

ON SOME ASPECTS OF TAXONOMY, STRUCTURE AND
EARLY DEVELOPMENT OF THE NUDIBRANCHIATE GASTROPOD,
DISCODORIS FRAGILIS (ALDER & HANCOCK)

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ABSTRACT

The present paper deals with observations on specimens of a doridacean nudibranch, *Discodoris fragilis* (Alder & Hancock) found among the sea grass *Cymodocea ciliata* in the Palk Bay lagoons along the south eastern coast of India. *D. fragilis* is a widely distributed species in the Indo-Pacific. The species has often been confused by some workers with other species having certain outward resemblances. With the help of photographic representations the taxonomic characters of the species have clearly been described. The morphological characters of this species with related species have been compared. The nature of the dorsal tubercles which are low conical spiculate and with blunt white tips, the foot with a frontal groove but without a median notch, the rhinophores each with a white line on its posterior face, the labial disc having paired elongated triangular patches of close-set rodlets, the radula with a varying number of lateral hamate teeth in numerous transverse rows but without the rachidial teeth, an enlarged prostate in two distinct lobes and a conical penis without armature among the reproductive organs are good taxonomic characters when taken along with the distinct pattern of colouration of the mantle and the foot. The mantle is very fragile and the animal often autotomizes it in portions.

The mating habits, spawn and early developmental stages have been described. The just hatched veliger measured about, 180 μ on its long axis, having rather a broad spiral shell of a pale pinkish hue.

INTRODUCTION

THE species dealt with here was first described as *Doris fragilis* by Alder and Hancock (1866) from a collection of nudibranchiate molluscs made in India. The original all-comprehensive genus *Doris* under the family Dorididae has been divided subsequently into distinctly separate genera under different subfamilies one of them being *Discodoris* Bergh under the subfamily Discodoridinae which includes doridiform animals possessing a mantle which is soft and sometimes granulated or tuberculated, a labial disc with rodlets and male genitalia without armature. A close scrutiny into the literature on the subject shows that *D. fragilis* which has a wide distribution in the Indo-Pacific region has often been confused by some workers with other dorids having somewhat similar external appearance in possessing brown markings on the mantle and the foot. In the present paper some unmistakable external and internal morphological characters of *D. fragilis* are given, accompanied by suitable illustrations and photographs of the living material. The material was collected from the shallow waters of the Palk Bay in the close vicinity of the Regional Centre of the Central Marine Fisheries Research Institute at Mandapam Camp along the south eastern coast of India. The animals occurred almost round the year in 1962 among the thick growth of the sea grass *Cymodocea ciliata*. They could be kept alive in the laboratory aquaria in which they copulated and deposited spawn from which the early developmental stages have been traced.

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SYNONYMY AND DISTRIBUTION

Some of the synonyms are 1. *Doris fragilis* Alder and Hancock (1866-from the east coast of India); 2. *Discodoris morphaea* Bergh (1877 and 1884-from Philippines); 3. *Discodoris concinna* Gohar and Soliman (1967-from Red Sea), Lim & Chou (1970-from Malaya); 4. *Discodoris fragilis* Eliot (1899-from Samoa, 1909-from Sri Lanka, 1910-from Chagos Archipelago); Kay and Young (1969-from Hawaiian Islands), Edmunds (1971-from Tanzania, East Africa).

The dorid first described as *Doris concinna* by Alder & Hancock (1866) and subsequently renamed *Discodoris concinna* (Alder & Hancock) is a separate valid species, possessing labial cuticle, radular formula and structure of teeth which are different from those met with in *D. fragilis* as pointed out by Edmunds (1971).

The general distribution of *D. fragilis* is along coasts of Indian and the Pacific Oceans. Under the synonymy, the particular localities wherefrom the species was hitherto recorded have been given.

EXTERNAL FEATURES

The specimens of *Discodoris fragilis* collected from the Palk Bay are doridiform in appearance, the smallest of them measuring 30 mm in length by 19 mm in width and the largest 110 mm in length by 66 mm in width (Pl. I A, B). The mantle is large, extending beyond the foot all round. Its upper surface is soft, but raised into small close-set tubercles of varying sizes. The edge of the mantle is thin and presents an undulated appearance. The species often autotomizes the mantle portions when it is disturbed. Consequently in some of the specimens the mantle edge has been found to be not continuous, but with gaps indicating missing portions.

The tubercles on the mantle surface vary from a fraction of a millimetre to nearly three millimetres in diameter. They are slightly elevated, in appearance of a low cone, brownish on the surface except at the top which is whitish (Fig. 1 B, tu). The surface of the back or the notum bears innumerable blotches, some of which are dark brown and others of a lighter hue, fading to light yellow. The slightly elevated midregion of the notum is of a darker colouration than the wide mantle border which is of a paler yellowish hue. It is difficult to describe the complicated pattern of the brown blotches but among them four in a longitudinal row on either side on the notum are prominent, being comparatively larger. The blotches in one longitudinal row are paired with the corresponding ones on the opposite longitudinal row. This arrangement is slightly altered in some specimens in which other brownish blotches close to those in the two longitudinal rows are also equally prominent. Middorsally also there is a row of somewhat large brown blotches, although they are not as prominent as those on either side. All the peripheral blotches are invariably of much smaller size and of a lighter hue.

At a distance of 15 mm from the anterior edge of the mantle in the largest specimen, the head region bears a pair of rhinophores encircled by fairly elevated rhinophore sheaths the surface of which is tuberculated and the free margin crenulated. The rhinophore has a prominent stalk which is brownish. The distal region is conical and perfoliate, the perfoliations being about 25 to 30 which are brownish. Apically the rhinophore has a small whitish knob from which extends downwards a whitish streak between the perfoliations, on its posterior face.

The branchiae are large in size 6 in number and tripinnately branched. They are situated rather more posteriorly than in *Asteronotus* and most other dorids. They are retractile into a spacious branchial space, the border of which presents 6 angular facets corresponding to the number of the branchiae. The pinnately branched branchial plumes are large and almost colourless, but sparsely covered with brown splashes. In the centre of the branchial circlet is the anus with crenulate border on an elevated papilla. The excretory pore is minute in the branchial space close to the right of the anal papilla.

In a ventral view of the animal (Fig. 1 A), the under surface of the mantle presents blotches of chocolate brown of varying sizes, which are often united together forming irregular patterns (Pl. I B). The edges of the lower surface of the mantle and the spaces in between the coloured markings are yellowish white. At the junction of the foot with the mantle all round, there is a dark brown streak. The foot is ovately elongated, conforming to the general shape of the body. Anteriorly it presents a two-folded appearance with a narrow groove in between, extending to some distance along the sides. Its surface presents brownish blotches of slightly lighter hue than those on the under surface of the mantle. Midanteriorly, the foot is not notched but presents a depression immediately behind the mouth opening. The mouth is bounded by labial thickenings which are united anteriorly. The labial thickening of each side is drawn into a short digitiform oral tentacle which is pale white. The genital aperture is on the right side between the mantle and the foot at about a fourth of the animal's length from the anterior end.

INTERNAL ORGANS

The integument is characterised by the presence of bundles of spicules (Fig. 1 C, spi), slightly protruding out through the epidermal layer (epi), especially the one covering the tubercles (tu). Muscle fibres (mf) pass through the loose, thick subcutaneous tissue and there are numerous irregularly stellate chromatophores (pi) beneath the epidermal layer to a considerable depth. The arrangement of the spicules appears to be in two layers, one immediately below the epidermal surface and the other deeper down.

The digestive organs are disposed in the manner found in the rasping, sponge-feeding dorids described by Young (1969). In *D. fragilis* the mouth leads into the buccal apparatus which consists of a narrow short, longitudinally folded oral tube, a short and thin walled buccal vestibule and a large highly muscular buccal mass. At the entrance of the buccal mass is a pair of light brown labial plates (Fig. 1 D) broad dorsally, arched at the sides and narrow ventralwards. The outer face of each of these plates shows a close-set overlapping microscopic rodlets forming the labial armature (Fig. 1 E a, b). These rodlets are chitinous and transversely striated.

The buccal mass lodges the odontophoral cushion and the radula with the radular sac. The radular formula is $30-45 \times 69-80.0.69-80$. The teeth are hamate or hooked. The centrally located teeth in each half row of the radula are well developed (Fig. 1 F, c) but the first few and the last few are much smaller and less developed (Fig. 1 F a, b, d).

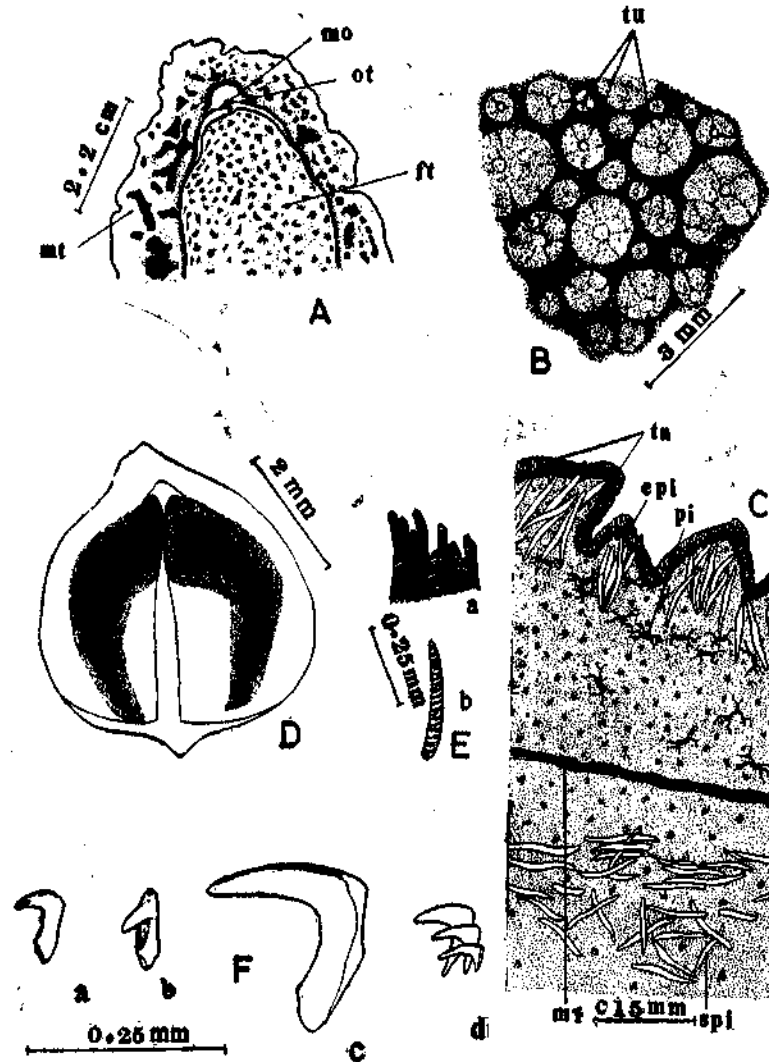


Fig. 1. *Discodoris fragilis*: A. Anterior ventral aspect of the animal; B. Dorsal tubercles enlarged; C. Section through the integument; D. Labial armature on patches of cuticle *in-situ*; E. Rodlets on cuticle magnified; F. Radular teeth of each half row: a, b—First two teeth, c. centrally located tooth, d—last few teeth.

From the postero-dorsal region of the buccal mass arises the oesophagus which proceeds hindwards as an enlarged crop with longitudinally folded walls. It leads into the thin-walled midgut, partially enveloped by the midgut gland. The midgut

which has a lobate caecum, receives the branches of midgut gland duct and is continued by the intestine, the latter forming an arched loop in front of the digestive gland. It is then continued by a short rectum which turns upwards to open by the anus on a raised papilla in the centre of the branchial circlet. There is a pair of thin long, slightly looped salivary glands opening, one on either side on the roof of the buccal mass close to the origin of the oesophagus.

The general arrangement of the organs of blood circulation is fundamentally the same as in other dorids. The blood gland is in two lobes, one behind the other in the region of the buccal mass. The central nervous system enclosed in a fibrous capsule presents the usual ganglionic mass situated over the roof of the oesophagus at its origin from the buccal mass.

The reproductive organs (Fig. 2 A) are well developed in the larger specimens examined. The hermaphrodite gland (hgl) envelops the midgut gland almost completely except middorsally in its anterior portion where a deep cleft is left in which lies the narrow hermaphrodite duct (hd). The major part of the posterior half of the body space is occupied by the hermaphrodite gland. In freshly fixed material it is yellowish in appearance with a superficial light pinkish hue. The hermaphrodite duct proceeds anteriorly and is enlarged into a stout, elongate ampulla (am) which is thrown into lateral flexions. Anteriorly on the surface of the mucoalbuminous gland (mag) the ampulla divides into two short narrow ducts, one leading to the prostate gland (pr) and the other to the fertilization chamber. The prostate gland is large and in two portions, the proximal one short and stout and the distal one a little longer, the latter being continued by a narrow slender vas deferens (vd) communicating with the ejaculatory duct (ed) which lodges the conical, eversible penis without any armature. The male genital opening is distinct from the vaginal opening. The latter leads into an almost straight or slightly undulated vagina (va) communicating with a large, roundish spermatheca (spt) brownish in appearance because of its contents having the same colouration. The outgoing duct from the spermatheca is separate from the vaginal passage. This duct is at first connected with a small pear-shaped spermatocyst (spc) by a short narrow passage and then enters the fertilization chamber. The onward course from the fertilization chamber is through the coiled passages in the mucoalbuminous gland which finally communicates with an oviduct (ovd) leading out by the female genital orifice situated close to the vaginal opening.

BREEDING AND EARLY DEVELOPMENT

Mating and Oviposition: Mating takes place at night in which act lasting for an hour or longer two individuals come together in opposite directions with the genital orifices situated on the right sides of their bodies facing each other followed by the mutual transference of sperms through the eversible penis of one into the vagina and thence into the spermatheca of the other. The individuals then separate and deposit the spawn, either in the early morning hours or even during day time. Oviposition takes place more than one time after a single mating if the animals are kept separately. Mating is repeated if they are left together in the aquaria. The spawn is in the form of a spirally coiled flat, thin ribbon with one edge attached all along to the base on which it is deposited with the other parallel edge free presenting undulations, wafted by any slight movement of the water. Of the spawn ribbons observed (Pl. I C, D), the largest was 9.5 mm broad, 0.8 mm thick and 340 mm long, deposited in three coils which from the centre to the periphery is twisted anti-

clockwise. It is soft and of gelatinous consistency, almost transparent with strings of eggs in roughly double rows between parallel edges, across the ribbon (Pl. I D). When freshly deposited the ribbon is pale yellowish white, but the colouration changes as the development of the embryos advances. In the aquaria or in troughs

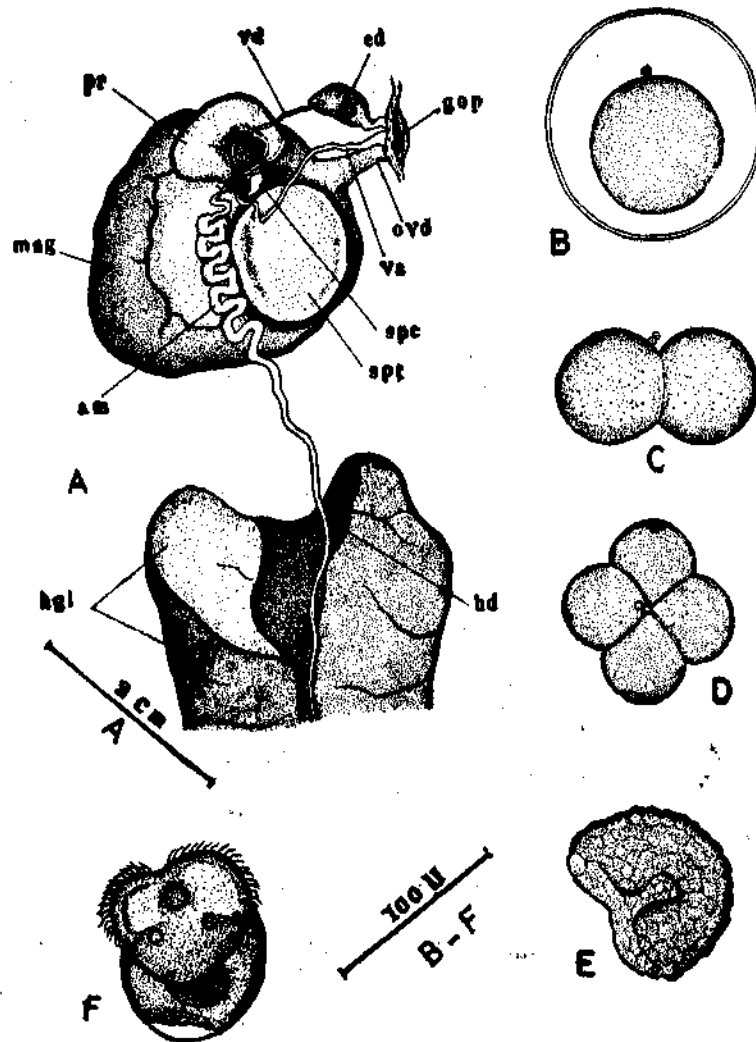


Fig. 2. *Discodoris fragilis*: A. Reproductive organs; B. Freshly deposited egg; C, D. First and second cleavages; E. Gastrula and F. Early veliger.

the spawn was deposited on the glass and in the natural habitats in the Palk Bay lagoons amidst the sea grass. Based on the number of eggs counted per millimetre width of a strip, it has been estimated that the total number of eggs in the ribbon was about 50,000.

The eggs are minute, round almost colourless measuring $70\ \mu$ to $75\ \mu$ in diameter, heavily yolk laden and covered by a thin vitalline membrane. They are enclosed in thin double-walled membranous egg capsules of about $125\ \mu$ in diameter, with colourless albuminous fluid surrounding the egg (Fig. 2B).

Early development : The sequence of the formation of the early developmental stages of *D. fragilis* is the same as in other nudibranchiate molluscs viz., *Eolidina mannarensis* (Rao and Alagarwami, 1960) *Cuthona* (= *Cratena*) *adyarensis* (Rao, 1961a) and *Favorinus argentimaculatus* (Rao, 1969). The two polar bodies

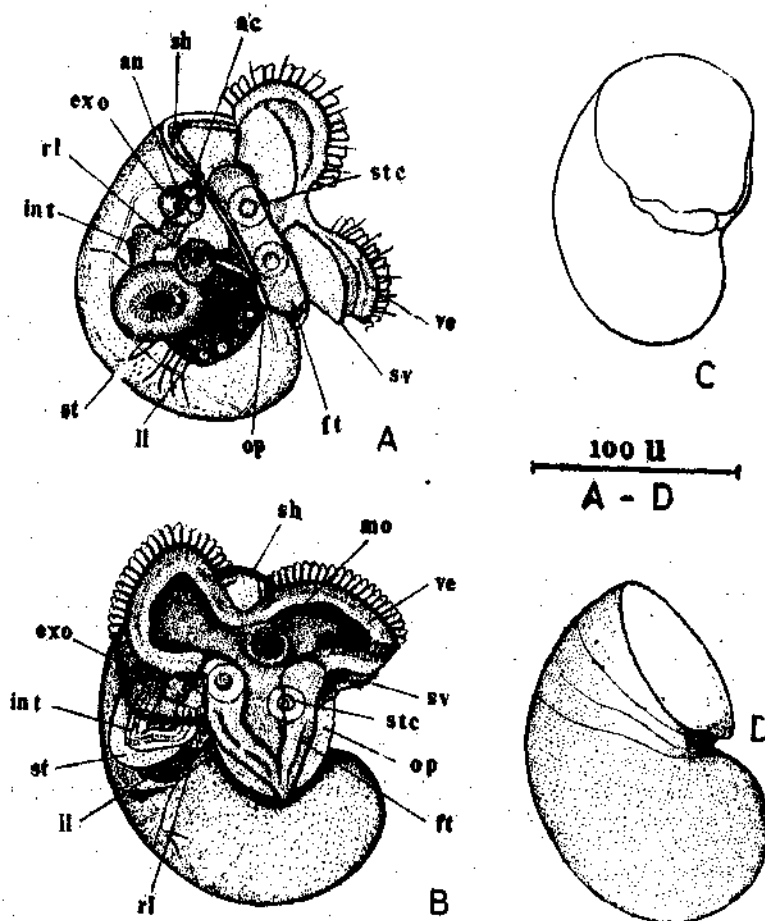


Fig. 3. *Discodoris fragilis*: A and B. Fully formed veligers; C, D. Larval shell without the operculum.

Figs. 8, 9) have extruded out in about half an hour after oviposition. The first two cleavages which were vertical took place within one hour (Fig. 2 C, D). The third cleavage, after one and half hours, was horizontal resulting in four small micromeres and four large megameres. Subsequent cleavages followed in succession re-

sulting in the formation of a blastula after twelve hours. The cleavages were spiral. Soon after blastula formation, gastrulation has commenced by epiboly. Gastrula formation was complete in 28 hours (Fig. 2 E) with a slit like blastopore which subsequently closed. Further development followed on the same lines as was observed in *Cuthona* (Rao, *loc. cit.*) leading after forty hours to the formation of the early veliger stage with rather incompletely developed velar lobes, foot, statocysts and the alimentary canal with the associated structures (Fig. 12). Rotatory movement which commenced soon after gastrulation, has since increased. With the formation of the shell, the colouration of the spawn has changed to pale pink.

The veliger larvae were well formed by 56 hours. They were rotating within the egg capsules with jerking movements caused by vigorous, rhythmic beating of the large powerful velar cilia. About 110 hours after oviposition, a few larvae were liberated and by 120 hours all were set free from the capsules into the surrounding water.

The just hatched larva (Fig. 3 A, B) was about 185 μ long and 130 μ broad. The spiral shell (Fig. 3 C, D-sh) measured 165 μ in its long axis. It was transparent smooth on its surface and pale pinkish. The aperture was provided with a close fitting operculum (op). The colouration was intensified at the thickest region of the shell, ventral to the aperture. Below the level of each velar lobe (ve), there was a row of cilia forming the subvelum (sv). The well developed foot (ft) overlying the operculum was triangular and tongue-shaped when fully expanded. The mouth (mo) between the two velar lobes, a fairly wide oesophagus and a spacious saccular stomach (st) with the bilobed digestive gland (ll & rl) were as in other nudibranch larvae. The intestine (int) was long and looped after its emergence from the stomach. The excretory organ (exo) was vesicular and colourless, situated close to the anus (an) on the left side opening into the mantle space. A pair of anal cells (ac) of little known function was also present close to the anus. There was a pair of larval kidneys revealed only after staining with methylene blue, each as an aggregation of vesicular cells, one close to the excretory organ on the right side and the other on the opposite side of the larva in the same position. The paired statocysts (stc) were prominently seen. The eyes were absent and they did not make their appearance even after rearing them in the fingerbowls for about a week. The larvae did not undergo any further changes when reared in the laboratory.

DISCUSSION

Some of the doridiform nudibranchs belonging to different taxonomic groups are outwardly much alike and yet some of the characters vary within the same species at different growth states. The external colour patterns of the adults are often different from those of the juveniles. The labial armature may be present at times in a poorly developed condition in forms known to possess no armature at all. Numerical variations in the radular formula are invariably met with in individuals of different size ranges and even the radular teeth when viewed from different angles present deviations from the normal structure. All these diversities in structure present great difficulties in the identification of some of the closely allied species of dorids.

Satyamurthy (1952) in his account of a dorid from Krusadai Island in the Gulf of Mannar, under the name of *Thordisa crosslandi* has stated that the very same specimen was identified and reported earlier under two different names i.e. *Discodoris*



PLATE I. *Discodoris fragilis*: A. Dorsal view of narcotized living animal. Actual size, 8.5 cm in length; B. Lateral view of the formalin fixed animal showing characteristic brownish spots; C. Spawn, detached from substratum. Actual width of ribbon 9.5 mm and D. Spawn magnified showing arrangement of rows of eggs.

fragilis and *Argus indicus* (O'Donoghue, 1932). Many of the Indian and Pacific Ocean species described under the names of *Doris nubilosa* (Pease, 1871), *Thordisa crosslandi* (Eliot, 1903, 1906, 1910), *Dialula gigantea* (Bergh, 1905), *Archidoris nubilosa* (Kay & Young, 1969), and *Sebadoris crosslandi* (Marcus & Marcus, 1970) are according to Edmunds (1971) referable to *Sebadoris nubilosa* (Pease). *Discodoris fragilis* (Ald. & Han.) has the same ground colouration of the notum as in *S. nubilosa*, including the more prominent dark brown blotches in a line behind each rhinophore. However, the dorsally situated processes of the mantle are low, conical and tuberculate in *D. fragilis* and elongate and papillate, even at times branched at their tips in *S. nubilosa*. On the ventral surfaces of the mantle and the foot in both the species there are brown markings. In *S. nubilosa* a dark line runs round the under surface of the mantle a little away from the outer margin and is followed by some scattered brown spots. In the younger specimens of the species from Tanzania, it has been reported by Edmunds (1971) that no distinct dark line could be noticed, but only the scattered brown spots. In *D. fragilis* even in the full grown adults, no dark brown line is found but only dark brown irregular spots on the ventral surface of the mantle. *Sebadoris* is characterised by an elongate coiled penis with a distinct double row of spiny processes whereas in *D. fragilis* the penis is short conical and without armature.

According to the first description by Alder & Hancock (1866), *D. fragilis* is characterised by broadly oval depressed body, with the upper mantle surface covered by scattered, spiculate, blunt somewhat pale tubercles of varying sizes, against a background colouration of yellowish brown, marbled with dark brown and whitish blotches. The dorsal tentacles are laminated, the laminae being darkly yellowish. The branchial plumes are six, quadripinnate and covered with dark brown speckles. The ventral surface is blotched reddish brown, the blotches being free at the margin and uniting near the foot. The foot is ovate, reddish brown with dark blotches and deeply grooved in front, without a median notch. The spicules in the integument are numerous, usually bent in the centre with extremities obtuse or a little enlarged. The radular structure was not described by them except that it resembled that of *D. tuberculata*. A prehensile collar was present and the specimens examined by them were much mutilated in view of the mantle being very brittle, breaking off to pieces even in the live animals. It is known since a long time to the earlier workers that autotomy of the mantle takes place in members belonging to several genera, viz., *Discodoris*, *Platydoris* and *Peliodoris* (Marcus & Marcus, 1966). However, it may be mentioned that in *D. fragilis* this is most pronounced. Edmunds (1971) considers that the presence of a white line extending along the entire length of the rhinophore on its posterior face, terminating distally in a whitish point and the shape of the labial cuticle with two elongated triangular patches with numerous rodlets could also be considered as good taxonomic characters in determining this species.

Discodoris concinna (Alder & Hancock) is also a similarly coloured species as *D. fragilis* on the upper and under surfaces of the mantle and the foot. As seen from the original description of the species, the tubercles in the former are conical finely pointed, whereas in the latter they are conical and blunt. In both, the anterior region of the foot is deeply grooved but distinctly notched only in *D. concinna*. In the specimen reported from Sagami Bay, Japan (Baba, 1949) the branchial plumes are five as contrasted with six of them in the original description of *D. concinna* by Alder and Hancock (1866).

In so far as the shape of the teeth of the radula in *D. fragilis* is concerned, the present description agrees well with the descriptions of Gohar and Soliman (1967), Kay and Young (1969) and Edmunds 1971. The radular formula has been observed

to differ depending on the size of the specimens examined by different authors. Gohar and Soliman (1967) have given the formula for a large specimen as $48 \times 88.0.88$; Kay and Young (1969) for 5 to 35 mm long specimens as $18-22 \times 28-30.0.28-30$; Edmunds (1971) for 105 mm specimen as $40 \times 70.0.70$, and for 70 mm specimen $35 \times 64.0.64$. In the present report dealing with the specimens ranging from 50-110 mm in length the radular formula is $30-45 \times 69-80.0.69-80$, which agrees fairly closely with what is given by Gohar and Soliman for the Red Sea specimens. It may be observed here that the specimens examined by Kay and Young (1969) were very small not exceeding 35 mm in length.

There is yet another species of *Discodoris*, namely *D. boholiensis* Bergh on record from the east and west coasts of India and from the Andaman Islands (Rao, 1961; Narayanan, 1968) in the Indian territory. This species is characterised by a very broad thin mantle extending all round, with its mid-dorsal region prominently elevated between the rhinophores and the branchiae; the mantle has a dense covering of minute slender papillae dorsally, but no tubercles. The general colouration on its upper surface, as also on its lower surface and the foot are pale yellow. The mid-dorsal elevation between the rhinophores and the branchiae is marbled brown. Ventrally, the mantle rim as also the edge of the foot are dark brown. The dorsal papillae are dark brown or yellow. In these very characteristics the species differs from *D. fragilis*. In *D. boholiensis* the labial cuticle is provided with rodlets and the radular teeth are hamate with a formula somewhat similar to that of *D. fragilis*. In the younger individuals, a brownish with pinkish colouration has been noted from those obtained from the Gulf of Kutch.

It is interesting to note that even the diameter of the egg in *D. fragilis* is found to vary to some extent with the size of the individual depositing the spawn. Kay and Young (1969) have reported the diameter of the egg to be 65μ and the enclosed capsule 100μ in the spawn deposited by 35 mm long specimen. In 90-150 mm long specimens examined by Gohar and Soliman the eggs deposited were found to 75μ in diameter with the capsules measuring from $110-126 \mu$. In the present observations the diameter of the egg was found to be $70-75 \mu$ and the capsule about 126μ .

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KEY TO LETTERING IN FIGS. 1 to 3

ac. anal cells ; am. ampulla ; an. anus ; ed. ejaculatory duct ; epi. epidermis ; exo. excretory organ ; ft. foot ; gp. genital orifice ; hd. hermaphrodite duct ; hgl. hermaphrodite gland ; int. intestine ; l.l. left midgut gland lobe ; mag. mucoalbuminous gland ; mf. muscle fibres ; mo. mouth ; mt. mantle ; op. operculum ; ot. oral tentacle ; ovd. oviduct ; pi. chromatophores ; pr. prostate ; r.l. right midgut gland lobe ; sh. shell ; spc. spermatocyst ; spi. spicules ; spt. spermatheca ; st. stomach ; stc. statocyst ; sv. subvelum ; tu. tubercle ; va. vagina ; vd. vas deferens ; ve. velum.