THE VELIGER

The Veliger 26(1):30–36 (July 1, 1983)

Studies on the Reproductive Biology of Some Prosobranchs from the Coast of Pakistan Bordering the Northern Arabian Sea. II. Egg Capsules and Larvae of Four Species of *Thais*

by

SOHAIL BARKATI AND MUZAMMIL AHMED

Institute of Marine Biology, University of Karachi, Karachi-32, Pakistan

Abstract. Egg masses of four species of *Thais*, namely, *T. rudolphi, T. carinifera, T. bufo,* and *T. tissoti,* are reported from the coast of Pakistan for the first time. Based on the incidence of their egg capsules, the respective breeding seasons of the four species are: June to September, February to November, April to August, and March to August. The four species deposit benthic egg capsules from which free-swimming veligers are hatched. A comparative account of numbers and dimensions of capsules, number and sizes of eggs, and developmental periods of shelled larvae is presented.

INTRODUCTION

THE EGG MASSES and capsules of prosobranch mollusks, apart from the fact that they are of scientific interest in themselves, yield information about the breeding seasons of the parent species, may prove of assistance in the precise identification of closely related species, and provide larval stages and juveniles should there be a need for their commercial rearing. Although the literature in this field is vast, only the following are the major publications on the gastropods of the Arabian Sea: THORSON (1940) from the Persian Gulf; NATARAJAN (1957) from the Gulf of Mannar and Palk Bay; GOHAR & EISAWAY (1962, 1967a, b) from the Red Sea; and DESAI (1962), GANAPATI & SASTRY (1973), RAMAMOORTHY & NATARAJAN (1973), and KASINATHAN *et al.* (1974) from different parts of the Indian coast. No information is available on the egg masses and larval development of marine gastropods from the coast of Pakistan bordering the northern Arabian Sea. It was in view of this paucity of information that a project was initiated in 1976 at the Institute of Marine Biology, University of Karachi, to study the same. Observations on the juveniles of the gastropod *Planaxis sulcatus* from the coast of Karachi have already been published (BARKATI & AHMED, 1982). The present report on four species of *Thais* is the second in the series.

MATERIAL AND METHODS

In order to collect egg masses and capsules of local gastropods, regular biweekly visits were made during the period June, 1976, to July, 1977, to Buleji, which is a rocky and partly sandy-cum-muddy beach about 18 km northwest of Karachi. Egg capsules were also collected rather irregularly from some other beaches in the Karachi area, namely, Manora Island, Keamari Seawall, Paradise Point, and Korangi Creek, and from Gawader and Jiwani on the Mekran coast, about 600 km northwest of Karachi. Some egg capsules had been collected prior to June, 1976, and others after July, 1977. Except for a couple of rainy months in summer the salinity at all these sites is high, ranging from 36–40‰. In most of the cases the spawning female snails were present near their egg masses. It was difficult to ascertain the number of egg capsules spawned by individual snails since the capsules are laid together. During the study, therefore, only representative samples of egg capsules were collected although some of these consisted of the entire lots of capsules spawned by individual snails.

Attempts to spawn specimens of the different species of *Thais* in the laboratory in limited quantities of water did not succeed. The egg capsules, and the larvae hatching from these, were maintained in filtered and aerated sea

water in 1600-ml glass bowls. They were fixed in 5% formalin and then preserved in 70% ethanol for subsequent study. Measurements of the size of capsules, eggs, and larvae were made with an ocular micrometer on a microscope. Illustrations were prepared with a camera lucida.

OBSERVATIONS

Breeding Season

The four species of *Thais* investigated occur near the low and mid-tidal zones of the rocky beaches of the coast of Pakistan. The number of egg masses of four species collected from different localities is given in Table 1. It is apparent from this table that *T. rudolphi* (Lamarck) spawns from June to September, *T. tissoti* (Petit) from March to August, and *T. bufo* (Lamarck) from April to August. An egg mass of *T. carinifera* (Lamarck) was taken at station 45 (63°46′N latitude) along the Mekran coast on March 1, 1977, in a purse seine haul of the Norwegian Fisheries Research Vessel "Dr. Fridtjof Nansen" (egg capsules of this species in THORSON's [1940] collection from the Persian Gulf were obtained from a depth of 11–22 m). Since some of the capsules in this egg mass were of purple color they must have been spawned in February. Recently, an egg mass of *T. carinifera* was also collected from Port Qasim, about 30 km southeast of Karachi. The spawning season of *T. carinifera* on the coast of Pakistan, therefore, seems to extend from February to November.

Table 1

The incidence of egg masses of four species of *Thais* on the coast of Pakistan. Exposure of shore abbreviated as: Exposed, E; Protected, P; Semi-exposed, SE; Subtidal, ST.

Locality	Exposure	Date	Year	Egg masses
		T. rudolphi		
Manora Island	E	June 9	1970	Many
Buleji	E	June 15	1976	1
Manora Island	E	June 16	1976	2
Buleji	E	July 2	1976	2
Buleji	E	July 3	1977	4
Buleji	E	August 13	1976	1
Paradise Point	E	August 26	1975	1
Buleji	E	September 8	1975	1
Buleji	E	September 9	1976	2
Paradise Point	E	September 9	1976	1
		T. carinifera		
Mekran Coast	ST	March 1	1977	1
Jiwani	SE	April 29	1979	3
Korangi Creek	P	April 30	1978	1
Native Jetty	P	May	1972	Many
Buleji	E	June 14	1980	1
Keamari Seawall	P	August 1	1976	3
Port Qasim	P	November 1	1982	1
		T. tissoti		
Sandspit Bridge	P	March 16	1979	1
Jiwani	SE	April 29	1979	2
Korangi Creek	P	April 30	1978	1
Buleji	SE	June 4	1980	1
Manora Island	E	June 9	1970	Many
Keamari Seawall	P	August 1	1976	1
Korangi Creek	P	August 21	1977	Many
		T. bufo		
Jiwani	SE	April 29	1979	1
Keamari Seawall	P	May	1975	3
Keamari Seawall	P	May 18	1976	1
Manora Island	E	June 9	1970	Many
Keamari Seawall	P	June 13	1975	1
Manora Island	E	June 13	1979	1
Keamari Seawall	P	August 1	1976	1

Characteristics of Egg Capsules, Eggs, and Larvae

Egg capsules of *T. rudolphi* (Figure 1A, B), like those of other species of *Thais,* are creamy white in color when deposited and become dark gray with the advancement of embryonic development. A change in color from yellow to gray was also observed by NATARAJAN (1957) in *T. bufo.* The capsules are deposited in clusters of several irregular, short rows imparting a circular shape to the egg mass in general. There is always one layer of capsules the basal plates of which unite to form a common basal membrane that is firmly glued to the substratum. Each capsule has translucent, tough leathery walls. An aperture for the release of larvae, 0.32 mm in diameter, is present slightly off center on the flattened, apical surface of each capsule and is covered with a transparent membrane which ruptures at the time of larval hatching. Dimensions of capsules, eggs, and larvae of this species are given in Table 2. The larvae just after hatching (Figure 1C, D) possessed shell lengths of 211 to 251 μm and widths of 171 to 182 μm. They swam actively and gathered near the walls of the glass bowls. Their shells consisted of one and a half whorls. They measured 353 to 376 μm in height and 274 to 285 μm in width 36 h after hatching.

The egg mass of *T. carinifera* consists of closely spaced, stalkless, somewhat curved and thin tubular capsules that have very smooth translucent walls without any ridges (Figure 2A, B). They are of uniform width but taper at the apex to form a nipple-like structure. The apex functions as an operculum which is shed at the time of hatching so as to provide an exit for the larvae. This aperture is 0.4 mm in diameter. Dimensions of capsules, eggs, and larvae of this species are given in Table 2. The larvae 12 h after hatching (Figure 2C, D) measured 388 × 295 μm. Their shell walls were smooth and transparent and consisted of one and a half whorls. They attained a size of 401 × 301 μm (Figure 2E) after 36 h of development. Very few larvae survived in the laboratory for 60 h without food. The egg mass of *T. carinifera* was described

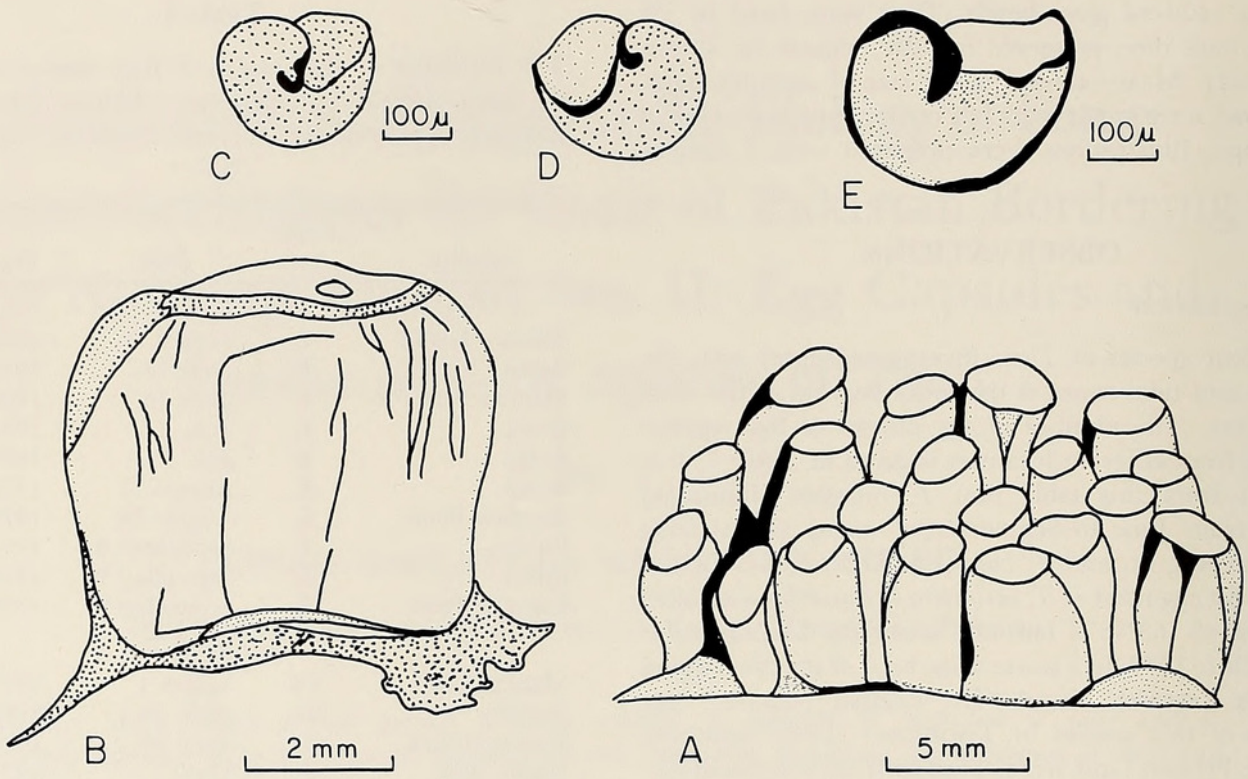

Figure 1

Thais rudolphi: A. dorsolateral view of a portion of an egg mass; B. dorsolateral view of an egg capsule; C. ventral view of a larval shell just after hatching; D. dorsal view of the same; E. ventral view of 36-h larval shell.

earlier by ANNANDALE & KEMP (1916) from Chilka Lake, India, and by THORSON (1940) from the Red Sea. NATARAJAN (1957) also described an egg mass that closely fits the above description but he was not able to assign it to any species.

Egg capsules of *T. tissoti* are stalkless (Figure 3A, B) and attach themselves to the substratum by their basal plates, which unite to form a basal membrane. The capsules are smaller than those of *T. carinifera.* They are cylindrical, somewhat broader in the middle, taper at both ends, and curve on one side. Their walls are smooth and without ridges. A preformed aperture for the release of larvae does not exist but the apex of the capsule sheds off at the time of hatching. The part shed measures 0.72 × 0.32 mm across. Dimensions of capsules, eggs, and larvae of this species are given in Table 2. The larval shell (Figure 3C) soon after hatching consists of one and a half whorls. Changes in the size of the larval shell of this species with time are shown in Table 3. The larvae thrived in the laboratory without food for about nine days but showed very little increase in shell dimensions after 84 h. The maximum shell dimensions recorded were: height 467 μm and width 456 μm.

The capsules of *T. bufo* (Figure 4A, B, C) have smooth and very thick walls, are tubular in shape, and have long thin stalks which unite at the base and are glued to the substratum. The proximal end of the capsules is swollen and carries a rounded aperture for the exit of larvae. The aperture measures 0.49 to 0.58 mm in diameter and is covered by a thin membrane. The larvae (Figure 4D, E) hatch from the capsules as free-swimming veligers. Their dimensions appear in Table 2.

The egg mass of *T. bufo* was earlier described from south Indian waters by Gravely (1942, in NATARAJAN, 1957), Chari (1950, in NATARAJAN, 1957) and by NATARAJAN (1957) and the above account describes it closely.

An egg mass was collected from the bottom of a crevice of a steep rocky ledge at Paradise Point that might be from a fifth species of *Thais* (or another muricid). This ball-like egg mass measured 2.4 × 2.2 cm across and consisted of two layers of low rounded and irregularly shaped capsules which were stalkless, with their basal plates united to form a common membrane.

DISCUSSION

Observations made during the present study show that three of the four species of *Thais* examined, namely, *T. bufo, T. tissoti,* and *T. carinifera,* spawn for about six to seven months in the spring and summer during the period February to August, whereas *T. rudolphi* has the shortest spawning season of four months, restricted to the summer months of June to September. There is evidence that spawning in at least two of these species, namely, *T. bufo*

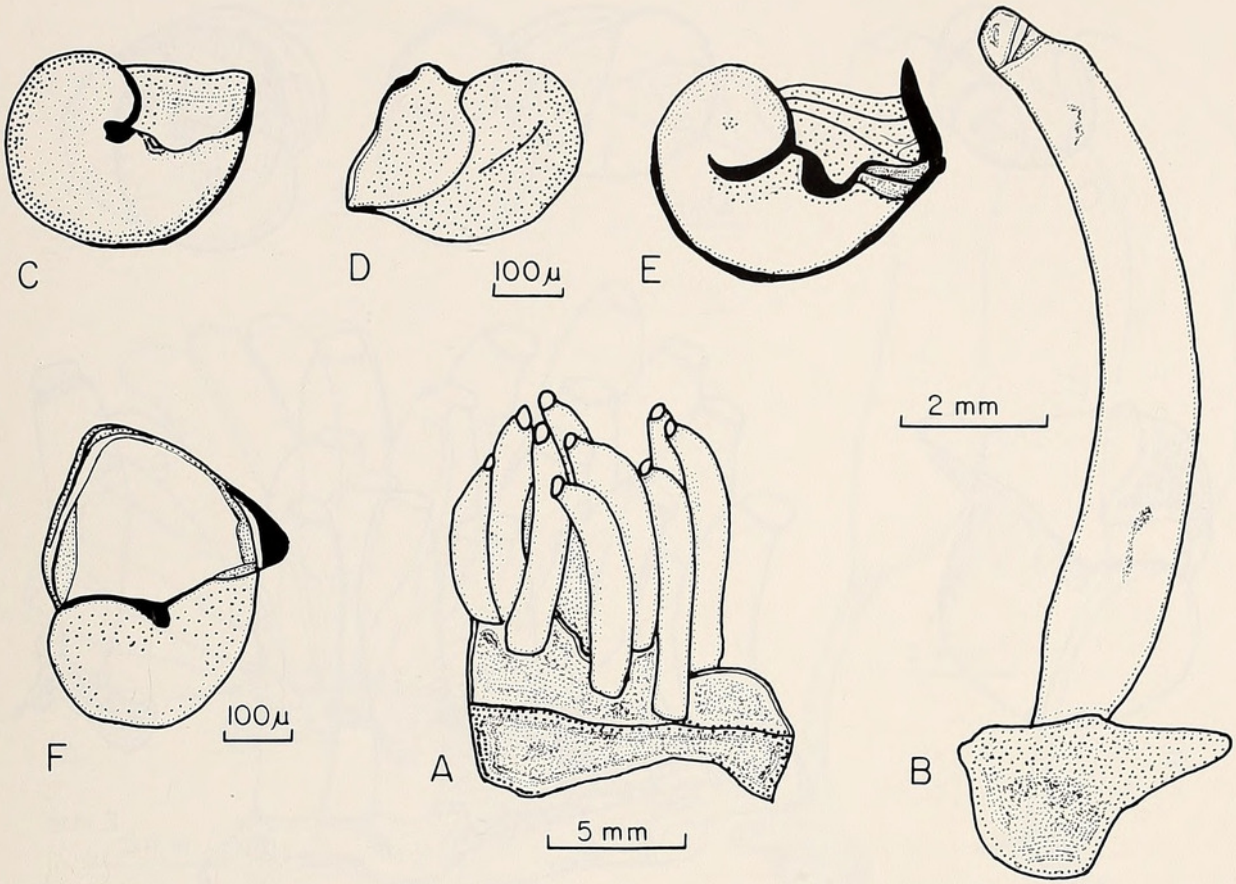

Figure 2

Thais carinifera: A. dorsolateral view of a portion of an egg mass; B. lateral view of a single egg capsule; C. ventral view of veliger shell 12 h after hatching; D. dorsal view of the same; E. ventral view of larval shell 36 h after hatching; F. front view of the same.

Table 2

A comparative account of the characteristics of egg capsules, eggs, and larvae of four species of *Thais*. Data are presented as averages with the range of values given in parentheses.

Characteristics	*T. rudolphi*	*T. carinifera*	*T. tissoti*	*T. bufo*
Approximate size of females (cm)	6.8 (4.0–8.0)	4.6 (3.5–6.0)	3.2 (2.5–4.0)	5.8 (4.0–7.0)
Number of egg capsules per mass	170 (97–257)	247 (220–268)	257 (255–295)	80 (65–92)
Capsule height (mm)	4.6 (3.8–5.0)	9.1 (8.0–10.5)	4.2 (4.0–4.4)	7.9 (7.2–9.0)
Capsule width (mm)	5.3 (4.0–6.1)	1.3 (1.2–1.5)	1.2 (1.1–1.2)	2.0 (1.8–2.5)
Number of eggs per capsule	1094 (813–1422)	140 (120–160)	37 (25–40)	228 (183–268)
Egg diameter (μm)	142 (137–148)	230 (216–250)	215 (200–250)	252 (198–350)
Hatching time (days)	17 (16–18)	19 (18–20)	19 (18–20)	20 (18–22)
Larval size at hatching (L × W) (μm)	224 × 173	340 × 276	231 × 198	322 × 255

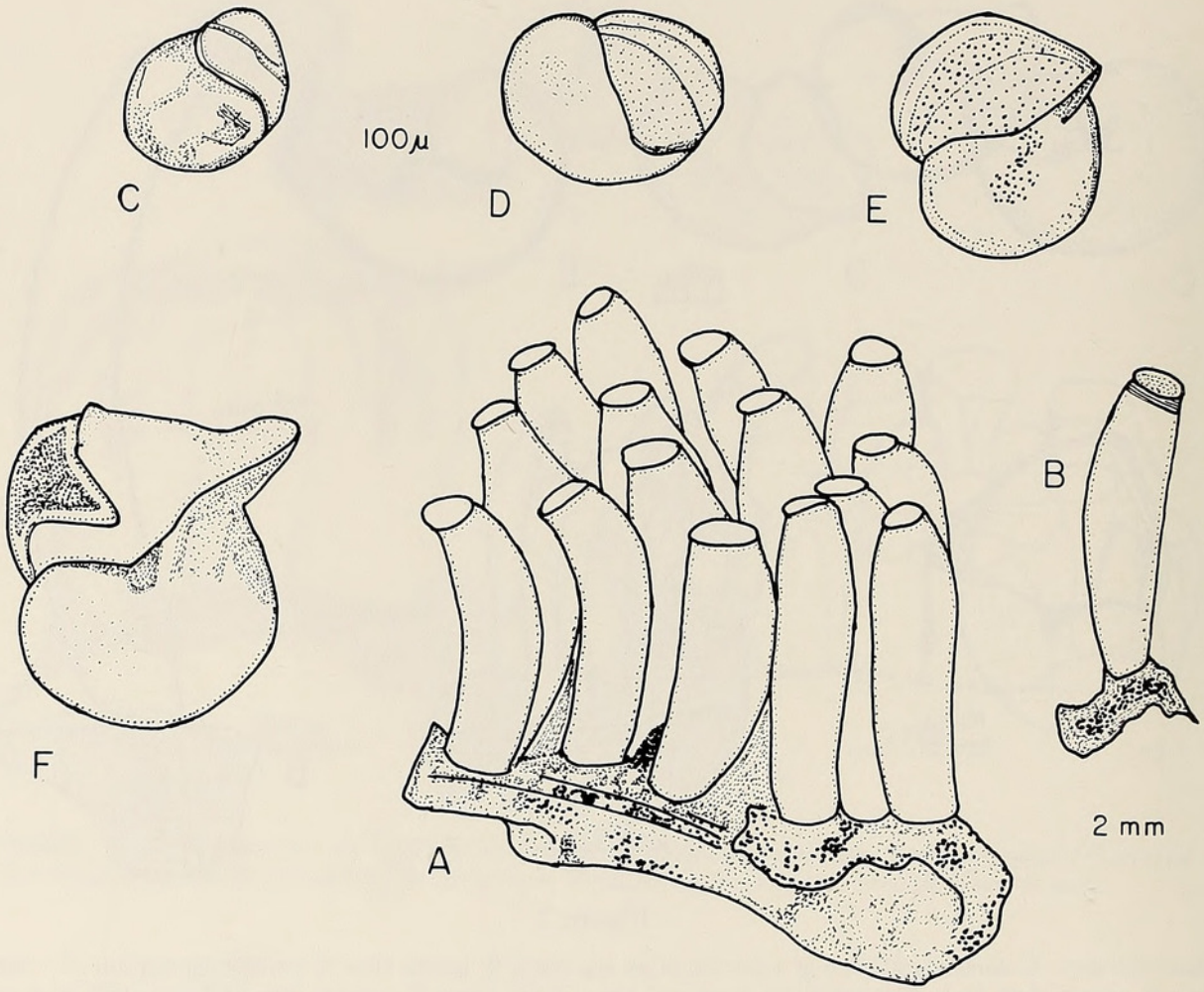

Figure 3

Thais tissoti: A. dorsolateral view of a portion of an egg mass; B. lateral view of a single egg capsule; C. ventral view of veliger shell taken out of a capsule; D. ventral view of 24-h veliger shell; E. front view of 84-h veliger shell; F. front view of larval shell 13 days after hatching.

and *T. carinifera*, may commence slightly earlier on the coast of Mekran than on the coast of Karachi. Be as it may, spawning in the four species of *Thais* seems to occur with the rising temperatures of spring and summer when a lowering of salinity may also occur due to the southwest monsoon rains (see AHMED, 1980).

The study shows that *T. rudolphi* produces the highest numbers of eggs per capsule, and *T. carinifera, T. bufo,* and *T. tissoti* follow it in that order. Survival of the brood in the natural environment seems to be in the same proportion, since *T. rudolphi* is the most abundant species of *Thais* on the coast of Karachi followed by *T. carinifera. Thais rudolphi* has not been recorded from Gawader and Jiwani on the Mekran coast where *T. carinifera* does occur (AHMED *et al.*, in press). *Thais rudolphi,* the species with the highest fecundity, also has been found in the present study to have eggs and larvae of the smallest size among the four species. Larvae of the four species spend about 16–22 days within egg capsules but those of *T. rudolphi* hatch the earliest.

Table 3

Changes in the size of the larval shell of *Thais tissoti.* Egg size is 200–225 μm.

	Size (μm)					
	Just after hatching	12 h	36 h	60 h	84 h	9 d
Length	231	281	313	338	385	460
Width	198	229	232	269	302	442

Species of *Thais* are known to display two types of larval development. The first is the indirect development in which pelagic planktotrophic or lecithotrophic veliger larvae hatch from egg capsules. The second is direct or non-pelagic development in which crawling miniature snails emerge from egg capsules and where a planktonic stage is missing. The four species of *Thais* examined in the present study also possess indirect development, which

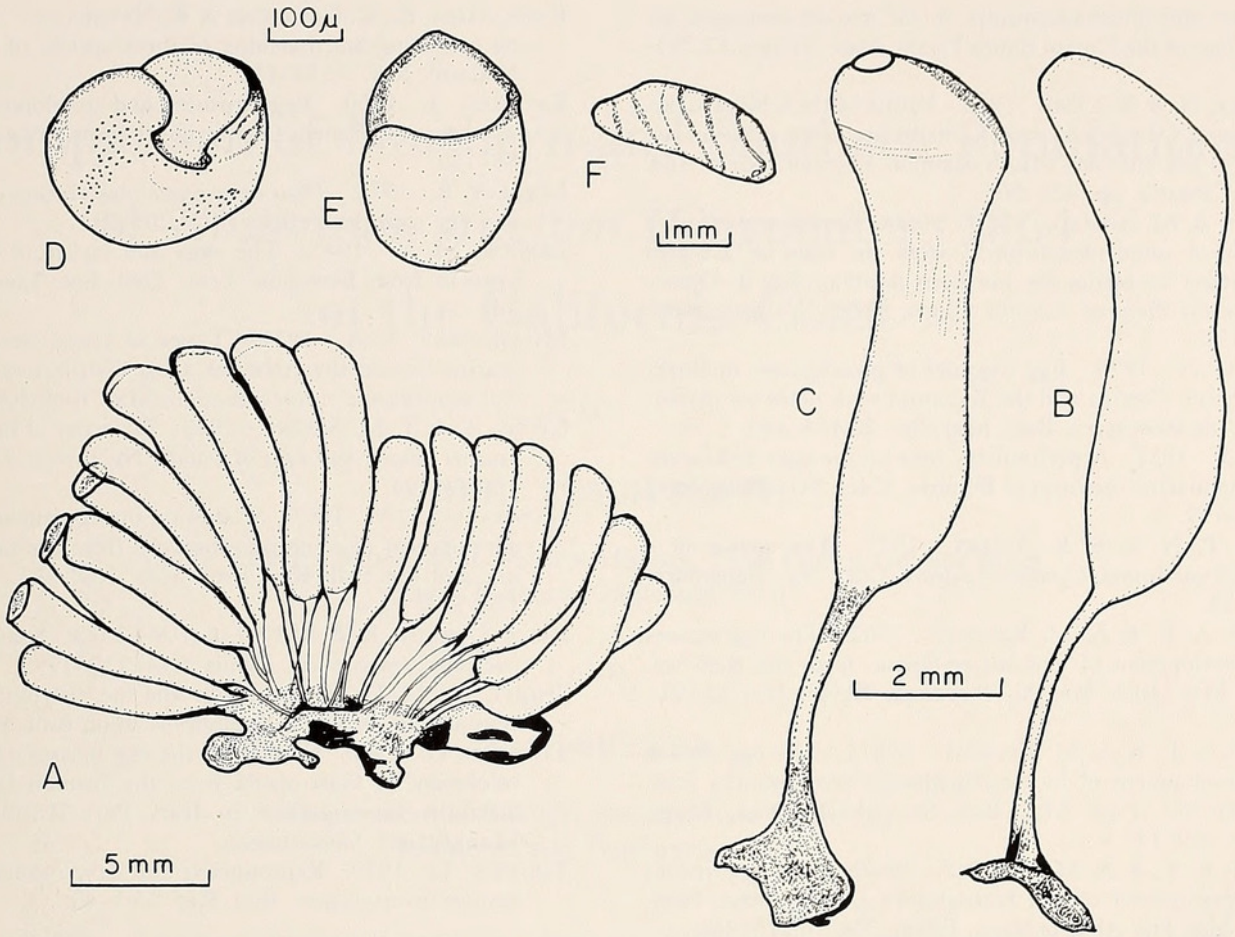

Figure 4

Thais bufo: A. lateral view of an egg mass; B. and C. dorsal and ventral views of egg capsules; D. ventral view of a veliger shell taken out of a capsule just before hatching; E. front view of the same; F. tip of an egg capsule.

is shown by a majority of the species of *Thais* studied so far in different parts of the world: for instance, *T. carinifera* (THORSON, 1940); *T. fasciata* (LEBOUR, 1945); *T. coronata* (KNUDSEN, 1950); *T. bufo, T. tissoti,* and three unidentified species of *Thais* from India (NATARAJAN, 1957); and *T. haemastoma* (D'ASARO, 1970). Species that show direct development are *T. hippocastaneum* (THORSON, 1940), *T. lapillus* (see THORSON, 1940), *T. lamellosa, T. emarginata* (=*T. lima*), and *T. canaliculata* (see AHMED & SPARKS, 1970), and *T. emarginata* (LEBOEUF, 1972; SPIGHT, 1976). There are, however, instances where members of the same species of *Thais* may behave differently under different environmental conditions. For instance, *T. haemastoma* is believed to have pelagic larval development in Louisiana but direct development in the West Indies (see THORSON, 1950; NATARAJAN, 1957). LYONS & SPIGHT (1973) have considered the members of the Muricacea as sufficiently variable that geographically separated species may develop according to the local conditions. We wish to point out here that some workers feel that the above reference to direct development in the West Indian species of *Thais* is based on misinformation and should not be attributed to either Thorson or Natarajan.

It is generally believed that species of prosobranch mollusks occurring in cold waters of higher latitudes show direct development but those occurring in warm tropical and subtropical latitudes possess pelagic indirect development (THORSON, 1950). However, MILEIKOVSKY (1971) pointed out, as an exception to Thorson's generalization, that pelagic development is not altogether absent in colder waters of higher latitudes and that an occasional species may display such a developmental pattern. Also as an exception can be mentioned the case of the gastropod *Planaxis sulcatus* which shows direct development on the coast of Karachi, a subtropical locality (BARKATI & AHMED, 1982).

LITERATURE CITED

AHMED, M. 1980. The breeding and recruitment of marine animals of the coast of Pakistan bordering the Arabian Sea. Proc. First Pakistan Cong. Zool: pp. 55–96.

AHMED, M., H. N. RIZVI & M. MOAZZAM. The distribution and abundance of intertidal organisms on some beaches of Mekran coast in Pakistan (northern Arabian Sea). Pakistan J. Zool. (in press).

AHMED, M. & A. K. SPARKS. 1970. A note on the chromosome

number and interrelationships in the marine gastropod genus *Thais* of the United States Pacific coast. Veliger 12:293–294.

ANNANDALE, N. & S. KEMP. 1916. Fauna of the Chilka Lake. Mollusca, Gastropoda and Lamellibranchiata with an account of the anatomy of the common *Solen* etc. Mem. Ind. Mus. Calcutta: pp. 328–366.

BARKATI, S. & M. AHMED. 1982. Studies on the reproductive biology of some prosobranchs from the coast of Karachi (Pakistan) bordering the northern Arabian Sea. I. Observations on *Planaxis sulcatus* (Born, 1780). Veliger 24(4): 355–358.

D'ASARO, C. N. 1970. Egg capsules of prosobranch mollusks from South Florida and the Bahamas with notes on spawning in the laboratory. Bull. Mar. Sci. 20:414–440.

DESAI, B. N. 1962. A preliminary note on the eggs and larvae of some marine molluscs of Bombay. Curr. Sci. (Bangalore) 4:158–159.

GANAPATI, P. N. & S. R. SASTRY. 1973. The spawn of a cymatid gastropod, *Cymatium pileare*. Curr. Sci. (Bangalore) 42(1):25.

GOHAR, H. A. F. & A. M. EISAWAY. 1962. The egg masses and development of *Trochus erythraeus* from the Red Sea. Publ. Mar. Biol. Sta. Al-Ghardaqa, Egypt, No. 12:191–203.

GOHAR, H. A. F. & A. M. EISAWAY. 1967a. The egg masses and development of four taenioglossan prosobranchs from the Red Sea. Publ. Mar. Biol. Sta. Al-Ghardaqa, Egypt, No. 14:109–147.

GOHAR, H. A. F. & A. M. EISAWAY. 1967b. The egg masses and development of five rachiglossan prosobranchs. Publ. Mar. Biol. Sta. Al-Ghardaqa, Egypt, No. 14:215–268.

KASINATHAN, R., K. GOVINDAN & R. NATARAJAN. 1974. Notes on spawning and hatching of three species of Gastropoda. Malacol. Rev. 7:133–135.

KNUDSEN, J. 1950. Egg capsules and development of some marine prosobranchs from tropical west Africa. Atl. Rep. 1: 85–130.

LEBOEUF, R. 1972. *Thais emarginata*: description of the veliger and egg capsule. Veliger 14(2):205–211.

LEBOUR, M. V. 1945. The eggs and larvae of some prosobranchs from Bermuda. Proc. Zool. Soc. Lond. 114:462–489.

MILEIKOVSKY, S. A. 1971. Types of larval development in marine bottom invertebrates, their distribution and ecological significance: a re-evaluation. Mar. Biol. 10(3):193–213.

LYONS, A. & T. M. SPIGHT. 1973. Diversity of feeding mechanisms among embryos of Pacific Northwest *Thais*. Veliger 16:189–194.

NATARAJAN, A. V. 1957. Studies on the egg masses and larval development of some prosobranchs from the Gulf of Mannar and the Palk Bay. Proc. Ind. Acad. Sci., Sect. B. 46: 170–228.

RAMAMOORTHY, K. & R. NATARAJAN. 1973. Spawning in *Telescopium telescopium*. Venus 31(4):157–159.

SPIGHT, T. 1976. Hatching size and the distribution of nurse eggs among prosobranch embryos. Biol. Bull. 150:491–499.

THORSON, G. 1940. Studies on the egg masses and larval development of Gastropoda from the Iranian Gulf. Danish Scientific Investigations in Iran, Part II:159–238. Ejner Munkegaard, Copenhagen.

THORSON, G. 1950. Reproductive and larval ecology of marine bottom invertebrates. Biol. Rev. 25:1–45.