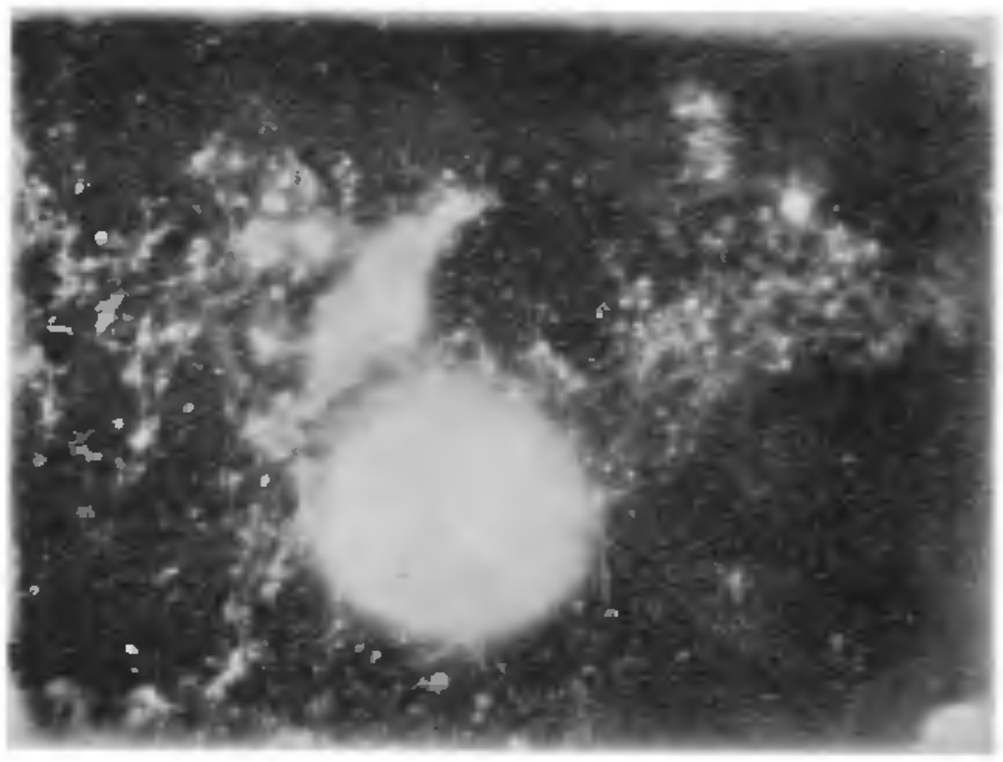
figures and also from analysis of the hafnium-zirconium ratio in meteoric stones, it follows that in the fluid-gaseous stage of our solar system a zirconium-hafnium ratio of about 60 : 1 prevailed throughout and, on account of their similarity, the same ratio is found in present lithosphere. About 1/200,000 part of the earth crust is built up of hafnium, the terrestrial abundance of the latter being as large as that of arsenic, molybdenum or tin.

Hermaphroditism in *Dasychone cingulata*, Grube.

By R. Gopala Aiyar and M. K. Subramaniam.
(*From the University Zoological Research Laboratory, Madras.*)

DASYCHONE CINGULATA occurs in large numbers attached to the buoys in the Madras Harbour in the 'tank' in front of the Yacht Club. While studying its oogenesis[1] and its anatomy[2] male worms were not seen in the collections. This led to a doubt that it may be hermaphrodite and the occurrence of groups of small cells resembling spermatocytes only confirmed our suspicions. In Champy fixed material, careful differentiation and counterstaining often showed some tail-like structures but in all such cases the head was devoid of any detail. Examination of fresh material under very high magnification revealed occasionally what appeared to be sperms. To verify the discovery we examined the cœlomic content under dark ground illumination. Innumerable sperms occur in each segment along with oocytes in various stages of development. The sperms are minute and the tails very slender (photomicrograph).



After examination of the contents under dark ground illumination a change to ordinary light by a change of condenser reveals only a few sperms and that after very careful scrutiny.

In fixed preparations, except in the first four and the last few, all the segments contain both developing oocytes and spermatocytes, which float freely in the cœlomic fluid. The animal appears to breed throughout the year and no special abundance of either of the sexual products was observed in any particular season.

Since the publication of the list of hermaphrodite polychætes by Johnson[3] only a few forms seem to have been added. We are giving below a list of the known hermaphrodite Polychætes which have come to our notice in the literature available to us.

Hermaphroditism occurs in Polychæta without any discoverable cause and is not confined to any one family or any one group of related families. *Branchiomaldane vincenti* and *Lycastis quadraticeps* are considerably smaller than their immediate allies; but their ova are much larger than those of their diœcious relatives. This increase in size of their ova is not followed by any complexity of organisation or any real advance towards higher plane of being. In fact both *Branchiomaldane* and *Lycastis quadraticeps* are of comparatively simple organisation. Ashworth[4] remarks in the case of *Branchiomaldane vincenti* "In particular, the occurrence of hermaphroditism affords strong evidence of departure from the primitive condition; for hermaphroditism is secondary in Polychæta as it is in Mollusca. This seems clear for, at least, two reasons: (1) because of the few cases of hermaphroditism—only about a score of species—known in Polychæta and (2) because hermaphroditism is generally associated in members of this order, with some obviously secondary modification of structure or mode of life. About half the known hermaphrodite Polychæta are tube-dwelling Sabelliformia while most of the others are Polychætes of unusually small size and simplified structure,—*e.g.*, *Lycastis quadraticeps*, *Ophryotrocha puerilis*. In *Branchiomaldane* hermaphroditism is associated with sedentary habits (as in the case of hermaphrodite Serpulids *Spirorbis* and

List of Hermaphrodite Polychætes.

Name of Species	Family	Finder	Remarks	Reference
Nereis diversicolor	Nereidæ	..	..	..
Platynereis dumerili	..	Caullery et Mesnil.	Incipient. Occasionally Hermaphrodite.	*Ann. d. l'Univ. d. Lyon.*, 1898, **39,** 200.
Lycastis quadraticeps	..	Johnson, H. P.	Giant eggs. Male and female in middle segments.	*Biol. Bull.*, 1998, **14, 371.**
Lycastis indica	..	Aiyar, R. G.	Male and female cells in all segments except in front and behind.	*Curr. Sci.*, 1935, **3,** 367.
? Lycastis hawaiiensis	..	Horst, R.	Only egg bearing individuals have been recorded.	*Extrait du department de l' Agriculture aux 'Indes Niederlandaises'*, 1909, **25, 1.**
Lycastopsis catarractarum	..	Feuerborn, H. J.	..	*Verhandl. d. Int. Vereinigung Fur Theor u. Angew. Limnologie*, 1932, **5.**
Macellicephala violacea	Aphroditidæ	Wiren, A.	Hermaphroditism incipient. Males and females occur.	*Zoolog. Studier. Upsala.*, 1902, 289.
Syllis corruscans	Syllidæ	Haswell, W. A.	Anterior somites with eggs and posterior with sperms. Male and female buds occur.	*Proc. Linn. Soc., N S. W.*, 1885, **10,** 733.
Pionosyllis Neapolitana	..	Goodrich, E. S.	Three anterior segments male and several posterior segments female.	*Quart. Journ. Micros. Sci.*, 1930, **73,** 652.
Grubea protandrica	..	Du Plessis.	..	*Rev. Suisse. Zool.*, 1908, **16.**
Grubea pussilloides	..	Haswell, W. A.	Two anterior male segments and several posterior female segments.	*Jour. Linn. Soc.*, 1918, **34.**
Ophryotrocha puerilis	Lumbriconereidæ	Korschelt, E.	Protandric with hermaphrodite organs.	*Zeit. f. wiss. Zool.*, 1894, **57,** 224.
Sabella microphthalmia	Sabellidæ	Gregory, L. H.	Protogynous—paired hermaphrodite organs.	*Biol. Bull.*, 1905, **9,** 285.
Dasychone cingulata	..	Aiyar, R. G., and Subramaniam, M. K.	Male and female cells in all segments except in front and behind.	*Current Science.*
? Caobangia billeti	..	Giard, A.	Only egg-bearing worms have been observed.	*C. R. Soc. Biol.*, 1893, V Ser. **9,** 473.
Amphiglena armandi	Eriographidæ	Claparede, E.	..	*Mem. Soc. Phys. Geneva*, 1868–70, **19–20, 1.**
Spirorbis borealis	Spirorbidæ	Schively, M. A.	Female cells in first two abdominal segments. Male in posterior abdominal segments.	*Proc. Acad. Nat. Sci. Philadelphia*, 1897, 153.
Spirorbis lævis	..	Claparede, E.	..	*Mem. Soc. Phys. Geneva*, 1868–70, **19–20, 1.**
Spirorbis pagenstecheri	..	Pagenstecher, H. A.	Female cells in the middle segments and male cells behind.	*Zeit. f. wiss. Zool.*, 1863, **12,** 486.
*Salmacina dysteri Filograna implexa**	Serpulidæ	Huxley, T. H.	Male gonads 3–5 anterior segments. Female 8–20 segments.	*Edin. New Phil. Journ.*, 1855, **1,** 113.
Salmacina ædificatrix	..	Claparede, E.	Ova in anterior abdominal segments. Sperms in posterior ones.	*Mem. Soc. Phys. Geneva*, 1868–70, **19–20, 1.**
Salmacina incrustans	..	..		..
Pileolaria militaris	..	..		..
Hesione sicula	Hesionidæ	Bergman, W.	With paired hermaphrodite organs.	*Zeit. f. wiss. Zool.*, 1902, **73,** 278.
Branchiomaldane vincenti	Arenicolidæ	Ashworth, J. H.	Male and female elements in middle segments. Giant Ova.	*Proc. Roy. Soc. Edin.*, 1912, **32,** 62.

* G. H. Faulkner[9] thinks with M. Intosh that *Salmacina dysteri* and *Filograna implexa* are synonymous.

Salmacina), and with small size and comparatively simple external form, and may be safely regarded, as in other cases mentioned above, as a secondary character." As *Lycastis indica*[5] which is also hermaphrodite is not " of unusually small size and simplified structure". It is doubtful whether such organisation is a prime necessity for the hermaphrodite condition. *Dasychone* is a tube dweller, but we are of opinion that tube-dwelling may form only one of the many predisposing causes. A search through the literature on hermaphrodite Polychætes reveals that little attention has been paid to the habitat of the animals. Haswell records in the case of *Syllis corruscans* that in specimens obtained between tide marks at Port Jackson in the month of August the posterior orange coloured male region contained only imperfectly developed testes while in specimens taken from deeper water " the posterior orange coloured region was found to be considerably longer; in most it had developed on its first segment two pairs of large eyes, and frequently was found altogether detached from the female." Is this difference caused by the difference in the environmental conditions?

Dr. R. Horst[6] mentions that the genus *Lycastis* is characterised by the facility with which they accommodate themselves to water of greatly reduced salinity. " For, of eight species belonging to this genus five are living in brackish or fresh-water whereas one of them has a strictly fresh-water habitat." In the fresh-water forms Horst observed ripe eggs but no spermatozoa. A re-examination of the sperms of *Lycastis* by us reveals that it is very minute being smaller in size than those of *Dasychone*. It is quite possible that Dr. Horst's failure to see spermatozoa may be due to their minute size. In a footnote to Dr. Horst's paper it is mentioned that *Lycastis hawaiiensis* in the Botanical Gardens at Buitenzorg may have been brought over from the sea along with mangrove plants. " If so, then it is no doubt a very remarkable fact that where in the last two years no mangrove plants have been brought from the sea to our gardens, these worms were able, not only to maintain themselves but even to multiply in these to them quite new surroundings."

We believe that environment and sedentary habits have contributed to the evolution of the hermaphrodite condition. Definite details of the habitats of most of the hermaphrodite Polychætes recorded are unfortunately lacking and our suggestion based on the observations of the habitats of *Dasychone* and *Lycastis* can only be tentative. Brackish water inhabitants show peculiar adaptations associated with reproduction and it is quite probable that a brackish water habitat with fluctuating physico-chemical factors may be responsible for hermaphroditism. In this connection it is remarkable that absolutely nothing is known about the reproductive habits of *Lycastis*. Whether in the brackish and fresh-water forms other modifications affecting reproduction have followed hermaphroditism is not known and a knowledge of it would be of absorbing interest. *Lycastis* has been collected only from the brackish waters of Madras while *Dasychone* which occurs in the Madras Harbour has been collected mostly from the still waters of the 'tank' in front of the Yacht Club where the water exhibits wide fluctuations in its physico-chemical factors, especially during the rainy season.

Pflugfelder[7] in a recent paper describes some new land Polychætes belonging to the genera *Nereis*, *Lycastis* and *Lycastopsis* from Sumatra. One characteristic of these so-called land Polychætes is the enormous development of the mucous glands as seen also in *Lycastis indica*. *Lycastopsis amboinensis* is terrestrial, but *Lycastopsis catarractarum* (Feuerborn[8]) is hermaphrodite and occurs in fresh-water in Java and Sumatra. As most Oligochæta are brackish water, fresh-water and terrestrial in distribution is it not possible that the hermaphrodite condition originated during adaptation to their new habitats through greatly fluctuating environmental conditions?

BIBLIOGRAPHY.

1 Subramaniam and Gopala Aiyar, *Proc. Ind. Acad. Sci.*, 1936, **3**, 175.
2 Sankara Menon and Gopala Aiyar, Unpublished.
3 Johnson, *Biol. Bull.*, 1908, **14**, 371.
4 Ashworth, *Proc. Roy. Soc. Edin.*, 1912, **32**, 62.
5 Gopala Aiyar, *Curr. Sci.*, 1935, **3**, 367.
6 Horst, *Extrait du Department de l' Agriculture aux 'Indes Niederlandaises'*, 1909, **25**, 1.
7 Pflugfelder, *Zool. Anz.*, 1933, **105**, 65.
8 Feuerborn, H. J., *Verhandl. d. Int. Vereinigung fur theor. u. angew Limnologie*, 1932, Bd. **5**.
9 Faulkner, *Proc. Linn. Soc. Zool.*, 1930-31, **37**, 109.