Annexure 2

BIOLOGICAL ASPECTS OF CHUB MACKERELS AND ROUND SCADS ON THE WEST COAST OF THAILAND

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Introduction

Chub mackerels have played an important role in the marine fisheries production along the west coast of Thailand for many decades. Due to the recent introduction of the light luring purse seine as well as to the development of canning industries, round scads have also became an important species in the pelagic fisheries. Their catches increased until 1983 but started decreasing in subsequent years. The light luring purse seine fishery is concentrated in the central part of the coastline (Area II; see Figure 1 a), which is considered to contribute to the large catches of juveniles of mackerels and other species. The Department of Fisheries established a closed season from April 15 to June 15 in this area in 1985.

Egg and larval surveys were conducted to verify the hypothesis on spawning season and spawning grounds. Other biological data have also been collected. The results would be essential for management of the valuable mackerel and scad resources in the Thai part of the Bay of Bengal.

Tagging of *R brachysoma*

Mackerels are distributed all along the west coast of Thailand. *R. brachysoma* has been found abundantly in the inshore waters along the east coast of Phuket Island and from the Phang Nga Bay and Krabi Bay (Area II) downward to the southern end of Thai waters.

Tagging experiments were conducted in 1981, in Area III, close to the Thai — Malaysian boundary. Of the 6,386 fish tagged, 84 (1.32%) were recovered in that area. Some of them moved northward to Trang Province but did not enter into Area II and some moved south into Malaysian waters, north of Penang (Pu Paya and Pu Bidan).

In 1984 the experiments were conducted in Area II, where 526 fish were tagged. 107 fish (20.34%) were recaptured and it was found that most of the tagged fish were caught off the eastern coast of Phuket Island of Phang Nga Bay and in Krabi Bay and that some moved southward to Pipi Island and South Lanta Island. However, fish tagged in Area II and Area III failed to show intermingling between these two areas. The results of the tagging experiments are shown in Tables 1 and 2 and Figure 1 b.

Sex ratio (Male: Female)

For estimating the sex ratio of chub mackerels and round scads data from the sampling surveys conducted by the Phuket Marine Fisheries Station during 1985-86 were used. The results are summarized below:

Sex ratio

	Area I	Area II	Area III
R. brach ysoma	1:1 .1593	1:1.0872	1:0.968
R. kanagurta	1:0.9934	1:1.0717	1: 1.0244
D. maruadsi/russelli	1 :1.0616 for all three areas		
D. macrosoma	1:0.9709 for all three areas		

The monthly sex ratios of *R. brachysoma* and *R. kanagurta* in three areas are shown in Figures 2 and 3 and those of *D. maruadsi* and *D. macrosoma* in Figure 4. Some dissimilarities were observed between areas, for each species. The monthly sex ratio of *R. brachysoma* from commercial trawl catches is presented in Figure 5.

The monthly sex ratios by size group are presented in Figures *6-9,* for *R. brachysoma, R. kanagurta,* and the *Decapterus* species respectively. Males of *R. brachysoma* appeared to

be predominant among fish smaller than 18 cm and females predominate in fish larger than 20 cm. Males and females were almost equally represented in the 18-20 cm size range.

In the case of R. kanagurta, the predominance of males in the size range above 21 cm was observed in Areas II and III. Even in Area I there was evidence of increasing proportion of males from <15 cm to >21 cm size group, though males were not dominant in any of the size groups.

Males of *D.* maruadsi/russelli were predominant in all size ranges caught, whereas in the case of *D. macrosoma,* the males were predominant in fish smaller than 18 cm, females in fish larger than 20 cm and both sexes were in equal proportions in the 18-20 cm size range. The percentages of males by size group are summarised in Table 3. It appears that the differences in sex ratios between different areas and seasons are influenced by the differences in the size compositions of the catch.

Maturity and spawning

The percentage of mature fish was plotted as a function of length and the mean length at which the samples represented 50% of mature fish was taken as the mean length at first maturity. The results are summarised below:

	Size at first maturity (cm)	Peak monthly mean gonad index	Seasons of occurrence	Peak percentage of ripe stage (iv)	Season of occurrence
R. brachysoma					
Area I	18.00	39.04	Feb.	38.89	Feb./Sept
Area II	17.00	41.49	Feb.	36.51	Feb.
		36.68	Aug.	26.19	Apr.
				18.32	Aug.
Area III	16.50	42.73	Jan.	50.49	Jan.
		42.27	Jun.	41.76	May
				33.13	Sept
R. kanagurta					
Area I	19.50	46.52	Dec.	70.85	Dec.
		27.20	Mar.	12.66	Mar.
Area II	19.50	40.48	Jan.	33.33	Jan.
		21.96	Aug.	5.41	Aug.
Area III	17.0	52.00	Sep.	66.67	Sept.
		23.04	Apr.	18.18	June
D. maruadsi/ russelli	17.0	38.76	Feb.	NA	
		34.50	Dec.		
D. macrosoma	17.2	72.71	Feb.	NA	
		67.56	Dec.		

The results of the study on spawning seasons, G.I. values and percentage of ripe stages with their seasons for the mackerels in each of the three areas and for round scads in all areas combined are shown in Figures 1 O-I 3 for *R. brachysoma,* and Figures 14-I *7* for *R. kanagurta* and in Figures 18-20 for the two *Decapterus* species.

The spawning seasons of R. brachysoma seem to occur from February to April (Areas I and II) and in August (Area II) and September (Area I).

An attempt has been made to sample trawl catches for R. brachysoma caught at 30-40 m depth in Area II. Although the data are rather insufficient they indicate that the spawning pattern in this area matches the data from the purse seine fishery. The mean G.I. value appears to be high (53.57) in February while some individual fish show a G.I. value of 122.81. In April, a smaller peak with a mean G.I. of 29.01 was observed (highest individual value 118.52) (Figures 21 and 22).

In Area III, spawning seems to take place in January, May and September.

The spawning seasons for R. kanagurta appear to have a peak in December and a smaller one in March. In Area I. In Area II, the peak season occurs during December and January. No clear peaks were observed during the rest of the year. Area III had its peak season in September.

D. maruadsi/russelli probably spawns from December to June and D. ***macrosoma*** similarly from December to May in all three areas.

Egg and larval surveys

Egg and larval surveys have been conducted during March, April, June and July in Area II in 1985 and were extended to the upper part of Area III during February, March and April, 1986. The surveys were conducted in 47 grids (grids of 5 x 5 square miles) from the lower part of Phang Nga Bay, Krabi Bay to Talibong Island in Trang Province (Figure 25). Plankton net of mesh size 333 micron and larva net of mesh size 1,000 micron were used, for oblique towing, ten minutes in each grid with a speed of 2-3 knots. The salinity, surface temperature and depth of water at the locations were examined. The egg size, shape of oil globules and the important characters of the larvae during these surveys were identified following the results of the experiments on artificial fertilisation and descriptive studies of eggs and larvae of the Indo-Pacific mackerel by Boonprakob and Dhebtaranon (1971).

These authors found that the fertilized eggs of this species were transparent and spherical. The egg contained a fairly large oil globule and rather narrow perivitelline space indicating the floating character of the eggs. The diameter of the egg and oil globules depended on the size of the female, ranging from 718 to 864 micron for eggs and from 186 to 226 micron for oil globules.

The size of the hatching larvae was 1.33-2.23 mm; the larvae developed to the post larval stage (2.76-2.86 mm) in 72 hours. The larvae, after hatching, were transparent and 31 myotomes could be observed. Additionally, there were some distinct characters for this species such as the absence of a spine on the operculum and the appearance of teeth on the upper jaw with a size of 3.06 mm.

The post larval stage was foliowed by absorption of the yolk sac and opening of the mouth. At this stage, the head was short and wide, the body narrowing in posterior direction, pelvic fin large, and 15-20 pigments from anus to caudal peduncle. The number of pigments decreased to 13-l 5 when the larva grew up to 3.7-4.8 mm and the number decreased continuously to 8-l 1 pigments of size 1 O-l 1.8 mm.

Several organs were also observed while they were developing and the fish grew until the early juvenile stage, having passed the transparent stage with the pigments distribution becoming as in the adult stage. Different stages of development of larvae are shown in Figures 23 and 24.

The results of egg and larval surveys conducted during March, April, June and July 1985 (Figure 25) indicated that eggs and larvae were found in March around Pipi Islands in the highest densities and found in moderate density on the east coast of Yao Yai Island and around Lanta Island. In March the size of larvae caught by plankton net were 1.96 mm (SD 0.32)-2.04 mm (SD 0.31) and those caught by larva net had a mean length of 3.7 mm (SD 0.50). In April, the abundance of eggs and larvae appeared to have shifted southward and the highest density occurred in the south of Lanta Yai Island while the moderate density occurred in the northern part of Area III. On the east coast of Yao Yai Island the eggs and larvae still appeared to occur in moderate abundance during this month. In April, the mean length of the larvae collected by plankton net and larval net were 1.94 mm (SD 0.21) and 4.48 mm (SD 0.70) respectively. In June and July, the surveys were hampered by the heavy monsoon and the larvae were found in low densities (Figures 26 and 27).

It may be concluded that the surveys conducted during the mentioned period in 1985 indicated that the spawning grounds for ***R. brachysoma*** are in Area II, with the main grounds around Pipi Island, south of Lanta Yai Island and east of Yao Yai Island. The period of occurrence of high larval densities (March and April) matches the seasons of high mean G.I. values and the seasons with a high percentage of ripe fish.

The surveys conducted from February to April 1986 using plankton nets showed moderate Densities of the larvae distributed off the east of Yai Noi Island, and from Pipi Islands to south of Lanta Yai Island. The highest abundance in March was observed south of Lanta Yai Island (Area II) and in the area between Kradan Island and Rok Nai Island, located in the northern part of Area III. The size of larvae found by this technique ranged from 2.31 mm to 2.39 mm. The larva net catches showed results similar to those of the plankton net, except that smaller numbers of larvae were found south of Trang Province (Area Ill). The size of larvae caught by the larva net ranged from 3.2 mm 5.98 mm (Figures 28 and 29). From the results of the 1986 survey it seems likely that the fish may spawn before February (this may be seen from the peak in GSI also).

It may be concluded from the results of the egg and larval surveys in 1985 and 1986 that the main spawning grounds for R. brachysoma are in Area II, around Pipi Islands and south of Lanta Yai Island. The small-size larvae of 1.5 — 1.9 mm (age 3 days, according to Boonprakob and Dhebtaranon 1971) were collected from Area 'II, while most of the larger size larvae (2.0 — 4.5 mm) were observed in the inshore areas. This distribution pattern may depend on a number of factors such as wind and surface currents.

References cited

Boonprakob, U and Y. Dhebtaranon, 1971. "Experiment on artificial fertilisation and descriptive studies of eggs and larvae of the Indo-Pacific mackerel *Rastrelliger neglectus* (Van Kampen)." In Reports on Mackerel Invest. 1963-1965, Mar. Fish. Lan., Division of Res. and Invest., Dept., of Fish., Bangkok, pp. 379-406.

Table 1

Yearly change in recapture rate of Indo-Pacific mackerel (R. brachysoma) tagged on the west coast of Thailand, 1981-1984

Area	Year	Release area	No. of released fish	Number of recaptured fish in each area: Area I Phuket	Area I Phang Nga	Area I Krabi	Area I No data	Area II Trang	Area II Satul	Area II Kedah Malaysia	Area II No data	Total no of recaptured fish	% of recaptured fish
III	1981	Satul	513	—	—	—	—	2	6	—	—	8	1.56
III	1982	Satul	1,074	—	—	—	—	1	24	3	—	28	2.61
III	1983	Satul	4,799	—	—		—	10	21	1	16	48	1 .00
Total		81-83	—	—	—	—	—	—	—	—	16	84	1.32
II	1984	Krabi	526	—	15	82	10	—	—	—	—	107	20.34

Table 2

Results of the tagging experiment of R. brachysoma on the west coast of Thailand, 1981-1984

Released area		II	III			
Numbers released/year		1/1984	* 111981	1-2/1982	1-211983	Total
Numbers of released fish		526	513	1074	4799	6386
Days elapsed	0-30	58	1	13	23	37
	31-60	35	5	10	12	27
	61-90	11	—	2	7	9
	91-120	3	—	2	4	6
	151-150	—	-	1	2	4
	151-180	—	—	—	—	—
Numbers of recaptured fish		107	7	28	48	83
Total mortality (Z)		1.004	—	0.674	0.598	0.595
Natural mortality (M)		0.785	—	0.657	0.592	0.587
Fishing mortality (F)		0.219	—	0.017	0.006	0.007
Survival rate (S)		0.366	—	*0.509*	*0.549*	0.561
Exploitation rate (E)		0.218	—	0.026	0.011	0.013
R^2		*0.967*	—	*0.905*	*0.998*	*0.960*

* 1/1981 Area III, no analysis

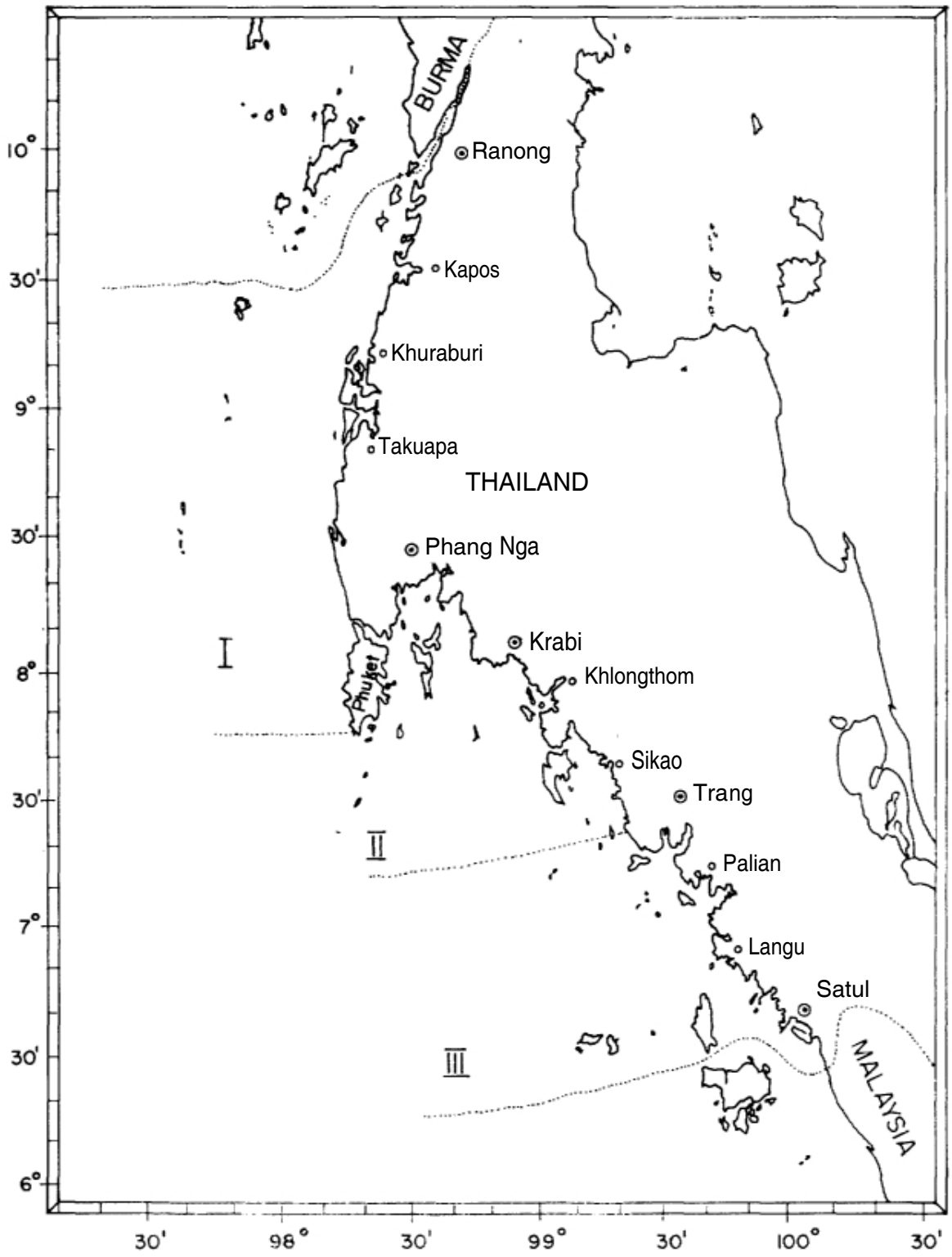
Table 3

Percentage of males of scads and mackerels by size group on the west coast of Thailand

	Area I	Area II	Area III
R. brachysoma			
< 18 cm	54.88	58.02	56.50
18-20 cm	56.63	49.93	52.39
> 20 cm	49.56	45.32	41.10
I?. kanagurta			
< 19 cm	42.72	47.79	—
19-21 cm	45.34	52.80	51.82*
> 21 cm	48.16	52.26	51.65
*D. maruadsi/russelli** *			
<18 cm	—	52.36	—
18-20 cm	—	53.69	—
> 20 cm	—	52.92	—
D. macrosoma * *			
<18 cm		53.87	—
18-20 cm	—	50.71	—
> 20 cm	—	45.43	—

*<21 cm ** all areas

Figure 1a. *Fishing areas on the west coast of Thai/and (Area (from Ranong to Phuket, Area II from Phuket to Trang, Area III from Trang to Satul).*



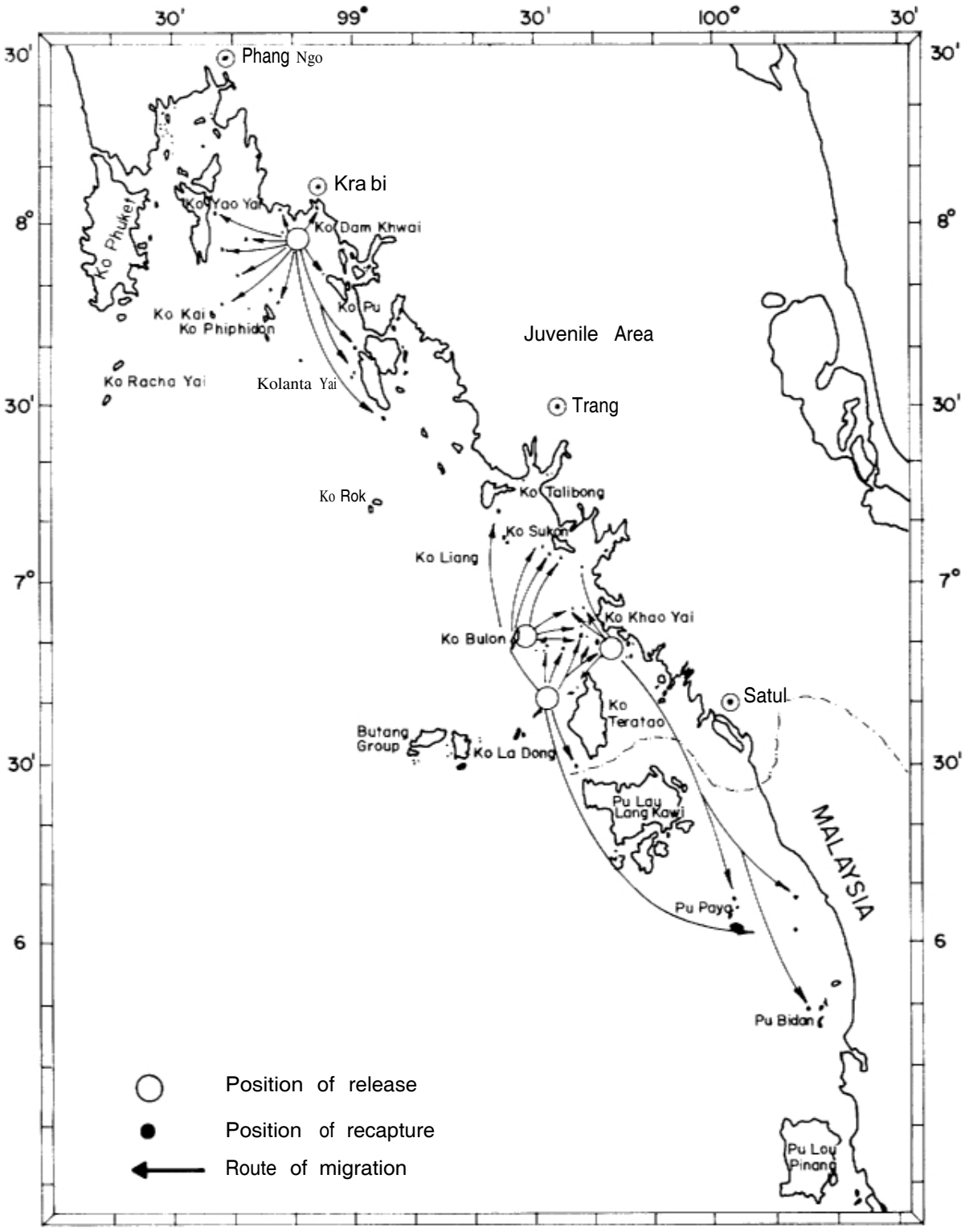


Figure lb. *Results of the tagging experiments with* R. brachysoma *on the west coast of Thailand, 1981-1984.*

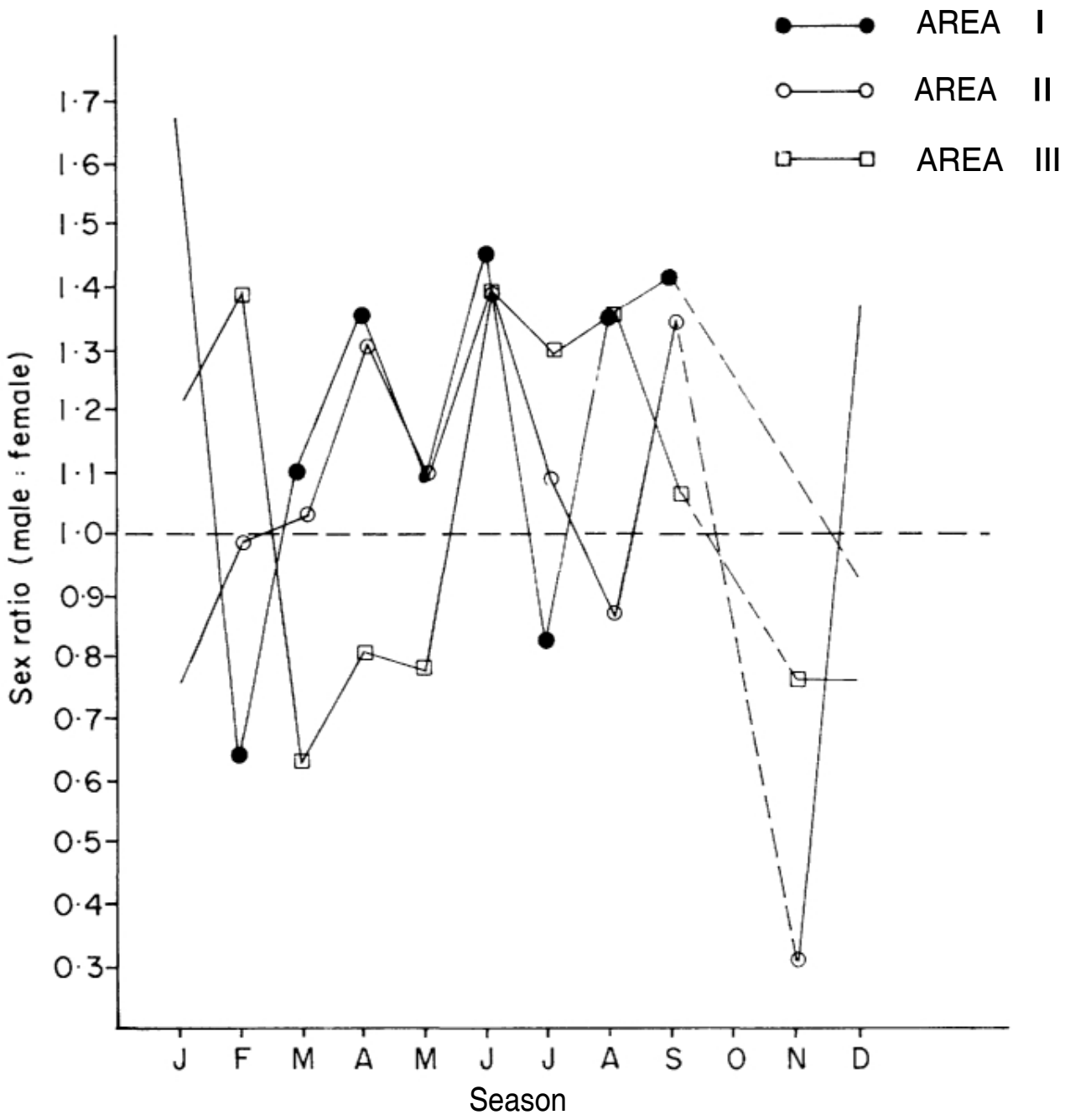


Figure 2. Monthly sex ratio of R. brachysoma *on the west coast of Thailand (1985).*

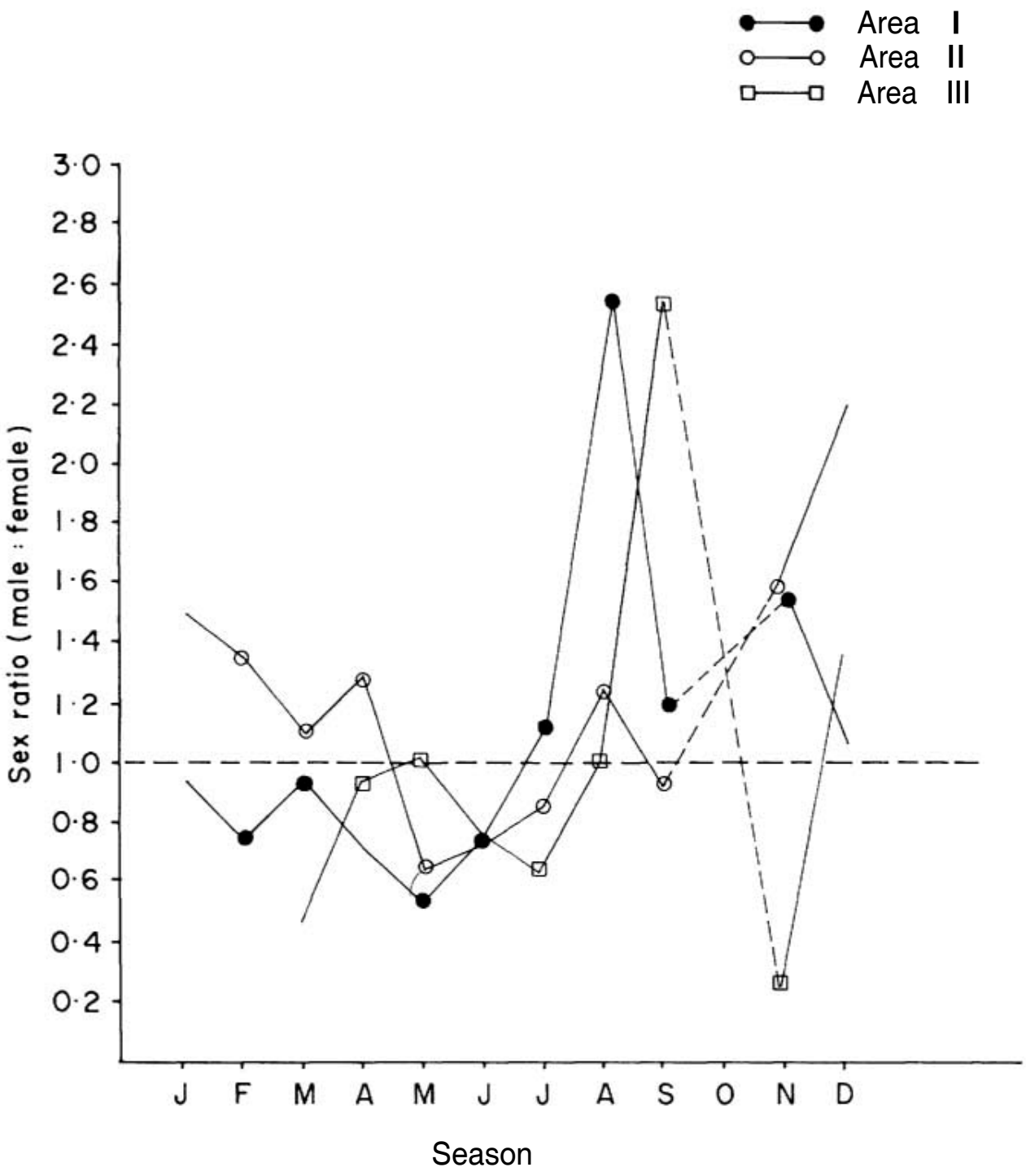


Figure 3. *Monthly sex ratio of* R. kanagurta *on the west coast of Thailand (1985).*

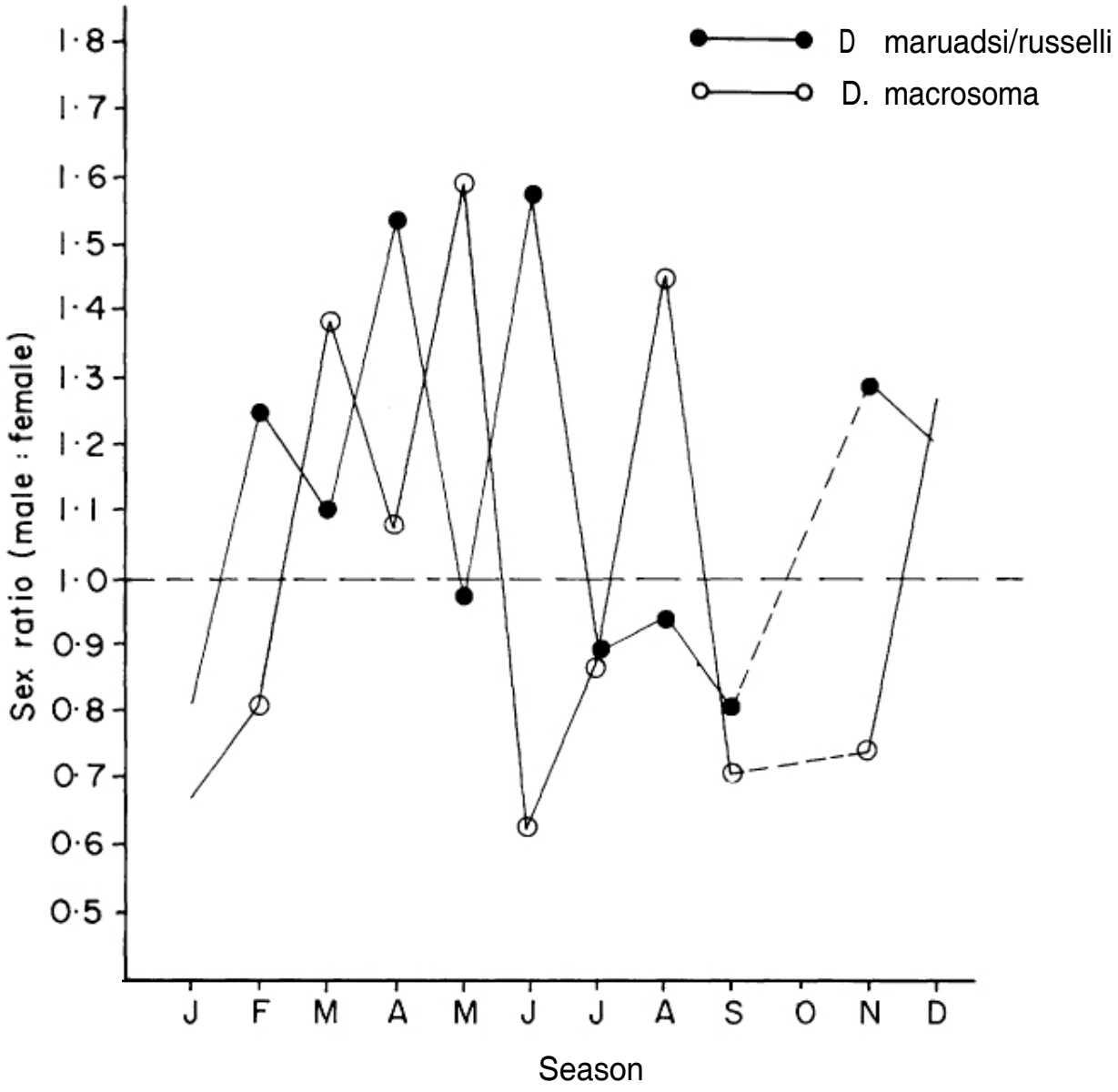


Figure 4. Monthly sex ratio of O. russelli and D. macrosoma on the west coast of Thailand (1985).

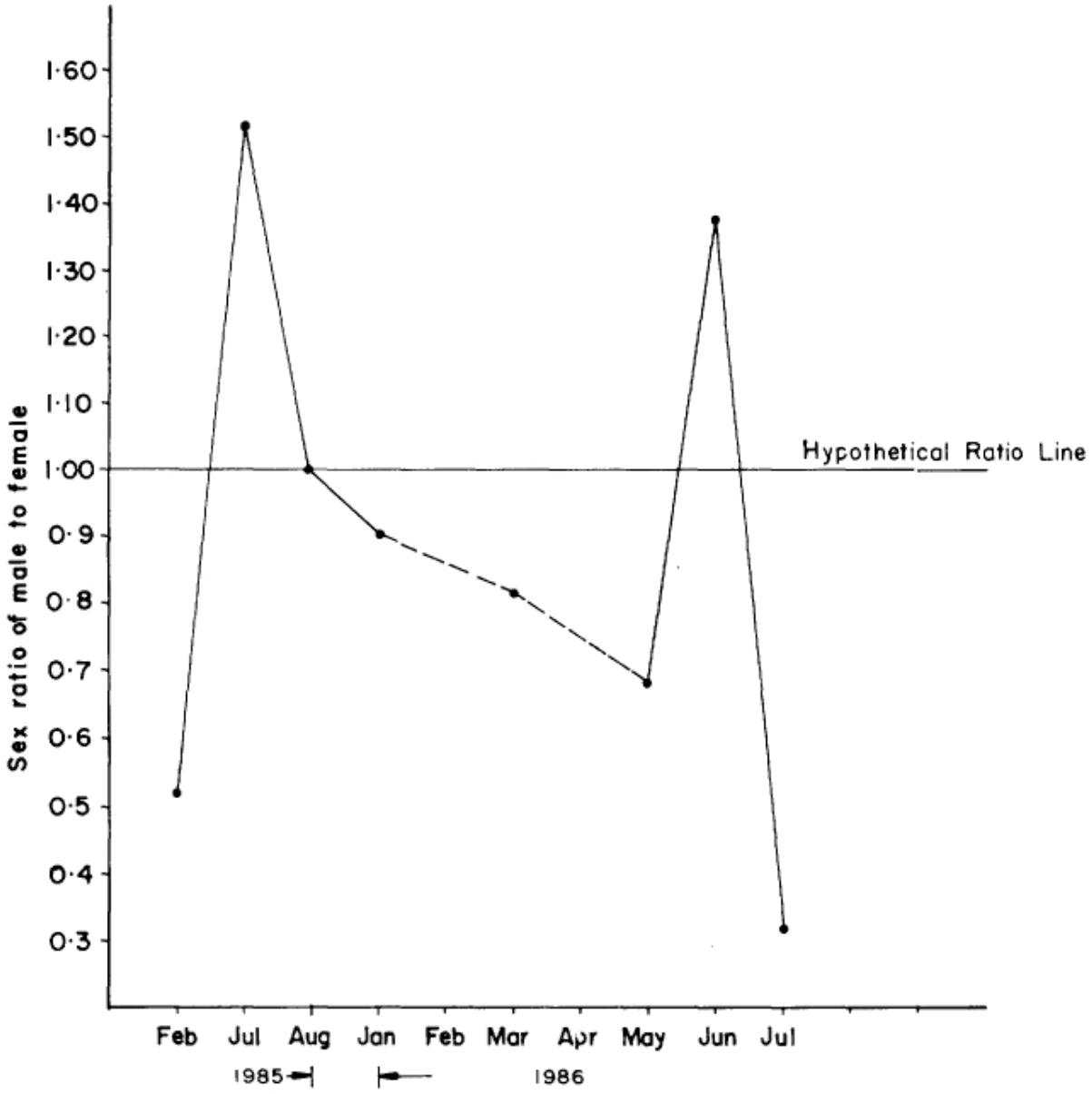


Figure 5. *Sex ratio of* R. brachysoma *from trawl catches in Area II on the west coast of Thailand (1985-1986).*

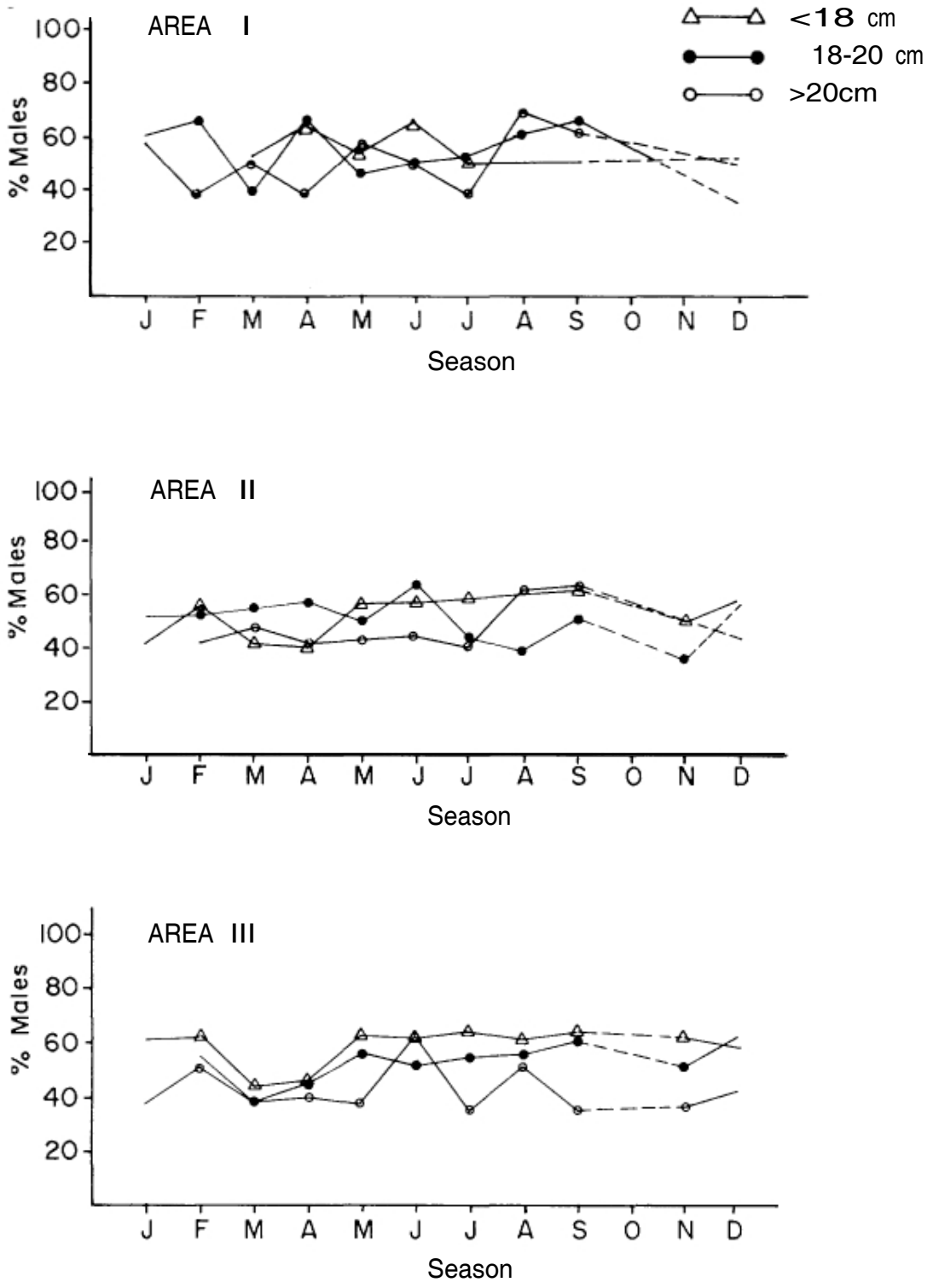


Figure 6. *Monthly sex ratio bysize group of* R. brachysoma *on the west coast of Thailand(1985).*

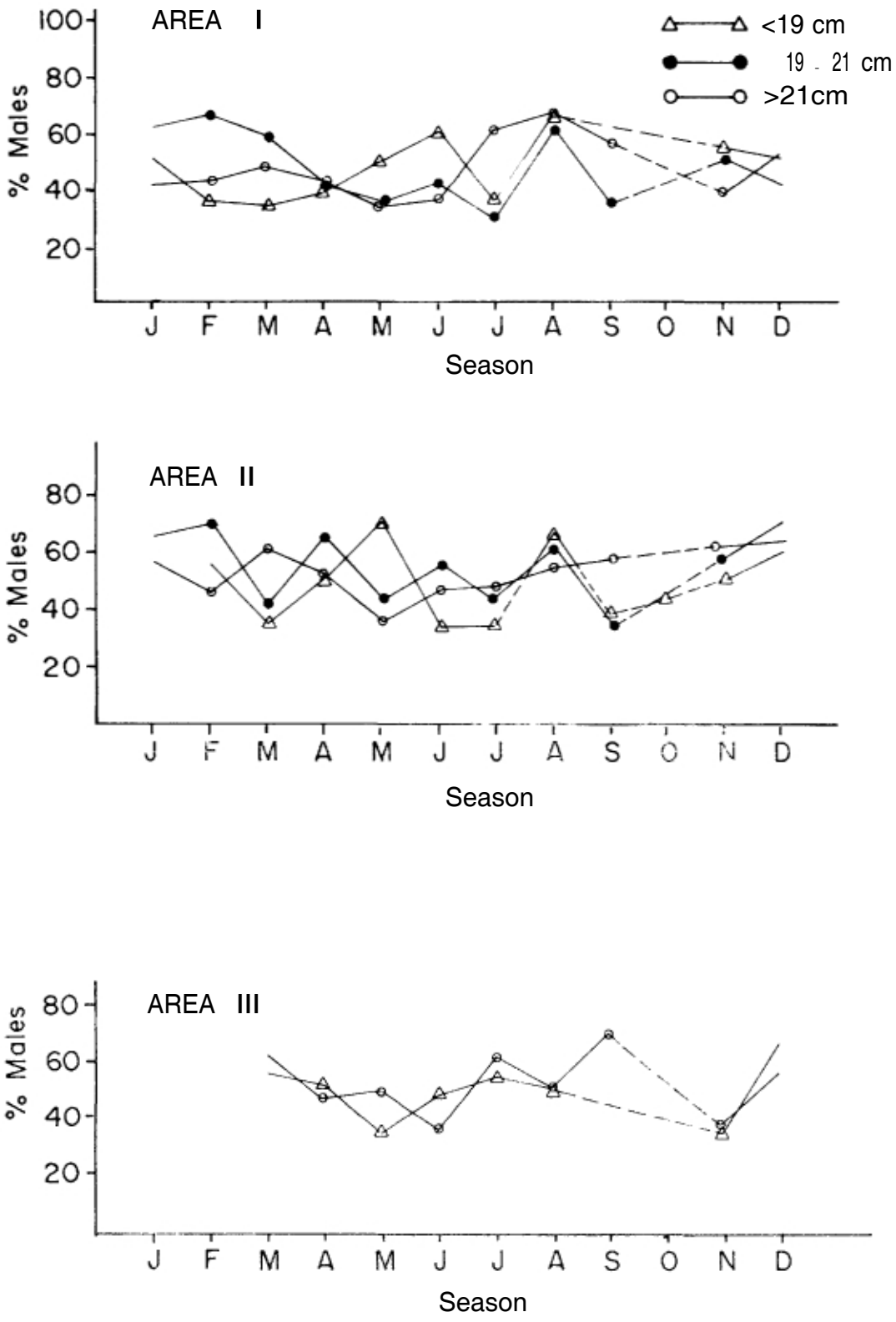


Figure 7. Monthly ratio by size group of R. kanagurta on the west coast of Thailand (1985)

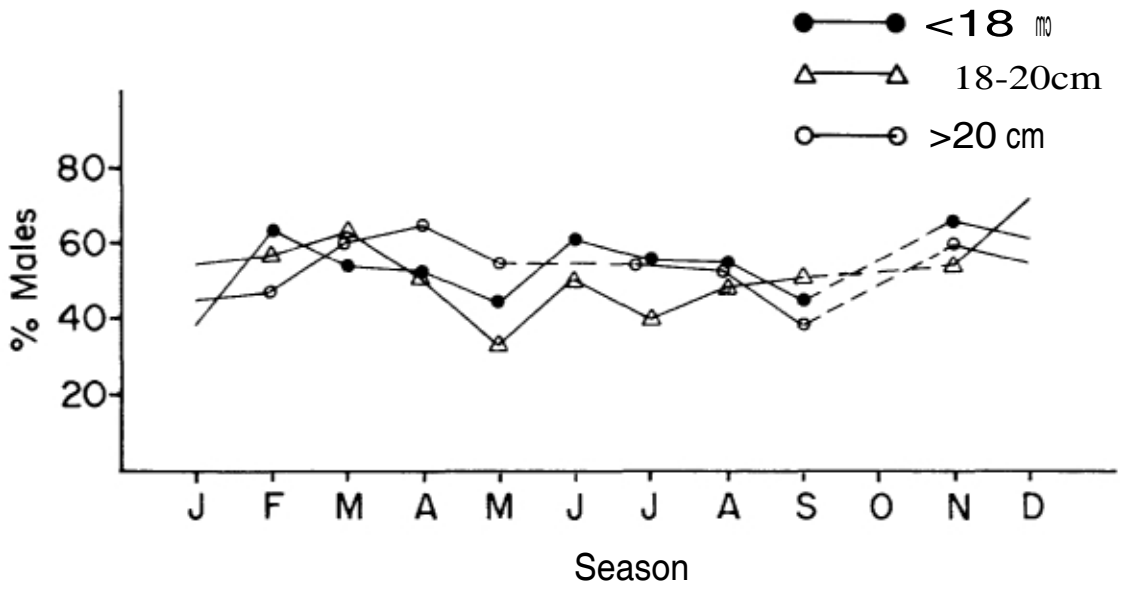


Figure 8. Monthly sex ratio by size group of D. russelli *the west coast of Thailand (1985).*

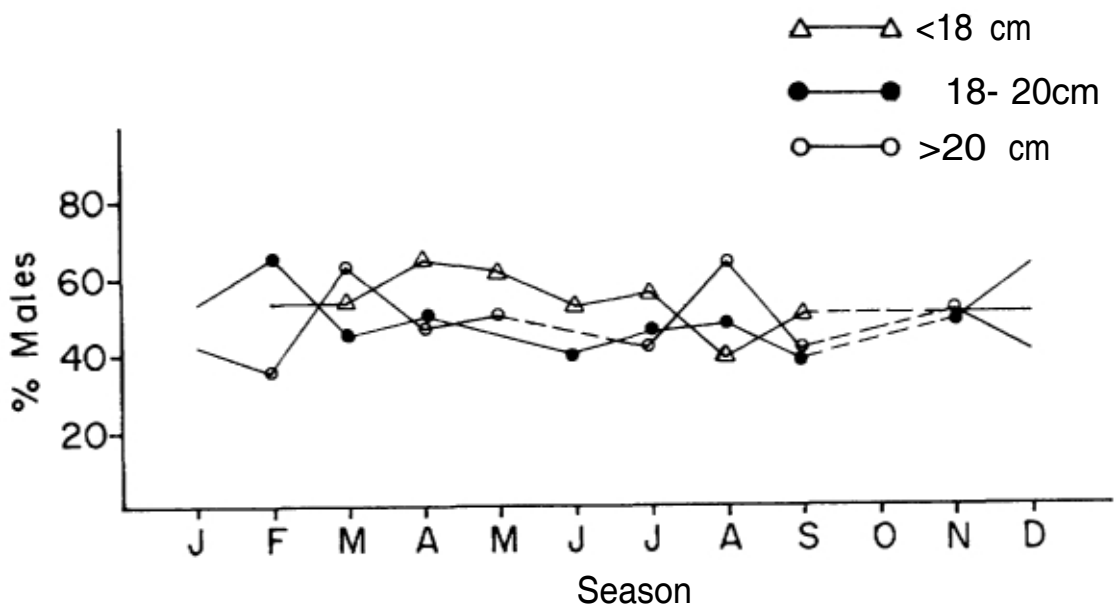


Figure 9. Monthly sex ratio by size group of D. macrosoma *on the west coast of Thailand (1985).*

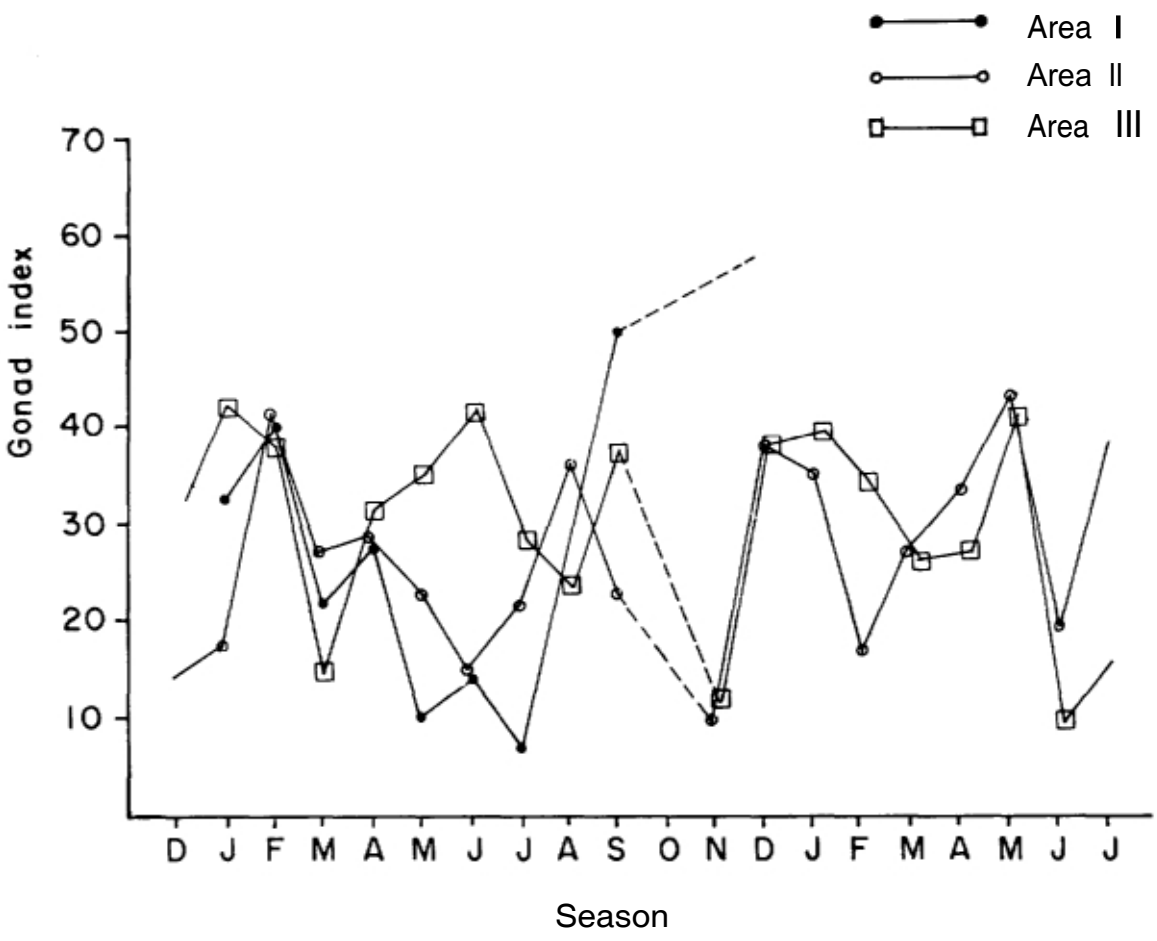


Figure 10. Variation in the mean gonad index of R. brachysoma *on the west coast of Thailand (1985).*

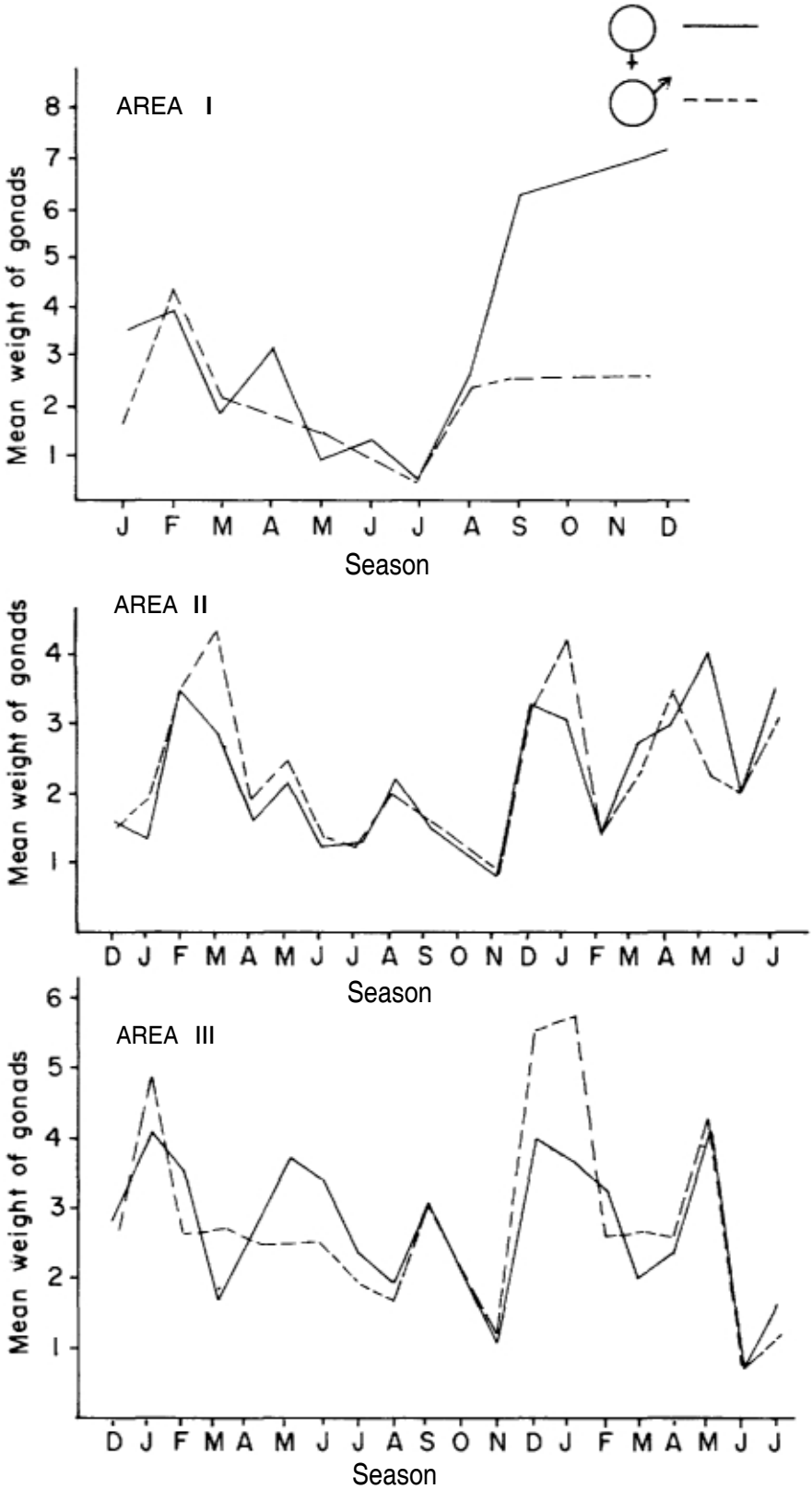


Figure 11. Variation in the mean weight of ovary sacs and sperm sacs of R. brachysoma *on the west coast of Thailand (1985).*

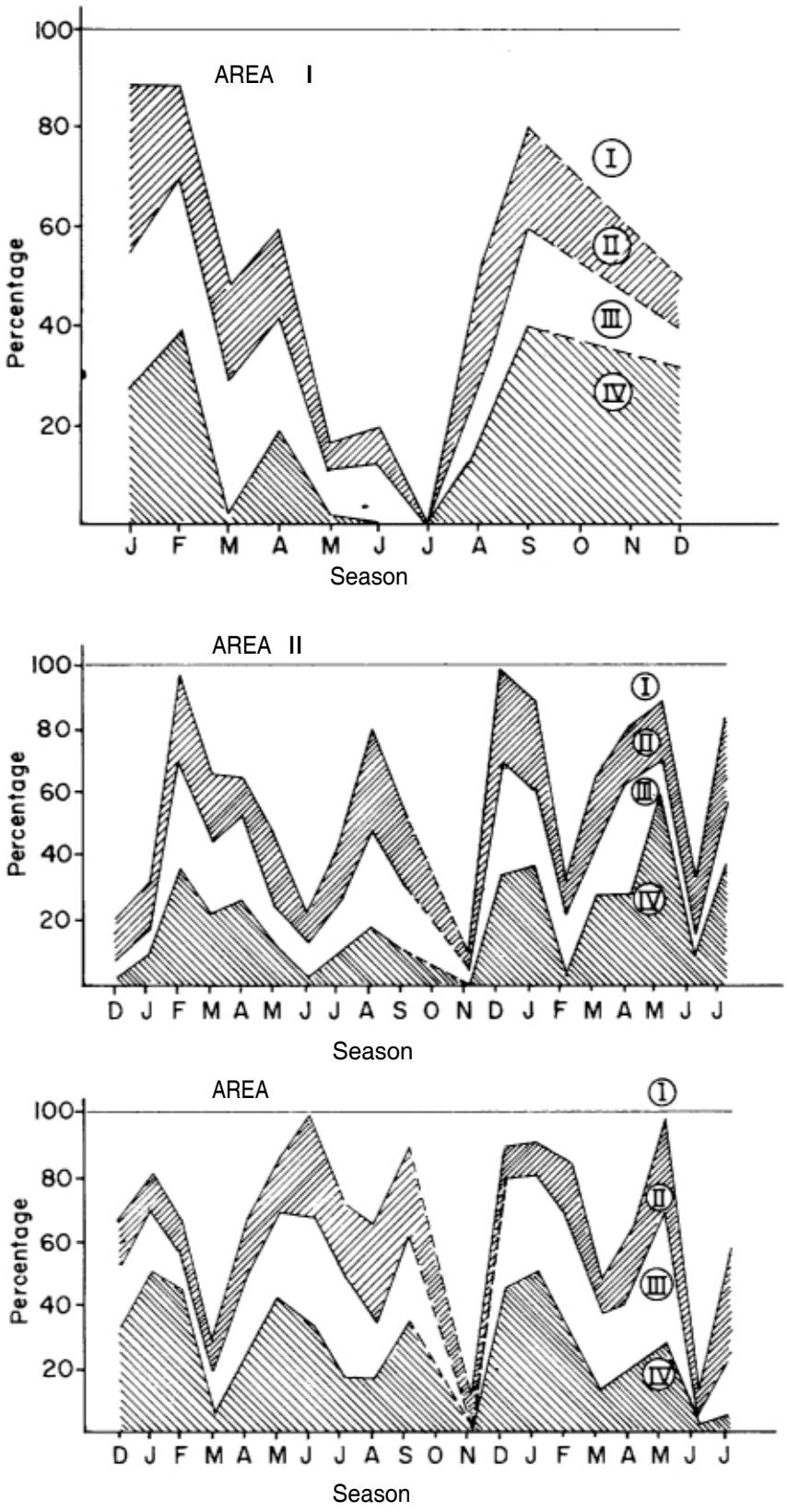


Figure 12. Variation in thepercentage ofstages ofmaturity of R. brachysoma *on the west coast of Thailand (1985).*

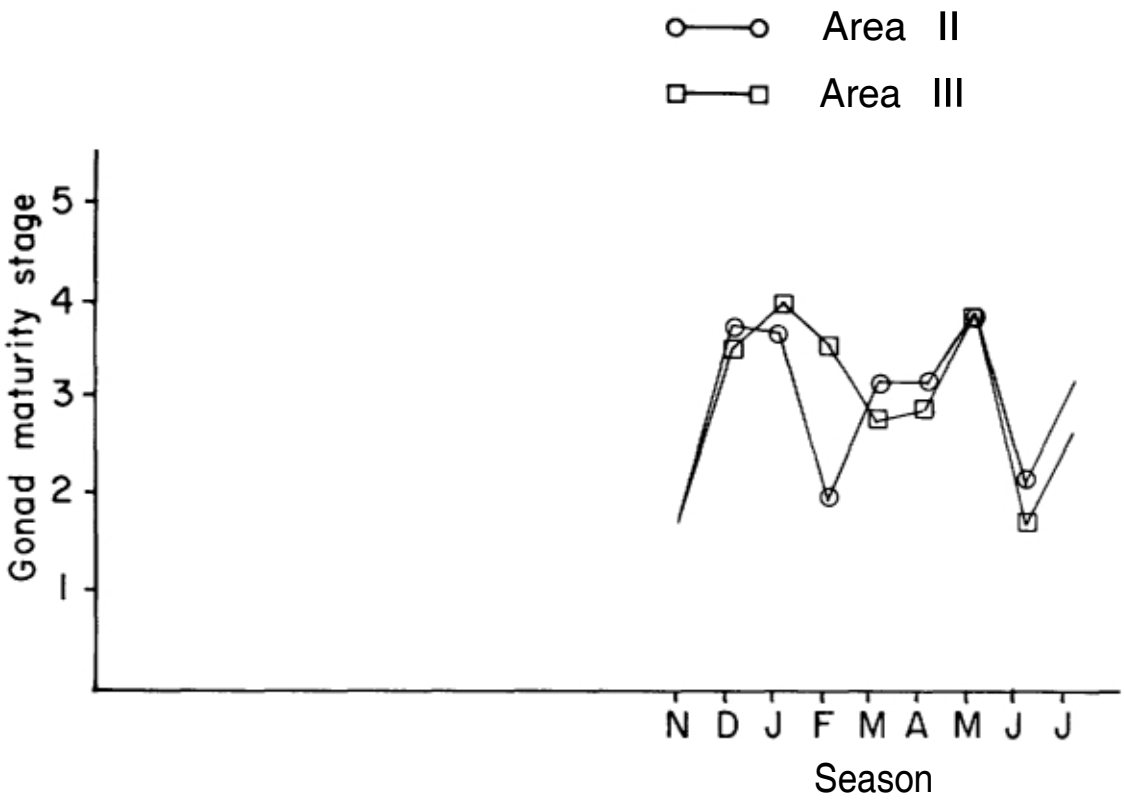


Figure 13. Variation in the mean gonad maturity stages of R. brachysoma *on the west coast of Thai/and (1985).*

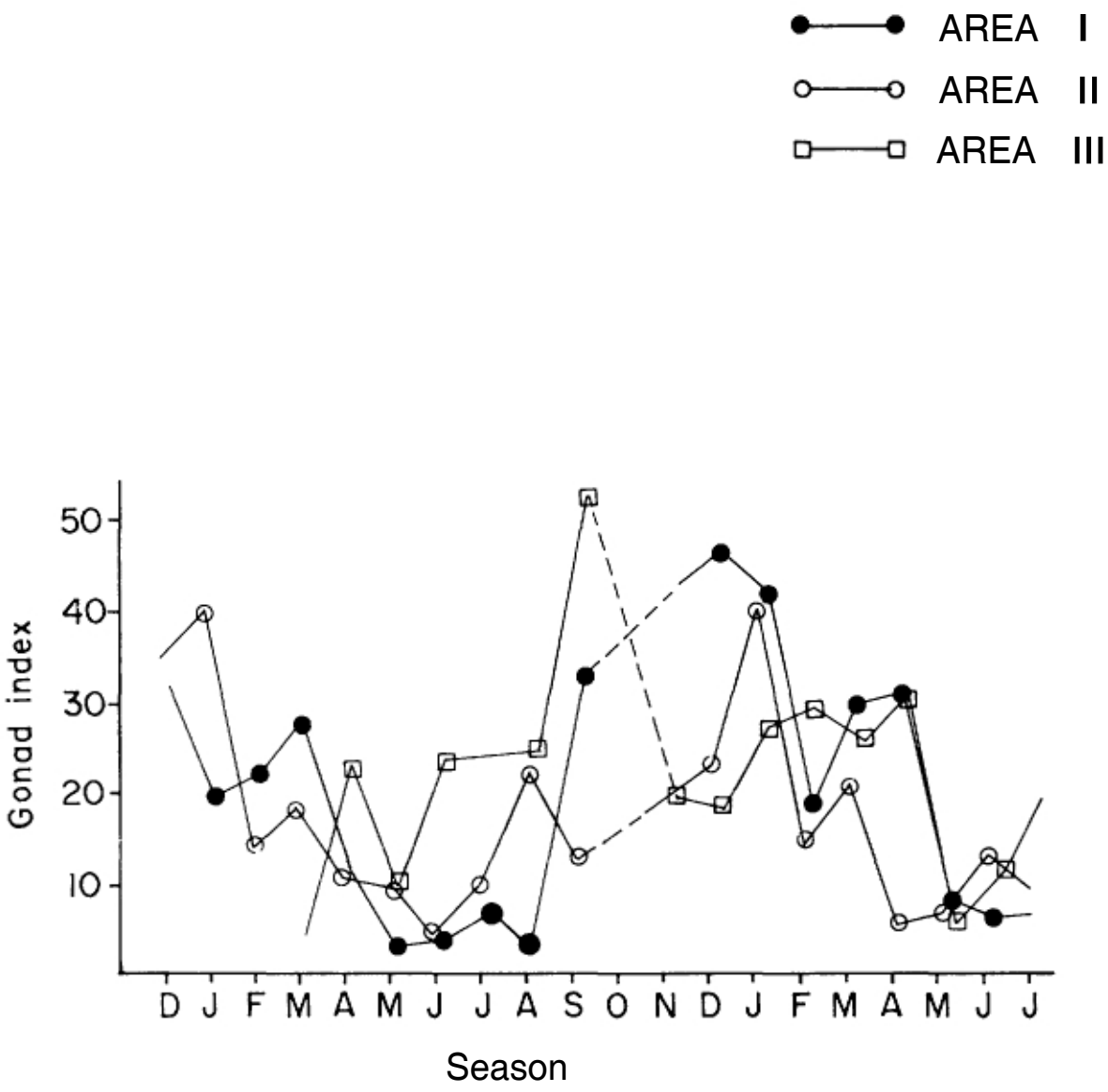


Figure 14. Variation in the mean gonad index of R. kanagurta *on the west coast of Thailand (1985).*

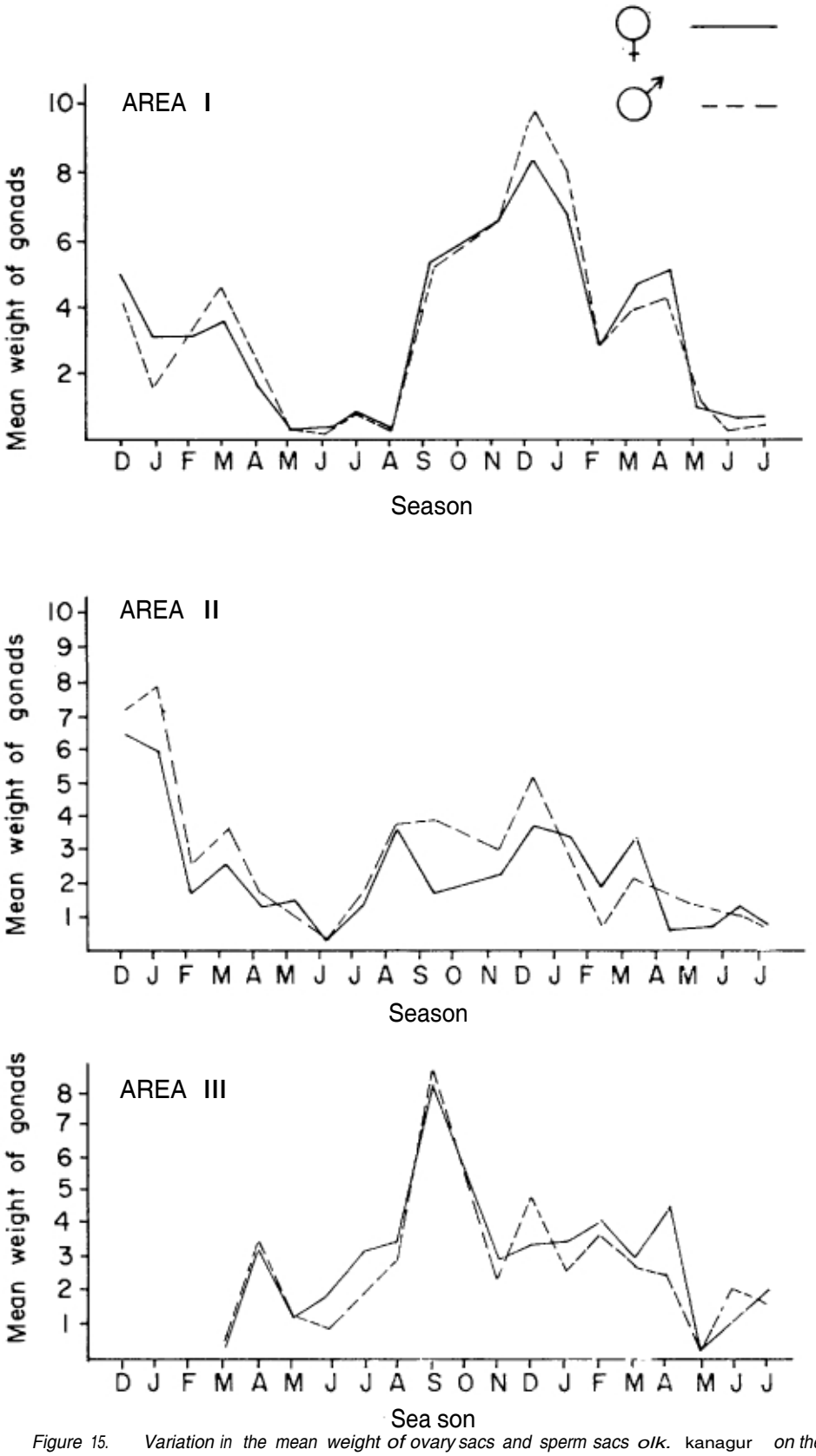


Figure 15. Variation in the mean weight of ovary sacs and sperm sacs of kanagur *on the west coast of Thailand (1985).*

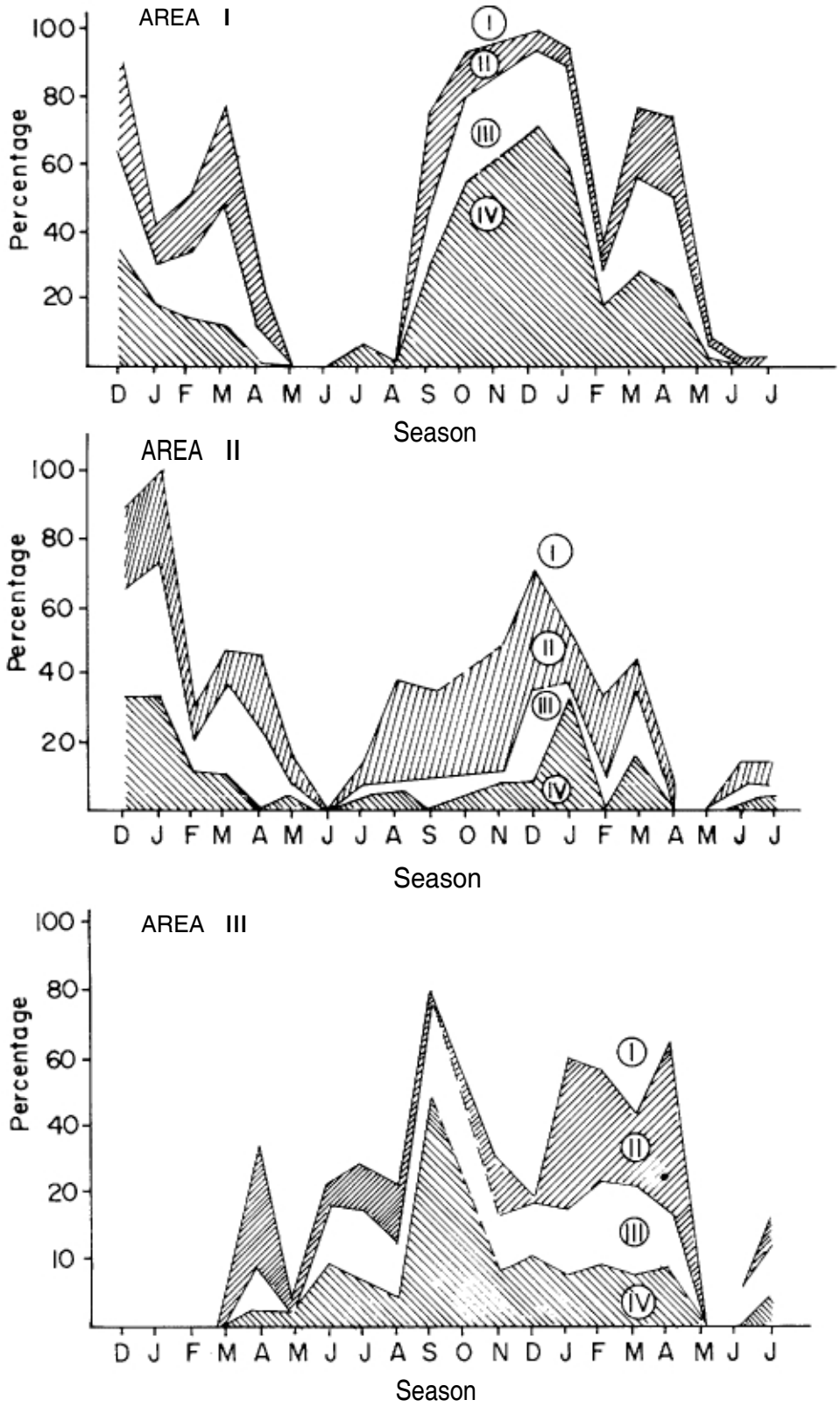


Figure 16. *Variation in the percentage of stages of maturity of* R. kanagurta *on the west coast of Thailand (1985).*

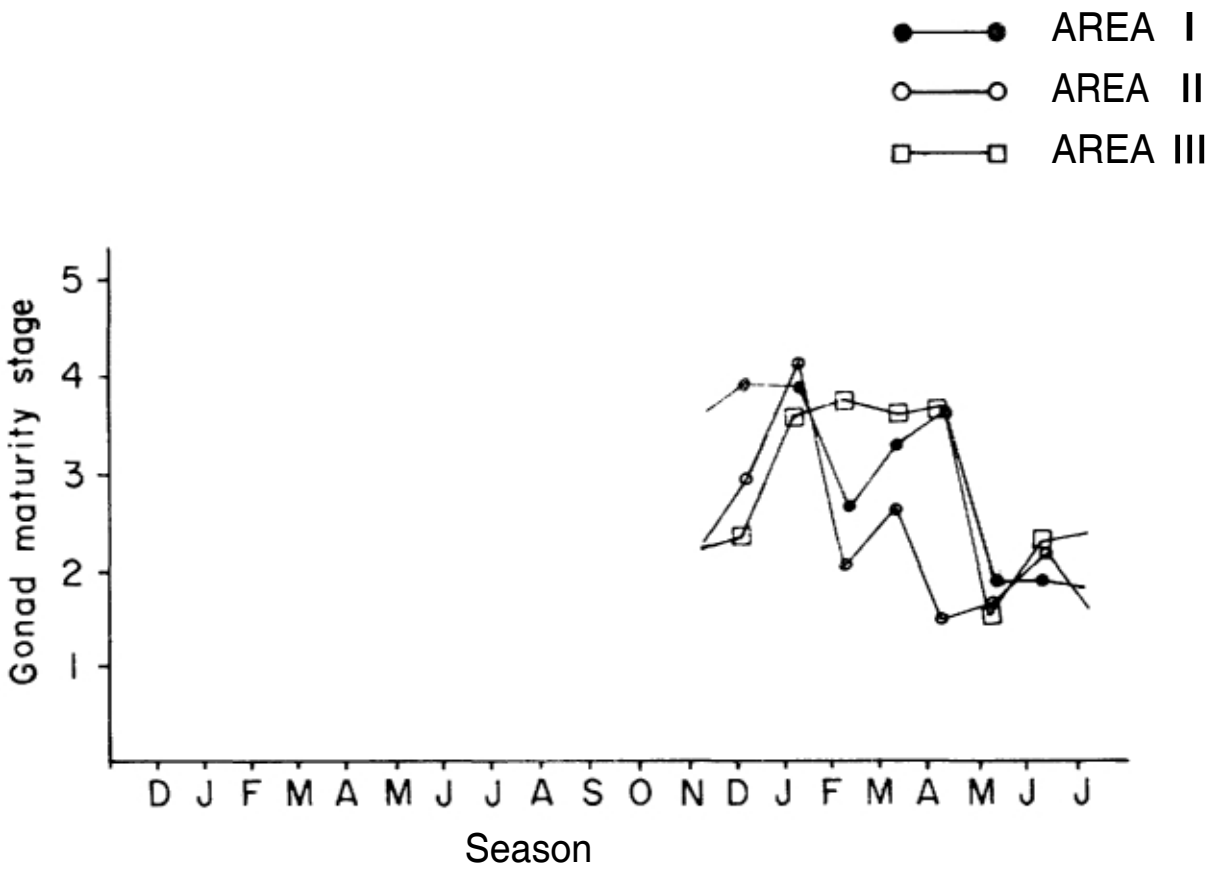


Figure 17. Variation in the mean gonad maturity stages of R. kanagurata *on the west coast of Thai/and (1985).*

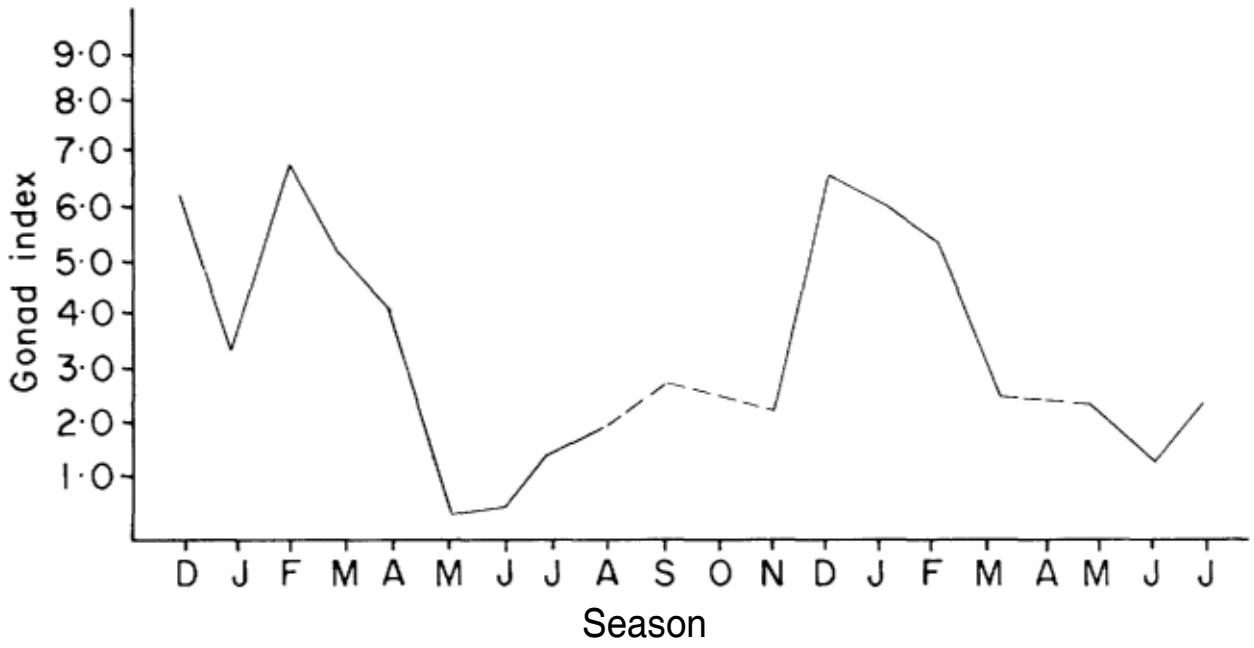


Figure 18a. *Variation in the mean gonad index of* D. macrosoma *on the west coast of Thailand (1984-1986).*

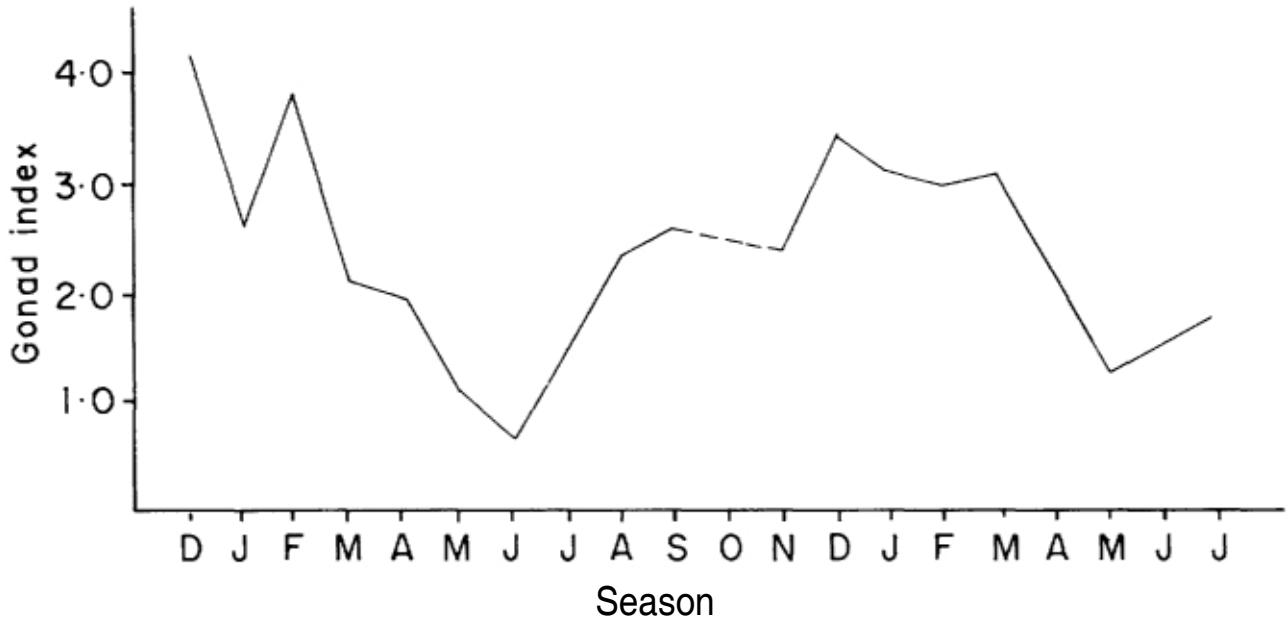


Figure 18b. *Variation in the mean gonad index of D.* russelli *on the west coast of Thailand (1984-1985).*

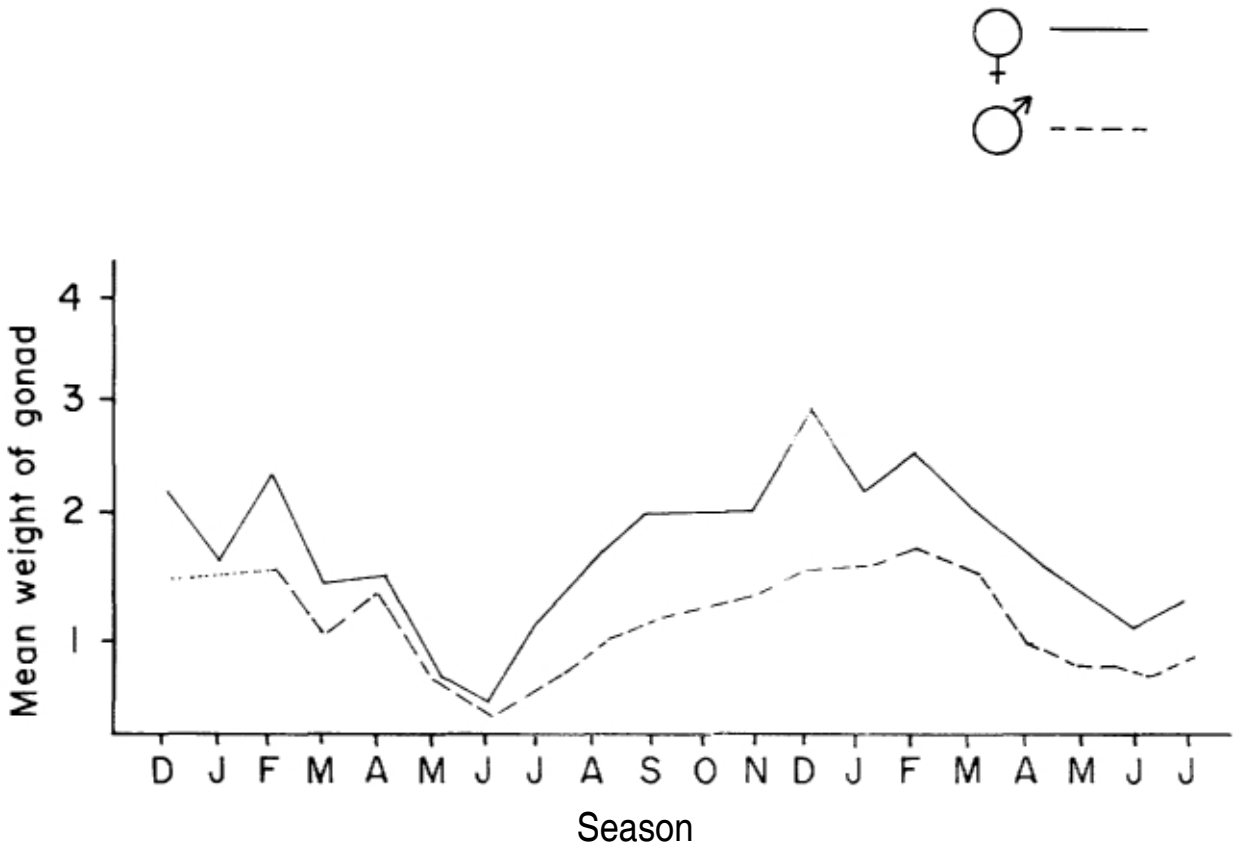


Figure 19a. *Variation in the mean weight of ovary sacs (female) and sperm spacs (male) of* D. russelli *on the west coast of Thailand (1984-1986).*

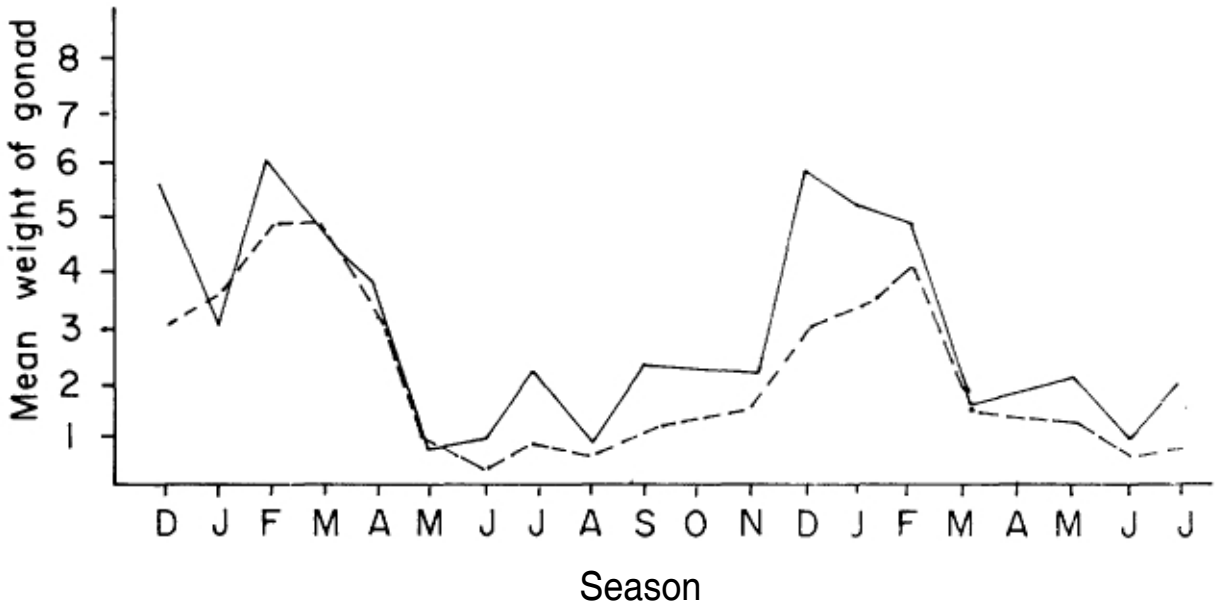


Figure 19b. *Variation in the mean weight of ovary sacs (feiriale) and sperm sacs (male) of* D. macrosoma *on the west coast of Thailand (1984-1986).*

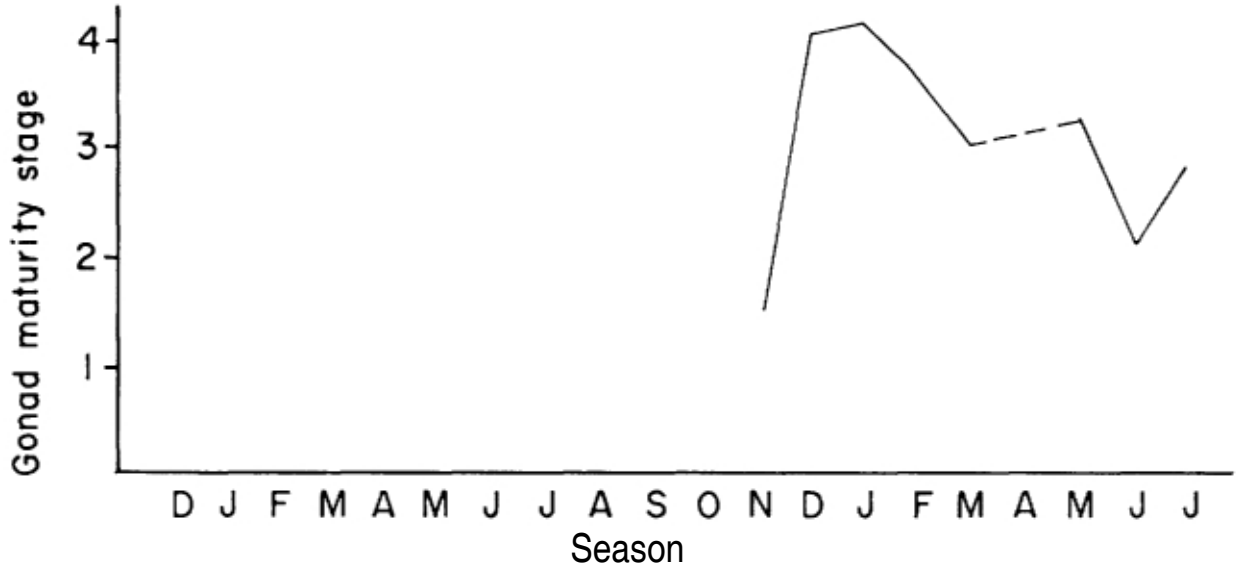


Figure 20a. *Variation in the mean gonad maturity stages of* D. macrosoma *on the west coast of Thailand (1985-1986).*

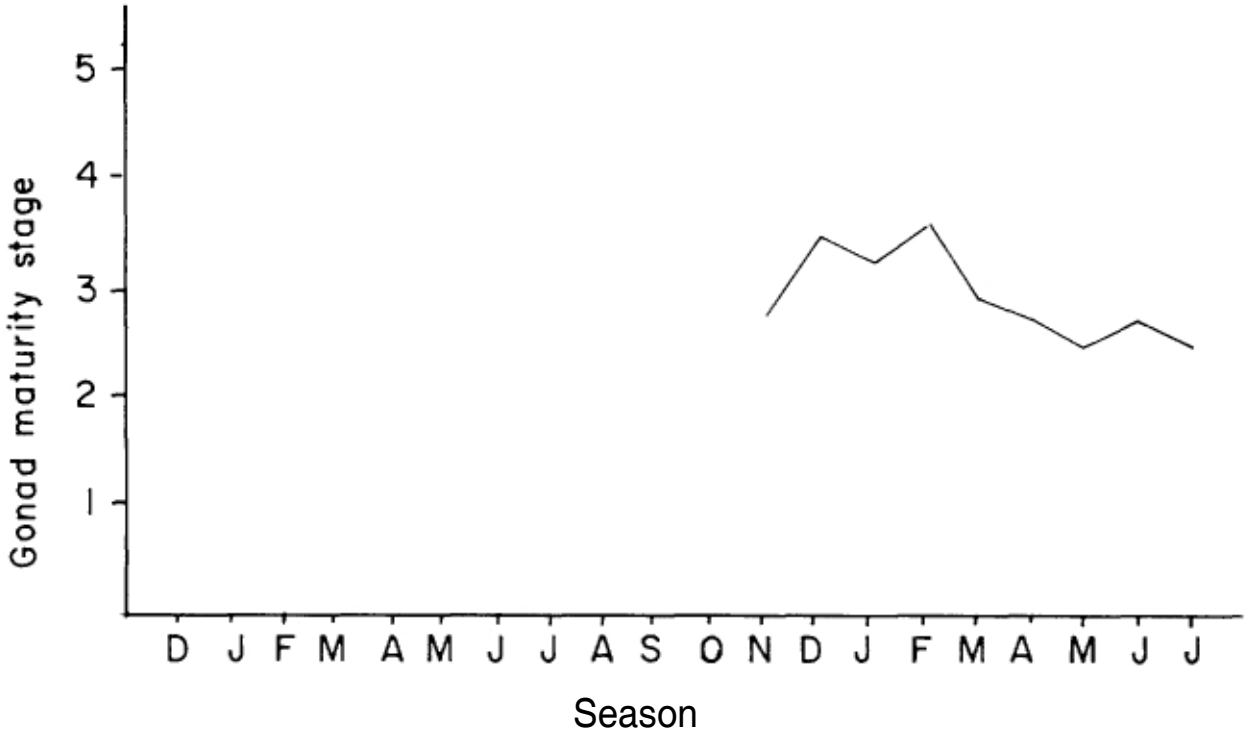


Figure 20b. *Variation in the mean gonad maturity stages of* D. russelli *on the west coast of Thailand (1985-1986).*

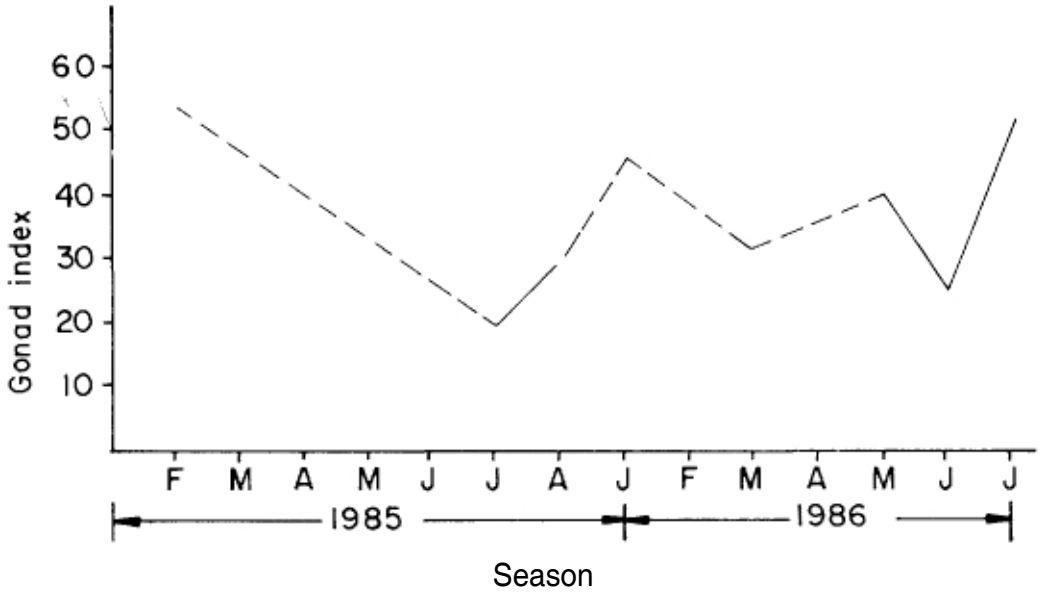


Figure 21. *Variation in the mean gonad index of* R. brachysoma *from trawl catches in Area II on the west coast of Thailand (1985)*

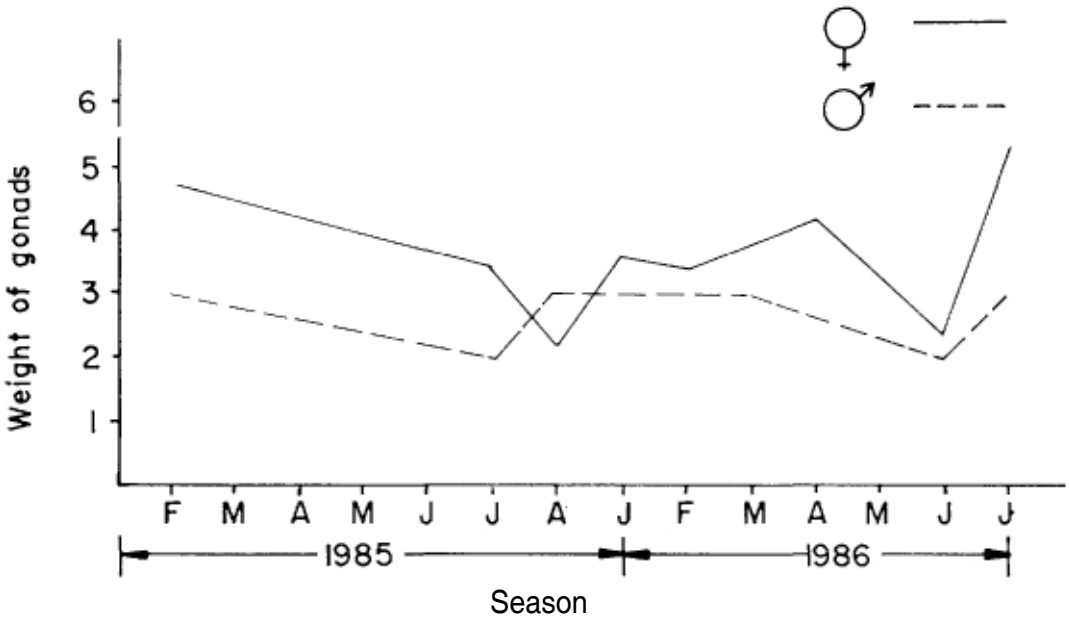


Figure 22. *Variation in the mean weight of ovary sacs (female) and sperm sacs (male) of* R. brachysoma *from trawl catches in area II on the west coast of Thiland (1985).*