found more or less complete among the stomach-contents. Even when only fragments were obtained the genus if not the species to which they belonged could be determined. Characteristic appendages were often helpful in the identification of the species. Annelids were easily acted upon by digestive juices, and often the only evidence obtained of their presence was some mucus mixed up with setae and sometimes parts of segments. Teleosteans met with were usually post-larval forms, but the fins, when present, gave a fairly good clue to their identification. The Molluscs obtained were all minute forms and when their shells were perfect, as occasionally they were, they could easily be distinguished; but often they were fragmentary, being corroded by the gastric juice if not crushed by the raptorial pharyngeal teeth of the fish. The Echinoderms observed usually consisted of discs and arms of tiny Ophiuroids, but sometimes small specimens were seen to appear intact, while at times broken plates and spines were the only evidence for Echinoderms having been taken in. One interesting point observed during the analysis of the food-contents was that Campanulariid colonies occasionally formed a portion of the menu of *Therapon puta*, while Ciliates such as *Zoothamnium* were eaten in the form of large tufts by *Therapon jarbua*. In rare instances small quantities of Foraminiferan shells and sand particles were met with. Devanesen (*op. cit.*) found Foraminiferans and sand particles in some of the specimens of *Sardinella gibbosa* caught from the Kundugal point, while the vast majority of the specimens examined by him never contained them, and he left this as a problem yet to be solved. In the perches, however, the traces of Foraminifera and sand can be explained as accidentally swallowed along with the food, or taken indirectly, being conveyed as the food of the prey. Houston (cited by Day, 1883) showed "at the Zoological Society a 2½' long angler containing inside its stomach the skeleton of a 2' long cod, within whose stomach again were contained the skeleton of two whiting of ordinary size, while inside the stomach of each of these lay numerous half digested bones of little fishes too small and too comminuted to be identified" This shows that in the consideration of the stomach-contents the food of the prey which is consumed is a factor that cannot be ignored.

Statements about the details of observations with regard to the perches dealt with follow in the order in which their names are listed in the contents. In each case concise introductory observations are followed by a general analysis of the diet. Detailed records of the stomach-contents of the individuals examined are tabulated, omitting those with empty stomachs. Diet tables are appended showing percentages, by months, of the different food items. In the case of species like *Therapon puta*, *Therapon jarbua* and *Lutianus vaigiensis* large numbers of which were examined, the average percentages of the various food items for the species are represented in text-fig. 1. The average percentages for the total number of specimens under individual genera

¹ My thanks are due to my colleague, Dr. N. Kesava Panikkar, for his kind assistance in the identification of several Crustaceans.

are represented by charts on plate VI. In suitable instances graphs are also given to show the minima and maxima of the important kinds of food at different times of the year. Photographs of pickings from typical stomach-contents of various species are included in plate V.

OBSERVATIONS ON THE STOMACH-CONTENTS OF PERCHES.

Genus **Therapon** Cuvier.

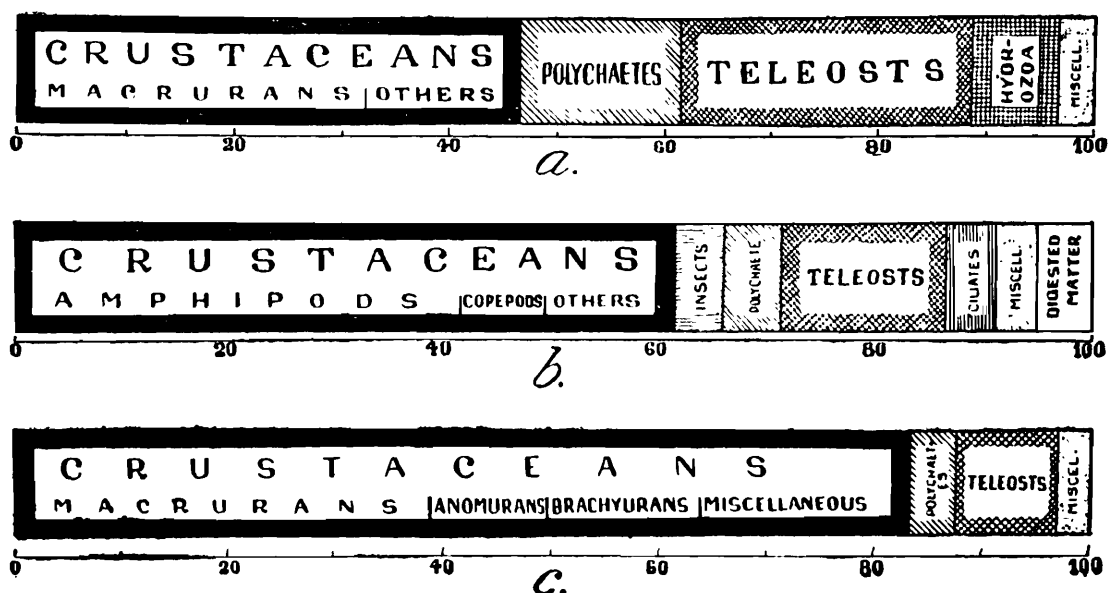
Fishes of this genus have been observed to inhabit the tropical Indo-Pacific seas, some entering fresh waters. While the species of the Australian rivers are entirely limited to fresh waters and valued as food, the Indian species are not very much esteemed, being small in size and reputed to feed on carrion, but they are eaten by the poorer classes. The only record available about the food of the genus is the brief statement by Günther, that these fishes feed "usually on small sized prey of comparatively soft consistency" Of about twenty species comprising the genus the common ones occurring at Madras are *Therapon puta* and *Therapon jarbua*. Two hundred and forty-one specimens, representing these two species were examined. Plate VI, fig. 1 represents the proportions of the food-components for the genus as represented by the two species studied.

Therapon puta Cuvier and Valenciennes.

The "Kove Keetchan" of Madras is a widely distributed marine fish which has been observed to enter brackish waters. Hora (1923), however, mentions it as living "in salinities varying from fresh water to water as saline as that of the Bay of Bengal" At Madras it is caught by fishermen in large numbers both from the sea as well as from the mouths of the rivers Adyar and Cooum, being most abundant from October to March. Here it grows to a size of six and a half inches in length. Its flesh is not much esteemed, but in season it is cheap and easily available in large quantities.

Eighty-two specimens were obtained from October 1936 to April 1937, and their stomach-contents were duly examined. The catches were made in the forenoon, usually between 9 A.M. and 11 A.M. and in the afternoon, between 3 P.M. and 6 P.M. Eleven of them were caught at 9 A.M., 43 at 10 A.M., 6 at 11 A.M., 18 at 3 P.M. and 4 at 6 P.M. Their size ranged from 100 mm. to 159 mm. As regards their sex, the males outnumbered the females, their numbers being 45 and 37 respectively. Of the males 5 were immature, 29 were fully mature and 11 were nearly spent. Of the females, 1 was immature, 6 were fairly mature and the gonads of the remaining 30 were fully developed. Food was present in the stomachs of 38 specimens. Analysis of the food-contents shows that *Therapon puta* is almost exclusively carnivorous. Traces of algae and other vegetable matter, which were only rarely met with, might have been taken quite accidentally. About half of the total food was made up of Crustaceans, about one-quarter of Teleosteans and the remainder consisted of the following:—Polychaetes, Hydrozoa, Molluscs, plants,

Salpa, Foraminifera and sand. Thus the chief food is of a type similar to that which is hunted by sight—a type which may be said



TEXT-FIG. 1.—Charts representing the proportions of the food-components of (a) *Therapon puta* Cuvier and Valenciennes; (b) *Therapon jarbua* (Forskål); (c) *Lutianus vaigiensis* (Quoy and Gaimard).

(The proportions are the results of dividing the totals of the percentages of the different food items of individual fishes of each species by the number of fish with food in stomach.)

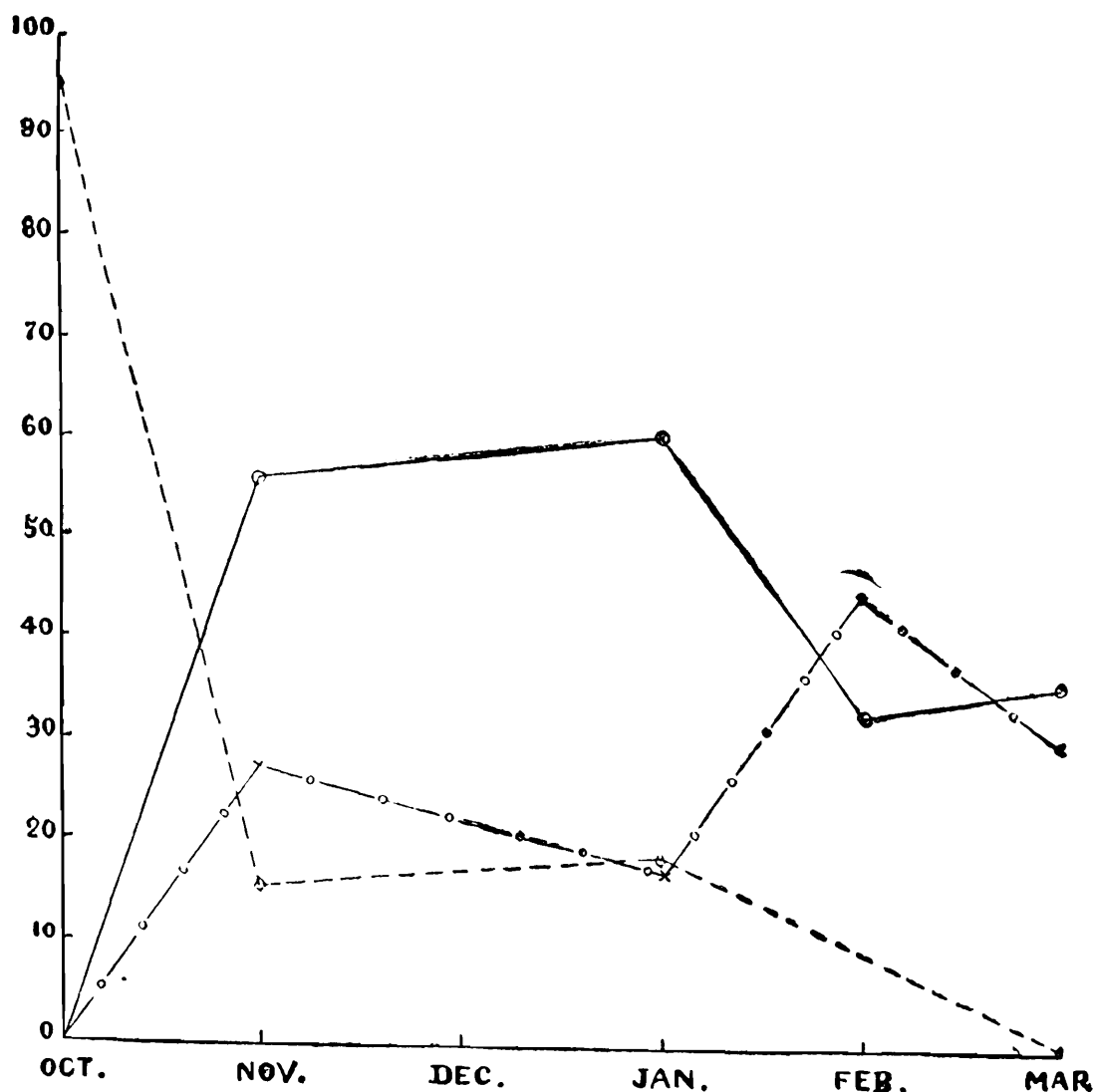
to be 'more solid' than the fragile microplankton which forms the usual food of the herring described by Huxley (1881). It has to be observed that the proportions of the components vary in different months. This is not surprising since as Yarrell (cited by Sim, *op. cit.*) has noted the food of fishes is very different at different times of the year. Details of the diet of *Therapon puta* are as follows:—

Crustaceans.—Decapods, mainly Macrurans like *Acetes erythraeus*, *Penaeus indicus*, *Palaemon lamarrei* and *Leander* sp. composed the main portion. The Decapods, though absent in the October specimens, rose to more than one-half of the total food in November, and thereafter continued to form a considerable part of the diet. Besides Macruran Decapods, small numbers of Brachyuran crabs, traces of Anomurans, Isopods. Amphipods, Mysids and Entomostracans represented by Copepods and Pedunculate Cirripedes were occasionally eaten. Cirripedes that were usually found in association with the branchiae of crabs were probably swallowed along with the latter.

Polychaetes.—The maximum was in October, nearly 95 per cent. of the total food in that month being composed of them. But thereafter the amount decreased gradually until in March only traces of them were found.

Teleosteans.—Appearing in fairly large quantities in November, Teleosteans continued thereafter to form a considerable proportion of the food. Usually they were in the form of post-larval fishes such as *Megalops cyprinoides*, *Pellona* sp., *Elops* sp., etc., while packets of fairly large fish scales were often found with neither the soft parts nor any trace of the endoskeleton of the prey. This fact, especially the fairly

large size of the scales, indicates that this species might have been feeding on some dead fish of a large size or on the offal from the "table" of some larger fishes of prey.



TEXT-FIG. 2.—Monthly variations in the proportions of the three chief food-components of *Therapon puta* Cuvier and Valenciennes during the period of investigation.

(The abscissa represents the months and the ordinate, the percentages; the continuous line represents Crustaceans eaten, the broken line Polychaetes and the chain Teleosteans.)

Molluscs.—Minute Bivalves and small Cephalopods were also found in small numbers.

Coelenterates.—Colonial Hydrozoans such as *Laomedea spinulosa* and *Thyroscyphus juncea* were met with in rare cases.

Salps.—These were extremely rare, being found only in a solitary instance in the month of March.

Foraminiferans.—These again were but rarely seen, being observed only in a single case in the month of February. They belonged to the genus *Polystomella*.

Vegetable matter.—Algae and sea weed were obtained only in minute traces from the stomach of one fish in October and of another in March.

Sand.—In spite of the frequent turbidity of the waters in which the fish feeds, sand was not usually found in the stomachs, and with the exception of Polychaete tubes the only instance of its presence was in

one fish in November, and even in this case it formed a very small percentage of the stomach contents.

Parasites.—No entozoic parasites were discovered in the stomach of any of the fish examined.

Plate V, fig. 1 shows pickings from typical stomach-contents of *Therapon puta*. Table 1 gives the details of the size, sex, stomach-contents, etc., of the 38 specimens found with food. Diet table 1 shows the percentages of the different items of food for the different months. Text-fig. 1a shows the percentages for the total number analysed. Text-fig. 2 represents the monthly variation of the three chief constituents of the diet of this species.

***Therapon jarbua* (Forskål).**

The “Palin Keetchan” is another member of this genus very common along the Madras Coast. It is a hardy fish, characterised by three, or sometimes, four large downwardly convex lateral bands on either side. At Madras the fish occurs both in the open sea and in the brackish-water near the mouths of the rivers Cooum and Adyar, and also in the Fort St. George moat. It is found to breed in the Adyar river. Specimens measuring up to 9" have been obtained, while, according to Day, it attains a size of 12 to 13 inches. The flesh is fairly good eating, especially when the fish is mature and full of fat.

As for previous observations on the food of this fish, Tickell (cited by Day, 1888) remarks that *Therapon jarbua* is termed in Arracan as ‘nga-sabasa-msa’ (paddy eating fish), in consequence of the young being so frequent in the inundated rice fields. Wilson (1917) and Moses (*op. cit.*) have recorded it to be a mosquito larvicide.

During the present investigation 159 specimens were examined in the months of January, April, May, September and October, in the year 1937. The fish were caught, some in the forenoon between 8 and 10 A.M. and others in the evening between 3 and 6 P.M. The largest specimen measured 171 mm. in length, while the smallest was 28 mm. long. Of these, 47 were found to be males, 71 females, and in the remaining 41 the sex could not be determined. Of the males 39 were immature and 8 had fairly well-developed gonads. Sixty-four females were immature, while 7 specimens had their ovaries very well developed. Seventy-one specimens were found with food in their stomachs.

An examination of the stomach-contents shows that while the fish is a versatile feeder, Crustaceans and Teleosts form the major portion of the diet. Small quantities of Polychaetes and insect parts were found among the stomach-contents of many. Filamentous algae were seen in a few cases. Eggs of both fishes and Crustaceans were occasionally met with. A small percentage of the food was in a digested state and could not be identified. A general analysis of the diet is as follows :—

Crustaceans.—Amphipods, such as *Grandidierella gilesi*, *G. magna* and *Paracalliope fluviatilis*, were the chief items. Natantian Macrurans like the young ones of *Penaeus indica* and *Palaemon lamarrei* appeared

in small proportions. Copepods, such as *Pseudodiaptomus annandalei* and *Acartia southwelli*, were occasionally met with, especially in September and October. Mysids like *Mesopodopsis orientalis* and *Rhopalophthalmus egregius* were present in a few samples. *Squilla*, *Caprella* and Crustacean eggs also appeared in small quantities.

Teleosteans.—These were very frequent both as young of Clupeids like *Pellona* sp. as well as packets of large scales.

Polychaetes.—The amount of Polychaetes consumed was conspicuously small, and these were mainly *Owenia* sp. and *Marphysa graveleyi*.

*Insects*¹.—A number of mosquito larvae and larvae of mayflies and dragonflies were found among the stomach-contents of several fish, especially young ones. Even adult mosquitoes, with well-developed wings, were found to have been swallowed. Obviously the fish devours the adult insects as they emerge out of the pupal cases or settle on the surface of the water for oviposition and may even spring out of the water and snap at them as they hover near the water surface. Maggots of insects and adult mites also occurred in a few cases. Some of these fish were caught from the Fort St. George moat. Though the fish does not feed exclusively on mosquito larvae, the large numbers of the latter observed in the stomachs of many individuals show that they are active larvicides and will be of use in the biological control of mosquito-borne diseases. These findings agree with the statements of Wilson (*op. cit.*) and Moses (*op. cit.*). The present observations, however, indicate further that while in the sea and river mouths *Therapon jarbua* appropriates Crustaceans and Teleosteans swimming about it, in enclosed waters it feeds ravenously on insect larvae² and also that the fish is a better larvivore in the young and immature stages³ when its comparatively feeble mouth-parts induce it to prefer larvae and other elements of a fragile nature.⁴ Wilson states that the species can be found in all backwaters and will live and thrive in brackish- and fresh-water ponds. The fish being easily acclimatising, the possibility of transporting it into inland

¹ I am thankful to Mr. S. Jones, Assistant Entomologist to the Government of Travancore, for his kind assistance in the identification of some of the insect remains.

² Scepticism has been expressed in certain quarters (Sen, 1937; Roy, 1938) about the efficiency of indigenous fishes as larvicides in the destruction of mosquitoes. Several authors are, however, convinced about the utility of indigenous species with larvivorous tendencies. Hora (1937) affirms, and the practical results obtained by workers such as Chatterjee (1933; 1934), Gravely (1937), Hora and Nair (1938); and Job (1940a) corroborate this, that the "biological control of mosquito larvae by the use of fish will prove very effective in India", though "considerable work on proper lines remains to be done to determine the utility of the different species under field conditions."

³ A decrease in the proportion of insect elements consumed as the young fish grows into adult has been observed also in the case of Pickerel (Hunter and Rankin, 1939).

⁴ It is sad to note that large numbers of *Therapon jarbua* are too often caught along with larger fishes and prawns, and, being too small for consumption, are thrown away to perish on the shore. The writer has often observed that many of the "Katcha valai" used by the shore fishermen have their meshes too small to allow the escape of the young fish (Plate V, fig. 3). Such wasteful methods of fishing resulting in the destruction of large numbers of these young fish not only inhibit the number of large ones which would otherwise thrive and fill our waters, but also take away a valuable agency of mosquito-control. Such criminal waste continues in the absence of proper legislation regarding methods of fishing in this country.

waters and utilising it both as a food-fish¹ and a larvicide are quite obvious.

Vegetable matter.—The occasional appearance of filamentous algae like species of *Oscillatoria* and other vegetable remains are only to be explained as being taken in accidentally along with the normal diet.

Protozoa.—Tufts of *Zoothamnium* sp. were met with both alone and in association with egg masses in several specimens. In this connection it may be mentioned that Jones and Job (1938) have observed in the case of 'Synoecy?' between *Acentrogobius neilli* and *Zoothamnium* sp. that though colonies of *Zoothamnium* sp. flourished in the oral region of the fish, the stomach-contents of no specimen of *A. neilli* revealed any indication of *Zoothamnium* sp. having been swallowed. Unlike *A. neilli*, *Therapon jarbua* was seen to have deliberately consumed appreciable quantities of *Zoothamnium* sp.

Parasites.—No entozoic organism was observed among the stomach-contents.

Plate V, fig. 2, shows pickings from typical stomach-contents of *Therapon jarbua*. Table 2 gives the details of the stomach-contents of the specimens found with food. Diet table 2 gives the volumetric percentages of the food-constituents for the different months. Text-fig. 1b represents the percentages for the total number of specimens studied.

Genus *Pelates* Cuvier and Valenciennes.

Pelates quadrilineatus (Bloch).

This is one of the commonest perches caught from the Madras coast. The largest number of specimens were obtained from October to January. The fish is often found to enter the brackish waters of the Adyar and the Cooum. Specimens measuring up to 6 inches have been secured, while Weber and Beaufort (1931) have recorded a length of 8½ inches. The flesh is not much of a delicacy, but being a cheap and abundant food fish, it is of considerable value to the poor. The author could find no previous record regarding the food of this fish.

One hundred and forty adult specimens were examined from August 1936 to the end of February 1937. The catches were made usually in the forenoon, while a few were obtained in the evening. The length of the specimens ranged from 108 mm. to 152 mm. Sixty-nine of them were males and seventy-one females. Of the males, 3 were immature, 29 were seen to be advancing towards maturity and 30 possessed fully developed gonads, while 7 were in a spent condition. Of the females,

¹ There is a prejudice attached to *Therapon jarbua* as it is reputed to be a carrion-feeder, and this stands in the way of its popularity as a food-fish. However, during the present investigation no evidence of its feeding on corpses has been seen, and the only evidence of its ever having tackled discarded parts of offal from the "tables" of larger fishes of prey was the occurrence of packets of large fish scales in the stomach; for it is incredible that it could have swallowed Teleosts of such a size as to own such large scales. In waters where abundance of life and a variety of low forms exist, fishes cannot be expected to develop epicurian tastes. Perches are not the only creatures which may prey upon an appetising morsel of animal remains, and even if the "zoned perch" could occasionally be detected in the vicinity of some drifting carcase, it would be unjust to taboo it as an exclusive carrion-feeder, considering the amount of wholesome food discovered in the stomachs of the numerous individuals examined in the course of the present study.

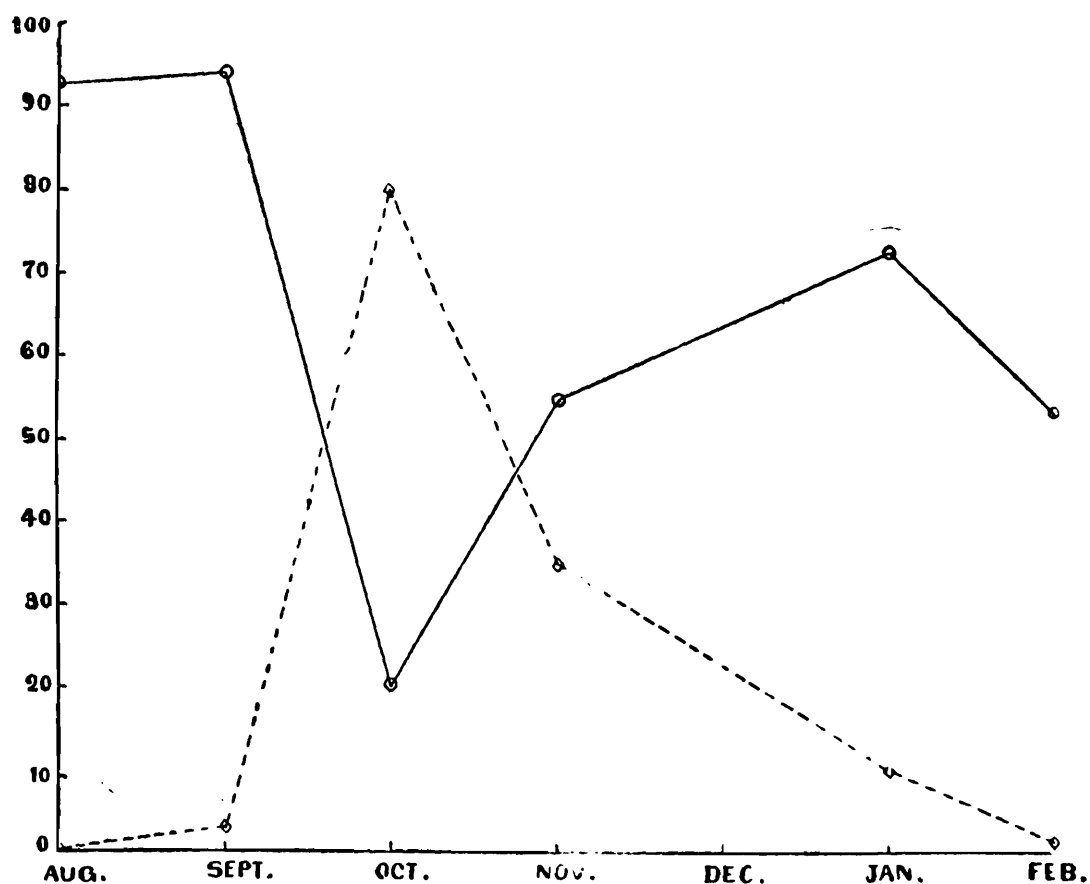
6 were immature, 15 were fairly mature and 43 had fully developed gonads, whereas the ovaries of 7 were in a spent state. As to the extent of feeding, 79 specimens had considerable amounts of food in the stomach. Even in the others the intestines often contained undigested parts of food, chitinous tests of Crustaceans, Polychaete setae etc., while not rarely shrimps and other Crustaceans were met with, gorging the mouth and the oesophagus. However, among all the catches made, both in the morning as well as in the afternoon, specimens were found with moderate quantities of animal food. Hence it may be concluded that though intermittent feeders, they are carnivorous in taste, appropriating available food at all hours of the day. Only in one instance was the stomach seen to be gorged with food (1+); two were just full (1), four were pretty full (0.8), eleven were about half full (0.6), twenty-three 0.4, twenty-nine were 0.2, nine 0.1 and the remaining sixty-one were empty (0.0). The data given in table 4 point to the conclusion that in general, as far as this fish is concerned, the feeding activities grow sluggish as the gonads ripen, though the fish may not completely cease to feed. In this respect the fish agrees more or less with the salmon, trout and anadromous shad (Day, 1883). This is probably owing to the reproductive activity engaging the major part of the fishes' energy, rendering them comparatively weak and incompetent to chase and capture their usual prey. Also, immediately after spawning the fish seem to be exhausted by the effort, so that feeding activity is again at a low ebb during this period. These observations are confirmed by the fact that gravid specimens captured and handled are most often seen to be comparatively lethargic and inactive.¹

A study of the food-contents reveals that the fish feeds ravenously on Crustaceans, about three-fifths of the total food being composed of them; Polychaetes form about one-fourth and the remainder is made up of Molluscs, Teleosteans, vegetable matter, Echinoderms, Foraminiferans, Polyzoans and occasional traces of sand particles, of which the last might have been accidentally swallowed.

Crustaceans.—About two-thirds of the Crustaceans consumed are Decapods, about one-sixth Amphipods and the remainder miscellaneous Crustaceans. The Decapods are mainly Macrurans, and of these the Sergestid, *Acetes erythraeus* is the most dominant. *Penaeus indicus*, *Alpheus malabaricus*, *Palaemon lamarrei* and species of *Leander* and *Leucifer* also were often met with. In August the Macrurans appeared in large quantities, but little was seen in the fish examined in September and October. However, they again began to appear in considerable proportions from November onwards. The chief Amphipods were *Grandedierella magnae* and *Paracalliope fluviatilis*. They were eaten in large quantities in August and September; then followed a decline in their amount, but they again began to rise in appreciable quantities towards January and February. The miscellaneous Crustaceans were Mysids like *Mesopodopsis orientalis* and *Rhopalophthalmus egregius*, Stomatopod larvae, Entomostraca represented by Copepods

¹ Regarding the Mountain Barbel, *Oreinus*, Malik (*op. cit.*) writes, "During the breeding season the ripe males and females probably give up feeding and depend for nourishment on the fat stored in the viscera".

like *Pseudodiaptomus annandalei*, *Pontella danae*, *Acartia southwelli*, etc. and Ostracod fragments. Occasionally Bopirid and Sphaeromid Isopods



TEXT-FIG. 3.—Monthly variations in the proportions of the two chief food-components of *Pelates quadrilineatus* (Bloch) during the period of investigation.

(The abscissa represents the months and the ordinate, the percentages: the continuous line represents Crustaceans eaten and the broken line Polychaetes.)

were met with. These, however, might have gained entrance into the stomach of the fish as parasites of the prey which was swallowed.

Polychaetes.—Tube-dwelling spioniform Polychaetes like *Owenia* sp. formed the main item. Small quantities of Eunicids such as *Marphysa gravelyi* and *Diopatra variabilis* and a few larval worms were also common. Most of the Polychaetes, especially the larvae, were seen to be very much acted upon by the digestive juices, and the setae were sometimes the only remains left undissolved. Polychaetes were rare in August, but soon rose up to a maximum of about 80 per cent. in October while they again began to decrease towards February.

Mollusca.—These were mainly small Gastropods like *Gyraulus* sp. with fragments of bivalves.

Teleosteans.—Teleosteans were but sparingly eaten, being found only in a solitary instance in the month of January. On another occasion a post-larval Clupeid, *Pellona elongata*, was discovered entangled in the gills of a specimen; but this was probably a case of accident.

Vegetable matter.—In rare cases minute quantities of species of *Oscillatoria* and *Trichodesmium* were met with. But as these were invariably seen to be in an unplasmolised state it is very likely that these had been devoured accidentally along with the Invertebrates which are usually

associated with filamentous algae. Hence the fish cannot be said to be intentionally vegetarian to any cognisable extent.

Echinoderms.—These were minute Ophiuroids like *Ophiothela danae* and *Ophiothrix* sp., traces of Echinoids and spines and fragments of shells.

Parasites.—But for a solitary case of a Trematode discovered in the month of August and traces of Nematodes met with in very rare cases, no entozoic organism was seen in the stomachs of the fish.

Table 3 gives the details of the 79 specimens of *Pelates quadrilineatus* which had food-contents in their stomachs. Diet table 3 shows the volumetric percentages of the various articles of diet appropriated by the species in the different months, while Pl. VI, fig. 2 represents diagrammatically the proportions of the food-components for the genus *Pelates* as represented by the total number of specimens. Text-fig. 3 shows the monthly variation in the percentages of the two main constituents of the food.

Genus *Lutianus* Bloch.

Extensively salted and dried in many localities, fishes of this genus are all as a rule good for food, though a few are said to be rather insipid in the fresh state. Day (1873) mentions that these (included by him under the genus *Mesoprion*) are of "great value in the production of food, because they appear to come inland to breed and are consequently much more frequently captured, some growing very large" Bridge (1922) speaks of some species as normally hermaphrodite. One hundred and fourteen individuals belonging to five species of the genus were examined. These are:—*Lutianus vaigiensis*, *L. sanguineus*, *L. lutianus*, *L. lineolatus*, and *L. johnii*. Plate VI, fig. 3 represents the proportions of the food components for the genus as represented by the five species.

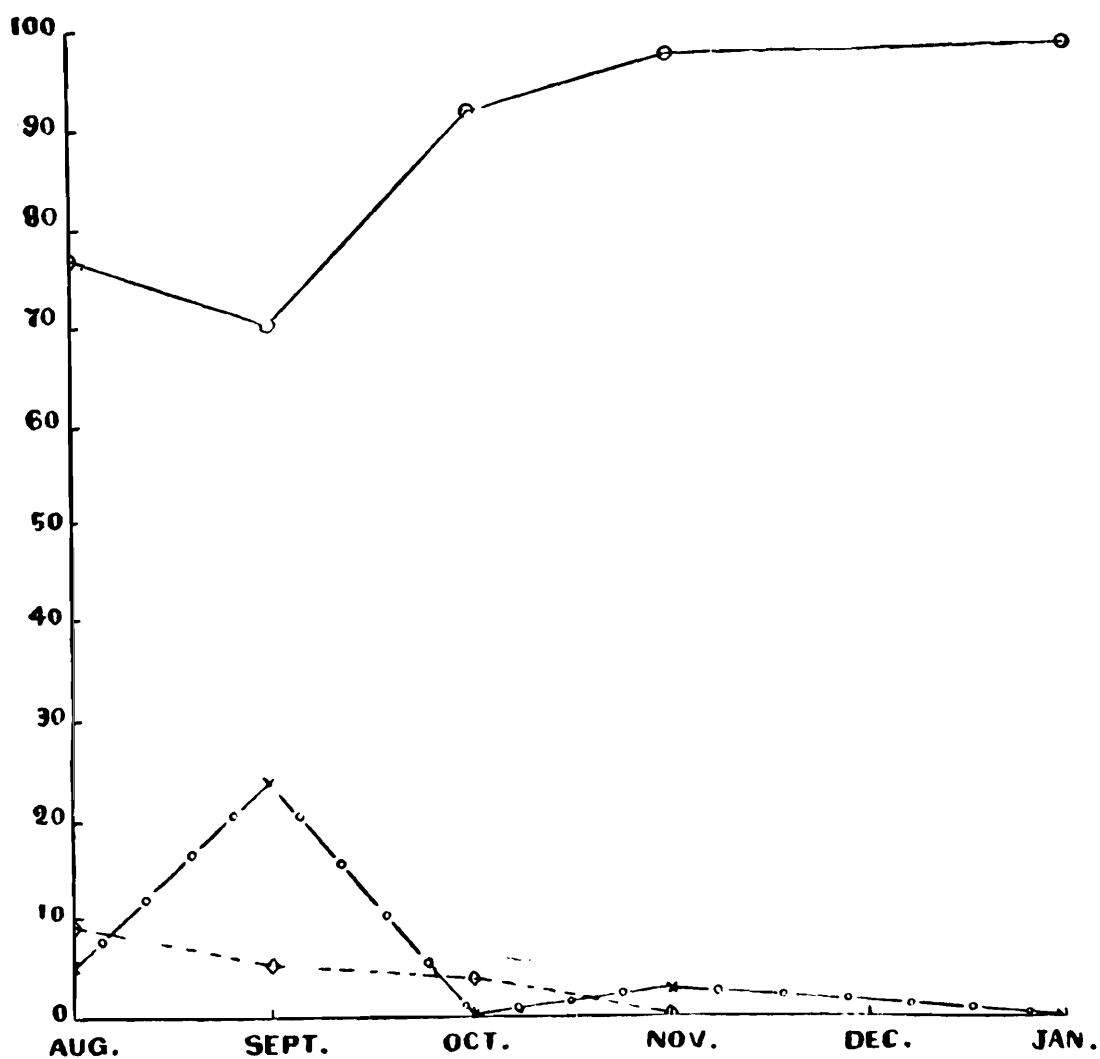
Lutianus vaigiensis (Quoy and Gaimard).

Eighty-eight specimens of the "sungarah" were obtained from August 1936 to April 1937 except for the months of December, February and March. The catches were made in the forenoon between 10 and 11 A.M. and in the afternoon between 2 and 6 P.M. The size of the individuals ranged from 80 mm. to 164 mm. Food was present in the stomachs of 29 fish. As the gonads were poorly developed in the specimens the sexes could not be made out.

An analysis of the food contents shows that the fish feeds mainly on Malacostracan Crustacea, supplemented by traces of Teleosteans, Copepods and Polychaetes. Less than 2 per cent of the food was seen to be composed of vegetable matter. But as this was always found in an unplasmodised condition it does not warrant one to regard the fish as intentionally vegetarian. The details of the diet are as follows:—

Crustacea.—From three-fourths of the total food in August and September Crustaceans rose to nine-tenths in October and almost cent per cent from November onwards. *Acetes erythraeus* was the most dominant item. Shoals of this Crustacean have been followed and consumed, since no fewer than 34 of them were discovered in some of the

fish. *Metapenaeus monoceros* was eaten in October. *Alpheus malabaricus* was also frequent in that month. Hermit crabs appeared in considerable proportions in September and October, while *Hippa* were seen exclusively in the stomach of an individual in the month of April. Brachyuran crabs like *Grapsus maculatus*, *Neptunus pelagicus* and *N. sanguinolentus* were very common from August to October, rising to very high percentages in the latter months. Schizopods like *Mesopodopsis orientalis* and *Rhopalophthalmus egregius* appeared in small quantities in August and in large numbers thereafter. Amphipods were seen from August to October, mainly represented by *Grandedierella gilesi*. Stomatopod larvae were met with in rare cases in September. Entomostracans were represented by Copepods which occurred in minute quantities in August and October.



TEXT-FIG. 4.—Monthly variations in the proportions of the three chief food-components of *Lutianus vaigiensis* (Quoy and Gaimard) during the period of investigation.

(The abscissa represents the months and the ordinate the percentages; the continuous line represents Crustaceans eaten, the broken line Polychaetes and the chain Teleosteans.)

Teleosteans.—In August and September small Carangids and Clupeids appeared in plenty, while fish scales appeared in small quantities in November.

Polychaetes.—Small quantities of *Pectinaria* sp. and *Laonome indica* were eaten in August, *Diopatra variabilis* in August and September, and some *Marphysa gravelyi* in October.

Vegetable matter.—About 4 per cent of the stomach-contents in August and October were composed of algal matter, while traces of it also appeared in January. But for this and a tiny piece of sea-weed found swallowed in November the fish were decidedly carnivorous. Possibly the vegetable matter was accidentally swallowed along with the animal diet.

Of the twenty individuals caught in the forenoon, three were gorged with food, two were full and the stomach-fill in the case of two was 0·8, in two 0·6, in two 0·4, in two 0·2 and only seven were devoid of food. Of the forty-two specimens caught in the evening, one was full, and the stomach-fill in the case of four was 0·8, in five 0·6, in one 0·4, in one 0·2, in four 0·1 and twenty-six were empty. As far as the data show, in general, feeding is comparatively more active in the earlier part of the day than late in the evening. Plate V, fig. 4 shows pickings from typical stomach-contents of the species. Table 5 gives the details of the contents. Diet Table 4 shows the percentages of the items of diet for the different months. Text-fig. 4 represents the monthly variations of the three chief constituents of food. Text-fig. 1c represents the proportions of the food-components for the species.

Lutianus sanguineus (Cuvier and Valenciennes).

Seven specimens were obtained in the month of August. Their lengths ranged from 180 mm. to 200 mm. Only in two individuals food appeared in appreciable quantities. The stomach-contents consisted of Crustaceans like *Leucifer*, Decapod appendages and a Pedunculate Cirripede, cycloid scales, Gastropod remains and Teleostean otoliths along with a piece of intestine, probably of a Teleost. Table 6 gives the details of the stomach-contents. Diet Table 5 shows the percentages of the items.

Lutianus lutianus Bloch.

Six specimens were obtained in the month of August. They were caught in the afternoon. In no case were the gonads sufficiently developed to distinguish the sex. The largest specimen measured 164 mm. in length and its stomach was nearly full of food, which consisted of a partly digested Carangid, a little *Oscillatoria* and some digested stuff. The stomach of another which measured 155 mm. was about half full, the contents being made up entirely of partly digested Teleostean remains, mainly *Ambassis* sp. A third measuring 152 mm. contained only a small amount of fish remains, digested stuff and algal filaments. The stomachs of the other three specimens were empty. Table 7 gives the details of the stomach-contents. Diet Table 6 shows the percentages of the items.

Lutianus lineolatus (Rüppell).

Twenty specimens were examined, 10 in September and 10 in October. They measured from 108 mm. to 146 mm. The gonads were poorly developed. Only two of the specimens had full stomachs, while 8 had small quantities of food and the rest were empty. The food was chiefly composed of Teleosts (55 per cent) and the remainder consisted of digested stuff. Table 8 gives the details of the stomach-contents. Diet Table 7 shows the percentages of the items.

Lutianus johnii (Bloch).

Five specimens were obtained in November. The largest one measured 300 mm. and the smallest 22 mm. The gonads were not well developed. Only two fish contained food in the stomach. The food consisted of remnants of Teleosts (25 per cent), Brachyuran remains (50 per cent), Chitinous tests (10 per cent) and digested matter (15 per cent). Table 9 gives the details of the stomach-contents. Diet Table 8 shows the percentages of the items.

Genus **Epinephelus** Bloch.

This genus comprises the "sea perches" proper (Günther, 1880). The majority are small, about one to two feet, while many like *Epinephelus tauvina* attains a length of about 7 feet and a weight of about 300 lbs. Owing to their predaceous habits some are even said to be dangerous to man. Günther mentions bathers having been "attacked at the Seychelles and Aden by a gigantic species, the persons having died from the injuries received" Nearly all of the numerous species are edible and esteemed as food. Several species are reported by Bridge (1922) to be normally hermaphrodite. Usually living in the coastal and deep waters of the tropical and sub-tropical seas, a few species are said to enter brackish- or even fresh-water. Those ascending rivers, however, do so for predaceous purposes, as all of them spawn in the sea. At Madras the species are all marine, but, small specimens of some, such as *Epinephelus tauvina*, are found to enter the mouths of the Adyar and the Cooum. Forty-two specimens of five species were examined. Plate VI, fig. 4 represents the proportions of the food-components for the genus as represented by them.

Epinephelus tauvina (Forskäl).

21 specimens were obtained from September 1936 to February 1937 excepting the month of December. The size ranged from 93 mm. to 222 mm. The gonads were in all cases undeveloped. One of the specimens was seen to be gorged with a large sized crab. 13 were devoid of food. Two were full, and the stomach-fill in two were 0.6, in one 0.4, in one 0.2 and in one 0.1. They were caught, two in the forenoon between 10 and 11 A.M. and the others in the afternoon between 2 and 4 P.M.

Crustaceans formed the main constituent, the chief components being hard-shelled Brachyuran crabs like *Neptunus pelagicus* and *Dotilla* sp.

It is significant that the crabs were found to have been swallowed whole, unlike the case of the "native dora", a Mediterranean perch, which is said to grind up the calcareous carapace. It is surprising how *E. tauvina* breaks up the hard test of these crabs especially since the stomach walls are more or less thin and transparent when distended with food. Probably their digestion is so powerful that a considerable portion of the test is dissolved as in the case of the cods described by Day (1883). Next came Macruran Decapods like *Leander* sp., and a considerable portion of the stomach contents was made up of small Teleosts. One specimen obtained in December 1937 was seen to have swallowed a fairly large specimen of *Therapon puta*, with which its stomach was gorged (Plate V, fig. 6). Table 10 gives the details of the stomach-contents. Diet Table 9 shows the percentages of the items. Plate V, fig. 5 shows pickings from typical stomach-contents of *Epinephelus tauvina*.

***Epinephelus undulosus* (Quoy and Gaimard).**

Southwell (1913) records Cephalopods, oysters, small fish, crabs, etc., from the stomach of this species from Ceylon. In the present study 9 specimens were examined in October 1936. One was obtained at 10 A.M. and the others at 2 in the afternoon. The largest was 144 mm. and the smallest 77 mm. In none of them the gonads had developed. Three had food-contents in them. The stomach of one was gorged with a Macruran Decapod, *Alpheus malabaricus*, while another contained the anterior part of a young Teleostean, appendages of crabs, a small Brachyuran and the anterior part of a young Alphaeid. In another, which was nearly empty, the food consisted of traces of Polychaete setae with some Crustacean appendages. The stomachs of the remaining ones were empty but for a little mucus which was present in some of them. Table 11 gives the details of the stomach-contents. Diet Table 10 shows the percentages of the items.

***Epinephelus maculatus* (Bloch).**

This species has been reported from the sea only. Five specimens were examined in October 1936. They were caught in the afternoon. The largest was 174 mm. while the smallest was 129 mm. in length. The gonads had not developed. Only two of them contained food, while the others were empty. The stomach-contents were seen to consist of crushed parts of Macruran Decapods of the genus *Leander* along with their dislocated appendages, besides a small amount of digested matter (Table 12 and Diet Table 11).

***Epinephelus boenack* (Bloch).**

The "veri-cullawah" is a brilliantly coloured sea perch often caught by the fishermen of the coast. 5 specimens were examined, two in September 1936 and three in March 1937. The stomach in the first two were empty, while the other three contained food (Table 13 and Diet Table 12).

Nearly four-fifths of the food were composed of hard shelled Decapods, namely, *Grapsus maculatus* and *Alpheus malabaricus* with megalopa stages of crabs. The anterior part of an *Ambassis* sp. appeared in the stomach of one of the specimens. A small percentage of the food was too well digested for identification. Considerable traces of sand were seen along with the food, possibly indicating bottom feeding.

***Epinephelus lanceolatus* (Bloch).**

The "wutla-cullawah" attains a large size and is very valuable, the fish having an agreeable flavour. Being a bottom feeder this is expected to contribute to the success of steam trawling when introduced in these parts. Weber and Beaufort (1931) record it as occurring "in the sea", but mention them to be entering rivers.

Two specimens were obtained in September 1936. The larger one was 400 mm. but had an empty stomach while the smaller measured 370 mm. in length and a fairly large berried female *Leander* was seen to block the oesophagus; besides, some digested material and mucus was also present inside the stomach (Table 14 and Diet Table 13).

Genus ***Pomadasys*** Lacépède.

These are shore fishes very common between the Tropics, and some are said to extend into the neighbouring sub-tropical parts. *Pomadasys* is called a "grunter" from its habit of making a grunting noise when disturbed. Plate VI, fig. 5 represents the food-components of the genus as represented by two species which were studied.

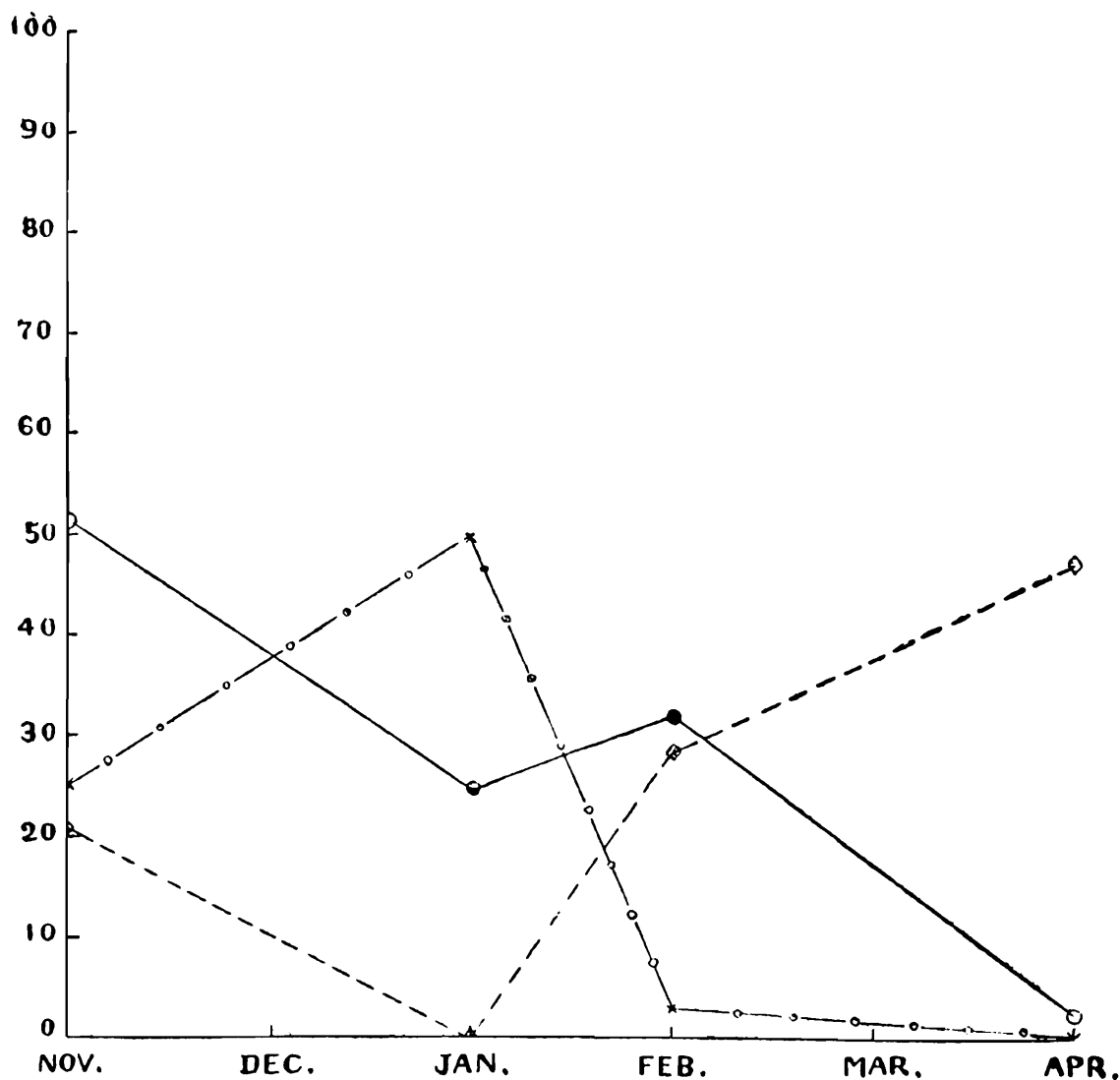
***Pomadasys maculatus* (Bloch).**

The fish is called "kallanthalai" owing to the presence of 'stones' in the head, which are said to be of medicinal value. Locally it is known as the "kurrutche" and is said to grow up to 16 inches in length and to breed in April and May. The fishes of this genus are fair as food but not much esteemed; the air bladder in some cases is collected for isinglass. Southwell found only prawns in the stomach-contents of some of the specimens examined by him in Ceylon.

Fifty specimens were examined from November 1936 to April 1937 excepting the month of March. 21 of them were males and 29 females. 17 specimens were found to contain food. The fish were caught in the morning from 9 to 11 A.M. and in the afternoon from 2 to 6 P.M. Only two individuals had their stomachs filled with food, while one was fairly full (0.6), the stomach-fill in four was 0.4, in eight 0.2 and two had only traces of food in them. The large number of fish with empty stomachs indicates that the feeding is probably intermittent.

Food analysis showed that Crustaceans like *Acetes erythraeus*, *Penaeus indicus*, crabs and Amphipods represented by *Grandedierella gilesi* formed more than half of the food. Polychaetes formed one-fifth. The rest was composed chiefly of Teleosts with small quantities of young

Gastropods, Pectinibranchiate larvae, Larvaceae, Asteroids, Hydrozoa and sand (Table 15 and Diet Table 14). Text-fig. 5 represents the monthly variations of the chief food-components.



TEXT-FIG. 5.—Monthly variations in the proportions of the three chief food-components of *Pomadasys maculatus* (Bloch) during the period of investigation.

(The abscissa represents the months and the ordinate the percentages; the continuous line represents Crustaceans eaten, the broken line Polychaetes and the chain Teleosteans.)

***Pomadasys olivaceus* (Day).**

Six specimens were obtained in October 1936. The largest measured 130 mm. while the smallest was 122 mm. long. Four of them were males and two females. Two had empty stomachs. The other four contained a fair amount of partly digested food, which was mainly composed of Polychaetes, Penaeids, Brachyurans and Amphipods (Table 16 and Diet Table 15).

Genus *Apogon*, Lacépède.

These small fishes abound in sheltered spots, some having been caught, as Day (1889) states, at the mouths of, or even a short distance up, tidal rivers and backwaters. They are called "coral fish", being found in

great abundance in or near coral reefs. Bridge (1922) observes how the males in some species take care of the eggs in their mouth. Though small, these fishes are eaten both in the fresh state and when salted and dried. Plate VI, fig. 6 represents the proportions of the food-components for the genus as represented by the single species *Apogon nigripinnis*.

Apogon nigripinnis Cuvier and Valenciennes.

Nine specimens were examined, 5 in August and 4 in November 1936. Five of them had food contents, while four were empty.

The food was mainly composed of Macruran Decapods, chiefly prawns of the genus *Leander* and other young Penaeids and young Teleosteans like *Sciaena*. A small portion of the contents was digested beyond identification (Table 17 and Diet Table 16).

Genus **Ambassis** Cuvier and Valenciennes.

The little bony fishes composing this genus are eaten by the poorer classes. Owing to their thin shape they are easily dried without salt. Some species are exclusively found in fresh water. As several fishes of this genus constitute the food of larger fish, the latter are often enticed by them to come nearer inshore to be easily caught by man. Plate VI, fig. 7 represents the proportions of the food-components for the genus as represented by the single species studied.

Ambassis gymnocephalus (Lacépède).

This small species is common in the coastal waters, often ascending the rivers. Twelve specimens were procured, 8 in the month of November 1937 and 4 in February 1938. The largest was 68 mm. and the smallest 50 mm. Seven of them were females and the other five males. Eight of them were empty. In the others the stomach-contents were made up of Crustaceans like Copepods, Mysids, digested stuff, algal matter and some sand. In specimens caught from the Fort St. George moat large numbers of Copepods, mainly *Pseudodiaptomus annandalei*, were seen. An examination of the gill-rakers of this fish shows that its comparatively long and filamentous rakers, especially those of the first true gills serve as sieves somewhat as in the case of the herring and mackerel, to strain the micro-organisms from the water passing through the gills. Even here, however, the power of selecting and rejecting is remarkable as evinced by the stomachs found packed full of *Cyclops*, while the surrounding water contained various other organisms as well. The fish resembles the mackerel described by Bullen (1912) in having two distinct methods of procuring food, viz., (i) a system of filtration (through the gill sieve) and (ii) hunting by sight prey of a larger size. The cyclops-cidal tendencies of the fish point to its probable utility in the biological control of Guinea Worm disease. But sufficient data are not yet available for discussing the point. Table 18 gives the details of the stomach-contents. Diet Table 17 shows the percentages of the items.

Genus **Gerres** Cuvier.

About 30 species which compose this genus live in the tropical seas, most species entering fresh water. These plain silvery perches are small, being often less than 10 inches in size. Plate VI, fig. 8 represents the proportions of the food-components for the genus as represented by the single species studied.

Gerres punctatus Cuvier and Valenciennes.

The "oodan" is the "silver belly" common at Madras both in the sea and in the brackish waters of the Adyar and the Cooum. Day records about 8 inches as its maximum length. The specimens studied ranged from 129 mm. to 147 mm. The fish, while not very popular in the fresh condition owing to too many bones and lack of flavour, is more esteemed when salted and dried and is even exported.

Fourteen specimens were examined, 10 in November 1936 and 4 in February 1937. The specimens obtained in February were devoid of any food. Four were caught in the morning at about 9 o'clock and 1 at 10. The others were obtained late in the forenoon, at about 11 o'clock. Eight of them were males and six females. The gonads were well developed, so that the sexes could be easily identified. The four specimens caught at 9 o'clock and the one caught at 10 contained food, but even in these the stomachs were not completely full. In the case of one of the males however the stomach was nearly filled with Crustacean limbs.

Polychaetes like Chaetopterids and Eunicids formed more than half of the total food. Crustaceans formed the major part of the remainder, while Molluscs and larval Cephalochordates appeared in rare instances (Table 19 and Diet Table 18).

DISCUSSION.

Feeding Habits.—These investigations show that none of the perches of the Madras Coast habitually feeds on vegetable matter; minute traces of it met with in very rare cases are too insignificant to be considered of any importance in connection with their food, and their presence is undoubtedly accidental. These perches are decidedly carnivorous, and probably this is one of the reasons why they are so highly prized; for, as food-fishes, carnivorous fishes are said to be preferred to herbivorous ones. Animal food is abundant in the coastal waters of Madras, and the rich zooplankton of the region also helps in the nutrition, partly directly, but much more indirectly, of the perches, both young and adult. While carnivorous perches like *Epinephelus* and *Lutianus* are actively predaceous, the comparatively innocuous forms like *Ambassis* are, in this respect, more "sinned against than sinning", as judged from the numbers of them discovered in the stomachs of larger perches, to say nothing of the quantities which may be consumed by other large fishes of prey.

The perches, however, cannot be reckoned as indiscriminate carnivores¹. Nor have these been found to act as "filth-feeders" like the sucker and the blunt-nosed minnows, which according to Pearse (1916) obtain organic remains from the mud and debris at the bottom.² The packets of large scales seen in *Therapon* may indicate offal-feeding, but regular mud-feeding has never been observed in these perches. On the other hand, the general results brought out by the examination of these fishes serve to show that excepting forms such as *Ambassis* possessing comparatively slender gill-rakers, the large perches are incapable of nourishment by means of filtration, and even the larger planktonic organisms appear to be hunted by sight, the fish being capable of selective feeding. It is but natural that being devoid of feelers or other similar appendages these keen-eyed active swimmers should be mainly sight-feeders like the yellow perch of the Wisconsin lakes described by Pearse and Achtenberg (*op. cit.*). However, the sense of smell seems to supplement sight in food capture; for, the present writer has observed several perches with impaired eye-sight in the Madras Marine Aquarium approach and devour bits of fish thrown into the water. These carnivores are to some extent cosmopolitan in their tastes, exhibiting carcinivorous, piscivorous and vermivorous tendencies, while at least one form, *Therapon jarbua*, is, in addition, insectivorous.

On reviewing the diet charts of the various genera studied, it is seen that in the majority of cases Malacostracan Crustaceans form the main part of their food. Entomostracans are conspicuously rare except in the case of *Ambassis*. Evidently these perches, excepting the last mentioned, cannot, like *Sardinella gibbosa* or *S. longiceps*, be said to be microplankton-feeders. The absence of Entomostracans or diatoms cannot be attributed to the absence of these forms in the waters; for, stomach-contents entirely composed of these forms have been obtained by the writer in the case of Scombrid fishes from the same region. On the other hand, the absence in the perches of the sieve-like straining mechanism seen in the Clupeidae and Scombridae, makes it impossible for the perches to appropriate minute planktonic organisms which easily escape out of their loose-meshed 'gill-basket'. The size and condition of food is a decisive factor directly concerned with the act of taking food. While the "too large to be swallowed" or "too hard and unsuitable for nibbling into small pieces" form the upper limitations, the "too small to be retained within the gill-sieve" or the "too flocculent as to be melting in the mouth" form the lower. Under these circumstances many of the perches naturally prefer the deeper layers of water to prey upon larger animals which abound at this level and some like *Epinephelus tauvina* almost confine themselves to the bottom. The presence of bottom-dwelling Spioniform Polychaetes and Gastropods along with

¹ Discussing on the stomach-contents of certain cod fishes, Day (1883) records such things as "an entire partridge from one, a hare from another, a black guillemot from a third, a piece of tallow candle from two others, a white turnip, a bunch of keys, etc., from other cod fishes".

² Discussing on the food of *Oreinus*, Malik (1940) writes that it feeds on slimy vegetable matter encrusting rocks and stones in rapid waters, and adds that "the fish is a bottom-feeding vegetarian, and any animal matter found in the intestine is probably accidental".

pelagic Crustaceans like *Acetes erythraeus* in the stomachs of species of *Therapon*, *Lutianus*, etc., on the other hand indicates considerable vertical feeding in the case of these fishes. Being rovers into all layers of the sea they can obtain the most and the best of food and this ability to change from one layer to another is of immense help in the struggle for existence.

Diet Table 19 shows a summary of the proportions of the food-components for all the perches investigated. Of the Malacostracans, the Decapods rank foremost. Macrurans are profusely consumed, while bottom-dwelling crabs and Alpheids form the staple article of diet of the species of *Epinephelus*. Hence it is obvious that these fish feed at or near the bottom like the yellow perch described by Pearse and Achtenberg (*op. cit.*). It is surprising to find hard shelled and well armed crabs in the stomachs of these fish. No parallel to Green's record (cited by Jordan, 1907) of young cat fish erecting their spines inside the stomach of the Sacramento perch and tearing open its stomach wall was observed in the case of any of the Madras perches; and in no case did the writer observe any injury to the stomach walls caused by spinose Crustaceans. Also no pearl-like concretions such as those described by Rao (1936) from the stomach-contents of the Hammer-headed shark, *Zygaena blochii*, and of *Caranx* (*Caranx*) *melampygus*, from the Andamans and from the remains of *Rita rita* (Rao, 1937) have been noticed in the stomach-contents of the perches. Possibly such pearls are, as Rao (1937) has suggested, peculiar to the Siluroids, and no Siluroid remains were ever met with in the case of the perches studied.

Preferring a rocky bottom, species of *Epinephelus* are not serious rivals in the matter of food to other perches which move about and pursue Macruran shoals at the higher levels. Sluggish and slow moving though these sea perches are, they are cautious and cunning enough to lay in wait or even rise up and snatch at their weaker brethren, who, though agile and swift in their own way, happen to come in the vicinity of their formidable jaws, unwary of danger. Being highly voracious they greedily gulp in prey that is often too large for their stomachs, and in one case observed (Pl. V, fig. 6) by the writer a specimen of *Therapon puta* that was swallowed had caused a great distention of the stomach of an *Epinephelus taurina*, even though the tail of the prey was still sticking out of its oesophagus. In some cases the fishes devoured remained quite fresh. One is reminded of the words of Aflalo and Marston (1904) about the torpedo and the angler fish feeding and digesting more after the fashion of pythons, devouring a large victim at a meal and then lying quiet to digest at leisure, and of the bass and other fishes being recovered from their inside, often having sustained such trifling injury as to be quite good for sale; as also the large fresh specimens of *Sillago sihama*, reported from the stomach of *Ichthyscopus inermis* (Job, 1937).

Damage to Fisheries.—As is clear from the tables, the predaceous propensities on the part of the perches are responsible for considerable damage to many food-fishes, especially to their spawn and young stages. The danger, however, does not seem to be so great as in the case of some of the fresh-water perches described by Günther (1880). As long as smaller perches like *Ambassis* serve to satisfy the piscivorous appetites

of the larger perches the danger to the valuable food-fishes can be minimised by the proper direction of the supply of these easily available small fish.

Several Decapods suffer a great deal at the hands of the perches of the Madras Coast. Moses (*op. cit.*) states, that "both in quantity and value the crustaceans are of greater importance than any kind of fish in Madras". Prawns top the list, while crabs come next. He records 678,654 pounds of prawns worth Rs. 91,118-7-0 ; 338,584 pounds of crabs worth Rs. 40,243-15-0 and 33,004 pounds of shrimps worth Rs. 3,694-8-0 as being caught from Madras alone during the year from July 1921 to July 1922. The perches are inimical to these forms as many of the Decapods, as adults, larvae and eggs, enter into the diet of the perches. However, large quantities of Amphipods like *Grandedierella magna* and *Paracalliope fluviatilis* are also eaten by forms like *Pelates quadrilineatus*, and the fish, while swallowing them when available in the open sea, also prey upon the large numbers of them found in the algal beds, when they enter brackish-water ; and this must be the reason why fishermen make better catches of these perches from the neighbourhood of "paschee", as they term the beds of algae and vegetable growth. Hence in pericultural projects and perch acclimatisation schemes a proper supply of these small Crustaceans may profitably be attempted so as to solve the main problem of the diet of these fish.

Worm diet.—The amount of Polychaetes consumed is fairly large. Worms are eaten in large quantities by *Pelates quadrilineatus*, *Therapon puta*, *Pomadasys maculatus* and *Pomadasys olivaceus*. The monthly variations in the amounts of Polychaetes consumed are graphically represented in text-figures 2-5. In the month of October a decided maximum is observed in the cases of both *Pelates quadrilineatus* as well as *Therapon puta*. Such seasonal variations in food-items have been observed in the case of the yellow perch by Pearse and Achtenberg (*op. cit.*).

Comparison with Fresh-Water Perches.—On comparing the food of these coastal perches with that of the inland fresh-water forms like the yellow perch of the Wisconsin lakes (Pearse and Achtenberg, *op. cit.*) it is seen that while insects, both larval and adult, Oligochaetes, Entomostracans and Molluscs form a high percentage of the food of the fresh-water perch, the coastal forms treated in the present paper show a decided preference for Malacostracans, Polychaetes and Teleosteans. Scott (1902) referring to the fresh-water perch *Perca fluviatilis* from Marlee Loch, Forfarshire, observes that they "were found to have been living almost exclusively on insect larvae". The difference in the diet is mainly due to the difference in the environment ; for, often the food of fishes varies in accordance with the locality inhabited as has been shown in the case of the haddock (Day, 1883) and of *Therapon jarbua* in the present study.

The proportion of vegetable matter is greater in the case of the yellow perch, but this is because deposits of loose and broken-up plants are the favourite resorts of insect larvae along with which they are swallowed. A fair parallel is seen in the case of *Therapon jarbua*, specimens of which captured from the Fort St. George moat, Madras, contained

in their stomachs considerable quantities of plants mixed with insect larvae.

In spite of the apparent difference in the diet between the coastal forms and the inland forms, it becomes clear, when due consideration is paid to the wide range of variety in the food of these fishes and the presence of forms like *Therapon* of an intermediate habit between the true sea-perches and the fresh-water forms, that the perches would be one of the easiest for acclimatisation in lakes and for the development of inland fisheries. The loss caused by the predaceous habits of a few forms will be insignificant as compared to their yields.

Mucus Factor.—A large amount of mucus discovered in the stomachs whenever the latter contained gritty food and spiny articles of diet as tubiculous Polychaetes, Echinoderm spines and Crustaceans like crabs with sharp armature, deserves consideration. As Macginite (1937) states, little is definitely known about the chemical composition of mucin and much less of its physical properties. His observation on the formation in the case of *Chaetopterus variopedatus*, by the aliform notopodia, of mucus filter bags entangling food and being rolled into balls which are passed into the stomach is of course not applicable in the case of the perches. In the latter case one thing is certain, that one of the main purposes served by the viscid mucus is to form a slippery protective investment for the delicate gastric mucosa and to bind the food-contents into a smooth yielding mass; for, as Cowdry (1934) holds, possibly "the physical properties of mucin as outlined by Inouye (1930) are more important than the chemical", and owing to its viscid consistency it can easily form a protective sheet. The prime causative factor in the abundant secretion of mucus in the presence of gritty food is most probably the irritation caused by those articles as they enter the stomach.¹ Cowdry states that any form of local irritation excites the flow of mucus, and this appears to be a natural means of protection against any possible injury to which the more or less thin walls of the stomachs of the perches may be subjected to.

Migration.—Food is one of the main factors with which migration of fish is associated; for, besides the changes in Oceanic currents, as Pearse (1916) observes, "the annual succession of season brings breeding, changes in gases and minerals in the water, variations in temperature, fluctuations in the food supply and shelter and other things which require variations in behaviour. Through all these changing influences, food is in general more important than any other single factor in causing fish to select particular habitats"

In the food of some of the perches studied, planktonic organisms like post-larval Decapods, *Acetes erythraeus* for instance, are quite dominant. These perches are reported to enjoy a wide distribution, many of them

¹ Rao (1936) writes that "Fourcroy and Vauquelin (1807) recorded the remarkable occurrence of a fish-hook in the stomach of a fish coated by concentric layers of a dull yellowish material, smooth and brilliant, and composed of calcium carbonate, calcium phosphate, and some gelatinous organic matter. The material and manner of deposition on the fish-hook seemed to show that the former was of the nature of a concretion secreted by the tissues of the fish around the nucleus provided by the irritant fish-hook." No such case of permanent source of irritation and consequent deposit was met with in the perches studied.

being recorded from the Red Sea to the Australian waters. However, until the times of appearance of these fishes in different places and the ecological details connected therewith are definitely known, it would be premature to discuss the question of their migration.

SUMMARY.

Six hundred and forty-one specimens of eighteen species belonging to eight genera of perches were procured from the Madras Coast, and their stomach-contents studied with a view to determine the mode of nutrition of these valuable food-fishes.

They were found to be decidedly carnivorous, the minute traces of vegetable matter occasionally met with being but accidentally taken in along with other food.

With the exception of *Ambassis gymnocephalus* the perches examined do not feed on microplankton as their gill-apparatus is not adapted for feeding on such forms. Selective feeding in the case of these fishes is apparent; for, while appropriating available elements within a considerably wide range, the main items of diet seem to be hunted by sight, and in some cases specific preferences are discernible as in the different species of the genus *Therapon*.

In the case of *Ambassis gymnocephalus*, in addition to sight-feeding, filtration also seems to play some part in the feeding of the species.

More than half of the total food eaten by the perches studied is composed of Malacostracan Crustaceans ranging from small Macrurans and Mysids with comparatively soft test, consumed by species of *Therapon*, *Pelates*, *Pomadasys* and *Gerres* to Alpheids and hard shelled Brachyuran crabs swallowed by species of *Epinephelus* and *Lutianus*. About one-seventh of the food is composed of small Teleosteans, often in the post-larval stages. Fishes of the genera *Lutianus* and *Epinephelus* as also *Therapon jarbua* show a definite liking for piscine diet. Another one-seventh of the food consists of Polychaetes such as Eunicids, Nereids, Sabellids and Spioniform tube-dwellers, which are eaten in large quantities by species of *Therapon*, *Pelates*, *Pomadasys* and *Gerres*. Species of *Lutianus* and *Epinephelus* do not seem to feed on worms to any appreciable extent.

The other constituents met with in the stomach-contents in small quantities are, Gastropods, Bivalves, Ophiuroids, Echinoids, Polyzoans, Hydromedusae, larval Cephalochordates, Ciliates, Foraminiferans, algae, diatoms and sand.

While often rising to the surface, the perches feed usually at moderate depths. Some like *Epinephelus tauvina* are definitely bottom feeders. Species of *Therapon*, *Pelates* and *Lutianus* mainly feed on Crustaceans, both pelagic and bottom forms; but also derive a certain amount of their food from the fauna among the algal beds of the estuarine waters. *Therapon jarbua* often resorts to surface feeding as is proved by the presence of insect larvae and even adult mosquitoes in its stomach-contents.

As enemies to the fisheries the perches cause considerable damage to the prawn, shrimp and crab fisheries. The piscivorous forms like *Lutianus* and *Epinephelus* destroy many Clupeids and Carangids in

their young stages, and even devour smaller perches themselves. Eggs of fishes and crabs are also eaten by species of *Therapon* and *Pelates*.

Therapon jarbua which exhibits definite insectivorous tendencies is an important edible and larvicidal fish, and its utility as a scavenger cannot be overlooked. It is also noted that cyclopscidal propensities of forms like *Ambassis* point to their probable utility in the biological control of Guinea Worm disease.

The nature of the food elements shows that the inland migration of forms like *Therapon* is to some extent at least governed by the attraction offered by the rich brackish-water fauna and by the presence of items like *Penaeus* which attract these fishes of prey into inland waters.

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TABLES OF DETAILS OF SIZE, SEX, STOMACH-CONTENTS, ETC.

TABLE 1.—*Details of Size, Sex, Stomach-contents, etc., of Thirty-eight Specimens of Therapon puta Cuv. & Val. with Food.*

No.	Date.	Time of catch.	Length in mm.	Sex.	Condition of gonads.	Amount of feed.	Per cent.	Stomach-contents.
1	17th October 1936	10 A.M.	106	Male	Ripening	0.4	90 4 6	Eunicid Polychaete parts (<i>Marphysa</i> sp.). Algal filament (<i>Oscillatoria</i> sp.). Fragment of water weed.
2	Do.	10 A.M.	109	Female	Do.	0.2	100	Polychaete remains.
3	9th November 1936	9 A.M.	110	Do.	Fully mature	0.6	92 5 3	A Palaemonid (<i>Leander</i> sp.), a Sergestid (<i>Acetes erythraeus</i>) and a few post-larval Penaeids. A post-larval Clupeid (<i>Megalops cyprioides</i>). Sand grains.
4	Do.	9 A.M.	105	Do.	Ripening	0.6	60 38 2	Sergestid Macrurans (<i>Acetes erythraeus</i>). Broken up parts of a Eunicid Polychaete. Cycloid scales.
5	Do.	9 A.M.	104	Do.	Fully mature	1+	85 10 5	Several Sergestid Macrurans (<i>Acetes erythraeus</i>). A post-larval Clupeid (<i>Megalops cyprioides</i>). Part of a small Cephalopod.
6	27th November 1936	10 A.M.	131	Do.	Do.	0.1	50 35 15	Penaeid fragments. Brachyuran appendages. Cycloid scales.

TABLE 1.—*Details of Size, Sex, Stomach-contents, etc., of Thirty-eight Specimens of Therapon puta Cuv. & Val. with Food—contd.*

No.	Date.	Time of catch.	Length in mm.	Sex.	Condition of gonads.	Amount of feed.	Per cent.	Stomach-contents.
7	27th November 1936	10 A.M.	135	Female	Fully mature	0.6	80	Sergestid Macrurans (<i>Acetes</i> sp.) and post-larval <i>Penaeus</i> sp.
							16	Young Teleost (<i>Elops</i> sp.).
							4	Cycloid scales.
8	Do.	10 A.M.	105	Do.	Do.	0.6	35	Pectoral girdle and part of fin skeleton of a Teleost.
							60	Cycloid scales.
							3	Anomuran remains.
							2	Amphipod remnants.
9	28th November 1936	10 A.M.	133	Male	Do.	0.2	98	Polychaete fragments.
							2	Part of a fish scale.
10	30th November 1936	9 A.M.	144	Female (infested by Nematodes).	Do.	0.2	75	Part of female crab with eggs at various stages of growth.
							8	Branchial chamber of a crab.
							2	A pedunculate Cirripede allied to <i>Lepas</i> , commensal attached to the branchiae of item 2.
							15	Brachyuran appendages.
11	Do.	9 A.M.	100	Female	Immature	1	95	The fin skeleton and liver of a Teleost.
							5	Fish scales.
12	8th January 1937	10 A.M.	124	Do.	Fully mature	0.6	95	Six Sergestid Macrurans (<i>Acetes erythraeus</i>).
							5	Cycloid scales.

13	9th January 1937	3 P.M.	128	Do.	Do.	0.2	80 20	Two Sergestids (<i>Acetes erythraeus</i>). A small Octopodid Cephalopod.
14	Do.	3 P.M.	130	Male	Nearly spent	0.1	100	Crustacean fragments.
15	Do.	3 P.M.	119	Female	Fully mature	0.2	100	Two specimens of <i>Acetes erythraeus</i> .
16	Do.	3 P.M.	111	Male	Ripening	0.4	80 10 9 1	Part of <i>Diopatra variabilis</i> . Crustacean fragments. Cycloid scales. Bivalve remains.
17	18th January 1937	10 A.M.	157	Female	Fully mature	0.8	60 30 5 5	Crustacean remains. Remains of <i>Eupagurus</i> sp. Cycloid scales. An <i>Acetes erythraeus</i> .
18	Do.	10 A.M.	129	Male	Ripening	1	90 2 2 2 2 1 1	Several Sergestids (<i>Acetes erythraeus</i>). Cycloid scales. A small Teneidacean. <i>Mesopodopsis orientalis</i> . Part of Campanulariid colony (<i>Thyroscyphus juncea</i>). Amphipod remains. Copepod (<i>Pseudodiaptomus annandalei</i>).
19	Do.	10 A.M.	139	Female	Do.	0.6	50 25 25	Part of a prawn (<i>Palaemon lamarrei</i>). Remains of <i>Eupagurus</i> sp. Decapod remains.
20	Do.	10 A.M.	133	Male	Do.	0.4	60 40	Polychaete remains. Crustacean remains (<i>Acetes</i> and other Macruran appendages).
21	Do.	10 A.M.	129	Do.	Fully mature	0.4	100	Partly digested Polychaete.

TABLE 1.—*Details of Size, Sex, Stomach-contents, etc., of Thirty-eight Specimens of Therapon puta Cuv. & Val. with Food—concl'd.*

No.	Date.	Time of catch.	Length in mm.	Sex.	Condition of gonads.	Amount of feed.	Per cent.	Stomach-contents.
22	20th January 1937	3 P.M.	172	Female	Fully mature	0·6	80 10 10	A vertebra of a Teleost. Orbit region of fish. Fish scales.
23	Do.	3 P.M.	134	Male	Do.	0·2	100	Cycloid scales.
24	21st January 1937	3 P.M.	113	Do.	Ripening	0·8	60 10 10 15 5	<i>Acetes erythraeus</i> . Scales and other Teleost remains. A Macruran belonging to the genus <i>Leander</i> . Campanulariid hydroids. Crustacean remains.
25	2nd February 1937	3 P.M.	159	Female	Fully mature	0·6	70 20 10	Part of a Bivalve. A post-larval Teleost (<i>Elops</i> sp.). A small Brachyuran (<i>Neptunus pelagicus</i>).
26	Do.	3 P.M.	145	Male	Do.	0·4	60 10 10 1 2 17	A packet of cycloid scales. The gastric armature of a Decapod. A prawn (<i>Penaeus indicus</i>). Calegid Copepods. Another Copepod (<i>Pseudodiaptomus annandalei</i>). Digested matter.
27	5th February 1937	10 A.M.	138	Female	Do.	0·6	30 5 4 5 1 55	Macruran Decapods (<i>Palaemon lamarrei</i>). An Isopod of the genus <i>Cirolana</i> . Calegid Copepods. Decapod larvae. A Foraminiferan of the genus <i>Polystomella</i> . Crustacean fragments.

28	Do.	10 A.M.	132	Do.	Do.	1	100	Two post-larval Clupeids of the genus <i>Elops</i> .
29	2nd March 1937	10 A.M.	155	Male	Immature	0.4	100	Partly digested Hydrozoan colony.
30	Do.	10 A.M.	135	Do.	Fully mature	0.4	86 4 5 1 4	A young Clupeid (<i>Megalops cyprinoides</i>). Part of another Teleost with Mysid remains inside it. <i>Acetes erythraeus</i> . Polychaete setae. Algal filaments.
31	Do.	10 A.M.	134	Do.	Do.	0.2	40 50 5 5	Head of a small Clupeid. Hydrozoa. Amphipods (<i>Grandedierella magna</i>). Decapod remains.
32	Do.	10 A.M.	128	Do.	Do.	0.2	90 10	Hydrozoan colony (<i>Laomedea spinulosa</i>). Partly digested <i>Salpa</i> .
33	4th March 1937	10 A.M.	144	Female	Maturing	1	90 10	Three specimens of <i>Megalops cyprinoides</i> . An Anomuran (<i>Clibenarius olivaceus</i>).
34	Do.	10 A.M.	142	Male	Fully mature	0.6	100	<i>Acetes erythraeus</i> .
35	Do.	10 A.M.	130	Female	Maturing	1	70 10 12 5 3	A Clupeid (<i>Megalops cyprinoides</i>) An Anomuran (<i>Clibenarius olivaceus</i>). Parts of a Bivalve. Hydrozoan colony of the genus <i>Lyomedea</i> . Gastropod remains.
36	6th March 1937	11 A.M.	150	Male	Do.	0.2	40 60	An <i>Acetes erythraeus</i> . A mass of Hydrozoan bits.
37	Do.	11 A.M.	140	Do.	Do.	1	100	Fifteen specimens of <i>Acetes erythraeus</i> .
38	Do.	11 A.M.	135	Do.	Do.	0.8	90 10	Ten <i>Acetes erythraeus</i> . Part of a Clupeid.

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TABLE 2.—*Details of Size, Sex, Stomach-contents, etc., of Seventy-one Specimens of Therapon jarbua (Forsk.) with Food.*

No.	Date.	Time of catch.	Length of fish in mm.	Sex.	Condition of gonads.	Amount of feed.	Per cent.	Stomach-contents.
1	15th January 1937	9 A.M.	79	Female	Immature	0.6	95 5	Hind part of a Teleost. Uropod and other appendages of a Decapod.
2	Do.	9 A.M.	65	Not clear	Do.	0.4	98 2	Decapod remains (<i>Penaeus indica</i>). Cycloid scales.
3	Do.	9 A.M.	64	Do.	Do.	0.2	80 18 2	Mysid (<i>Mesopodopsis orientalis</i>). Chironomid larvae. Cycloid scales.
4	Do.	9 A.M.	86	Female	Do.	0.1	90 5 5	Cycloid scales. Remains of <i>Mesopodopsis orientalis</i> . Fragments of Spioniform Polychaete.
5	20th January 1936	3 P.M.	144	Male	Do.	0.6	95 5	A lump of cycloid scales. Fish pulp.
6	2nd April 1937	6 P.M.	171	Female	Fully mature	0.2	20 80	Fish scales. Digested matter.
7	Do.	6 P.M.	161	Male	Do.	0.1	100	Crustacean fragments.
8	29th May 1937	4 P.M.	134	Do.	Immature	0.6	100	Closely packed cycloid scales.
9	Do.	4 P.M.	135	Female	Do.	0.8	100	Clupeid scales with some mucus.
10	21st September 1937	9 A.M.	118	Do.	Do.	0.2	20 10 60 5 5	Two Mysids (<i>Rhopalophthalmus egregius</i>). Larval insect. Cycloid scales. An Amphipod (<i>Grandedierella magna</i>). Digested matter.

11	28th September 1937	9 A.M.	105	Do.	Do.	0.6	100	Piece of a fairly big Teleost (offal feeding).
12	Do.	9 A.M.	100	Do.	Do.	0.4	100	Teleostean eggs.
13 to 20	Do.	9 A.M.	80 to 115	Do.	Do.	Fair	40	<i>Zoothamnium</i> tufts.
							10	Polychaetes.
							10	Caprellines.
							10	Fish scales.
							10	Copepods (<i>Acartia southwelli</i>).
							10	Crustacean eggs.
							10	Remnants of Crustaceans.
21	5th October 1937	10 A.M.	68	Male	Do.	0.1	100	Copepods (<i>Pseudodiaptomus annandalei</i>).
22	Do.	10 A.M.	69	Do.	Do.	0.1	100	Copepods (<i>Pseudodiaptomus annandalei</i>).
23	Do.	10 A.M.	70	Female	Do.	0.1	90 10	Copepods (<i>Pseudodiaptomus annandalei</i>). Unidentifiable dark matter.
24	Do.	10 A.M.	72	Male	Do.	0.3	90 10	Amphipods (<i>Grandedierella magna</i>). Polychaete larvae.
25	Do.	10 A.M.	76	Female	Do.	0.5	95 5	Several Squillids with eggs. Digested matter.
26	Do.	10 A.M.	78	Do.	Do.	0.6	95 5	Polychaete remains. Digested matter.
27	Do.	10 A.M.	102	Do.	Do.	0.1	80 15 5	Amphipods (<i>Paracalliope fluviatilis</i>). Copepods (<i>Acartia southwelli</i>). Digested matter.
28	Do.	10 A.M.	95	Male	Do.	0.2	50 5 2 43	Cycloid scales. Copepods (<i>Acartia southwelli</i>). <i>Chaetomorpha</i> . Digested matter.

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TABLE 2.—*Details of Size, Sex, Stomach-contents, etc., of Seventy-one Specimens of Therapon jarbua (Forskål) with Food—contd.*

No.	Date.	Time of catch.	Length of fish in mm.	Sex.	Condition of gonads.	Amount of feed.	Per cent.	Stomach-contents.
29	5th October 1937.	10 A.M.	110	Female	Immature	0.3	75 20 5	Eunicid Polychaetes (<i>Marphysa graveleyi</i>). Insect larvae. Copepods (<i>Pseudodiaptomus annandalei</i>).
30	Do.	8 A.M.	98	Male	Do.	0.2	100	An Amphipod holding a smaller female.
31	Do.	8 A.M.	99	Female	Do.	0.2	2 2 96	Insect remains. Algal matter (<i>Oscillatoria</i>). Digested matter.
32	Do.	8 A.M.	98	Do.	Do.	0.3	75 10 15	Cycloid scales. Vegetable matter (<i>Oscillatoria</i>). Insect larvae.
33 to 71	} Do.	8 A.M. {	28 to 95	}	..	..	68.5 3 3.5 2.5 1 3 3.5 6.5 4.5 4	Amphipods (<i>Paracalliope fluviatilis</i> and <i>Grandedierella magna</i>). Syllids. Copepods (<i>Acartia southwelli</i>). Fish scales. Eggs. <i>Oscillatoria</i> sp. <i>Squilla</i> remains. Insects, mainly mosquito, larval and adult, as well as dragon fly larvae. Macruran Decapods, chiefly <i>Palaemon lamarrei</i> . Digested matter.

TABLE 3.—Details of Size, Sex, Stomach-contents, etc., of Seventy-nine Specimens of *Pelates quadrilineatus* (Bloch) with Food.

No.	Date.	Time of catch.	Length in mm.	Sex.	Condition of gonads.	Amount of feed.	Per cent.	Stomach-contents.
1	15th August 1936	10 A.M.	140	Female	Immature	0.8	80	Numerous Amphipods (<i>Grandedierella magna</i>).
							2	Tiny Bivalve fragment.
							3	A small Gastropod shell (<i>Fenella</i> sp.).
							5	A Trematode worm.
							10	Matter digested beyond identification.
2	Do.	10 A.M.	125	Do.	Do.	0.8	20	Amphipods (<i>Grandedierella magna</i>).
							50	A Palaemonid Macruran (<i>Leander</i> sp.).
							10	A delicate Schizopod (<i>Mesopodopsis orientalis</i>).
							10	A Sergestid Macruran (<i>Leucifer</i> sp.).
							2	A tiny Gastropod shell (<i>Fenella virgata</i>).
							8	Digested matter.
3	18th August 1936	10 A.M.	132	Male	Do.	0.6	80	Amphipods (<i>Paracalliope fluviatilis</i>).
							20	Crustacean remains.
4	Do.	10 A.M.	124	Female	Do.	0.8	100	A prawn of the genus <i>Leander</i> .
5	4th September 1936	10 A.M.	135	Do.	Do.	1	40	Numerous Amphipods (<i>Paracalliope fluviatilis</i> and <i>Grandedierella magna</i>).
							40	Caprelline fragments.
							6	Part of a Eunicid Polychaete (<i>Onuphis</i> sp.).
							6	Gastropod shell fragments.
							8	Decapod remains.

TABLE 3.—*Details of Size, Sex, Stomach-contents, etc., of Seventy-nine Specimens of Pelates quadrilineatus (Bloch) with Food—contd.*

No.	Date.	Time of catch.	Length in mm.	Sex.	Condition of gonads.	Amount of feed.	Per cent.	Stomach-contents.
6	4th September 1936	10 A.M.	130	Male	Immature	0·8	70 20 10	Numerous Amphipods (<i>Grandedierella magna</i>). Fragment of a post-larval <i>Squilla</i> . Decapod remains.
7	17th October 1936	10 A.M.	125	Do.	Do.	1+	70 10 20	Tufts of Spioniform Polychaetes (<i>Owenia</i> sp.) with sand tubes. Amphipods (<i>Grandedierella magna</i>). Mysids (<i>Rhopalophthalmus egregius</i>).
8	Do.	10 A.M.	130	Female	Do.	1	90 10	Spioniform Polychaete (<i>Owenia</i> sp.). Amphipods (<i>Paracalliope fluviatilis</i>).
9	9th November 1936	9 A.M.	111	Do.	Fully mature	0·2	20 20 20 20 8 5 4 3	Crustacean fragments. Eunicid Polychaete (<i>Marphysa</i> sp.). Crisiid Polyzoon (<i>Crisia</i> sp.). Ophiuroid (<i>Ophiothela danae</i>). Copepods (<i>Pseudodiaptomus annandalei</i>). Amphipods (<i>Paracalliope fluviatilis</i>). Gastropod remains. Bivalve shell.
10	Do.	9 A.M.	105	Do.	Do.	0·6	70 30	A Palaemonid (<i>Leander</i> sp.) and a Sergestid (<i>Acetes erythraeus</i>). Spioniform Polychaete (<i>Owenia</i> sp.).
11	Do.	9 A.M.	102	Do.	Do.	0·2	95 5	Spioniform Polychaete (<i>Owenia</i> sp.). Digested matter.
12	Do	9 A.M.	98	Do.	Do.	0·2	70 30	Spioniform Polychaete (<i>Owenia</i> sp.). Sergestid Macruran (<i>Acetes erythraeus</i>).

13	Do.	9 A.M.	106	Male	Do.	0.2	90 10	Spioniform Polychaete (<i>Owenia</i> sp.). Ostracod fragments.
14	Do.	9 A.M.	101	Female	Do.	0.6	70 27 3	Sergestid Macruran (<i>Acetes erythraeus</i>). Spioniform Polychaete (<i>Owenia</i> sp.). Ostracod fragments.
15	11th November 1936	9 A.M.	98	Do.	Do.	0.2	100	Sergestid Macruran (<i>Acetes erythraeus</i>).
16	Do.	9 A.M.	92	Male	Ripening	0.2	95 3 2	Spioniform Polychaete (<i>Owenia</i> sp.). Gastropod shell (<i>Gyraulus</i> sp.). Digested matter.
17	Do.	9 A.M.	106	Do.	Fully mature	0.4	90 5 5	Spioniform Polychaete (<i>Owenia</i> sp.). Chitinous bits of Brachyuran test. Sand grains.
18	Do.	9 A.M.	103	Female	Do.	0.1	25 75	Sergestid Macruran (<i>Acetes erythraeus</i>). Digested matter.
19	13th November 1936	10 A.M.	115	Male	Ripening	0.6	80 6 3.5 2 2 1 2.5 1.5 1.5	Spioniform Polychaete (<i>Owenia</i> sp.). Sergestid Macruran (<i>Acetes erythraeus</i>). Echinoderm spines. Macruran parts. Ostracod parts. Brachyuran appendages. Crustacean remains. Gastropod fragments. Digested matter.
20	Do.	10 A.M.	122	Do.	Do.	0.6	86 8 2 1 1 1 0.5 0.5	Sergestid Macruran (<i>Acetes erythraeus</i>). Crustacean appendages. Spioniform Polychaete (<i>Owenia</i> sp.). A Sphaeromid Isopod (<i>Sphaeroma vastator</i>). Echinoderm spines. Polyzoan fragment. Gastropod remains. Bivalve shell.

TABLE 3.—*Details of Size, Sex, Stomach-contents, etc., of Seventy-nine Specimens of Pelates quadrilineatus (Bloch) with Food—contd.*

No.	Date.	Time of catch.	Length in mm.	Sex.	Condition of gonads.	Amount of feed.	Per cent.	Stomach-contents.
21	17th November 1936	10 A.M.	112	Female	Ripening	0.4	90 10	Four large and three small specimens of Sergestid Macruran (<i>Acetes erythraeus</i>). Parts of a Palaemonid (<i>Leander</i> sp.).
22	Do.	10 A.M.	102	Male	Do.	0.4	80 10 10	Two specimens of <i>Acetes erythraeus</i> . Nereid fragments. Crustacean remains.
23	Do.	10 A.M.	88	Do.	Do.	0.4	100	Sergestid Macrurans (<i>Acetes erythraeus</i>).
24	Do.	10 A.M.	92	Do.	Do.	0.4	100	Three Sergestid Macrurans (<i>Acetes erythraeus</i>).
25	Do.	10 A.M.	93	Do.	Do.	0.4	95 5	A partly digested Sergestid Macruran (<i>Acetes erythraeus</i>). Chitinous pieces of Crustacean test.
26	Do.	10 A.M.	118	Do.	Do.	0.2	70 20 5.5 2.5 2	Sergestid Macruran (<i>Acetes erythraeus</i>). Eunicid Polychaete remains (<i>Marphysa</i> sp.). Crisiid Polyzoon (<i>Crisia</i> sp.). Amphipods (<i>Paracalliope fluviatilis</i>). Digested matter.
27	Do.	10 A.M.	95	Do.	Do.	0.4	100	Four small Sergestid Macrurans (<i>Acetes erythraeus</i>).

28	23rd November 1936	9 A.M.	144	Female	Fully mature	0.6	80 10 5 4 1	A Palaemonid Macruran (<i>Leander</i> sp.). Bopyrid Isopods (Probably parasitic on <i>Leander</i>). Amphipods (<i>Paracalliope fluviatilis</i>). Digested matter. Sand grains.
29	Do.	9 A.M.	119	Male	Do.	0.2	100	Digested matter.
30	Do.	9 A.M.	124	Female	Do.	0.4	90 5 5	Eight Sergestid Macrurans (<i>Acetes erythraeus</i>). Amphipods (<i>Paracalliope fluviatilis</i>). Digested matter.
31	Do.	9 A.M.	128	Do.	Do.	0.6	100	Sergestid Macrurans (<i>Acetes erythraeus</i>).
32	Do.	9 A.M.	119	Male	Do.	0.2	92 1 7	Sergestid Macruran (<i>Acetes erythraeus</i>). Amphipod fragment. Digested matter.
33	Do.	9 A.M.	120	Do.	Ripening	0.4	90 10	Spioniform Polychaete (<i>Owenia</i> sp.). Amphipods (<i>Paracalliope fluviatilis</i>).
34	Do.	9 A.M.	121	Do.	Fully mature	0.2	98 2	Sergestid Macruran (<i>Acetes erythraeus</i>). Gastropod fragment.
35	Do.	9 A.M.	114	Do.	Do.	0.2	100	A partly digested Sergestid Macruran (<i>Acetes erythraeus</i>).
36	Do.	9 A.M.	122	Do.	Do.	0.2	99 1	A mucus covered mass of Spioniform Poly- chaete tubes (<i>Owenia</i> sp.). A young Amphipod (<i>Paracalliope fluvia- tilis</i>).

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TABLE 3.—*Details of Size, Sex, Stomach-contents, etc., of Seventy-nine Specimens of Pelates quadrilineatus (Bloch) with Food*—contd.

No.	Date.	Time of catch.	Length in mm.	Sex.	Condition of gonads.	Amount of feed.	Per cent.	Stomach-contents.
37	23rd November 1936	9 A.M.	123	Male	Ripening	0.4	92 2.5 1 0.2 0.8 1 2.5	Segestid Macruran (<i>Acetes erythraeus</i>). Copepods (<i>Pseudodiaptomus annandalei</i>). Eunicid larvae. Nematode worm. Digested matter. Algal filament (<i>Oscillatoria</i> sp.). Sand grains.
38	24th November 1936	9 A.M.	125	Do.	Do.	0.6	100	Two Sergestid Macrurans (<i>Acetes erythraeus</i>).
39	Do.	9 A.M.	115	Do.	Do.	0.6	27 10 2 51 10	Amphipods (<i>Paracalliope fluviatilis</i>). Eunicid. Polychaete (<i>Diopatra variabilis</i>). Echinoderm parts (<i>Ophiothrix</i> sp.). Digested matter. Sand grains.
40	27th November 1936	10 A.M.	110	Do.	Fully mature	0.4	80 20	Mucus covered Spioniform mass (<i>Owenia</i> sp.). Crustacean fragments.
41	Do.	10 A.M.	120	Female	Ripening	0.6	70 30	Mucus covered mass of Spioniform Polychaete (<i>Owenia</i> sp.). Sergestid Macruran (<i>Acetes erythraeus</i>).
42	Do.	10 A.M.	120	Male	Do.	0.4	65 30 5	A small Sergestid (<i>Acetes erythraeus</i>). Eunicid Polychaete (<i>Diopatra variabilis</i>). Larval Eunicids.

43	Do.	10 A.M.	126	Female	Do.	0.2	50	A young Amphipod (<i>Paracalliope fluviatilis</i>).
							20	Crustacean fragments.
							25	Digested matter.
							5	Vegetable matter (<i>Trichodesmium</i> sp.).
44	Do.	10 A.M.	120	Male	Do.	0.4	35	A complete specimen and the hind parts of Sergestid Macrurans (<i>Acetes erythraeus</i>).
							65	Mucus covered mass of Spioniform Polychaete (<i>Owenia</i> sp.).
45	Do.	10 A.M.	113	Do.	Spent	0.4	40	Sergestid Macruran (<i>Acetes erythraeus</i>).
							60	Mucus-covered mass of Spioniform Polychaete (<i>Owenia</i> sp.).
46	Do.	10 A.M.	119	Do.	Fully mature	0.6	100	Mucus-covered mass of Spioniform Polychaete (<i>Owenia</i> sp.).
47	Do.	10 A.M.	124	Female	Ripening	0.2	90	Sergestid Macruran (<i>Acetes erythraeus</i>).
							10	Mucus-covered Spioniform Polychaete (<i>Owenia</i> sp.).
48	Do.	10 A.M.	130	Do.	Do.	0.4	60	Mucus-covered Spioniform Polychaete (<i>Owenia</i> sp.)
							12.5	Penaeid remains.
							7.5	Crustacean fragments.
							5	Eunicid Polychaete (<i>Diopatra variabilis</i>).
							1	Nematode worm.
							14	Digested matter.
49	Do.	10 A.M.	113	Do.	Do.	0.4	86	Polychaete fragments.
							10	Mucus-covered Spioniform Polychaete tubes (<i>Owenia</i>).
							4	Metanauplius stages of Copepods.

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TABLE 3.—*Details of Size, Sex, Stomach-contents, etc., of Seventy-nine Specimens of Pelates quadrilineatus (Bloch) with Food—contd.*

No.	Date.	Time of catch.	Length in mm.	Sex.	Condition of gonads.	Amount of feed.	Per cent.	Stomach-contents.
50	28th November 1936	10 A.M.	130	Female	Ripening	0.4	90	Four Sergestid Macrurans (<i>Acetes erythraeus</i>).
							10	Mucus-covered Spioniform Polychaete tubes (<i>Owenia</i>).
51	Do.	10 A.M.	121	Male	Fully mature	0.1	100	Digested matter.
52	30th November 1936	9 A.M.	90	Female	Ripening	0.2	100	Mucus-covered Spioniform Polychaete (<i>Owenia</i> sp.).
53	8th January 1937	10 A.M.	130	Do.	Fully mature	0.4	70	Sabellid remains.
							12	Sergestid Macruran (<i>Acetes erythraeus</i>).
							8	Small Ophiuroids (<i>Ophiothrix</i> sp.).
							4	Amphipods (<i>Paracalliope fluviatilis</i>).
							6	Digested matter.
54	Do.	10 A.M.	138	Do.	Do.	0.2	96	Two whole and broken up parts of Sergestid Macrurans (<i>Acetes erythraeus</i>).
							4	An Amphipod (<i>Paracalliope fluviatilis</i>).
55	Do.	10 A.M.	123	Male	Spent	0.1	60	Amphipods (<i>Grandedierella magna</i>).
							40	Digested matter.
56	Do.	10 A.M.	119	Do.	Fully mature	0.2	80	Three Sergestid Macrurans (<i>Acetes erythraeus</i>).
							15	Amphipods (<i>Grandedierella magna</i>).
							5	Mucus-covered sand.

57	25th January 1937	10 A.M.	140	Do.	Do.	0.4	80	An Alpheid Macruran (<i>Alpheus malabaricus</i>).
							7	Macruran parts (<i>Leucifer</i> sp.).
							5	Amphipods (<i>Paracalliope fluviatilis</i>).
							3	Nematode worm.
							2	Ophiuroids (<i>Ophiothela danae</i>).
							1	Echinoid spines.
							1	Digested matter.
							1	Algal filament (<i>Oscillatoria</i> sp.).
58	Do.	10 A.M.	121	Do.	Spent	0.2	80	Amphipods (<i>Paracalliope fluviatilis</i>).
							20	Mucus-covered sand.
59	Do.	10 A.M.	135	Female	Fully mature	0.4	80	Sergestid Macrurans (<i>Acetes erythraeus</i>).
							5	Amphipods (<i>Paracalliope fluviatilis</i>).
							5	Ophiuroid fragments.
							5	Crustacean remains.
							5	A Nematode worm.
60	Do.	10 A.M.	124	Do.	Do.	0.4	70	Sergestid Macruran (<i>Acetes erythraeus</i>).
							20	Amphipods (<i>Grandedierella magna</i>).
							6	Crustacean fragments.
							2	Algal filament (<i>Ulothrix</i> sp.).
							2	Digested matter.
61	Do.	10 A.M.	29	Do.	Ripening	0.4	40	Gills and other remains of Teleost.
							20	Amphipods (<i>Paracalliope fluviatilis</i>).
							5	Mucus-covered Ophiuroid arm.
							10	Ostracod fragments.
							1	A Nematode worm.
							24	Digested matter.
62	Do.	10 A.M.	140	Male	Do.	0.1	100	Tube of Chaetopterid Polychaete with fragments of body.

TABLE 3.—*Details of Size, Sex, Stomach-contents, etc., of Seventy-nine Specimens of Pelates quadrilineatus (Bloch) with Food—contd.*

No.	Date.	Time of catch.	Length in mm.	Sex.	Condition of gonads.	Amount of feed.	Per cent.	Stomach-contents.
63	25th January 1937	10 A.M.	142	Male	Fully mature	0.2	68 10 10 2 10	Penaeid fragments. Crustacean remains. Amphipods (<i>Paracalliope fluviatilis</i>). Digested matter. Sand particles.
64	Do.	10 A.M.	137	Female	Spent	0.2	30 10 30 5 25	Five small Sergestid Macrurans (<i>Acetes erythraeus</i>). Amphipods (<i>Grandedierella magna</i>). Crustacean appendages. Algal filament (<i>Ulothrix</i> sp.). Digested matter.
65	Do	10 A.M.	130	Do.	Fully mature	0.4	10 20 4.5 30 35.5	Pieces of Sergestid Macruran (<i>Acetes erythraeus</i>). Numerous Amphipods (<i>Paracalliope fluviatilis</i>). Eunicid Polychaete (<i>Marphysa gravelyi</i>). Algal filament (<i>Ulothrix</i> sp.). Digested matter.
66	Do.	10 A.M.	134	Male	Do.	0.2	85 5 10	A Sergestid Macruran (<i>Acetes erythraeus</i>). A young Amphipod (<i>Paracalliope</i> sp.). Crustacean fragments.
67	Do.	10 A.M.	124	Do.	Do.	0.2	25 40 20 15	Part of a Sergestid Macruran (<i>Acetes erythraeus</i>). Small Amphipods (<i>Paracalliope fluviatilis</i>). Digested matter. Sand particles.

68	Do.	10 A.M.	129	Do.	Do.	0.2	90 10	Crustacean fragments. Polychaete setae.
69	28th January 1937	11 A.M.	151	Female	Ripening	0.2	100	Three Sergestid Macrurans (<i>Acetes erythraeus</i>). (A young post larval Teleost <i>Pellona elongata</i> remained entangled in the gills.)
70	Do.	11 A.M.	143	Do.	Fully mature	0.2	98 1 1	Sergestid Macrurans (<i>Acetes erythraeus</i>). Crustacean fragments. Gastropod shell.
71	Do.	11 A.M.	135	Do.	Ripening	0.2	50 20 5 25	Sergestid Macrurans (<i>Acetes erythraeus</i>). Amphipods (<i>Paracalliope fluviatilis</i>). Copepods (<i>Acartia southwelli</i>). Digested matter.
72	3rd February 1937	10 A.M.	152	Do.	Fully mature	0.1	15 10 10 45 20	Amphipods (<i>Paracalliope fluviatilis</i>). Polychaete fragments. Copepods (<i>Pontella danae</i>). Digested matter. Sand grains.
73	5th February 1937	10 A.M.	151	Do.	Do.	0.2	80 2.6 0.6 0.6 0.6 10.6 5	Crustacean fragments. Polychaete remains. Foraminiferans. Bivalve shell. Algal filament (<i>Ulothrix</i> sp.). Digested matter. Sand grains.
74	Do.	10 A.M.	142	Male	Do.	0.1	50 5 5 5 35	Amphipods (<i>Grandedierella magna</i>). Copepods (<i>Pontella danae</i>). Bivalve shell fragment. Foraminiferans. Digested matter.

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TABLE 3.—Details of Size, Sex, Stomach-contents, etc., of Seventy-nine Specimens of *Pelates quadrilineatus* (Bloch) with Food—concl'd.

No.	Date.	Time of catch.	Length in mm.	Sex.	Condition of gonads.	Amount of feed.	Per cent.	Stomach-contents.
75	5th February 1937	10 A.M.	146	Female	Fully mature	0.1	30 10 10 49 1	Amphipods (<i>Grandedierella magna</i>). Copepods (<i>Oithona</i> sp. and <i>Pontella danae</i>). Sergestid Macruran (<i>Acetes</i> sp.). Crustacean fragments. Ophiuroid remains.
76	Do.	10 A.M.	133	Do.	Do.	0.1	10 5 85	Amphipods (<i>Grandedierella magna</i>). Copepods (<i>Pontella danae</i>). Digested matter.
77	Do.	10 A.M.	140	Male	Do.	0.2	20.75 0.25 25.5 1.5 5 44 3	Gammarid Amphipods (<i>Grandedierella magna</i>). Ophiuroid fragment. Crustacean remains. Macruran parts (<i>Leucifer</i> sp.). Copepod (<i>Pontella</i> sp.) metanauplii. Digested matter. Sand grains.
78	Do.	10 A.M.	131	Do.	Do.	0.1	20 5 1 69 5	Gammarid Amphipod (<i>Grandedierella magna</i>). Copepod (<i>Acartia</i> sp.). Polychaete setae. Digested matter. Vegetable matter (<i>Biddulphia</i> sp.).
79	Do.	10 A.M.	141	Female	Do.	0.2	20 50 30	Gammarid Amphipods (<i>Grandedierella magna</i>). Crustacean fragments. Digested matter.

TABLE 4.—*Correlation between Gonadal development and Feeding Activity in Pelates quadrilineatus (Bloch).*

AMOUNT OF FEEDING.	NUMBER OF FISH.												TOTAL.	
	IMMATURE.			MATURE.										
	Males.	Females.	Total.	Gonads developing. Males. Females. Total.			Gonads fully developed. Males. Females. Total.			Gonads spent. Males. Females. Total.				TOTAL.
Gorged (1+)	1	..	1	..	..	..	..	..	..	..	..	..	..	1
Full (1)	..	2	2		..	..	..	..	..	..	..	..	..	2
Pretty full (0·8)	1	3	4	..	..	..	..	..	..	..	..	..	..	4
About half (0·6)	1	..	1	4	1	5	1	4	5	..	..	..	10	11
Appreciable (0·4)	..	..	..	8	6	14	3	5	8	1	..	1	23	23
A little (0·2)	..	..	..	2	5	7	12	8	20	1	1	2	29	29
Very little (0·1)	..	..	..	1	..	1	3	4	7	1	..	1	9	9
Empty (0·0)	..	1	1	14	3	17	11	22	33	4	6	10	60	61
TOTAL	3	6	9	29	15	44	30	43	73	7	7	14	131	140

TABLE 5.—*Details of Size, Sex, Stomach-contents, etc., of Twenty-nine Specimens of Lutianus vaigiensis (Q. & G.) with Food.*

No.	Date.	Time of catch.	Length of fish in mm.	Sex.	Condition of gonads.	Amount of feed.	Per cent.	Stomach-contents.
1	18th August 1936	4 P.M.	80	Indistinguishable.	Immature	0.8	100	<i>Acetes erythraeus</i> .
2	Do.	4 P.M.	82	Do.	Do.	0.8	100	Four specimens of <i>Acetes erythraeus</i> .
3	26th August 1936	11 A.M.	125	Do.	Do.	0.4	30	Anterior part of a Polychaete (<i>Pectinaria</i> sp.)
							30	Echinoderm remains.
							24	Part of a Sabellid worm.
							16	Algal matter.
4	Do.	11 A.M.	123	Do.	Do.	0.2	95	A young Brachyuran (<i>Grapsus maculatus</i>).
							3.8	Crustacean remains.
							1.2	Copepod remains.
5	Do.	11 A.M.	103	Do.	Do.	0.2	30	Fish scales.
							30	Mysid remnants.
							6	Hind part of an Amphipod.
							31	Part of a crab of the genus <i>Grapsus</i> .
							3	Algal filaments.
6	Do.	11 A.M.	119	Do.	Do.	1+	70	<i>Acetes erythraeus</i> .
							25	Crustacean remains.
							5	Algal matter.
7	10th September 1936	4 P.M.	85	Do.	Do.	0.8	100	<i>Clibanarius padavensis</i> .
8	Do.	4 P.M.	101		Do.	0.1	100	Crustacean remains.
9	Do.	4 P.M.	100	Do.	Do.	0.6	50	Chitinous test of Crustacean.
							50	Parts of <i>Opisthopterus tartoor</i> .

10	Do.	4 P.M.	108	Do.	Do.	0.6	100	<i>Opisthopterus tartoor.</i>
11	23rd September 1936.	4 P.M.	183	Do.	Do.	0.1	100	Partly digested Crustacean parts.
12	Do.	4 P.M.	153	Do.	Do.	0.1	100	Penaeid remains.
13	Do.	4 P.M.	153	Do.	Do.	0.6	15 60 5 3 17	Clupeid parts. A Macruran (<i>Leander</i> sp) Young crabs of the genus <i>Dotilla</i> . Four Mysids (<i>Mesopodopsis orientalis</i>). Partly digested Crustacean parts.
14	28th September 1936.	11 A.M.	117	Do.	Do.	1	40 10 2 2 46	An <i>Acetes erythraeus</i> . Crustacean parts with Squillid larva. <i>Mesopodopsis orientalis</i> . An Amphipod (<i>Grandedierella gilesi</i>). A zoea, a Portumnid crab, a Grapsoid and a Pinnotherid crab.
15	Do.	11 A.M.	105	Do.	Do.	1	75 20 5	Two young Teleosts (<i>Equula insidatrix</i>). An <i>Acetes erythraeus</i> . A Brachyuran crab.
16	Do.	11 A.M.	101	Do.	Do.	0.6	40 50 10	Eight Pinnotherid crabs. Anterior part of <i>Diopatra variabilis</i> . An <i>Acetes erythraeus</i> .
17	5th October 1936	3 P.M.	120	Do.	Do.	0.8	70 10 17.5 2.5	Three Ocypodid crabs. Part of <i>Clibanarius padavensis</i> . Amphipod appendages. Argulid, crushed.
18	7th October 1936	11 A.M.	110	Do.	Do.	0.8	100	A <i>Metapenaeus monoceros</i> .
19	17th October 1936	10 A.M.	119	Do.	Do.	1+	40 20 9 0.5 30 0.5	Four Ocypodid crabs. Appendages of <i>Alpheus malabaricus</i> . Anterior part of a Eunicid. Amphipod remains. Crustacean appendages. Algal matter.

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TABLE 5.—*Details of Size, Sex, Stomach-contents, etc., of Twenty-nine Specimens of Lutianus vaigiensis (Q. & G.) with Food*
—contd.

No.	Date.	Time of catch.	Length of fish in mm.	Sex.	Condition of gonads.	Amount of feed.	Per cent.	Stomach-contents.
20	17th October 1936	10 A.M.	110	Indistinguishable.	Immature	1+	73 15 3 6 3	Crabs. Part of a Terebellid. <i>Mesopodopsis orientalis</i> , one specimen. Penaeid parts. Algal matter.
21	22nd October 1936	2 P.M.	92	Do.	Do.	0.1	100	Crustacean remains.
22	Do.	2 P.M.	81	Do.	Do.	0.2	80 20	Crustacean remnants. Algal filaments (<i>Oscillatoria</i> sp.)
23	24th November 1936	4 P.M.	163	Do.	Do.	0.6	95 3 2	<i>Acetes erythraeus</i> . Fish scales. Teleost remains.
24	Do.	4 P.M.	151	Do.	Do.	1	99 1	Several <i>Acetes erythraeus</i> . Algal filaments.
25	8th January 1937	10 A.M.	92	Do.	Do.	0.6	99 1	Four large and a few small <i>Acetes erythraeus</i> . A tiny knot of brown algae.
26	Do.	10 A.M.	95	Do.	Do.	0.8	100	Several <i>Acetes erythraeus</i> .
27	Do.	10 A.M.	90	Do.	Do.	0.4	98 2	<i>Acetes erythraeus</i> . Algal matter.
28	4th April 1937	6 P.M.	164	Do.	Do.	0.4	100	Parts of <i>Hippa</i> sp.
29	Do.	6 P.M.	160	Do.	Do.	0.6	100	Parts of <i>Hippa</i> sp.

TABLE 6.—Details of Size, Sex, Stomach-contents, etc., of Two Specimens of *Lutianus sanguineus* (Cuv. & Val.) with Food.

No.	Date.	Time of catch.	Length of fish in mm.	Sex.	Condition of gonads.	Amount of feed.	Per cent.	Stomach-contents.
1	10th August 1936	3 P.M.	200	Indistinguishable.	Immature	0.4	40 20 20 20	Crustacean remains. <i>Leucifer</i> sp. Fish scales. Teleost remains.
2	Do.	3 P.M.	185	Do.	Do.	0.2	80 10 10	Crustacean parts. Gastropod remains. Pedunculate Cirripede fragments.

TABLE 7.—Details of Size, Sex, Stomach-contents, etc., of Three Specimens of *Lutianus lutianus* (Bloch) with Food.

No.	Date.	Time of catch.	Length of fish in mm.	Sex.	Condition of gonads.	Amount of feed.	Per cent.	Stomach-contents.
1	10th August 1936	3 P.M.	164	Indistinguishable.	Immature	0.8	75 20 5	Vertebral column and other parts of a Teleost, probably a Carangid. Two otoliths. <i>Oscillatoria</i> sp.
2	Do.	3 P.M.	155	Do.	Do.	0.4	100	Teleost remnants (<i>Ambassis</i> sp.)
3	Do.	3 P.M.	148	Do.	Do.	0.2	80 10 10	Fish pulp. Algal matter. Digested matter.

TABLE 8.—Details of Size, Sex, Stomach-contents, etc., of Ten Specimens of *Lutianus lineolatus* (Rüpp.) with Food.

No.	Date.	Time of catch.	Length of fish in mm.	Sex.	Condition of gonads.	Amount of feed.	Per cent.	Stomach-contents.
1	10th September 1936	2 P.M.	115	Indistinguishable.	Immature	0.2	100	Pulpy digested mass.
2	Do.	2 P.M.	133	Do.	Do.	0.2	100	Fish pulp
3	Do.	2 P.M.	115	Do.	Do.	1	50	Remains of <i>Equula</i> sp.
4	23rd September 1936	11 A.M.	124	Do.	Do.	0.1	100	Digested matter.
5	Do.	11 A.M.	133	Do.	Do.	0.1	100	Unidentifiable speck.
6	9th October 1936	10 A.M.	133	Do.	Do.	1	90	Digested matter.
7	Do.	10 A.M.	141	Do.	Do.	0.4	10	Teleostean remains.
8	Do.	10 A.M.	124	Do.	Do.	0.2	90	Digested matter.
9	Do.	10 A.M.	146	Do.	Do.	0.1	10	Parts of <i>Equula insidiatrix</i> .
10	Do.	10 A.M.	108	Do.	Do.	0.2	90	Pulp.
							60	Clupeid remains.
							40	Digested matter.
							100	Teleost parts.
							60	Teleost remnants.
							40	Digested matter.

TABLE 9.—Details of Size, Sex, Stomach-contents, etc., of Two Specimens of *Lutianus johnii* (Bl.) with Food.

No.	Date.	Time of catch.	Length of fish in mm.	Sex.	Condition of gonads.	Amount of feed.	Per cent.	Stomach-contents.
1	25th November 1936	2 P.M.	297	Indistinguishable.	Immature	0.6	50	Crushed Teleostean head.
2	Do.	2 P.M.	285	Do.	Do.	0.2	20	Chitinous test.
							30	Digested matter.
							100	Grapsoid remains.

TABLE 10.—*Details of Size, Sex, Stomach-contents, etc., of Eight Specimens of Epinephelus tauvina (Forsk.) with Food.*

No.	Date.	Time of catch.	Length of fish in mm.	Sex.	Condition of gonads.	Amount of feed.	Per cent.	Stomach-contents.
1	10th September 1936	2 P.M.	165	Indistinguishable.	Immature	1	100	Four Brachyurans, a <i>Neptunus pelgicus</i> and a Portumnid crab.
2	28th September 1936	10 A.M.	192	Do.	Do.	0.1	80 20	A Macruran (<i>Metapenaeus monoceros</i>). Remains of <i>Neptunus</i> sp.
3	23rd October 1936	2 P.M.	90	Do.	Do.	0.6	70 30	Remains of Pleuronectid fish. Brachyuran appendages.
4	3rd November 1936	3 P.M.	210	Do.	Do.	1	99 1	Teleost remains. Macruran appendages.
5	24th November 1936	4 P.M.	220	Do.	Do.	1+	95 5	A large Xanthid crab. Penaeid remains.
6	Do.	4 P.M.	152	Do.	Do.	0.4	40 9 6 10 35	Two Portumnid crabs. A megalopa crab. Abdomen of an <i>Acetes</i> sp. Penaeid remains. Crustacean remnants (Macruran).
7	20th January 1937	3 P.M.	140	Do.	Do.	0.2	60 25 15	Broken up <i>Penaeus Indicus</i> . Fish scales. Teleost remains.
8	20th February 1937	3 P.M.	140	Do.	Do.	0.6	70 25 5	<i>Leander</i> sp. Young Teleost of the genus <i>Equula</i> . Fish pulp.

TABLE 11.—*Details of Size, Sex, Stomach-contents, etc., of Three Specimens of Epinephelus undulosus (Q. & G.) with Food.*

No.	Date.	Time of catch.	Length of fish in mm.	Amount of feed.	Per cent.	Stomach-contents.
1	22nd October 1936	2 P.M.	135	0·1	15 85	Polychaete setae. Crustacean remnants (crabs, 24 per cent. and other Decapods, 61 per cent.).
2	Do	2 P.M.	140	0·4	75 21 4	Part of fish belonging to the genus <i>Sciaena</i> . Brachyuran remains (<i>Pinnotheres</i> genus). Part of young <i>Alpheus malabaricus</i> .
3	23rd October 1936	2 P.M.	75	1+	100	<i>Alpheus malabaricus</i> .

TABLE 12.—*Details of Size, Sex, Stomach-contents, etc., of Two Specimens of Epinephelus maculatus (Bl.) with Food.*

No.	Date.	Time of catch.	Length of fish in mm.	Amount of feed.	Per cent.	Stomach-contents.
1	22nd October 1936	2 P.M.	126	0·4	100	A Macruran of the genus <i>Leander</i> .
2	Do.	2 P.M.	170	0·2	50 50	Macruran remains of genus <i>Leander</i> . Digested matter.

TABLE 13.—*Details of Size, Sex, Stomach-contents, etc., of Three Specimens of Epinephelus boenack (Bl.) with Food.*

No.	Date.	Time of catch.	Length of fish in mm.	Amount of feed.	Per cent.	Stomach-contents.
1	9th March 1937	5 P.M.	217	0.2	40 40 20	Small Brachyuran crabs. A young <i>Alpheus malabaricus</i> . Digested matter.
2	Do.	5 P.M.	214	0.2	94 6	Portion of a Penaeid. Sand particles.
3	Do.	5 P.M.	230	0.4	75 21 4	Brachyurans of genus <i>Neptunus</i> . Carangid remains. Digested matter.

TABLE 14.—*Details of Size, Sex, Stomach-contents, etc., of a Single Specimen of Epinephelus lanceolatus (Bl.) with Food.*

No.	Date.	Time of catch.	Length of fish in mm.	Amount of feed.	Per cent.	Stomach-contents.
1	18th September 1936	10 A.M.	370	0.4	80 20	A berried female of the genus <i>Leander</i> . Digested matter.

TABLE 15.—*Details of Size, Sex, Stomach-contents, etc., of Seventeen Specimens of Pomadasys maculatus (Bl.) with Food.*

No.	Date.	Time of catch.	Length of fish in mm.	Sex.	Condition of gonads.	Amount of feed.	Per cent.	Stomach-contents.
1	24th November 1936	9 A.M.	115	Male	Immature	1	82 3 3 3 2 4 3	Several specimens of <i>Acetes erythraeus</i> . Polychaete remains. Ophiuroids. An Amphipod (<i>Grandedierella gilesi</i>). <i>Ligia exotica</i> . A young Teleostean of genus <i>Opisthopterus</i> . Fish scales.
2	Do.	9 A.M.	124	Female	Do.	0.2	60 20 20	An <i>Acetes erythraeus</i> . Appendages of tiny Brachyuran. Polychaete remains.
3	Do.	9 A.M.	115	Male	Do.	0.4	80 10 2 5 1 2	Fish scales. Polychaete remains. <i>Grandedierella gilesi</i> . Crustacean remains. Gastropod shell fragment. Sand.
4	27th November 1936	10 A.M.	113	Do.	Do.	0.4	80 5 3 2 10	Fish scales. Crustacean appendages. Hydrozoans. <i>Grandedierella gilesi</i> . Digested matter.
5	Do.	10 A.M.	106	Do.	Do.	0.6	75 15 5 5	Five specimens of <i>Acetes erythraeus</i> . <i>Penaeus indicus</i> . Fish scales. Partly digested fish fragments.

6	28th November 1936	10 A.M.	122	Female	Do.	0.2	92 8	Partly digested Crustacean remains. Tubes of <i>Owenia</i> sp.
7	30th November 1936	9 A.M.	110	Do.	Do.	0.1	100	<i>Owenia</i> sp.
8	20th January 1937	3 P.M.	146	Male	Ripening	0.4	100	Parts of Teleostean of genus <i>Equula</i> .
9	Do.	3 P.M.	121	Female	Do.	0.2	100	Partly digested fish remains.
10	21st January 1937	3 P.M.	112	Do.	Immature	1	60 10 10 20	Malacostracan remains, probably of some Penaeid. Brachyuran appendages. An <i>Acetes erythraeus</i> . An Anomuran of genus <i>Albunia</i> .
11	25th January 1937	10 A.M.	117	Do.	Do.	0.2	98 2	Three fish scales. Digested matter.
12	17th February 1937	11 A.M.	120	Male	Do.	0.2	70 30	Partly digested Crustacean appendages. Digested matter.
13	Do.	11 A.M.	118	Female	Do.	0.1	10 5 45 40	A fish scale. <i>Grandedierella magna</i> . Partly digested Crustacean. Digested matter.
14	Do.	11 A.M.	125	Male	Mature	0.2	60 15 15 10	Pectinibranchiate larva. Polychaete remains. Larvacae. <i>Grandedierella magna</i> .
15	Do.	11 A.M.	122	Female	Immature	0.2	95 5	Polychaete remains. Eggs, probably of the above.
16	4th April 1937	6 P.M.	140	Male	Mature	0.4	100	Digested pulpy matter.
17	19th April 1937	2 P.M.	121	Do	Immature	0.2	95 5	Polychaete remains. Fragments of <i>Stomatopod</i> larva.

TABLE 16.—*Details of Size, Sex, Stomach-contents, etc., of Four Specimens of Pomadasys olivaceus (Day) with Food.*

No.	Date.	Time of catch.	Length of fish in mm.	Sex.	Condition of gonads.	Amount of feed.	Per cent.	Stomach-contents.
1	7th October 1936	2 P.M.	125	Male	Immature	0.4	24	<i>Penaeus indicus.</i>
							12	<i>Paracalliope fluviatilis.</i>
							12	Brachyuran young of genus <i>Scylla.</i>
							12	Crustacean remnants.
							40	Digested matter.
2	Do.	2 P.M.	128	Female	Do.	0.4	90	Polychaete remains.
							10	Digested pulpy matter.
3	14th October 1936	11 A.M.	130	Do.	Do.	0.6	100	Polychaete remains.
4	18th October 1936	10 A.M.	122	Male	Do.	0.4	20	Crustacean appendages.
							10	Polychaete parts.
							70	Digested pulpy matter.

TABLE 17.—*Details of Size, Sex, Stomach-contents, etc., of Five Specimens of Apogon nigripinnis Cuv. & Val. with Food.*

No.	Date.	Time of catch.	Length of fish in mm	Sex.	Condition of gonads.	Amount of feed.	Per cent.	Stomach-contents.
1	15th August 1936	10 A.M.	82	Female	Mature	0.4	25	A Macruran of genus <i>Leander</i> .
							75	Other Macruran appendages.
2	Do.	10 A.M.	90	Do.	Do.	0.4	80	Remains of young Penaeids.
							20	Part of Teleostean of genus <i>Sciaena</i> .
3	21st September 1936	2 P.M.	85	Male	Do.	0.4	50	Macruran of genus <i>Leander</i> .
							50	<i>Penaeus carinatus</i> .
4	Do.	2 P.M.	88	Female	Do.	0.2	45	Penaeid appendages.
							5	Teleostean remains.
							50	Digested matter.
5	Do.	2 P.M.	78	Do.	Do.	0.2	75	Macruran of genus <i>Leander</i> .
							25	Digested pulpy matter.

TABLE 18.—*Details of Size, Sex, Stomach-contents, etc., of Four Specimens of Ambassis gymnocephalus (Lacép.) with Food.*

No.	Date.	Time of catch.	Length of fish in mm.	Sex.	Condition of gonads.	Amount of feed.	Per cent.	Stomach-contents.
1	8th November 1937	11 A.M.	60	Female	Mature	0.2	30	Two specimens of <i>Rhopalophthalmus egregius</i> .
							70	Digested pulpy matter.
2	Do.	11 A.M.	68	Male	Do.	0.4	50	Seven specimens of <i>Rhopalophthalmus egregius</i> .
							28	Digested matter.
							12	Algal matter.
							10	Sand.
3	11th February 1937	2 P.M.	57	Female	Immature	0.6	50	<i>Cyclops</i> .
							50	<i>Acartia southwelli</i> .
4	Do.	2 P.M.	65	Do.	Do.	0.2	10	<i>Pseudodiaptomus annandalei</i> .
							90	Digested pulpy matter.

TABLE 19.—*Details of Size, Sex, Stomach-contents, etc., of Five Specimens of Gerres punctatus Cuv. & Val. with Food.*

No.	Date.	Time of catch.	Length of fish in mm.	Sex.	Condition of gonads.	Amount of feed.	Per cent.	Stomach contents.
1	28th November 1936	9 A.M.	147	Male	Mature	0.4	40 55 5	Eunicid Polychaetes. Part of a worm of genus <i>Chaetopterus</i> . A larval Cephalochordate.
2	29th November 1936	9 A.M.	145	Female	Do.	0.4	100	Chaetopterid remains.
3	Do.	9 A.M.	148	Male	Do.	0.2	95 5	Crustacean fragments. A few <i>Temora turbinata</i> .
4	Do.	9 A.M.	142	Do.	Do.	0.6	100	Crustacean appendages.
5	30th November 1936	10 A.M.	129	Do.	Do.	0.4	90 10	Polychaete remains. Bivalve fragments.

DIET TABLES.

DIET TABLE 1.—*Volumetric Percentages of the Food-components in Therapon puta Cuv. & Val.*

Month.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apl.	TOTAL.
No. Specimens Examined.	4	17	3	26	8	20	4	82
No. with food-contents	2	9	..	13	4	10	..	38
CRUSTACEA	..	56·32	..	60·85	33	36·5	..	Monthly Average 37·34
ENTOMOSTRACA	..	0·22	..	0·08	1·75	..	..	0·41
Copepods	..	..	..	0·08	1·75	..	..	0·37
Cirripedes	..	0·22	..	..	..	..	..	0·04
MALACOSTRACA	..	56·1	..	44·23	17·5	36·5	..	30·87
Mysids	..	..	..	0·15	..	..	..	0·03
Isopods	..	..	..	..	1·25	..	..	0·25
Amphipods	..	0·22	..	0·08	..	0·5	..	0·16
Decapods	..	55·88	..	44	16·25	36	..	30·43
Macrurans	..	40·78	..	37·85	10	33·5	..	24·42
Anomurans	..	0·33	..	..	..	2	..	0·47
Pagurids	..	..	..	4·23	..	..	..	0·85
Brachyurans	..	6·44	..	..	2·5	..	..	1·79
Crab eggs	..	8·33	..	..	..	..	..	1·67
Decapod parts	..	..	..	1·92	3·75	0·5	..	1·23
Crustacean parts	..	..	..	16·54	13·75	..	..	6·06
POLYCHAETA	95	15·11	..	18·46	..	0·1	..	25·73
Eunicids	..	4·22	..	..	..	..	..	0·84
Polychaete parts	95	10·89	..	18·46	..	0·1	..	24·89
TELEOSTEI	..	27·68	..	17·77	45	30	..	24·09
Scales	..	9·79	..	9·31	15	..	..	6·82
Clupeids	..	..	..	..	..	29·0	..	5·8
Teleost parts	..	17·89	..	8·46	30	1	..	11·47
MOLLUSCA	..	0·56	..	1·62	17·5	1·5	..	4·24
Bivalves	..	..	..	0·08	17·5	1·5	..	3·82
Cephalopods	..	0·56	..	1·54	..	..	..	0·42
Hydrozoan colonies	..	..	..	..	..	30·5	..	6·1
Campanularia zooids	..	..	..	1·3	..	..	..	0·26
Salpa	..	..	..	..	..	1	..	0·2

DIET TABLE 1.—*Volumetric Percentages of the Food-components in Therapon puta Cuv. & Val.—contd.*

Month.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apl.	TOTAL.
FORAMINIFERA	..	..	..	..	0.25	..	..	0.05
DIGESTED MATTER.	..	..	..	..	4.25	..	..	0.85
PLANT	5	..	..	..	..	0.4	..	1.08
Algae	2	..	..	..	..	0.4	..	0.48
Sea weed	3	..	..	..	..	..	..	0.6
SAND	..	0.33	..	..	..	..	..	0.06

DIET TABLE 2.—*Volumetric Percentages of the Food-components in Therapon jarbua (Forsk.).*

Month.	Jan.	Apl.	May.	Sept.	Oct.	TOTAL.
No. Specimens Examined	9	3	5	41	101	159
No. with food-contents	5	2	2	11	51	71
CRUSTACEA	37.4	50	..	31.36	74.29	Monthly Average 38.61
ENTOMOSTRACA	..	..	..	7.27	8.82	3.218
Copepods	..	..	..	7.27	8.82	3.218
MALACOSTRACA	37.4	50	..	24.09	65.47	35.392
Macruran Decapods	19.6	..	..	..	3.33	4.586
Mysids	17	..	..	1.82	..	3.764
<i>Squilla</i>	..	..	..	..	4.52	0.904
Amphipods	..	..	..	0.46	57.62	11.616
<i>Caprella</i>	..	..	..	7.27	..	1.454
Eggs of Crustacea	..	..	..	7.27	..	1.454
Crustacean remains (Malacost- traca).	0.8	50	..	7.27	..	11.614
TELEOSTEI	58	10	100	30.91	4.76	40.734
Scales	37.8	10	100	12.73	4.76	33.058
Fish	20.2	..	..	9.09	..	5.858
Eggs of fish	..	..	..	9.09	..	1.818
ZOOTHAMNIUM.	..	..	..	29.09	..	5.818
POLYCHAETA	1	..	..	7.27	5.59	2.772
INSECTA	3.6	..	..	0.91	5.83	2.068
EGG MASSES	..	..	..	..	0.72	0.144
DIGESTED MATTER	..	40	..	0.46	6.22	9.336
PLANT	..	..	..	..	2.59	0.518

DIET TABLE 3.—*Volumetric percentages of the Food-components in Pelates quadrilineatus (Bl.).*

Month.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	TOTAL.
No. Specimens Examined.	10	7	11	64	7	28	13	140
No. with food-contents	4	2	2	44	..	19	8	79
CRUSTACEANS	92.5	94	20	54.42	..	72.39	52.73	Monthly Average 64.34
ENTOMOSTRACA	..	..	..	0.67	..	0.79	5	1.08
Ostracods	..	..	..	0.34	..	0.53	..	0.15
Copepods	..	..	..	0.33	..	0.26	5	0.93
MALACOSTRACA	87.5	94	20	51.64	..	63.6	22.13	56.47
Mysids	2.5	..	10	..	..	..	..	2.08
Isopods	..	..	..	0.25	..	..	..	0.04
Amphipods	45	55	10	2.42	..	16.7	20.7	24.97
Caprellines	..	20	..	..	..	..	..	3.33
Decapods	40	9	..	48.97	..	46.9	1.43	24.38
Macrurans	40	..	..	48.83	..	46.9	1.43	22.86
Prawns	25	..	..	..	..	..	..	4.17
Acetes	12.5	..	..	48.5	..	38.69	1.43	16.85
Leucifer	2.5	..	..	..	..	..	..	0.42
Alpheus	..	..	..	..	..	4.21	..	0.7
Macruran parts	..	..	..	0.33	..	4	..	0.72
Brachyurans	..	..	..	0.14	..	..	..	0.02
Decapod parts	..	9	..	..	..	..	..	1.5
Stomatopoda	..	10	..	..	..	..	..	1.67
Crustacean parts	5	..	..	2.11	..	8	25.6	6.79

DIET TABLE 3.—*Volumetric percentages of the Food-components in Pelates quadrilineatus (Bl.)—contd.*

Month.	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	TOTAL.
POLYCHAETA	..	3	80	34.55	..	9.7	1.7	21.49
<i>Owenia</i>	..	..	80	30.3	..	..	..	18.38
Sabellids	..	..	..	..	..	3.7	..	0.61
Polychaete larvae	..	..	..	0.25	..	..	..	0.04
Polychaete parts	..	3	..	4	..	6	1.7	2.45
MOLLUSCA	1.75	3	..	0.33	..	0.05	0.7	0.97
Bivalves	0.5	..	..	0.08	..	..	0.7	0.21
Gastropods	1.25	3	..	0.25	..	0.05	..	0.76
TELEOSTEI	..	..	..	..	..	2.1	..	0.35
ECHINODERMATA	..	..	..	0.6	..	1.1	0.14	0.31
Ophiuroids	..	..	..	..	..	1.05	0.14	0.2
Echinoids	..	..	..	..	..	0.05	..	0.01
Echinoderm parts	..	..	..	0.6	..	..	..	0.1
POLYZOA	..	..	..	0.6	..	..	..	0.1
FORAMINIFERA	..	..	..	..	..	..	0.7	0.12
DIGESTED ANIMAL MATTER.	4.5	..	..	8.91	..	9.51	39.83	10.46
NEMATODA	..	..	..	0.03	..	0.47	..	0.08
TREMATODA	1.25	..	..	..	..	..	..	0.21
PLANT	..	..	..	0.14	..	2	0.7	0.47
Algae	..	..	..	0.14	..	2	..	0.35
Sea Weed	..	..	..	..	..	..	0.7	0.12
SAND	..	..	..	0.42	..	2.68	3.5	1.1

DIET TABLE 4.—*Volumetric percentages of the Food-components in Lutianus vaigiensis (Q. & G.).*

Month.	Aug.	Sept.	Oct.	Nov.	Jan.	Apl.	TOTAL.
No. Specimens Examined	16	33	20	6	6	7	88
No. with food contents	6	10	6	2	3	2	29
							Monthly Average
CRUSTACEA	77	71	92·1	97	99	100	89·42
ENTOMOSTRACA	0·2	..	0·4	..	..	..	0·1
Copepods	0·2	..	0·4	..	..	..	0·1
MALACOSTRACA	72	44·3	56·7	97	99	100	78·17
Mysids	5	0·5	0·5	..	..	..	1
Amphipods	1	0·2	3	..	..	..	0·7
Decapods	66	42·6	53·2	97	99	100	76·3
Macrurans	45	23	21	97	99	..	47·5
<i>Alpheus</i>	..	..	6	..	..	..	1
<i>Acetes</i>	45	7	..	97	99	..	41·33
Macrurans parts	..	16	..	..	..	..	2·67
<i>Penaeus</i>	..	..	15	..	..	..	2·5
Anomurans	..	10	1·7	..	..	100	18·62
Hermit crabs	..	10	1·7	..	..	..	1·95
<i>Hippa</i>	..	..	..	..	..	100	16·67
Brachyuran Crabs	21	9·6	30·5	..	..	..	10·18
Crustacean remnants	4·8	27·7	35	..	..	..	11·25
POLYCHAETA	9	5	4	..	..	..	3
Sabellids	4	..	..	..	..	..	0·67
<i>Pectinaria</i>	5	..	..	..	..	..	0·88
Eunicids	..	5	1·5	..	..	..	1·08
Terebellids	..	..	2·5	..	..	..	0·42
TELEOSTEI	5	24	..	2·5	..	..	5·25
ECHINODERMATA	5	..	..	..	..	..	0·84
PLANT	4	..	3·9	0·5	1	..	1·57
Algae	4	..	3·9	..	1	..	1·49
Sea weed	..	..	..	0·5	..	..	0·08

DIET TABLE 5.—*Volumetric percentages of the Food-components in Lutianus sanguineus (Cuv. and Val.).*

	August.
No. examined	7
No. with food	2
	Per cent.
CRUSTACEA	75
Leucifer	10
Pedunculate Cirripede	5
Crustacean remains	60
TELEOSTEI	20
MOLLUSCS	5
	100

DIET TABLE 6.—*Volumetric percentages of the Food-components in Lutianus lutianus Bl.*

	August.
No. examined	6
No. with food	3
	Per cent.
TELEOSTEI	85
DIGESTED MATTER	10
VEGETABLE MATTER	5
	100

DIET TABLE 7.—*Volumetric percentages of the Food-components in Lutianus lineolatus (Rüpp.).*

	Sept.	Oct.	Total.
No. examined	10	10	20
No. with food	5	5	10
			Per cent.
TELEOSTEI			55
DIGESTED MATTER			45
			100

DIET TABLE 8.—*Volumetric percentages of the Food-components in Lutianus johnii (Bl.).*

	Nov.
No. examined	5
No. with food	2
	Per cent.
CRUSTACEA	50
Brachyurans	50
TELEOSTEI	25
MISCELLANEOUS	10
DIGESTED MATTER	15
	100

DIET TABLE 9.—*Volumetric percentages of the Food-components in Epinenphelus tauvina (Forsk.).*

Month.	Sept.	Oct.	Nov.	Jan.	Feb.	TOTAL.
No. Specimens Examined	5	5	5	3	3	21
No. with food-contents	2	1	3	1	1	8
						Monthly Average 65.4
CRUSTACEA	100	30	67	60	70	
ENTOMOSTRACA	..	..	..	..	..	..
MALACOSTRACA	100	30	67	60	70	65.4
Macrurans	40	..	19	60	70	37.8
<i>Acetes</i>	..	..	2	..	70	14.4
Other Macrurans	40	..	5	60	..	21
Macruran remnants	..	..	12	..	..	2.4
Brachyura	60	30	48	..	..	27.6
<i>Neptunus</i>	60	30	45	..	..	27
Dromeacean crabs	..	..	3	..	..	0.6
TELEOSTEI	..	70	33	40	30	34.6

DIET TABLE 10.—*Volumetric percentages of the Food-components in Epinephelus undulosus (Q. & G.).*

	Oct.
No. examined	9
No. with food	3
	Per cent.
CRUSTACEA	70
Brachyurans	15
Alphaeids	1.33
Other Macrurans	33.34
Other Decapods	20.33
TELEOSTEI	25
POLYCHAETES	5
	100

DIET TABLE 11.—*Volumetric percentages of the Food-components in Epinephelus maculatus (Bl.).*

	Oct.
No. examined	5
No. with food	2
	Per cent.
CRUSTACEA	75
Macrurans	75
DIGESTED MATTER	25
	100

DIET TABLE 12.—*Volumetric percentages of the Food-components in Epinephelus boenack (Bl.).*

	Sept.	Mar.	Total.
No. examined	2	3	5
No. with food	..	3	3
			Per cent.
CRUSTACEA			83
Brachyurans			38.33
Alphaeids			44.67
TELEOSTEI			7
DIGESTED MATTER			8
SAND			2
			100

DIET TABLE 13.—*Volumetric percentages of the Food-components in Epinephelus lanceolatus (Bl.).*

	Sept.
No. examined	2
No. with food	1
	Per cent.
CRUSTACEA	80
Macrurans	80
DIGESTED MATTER	20
	100

DIET TABLE 14.—*Volumetric percentages of the Food-components in Pomadasys maculatus (Bl.).*

Month.	Nov.	Dec.	Jan.	Feb.	Apl.	TOTAL.
No. Specimens Examined	14	4	8	10	14	50
No. with food-contents	7	..	4	4	2	17
						Monthly Average 27.955
CRUSTACEA	51.86	..	25	32.5	2.5	
ENTOMOSTRACA	..	..	..	..	..	..
MALACOSTRACA	51.86	..	25	32.5	2.5	27.95
Isopods	0.29	..	..	..	..	0.07
Amphipods	1	..	..	3.75	..	1.19
Penaeus	2.14	..	..	..	..	0.53
Acetes	31	..	2.5	..	..	8.37
Anomurans	..	..	5	..	..	1.25
Brachyuran crabs	2.86	..	2.5	..	..	1.34
Stomatopods	..	..	..	..	2.5	0.625
Malacostracan remains	14.57	..	15	28.75	..	14.58

DIET TABLE 14.—*Volumetric percentages of the Food-components in Pomadasys maculatus (Bl.)—contd.*

Month.	Nov.	Dec.	Jan.	Feb.	Apl.	TOTAL.
POLYCHAETA	20.14	..	..	28.75	47.5	24.097
TELEOSTEI	25.28	..	49.5	2.5	..	19.32
MOLLUSCANS	0.14	..	..	15	..	3.79
OPHIUROIDS	0.43	..	..	..	..	0.11
HYDROZOA	0.43	..	..	..	..	0.11
LARVACEAE	..	..	..	3.75	..	0.94
DIGESTED MATTER	1.43	..	25.5	17.5	50	23.61
SAND	0.29	..	..	..	..	0.07

DIET TABLE 15.—*Volumetric percentages of the Food-components in Pomadasys olivaceus (Day).*

	Oct.
No. examined	6
No. with food	4
	Per cent.
CRUSTACEA	20
Amphipods	3
Macrurans	6
Brachyurans	3
Crustacean remains	8
POLYCHAETES	50
DIGESTED MATTER	30
	100

DIET TABLE 16.—*Volumetric percentages of the Food-components in Apogon nigripinnis Cuv. & Val.*

	Aug.	Sept.	Total.
No. examined	5	4	9
No. with food	2	3	5
			Per cent.
CRUSTACEA			80
Macrurans			80
TELEOSTEI			5
DIGESTED MATTER			15
			100

DIET TABLE 17.—*Volumetric percentages of the Food-components in Ambassis gymnocephalus (Lacép.).*

	Nov. 1937.	Feb. 1938.	Total.
No. examined	8	4	12
No. with food	2	2	4
			Per cent.
CRUSTACEA			47·5
Mysids			20
Copepods			15
Crustacean remains			12·5
DIGESTED MATTER			47
SAND			2·5
ALGAE			3
			100

DIET TABLE 18.—*Volumetric percentages of the Food-components in Gerres punctatus Cuv. & Val.*

	Nov. 1937.	Feb. 1938.	Total.
No. examined	10	4	14
No. with food	5		5
			Per cent.
CRUSTACEA			40
Copepods			1
Crustacean remains			39
POLYCHAETES			57
Eunicids			8
Chaetopterids			31
Polychaete remains.			18
MOLLUSCS			2
CEPHALOCHORDATE LARVA			1
			100

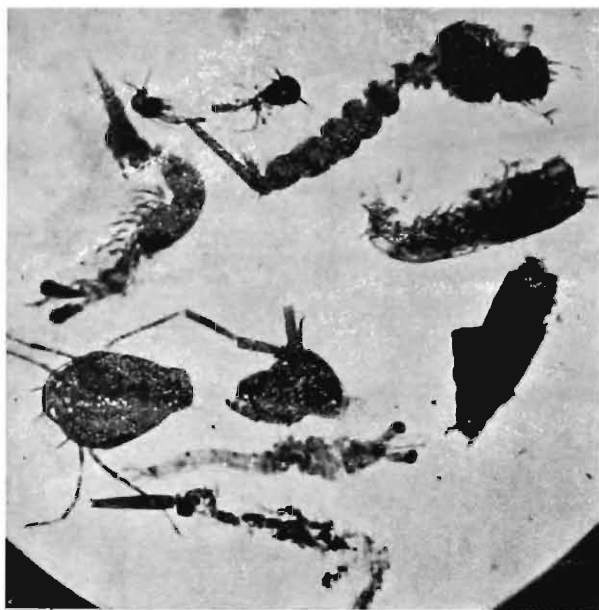
DIET TABLE 19.—*Volumetric percentages of the Food-components for the Perches of the Madras Coast as represented by the eighteen species studied.*

(The proportions are the results of dividing the totals of the percentages of the different food items of individual fishes by the total number of perches with food in stomach.)

No. examined	641
No. with food	286
	Per cent.
CRUSTACEA	57·07
Copepods	2·33
Schizopods	0·89
Amphipods	13·69
Decapods	31·01
Macrurans	24·35
Anomurans	1·23
Brachyurans	4·02
Decapod remains	1·41
Miscellaneous Crustacean remains	9·15
INSECTA	1·11
POLYCHAETA	13·29
TELEOSTEI	14·04
MOLLUSCS	0·79
MICELLANEOUS ANIMAL MATTER	3·34
PLANTS	0·96
SAND	0·41
MATTER DIGESTED BEYOND IDENTIFICATION	8·99
	100

EXPLANATION OF PLATE V.

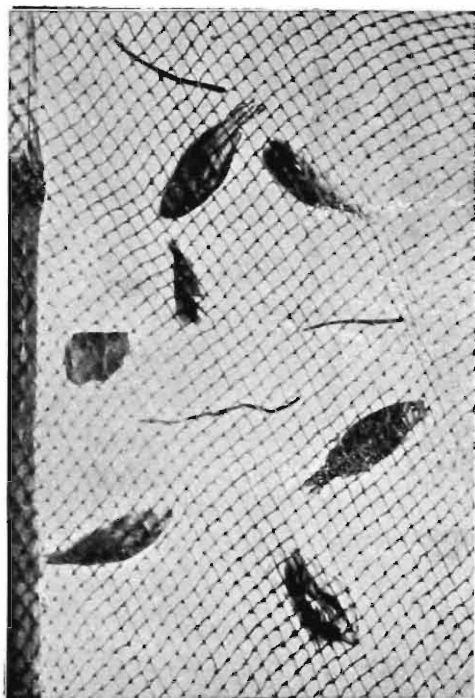
- FIG. 1.—Pickings from typical stomach-contents of *Therapon puta* Cuvier and Valenciennes. Nat. size.
- FIG. 2.—Pickings from typical stomach-contents of *Therapon jarbua* (Forskål): $\times ca. 10$.
- FIG. 3.—Part of a 'katcha valai' in which are entrapped several young *Therapon jarbua* (Forskål) which cannot escape through the narrow meshes of the net — a criminal waste of efficient larvicides: $\times ca. 2/3$.
- FIG. 4.—Pickings from typical stomach-contents of *Lutianus vaigiensis* (Quoy and Gaimard). (Nat. size.)
- FIG. 5.—Pickings from typical stomach-contents of *Epinephelus tauvina* (Forskål): $\times ca. 3/2$.
- FIG. 6.—An immature specimen of *Epinephelus tauvina* with its caecal stomach gorged with another perch, *Therapon puta*: $\times ca. 5/9$. The features of the prey are visible through the stretched walls of the stomach which has assumed the shape of the prey.



2.



5.



3.



6.



4.



1.

Food of Madras Perches.

EXPLANATION OF PLATE VI.

Charts representing the proportions of the food-components¹ for the following genera :—

FIG. 1.—*Therapon* Cuvier as represented by the two species *T. puta* Cuvier and Valenciennes and *T. jarbua* (Forskål).

FIG. 2.—*Pelates* Cuvier and Valenciennes as represented by *P. quadrilineatus* (Bloch).

FIG. 3.—*Lutianus* Bloch as represented by the five species, *L. vaigiënsis* (Quoy and Gaimard), *L. sanguineus* (Cuvier and Valenciennes), *L. lutianus* Bloch, *L. lineolatus* (Rüppell) and *L. johnii* (Bloch).

FIG. 4.—*Epinephelus* Bloch as represented by the five species *E. tauvina* (Forskål), *E. undulosus* (Quoy and Gaimard), *E. maculatus* (Bloch), *E. boenack* (Bloch) and *E. lanceolatus* Bloch ;

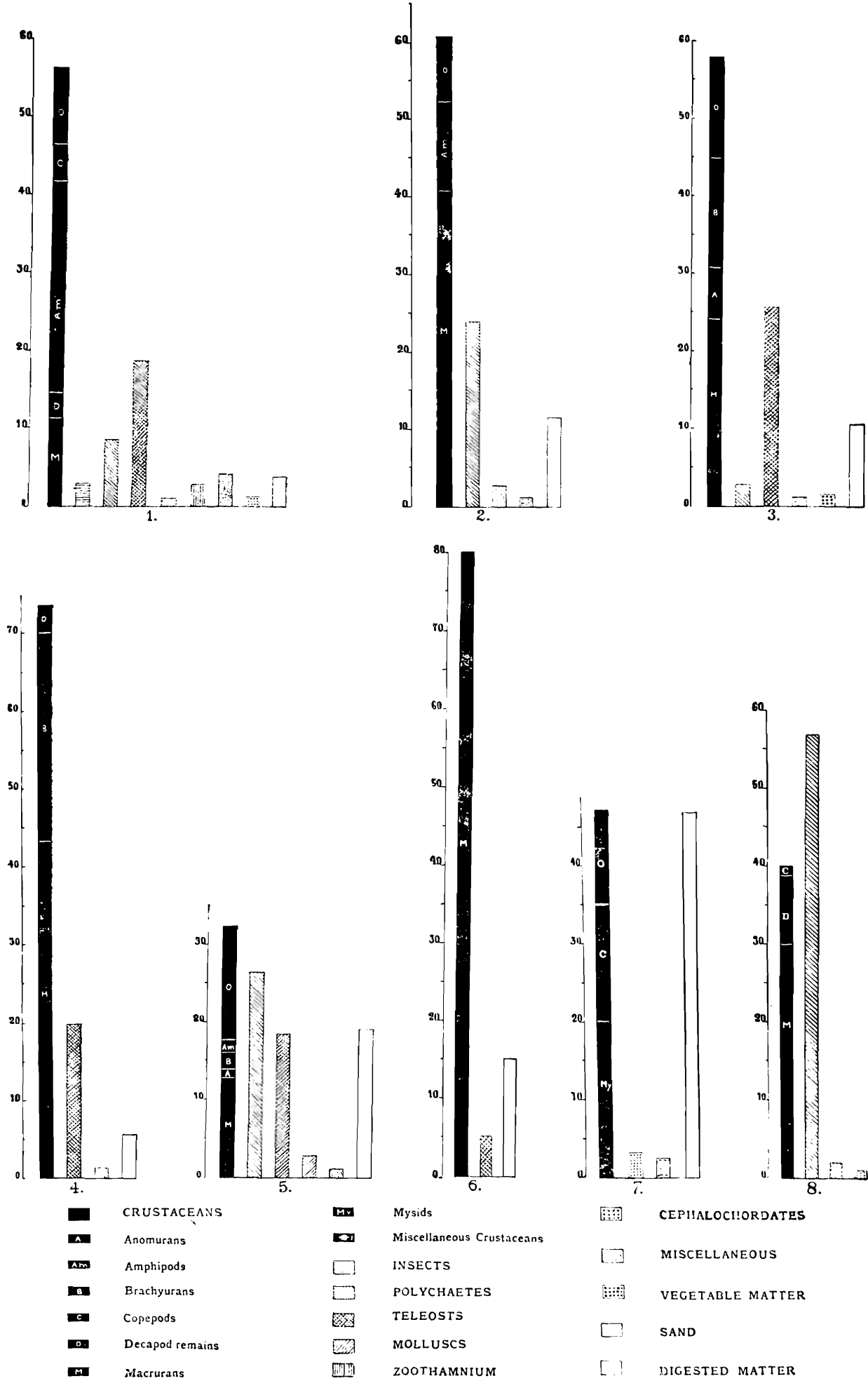
FIG. 5.—*Pomadasys* Lacépède as represented by *P. maculatus* (Bloch) and *P. olivaceus* (Day).

FIG. 6.—*Apcgon* Lacépède as represented by *A. nigripinnis* Cuvier and Valenciennes.

FIG. 7.—*Ambassis* Cuvier and Valenciennes as represented by *A. gymnocephalus* (Lacépède).

FIG. 8.—*Gerres* Cuvier as represented by *G. punctatus* Cuvier and Valenciennes.

¹ The proportions are the results of dividing the totals of the percentages of the different food items of individual fishes of the species of each genus by the number of fish.



Graphical representation of food-components.

ON A COLLECTION OF FISH FROM THE HEADWATERS OF THE MAHANADI RIVER, RAIPUR DISTRICT, C. P.

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In December 1939 my colleague, Dr. H. S. Rao, made a survey of the aquatic fauna of the Mahanadi river and its affluents in the Raipur District of the Central Provinces. The Mahanadi rises near Sihawa in Dhamtari Tahsil and the area surveyed by Dr. Rao comprises a part of the headwaters of the river. It may be noted that the Sihawa range, the general altitude of which ranges between 2,000 to 2,500 feet, forms a watershed between the affluents of the Mahanadi and those of the Godavari. The general characteristic of the Mahanadi and its affluents is that the beds of these streams are wide wastes of sand, dry for more than half the year, and never containing much water except during seasons of high floods. At the time of Dr. Rao's visit, therefore, most of the streams had either scanty flowing water or were cut up into pools and puddles, which were sometimes connected by a small trickle of water. Only in a very few instances fish were collected from rocky streams. It is no wonder, therefore, that the collection under report comprises young specimens of a large number of pool-dwelling species. Incidentally, the material collected shows that most of the small fresh-water fishes in this part of India breed in the autumn months after the cessation of the monsoon. I give below brief descriptions, based on Dr. Rao's notes, of the localities from which fish were collected, and the lists of fishes obtained from each locality. A general account of the collection and the zoogeographical significance of some of the species represented are also given.

DESCRIPTIONS OF LOCALITIES WITH LISTS OF FISHES COLLECTED FROM EACH.

Bokori Nallah, about 3 miles North-East of Kusumkhunta. 7.xii.1939.

It is a small stream broken up into pools of depths varying from 2 to 5 feet, with sandy bottom which, in parts, is strewn with large stones over which there is a slight trickle of water. Weeds of various types, and algae occur in abundance.

			mm.	Specimens.
<i>Brachydanio rerio</i> (Ham.)	..	..	15—24	9
<i>Rasbora daniconius</i> (Ham.)	..	..	41—43	3
<i>Barbus (Puntius) ticto</i> Ham.	..	..	28	1
<i>Lepidocephalichthys guntea</i> (Ham.)	..	..	43	1

Village tank, Singpur. 9.xii.1939.

The tank is used for washing and bathing; it is overgrown with lilies, *Elodea*, and other water plants. Near the edge of the tank a species of Scrophularinae with spines and blue flowers and the reeds of a species of Cyperaceae are common.

			mm.	Specimens.
<i>Brachydanio rerio</i> (Ham.)	..	..	24—29	4
<i>Rasbora daniconius</i> (Ham.)	..	..	32—71	3
<i>Barbus (Puntius) sophore</i> Ham.	..	..	67	1

'Jheel' at Nagri on the Raipur Forest Tramway. 11.xii.1939.

The 'jheel' is about $\frac{1}{2}$ a mile from the Forest Rest House at Nagri; it is situated in an open maidan and is surrounded by rice fields on all sides. It is apparently fed by rains as no streams of any size are to be seen in the vicinity. The 'jheel' is full of weeds of all kinds—*Potamogeton*, *Elodea*, *Trapa spinosa*, lilies, etc. Various grasses grow at the edge, and a few strands of filamentous algae are also seen.

			mm.	Specimens.
<i>Brachydanio rerio</i> (Ham.)	..	..	19—29	26
<i>Esomus danricus</i> (Ham.)	..	..	36—42	2
<i>Barbus (Puntius) ticto</i> Ham.	..	..	30—40	2
<i>Lepidocephalichthys guntea</i> (Ham.)	..	..	24—56	19
<i>Ophicephalus gachua</i> Ham.	..	..	70	1
<i>Ophicephalus punctatus</i> Bloch	..	..	65	1
<i>Nandus nandus</i> (Ham.)	..	..	83	1

Mahanadi river at Sihawa. 12.xii.1939.

			mm.	Specimens.
<i>Barilius prox. bendelisis</i> Ham.	..	..	11—19	49
<i>Brachydanio rerio</i> (Ham.)	..	..	15—29	33
<i>Barbus (Puntius) ticto</i> Ham.	..	..	22—37	2
<i>Nemachilus denisonii</i> Day	..	..	25	1

Tank in Forest Village about 4 miles from Sihawa. 13.xii.1939.

The tank was full of weeds of all kinds, lilies, *Cyperus*, etc.

			mm.	Specimens.
<i>Rasbora daniconius</i> (Ham.)	..	..	30—41	5
<i>Amblypharyngodon mola</i> (Ham.)	..	..	20	1
<i>Lepidocephalichthys guntea</i> (Ham.)	..	..	25—44	8
<i>Ophicephalus gachua</i> Ham.	..	..	106	1

Biweekly Market at Sihawa. 13.xii.1939.

			mm.	Specimens.
<i>Rhynchobdella aculeata</i> (Bloch)	..	..	109—122	2
<i>Barilius bendelisis</i> Ham.	..	..	46—150	9
<i>Brachydanio rerio</i> (Ham.)	..	..	21—23	2
<i>Rasbora daniconius</i> (Ham.)	..	..	42—71	8
<i>Barbus (Puntius) dorsalis</i> (Jerdon)	..	..	44—74	20
<i>Barbus (Puntius) gunganio</i> (Ham.)	..	..	29—33	10
<i>Barbus (Puntius) sarana</i> (Ham.)	..	..	81—161	5
<i>Barbus (Puntius) ticto</i> Ham.	..	..	32—42	26
<i>Garra mullya</i> (Sykes)	..	..	69—97	2
<i>Labeo boggut</i> (Sykes)	..	..	109—116	2
<i>Lepidocephalichthys guntea</i> (Ham.)	..	..	32—60	14
<i>Mystus cavasius</i> (Ham.)	..	..	49—89	4
<i>Mystus tengara</i> (Ham.)	..	..	48—70	3
<i>Mystus vittatus</i> (Bloch)	..	..	44—72	16
<i>Bagarius bagarius</i> (Ham.)	..	..	287	1
<i>Ophicephalus gachua</i> Ham.	..	..	92	1
<i>Nandus nandus</i> (Ham.)	..	..	98	1

Mahanadi river before its junction with the Balka Nallah about 3 miles from Sihawa. 14.xii.1939.

The Mahanadi proper before it receives the Balka Nallah is a deep-cut stream with high banks. In places it is 7-10 feet deep. The bottom is muddy ; in places it is sandy and strewn over with small pebbles.

			mm.	Specimens.
<i>Laubuca laubuca</i> (Ham.)	..	..	22—36	11
<i>Barilius bendelisis</i> Ham.	..	..	35	2
<i>Brachydanio rerio</i> (Ham.)	..	..	13—30	48
<i>Esomus danricus</i> (Ham.)	..	..	40—41	2
<i>Rasbora daniconius</i> (Ham.)	..	..	30	1
<i>Barbus (Puntius) gelius</i> Ham.	..	..	18	1
<i>Barbus (Puntius) guganio</i> (Ham.)	..	..	26—31	2
<i>Barbus (Puntius) ticto</i> Ham.	..	..	20—41	55
<i>Nemachilus botia</i> (Ham.)	..	..	22—28	2
<i>Nemachilus denisonii</i> Day	..	..	21—42	21
<i>Lepidocephalichthys guntea</i> (Ham.)	..	..	29—65	52
<i>Mystus tengara</i> (Ham.)	..	..	42—48	3
<i>Erethistes hara</i> (Ham.)	..	..	37	1
<i>Ophicephalus punctatus</i> Bloch	..	..	102	1

Balka Nallah about 3 miles from Sihawa. 14.xii.1939.

The Balka is a sandy stream with only ankle-deep water in which algae and other weeds occur.

			mm.	Specimens.
<i>Laubuca laubuca</i> (Ham.)	..	..	25—29	13
<i>Barilius prox. bendelisis</i> Ham.	..	..	16—23	3
<i>Brachydanio rerio</i> (Ham.)	..	..	16—31	46
<i>Barbus (Puntius) gelius</i> Ham.	..	..	17	1
<i>Barbus (Puntius) ticto</i> Ham.	..	..	25—34	15
<i>Lepidocephalichthys guntea</i> (Ham.)	..	..	43—48	7

Muddy road-side pools between Sihawa and Birgudi. 15.xii.1939.

			mm.	Specimens.
<i>Brachydanio rerio</i> (Ham.)	..	..	10—18	36
<i>Barbus (Puntius) ticto</i> Ham.	..	..	12—32	12

Village tank near Birgudi about 3 miles from Sihawa. 15.xii.1939.

The tank is used as a buffalo-wallow ; it is overgrown with reeds (Cyperaceae) and weeds (*Potamogeton* and *Elodea*) of various kinds, and its sides are swampy.

			mm.	Specimens.
<i>Brachydanio rerio</i> (Ham.)	..	..	15—25	6
<i>Barbus (Puntius) sophore</i> Ham.	..	..	15—34	3

Small, deep stream close to the Forest Rest House at Gattasilli. 16.xii.1939.

			mm.	Specimens
<i>Brachydanio rerio</i> (Ham.)	..	..	9—15	7

Ama Nallah about 2 miles from Gattasilli. 17.xii.1939.

A shallow stream on the edge of the forest at Gattasilli in the Birgudi range. The bottom is flat and sandy with a few rocks here and there.

The water is only ankle-deep, and there is a layer of green algae at the bottom. Many patches of long trailing grass also occur.

			mm.	Specimens.
<i>Brachydanio rerio</i> (Ham.)	..	..	12—35	206
<i>Esomus danricus</i> (Ham.)	..	..	25—46	39
<i>Rasbora daniconius</i> (Ham.)	..	..	40—68	4
<i>Barbus (Puntius) sophore</i> Ham.	..	..	42	1
<i>Barbus (Puntius) ticto</i> Ham.	..	..	17—51	16
<i>Lepidocephalichthys guntea</i> (Ham.)	..	..	36—53	9

Nenginallah swamp near Gattasilli. 18.xii.1939.

The sides of the swamp are overgrown with reeds, while the water is full of *Potamogeton*, *Cyperus*, filamentous algae, and other weeds.

			mm.	Specimens.
<i>Brachydanio rerio</i> (Ham.)	..	..	20—27	29
<i>Barbus (Puntius) gunganio</i> (Ham.)	..	..	21—25	2
<i>Barbus (Puntius) sophore</i> Ham.	..	..	14—19	4
<i>Barbus (Puntius) ticto</i> Ham.	..	..	20—26	2
<i>Lepidocephalichthys guntea</i> (Ham.)	..	..	50—70	2
<i>Ophicephalus punctatus</i> Bloch	..	..	46—61	4
<i>Nandus nandus</i> (Ham.)	..	..	46—51	2

Small stream and swamp near Dokal Forest Rest House. 20.xii.1939.

Some portions of the stream are muddy while others are sandy; it flows over rocky ground before reaching the swampy portion. The edges of the stream are overgrown with grass, weeds and shrubs. In the rocky portion there are small rounded buttons of mucilaginous light green algae in small patches.

The swamp was obviously lately cultivated as the stumps of paddy 2 to 3 feet high, which are still to be seen over it, show. Puddles of water full of *Potamogeton* are left in various parts of the swamp.

			mm.	Specimens.
<i>Brachydanio rerio</i> (Ham.)	..	..	18—34	157
<i>Danio aequipinnatus</i> (McClell.)	..	..	53—60	5
<i>Esomus danricus</i> (Ham.)	..	..	33—47	36
<i>Rasbora daniconius</i> (Ham.)	..	..	34—92	29
<i>Barbus (Puntius) dorsalis</i> (Jerdon)	..	..	36—41	2
<i>Lepidocephalichthys guntea</i> (Ham.)	..	..	48	1
<i>Nemachilus denisonii</i> Day	..	..	21—43	23
<i>Ophicephalus gachua</i> Ham.	..	..	64—73	4

Morrumsilli Reservoir, about 5 miles to the south-west of Banroud.
23.xii.1939.

The reservoir is formed by putting a dam across the Silari river and is about 180 sq. miles in extent. Below the dam the Silari continues as a small stream. There are great numbers of fish of all kinds, but it is difficult to catch them without suitable appliances.

			mm.	Specimens.
<i>Brachydanio rerio</i> (Ham.)	..	..	22—29	11
<i>Rasbora daniconius</i> (Ham.)	..	..	36	1
<i>Barbus (Puntius) ticto</i> Ham.	..	..	16	1
<i>Lepidocephalichthys guntea</i> (Ham.)	..	..	30	1
<i>Xenentodon cancila</i> (Ham.)	..	..	41	1

Mahanadi river at Rudri. 24.xii.1939.

The Mahanadi river is situated at a distance of about one mile from the P. W. D. Inspection Bungalow at Rudri ; it is about a mile broad. The main stream flows about the centre of the bed and is knee-to waist-deep in many places. The bed is mostly sandy though, in places, sand is mixed with mud. The current is fairly swift.

			mm.	Specimens.
<i>Mastacembelus pancalus</i> (Ham.)	..	..	57—73	2
<i>Rasbora daniconius</i> (Ham.)	..	..	19	1
<i>Barilius prox. bendelisis</i> Ham.	..	..	10—17	4
<i>Barbus (Puntius) dorsalis</i> (Jerdon)	..	..	30—48	27
<i>Barbus (Puntius) guganio</i> (Ham.)	..	..	19—23	7
<i>Barbus (Puntius) sophore</i> Ham.	..	..	24	1
<i>Barbus (Puntius) ticto</i> Ham.	..	..	15—34	133
<i>Oreichthys cosuatus</i> (Ham.)	..	..	21—25	3
<i>Lepidocephalichthys guntea</i> (Ham.)	..	..	36—54	86
<i>Nemachilus botia</i> (Ham.)	..	..	26—40	5
<i>Ophicephalus gachua</i> Ham.	..	..	70	1

Dhamtari Bazaar (Mahanadi river). 24.xii.1939.

			mm.	Specimens.
<i>Mastacembelus pancalus</i> (Ham.)	..	..	44—106	5
<i>Rhynchobdella aculeata</i> (Bloch)	..	..	120	1
<i>Chela bacaila</i> Ham.	..	..	54—75	3
<i>Barilius barna</i> Ham.	..	..	58—66	2
<i>Barilius bendelisis</i> Ham.	..	..	46—140	15
<i>Rasbora daniconius</i> (Ham.)	..	..	28—53	24
<i>Amblypharyngodon mola</i> (Ham.)	..	..	44—64	3
<i>Aspidoparia morar</i> (Ham.)	..	..	32—82	17
<i>Barbus (Puntius) dorsalis</i> (Jerdon)	..	..	42—61	43
<i>Barbus (Puntius) gelius</i> Ham.	..	..	27	1
<i>Barbus (Puntius) sarana</i> (Ham.)	..	..	130—143	3
<i>Barbus (Puntius) sophore</i> Ham.	..	..	40—59	36
<i>Barbus (Puntius) tetrapogon</i> (McClell.)	..	..	49—89	5
<i>Barbus (Puntius) ticto</i> Ham.	..	..	30—55	4
<i>Labeo boggut</i> (Sykes)	..	..	35—84	2
<i>Lepidocephalichthys guntea</i> (Ham.)	..	..	28—54	10
<i>Nemachilus botia</i> (Ham.)	..	..	45—56	4
<i>Clarias batrachus</i> (Linn.)	..	..	140—153	2
<i>Heteropneustes fossilis</i> (Bloch)	..	..	92—96	2
<i>Mystus aor</i> (Ham.)	..	..	190—195	2
<i>Mystus cavasius</i> (Ham.)	..	..	65—86	5
<i>Mystus tengara</i> (Ham.)	..	..	46—78	15
<i>Mystus vittatus</i> (Bloch)	..	..	58—65	6
<i>Pseudotropius atherinoides</i> (Bloch)	..	..	50	2
<i>Xenentodon cancila</i> (Ham.)	..	..	230	1
<i>Ophicephalus punctatus</i> Bloch	..	..	86—118	2
<i>Ambassis ranga</i> (Ham.)	..	..	30—32	2
<i>Nandus nandus</i> (Ham.)	..	..	48—125	6
<i>Badis badis</i> (Ham.)	..	..	17	1

Mahanadi Irrigation Canal, Rudri. 25.xii.1939.

The water is standing in disconnected pools at various places throughout the canal. The sides of the canal are rocky and the bed is strewn

over with small and large pieces of stone. The bed is pebbly, except in fairly deep water where it is muddy.

		mm.	Specimens.
<i>Mastacembelus armatus</i> (Lacép.)	..	94	1
<i>Chela bacaila</i> Ham.	..	95—107	2
<i>Laubuca laubuca</i> (Ham.)	..	29	1
<i>Brachydanio rerio</i> (Ham.)	..	22—24	2
<i>Rasbora daniconius</i> (Ham.)	..	36—44	4
<i>Barbus (Puntius) guganio</i> (Ham.)	..	34	1
<i>Barbus (Puntius) sophore</i> Ham.	..	83	1
<i>Barbus (Puntius) tetrapagrus</i> (McClell.)	..	93	1
<i>Barbus (Puntius) ticto</i> Ham.	..	33—57	64
<i>Garra mullya</i> (Sykes)	..	73—85	2
<i>Oreichthys cosuatus</i> (Ham.)	..	33—34	2
<i>Lepidocephalichthys guntea</i> (Ham.)	..	33—48	5
<i>Nemachilus botia</i> (Ham.)	..	35—58	19
<i>Nemachilus denisonii</i> Day		22—50	20
<i>Mystus cavasius</i> (Ham.)	..	93—98	2
<i>Amblyceps mangois</i> (Ham.)	..	26—49	7
<i>Ambassis ranga</i> (Ham.)	..	52	1
<i>Glossogobius giuris</i> (Ham.)	..	93	1

SYSTEMATIC ACCOUNT.

The collection under report comprises 1,872 specimens of 43 species. The systematic position of these species is shown in the following table :

Family MASTACEMBELIDAE.

1. *Mastacembelus armatus* (Lacépède).
2. *Mastacembelus pancalus* (Hamilton).
3. *Rhynchobdella aculeata* (Bloch).

Family CYPRINIDAE.

Subfamily ABRAMADINAE.

4. *Chela bacaila* Hamilton.
5. *Laubuca laubuca* (Hamilton).

Subfamily RASBORINAE.

6. *Barilius barna* Hamilton.
7. *Barilius bendelisis* Hamilton.
8. *Brachydanio rerio* (Hamilton).
9. *Danio aequipinnatus* (McClelland).
10. *Esomus danricus* (Hamilton).
11. *Rasbora daniconius* (Hamilton).

Subfamily CYPRININAE.

12. *Amblypharyngodon mola* (Hamilton).
13. *Aspidoparia morar* (Hamilton).
14. *Barbus (Puntius) dorsalis* (Jerdon).
15. *Barbus (Puntius) gelius* Hamilton.
16. *Barbus (Puntius) guganio* (Hamilton).
17. *Barbus (Puntius) sarana* (Hamilton).
18. *Barbus (Puntius) sophore* Hamilton.
19. *Barbus (Puntius) tetrapagrus* (McClelland).
20. *Barus (Puntius) ticto* Hamilton.
21. *Garra mullya* (Sykes).
22. *Labeo boggut* (Sykes).
23. *Oreichthys cosuatus* (Hamilton).

Family COBITIDAE.

24. *Lepidocephalichthys guntea* (Hamilton).
25. *Nemachilus botia* (Hamilton).
26. *Nemachilus denisonii* Day.

Family BAGRIDAE.

27. *Mystus aor* (Hamilton).
28. *Mystus cavasius* (Hamilton).
29. *Mystus tengara* (Hamilton).
30. *Mystus vittatus* (Bloch).

Family AMBLYCEPIDAE.

31. *Amblyceps mangois* (Hamilton).

Family SISORIDAE.

32. *Erethistes hara* (Hamilton).
33. *Bagarius bagarius* (Hamilton).

Family SCHILBEIDAE.

34. *Pseudeutropius atherinoides* (Bloch).

Family CLARIIDAE.

35. *Clarias batrachus* (Linnaeus).

Family HETEROPNEUSTIDAE.

36. *Heteropneustes fossilis* (Bloch).

Family BELONIDAE.

37. *Xenentodon cancila* (Hamilton).

Family OPHICEPHALIDAE.

38. *Ophicephalus gachua* Hamilton.
39. *Ophicephalus punctatus* Bloch.

Family AMBASSIDAE.

40. *Ambassis ranga* (Hamilton).

Family NANDIDAE.

41. *Nandus nandus* (Hamilton).

Family PRISTOLEPIDAE.

42. *Badis badis* (Hamilton).

Family GOBIIDAE.

43. *Glossogobius giuris* (Hamilton).

Of the 43 species listed above, 23 belong to the order Cyprinoidea (20 Cyprinidae and 3 Cobitidae), 10 to the order Siluroidea (4 Bagridae, 1 Amblycepidae, 2 Sisoridae, 1 Schilbeidae, 1 Clariidae and 1 Heteropneustidae), while the remaining ten species are of the families Mastacembelidae (3), Belonidae (1), Ophicephalidae (2), Ambassidae (1), Nandidae (1), Pristolepidae (1) and Gobiidae (1). With the exception of a few small species of carp-minnows all the others are fairly well known and do not call for any special comments from a systematic point of view. However, notes are given on the distribution of *Rhynchobdella aculeata*, *Nemachilus denisonii* and *Amblyceps mangois*.

From a zoogeographical point of view the occurrence of *Amblyceps mangois* in the Mahanadi system, and of *Barbus (Puntius) dorsalis* and *Nemachilus denisonii* so far north and east are very significant as showing former hydrographic relations of the present-day river systems. It may be noted that the Sihawa range is only a spur of the once extensive Satpura Mountains.

***Rhynchobdella aculeata* (Bloch).**

1938. *Rhynchobdella aculeata*, Shaw and Shebbeare, *Journ. Roy. As. Soc. Bengal, Science III*, p. 126, text-fig. 128, 1937.

Regarding the habitat of *Rhynchobdella aculeata*, Day¹ made the following observations :

"Brackish waters within tidal influence, also throughout the deltas of large Indian, Burmese, and Sind rivers, but appears to be absent from the northern portion of the Punjab and the Malabar coast : it extends to Borneo and the Moluccas : attaining about 15 inches in length. It conceals itself in the mud, and becomes drowned if placed in water so as to be unable to reach the surface, apparently requiring to respire air directly."

In 1935, while recording observations on the mode of aerial respiration in Mastacembelid fishes, I² stated that *Rhynchobdella aculeata* is found in great abundance in Bihar far above the tidal influence. Shaw and Shebbeare (*loc. cit.*) also made a similar observation on the authority of Mr. C. M. Inglis. The present record of the species from the Raipur District shows that fresh water is no bar to its distribution and it is likely that the fish will be found to be more widely distributed in the inland waters of India.

***Barbus (Puntius) dorsalis* (Jerdon).**

1936. *Barbus (Puntius) dorsalis*, Hora, *Rec. Ind. Mus.* XXXVIII, p. 2, text-figs. 1, 2.

In 1936, I discussed the systematic position of *Barbus dorsalis* and showed that it had been described under several names owing to colour variations during growth. Hitherto it has been found only in South India ("Kurnool, Mysore, throughout Madras as low as the Cauvery and Coleroon rivers and Ceylon" Day), and the present record from the Raipur District considerably extends its range towards north-east. From the large number of specimens collected by Dr. Rao, it seems that the species is fairly common in the Mahanadi system.

¹ Day, F., *Fish. India*, p. 338, pl. lxxii, fig. 1 (1876).

² Hora, S. L., *Trans. Nat. Inst. Sci. India*, I, p. 8 (1935).

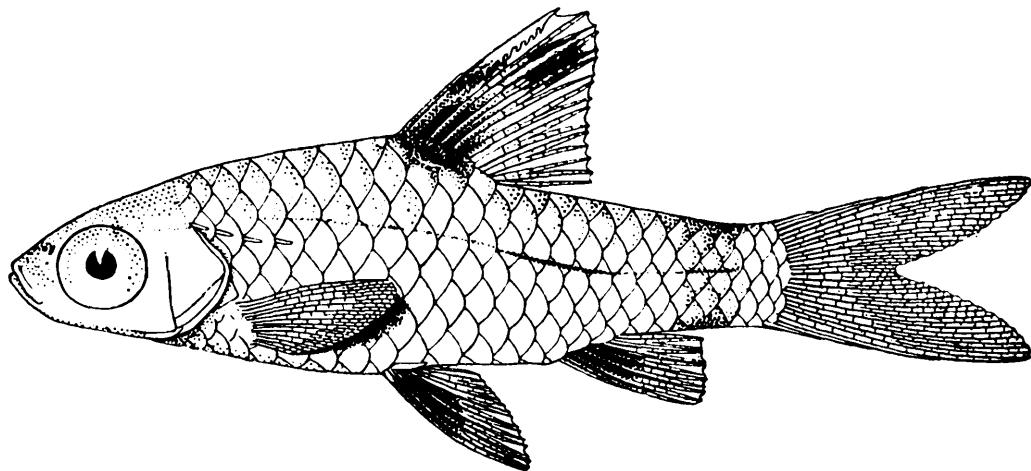
Though the specimens obtained by Dr. Rao range in total length from 30 to 74 mm., the characteristic black spots on the dorsal and anal fins are absent in all of them. The spot before the base of the caudal fin is present, being more marked in smaller specimens. The colour pattern of the scales is also indistinguishable. The dorsal spine is rather weak and articulated, and in this respect the specimens agree with the form described as *Puntius puckelli* by Day¹.

Barbus (Puntius) gelius Hamilton.

1878. *Barbus gelius*, Day, *Fish. India*, p. 577, pl. cxlv, fig. 3.

Barbus gelius is represented in the collection by three juvenile specimens. This species is liable to be confused with *Barbus phutunio*, but the two can be distinguished by their respective colour patterns. The distinguishing characters of the Indian Carp Minnows without barbels and with a serrated dorsal spine have been tabulated by Hora, Misra and Malik².

Hamilton's³ *Cyprinus canius* with reddish colours has been regarded by later workers as a synonym of *Cyprinus gelius* with yellowish colours. A close study of the descriptions of the two species shows their great



TEXT-FIG. 1.—Lateral view of *Barbus (Puntius) gelius* Hamilton: $\times 3\frac{2}{3}$.

similarity, and it seems probable that the colour differences between the two are correlated with sex. From our knowledge of sexual dimorphism in allied species it may be surmised that *C. canius* represents the males and *C. gelius* the females of one and the same species.

According to Day, *B. gelius* is found in Ganjam, Orissa, Bengal and Assam. It was originally described from ponds and ditches of the north-eastern parts of Bengal.

Barbus (Puntius) guganio (Hamilton).

1939. *Barbus guganio*, Das, *Rec. Ind. Mus.* XLI, p. 442, text-fig. 3.

In dealing with a collection of fish from the Hazaribagh District, Das (*loc. cit.*) discussed the systematic position of *Barbus guganio* and

¹ Day, F., *Proc. Zool. Soc. London*, p. 197 (1868).

² Hora, S. L., Misra, K. S., Malik, G. M., *Rec. Ind. Mus.* XLI, p. 273 (1939).

³ Hamilton, F., *Fish. Ganges*, p. 320 (Edinburgh, 1822).

showed that *Barbus ambassis* Day is to be regarded as its synonym. From the material collected by Dr. Rao from the Raipur District I am able to confirm the conclusions of Das. The characteristic black dorsal spine of the young specimens enables the species to be distinguished readily.

***Oreichthys cosuatus* (Hamilton).**

1822. *Cyprinus* (*Cabdio*) *cosuatus*, Hamilton, *Fish. Ganges*, p. 333.

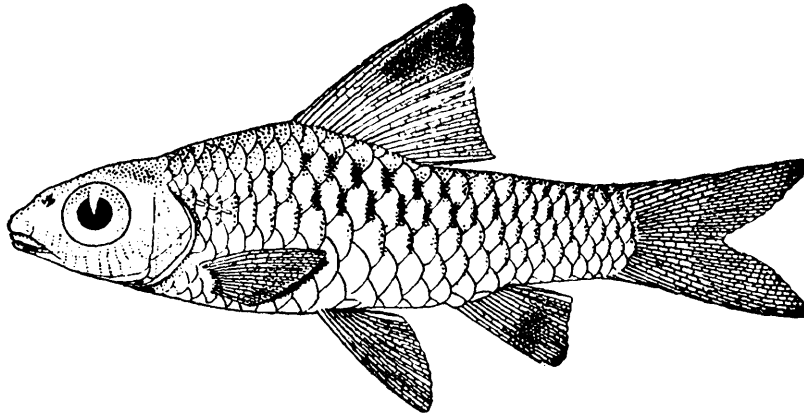
1877. *Barbus cosuatus*, Day, *Fish. India*, p. 581, pl. cxliv, fig. 1.

1933. *Oreichthys parvus*, Smith, *Journ. Siam. Soc. Nat. Hist. Suppl.* IX, p. 63.

1937. *Barbus cosuatus*, Hora, *Rec. Ind. Mus.* XXXIX, p. 17, fig. 6.

1937. *Oreichthys cosuatus*, Hora, *Rec. Ind. Mus.* XXXIX, pp. 331-333, text-fig. 1.

Oreichthys cosuatus is represented in Dr. H. S. Rao's collection from the Raipur District by 5 specimens, ranging from 21 mm. to 34 mm. in total length. The precise systematic position of this interesting species was discussed by me recently, and it was indicated that the range of the species extends to Siam. Comments were also made on the variation in colouration with the growth of the fish, and on the extent of the lateral line. In the specimens under report the precaudal, anal and



TEXT-FIG. 2.—Lateral view of *Oreichthys cosuatus* (Hamilton): $\times 2\frac{3}{4}$.

dorsal spots as such are absent, but the distal portions of a few of the anterior dorsal rays are black and a number of rays are dotted with black in the middle of their lengths. The rays of the anal fin are also similarly dotted so that an indistinct band is formed across the fin. The basal portions of the scales are streaked with black, and the lateral line extends only over a few of the anterior scales. The characteristic sensory folds on the head are fairly well marked, and enable the fish to be readily distinguished from a large number of small carp-minnows in the collection.

***Nemachilus denisonii* Day.**

1939. *Nemachilus* ? *denisonii*, Das, *Rec. Ind. Mus.* XLI, p. 446, text-fig. 4.

In recording *Nemachilus denisonii* from the Hazaribagh District, Das was very doubtful about his identification as this species had not been found previously outside South India and the Deccan. In Dr. Rao's recent collection from the Raipur District the species is represented by a large number of young, half-grown and adult specimens. The colour

varies considerably with age, but the general pattern is fairly characteristic of the species. While in the young specimens the fins are without any markings and the body is marked with a few short bands, in the adult the bands on the body are more regular and numerous, the dorsal fin is marked with a row of spots across its middle and the caudal fin is provided with several irregular rows of spots.

***Amblyceps mangois* (Hamilton).**

1939. *Amblyceps mangois*, Das, *Rec. Ind. Mus.* XLI, p. 448.

So far as the distribution of *Amblyceps mangois* in India proper is concerned it has hitherto been known from the Brahmaputra, Ganges and Indus river systems. The occurrence of the species in the Mahanadi system is, therefore, of considerable interest. Within the last few years the range of the species has been extended considerably—from the Kangra and the Raipur districts in the west to Siam and the Federated Malay States in the east.

SUMMARY.

A collection of fishes from the headwaters of the Mahanadi river is found to contain representatives of 43 well-known species. Short descriptions of localities with lists of fishes collected from each are given. Reference is made to the zoogeographical significance of the occurrence in the Raipur District of such forms as *Barbus* (*Puntius*) *dorsalis*, *Nemachilus denisonii* and *Amblyceps mangois*. Notes are given on *Rhynchobdella aculeata*, *Barbus* (*Puntius*) *dorsalis*, *B.* (*Puntius*) *gelius*, *B.* (*Puntius*) *guganio*, *Oreochthys cosuatus* and *Nemachilus denisonii*.

NOTES ON COPULATORY AND PENIAL SETAE IN *HOPLO- CHAETELLA* MICHAELSEN.

By MARGUERITE M. CHAPMAN, *University College, Rangoon, Burma.*

Although the genus *Hoplochaetella* Michaelsen was first established by Beddard in 1890 (under the name of *Hoplochaeta*) and has since been revised by Gates (1940) the quadriprostatic species of this genus are still by no means easily distinguishable and the status of several species is uncertain.

Certain ventral setae of both prostatic segments and those in the vicinity of spermathecal pores are slightly modified, displaced or possibly lost. Gates has referred to the modified ventral setae of xvii and xix as 'penial'

As characteristics of such modified setae have been found to be of considerable taxonomic value in the diagnosis of species in other genera (Pickford, 1937, p. 25), the present work was begun with the idea of discovering if similar setal characteristics are available for identification of species of *Hoplochaetella*. Unfortunately because of war conditions the work had to be abandoned before any satisfactory conclusions could be reached, but it may be noted that in two distinct species, *H. affinis* and *H. kempi*, the size, shape and ornamentation of copulatory setae are practically the same.

The author wishes to thank Dr. G. E. Gates for the preparation of setal material for examination which he was able to obtain while examining material lent by the Indian Museum, Calcutta, with the exception of *H. khandalaensis* which was supplied by the Bombay Natural History Society.

***Hoplochaetella affinis* Stephenson, 1917.**

Material examined.—Setae from specimen No. 2 of the type-series (*vide* Gates, 1940).

The shaft of the copulatory setae is fairly straight except for an abrupt ectal bend. Ectally the shaft is fairly uniform in thickness widening to a nodule at a distance roughly two thirds of the way down the shaft from the ectal margin. The tip is flattened but not widened, terminating in a bluntly-rounded or squared end.

The ornamentation consists of rows of teeth in an almost unbroken, spiral arrangement. The teeth, which are 'saw-like', are absent from the extreme ectal end but continue to between 120 and 160 micra from the ectal margin down the length of the shaft. All measurements are in millimetres except otherwise indicated.

Table of measurements of copulatory setae.

Segment	Length	Distance of nodulus from tip	Width 10 micra from tip	Width through nodulus
viii	0.64	0.46	0.012	0.032
	0.65	0.42	0.014	0.031
	0.66	0.43	0.012	0.028
	0.63	0.42	0.010	0.028
	0.61	0.40	0.020 (broken)	0.033
	0.48	0.39	0.020 („)	0.035
ix	0.65	0.44	0.012	0.027
	0.61	0.41	0.012	0.025
	0.57	0.42	0.011	0.023
	0.014 ¹	0.008	0.012	0.015
	0.60	0.46	0.013	0.030
?	0.54	0.38	0.009	0.025
	0.56	0.40	0.010	0.026
	0.60	0.42	0.011	0.027
	0.56	0.40	0.009	0.026

¹ Reserve.**Hoplochaetella kemp**i Stephenson, 1917*Material examined.*—Setae from type of *H. kemp*i.

The shaft of the copulatory setae is straight except for an ental arc-like curvature ending in a knob. The ectal end is bluntly pointed and has the appearance of a central longitudinal ridge or groove on one side ; this, however, may be due to poor preservation of the material.

The ornamentation consists of spirally arranged 'spine-like' teeth present for some distance down the shaft but absent from the extreme tip. The spirals appear to be broken on one side but this seems to be due to the longitudinal ridge as the spiral can be traced as a continuous line by changing the focus of the lens.

Table of measurements of copulatory setae.

Segment	Length	Distance of nodulus from tip	Width 10 micra from tip	Width through nodulus
vii	0.56	0.35	0.009	0.024
	0.55	0.35	tip broken	0.026
	0.58	0.36	tip broken	0.027
	0.57	0.38	0.009	0.026
viii	0.57	0.39	0.010	0.026
	0.57	0.38	blunted	0.030
	0.56	0.40	blunted	0.027
	0.54	0.39	broken	0.022
	0.54	0.38	broken	0.025
	0.54	0.39	0.010	0.025
ix	0.54	0.35	0.009	0.025
	0.52	0.37	0.009	0.024

***Hoplochaetella khandalaensis* (Stephenson), 1924.**

Material examined.—Setae of specimens from Andheri.

Normal setae.—The shaft is curved in a slight arc at the ectal end terminating in a bluntly-pointed tip. A distinct nodulus is visible approximately one third of the length of the shaft from the ectal margin.

Ornamentation is entirely lacking.

Copulatory setae.—The shaft is straight ectally but entally tapers to a very slender curved region at right angles to the rest of the shaft and terminates in a pointed end. The ectal end is either pointed or rounded and there appears to be a slight longitudinal groove running down the shaft in the ental region.

The ornamentation consists of 'saw-like' teeth in the form of broken rows spirally arranged and continuous from the tip to 50 micra down the shaft.

Penial setae.—The shaft is practically straight though a slight ectal and ental curvature is visible and also a distinctly thickened region half way down the shaft. The shaft tapers gradually to within 10 micra of the ectal margin, when the tapering becomes much sharper, the shaft terminating in a bluntly-pointed or rounded end. The tip is rounded on one side, flattened or slightly concave on the other.

The ornamentation consists of small irregular 'saw-like' rows of teeth in broken rows spirally arranged. The teeth are entirely absent from the extreme tip and only continue entally to about 50 micra down the shaft.

Table of measurements of setae.

Segment	Type of setae	Length	Width at widest region	Distance of nodulus from tip	Width, 10 micra from tip
xxi	ordinary	0.33	0.025	0.11	0.010
		0.30	0.026	0.12	0.010
viii	copulatory	0.70	0.023	...	0.010
		0.74	0.028	...	0.010
		0.65	0.025	...	0.009
		0.71	0.028	...	0.010
		0.72	0.025	...	0.010
		0.74	0.027	...	0.010
xix	penial	0.44	0.019	0.23	0.012
		0.12		broken	
xvii	penial	0.29	0.016	0.18	0.007
		0.33	0.016	0.18	0.006
xix	penial	0.43	0.020	0.25	0.010
xix	penial	0.43	0.030	0.25	0.010
		0.35	0.022	0.21	0.006

Hoplochaetella mullani (Stephenson), 1924.

Material examined.—Setae from a type of *H. mullani*.

The ental part of the shaft is curved in a wide arc, tapering to a slender, bluntly-rounded base. Ectally the shaft is straight terminating in a bluntly-rounded or squared end.

The ornamentation consists of teeth in the form of a 'saw-like' jagged edge to deep serrations on the shaft itself. The teeth are in short broken rows, approximately 10 micra long and at a distance of 10-15 micra apart (*i.e.*, rows directly below each other). There is a slight suggestion of spiral arrangement though more probably the rows simply form unbroken circles. Teeth are absent from the extreme tip.

Table of measurements of copulatory setae.

Segment	Length	Distance of nodulus from tip	Width 10 micra from tip	Width through nodulus
viii	0.80	0.53	0.012	0.026
	0.78	0.49	0.010	0.026
	0.76	0.53	0.011	0.026
	0.74	0.53	broken	0.025
	0.74	0.50	0.011	0.023
	0.72	0.50	0.010	0.024
	0.70	0.53	0.010	0.020
	0.68	0.46	blunted	0.022
	0.68	0.50	0.010	0.025
ix	0.78	0.54	0.011	0.021
	0.78	0.49	0.010	0.022
	0.77	0.52	0.010	0.022
	0.77	0.50	0.010	0.022
	0.77	0.50	0.010	0.022
	0.76	0.50	0.010	0.023
	0.72	0.47	blunted	0.023
	0.71	0.48	0.010	0.022
	0.71	0.49	0.010	0.022
	0.45		broken	
	0.40		broken	

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ON THE SYSTEMATIC POSITION, STRUCTURAL MODIFICATIONS, BIONOMICS AND DEVELOPMENT OF A REMARKABLE NEW FAMILY OF CYPRINODONT FISHES FROM THE PROVINCE OF BOMBAY.

By C. V. KULKARNI, B.A. (Hons.), B.Sc., Piscicultural Assistant, Department of Industries, Bombay.

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INTRODUCTION.

Early in 1937, in the course of my observations on the breeding of fishes in the creeks of the Bombay Province, I collected a small, almost transparent fish from a backwater near Uttan in the Thana District. In the field the fish was taken to be the young of some Gobioid or Cyprinoid fish, but a few relatively larger specimens, all of which, subsequently proved to be females, were preserved for identification in the laboratory. Later, on dissection, ripe eggs were found in some of them showing thereby that they were adult individuals. A systematic study of the material showed that the fish was closely allied to *Oryzias*

Jordan and Snyder (= *Aplocheilus* McClelland of authors), but differed from the known species of the genus in having a larger number of rays in the anal fin. Later, males of the species were collected which possessed a remarkable, large male organ formed by the modification of the anterior rays of the anal fin. Not being familiar with the literature on Cyprinodont fishes, the species was provisionally described under *Aplocheilus* and Dr. S. B. Setna, Fisheries Officer, Bombay, very kindly undertook to have my results verified by sending my description and drawings to Dr. S. L. Hora of the Zoological Survey of India. After going through my account, Dr. Hora informed Dr. Setna that my fish was a perfect novelty and asked for a series of specimens of the new species with a view to study it more closely and to obtain views of other ichthyologists interested in this group of fishes. Accordingly fresh material, comprising males and females, was sent to him, but as he was unable to express any definite opinion on the systematics of the fish, he sent the material to Dr. G. S. Myers, Stanford University, California, and Dr. C. L. Hubbs, University of Michigan, Ann Arbor, for opinion. At the same time, Dr. Hora advised that detailed observations should be made on the morphology, ecology and bionomics of the species, with special reference to mating and breeding habits, for he believed that such a massive male organ could not possibly be introduced in the female genital opening for the internal fertilization of the eggs. Accordingly, from the very beginning he was of the opinion that in spite of the presence of the male organ, the fish will be found to be oviparous. His belief was further strengthened by the presence of long filamentous processes round the egg which could only be used for the attachment of the eggs to foreign objects. Both Dr. Hubbs (*vide infra*, pp. 383-385) and Dr. Myers not only agreed that the fish belonged to a new genus but suggested that it should be assigned to a distinct subfamily or even a family.

I was greatly encouraged by the above reports and spent a considerable part of my time in making observations on the fish both in the field and under artificial conditions in an aquarium. During all this period I was helped by Dr. S. B. Setna with his valuable suggestions. Accounts of further work done on the fish were sent to Dr. Hora from time to time who very kindly made suggestions regarding new lines of work and helped me with his criticism. He suggested to Dr. Setna that I should be allowed to complete my account of the new fish under his guidance at Calcutta in the laboratories of the Zoological Survey of India. This suggestion was readily accepted but unfortunately owing to the exigencies of service I could not visit Calcutta till August 1939, when I was able to devote four weeks to this work. I took with me a few living specimens of the fish also for making further observations in case the previous observations did not prove sufficient for elucidating any of the important points. My stay at Calcutta enabled me to revise the whole of my morphological work in the light of the literature available in the extensive library of the Department, and, after discussing the various problems with a number of workers on fishes in the Indian Museum, to elucidate the functions of the complicated external reproductive organs.

I take this opportunity to thank Dr. Baini Prashad, Director, Zoological Survey of India, for his kindness in permitting me to work in the laboratories of his department. To Dr. S. L. Hora, Dr. S. B. Setna and Dr. C. J. George, Wilson College, Bombay, I am greatly indebted for encouragement, ready help, valuable criticisms and suggestions. My sincerest thanks are also due to Dr. C. L. Hubbs and Dr. G. S. Myers for their comprehensive notes on the systematics of the fish. Mr. K. S. Misra and Mr. T. J. Job helped me in various ways during my stay at Calcutta, and for this I am obliged to them. Babu R. Bagchi, an artist of the Zoological Survey of India, very kindly made drawings Nos. 2-5, 7-9 and 11-15 under Dr. Hora's and my supervision, and I am thankful to him for his accurate delineations. The remaining drawings were made by Babu A. Mondal either from my rough sketches or specimens with his usual skill and care.

SYSTEMATIC ACCOUNT.

Classification of the order Cyprinodontes.

Classification of fishes of the order Cyprinodontes Agassiz (equivalent to Microcyprini of Regan) is somewhat complicated and has been revised from time to time in recent years. Papers dealing with these revised schemes are scattered in various journals, several of which are not always readily obtainable. As a clear idea of the position of the different groups now classed under the order Cyprinodontes is desirable, a bare skeleton of a recent classification scheme is given below for ready reference. Only such genera as are referred to in this paper are mentioned under their respective tribes.

Order : CYPRINODONTES (Microcyprini).¹

Suborder : *AMBLYOPSOIDEA*.

Family : *AMBLYOPSIDAE*.

Genera : *Chologaster* Agassiz.

Amblyopsis Dekay.

Suborder : *POECILIOIDEA*.

Family : *CYPRINODONTIDAE*.

Subfamily : *FUNDULINAE*.

Tribe : Fundulini.

Genera : *Fundulus* Lacépède.

Plancterus Garman.

Cubanichthys Hubbs.

Lucania Girard.

Tribe : Rivulini.²

Genus : *Panchax* Cuvier (= *Aplocheilus* McClelland).

Tribe : Aplocheilichthyni.

Tribe : Aplocheilini.²

Genus : *Oryzias* Jordan & Snyder (= *Aplocheilus melastigma* McClelland of authors).

¹ The classification followed here is mostly according to Hubbs (1924 and 1926) and Myers (1931 and 1938).

² Myers (1938), in a foot-note on p. 137, suggests that in future the tribe Rivulini (1931) should be called Aplocheilini, and that Aplocheilini of 1931 should be known as Oryziatini.

- Subfamily : *LAMPRICHTHYINAE*.
 Subfamily : *ORESTIATINAE*.
 Genus : *Orestias* Cuvier & Valenciennes.
 Family : *GOODEIDAE*.
 Subfamily : *ZOOGONETICINAE*.
 Genus : *Zoogoneticus* Meek.
 Subfamily : *CHARACODONTINAE*.
 Genera : *Characodon* Günther.
 Goodea Jordan.
 Family : *POECILIIDAE*.
 Subfamily : *GAMBUSIINAE*.
 Tribe : Gambusiini.
 Genera : *Gambusia* Poey.
 Belonesox Kner.
 Tribe : Heterandriini.
 Genus : *Pseudopoecilia* Regan.
 Tribe : Girardini.
 Genera : *Girardinus* Poey.
 Glaridichthys Garman.
 Tribe : Cnesterodontini.
 Genera : *Cnesterodon* Garman.
 Phalloceros Eigenmann.
 Phallotorhynchus Henn.
 Subfamily : *POECILIOPSINAE*.
 Genus : *Xenophallus* Hubbs.
 Subfamily : *POECILIINAE*.
 Tribe : Poecilini.
 Genus : *Lebistes* de Filippi.
 Tribe : Alfarini.
 Genus : *Alfaro* Meek.
 Subfamily : *TOMEURINAE*.
 Genus : *Tomeurus*¹ Eigenmann.
 Family : *JENYNSIIDAE*.
 Family : *ANABLEPIDAE*.
 Genus : *Anableps* (Gronow.) Bl. & Schn.
 Family : *ADRIANICHTHYIDAE*.
 Family : *PHALLOSTETHIDAE*.²
 Genera : *Phallostethus* Regan.
 Gulaphallus Herre.
 Family : *HORAICHTHYIDAE*, nov.
 Genus : *Horaichthys*, nov.

Family *HORAICHTHYIDAE*, nov.

Diagnosis of the family Horaichthyidae.—The new family³ *Horaichthyidae* comprises small, translucent, elongate and more or less strongly

¹ This fish has recently been found to be oviparous by Dr. Myers (*vide* Dr. Hubbs' letter, *infra* pp. 383-385). Drs. Hubbs and Myers, therefore, propose to place *Tomeurus* in a different family.

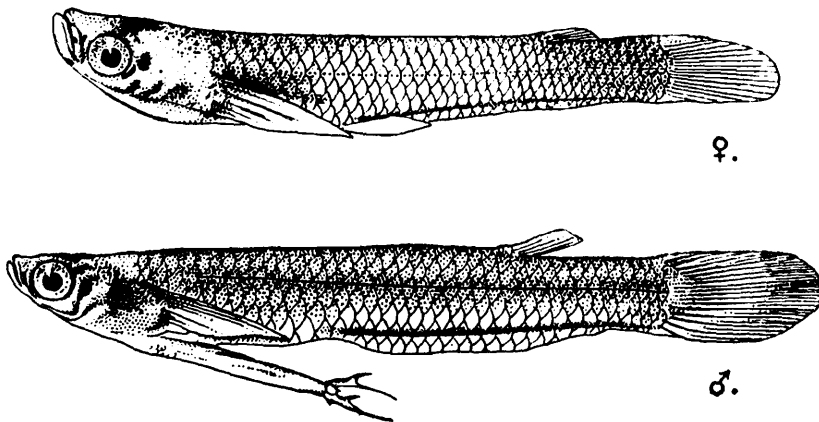
² This family has generally been regarded as belonging to the order Cyprinodontes, but Myers (1928) is of the opinion that it is not a member of that order.

³ The diagnostic characters of this fish family will be amplified on the completion of the study of its osteology.

compressed fishes. The head is depressed ; the head and the anterior part of the body are flattish above. The body is covered with thin, cycloid, scales which are rather large, about 32 in a longitudinal series along the lateral line. The head is scaly. The mouth is comparatively large and the premaxillaries are not protractile. Bones of both the upper and lower jaws are loosely connected. The teeth are sharp, conical and arranged in a single series in the jaws. The premaxillaries are produced below into an arm which lies outside the mouth and is provided with teeth. The pectoral fins are set high. The anal fin is long, with about 28 to 32 rays. In the males, six anterior rays of the anal fin are separated from the rest of the fin and modified into a large gonopodium. The dorsal fin is short and situated behind the anal. In the females the right pelvic fin is usually absent. The caudal fin is rounded. The genital opening of the female is asymmetrically situated, and the region surrounding it is strengthened by the development of callosities or genital pads. The gill-membranes are broadly united and are free from the isthmus.

The family is being erected to accommodate the new genus *Horaichthys* ; it appears to be allied to the Tribe Oryziatini (=Aplocheilini of the above list) of the family Cyprinodontidae, but in the latter the anal fin of the male is not modified into a gonopodium, and the female does not possess the characteristic genital pads. Moreover, the number of anal rays is much greater than that in *Oryzias*. It is probable that *Horaichthys* is evolved directly from *Oryzias*, but as the development of an elaborate male organ (gonopodium) is of outstanding significance, it is proposed to emphasize the difference by giving a distinct family rank to the new fish.

Both Drs. Myers and Hubbs noted the superficial resemblance (convergence) of this fish to *Tomeurus* Eigenmann from South America (text-fig. 1.) Dr. Hubbs, in his letter to Dr. S. L. Hora, dated May



TEXT-FIG. 1.—Lateral views of a male and a female of *Tomeurus gracilis* Eigenmann (after Eigenmann).

10, 1938, made the following remarks about the similarity and differences in the structures of the two fishes :—

“ On comparing your fish with *Tomeurus*, we note the same minute size, the same flattened upper surface and posterior dorsal fin, and subvertical dorsal mouth, all

indicative of the habit of swimming against the surface film (which habit has been observed by aquarium fish collectors for *Tomeurus*). Both fish have a similar disposition of fins, including the very posterior dorsal (still further back in your fish than in *Tomeurus*), the rounded caudal, the high pectoral fin with oblique axis, the main part of the anal fin far forward in the female and extremely far forward in the male (in this respect *Tomeurus* is the more extreme) and the pelvic fins far forward and much reduced in the female. The resemblance in fins is most striking in respect to the clasper-like modification of the anal. The resemblance goes into very considerable detail, for in both genera the modified organ is very large and has movable, pronged processes near its tip. When we examine the anal fin in more detail, however, we find striking differences. In your fish the modified tip is asymmetrical, the first prolonged ray being on the opposite side from the modified tip of the next prolonged ray and of different form, whereas the organ of *Tomeurus* is bilaterally symmetrical.

"An even more striking difference in the anal fin lies in the fact that this organ in *Tomeurus* is very short; it corresponds almost perfectly in size and in sexual dimorphism and in regard to position as well as structure with the anterior lobe of the anal fin of the Indian genus. The long posterior portion of the anal fin of your fish is represented in *Tomeurus* by a sharp keel formed from the scales. No doubt the functional relations are identical but the very distinct structure is suggestive of independent origin. This point assumes particular significance when we recall that practically all American Cyprinodonts of all families have a short-based and generally few rayed anal fin, whereas the old world types tend to run to long anal fins. This circumstance leads me to believe that *Tomeurus* and your new genus probably represent the end products of an independent but almost identical course of evolution—possibly the most extreme example among fishes of convergent evolution.

"Another difference between the genera confirms the view of independent origin. The premaxillaries in *Tomeurus*, as in American forms in general, are very protractile whereas as you have noted, the Indian fish has non-protractile premaxillaries strongly indicating an origin from the 'Aplocheilini'. I believe that we can accept the view that the two genera are of independent origin.

"The discovery that the Indian fish has an egg provided with filaments obviously for attachment is even paralleled in *Tomeurus*, for Dr. Myers has discovered that just such an egg is produced in the South American genus. This egg is so large and the body cavity so small that only a single egg can ripen at one time. There can be little question but that the highly modified anal fin in both genera is a clasper. The excessively modified anal region of the female in your form with cartilaginous ridges and grooves would seem to be modified as a part of a 'lock and key' mechanism. I note that only the *left* pelvic fin is developed in both ♀♀ at hand.

"Various ideas regarding the relationship of *Tomeurus* have been promulgated, but all with the idea that this genus was a member of the large, viviparous family Poeciliidae. In view of Myers' discoveries regarding the egg, it has seemed advisable to remove *Tomeurus* from the Poeciliidae, and Myers and I in a joint paper are proposing to do this. Your discovery of an independently derived but almost identical type fits nicely into the view so that I believe we should not now hesitate to remove the *Tomeurinae* from the Poeciliidae. I think the wisest course would be to erect a new family for the genus rather than to refer the subfamily to the Cyprinodontidae. By similar reference, your form should be made the type at least of a distinct subfamily and I would rather prefer to recognise its extreme modification by family separation. To do this would emphasize the remarkable example of convergent evolution which is involved.

"Although we remove *Tomeurus* from the Poeciliidae, we still have in that family a form which somewhat approaches your new genus in structural features and no doubt in habits. This is the genus *Alfaro*, which has the anal fin, especially in the male, very far forward and the ventral edge of the body running into a scaly keel much as in *Tomeurus*. Our most recent views as to the position of *Alfaro* as related to other Poeciliidae and to *Tomeurus* are given in a paper by Howell Rivero and myself (*Occasional Papers* of this Museum, No. 339, 1936).

"There is still another very close parallel to your new genus, and that parallelism again extends to details of size, appearance, structures, and, no doubt, habits. I refer to the extremely close resemblance of your fish to *Phallostethus*. I suppose it is remotely possible that your genus is more or less ancestral to *Phallostethus*. This view seems almost impossible in view of the extremely slight possibility that the priapium of the *Phallostethus* can be homologized with the claspers of your genus. I would assume that your new genus and *Phallostethus* represent still another example of convergent evolution. We have in mind Myers' reference of *Phallostethus* to the *Percesoces* (*American Museum Novitates*, No. 295, 1928). I assume of course that you have Regan's chief paper on the *Phallostethus* in *P. Z. S.*, 1916.

"In many respects the genus *Anableps* forms another parallel in structure and habits. This genus lives strictly on the surface and as you no doubt know is remarkable for having the eye divided so as to permit atmospheric and aqueous vision simultaneously. It is a larger and stronger fish, but also has the anal fin of the male modified and inserted anteriorly, and has the other fins rather similar to those of *Tomeurus*, your genus, and *Phallostethus*."

Genus **Horaichthys**, nov.

For the description of the genus reference may be made to the account of the family given above. For further details the description of the single species known (*vide infra*) may be referred to.

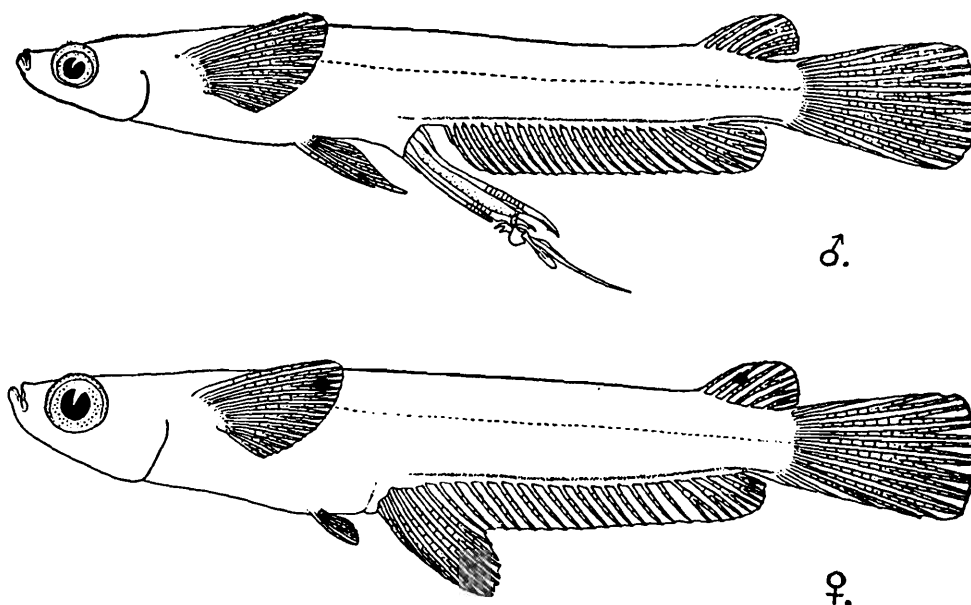
Genotype.—*Horaichthys setnai*, gen. et sp. nov.

Horaichthys setnai, gen. et sp. nov.

Male.—B. IV ; D. 7 ; A. 22-26 ; V. 5 ; C. 9 ; Ll. 32-34.

Female.—B. IV ; D. 6-7 ; A. 28-32 ; V. 5 ; C. 8-9 ; Ll. 32-34.

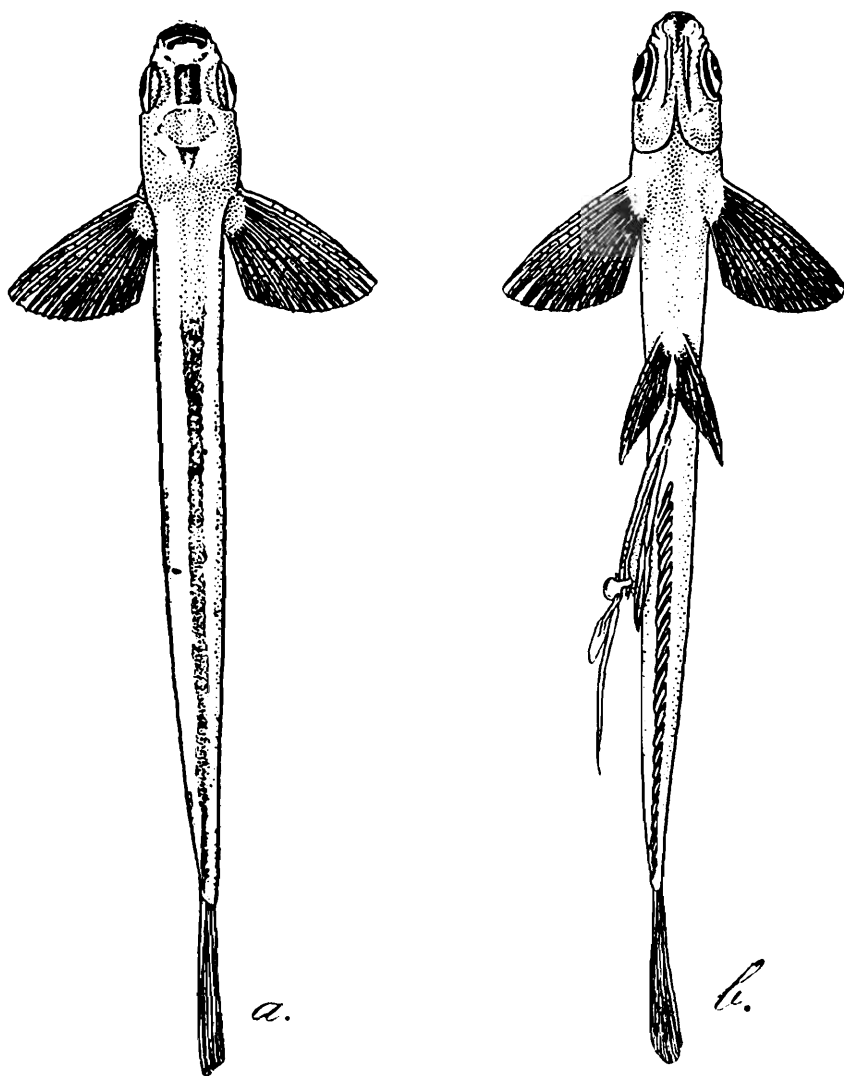
The body is elongate and narrow. The head is slightly depressed, while the rest of the body is somewhat compressed. Both the profiles



TEXT-FIG. 2.—Lateral view of a male and a female specimen of *Horaichthys setnai*, gen. et sp. nov. : $\times 4$.

are slightly arched. The snout is broad and truncated by the sub-vertical mouth. The length of the head in the male is contained from 6.0 to 6.8 times and that of the female from 5.5 to 6 times in the standard

length.¹ The width of the head of the male is contained nearly 1.5 times in its length, while that of the female is 1.2 to 1.4 times. The length of the snout is about half the diameter of the eye. The eyes are slightly oblong and lateral in position: they are visible both from the dorsal and the ventral surfaces. The diameter of the eye in the male is contained from 2.0 to 2.2 times and that of the female from 2.4 to 2.6 times



TEXT-FIG. 3.—Dorsal and ventral views of a male specimen of *Horaichthys setnai*, gen. et sp. nov.: $\times 4$.

a. Dorsal view.

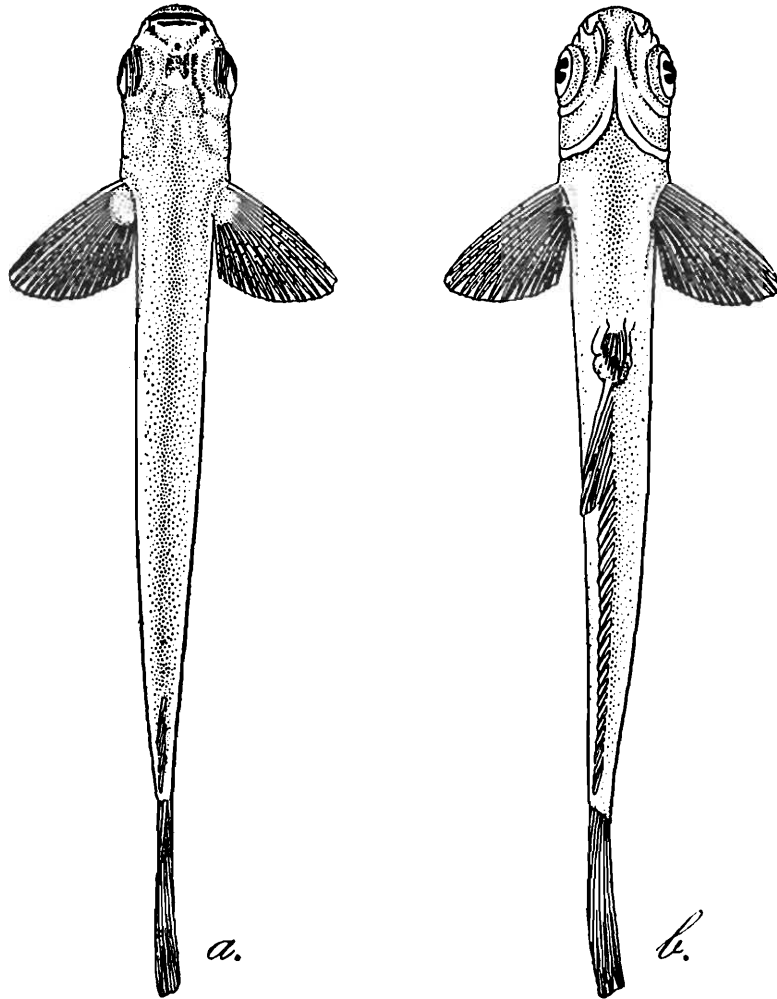
b. Ventral view.

in the length of the head. The interorbital space is raised as a broad ridge, and is about $\frac{2}{3}$ the diameter of the eye in the male and $\frac{3}{4}$ in the female. In front of the interorbital space and just behind the upper jaw there is a transverse oval depression. The nasal openings are inconspicuous and are situated dorsally between the anterior margin of the orbit and the dorso-lateral corner of the mouth.

¹ Though the lower jaw forms part of the dorsal profile and as such is included in the total length, the length of the head is recorded from the tip of the snout to the posterior margin of the operculum (Hora and Mukerji, 1938).

The mouth is large, non-protractile and transverse, extending across the entire width of the snout; it is so much upturned that the lower jaw forms a part of the dorsal profile. The cleft of the mouth extends downwards almost vertically, and for masticating purposes the mandibles, therefore, work backwards and forwards. The premaxillaries of the two sides do not fuse into a single bone in the middle of the upper jaw, but remain apart to make the mouth extensible. The dentaries of the lower jaw also are similarly separate in the middle.

Each jaw is provided with a single row of sharp conical teeth, but on account of congestion a slight overlapping of teeth occurs at times. The premaxillaries possess a stout, free and downward projecting arm on each side which bears teeth, like those of the jaws, but these teeth are comparatively much bigger, thicker and more closely set. They are somewhat obliquely disposed and their number varies between 7 and 9.

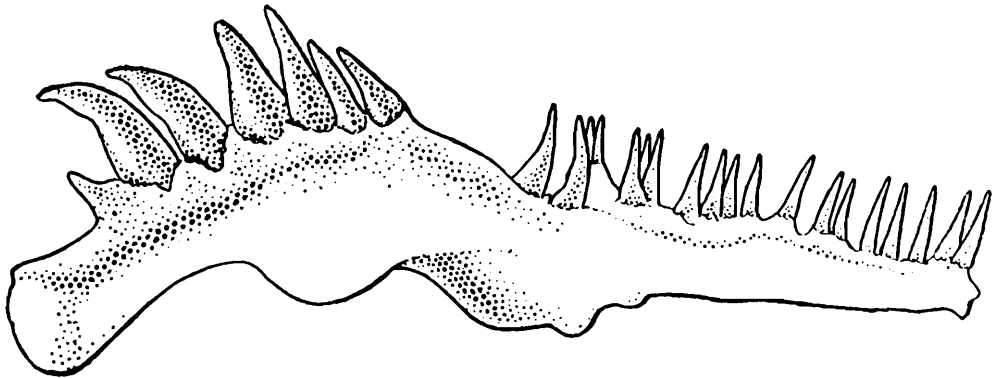


TEXT-FIG. 4.—Dorsal and ventral views of a female specimen of *Horaichthys setnai*, gen. et sp. nov.: $\times 4$.

a. Dorsal view.

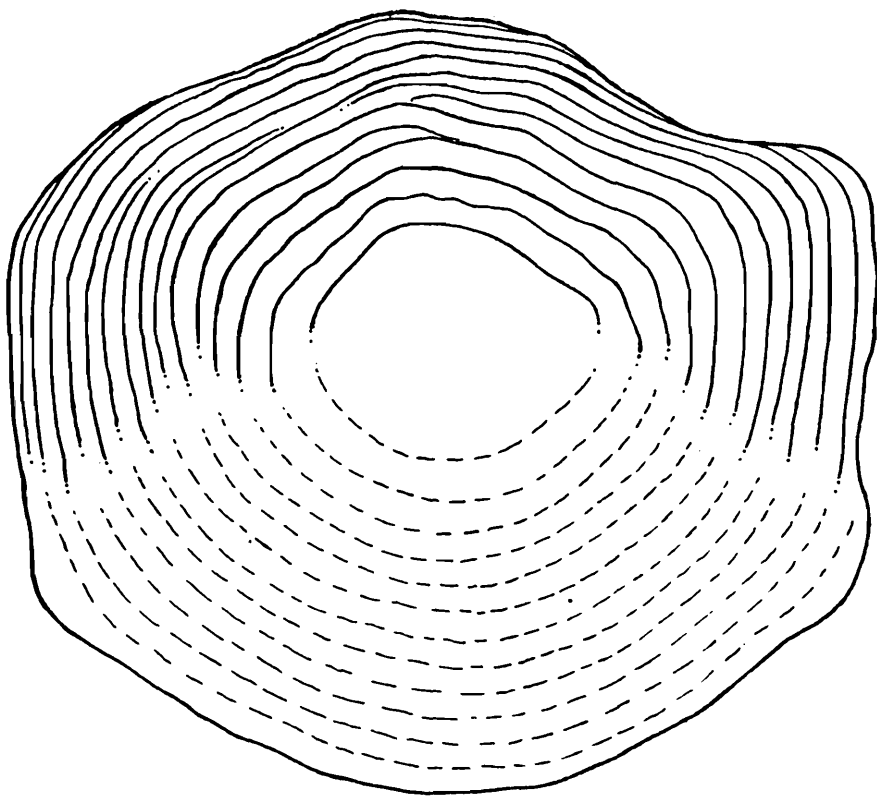
b. Ventral view.

A portion of the premaxilla at the angle of the jaw and the free arm is edentulous and has on its posterior face an articular facet for the attach-



TEXT-FIG. 5.—Premaxilla of the right side of *Horaichthys setnai*, gen. et sp. nov. : $\times 78$.

ment of the maxilla. The teeth of the upper jaw and its free arm are directed anteriorly, instead of downwards, in order to suit the working of the lower jaw, which has its teeth directed posteriorly. The toothed free arm of the premaxilla, remaining almost outside, does not, however, enter in the formation of the mouth and has no corresponding teeth in the lower jaw. The tongue is covered with fine tubercles visible only



TEXT-FIG. 6.—A scale of *Horaichthys setnai*, gen. et sp. nov. from above the lateral line: $\times 108$.

under high magnification. The pharyngeal teeth are simple and conical, like the teeth in the jaws, and are closely set into four groups.

The gill opening is of moderate size and extends slightly above the middle of the body between the base of the pectoral and the orbit of the eye. The gill membranes do not overlap, though they lie close together. The branchiostegals are four in number. There are four thick gills with short gill rakers.

The scales are thin moderately large and cycloid; there are 32-34 scales in a longitudinal series between the upper margin of the gill-opening and the base of the caudal fin. The lateral line appears to be rudimentary. In the male the region from the anal opening up to the base of the modified group of the anal rays is devoid of scales. In the female the region between the right ventral fin, the anal opening and the insertion of the anal fin is devoid of scales. The skin of the female in this region is thickened into irregular ridges and grooves, which I have termed "genital pads"; these are mostly round the urino-genital opening. One of these ridges is invariably continued towards the anal fin to form a thickening at its insertion. The thickened skin immediately posterior to the urino-genital opening is produced into a small conical process which probably serves as an accessory genital papilla.

The urino-genital opening in the majority of females is on the left side, somewhat anterior to the insertion of the anal fin. Sometimes, however, it lies on the right side, or is situated medially. The urino-genital opening in the male is shifted posteriorly from its normal position near the anal opening to the base of the modified group of the anal rays (the gonopodium). The anal opening in the female is deflected somewhat anteriorly to the right side from its normal position between the ventral fins, as in the male.

The dorsal fin is short and placed far back near the caudal; some of the rays almost reach the base of the caudal fin, but the two are quite distinct. The length of the base is smaller than the longest ray of the fin. The caudal fin is large and rounded. The caudal peduncle is broad. In the male the anal fin of the young fish becomes divided into two parts in the adult. The first six rays are separated off into an independent group and from the gonopodium, which is contained about 2.5 times in the standard length of the fish and remains folded on the right side, parallel to the anal fin. (The gonopodium in text-fig. 2 is shown at an angle, though actually it is nearly parallel to the body.) The longest process of this organ almost extends to below the base of the dorsal fin. The rest of the anal fin is long, it commences midway between the gill opening and the caudal base and ends below the last ray of the dorsal fin. All the rays, except for the last six or seven, are undivided and are of nearly uniform length. Anterior to the anal fin, there is a small longitudinal notch in the mid-ventral line in which the basal portion of the gonopodium is lodged. The pelvics are paired, of normal size in the male, abdominal in position and are placed at a distance slightly more than one-third of the standard length from the snout. One branch of the second ray in each fin is more elongated than the rest, has a slightly swollen tip and reaches the base of the gonopodium. In the female generally the pelvic fins are not paired, only a comparatively

small left fin being present. It is abdominal in position and is approximately in the same position as in the male. The anal fin in the female is long, commences in the anterior half of the body and extends up to a short distance from the base of the caudal fin; its second to the sixth rays are more elongated and somewhat more bent backwards than the rest. The fourth and the fifth rays are the longest. Most of the rays, except from the third to the sixth and a few at the end, are undivided; the entire fin is continuous.

The pectorals are large and well developed in both sexes. They are inserted obliquely behind the gill opening, high up on the body at the same level as the eyes; they are longer than the head and their bases are thick and muscular. The ventral edge of the caudal peduncle is not keel-shaped but has a narrow, short, fleshy, adipose edge which gradually protrudes to unite with the procurrent rays of the caudal. Dorsally, this adipose edge is still narrower.

The living specimens are nearly transparent. The head has a prominent dark occipital spot behind the eyes and a number of minute black spots scattered all over as well as on the upper margin of the jaws, the pre-orbital region and on the ventral surface. Similar spots are found on the bases of the pectoral fins, in their axils and on the thoracic region. In the position of the lateral line there is a thin black streak which is at times somewhat discontinuous. In living specimens this line consists of a number of black, elongate, closely-set dots. Above the base of the anal fin on each side there is another similar black line (made up of somewhat bigger dots), which in the male starts midway between the base of the gonopodium and the origin of the anal fin. The dorsal surface of the body and some parts above and below the lateral line are covered with fine black dots. In males the margins of one row of scales on each side of the mid-dorsal row have black pigment. There are pigment spots on the abdomen as well as between the bases of the pelvic fins and the gonopodium. Unlike the males, the whole of the dorsal surface in the females is uniformly covered with black pigment spots. The ventral surface of the head, thorax and the abdomen of female specimens on the other hand have comparatively fewer black spots than in the male. Minute elongate, black dots may be detected under a microscope along the fin rays of most of the fins in both sexes; those on the caudal and the pectoral fins being more pronounced. A slight yellow pigment occurs by the side of the base of the anal fin in both sexes.

Sexual dimorphism.—From the foregoing description it will be noted that *Horaichthys* exhibits remarkable differences in the structure and appearance of the body in the two sexes. The male differs from the female in the build of the body, possession of a gonopodium and certain details in colouration. The female is characterised by the possession of the genital pads, the absence of the right pelvic fin and the asymmetrical position of the urino-genital opening.

Distribution.—Backwaters along the coast about 100 miles north and south of Bombay.

Type-specimens.—No. F13203/1, Zoological Survey of India (*Indian Museum*), Calcutta.

STRUCTURAL MODIFICATIONS.

In the systematic account of *Horaichthys*, reference has already been made to certain remarkable modifications, particularly in the structures connected with sexual functions, undergone by *Horaichthys setnai*. Attention has also been directed to parallelism between this fish, the South American *Tomeurus gracilis* and a few others. In *Horaichthys*, not only have the anal rays attained remarkable complexity of organisation to form the gonopodium, but several other modifications of a peculiar kind are also noticeable. For instance, the genital opening of the female has shifted from its normal mid-ventral position to one side and callous pads have been developed round it. The right pelvic fin is absent in most of the females. It is, therefore, proposed to describe these remarkable modifications in greater detail in this section and to indicate their probable significance in the light of our present knowledge of the bionomics of the species.

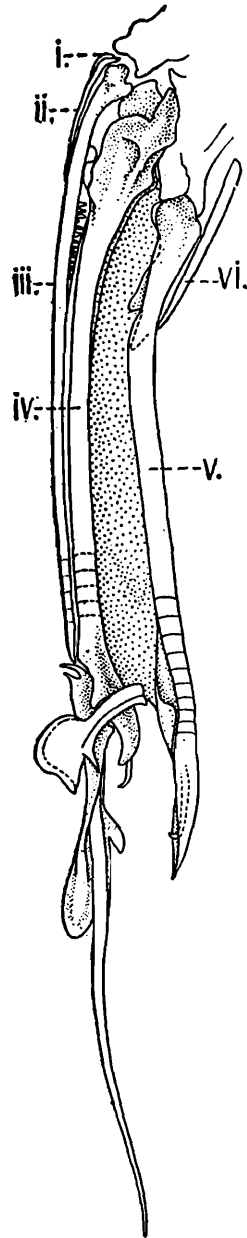
The gonopodium.—In the genera *Zoogoneticus*, *Characodon* and *Goodea* (now included in the family Goodeidae), first five or six rays of the anal fin in the male are shorter, thinner and stiffer and are separated by a notch from the rest of the fin. Langer (1913) coined the term 'spermatopodium' to distinguish these fin rays from the modified anal fin rays which were elongated and thickened as in the Poeciliidae, and for which Philippi (1908) had already suggested the name 'gonopodium'. The significance of the use of the two different terms, spermatopodium and gonopodium, is doubtful when the criteria of distinction are merely the comparative length and thickness of the differentiated fin rays. If Langer's standard of differentiation is applied, the modified group of anal rays in *Horaichthys* deserves to be called a gonopodium. It is, in fact, much more complex than the gonopodium in the Poeciliidae, even though the fish is oviparous, and it functions as an organ of transference of spermatophores to the body of the female and not as an intromittent organ. In view of the above-mentioned considerations, I have used the term gonopodium for the modified group of anal fin rays forming the male organ in *Horaichthys*.

The gonopodium (text-fig. 7) of *Horaichthys*, as stated before, is composed of the first six rays of the anal fin. It is about 7-8 mm. in length and is contained about 2.5 times in the length of the fish. In its natural position, it lies along the right side of the anal fin and is not easily visible. The third, fourth and fifth rays of the organ are thicker and longer, and all of them are modified in diverse ways. In order to follow the modifications undergone by them, the various structures of this organ are briefly discussed below.

The First Ray.

The first ray of the gonopodium is very short and is represented only as a nodule attached to the base of the second ray. It is normal in form in the early stages but becomes gradually smaller as development pro-

ceeds. It retains, however, its right and left halves intact, even in the adult stage, as may be seen in the view of its posterior face in text-fig. 8a.



TEXT-FIG. 7.—Gonopodium of *Horaichthys setnai*, gen. et sp. nov.: $\times 16$.

i. First ray ; ii. Second ray ; iii. Third ray ; iv. Fourth ray ; v. Fifth ray ; vi. Sixth ray.

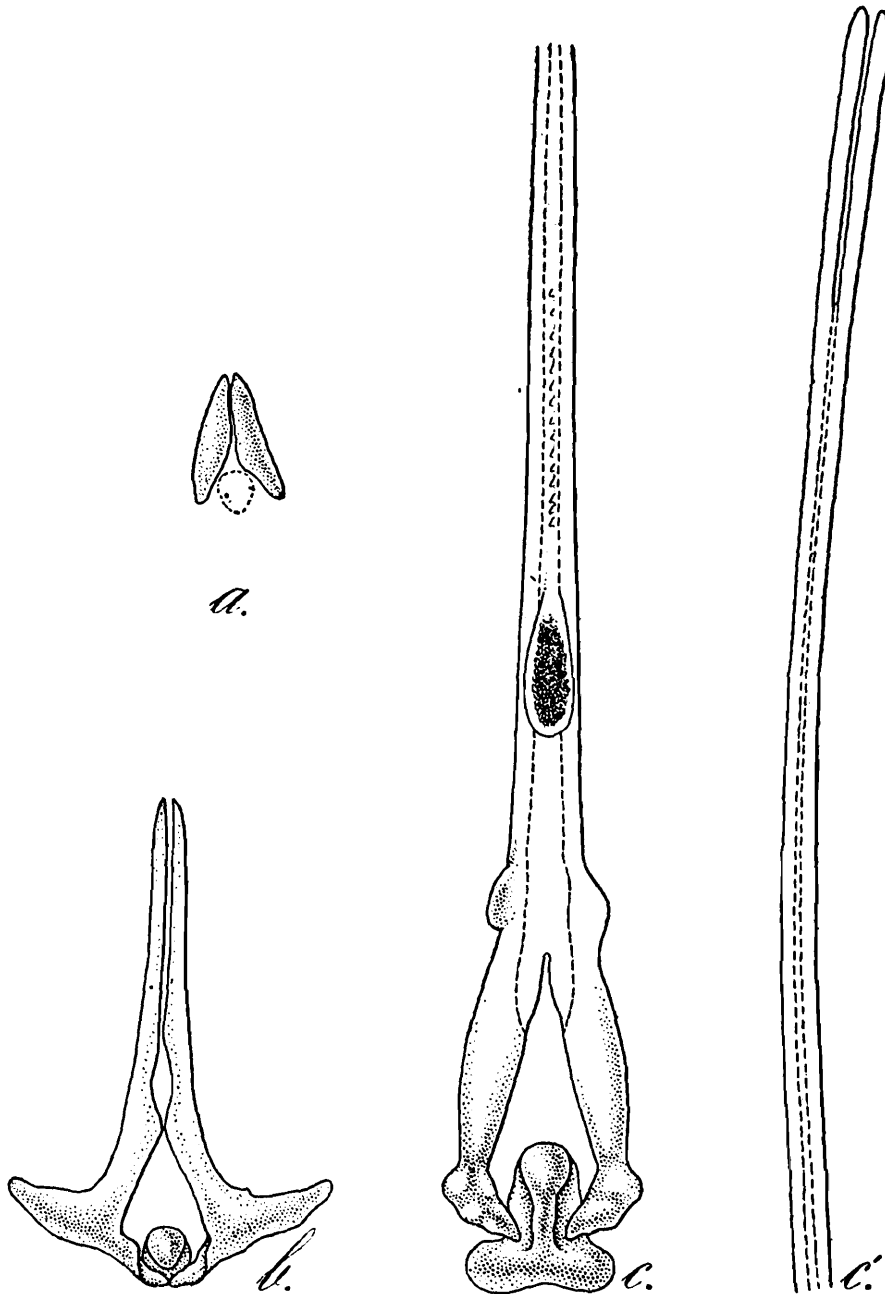
The space between their bases has a comparatively large cartilage, which represents distal segment of the first radial (pterygiophore).

The Second Ray.

The second ray (text-fig. 8b) is about three and a half times as long as the first ray. It is split to the base, though the two halves lie close together at the distal end. The basal part of each half is greatly flattened and produced sideways into curved processes which are directed posteriorly so as to embrace the base of the following ray.

The Third Ray.

The third ray is split at the base as well as at the extreme tip, and has the appearance of a pair of scissors (text-fig. 8 c, c'). The proximal



TEXT-FIG. 8.—First, second and third rays of the gonopodium of *Horaichthys setnai*, gen. et sp. nov. : $\times 82$.

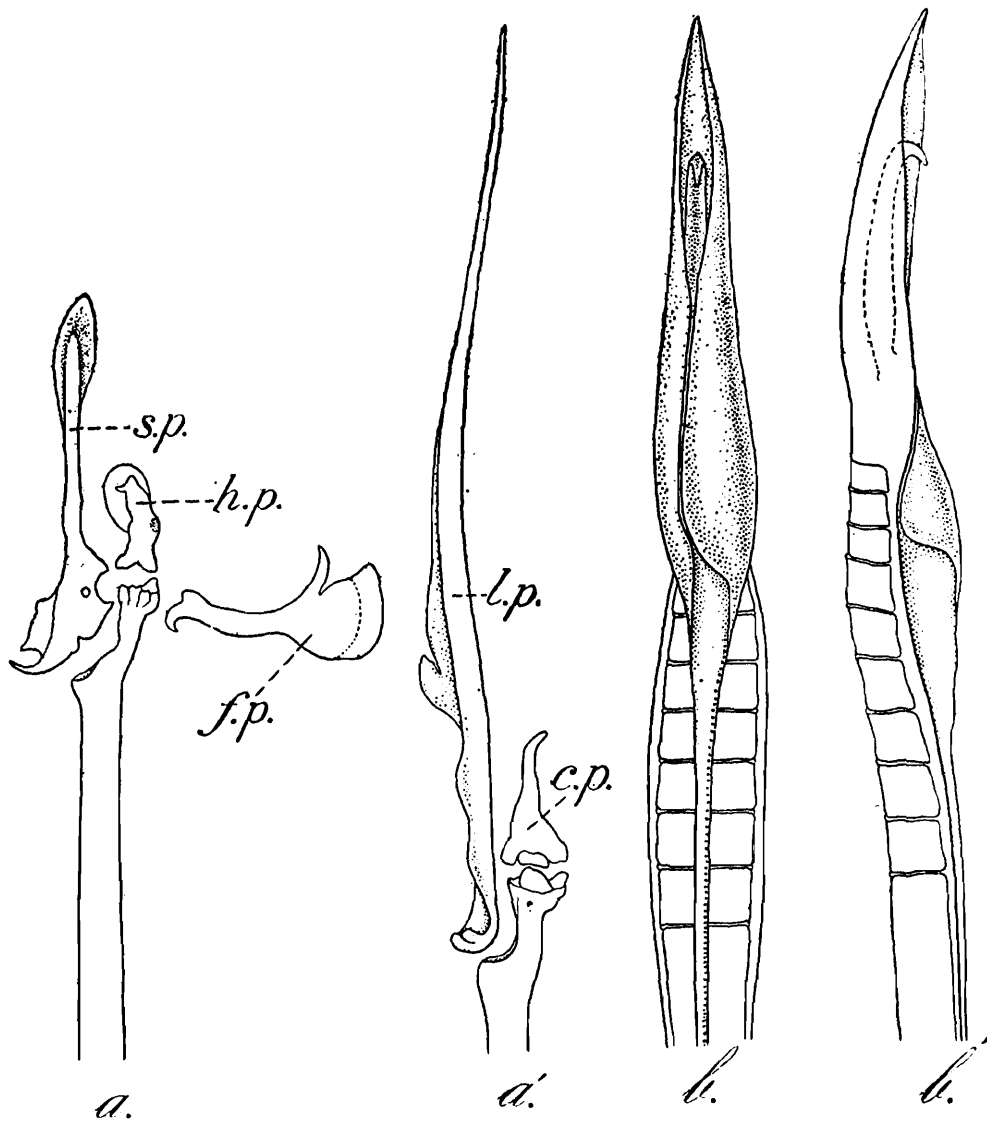
a. First ray. b. Second ray. c. c', Proximal and distal parts respectively of third ray.

portion of the ray has a few short knobs, the most prominent of them being the one on the posterior face near the fusion of the two halves. Beyond this prominent knob on the same posterior face there are fine denticles which progressively become smaller towards the distal region of the ray. The base of the ray has a cartilagenous nodule between the two halves. This cartilage is formed of two pieces and represents the distal segments of the pterygiophores probably of the third and also of the second ray.

The Fourth Ray.

The fourth ray is made up of several pieces and is the longest of the rays composing the gonopodium. Its proximal portion consists of two laterally flattened unfused halves, and the distal of five hyaline movable pieces. Though the two halves lie side by side close to each other, they are figured separately (text-fig. 9a, a') and are termed the right and the left components of the ray.

The proximal portion of the two components are almost identical in structure and have articular surfaces on their terminal portions, where the five pieces forming the distal part of the ray are articulated. In the basal region, the components are considerably flattened, each having three or four short knobs or processes and presenting an irregular appearance as shown in text-figs. 7, iv and 10, iv.



TEXT-FIG. 9.—Distal portions of fourth and fifth rays of the gonopodium of *Horaichthys setnai*, gen. et sp. nov.

a., a'. Right and left components respectively of 4th ray. : $\times 23$. b., b'. Side and front views respectively of 5th ray. : $\times 39$.

h. p., horn-like process ; s. p., spoon-shaped process ; c. p., Conical piece ; l. p., long process ; f. p., fifth piece.

In the distal portion, the right component of the ray has at its extremity a short, somewhat horn-like structure, as shown in text-fig. 9a, (h.p.)

This structure is bent on one side and has a short process or knob on the other side. There is also a thin roundish membrane around the bent point. Another structure, somewhat spoon-shaped in appearance (text-fig. 9*a*, *s. p.*), is attached slightly behind the first piece on the same component of the ray. The basal portion of this spoon-shaped piece has two small hooks. The remainder of the basal portion is thick and has one or two articular facets. The distal portion, which resembles the tip of a spoon, has a central hyaline rod and a thin membrane around it. The whole piece thus resembles, to some extent, a small spoon—the appearance of which varies slightly in different specimens.

The extremity of the left component also has a pointed conical piece (text-fig. 9*a*, *c. p.*) rotating on the articular facet. Its point is also slightly bent and the whole piece corresponds to the horn-like piece of the other component. Behind the attachment of this piece there is, as shown in text-fig. 9*a*, *l. p.*, a long pointed process articulated to the same component of the ray. The piece has a moderately thick base and at about the second-third of its length it is produced on one side into a thin membrane which is provided with a somewhat fleshy hood-like growth. After this hood-like growth the process gradually terminates into a long stiff point. This is the longest process of the gonopodium and corresponds to the spoon-shaped structure of the other component.

In addition to these somewhat paired structures, there is a fifth piece (text-fig. 9*a*, *f. p.*) which is jointed to the articular facets of both components at their distal ends. Unlike the other pieces, it has a curved stem and appears to encircle the basal region of the other pieces obliquely. As shown in the figure, it resembles a single pointed, fleshing knife of a cobbler with an additional pointed thumb-like process on a long curved handle. The broad terminal portion of the piece is leaf-like and has a thin membranous margin. This piece is remarkable in being movably articulated to both the components of the ray.

The Fifth Ray.

The fifth ray (text-fig. 9 *b.*, *b'.*) is not so complex as the fourth, though it is also considerably modified. It is not so much flattened as the fourth, and the two components are more or less fused along their entire length. Moreover, this ray unlike the former, is asymmetrical at the basal region and the number of short processes predominates on the right component. Other differences from the other rays of the gonopodium consist in an angular bend in the first-third of its length and the retention of the segmented (articulated) nature of the ray in its middle portion. Though the components are more or less fused, they are treated separately in the following description.

The right component has three short processes on its basal portion. The first is near the base and directed backward; the other two are a little away near the angular bend of the ray and are directed sideways. The anteriormost process is the most prominent. The left component has only one process near the base, the other two being undeveloped. The sides of both the components of the ray in their distal region grow into membranous, slightly concave lateral flaps. They are at their widest $\frac{3}{4}$ of the length of the ray from the base, but gradually narrow down dis-

tally as shown in text-fig. 9 b. At about $\frac{1}{3}$ of the length of the ray from the base, the inner edge of the right component grows into a narrow vertical fold and makes the ray a channel-like structure. The vertical fold, bounding the channel, is continued forward, and grows over obliquely to form an opening of a tubular portion in which the ray terminates. This tubular portion is pointed at its extremity. Presumably, it is formed by the fusion of the distal portions of both the components of the ray, their sides being rolled into a tube-like structure which remains incomplete on the anterior face, for it is formed merely by a close apposition of the two lengthwise edges of the tube. At the extremity (text-fig. 9 b) these edges remain slightly apart and give rise to a slit-like oval opening in which a hyaline recurved hook is developed on the inner wall of the tube.

The Sixth Ray.

The sixth ray (text-fig. 7, vi), though not so greatly modified as the preceding ones, differs from a normal anal ray. It is rod-like, osseous and uniformly thickened all along its length. Being comparatively short in length it reaches only up to the basal portion of the fifth ray.

General structure and function of the gonopodium.—The first four rays of the gonopodium lie close together, while the fifth is placed somewhat apart. The fin membrane between the fourth and the fifth rays thickens into a fold of skin; the fifth ray, as it thickens during development, tends to extend more towards the right side of the fold of the skin noted above. Due to this one-sided extension and the groove-like structures described above, the fifth and the fourth rays by their apposition enclose a canal.

The movement of the gonopodium is effected by the muscles on the lateral sides of the body. These muscles are inserted at the basal regions of the fourth and fifth rays. In addition to these, there are other short muscles between the bases of these two rays and their respective components for co-ordination of their actions. A more detailed study of the musculature of the gonopodium will be published at a later date.

The function of the gonopodium, as observed so far, is exclusively to transfer the spermatophores of the male (*vide infra* p. 410) to the female genital opening during copulation. The organ, as described above, is so complicated a structure that it is not possible to assign definite functions to its individual parts. It is clear, however, that the modifications described result in assuring a safer and surer transference of the sperms in the highly specialised spermatophores, to the female genital opening. The main burden of this task falls on the fourth and the fifth rays, which form a canal for the passage of the spermatophores. The first three rays and the sixth serve merely as supports; their unsegmented osseous nature seems to give more strength to the gonopodium at the base. The fourth ray is ossified except for a small segmented part in the middle. The fifth is ossified only in the proximal portion. From the arrangement of the supporting rays and the thickened ossified nature of the basal portion of the organ, it seems that the organ is meant to be held out firmly at an angle to the

body. Only the middle portion of the fifth ray characterised by the presence of the lateral flaps is, owing to its segmented nature, flexible. The articular surfaces and the movability of the various structures, associated with the fourth ray indicate that they are designed for independent movement while the rest of the body of the gonopodium is rigid. However, it has not been possible to assign any definite functions to these structures or to elucidate the nature of their movements.

Comparative account of the structure of the gonopodium.—The gonopodium, as an organ of the male for the transference of sperms to the female, has not so far been recorded in the oviparous Cyprinodonts. Dr. Hubbs' letter quoted above (*vide supra*, pp. 383-385) shows that *Phallostethus* and *Tomeurus* have recently been found to be oviparous, thus we have a few instances parallel to *Horaichthys*. The case of *Phallostethus* is somewhat different for two reasons ; firstly because it has been proposed by Myers (1928) to remove the fish from the order Cyprinodontes and secondly because the peculiar male organ of that fish, " the priapium ", is not homologous with the gonopodium of *Horaichthys*. The former is formed by a modification of the ventral fins, whereas in *Horaichthys* and other Cyprinodontes gonopodia are developed from the anal fin and are thus homologous. For elucidating further the similarity of the gonopodia of various Cyprinodontes, the structures found in *Horaichthys* may be compared, from an evolutionary point of view, with those found in other groups of the Top-Minnows and Killifishes.

In Cyprinodontidae, in the males of *Oryzias melastigma* McClelland a few of the anal rays are prolonged into filiform processes beyond the fin membrane. These are not the first six as in *Horaichthys*, but they are generally from near about the 8th to the 11th. Moreover, they are merely simple elongations to which no function has so far been assigned. In the American *Plancterus kansae* Garman of the same family, the male possesses " small slender contact organs hooked forward on the anal fin and the adjacent parts of the body " These are obviously to hold the female during copulation and they serve merely as claspers. Further, as they are not restricted to the anal fin only (being found on the adjacent parts of the body as well), they may not be homologous with the modifications of the anal fin in the male of *Horaichthys*.

There is no doubt that the gonopodium in *Horaichthys*, described above, is homologous with the gonopodia of the family Poeciliidae. In both the families, a few of the anterior rays of the anal fin are modified to form the sperm emission organ. In Poeciliidae this organ (for figure see Hubbs 1926, pl. ii, fig. 1), formed by the specialisation of the third, fourth, and fifth rays of the anal fin is continuous with the rest of the fin while in *Horaichthys* the six anterior rays of the anal fin, forming the organ, are separated from the rest of the fin at an early stage of development and are folded back along the right side of the anal fin, though, as in Poeciliidae, the actual important rays are only the 3rd, 4th and 5th.

Though the hyaline movable structures of different shapes found in the distal region of the gonopodial rays of *Horaichthys* are not to be met with in such complexity in the Poeciliidae, a few simple structures

do, nevertheless, occur among its different genera. *Tomeurus gracilis*¹ (*vide supra*, Dr. Hubbs' letter, pp. 383-385) has a few movable processes near the tip of its male organ (text-fig. 1), which are somewhat similar to those found in *Horaichthys*, but they cannot be further compared as their detailed structures have not yet been described. Besides the structures in *Tomeurus*, the two horn-like appendages in *Xenophallus* (Hubbs, 1924), "antorse appendage" in *Phalloceros* (Regan, 1913), long curved appendage in *Cnesterodon* (Regan, 1913) and the pair of curved horn-like processes of *Girardinus* (Regan, 1913), all to be found in the distal region of the respective gonopodia, though simpler and fewer in number, are probably homologous with the structures found at the distal end of the gonopodium of *Horaichthys*. Other comparable structures include the retrorse hook at the tip of the posterior branch of the fourth and the fifth rays of Gambusiini, which may possibly be homologised with the recurved hook in the tubular terminal opening of the fifth anal ray of *Horaichthys*.

In spite of these similarities, there are certain noteworthy differences between the gonopodium of *Horaichthys* and those of the Poeciliidae, the most obvious being the almost unsegmented (unarticulated) nature of the rays of the male organ in the former. All the rays of the gonopodia of the Poeciliidae are segmented right up to the extremities, whereas in *Horaichthys* only the fifth ray is segmented in the middle, the other rays are osseous. The middle portion of the fourth, though it retains a few marks of segmentation, is, in fact, thickened and osseous like the others. This condition shows that the gonopodia of the Poeciliidae are much more flexible than the similar structure of *Horaichthys*. Another outstanding difference is that the "serrae", "elbows" and the "spines" occurring as out-growths of the distal segments of the gonopodial rays in Poeciliidae are conspicuous by their absence in *Horaichthys*. Moreover, in the latter, the rays involved in the formation of the organ are unbranched² in contrast with the corresponding rays which bifurcate into anterior and posterior branches in the Poeciliidae; even the third ray which is sometimes unbranched in the Poeciliidae is branched in such species as *Gambusia holbrooki* and many others. Another difference is the asymmetrical growth of structures on the two halves of the gonopodial rays. Except in such genera as *Cnesterodon*, *Xenophalus*, etc., such asymmetry is not very common in the Poeciliidae.

Asymmetry of the nature noted above is probably not present (*vide* Dr. Hubbs' letter, pp. 383-385) even in *Tomeurus gracilis*, which, in the complexity of structure of the male organ, approaches very closely *Horaichthys setnai*. Moreover, neither the trowel-shaped scoop of the *Phallotorynus* nor the prepucelike hood of the Poeciliinae are represented in the gonopodium of *Horaichthys*.

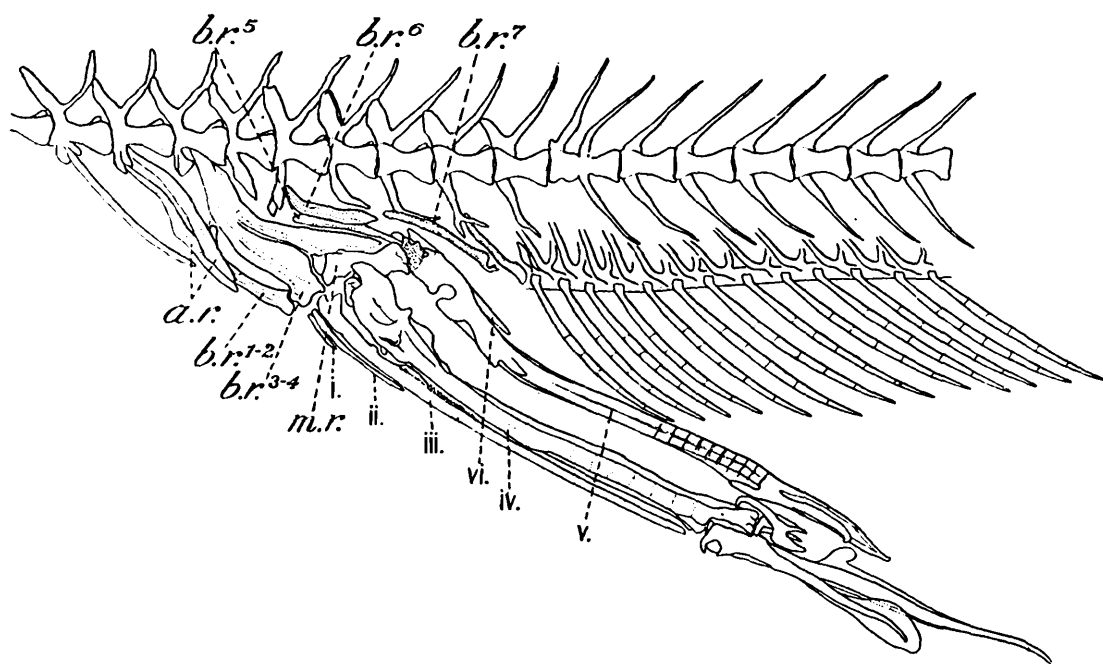
The members of the viviparous Poeciliidae are generally regarded as more specialised than the oviparous Cyprinodontes, but in the case of *Horaichthys*, an oviparous fish, the gonopodium is a very complicated

¹ Drs. Hubbs and Myers propose to separate *Tomeurus* into a new family (*vide supra*, p. 384).

² Presence of right and left components in a ray is not to be taken as evidence of branching, because even in early development they appear as two components. In a normal ray, they fuse into one in the adult.

structure and much more specialised than that of any member of the Poeciliidae.

Skeletal supports of the gonopodium.—The skeletal supports of the gonopodium of *Horaichthys* are the usual fin supports, the radials or the pterygiophores, being considerably thickened and modified. Kuntz (1913) characterised these supports in *Gambusia* as 'interhaemals', but Goodrich (1930, p. 64) names the support of the median fins as the radials or the pterygiophores. As the gonopodium in both the above-mentioned fishes is derived entirely from the modified anal fin rays, the supports of this organ are the same as the ordinary fin supports and hence are described as radials or pterygiophores in this paper.



TEXT-FIG. 10.—A part of the skeleton of *Horaichthys setnai*, gen. et sp. nov., to show the nature of the skeletal supports for the gonopodium. : $\times ca$ 10.

a. r., last pair of abdominal ribs ; b. r.¹⁻², basal radials of the first and second rays ; b. r.³⁻⁴, fused basal segments of the radials of the third and fourth rays ; b. r.⁵, basal radial of 5th ray ; b. r.⁶, basal radial of 6th ray ; b. r.⁷, basal radial of the 7th ray ; m. r., fused median segments of the 3rd and 4th rays ; i-vi., 1st to 6th rays of the gonopodium.

Just as in normal fin supports, the radials of *Horaichthys* are divided into basal, median and distal segments. The basal radials of the first and second rays are united into a somewhat thicker straight bone (text-fig. 10, b. r.¹⁻²), and are in contact with the last pair of the abdominal ribs. These ribs instead of being the thinnest, as is usually the case, are much thicker than the other ribs. The median segment of this radial is a small piece which fuses with the end of the basal portion of the third radial. The distal piece of the first radial is rounded and lies at the base of the first ray ; and that of the second radial appears to be fused with the corresponding segment of the third. The basal segments of the radials of the third and fourth rays are elongated, flattened and thickened. They are fused all along their length to form a large flat bone (text-fig. 10, b. r.³⁻⁴), extending from the vertebral column to the base of the gonopodium. The median segments of these radials also fuse to form a separate bone with several articular facets and cavities on it. The distal cartilages of these radials, as well as those of the following rays

are separate and lie at the base of each ray. The basal radials of the fifth and the sixth (text-fig. 10, *b. r.*⁵, *b. r.*⁶) are separate, thickened and rod-like, tending to form a common medial segment. The basal radial of the sixth ray, which is thicker than that of the fifth, is prolonged anteriorly and meets the haemal process of one of the vertebrae. The association of these thickened radials with the vertebral column, either directly, as in the case of the third, fourth and sixth rays, or indirectly through the vertebral ribs, as for first and second rays, is evidently to obtain an additional support and strength from the vertebral column during the movement of the organ.

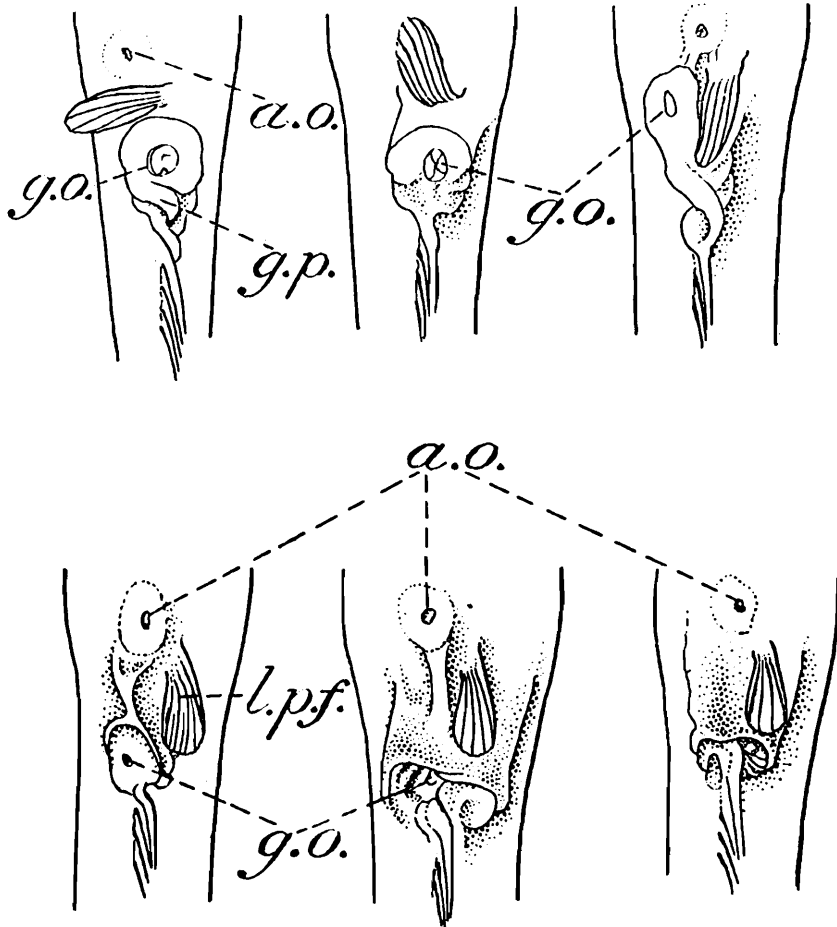
Thus, in *Horaichthys* the skeletal supports of the elaborate male organ are mainly the thickened radials described above. There are no gonapophyses, as in *Gambusia* and several other Poeciliids for the support of the muscles of the gonopodium. In *Gambusia*, only one fin support (called interhaemal by Kuntz, 1913) of the third ray has undergone a remarkable modification, the rest remaining normal. In *Belonesox belizensis* also, the basal radial of the third is well developed and that of the fourth is attached to it. The radials of the third and fourth rays in *Horaichthys*, in addition to mere thickening, as in *Gambusia* and *Belonesox*, unite to form a large bone for supporting the gonopodium. *Anableps anableps* (Müll.) and *Glaridichthys januaris* (Phil.) have also two or three basal radials somewhat similarly fused for the support of the gonopodium.

Deflection of the genital opening in the female.—A great majority of females of *Horaichthys* are remarkable in that their genital openings are shifted from the usual median position to the right or left side. Examination of about 210 specimens collected in different seasons of the year showed that about 60 per cent. of them had the genital pores on the left, 20 per cent. on the right and the rest medial. It is clear, therefore, that the position of the genital pore varies in different specimens and is sometimes intermediate in position between the three types described above. This intermediate position is at times temporarily due to the gravid nature of the specimens, though in many it is a permanent feature.

The above proportions of different types of individuals show that the deflection towards the left dominates over the other two positions. If one takes into consideration the right-sided situation of the gonopodium of the male, the left-sided position of the genital opening of the female would appear to be a natural adaptation for the successful transference of the spermatophores. These adaptations on the part of both sexes obviate the necessity of bending and twisting the gonopodia so as to reach the medially placed opening of the female, as has been observed in the Poeciliidae. Even such female specimens of *Horaichthys* as have the apparently disadvantageous variation of having the genital opening on the right, do not fail to lay fertilised eggs in the normal manner. Examination of preserved specimens of a few females (text-fig. 14) showed that even though the genital openings were to the right, spermatophores were found to be correctly attached to the edges of the openings. Thus it appears that being a right-sided female is not a serious bar in the way of propagation of the species. Nevertheless, it

seems that females with the genital opening on the left side have a better chance for a successful transference to them of the spermatophores.

Asymmetrical position of the genital opening though rare among fishes, is by no means unique, as a somewhat similar characteristic is recorded in *Anableps* where the females have the genital opening either



TEXT-FIG. 11.—A part of the ventral surface of 6 females of *Horaichthys setnai*, gen. et sp. nov., showing the asymmetrical position of the genital opening, the absence of the right pelvic fin and the presence of genital pads round the genital opening. $\times 7$.

a. o., anal opening; g. o., genital opening; g. p., genital pad; l. p. f., left pelvic fin.

on the right or on the left side. This difference in its situation is, however, due, as Garman (1895) believed, to "a large scale to cover the opening of the uterus and the ovary" He further adds that "it (the scale) is at one side or the other so as to open to the right in some and to the left in others" Thus a single large scale makes the females right or left-sided, in reference to the position of the female genital opening. The males also are of two types with the gonopodium either on the left or on the right side. In *Horaichthys*, however, all the males are of one type (right-sided), but are presumably capable of meeting the exigencies in case of wrong-sided females.

Another curious example of the unusual location of the genital opening is afforded by the blind fish *Amblyopsis*, in which the opening of the oviduct is placed far forward near the gill opening, so that the eggs may easily pass into the gill chamber for incubation (Henn, 1916). The genital opening in Phallostethidae also is removed far anteriorly, almost below the throat. The genital openings of both these fishes are, however, in the same position in all the individuals, but in *Horaichthys*,

as described above, the position of the genital opening is extremely variable in different female individuals. The occurrence of these variations in specimens from the same environment is certainly of great ecological interest and would require more extensive field work to understand its significance, if any.

Absence of right pelvic fin in the female.—Another remarkable feature of *Horaichthys* is that the females, instead of having paired pelvic fins, possess only a single, comparatively small fin on the left side; the right being invariably absent (text-fig. 11). A fully developed pelvic bone (the basipterygium) supporting the pelvic fins is also present on the left side only and is entirely absent on the right side. Even in the early stages, when the fins just begin to grow out only the left fin makes its appearance and neither the right fin nor its basipterygium could be traced in any stage of development. This shows that the fin normally does not develop at all. However, in five out of 210 specimens examined, both fins were found to be present. These cases in which both the basipterygia were normally developed certainly appear to be abnormal.

It is difficult to explain satisfactorily why such reduction should occur in the case of only a single fin. Even if the Lamarckian theory is brought in to explain the disappearance of the fin, there is no reason why only the right fin should run into such a disuse. The absence of pelvic fins in such families as the Muraenidae, Symbranchidae and Rhynchobdellidae, might be assigned to their habits of lurking in holes and crevices and also of burrowing in soft mud. But *Horaichthys* is a perfect surface dweller, rarely descending even to the bottom of shallow pools. Curiously enough, in genera like *Chologaster*, *Orestias* and *Tellia*¹, which resemble Top-Minnows in their habits, both the ventral fins are absent, thus differing materially from *Horaichthys*, in which only one fin is lost. The only probable explanation, therefore, is that the right fin must somehow come in the way of the movement of the gonopodium during copulation. Against this explanation, it may be urged that the male usually approaches the female from left, and that if any obstruction is felt during copulation, it must be at the left fin. The objection does not, however, hold good if the structure of the gonopodium and its movement during copulation (*vide infra*, p. 410) are taken into consideration. During this act the long process of the fourth ray which is longer than the fifth ray (from the tubular extremity of which the spermatophores are presumed to issue forth) may be the first to impinge against the right fin when the gonopodium is lashed over the left side obliquely from behind. This possibility becomes clearer when it is remembered that during the aforesaid movement, the long processes of the fourth ray (being longer than the fifth) must be going across the body of the female every time when an attempt is made for the tip of the fifth ray to reach the genital pore and then to dart away. Hence it may be presumed that by such constant striking, the right fin has in the course of time been reduced and ultimately lost.

Another possible view is to consider the absence of the right ventral fin as an indifferent genetical variation (mutation). Even if, according

¹ Females of *Tomeurus* were also supposed to have no ventral fins, but recently Dr. Myers informed Dr. S. L. Hora that both sexes of *Tomeurus* have these fins.

to this view, the mutant had no definite advantage over the double-finned specimens, there is no reason why the original form should have died out or run into such insignificant minority after the appearance of this new form. Logically, therefore, some survival value can be safely attached to the single-finned condition as at present.

Genital pads round the female genital opening.—Another adaptive feature of the female *Horaichthys* to which a reference may be made is that the area near the genital opening is covered by certain callosities of the nature of grooves and ridges and which I have termed “genital pads” As stated already, the skin in the region between the left ventral fin, the anal opening and the insertion of the anal fin is thickened and hardened to form folds and ridges in the area round the genital opening (text-figs. 11 and 14). These ridges are always irregular in disposition, transverse or longitudinal; one of them, however, is invariably continued to the anal fin to embrace the first ray. Moreover, the thickened skin at one place in this region assumes the form of a small conical process, which is probably a genital papilla; this is found always posterior to the genital opening. If the opening is to the extreme right or left, these thickenings are prominent only in the middle region. All the same, a small thickened ring does exist round the opening. These ridges are not present in the very early stages of the fish, but begin to appear when the larva is about 10 mm. in length, the anterior thickening of the anal fin being followed by the other thickenings.

Casually these thickened grooves and ridges may appear as modifications which serve as an interlocking arrangement for the hooks and process of the gonopodium, so as to enable the male to hold the female during copulation (Dr. Hubbs, *vide supra*, p. 384, in his letter mentioned a similar possibility). But in view of the quick process (*vide infra* p. 410) by which the spermatophores are transferred to the female, this explanation does not appear feasible. The probable function of these genital pads, therefore, may be for the protection of the genital area against the strokes which it receives during copulation. When the gonopodium is lashed during the momentary copulation against the body of the female, there may be, in addition to direct strokes, some piercing and scratching action of the genital area by the hooks and pointed processes of the terminal portion of the organ. In order to safeguard against such injury the development of genital pads in the female appears to be a useful device. Moreover, the tips of the abdominal ribs below this region, instead of ending in points as in other ribs, have their extremities slightly bent at times. Though this modification occurs in a limited number of specimens, it may also be regarded as an additional modification which has come about to counter the powerful strokes of the gonopodium during copulation. Similar protective modifications are also found in *Cubaniichthys*, in which “the genital opening is protected by a pair of specialised scales which in the female become enlarged” The single scale on the genital pore in *Anableps* may be regarded as having a protective function. In *Lucania* “the uro-genital opening is surrounded in the female by a membranous pouch which embraces the front of the anal fin” With these instances to support the surmise made above, it may confidently be stated that the genital pads in *Horaichthys* are protective in function.

BIONOMICS.

Habitat.—*Horaichthys setnai* is found in the backwaters and tanks within tidal limits along the western coast of Peninsular India about 100 miles north and south of the city of Bombay ; it is a typical back-water species and has not hitherto been found in open sea or in flowing waters. It is most frequent in puddles of stagnant brackish water and in pools resulting from artificial enclosures set up by fishermen, and its range of distribution extends to waters under tidal influence. For instance, during summer the fish was taken from a creek near Mahad in the Kolaba district as far inland as nearly 35 miles from the sea. During the monsoon, when vast areas of low-lying land near creeks are flooded, the fish becomes wide-spread, and breeds in sheltered places along the edges of the creeks. After the monsoon, when the water level is lowered, large numbers become isolated in puddles, and when even these dry up towards the approach of summer, almost all of the fish perish. Large numbers, however, still remain in perennial pools within tidal limits to propagate the species. Being of a very small size and therefore of little food value, it invariably escapes the depredation of fishermen.

A remarkable characteristic of *Horaichthys* is that, like *Panchax*, it occurs invariably near the surface of the water and mostly in the midst of such aquatic plants as *Enteromorpha*, *Ruppea*, etc., which usually abound along the edges of pools. It is generally found in swarms which move about in close formations. Though invariably swimming near the surface, it can not always be spotted because of its small size and transparent body.

Adaptability to different salinities of water.—In common with most estuarine fishes, *Horaichthys* is able to withstand a wide range of salinity. During summer, owing to intensive evaporation, isolated puddles of sea water, not always within reach of tidal influence, become highly impregnated with salt, and the fish thrives there. In one of such pools, the salinity, according to Kundson's method, was found to be 4.363 per cent. On the other hand, during the monsoon it is found in puddles with salinity as low as 1.348 per cent.

Acclimatization to fresh water.—In 1939 a few experiments were conducted with a view to determining whether the fish would thrive in fresh water. Specimens collected from a creek in May were kept in a pot of salt water for four hours in order to eliminate those which might have accidentally suffered from any injuries during collection. Out of 15 fish two died at the end of the four hours. Out of the survivors half a dozen were directly introduced into a freshwater aquarium tank in which the fish survived for only two days. In another experiment a dozen fish were introduced in a basin of brackish water in which a few marine weeds had been placed. Every day six ounces of this water was removed from the basin and 10 ounces of freshwater was added to it. This process was continued for 12 days after which the fish were transferred to a freshwater aquarium. There were only two casualties (both males) during the 12 days, and the rest lived in the aquarium for about $2\frac{1}{2}$ months. The fish, however, did not show their characteristic vigour or active habits in fresh water.

Another attempt to acclimatize the fish to fresh water was made in July 1939, when there was heavy rain-fall for a fortnight and the water of creeks and puddles had been considerably diluted. At this time half a dozen specimens were introduced directly into a freshwater aquarium in which they, with the exception of two males, which died on the 8th and the 10th day respectively, survived for about two months.

Some of the gravid females, when introduced into fresh water, laid eggs on the second day. The eggs were removed to another jar of fresh water. Out of the 15 eggs thus treated, only four hatched into larvae which died after three days.

Adaptations of the body structure for surface life.—The upturned mouth of the fish is adapted for seizing its prey by pouncing on it from below. The head, which is flat dorsally, enables the fish to swim just below the surface film of water. The mouth is comparatively large and both the jaws are provided with conical, prominent and closely-set teeth. Owing to the premaxillaries and the dentaries not being rigidly fixed the jaws are extensible. A peculiar feature is the presence of powerful teeth on the free arm of the premaxilla; these remain outside the gape of the mouth and may be helpful in holding the prey if, owing to size, it cannot be wholly swallowed. The eyes, which are large as compared to the size of the head, no doubt help the fish in locating its prey and watching the approach of any enemies.

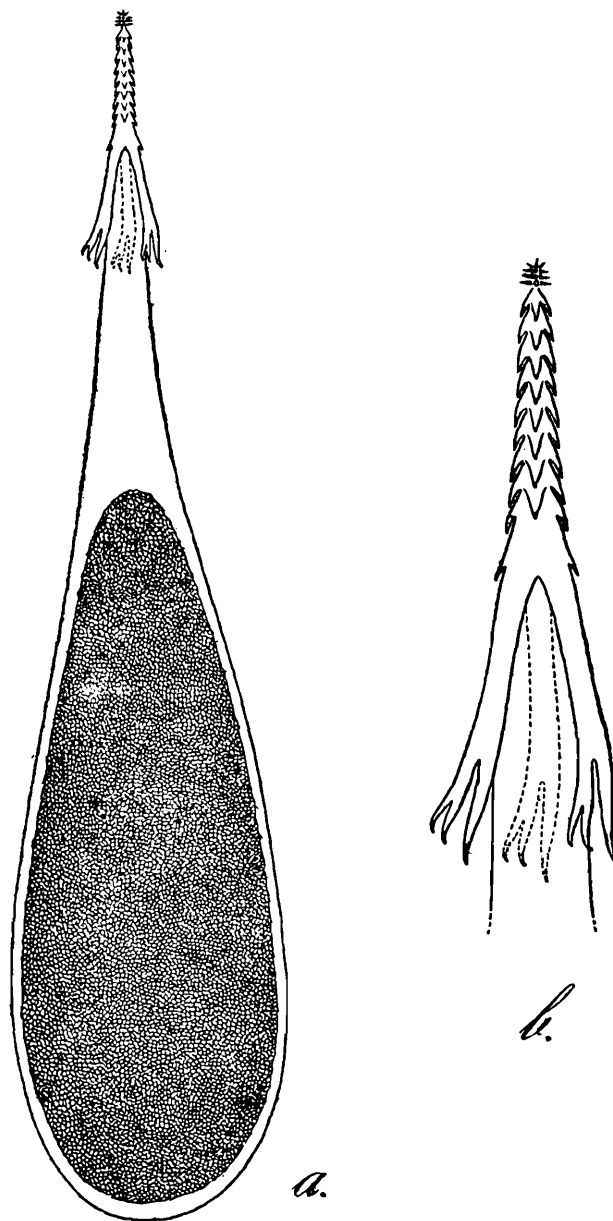
Feeding habits.—*Horaichthys* lives mainly on copepods, diatoms, minute crustacean larvae, etc. It seldom descends very much below the surface of the water for feeding purposes. In addition to its usual food mentioned above, it appears to devour voraciously whatever particles, whether of food or otherwise, may fall on the surface. Thus among the gut contents of several fish were found fine particles of sand, pieces of grass, leaves and other debris, which evidently do not form a part of their diet.

Like other allied carnivorous species, *Horaichthys*, too, has a short intestine. From an examination of the stomach contents, the fish does not appear to be cannibalistic in habit, but it was observed that hungry females, in captivity, at times devour their young ones.

Breeding season.—The fish breeds throughout the year, as gravid females were collected during every month of the year. However, the peak period of breeding appears to be during July and August, as the proportion of gravid females was found to be the highest in these months; at this time the water of the creeks is less saline and possesses more planktonic food. The eggs are laid in weeds along the edges of the pools in groups of about 20 to 30 at a time. They remain attached to the weeds and hatch out in about 8 to 10 days.

Spermatophores of the male.—A special feature of *Horaichthys* is that the testis of the male instead of giving rise to semi-fluid milt, with suspended spermatozoa, just as in other oviparous fishes, produces sperm-capsules or spermatophores in each of which innumerable spermatozoa are enclosed. About 250-280 spermatophores are encountered in different stages of development in a healthy male. When fully developed a spermatophore (text-fig. 12) is a hyaline club shaped body, the broad part of which contains sperms in a mass. On an average, it is 0.61

mm. in length and 0.11 mm. in thickness. For some distance towards the tapering end of the spermatophore, there are series of barb-like



TEXT-FIG. 12.—Spermatophore of *Horaichthys setnai*, gen. et sp. nov.

a. A complete spermatophore : $\times 205$. *b.* Tapering end of a spermatophore with barb-like processes : $\times 530$.

structures which point backwards. The three barbs nearer the wider part form a whorl of very stout and conspicuous bifid spines. Some of the bifurcations of these spines divide again into two near their tips. A short distance in front of these spines, there are 8 or 9 whorls of short and thick closely-set barbs. The space between the bifid spines and the upper series of barbs is usually smooth or at times may possess one or two solitary barbs. The barbs near the tip of the spermatophore, consisting of two or three whorls, are very thin and, unlike others, point nearly at right angles to the long axis ; and a few at the extreme tip are directed upwards. The rest of the body of the spermatophore is smooth. It is with the aid of these stiff processes and the barbs that

the spermatophores, when they are shot out, get attached near the genital opening of the female. The bifid spines by their outwardly spreading divisions probably serve to limit their penetration to the necessary depth only.

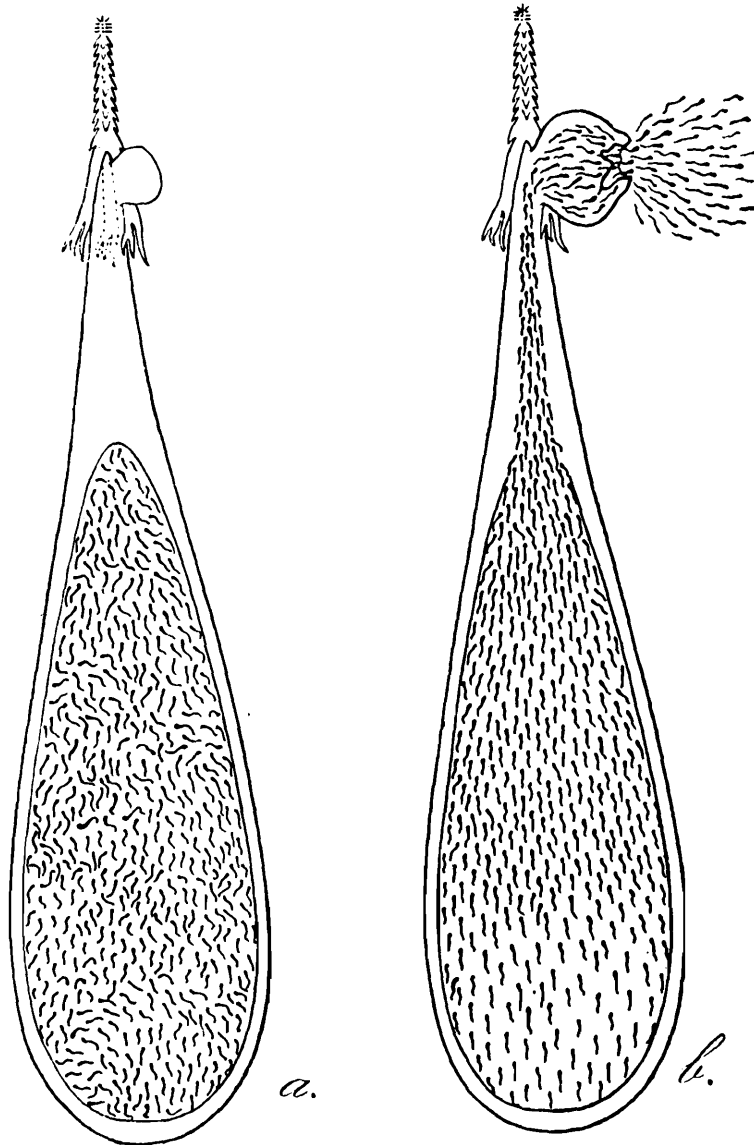
So far as I am aware, this appears to be the first instance when true spermatophores have been noted in fishes. Spermatophore-like bodies have been stated to occur in the family Poeciliidae. Philippi (1907), who first found these bodies in *Glaridichthys januarius* Hensel and *G. decemmaculatus* Janyus, called them "Spermozeugmata"¹ (sperm-masses) as they had no outer coating. In these two fishes sperms are merely rolled into a thick slightly oblong mass with their heads pointing to the periphery and a sticky cementing substance in the centre (figured by Philippi on p. 107). As described above, in *Horaichthys* there is a distinct hyaline case (outer cover) in which the inner sperm mass, corresponding to the spermozeugmata of *Glaridichthys*, is enclosed. Kuntz (1913, p. 186) refers, to the 'spermozeugmata' of *Gambusia* as spermatophores and says, "the walls of the spermatophores are exceedingly delicate" My observation on the sperm mass of *Gambusia affinis holbrooki* has convinced me that there is no such delicate wall round the sperm mass as mentioned by Kuntz and that the term spermatophore, in its strict sense, is not applicable to such a structure. Thus, it seems that a true spermatophore has not so far been recorded even in Poeciliidae.

Among invertebrates Cephalopoda (Mollusca) possess tubular, well-developed spermatophores; in certain species they may be as long as 2 cms. The hectocotyliised arm or the intromittant organ of *Sepia* is used for the transference of the spermatophores into the mantle cavity of the female, and in consequence there are no structures of attachment corresponding to the barbs and stiff processes as in the spermatophores of *Horaichthys*. Each spermatophore of *Sepia* has, however, a spring mechanism at the end of the structure by the action of which the wall of the spermatophore bursts to liberate the sperms whereas in *Horaichthys* this purpose, as is explained below, is attained by quite a different mechanism.

Escape of sperms from the spermatophores.—There is no permanent opening on the spermatophore for the liberation of sperms. The way in which the sperms are liberated in nature is clear only when a spermatophore from a live specimen is observed in normal saline solution. After a lapse of about 10 minutes a small rounded bulging appears between the basal portions of any two bifid spines and begins to enlarge (text-fig. 13a); this region of the spermatophore is presumably provided with somewhat weaker walls and some sort of osmotic pressure may be responsible for the bulging noted above. At a time the number of such protuberances may be even as many as three, each occurring in the interspace between two adjoining spines, but in such cases only the biggest becomes enlarged while the others remain stationary.

¹ According to Henn (1916), Ballowitz in the case of insects first proposed the term "spermozeugma" (plural "spermozeugmata") for aggregations of sperms which had no external investment.

When the protuberance is sufficiently large a semifluid substance from above the sperm mass slowly moves up and passes into it. This



TEXT-FIG. 13.—Diagrammatic representation of the escape of sperms from the spermatophore.

a. An early stage with a bulging between the basal portions of two bifid spines.
b. Later stage showing direction of movement of sperms, the rupturing of the distended wall and escape of sperms.

action is followed by the activation of a few adjoining sperms which slowly pass into the cavity. Other sperms do likewise with greater speed, and a large number of these concentrate into the bulging part and ultimately escape when the distended wall ruptures. By the time this opening is formed the movement of the sperms in the spermatophore is greatly accelerated and numbers of these are ejected at a time. Eventually the whole sperm mass inside the spermatophore is activated and there is a continuous movement up and down in the entire cavity of the spermatophore and innumerable sperms rush about in all directions to find an exit. After about an hour or so the whole of the spermatophore becomes empty.

Act of mating.—Breeding takes place all the year round and evidence of this may be gathered from the fact that males are often seen following the females. At the time of mating, the male, with his eyes always directed towards the female, swims below and behind her at a distance of about 2 to 3 cms. He then darts towards her on the left with almost lightning speed. As he approaches his mate he lashes out the gonopodium sideways almost at right angles to his body and strikes its terminal end against her genital opening. The spermatophores are transferred to the female in this momentary contact, and become attached by their distal hooks.

The male does not, however, always succeed in transferring the spermatophores to the female during these momentary contacts. Several attempts are made at times, the male always keeping himself to the left of the female—the side on which her genital opening is usually situated. At times the male merely darts towards the female, and this is probably a sort of courting. The male appears to be always afraid of the female which on occasions chases him away.

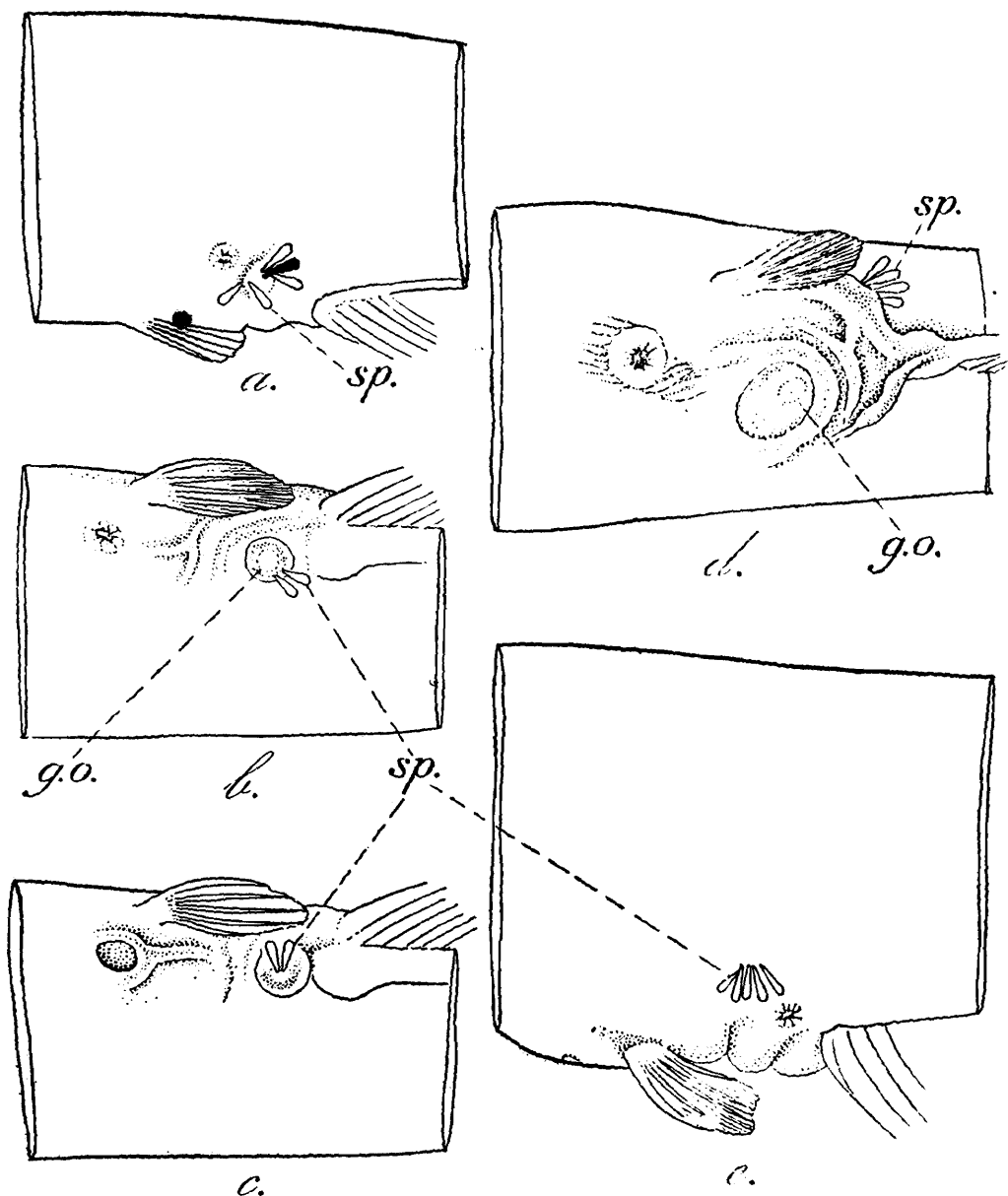
The small size of the spermatophores and the speed with which they are discharged make it almost impossible to observe the actual act of transference, but immediate examination of the female after the male's behaviour described above, may reveal the result of his amorous dashes towards his mate. On one occasion a female with no spermatophores previously attached to her body was immediately killed in formalin after it had been approached by the male. Examination of the female showed that she had 18 undischarged spermatophores attached to the anterior edge of the genital opening. They were so firmly attached, with their pointed ends imbedded in the flesh, that even the violent struggle for life by the fish, when it was put into formalin, did not dislodge them.

The gonopodium which is normally folded back along the right side of the anal fin, is capable of a forward movement when it lies at an angle to the body. The female genital openings of most females are generally situated towards the left. When the gonopodium is darted forwards from its resting position during the aforesaid activity of the male, the sperm duct which opens at the base of the 4th and 5th rays is presumably extended through the canal formed by these rays to their distal end. As the organ strikes against the body of the female during mating, the spermatophores are shot out from the sperm duct, and get attached to the female opening.

After the spermatophores are attached, the sperms are, as described above, liberated from the spermatophores, and are believed to reach the oviduct either by chance or under the chemical influence of the oviducal fluid. Their entry into and presence in the folds of the oviduct have been ascertained by dissecting live females in normal saline. Females separated from the males for about five days and having no spermatophores attached to them were dissected and the distal parts of the oviducts teased on a slide. Sperms in incredible numbers came out of the folds of the oviducal walls which seem to serve as a receptaculum seminis. Henn (1916), also observed innumerable sperms in the oviducal walls of *Lebistes* and *Pseudopocilia*, and found that the effect of the oviducal secretion on the sperm mass of the fish

was the immediate dissolution of the mass and the activation of the sperms. It is likely that the oviducal secretion in *Horaichthys* may have some chemical attraction for the sperms, but it has not been possible for me to verify this experimentally.

In some females the genital openings were found on the right side, and even with these the males do not seem to have had any difficulty



TEXT-FIG. 14.—Genital region of 5 females (a.-e.) of *Horaichthys setnai*, gen. et sp. nov. showing attachment of spermatophores in different positions: $\times 12$.

g. o., genital opening; sp., spermatophore.

in transferring the spermatophores to the genital opening, as spermatophores were noticed to be correctly placed in a few preserved specimens as shown in text-fig. 14 b and c. A detailed examination of these specimens showed that the exact place of attachment varied in different individuals. In some the spermatophores were fixed on the inner edge of the opening, while in others on the outside. From both situations, the sperms, when liberated from the spermatophores, would seem to be

capable of travelling the distance from the spermatophores to the oviduct. In exceptional cases they were attached rather away from the genital opening as shown in text-fig. 14*d* and it seems doubtful whether they are capable of covering so much distance in order to reach the oviduct.

Though the gonopodium of *Gambusia* is situated medially, the mode of mating is strikingly similar to that of *Horaichthys* in which the gonopodium is distinctly placed on the right side. Seal (1911),¹ who was the first to observe the mating of *Gambusia holbrooki*, describes it as follows :—

“The male follows incessantly and warily after the female, on the left side and to the rear, the female turning and making savage dives at him, causing him to turn and flee, but to return immediately and follow, watching for a moment when her attention will be distracted, when he will make a sudden dash, sometimes succeeding in inserting the intromittent organ² into the genital pore, but oftener apparently missing it because of a quick turn of the female from which he flees in apparent terror. The contact is so sudden and brief that it required many observations to verify it. In these movements the male organ is thrust forward and to the right towards the female.”

Philippi also gives a similar account of mating in *Phalloceros* and *Cnesterodon*.

It is thus clear that the mode of mating in *Horaichthys* is strikingly similar to that of the American Poeciliid fishes, though they are only very distantly related.

Longevity of sperms and fertilisation of eggs.—To study their breeding three gravid females collected from the field were kept in a jar. After a day each of them laid eggs and after 11 days another lot of eggs was laid. All the eggs were seen to develop normally. In the case of another batch,³ females were observed to lay eggs 14 days after their separation from the males. Some eggs, examined immediately after being laid, showed no trace of segmentation, the blastoderm being just in formation.

These observations make it clear that the eggs are fertilised within the body of the female and that the sperms are capable of living in the oviduct for at least 15 days. There are several records of such longevity of sperms in the oviduct in Poeciliidae. Hildebrand (1917) stated that “a female (*Gambusia*) kept under close observation produced five broods after she had been separated from all other fish” Henn (1916) states that Zolotnisky raised broods of *Phalloceros* more than ten weeks after separation from the male. It is not surprising, therefore, if the sperms of *Horaichthys* are found to live in the body of the female for more than a fortnight and are potent enough to impregnate even a third or fourth brood of eggs. The above observations also seem to show that in *Horaichthys* fertilisation occurs probably when the eggs are just being extruded as freshly laid eggs do not show any traces of segmentation. According to Villadolid and Manacop the eggs

¹ The account of mating in *Gambusia* published by Ryder (1885) from the details given by A. A. Duly is contradicted both by Philippi and Seal.

² It is doubtful whether the organ is in reality inserted in the genital pore as stated here. According to Philippi's account (*vide* Henn, 1916) the male “with extraordinary speed places the tip of the anal bearing a sperm capsule upon the urogenital papilla of the female”.

³ In this experiment, females at the time of separation from the males were found to have no spermatophores attached to them. Similar observations were not made in the first experiment.

of *Gulaphallus* are also believed to be fertilised internally in a similar manner.

Mode of laying eggs.—When the eggs are to be laid, the female moves over weeds, bends her caudal region sideways and ejects the eggs either towards the right or left, according to the position of the genital opening. The anal fin is pressed forwards, the abdomen being perhaps pressed with it, so that the fin which usually points posteriorly has its long fin rays pointed anteriorly while the eggs are being liberated. The solitary ventral fin is also pressed backwards. The eggs are shot out obliquely to a distance of about 5-6 mm., they are ejected quickly one after another, at intervals of less than a minute. When an egg is not completely ejected, but adheres to the genital opening, the next egg is ejected more forcibly, with the result that both eggs leave as it were in one conglomerate mass.

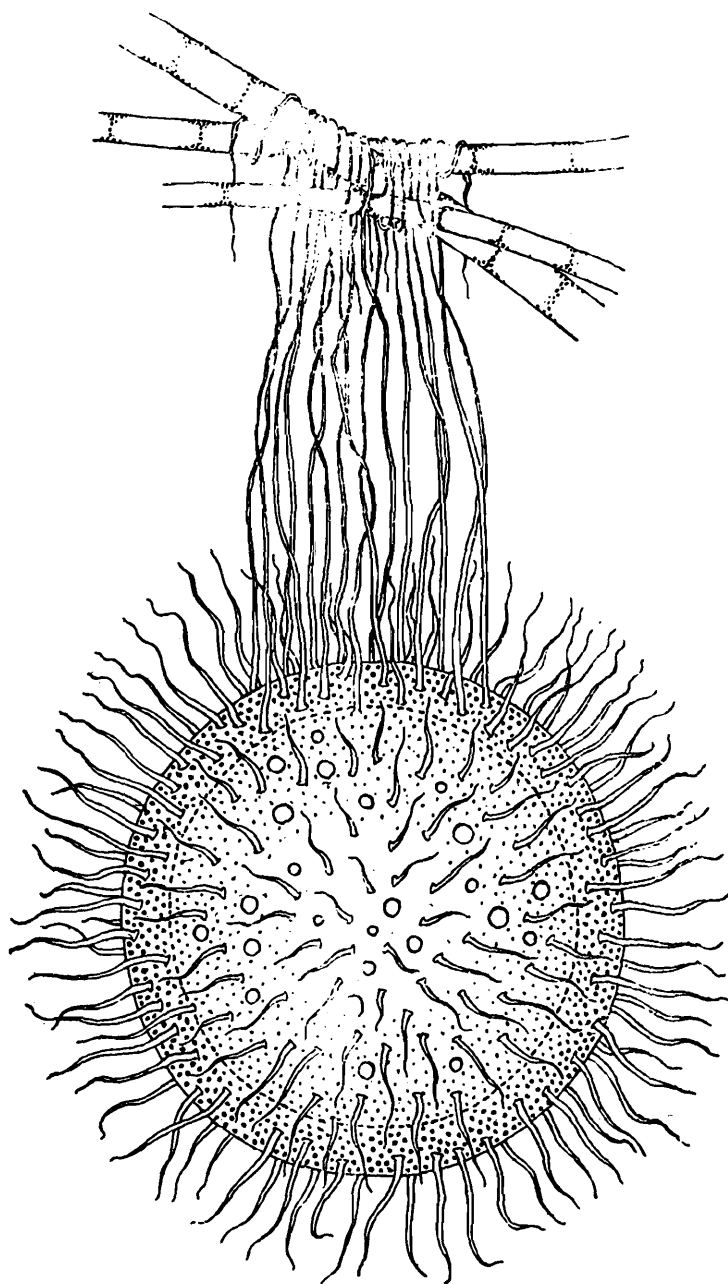
All the eggs are not laid at one spot. The female, while ejecting the eggs, is constantly on the move, though within a limited radius, evidently searching for fresh places to deposit the eggs. In this respect she manifests a preference for a place with filamentous algae, so that the eggs may get attached to them. A female which had ejected 23 eggs in 18 minutes was observed, on one occasion, to have deposited 21 more eggs after about 17 hours, but the interval at which each of these eggs was laid was not recorded. In most of the cases egg-laying occurred in the afternoon.

EMBRYOLOGY AND LARVAL DEVELOPMENT.

The Egg.—The egg of *Horaichthys*, which is almost transparent, spherical and demersal, usually measures about 1 mm. in diameter (text-fig. 15). Like the eggs of certain oviparous Cyprinodonts and Gar-fishes, it bears numerous hair-like, hyaline processes or filaments all over the surface. A group of these processes is exceptionally elongated and appears as a long tuft on the egg. It is by these processes that the eggs are attached to the weeds. These long processes are very elastic and invariably become coiled to ensure attachment of the egg as soon as it is laid. The short filaments are mostly of uniform length and vary from 0.21 to 0.35 mm. in length in different specimens. Thus, the egg of *Horaichthys*, with its two types of filaments, appears in many respects to be very similar to that of the Philippine *Gulaphallus* (Villadolid and Manacop, 1934). The egg of *Oryzias* (= *Aplocheilus*) *melastigma* (Jones, 1937) is also similar, though the shorter filaments, from Jones' figure, appear to be much smaller and the longer ones rolled into a thicker cluster than in *Horaichthys*.

The egg membrane in *Horaichthys* is transparent and has a granular texture. Between the egg membrane and the delicate vitelline membrane covering the ovum, there is a small perivitelline space. The ovum contains a large amount of yolk with a number of oil-globules in it. The globules are numerous, small and scattered in eggs just removed from the ovary of a female, but in those in which the development has partially proceeded the oil globules are large, fewer in number and concentrated at one pole. Even in respect of oil globules, the egg

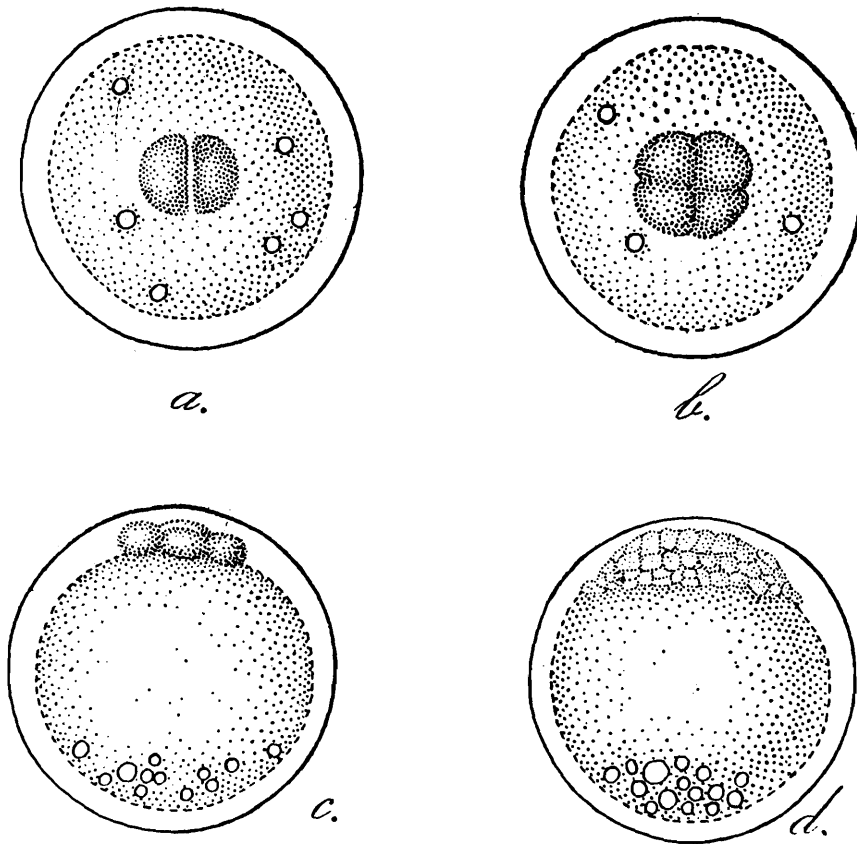
resembles that of *Gulaphallus* and also slightly that of *Aplocheilus blokii* (= *Panchax parvus*).



TEXT-FIG. 15.—An egg of *Horaichthys setnai*, gen. et sp. nov. attached to some filamentous algae. Diagrammatic.

Development of the egg.—Soon after the eggs are laid, the oil globules which are small and scattered in the yolk, begin to move towards the upper pole. While they are thus moving two or more of them come together and unite to form bigger globules, which, in turn, continue the same upward movement. The globules thus diminish in number, but simultaneously increase in size. By the time the second cleavage of the egg occurs the globules reach the upper pole and remain there till the entire development of the embryo is completed. No more coalescence of the neighbouring globules occurs after they have reached the upper pole. The number of those which persist varies from 15 to 30, and they have an average diameter of about 0.06 mm. During the movement of the oil globules towards the upper pole a circular blastodisc forms at the lower pole as a result of the concentration of the

protoplasm of the egg and presents a dome-like appearance on the mass of the yolk. The blastodisc before the first cleavage, which is

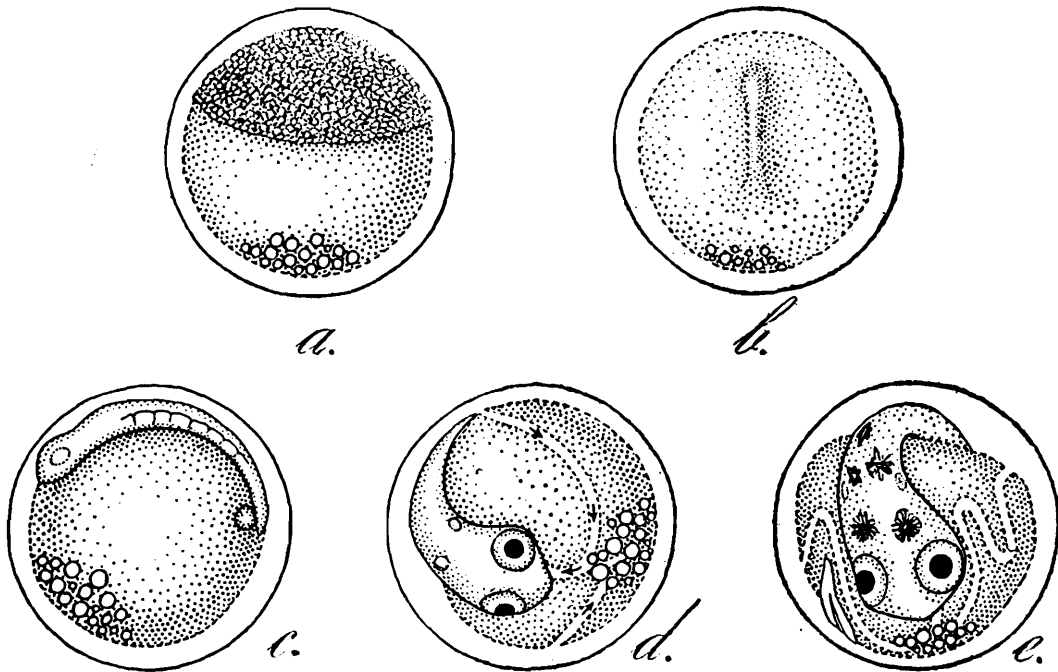


TEXT-FIG. 16.—Stages (a.-d.) in the cleavage of egg during the development of *Horaichthys setnai*, gen. et sp. nov. Diagrammatic.

about two hours after the egg is laid, becomes slightly elongated. The first cleavage divides the blastodisc into two equal blastomeres by a division along the axis of the egg (text-fig. 16a). The line of the second cleavage is also meridional and at right angles to the first, the division taking about two hours to complete. Thus at the end of about four hours the first four blastomeres are clearly visible and stand out on the lower pole as shown in text-fig. 16c.

The four blastomeres are divided later by a plane of division at right angles to the axis of the egg and give rise to eight cells. The process of division then continues in the usual manner, so that at the end of about eight hours a cap of large cells forms the blastoderm. The peripheral cells of the blastoderm at this stage have no distinct cell limits and divide rapidly to give rise to the periderm. As the division proceeds the cells of the blastoderm become smaller and spread outwards on the yolk. The blastoderm thus becomes thin and forms a uniform layer of small cells covering a larger circular area on the yolk (text-fig. 17). This process of expansion continues till the great part of the yolk is covered by the blastoderm cells. After about 26 hours a linear thickening of the cells, a few layers deep, is observed to develop in the blastoderm. This linear thickening (text-fig. 17b) is the embryonic axis, which later gives rise to the embryo. After the completion of the axis, the terminal portion, which is generally away from

the oil globules, gives rise to the cephalic region; this takes about 40 hours to develop. The caudal end, at this stage, merges imperceptibly



TEXT-FIG. 17.—Stages (a.-e.) in the formation of the embryo of *Horaichthys setnai*, gen. et sp. nov. Diagrammatic.

into the blastoderm layer. A few hours later the outline of the embryo becomes visible, with a faint outline of the head, eyes, about six or seven posterior somites and the terminal caudal end (text-fig. 17c). A small vesicle, probably the Kupfers' vesicle, appears under the caudal fin at a time when the cephalic region is faintly perceptible, grows larger and gets absorbed after a day or two. The egg membrane and the embryo being quite transparent, all the stages of development are clearly observable.

On the third day (after 54 hours) the outline of the embryo is more distinct, with its structural features clearly defined externally. The head now lies near the oil globules. The head and the caudal portion of the body are free from the yolk, while the rest of the ventral portion is continuous with it. The embryo at this stage has grown over nearly three-fourth the circumference of the yolk and has about 12 visible somites.

The outstanding feature of the development of the embryo on the fourth day is the appearance of three vitelline vessels bringing blood from the yolk to the newly formed auricle and the ventricle of the heart, which has just started pulsating rhythmically. The blood current in the three vessels, two lateral and one in the middle, is clearly visible and the vessels unite below the oil globules to join the heart, which seems to lie below the cephalic region at this stage (text-fig. 17d). The auditory pits can be easily distinguished, but possess none of the chromatophores which appear later. A pair of small protruberances, which later give rise to the pectoral fins, are visible behind the auditory region.

The pigment in the eyes first manifests itself on the fifth day. The outer edge of the choroidal layer is the first to get dark, this being followed by the pigment spreading inwards. A pair of large chromato-

phores appears on the head between the eyes and the auditory region, and a solitary chromatophore on the yolk to the right of the embryo. Three or four minute black chromatophores are also seen at the bottom of the auditory pits. The vitelline vessels, which are now more developed, are not straight as before, but assume a zigzag course and tend to spread over a larger area on the yolk. A small additional vessel joins the middle one in its posterior region. The blood corpuscles appear distinctly reddish. The embryo shows jerky movements at intervals, and changes its position within the egg.

On the sixth day the choroidal layer of the eyes is completely black (text-fig. 17e). In addition to the first, a second pair of medium sized chromatophores appear on the dorsal side, one or two on the mid-dorsal line and a pair on the yolk. The embryo is now coiled within the egg-membrane and completely encircles the yolk.

After the seventh day all the characteristic pigment spots on the body are developed. Both the jaws are formed and are capable of slight movement even inside the egg. The pectoral and the caudal fins are well developed and occasionally move while still in the egg. The embryo escapes from the egg membrane about the tenth day, and after lying still for about ten minutes begins to swim freely.

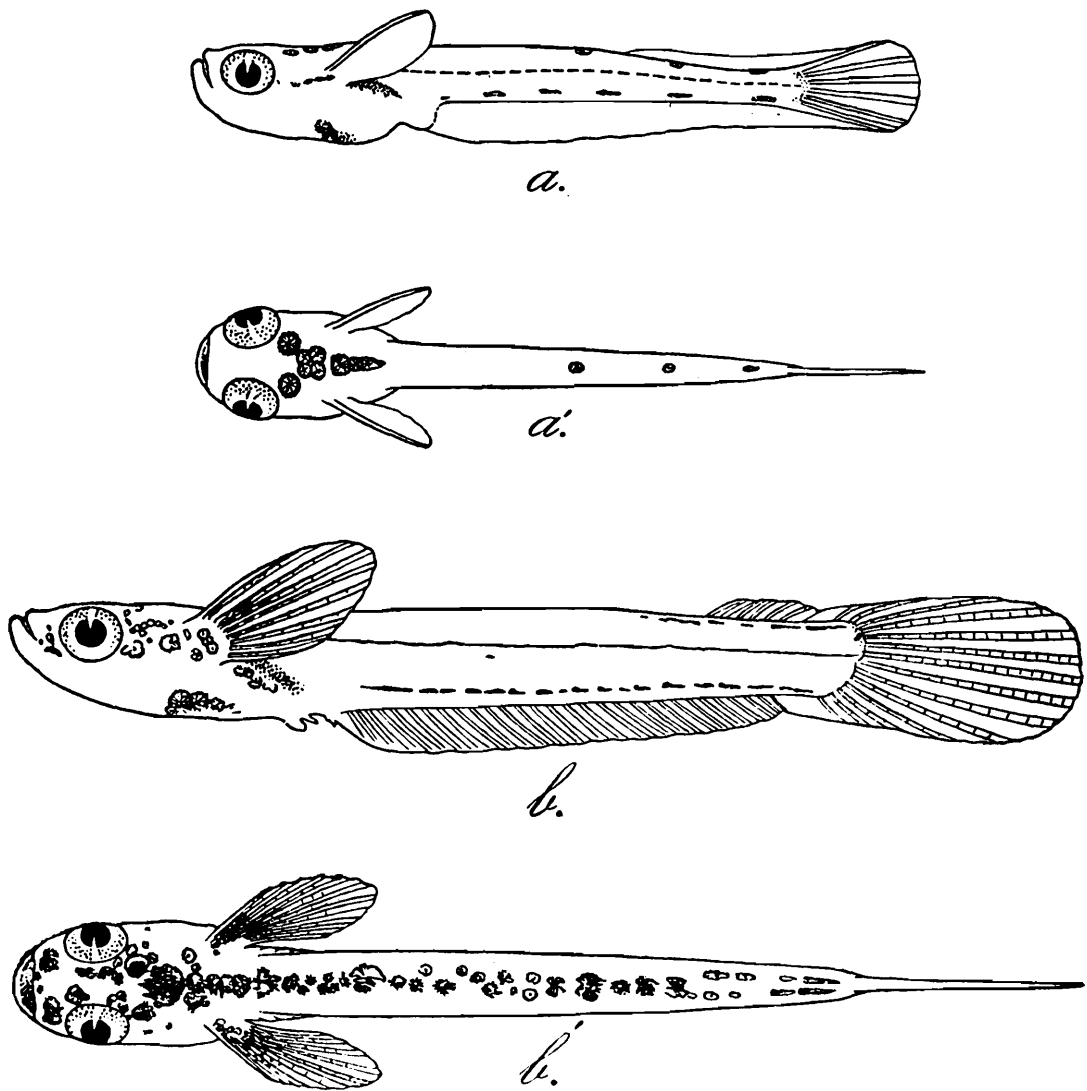
The time required for the eggs to hatch and for the various intermediate stages of development vary greatly according to the temperature and the oxygen content of the water. Even in the same room eggs laid at the same time and kept in water of the same temperature took 22 days to hatch, when the water of the vessel contained no aquatic plants. This shows that oxygenation of the surrounding water is essential for the normal development of the eggs.

Larva.—The newly hatched larva measures about 3.5 to 4 mm, from the tip of the snout to the tip of the caudal fin (text-fig. 18a, a'). There is no trace of the yolk sac appended to the body at the time the larva is hatched, but the bulging of the abdomen shows that a portion of the original yolk still persists. Even some of the oil globules of the yolk are faintly visible under the skin in some specimens. The head of the larva is about 0.75 mm. in length and 0.5 mm. in breadth. The rest of the body behind the pectoral fins is laterally compressed and gradually tapers to a thin membrane in the caudal extremity. The eyes and the mouth are well developed. Minute teeth are present in the lower jaw. The auditory capsule is clearly seen.

The pectoral fins are fully developed, have a broad base and are placed high up at the sides of the body. Each fin is about 0.5 mm. in length. The vertical fins appear as a continuous vertical fold starting dorsally at about 2/3rd of the body from the anterior end and pass round the caudal region of the body. No other fins are present. The dorsal, caudal and the anal fins originate from the ventral fold, while the others grow independently. The fin-rays have already developed in the caudal region of the vertical fold, while in other regions of this fold no such development is traceable.

The free living larva seems almost transparent to the naked eye, except for the prominent black eyes and a few dark spots on the head. The size as also the number of these large chromatophores (spots) on

the head are not constant. Generally they are two to four in number. The second pair of the chromatophores (*vide* p. 417) on the head fuses



TEXT-FIG. 18.—Two larval stages of *Horaichthys setnai*, gen. et sp. nov. in lateral and dorsal views.

a. a'. Newly hatched larva : $\times 20$. *b., b'*. A larva 10 mm. in length : $\times 10$.

at times to form a large chromatophore in the centre of the head. There is a whitish central area in each chromatophore, while there are two or three such areas in the one that is fused. As shown in text-fig. 18*a'*, there are two or three smaller (fused) chromatophores behind the larger ones and then follow three or four still smaller, slightly oblong black spots on the mid-dorsal side of the body. These spots are absent in some larvae. There is a row of dash-like black spots in the middle of the body on the lateral line. They are so closely set that they form an almost continuous line. There is another row of five or six dots similar to those on the dorsal side and situated just above the base of the ventral vertical-fold on both sides. A number of small black dots are visible in the axilla of the ventral fins. On the abdomen there are four or five irregular chromatophores. These appear on the yolk sac as one or two chromatophores during development and are now visible on the abdomen. A few tiny spots exist on the caudal rays also.

The larger as also the other smaller pigmented spots (chromatophores) are clear and well defined in outline in living specimens, while the outlines of those preserved in formalin spread outwards and they appear less dark in colour.

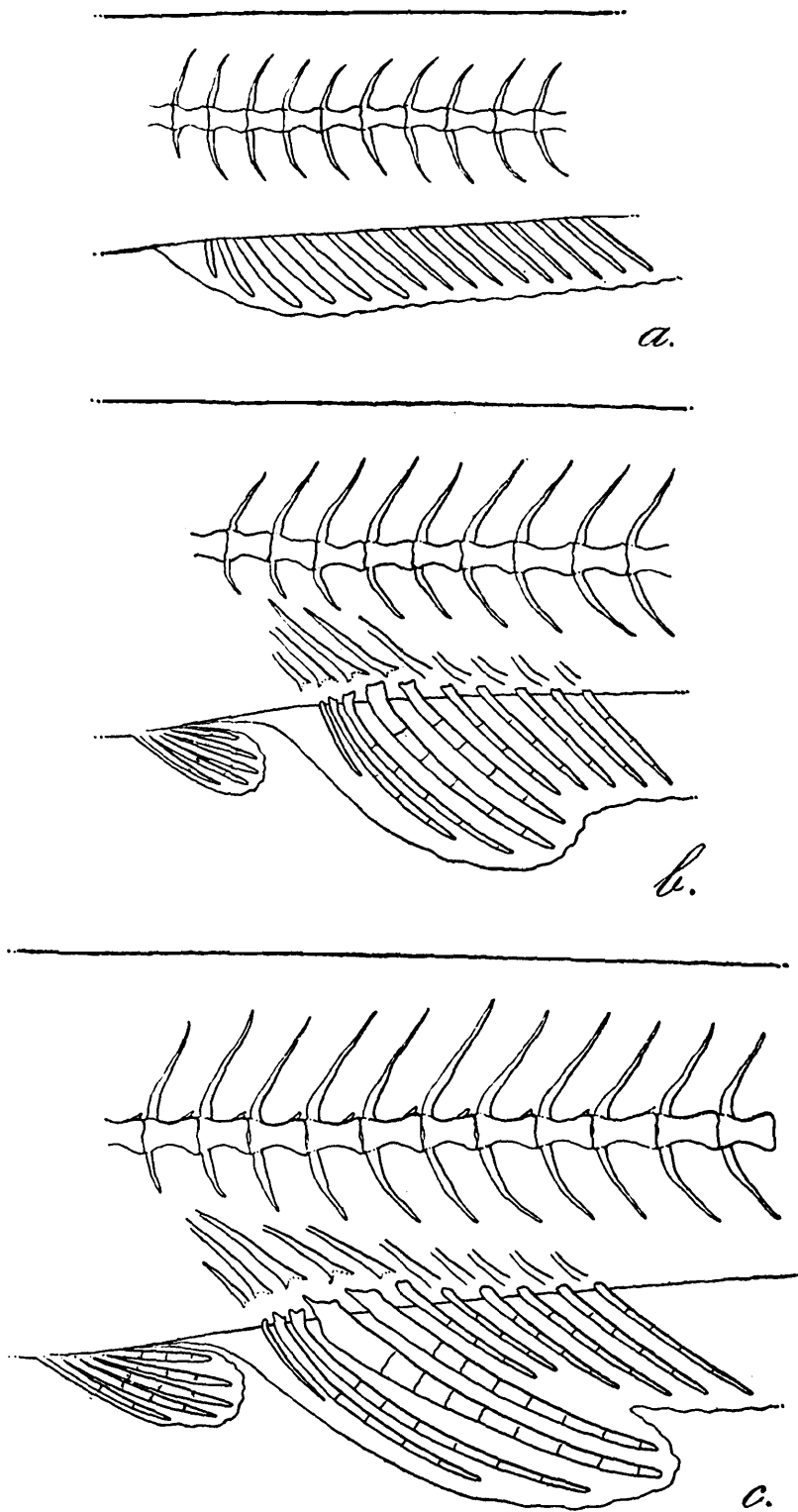
Development of the larva.—Several attempts to rear larvae in an aquarium were made, but under artificial conditions the specimens did not survive for more than a week. Those which survived till the seventh day did not exhibit many developmental changes. Only the caudal fin was slightly more demarcated, though continuous with the ventral fin fold, and traces of fin rays had appeared in the anal fin. The larvae did not thrive in the artificial surroundings probably owing to the absence of their normal food and other conditions, which have not been elucidated so far.

Even larvae of about 7 mm. in length, collected from creeks, show no development of pelvic fins. In these the fin rays are developed only in the anal portion of the vertical fold which is still continuous round the caudal. The pigment spots on the head, the mid dorsal line and by the side of the ventral vertical fold, have increased in number and size. In larvae of about 8 mm. mere outgrowths of the pelvic fins are marked and in those of about 10 mm. (text-fig. 18*b*), pelvic fins are clearly visible. These fins are paired in some and single in others. Individuals with paired fins are, in a majority of cases, males, while those with only one fin are definitely females. Thickenings of the skin in the genital area which later on give rise to the genital pads also begin to appear at this stage in the female larva. Except for the above-noted difference, both the sexes are superficially identical in all respects at this stage. The anal fin, which varies so greatly in two sexes in the adult form, is yet quite similar. The number of fin rays, about 28 to 32, and their sizes are also the same in both the sexes. Each ray of the anal is double with its right and left components having separate bases. Both dorsal and the anal fins have developed rays in them and are quite distinct from the caudal. The urino-genital opening of the male is seen near the base of the first anal ray. There are four pairs of teeth in the lower jaw and two pairs in the upper, but the free arm of the premaxilla (upper jaw) is so far edentulous. Some of the black pigment spots on the body of the larva have now become smaller, but their number has increased considerably on different parts of the body.

The 3rd, 4th and 5th anal rays of the male in a larva of about 12 mm. (text-fig. 19*b*) and the 3rd to 6th in a female larva of the same size are more elongated and the fins in both appear somewhat similar. At this stage the external morphological development of the female is almost complete, except for the teeth on the free arm of the premaxilla and slight modifications in the snout. The differentiation of the first six anal rays of the male to form the gonopodium starts only in the subsequent stages.

Development of the gonopodium.—In a male larva of about 14 mm. in length (text-fig. 19*c*) the 3rd, 4th and 5th anal rays increase in length, become thickened and bend towards the body. In later stages bending, thickening and lengthening continue, but the 4th and 5th rays are not

yet disconnected from the anal fin. When the larva grows to about 16 mm. in length (text-fig. 20a), the first six rays are separated from the

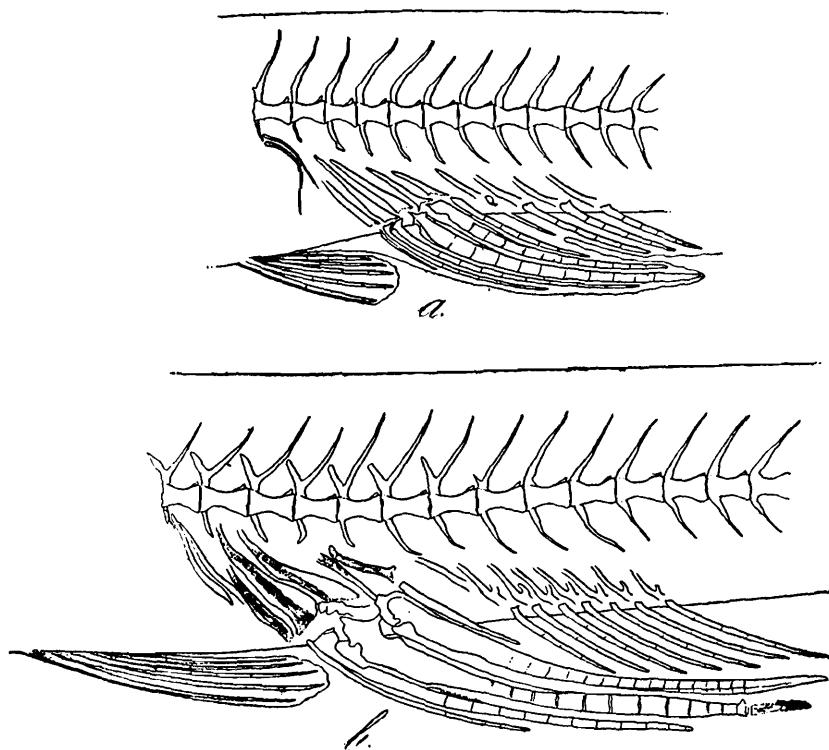


TEXT-FIG. 19.—Early stages (a.-c.) in the development of the genopodium of *Horaichthys setnai*, gen. et sp. nov.: $\times 22$.

a. 10 mm. stage. b. 12 mm. stage. c. 14 mm. stage.

rest of the fin and the growth of the 3rd to the 5th fin rays is continued further. It is suspected that the seventh ray atrophies at this stage and disappears completely. The sixth ray remains short throughout the growth of the fish. Thus the first six rays of the anal fin of the male form a separate group. The bending, thickening and lengthening of the 4th and 5th rays continue till ultimately the rays come to lie side

by side with the anal fin on the right side (text-fig. 20b). Each ray of the anal fin, which is double in origin during development, fuses to



TEXT-FIG. 20.—Later stage (a.-b.) in the development of the gonopodium of *Horaichthys setnai*, gen. et sp. nov. $\times 13$.

a. 16 mm. stage. b. A later stage.

form a single ray, but the 4th and 5th rays retain their double nature, and their halves thicken simultaneously to produce well-developed double rays, each having two condyles for its movement at the base. The component parts of the fourth are flatter and appear to be thicker than those of the fifth ray. Later on other structures which are at the distal end develop simultaneously on both the rays till they assume the form of the fully developed gonopodium (text-figs. 9 and 10).

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