

CHAPTER 3

RESULTS

I. Rhizostome Scyphozoans Diversity

After 13 months of field samplings in near shore water along the coasts of Chonburi, south of the Bangpakong River's mouth and Phetchaburi, near Baan Laem, Provinces, a total of 6 species of rhizomedusae were identified.

Phylum Cnidaria

Class Scyphozoa

Order Rhizostomeae

Family Cassiopeidae: Subumbrella muscles arranged in feather-like arcs, twice as many radial canals as rhopalia (sense organ), with four separated subgenital cavities, circular stomach, arm-disk is octagonal, with 4 primary canals (Cornelius, 1995).

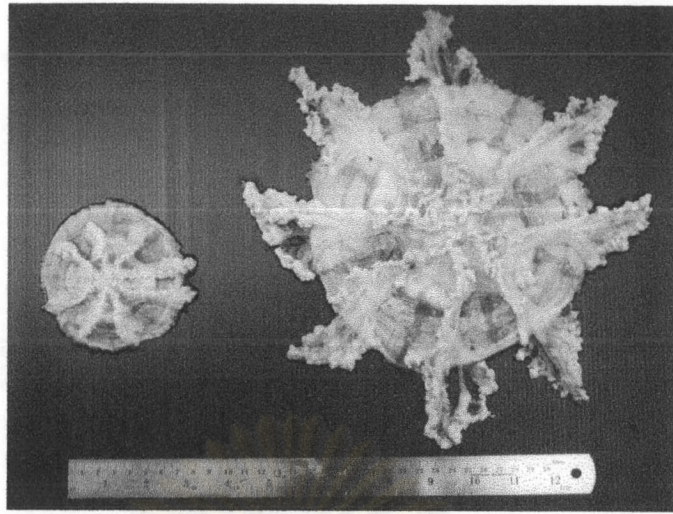
***Cassiopea andromeda* (Forskål, 1775)**

***Cassiopea andromeda* (Figure 12)**

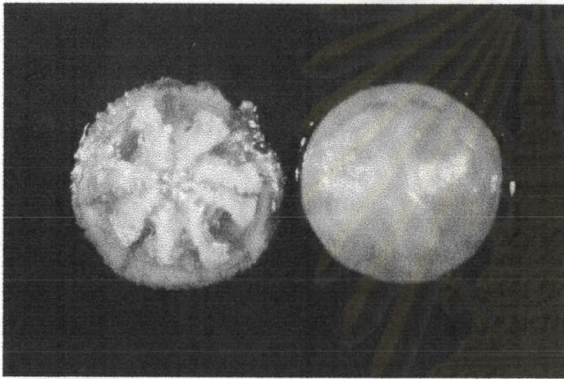
External Characteristics: The exumbrella surface of *C. andromeda*, commonly known as the upside-down jellyfish, is essentially smooth. Its contour is not interrupted by any protuberances. In fresh specimens, the exumbrella surface is usually brown in color, sometimes with white dots. Preserved specimens lack white spots and are usually greenish brown to green in color depending on the amount of zooxanthellae in the tissue. The shape of bell is rather flat, not hemispherical. Mouth arms, with lateral branches, are held sideways. Filamentous tentacles are present along the mouth arms and are especially numerous around the mouth. *C. andromeda* is very similar to a related species, *Cassiopea ornata*. According to Cornelius (1995), these two species are distinguished from each other by the mouth arms, which appear relatively broader in *C. andromeda*.

Distribution: Chon Buri and Phetchaburi.

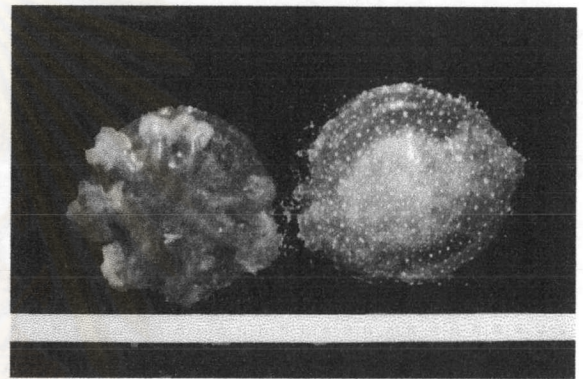
Size Range: 1 - 26 cm.



A.



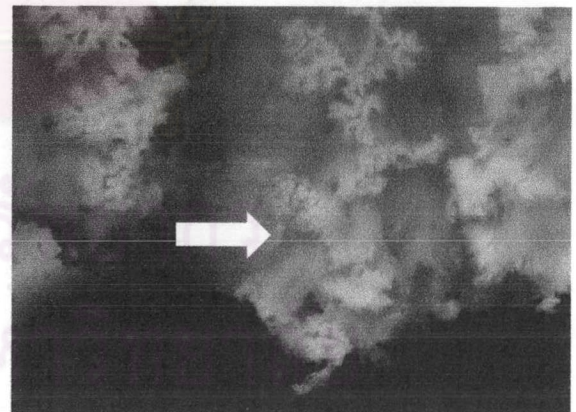
B.



C.



D.



E.

Figure 12. *Cassiopea andromeda*; (A&B) preserved specimens, (C) fresh specimens, (D) smooth bell surface x 6.6, and (E) mouth arms with filaments x 2.2 (arrow).

Family Catostylidae: Without scapulae, 16 radial canals, mouth arms are pyramidal, 8 rhopalar radial canals, 8 interrhopalar canals (Cornelius, 1995).

Acromitus flagellatus (Maas, 1903)

Acromitus hardenbergi

Catostylus townsendi Mayer, 1915

Acromitus flagellatus (Figure 13)

External Characteristics: The exumbrella surface of *A. flagellatus* is smooth and pale in color. The bell appears rounded but not hemispherical, usually with wrinkles in preserved specimens. Under close inspection, particularly under the stereomicroscope, bell surface appears finely granulated. The mouth arms hang down, without lateral branches. Filaments are commonly found along the sides of the mouth arms and near the mouth. The mouth arms, which are broad, tapering distally, have terminal whip-like clubs. The outline of the mouth arms is conical or pyramidal, sometimes with filaments projecting from the contour.

Distribution: Chon Buri and Phetchaburi.

Size Range: 2 – 17 cm.

Acromitus hardenbergi (Figure 14)

External Characteristics: The external characteristics of *A. hardenbergi* are eminently resembling those of *A. flagellatus*. The exumbrella surface of *A. hardenbergi* is smooth and pale in color. The bell is rounded and the mouth arms hang down, without lateral branches. Filaments are visible along the mouth arms, which are broad, tapering distally, and conical in shape. However, *A. hardenbergi* is distinguished from *A. flagellatus* by its lack of terminal whip-like clubs on the mouth arms.

Distribution: Chon Buri and Phetchaburi.

Size Range: 2 – 14 cm.

Catostylus townsendi (Figure 15)

External Characteristics: The exumbrella surface is smooth and creamy white in color. Some specimens have reddish brown or pale brown patches on the exumbrella surface. The shape of the bell is roughly hemispherical. The length of the mouth

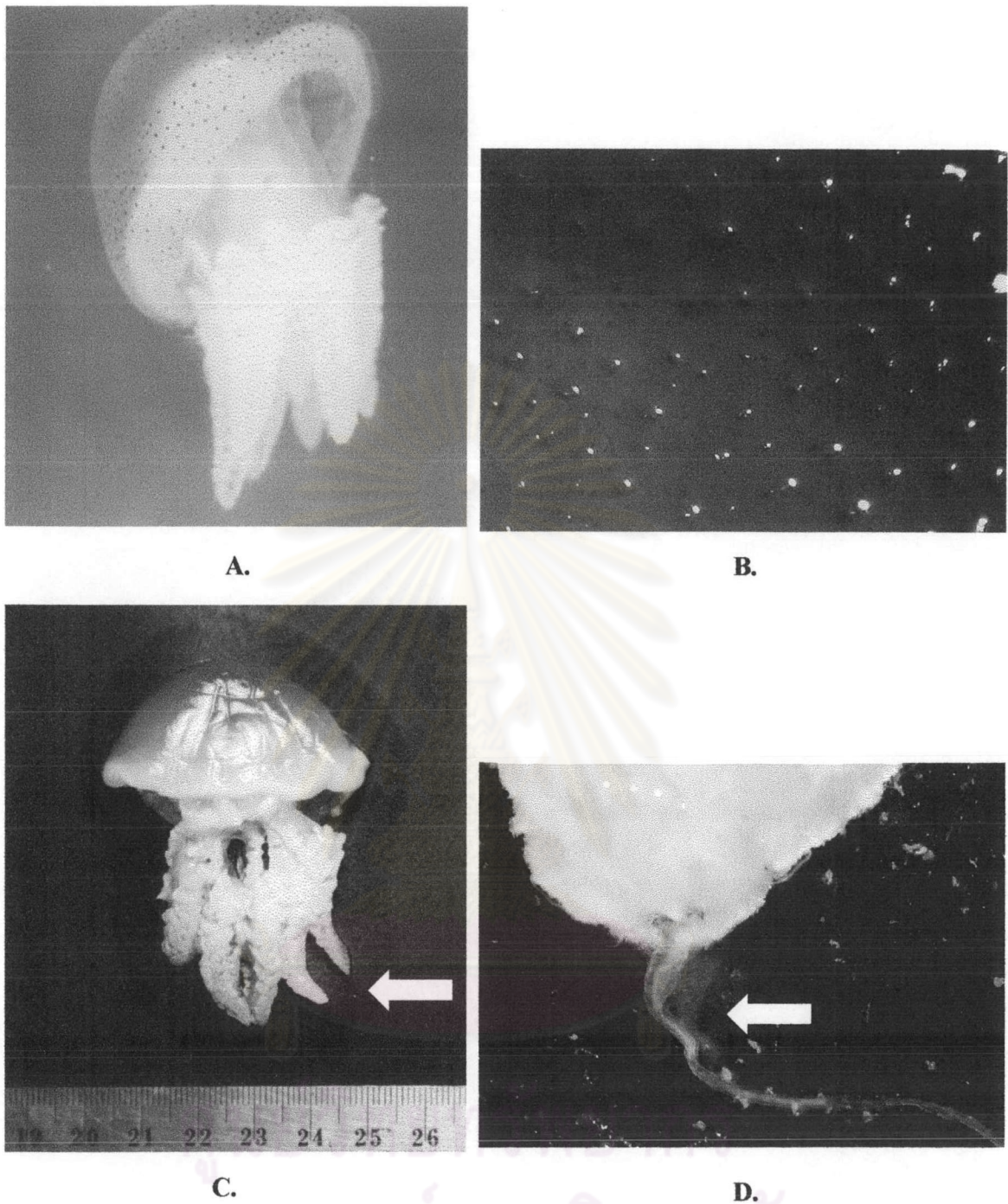
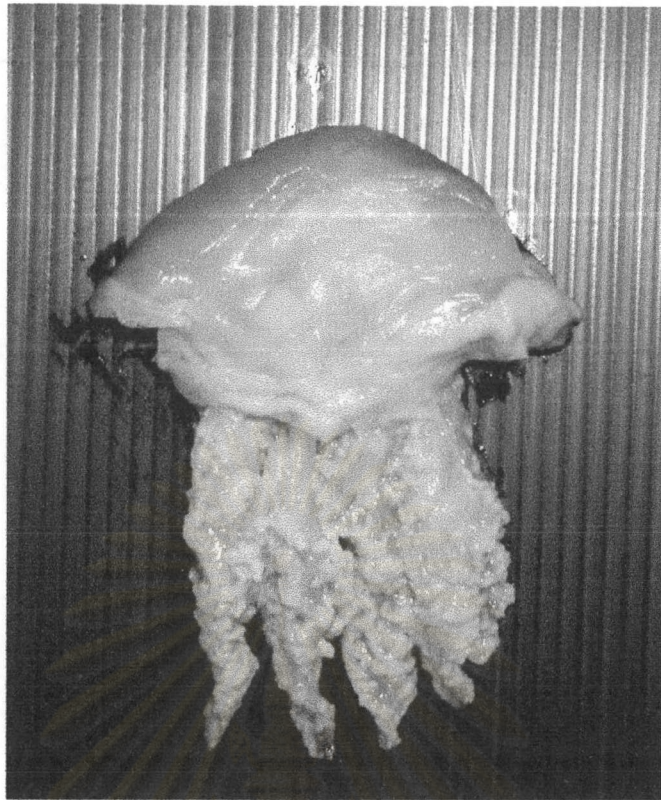
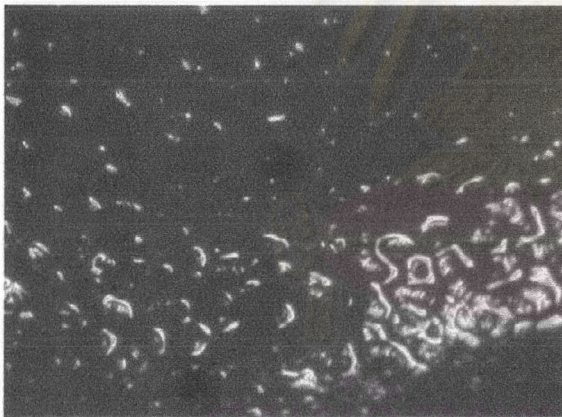


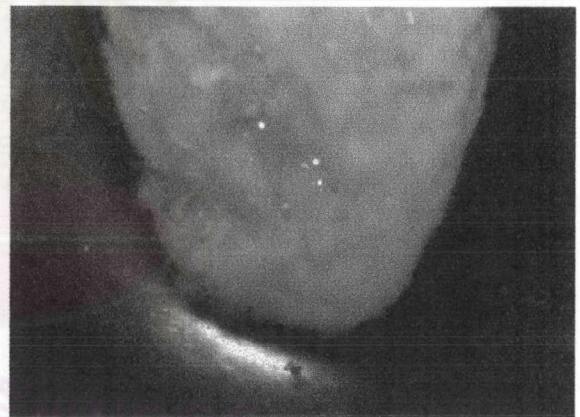
Figure 13. *Acromitus flagellatus*; (A) fresh specimen, (B) smooth bell surface x 6.6, (C) preserved specimen with terminal filaments (arrow), and (D) mouth arm with terminal filament x 2.2 (arrow).



A.

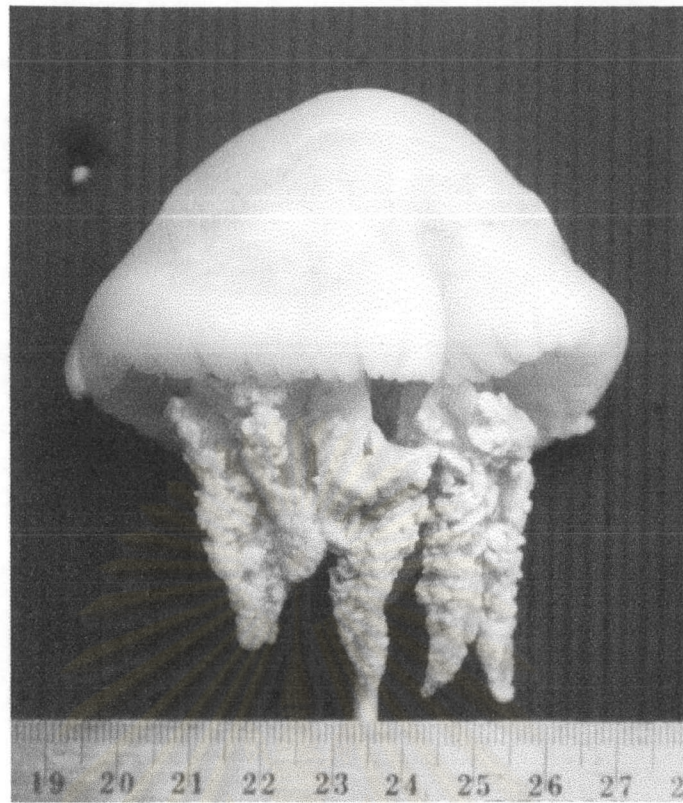


B.

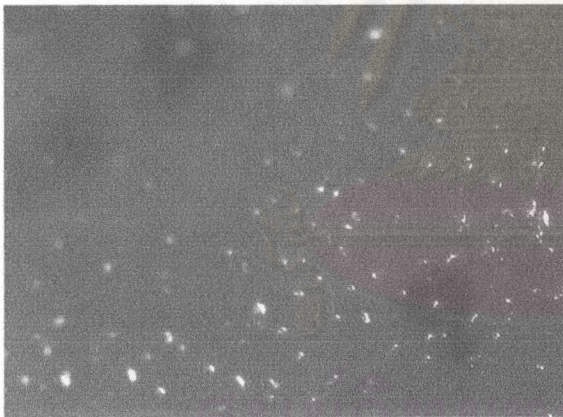


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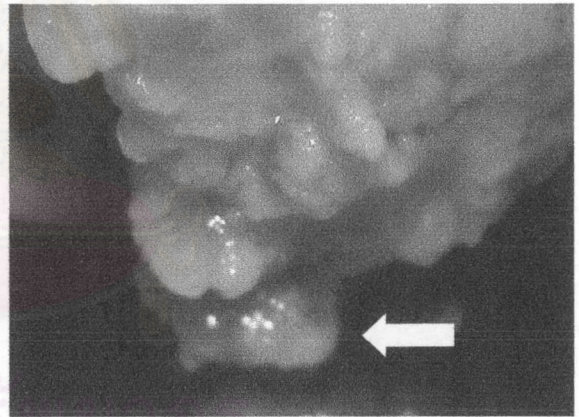
Figure 14. *Acromitus hardenbergi*; (A) preserved specimen, (B) smooth bell surface x 6.6, and (C) mouth arm with no terminal filament x 2.2.



A.



B.



C.

Figure 15. *Catostylus townsendi*; (A) preserved specimen, (B) smooth bell surface x 6.6, and (C) mouth arm without terminal filaments x 2.2 (arrow).

arms is approximately equal or shorter than the bell diameter. Mouth arms hang down, without terminal filaments and without filaments along the sides.

Distribution: Phetchaburi.

Size Range: 3 – 12 cm.

Family Lobonematidae: Without scapulae, 16-32 radial canals, mouth arms with openings in the membranes, elongated marginal lappets which look like tentacles (Cornelius, 1995).

***Lobonema smithii* Mayer, 1910**

Lobonema smithii (Figure 16)

External Characteristics: The exumbrella surface of *L. smithii* is certainly not smooth. Protuberances, warts, or papillae, are present throughout the exumbrella surface. Fresh specimens are pale purple and translucent in color. Papillae are essentially tubular in shape. Marginal lappets around the bell are long and not to be confused with marginal tentacles. Bell is round and nearly hemispherical. There are numerous filaments present all over the mouth arms, which lack scapulae that are present in *R. hispidum*. Most specimens are large.

Distribution: Phetchaburi.

Size Range: 24 – 53 cm.

Family Rhizostomatidae: With scapulae, without primary mouth opening, manubrium with a complex canal system, proximal portion of mouth arms are joined, distal portion is 3-winged (Cornelius, 1995).

***Rhopilema hispidum* (Vanhöffen, 1888)**

Rhopilema hispidum (Figure 17)

External Characteristics: The exumbrella surface of *R. hispidum*, white in color, is distinctly granulated and rough to touch. Fine granulation is present all over the bell surface. The shape of the fleshy bell is somewhat hemispherical, sometimes with tiny brownish dots. Mouth arms are with scapulae and numerous filaments along the sides. Most specimens found are usually larger than 15 cm in bell diameter.

Distribution: Chon Buri and Phetchaburi.

Size Range: 15 – 54 cm.



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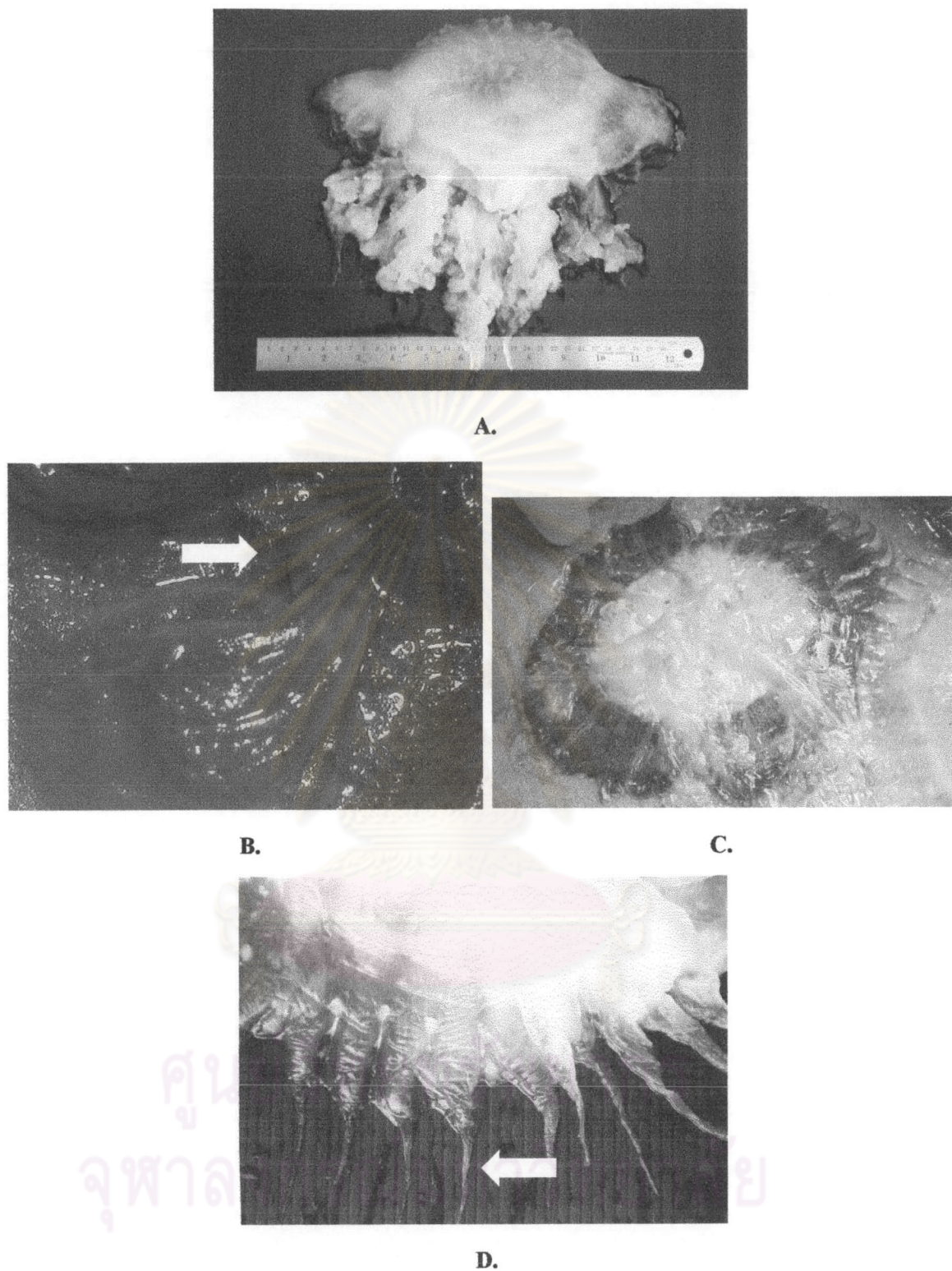
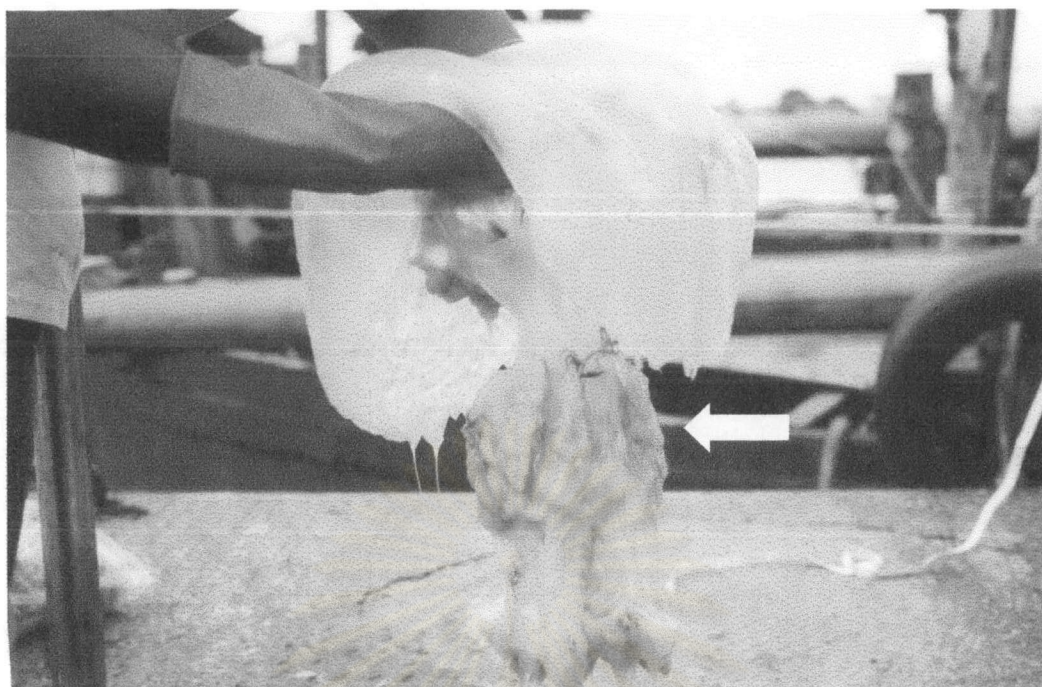
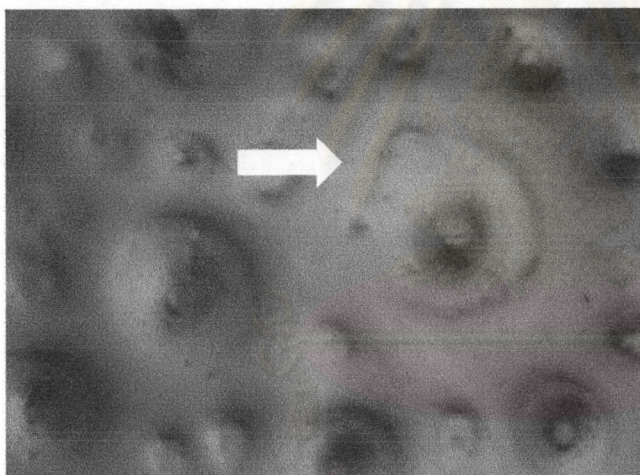


Figure 16. *Lobonema smithii*; (A) preserved specimen, (B) protuberances on bell surface or papillae x 2.2 (arrow), (C) fresh specimen, and (D) marginal lappets (arrow).



A.



B.



C.

Figure 17. *Rhopilema hispidum*; (A) fresh specimen with scapulae (arrow), (B) finely granulated bell surface with minute warts x 6.6 (arrow), and (D) scapulae.

II. Abundance of Rhizostome Scyphozoans

At Chon Buri Province, rhizomedusae occurred in highest abundance (> 23 individuals $\cdot 10^4 \text{ m}^{-3}$) during the month of March 2000. Relatively smaller number of rhizostome specimens (< 3 individuals $\cdot 10^4 \text{ m}^{-3}$) were found in January, February, May, and October 2000. No rhizostome specimens were found in other months. In comparison, the highest abundance at Phetchaburi Province occurred during the month of November 2000 (> 300 individuals $\cdot 10^4 \text{ m}^{-3}$). In addition, more than 25 individuals $\cdot 10^4 \text{ m}^{-3}$ of specimens were obtained in June and October 2000. No rhizomedusae were found during the months of March and September 2000. Interestingly, the abundance of medusae was more than 10 times higher in magnitude at Phetchaburi Province compared to Chon Buri Province (Figure 18A and B).

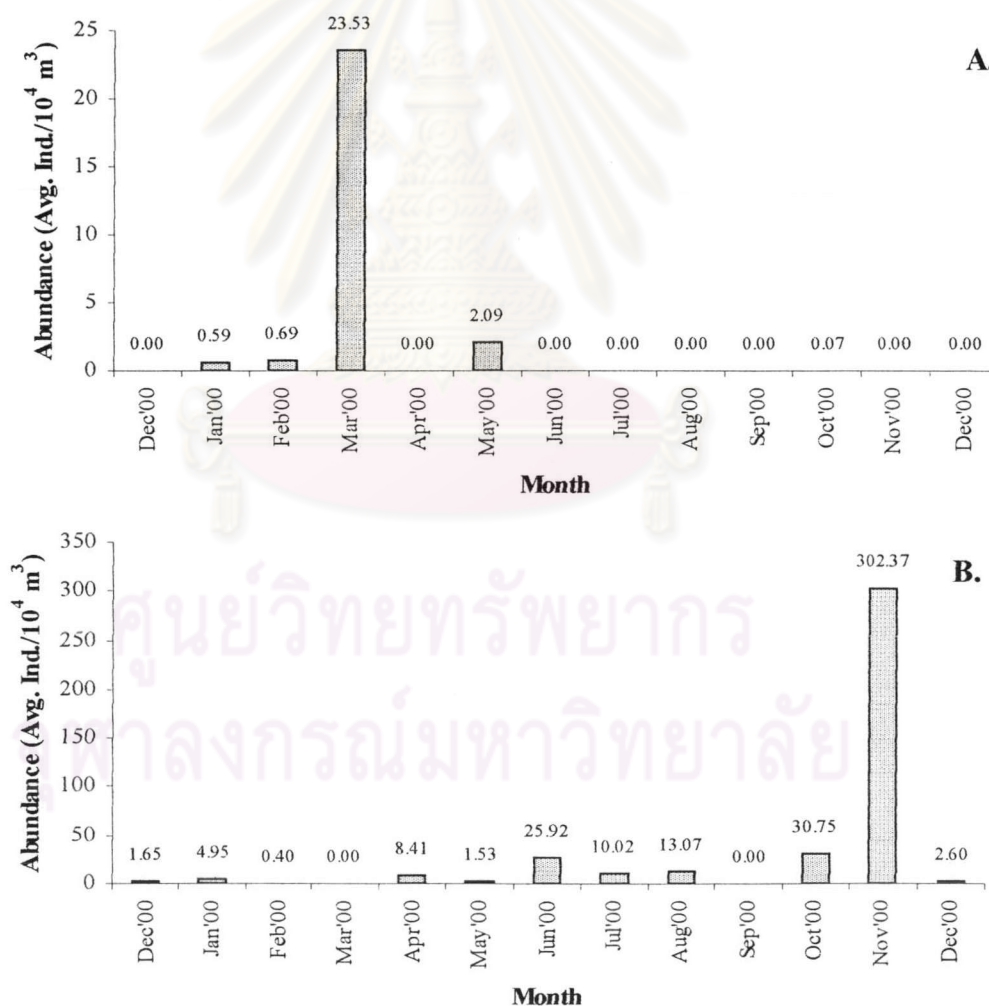


Figure 18. Abundance of rhizomedusae at (A) Chon Buri and (B) Phetchaburi Provinces from December 1999 to December 2000.

During the month of March, with the highest abundance of rhizomedusae observed at Chon Buri Province, the dominant species was *Acromitus flagellatus*, which was also a dominant species at Phetchaburi. Noticeably, at Chon Buri Province, *Cassiopea andromeda* was the most encountered species and was found in 5 months out of the 13-months sampling period. Both *A. flagellatus* and *C. andromeda* was the most encountered species at Phetchaburi Province and were predominantly found in 8 months out of the 13-months sampling period. In term of the number of species found at each sampling area, Phetchaburi Province appeared to have a relatively higher number of species of rhizomedusae, 6 species, in addition to cubomedusae and other scyphomedusae. There were only 3 species, yielded from the Chon Buri Province excluding *Rhopilema hispidum*, which was found outside the usual sampling area. Highest species diversity was observed in March 2000 for Chon Buri Province and June 2000 for Phetchaburi Province (Table 6, 7, and 8).

Table 6. Species, frequency of occurrence, maximum, and minimum abundance of rhizomedusae at Chon Buri and Phetchaburi Provinces. (*economic species, **extra sampling outside the usual sampling area)

Species	Chon Buri			Phetchaburi		
	Months	Max.	Min.	Months	Max.	Min.
<i>Cassiopea andromeda</i>	Jan'00, Feb'00, Mar'00, May'00, Oct'00	Mar'00	Oct'00	Dec'99, Jan'00, Feb'00, Apr'00, Jun'00, Jul'00, Aug'00, Dec'00	Jun'00	Feb'00, Jul'00
<i>Acromitus flagellatus</i>	Feb'00, Mar'00, May'00	Mar'00	Feb'00	Jan'00, Apr'00, May'00, Jun'00, Aug'00, Oct'00, Nov'00, Dec'00	Nov'00	Jan'00, May'00
<i>Acromitus hardenbergi</i>	Mar'00, May'00	Mar'00	May'00	Jan'00, Apr'00, Jun'00, Aug'00, Oct'00, Nov'00, Dec'00	Oct'00	Jan'00, Dec'00
<i>Catostylus townsendi</i>	-	-	-	Jan'00, Feb'00, Apr'00, May'00, Jun'00, Aug'00	Aug'00	Feb'00
<i>Lobonema smithii</i> *	-	-	-	Jun'00, Jul'00	Jul'00	Jun'00
<i>Rhopilema hispidum</i> *	Aug'00**	-	-	Jul'00	-	-

Table 7. Species and abundance of scyphomedusae obtained from 3 sampling transects at Chon Buri Province from December 1999 to December 2000. (Unit: individuals · 10⁴ m⁻³)

Date	Line 1		Line 2		Line 3	
	Species	Abun.	Species	Abun.	Species	Abun.
12-21-99	No jellyfish		No Jellyfish		No jellyfish	
01-22-00	<i>Cassiopea andromeda</i>	0.26	<i>Cassiopea andromeda</i> Unknown	0.88 0.29	<i>Cassiopea andromeda</i>	0.34
02-19-00	<i>Cassiopea andromeda</i>	0.58	<i>Acromitus flagellatus</i>	0.54	<i>Cassiopea andromeda</i>	0.96
03-21-00	<i>Acromitus flagellatus</i> <i>Acromitus hardenbergi</i> <i>Cassiopea andromeda</i> Unknown	16.15 0.84 0.28 0.56	<i>Acromitus flagellatus</i> <i>Acromitus hardenbergi</i> <i>Cassiopea andromeda</i> Unknown	29.97 5.66 1.13 2.26	<i>Acromitus flagellatus</i> <i>Acromitus hardenbergi</i> <i>Cassiopea andromeda</i> Other (Cubozoa)	11.17 0.29 2.29 0.57
04-22-00	No jellyfish		No jellyfish		No jellyfish	
05-14-00	<i>Acromitus flagellatus</i> Unknown	0.23 0.23	<i>Acromitus flagellatus</i>	1.13	<i>Acromitus flagellatus</i> <i>Acromitus hardenbergi</i> <i>Cassiopea andromeda</i> Unknown	2.63 0.58 0.29 1.17
06-15-00	No jellyfish		No jellyfish		No jellyfish	
07-15-00	No jellyfish		No jellyfish		No jellyfish	
08-18-00	No jellyfish		No jellyfish		No jellyfish	
09-16-00	No jellyfish		No jellyfish		No jellyfish	
10-17-00	No jellyfish		No jellyfish		<i>Cassiopea andromeda</i>	0.20
11-11-00	No jellyfish		No jellyfish		No jellyfish	
12-15-00	No jellyfish		No jellyfish		No jellyfish	

Table 8. Species and abundance of scyphomedusae obtained from 3 sampling transects at Phetchaburi Province from December 1999 to December 2000. (Unit: individuals · 10⁴ m⁻³)

Date	Line 1		Line 2		Line 3	
	Species	Abun.	Species	Abun.	Species	Abun.
12-22-99	<i>Cassiopea andromeda</i>	0.36	<i>Cassiopea andromeda</i>	2.54	<i>Cassiopea andromeda</i>	2.04
01-24-00	<i>Acromitus flagellatus</i> <i>Cassiopea andromeda</i> <i>Catostylus townsendi</i>	0.75 0.38 0.75	<i>Acromitus flagellatus</i> <i>Acromitus hardenbergi</i> <i>Cassiopea andromeda</i>	0.52 1.03 1.55	<i>Acromitus flagellatus</i> <i>Cassiopea andromeda</i> Other (Semeostomeae)	0.62 9.26 0.62
02-20-00	No jellyfish		<i>Cassiopea andromeda</i> <i>Catostylus townsendi</i>	0.61 0.61	Other (Semeostomeae)	1.16
03-22-00	No jellyfish		No jellyfish		Other (Semeostomeae)	0.56

Table 8. (Cont.) Species and abundance of scyphomedusae obtained from 3 sampling transects at Phetchaburi Province from December 1999 to December 2000. (Unit: individuals · 10⁴ m⁻³)

Date	Line 1		Line 2		Line 3	
	Species	Abun.	Species	Abun.	Species	Abun.
04-23-00	<i>Acromitus flagellatus</i>	4.09	<i>Acromitus flagellatus</i>	0.46	<i>Acromitus flagellatus</i>	3.95
	<i>Acromitus hardenbergi</i>	0.68	<i>Acromitus hardenbergi</i>	0.92	<i>Acromitus hardenbergi</i>	0.49
	<i>Cassiopea andromeda</i>	2.73	<i>Cassiopea andromeda</i>	4.14	<i>Cassiopea andromeda</i>	0.49
	<i>Catostylus townsendi</i>	1.36	Other (Semeostomeae)	0.92	<i>Catostylus townsendi</i>	0.99
	Unknown	2.04	Unknown	0.92	Unknown	1.98
05-15-00	<i>Acromitus flagellatus</i>	0.66	<i>Acromitus flagellatus</i>	1.96	Other (Cubozoa)	1.89
	Other (Semeostomeae)	2.64	<i>Catostylus townsendi</i>	1.31	Other (Semeostomeae)	15.78
	Unknown	0.66	Other (Semeostomeae)	33.33		
06-14-00	<i>Acromitus flagellatus</i>	16.84	<i>Acromitus flagellatus</i>	16.60	<i>Acromitus flagellatus</i>	7.65
	<i>Acromitus hardenbergi</i>	2.11	<i>Acromitus hardenbergi</i>	1.28	<i>Acromitus hardenbergi</i>	2.04
	<i>Cassiopea andromeda</i>	21.05	<i>Cassiopea andromeda</i>	3.40	<i>Cassiopea andromeda</i>	3.57
			<i>Catostylus townsendi</i>	0.85	<i>Catostylus townsendi</i>	1.02
			<i>Lobonema smithii</i>	0.43	<i>Lobonema smithii</i>	0.51
			Other (Cubozoa)	0.43		
			Unknown	0.43		
07-14-00	<i>Cassiopea andromeda</i>	0.59	<i>Lobonema smithii</i>	9.43	<i>Lobonema smithii</i>	13.77
	<i>Lobonema smithii</i>	5.87	<i>Rhopilema hispidum</i>	0.41		
	Other (<i>Aurelia aurita</i>)	2.93				
08-16-00	<i>Acromitus flagellatus</i>	10.53	<i>Acromitus flagellatus</i>	3.62	<i>Acromitus flagellatus</i>	4.88
	<i>Acromitus hardenbergi</i>	0.88	<i>Cassiopea andromeda</i>	1.03	<i>Acromitus hardenbergi</i>	0.89
	<i>Cassiopea andromeda</i>	0.88	<i>Catostylus townsendi</i>	3.62	<i>Cassiopea andromeda</i>	3.10
	<i>Catostylus townsendi</i>	1.75	Unknown	0.52	<i>Catostylus townsendi</i>	5.32
	Unknown	1.75			Unknown	0.44
09-17-00	No jellyfish		No jellyfish		No jellyfish	
10-18-00	<i>Acromitus flagellatus</i>	5.84	<i>Acromitus flagellatus</i>	42.36	<i>Acromitus flagellatus</i>	23.26
	<i>Acromitus hardenbergi</i>	3.25	<i>Acromitus hardenbergi</i>	4.86	<i>Acromitus hardenbergi</i>	8.79
	Unknown	1.30			Unknown	2.58
11-12-00	<i>Acromitus flagellatus</i>	139.20	<i>Acromitus flagellatus</i>	114.49	<i>Acromitus flagellatus</i>	646.65
					<i>Acromitus hardenbergi</i>	4.73
					Unknown	2.03
12-16-00	<i>Acromitus flagellatus</i>	1.45	<i>Acromitus flagellatus</i>	1.09	<i>Acromitus flagellatus</i>	2.68
	<i>Acromitus hardenbergi</i>	0.73	<i>Cassiopea andromeda</i>	0.73	<i>Cassiopea andromeda</i>	0.38
	<i>Cassiopea andromeda</i>	0.36			Unknown	0.38

The average weight of each species of rhizomedusae obtained from each month, from December 1999 to December 2000 at Chon Buri Province, appeared to be related to the abundance with the exception of *Cassiopea andromeda* (Figure 19). *C. andromeda* was found in highest abundance ($> 1 \text{ individuals} \cdot 10^4 \text{ m}^{-3}$) during March 2000. However, the highest weight of *C. andromeda* ($> 106 \text{ g}$) was observed in January 2000 due to the fact that most specimens were relatively larger, with the largest specimen measured 15 cm in diameter, compared to other months (Figure 19A). The highest abundance and weight of both *Acromitus flagellatus* and *Acromitus hardenbergi* were observed in March 2000 (Figure 19B and C).

At Phetchaburi Province, the highest abundance of *C. andromeda* was observed in June 2000 ($> 9 \text{ individuals} \cdot 10^4 \text{ m}^{-3}$). On the contrary, the highest weight observed was in April 2000 (Figure 20A). The abundance and the weight of *A. flagellatus* found at Phetchaburi Province were in correlation with each other. Both the highest abundance ($> 300 \text{ individuals} \cdot 10^4 \text{ m}^{-3}$) and weight ($> 75,000 \text{ g}$) was observed in November 2000 (Figure 20B). A similar trend was observed for *Catostylus townsendi*, *Lobonema smithii*, and *Rhopilema hispidum*, where the highest abundance and weight were observed in the same month (Figure 20D, E, and F). The highest abundance of *A. hardenbergi* was observed in October 2000 ($> 5 \text{ individuals} \cdot 10^4 \text{ m}^{-3}$) while the highest weight of rhizomedusae was observed in June 2000 ($> 340 \text{ g}$) (Figure 20C).

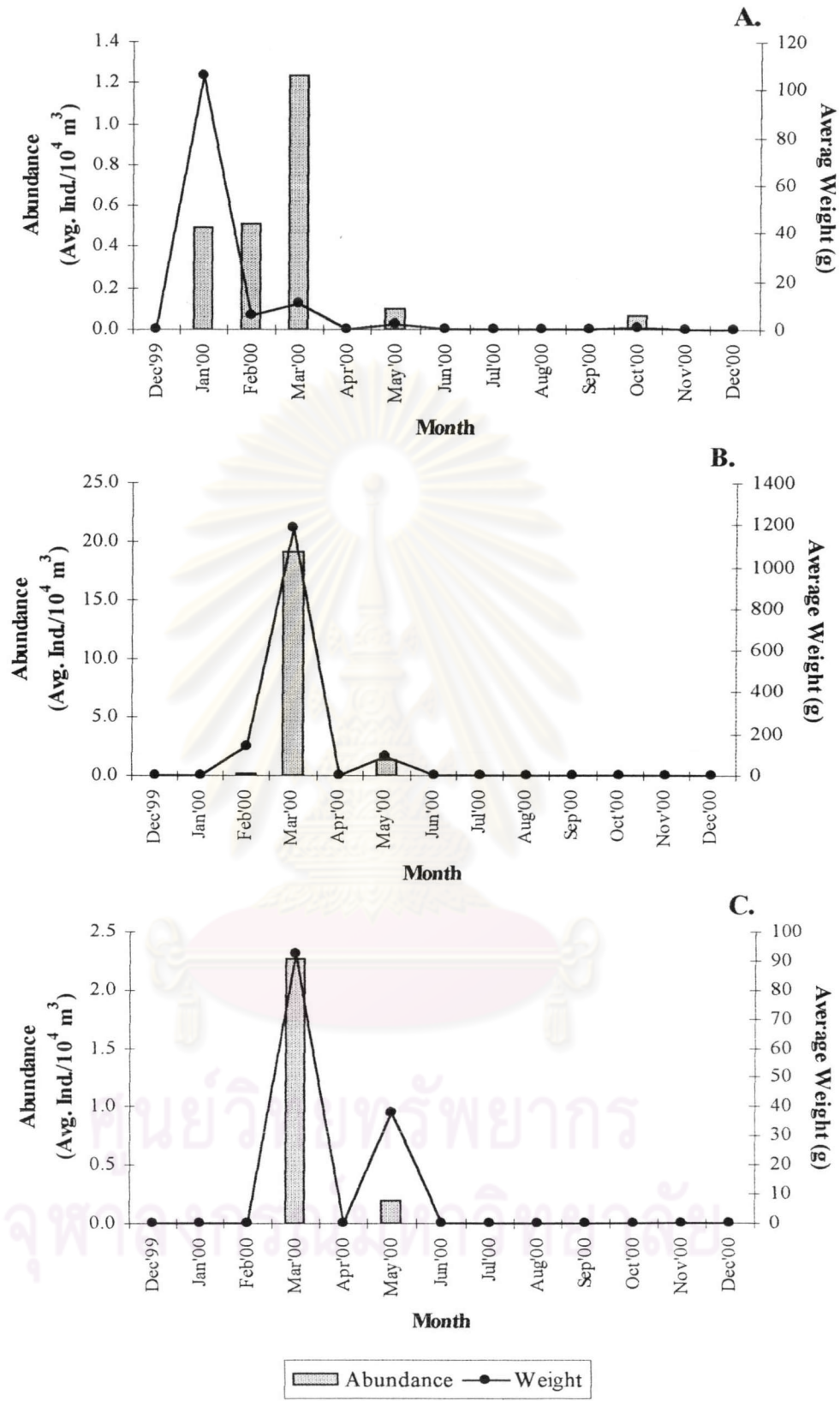


Figure 19. Abundance and average weight of (A) *Cassiopea andromeda*, (B) *Acromitus flagellatus*, (C) *Acromitus hardenbergi*, and (D) *Rhopilema hispidum* (extra sampling) at Chon Buri Province from December 1999 to December 2000.

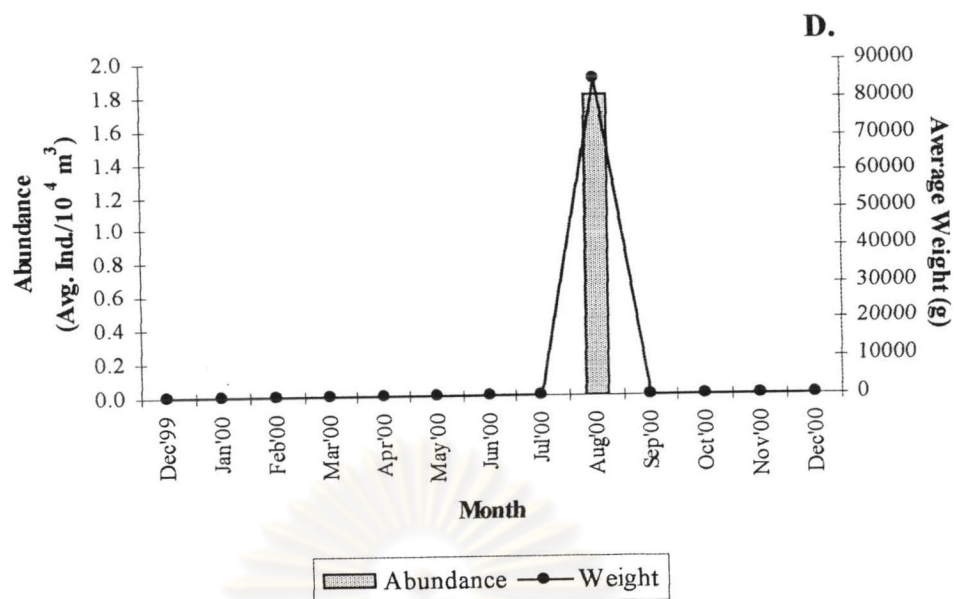


Figure 19. (Cont.) Abundance and average weight of (A) *Cassiopea andromeda*, (B) *Acromitus flagellatus*, (C) *Acromitus hardenbergi*, and (D) *Rhopilema hispidum* (extra sampling) at Chon Buri Province from December 1999 to December 2000.

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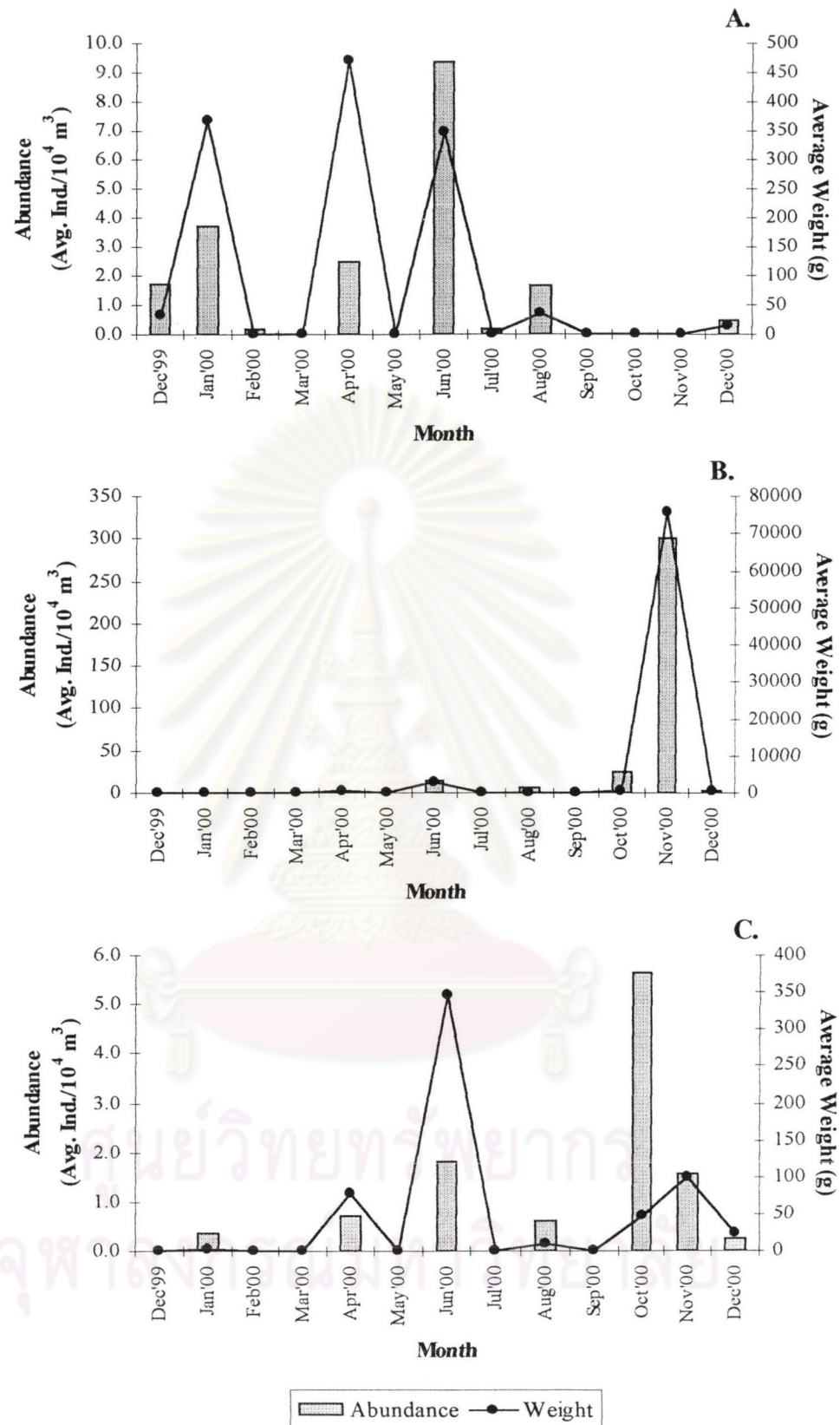


Figure 20. Abundance and average weight of (A) *Cassiopea andromeda*, (B) *Acromitus flagellatus*, (C) *Acromitus hardenbergi*, (D) *Catostylus townsendi*, (E) *Lobonema smithii*, and (F) *Rhopilema hispidum* at Phetchaburi Province from December 1999 to December 2000.

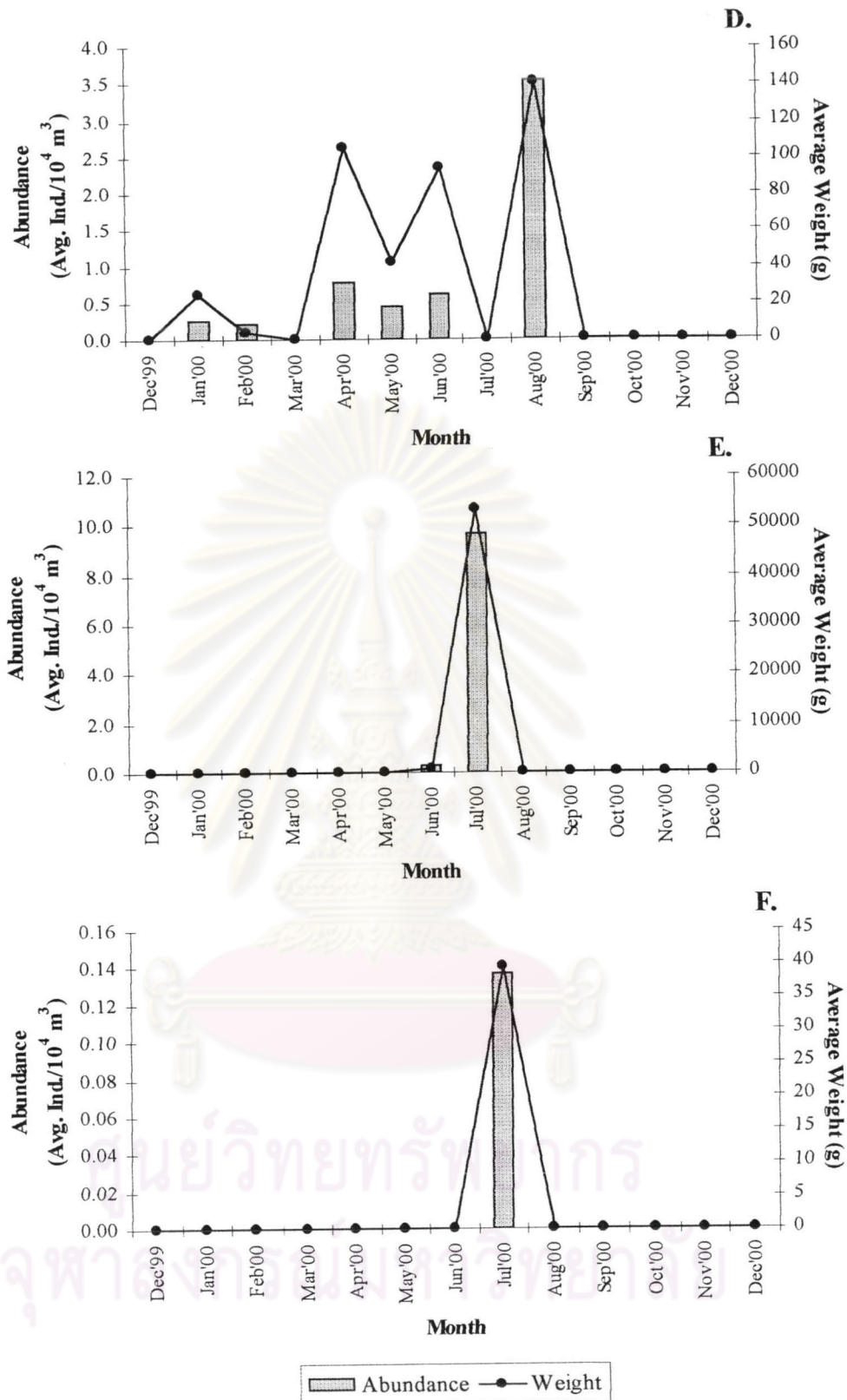


Figure 20. (Cont.) Abundance and average weight of (A) *Cassiopea andromeda*, (B) *Acromitus flagellatus*, (C) *Acromitus hardenbergi*, (D) *Catostylus townsendi*, (E) *Lobonema smithii*, and (F) *Rhopilema hispidum* at Phetchaburi Province from December 1999 to December 2000.

At the beginning of the sampling period, specimens obtained from Chon Buri Province were predominantly *Cassiopea andromeda*. By February 2000, *Acromitus flagellatus* began to appear and became dominant with small-size individuals in March and May 2000. In addition, *A. hardenbergi* of wide size range was also found. However, by October 2000, *C. andromeda* was the only species obtained from sampling (Figure 21). In August 2000, extra sampling was conducted outside the usual sampling area and the only species found was *Rhopilema hispidum*.

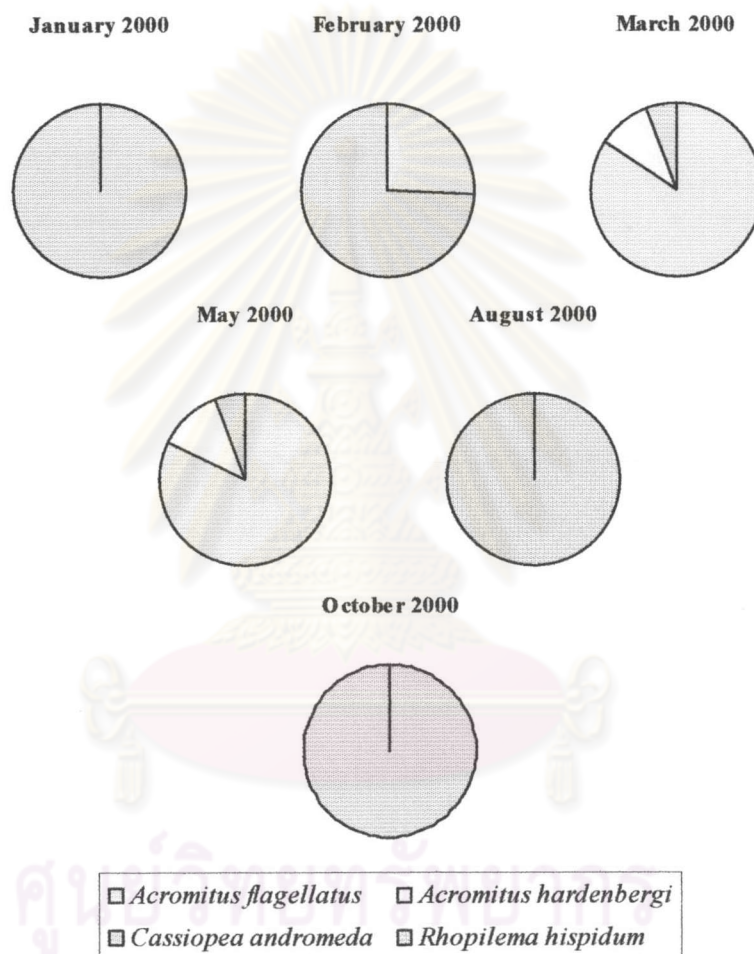


Figure 21. Monthly variation in species abundance at Chon Buri Province from December 1999 to December 2000.

At Phetchaburi Province, in December 1999, the only species obtained from sampling was *Cassiopea andromeda*, which was also the predominating species in January 2000. In addition to *C. andromeda*, *Acromitus flagellatus*, *A. hardenbergi*, and *Catostylus townsendi* were also found in January 2000, but not in February 2000. This is perhaps due to the different reproduction period, which will be discussed in the following

section. In February 2000, *C. andromeda* and *C. townsendi* were found in equal abundance. The predominating species in April, May, and June 2000 was *A. flagellatus*. *Lobonema smithii* was first obtained in June 2000 and became the species dominated the jellyfish abundance in July 2000. *Acromitus flagellatus* was the predominating species for the rest of the sampling period; August, October, November, and December 2000 (Figure 22).

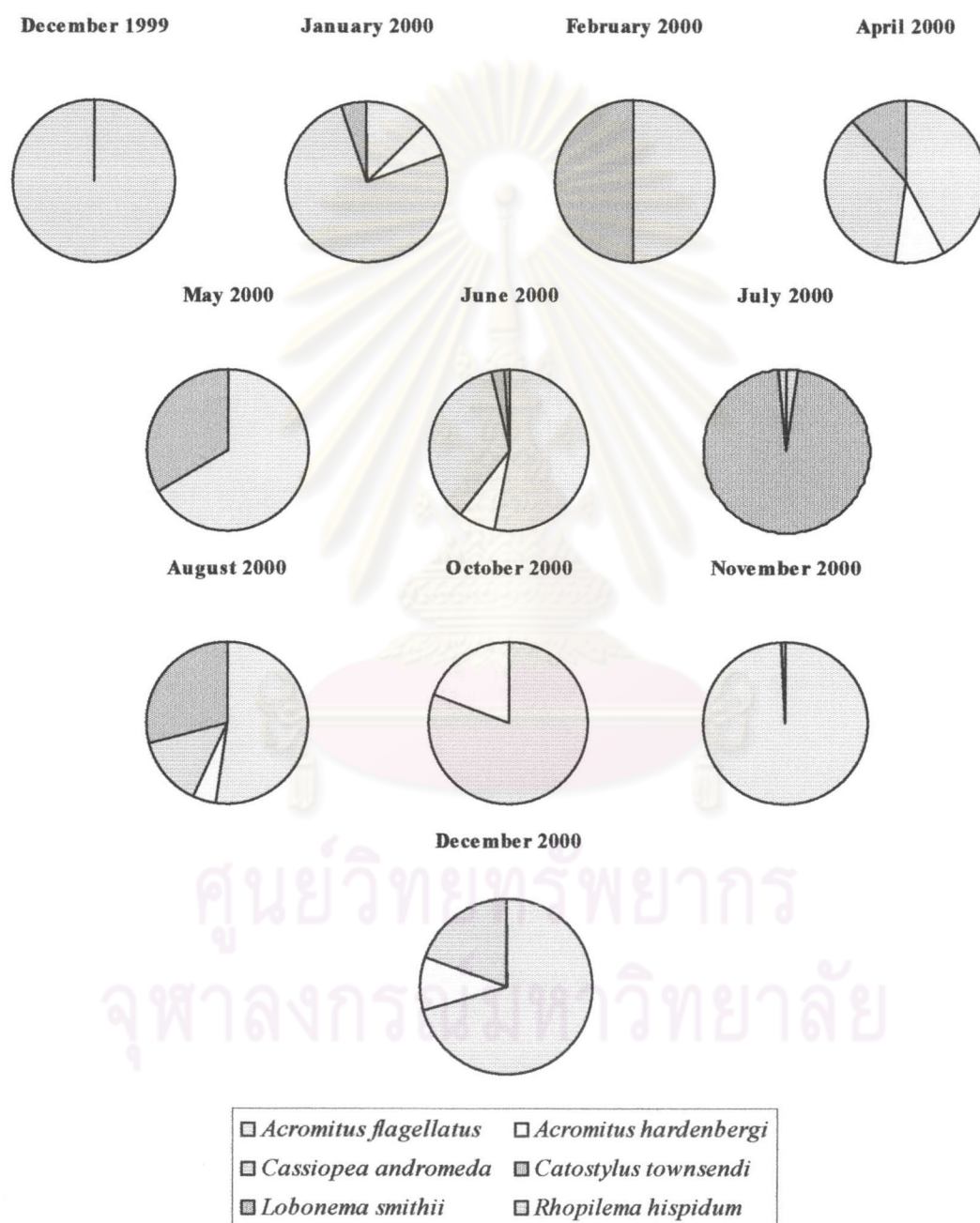


Figure 22. Monthly variation in species abundance at Phetchaburi Province from December 1999 to December 2000.

III. Size Distribution

In January 2000, at Chon Buri Province, *Cassiopea andromeda* specimens obtained were in various sizes ranging from 5 to 15 cm. Large specimens were not found in February 2000. Instead, relatively smaller sizes (1-7 cm) appeared in February and March 2000 (Figure 23). The majority of *C. andromeda* obtained from Phetchaburi Province in December 1999 was between 1-7 cm. In January 2000, the variation in sizes ranged from 1 to 19 cm, which was predominated by sizes smaller than 7 cm. Only few small-size specimens were found in February 2000. By April 2000, larger specimens of up to 25 cm were obtained in addition to the predominating smaller sizes. In June 2000, extremely small and large sizes disappeared. Specimens found were in medium size range (4-16 cm). Specimens larger than 11 cm were not found for the rest of the sampling period except in August 2000 where few specimens of approximately 14 cm in diameter were found (Figure 24).

At Chon Buri Province, relatively large *Acromitus flagellatus* of 14-16 cm were found in February 2000. Thereafter, the size of obtained specimens shifted to smaller size classes in March 2000 (2-13 cm) and May 2000 (4-8 cm) (Figure 25). In contrast, at Phetchaburi Province, most of the specimen found in January 2000 were relatively small (2-8 cm) compared to those found in February 2000 at Chon Buri Province. Relatively larger specimens (5-12 cm) were found in April and May 2000. By June 2000, specimens had shifted to larger size classes (9-17 cm). Large specimens were rarely found in August and October 2000. Instead, the majority of specimens obtained were in smaller size classes (2-9 cm). By November and December 2000, the sizes of specimens found were between 4-16 cm. However, 9-13 cm specimens were obtained in relatively large number (Figure 26).

Acromitus hardenbergi was found only in two months, March and May 2000, in Chon Buri Province. In March 2000, specimens were relatively small in size (2-8 cm) compared to May 2000 where relatively larger specimens (9-10 cm) were found (Figure 27). At Phetchaburi Province, the size classes of *A. hardenbergi* shifted throughout the sampling period. In January 2000, obtained specimens were relatively small (2-4 cm). The size classes increased to 7-11 cm in April and to relatively larger sizes (9-14 cm) in

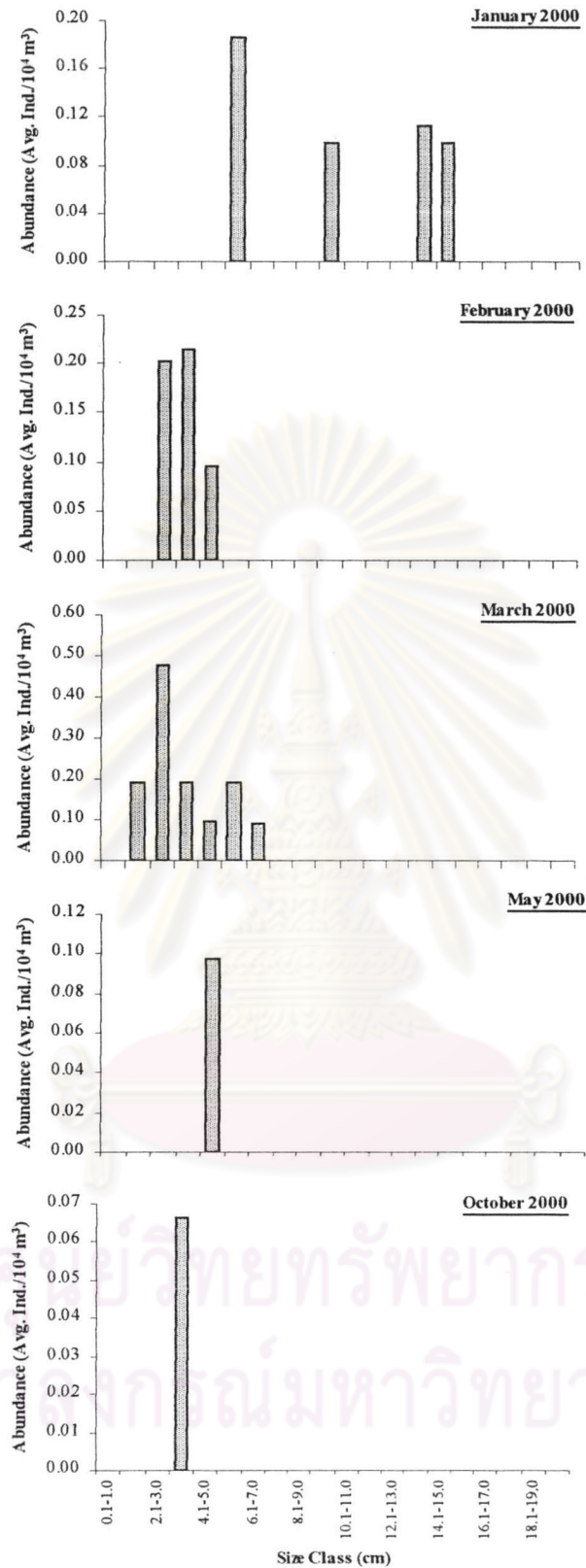


Figure 23. Size class distribution for *Cassiopea andromeda* at Chon Buri Province from December 1999 to December 2000.

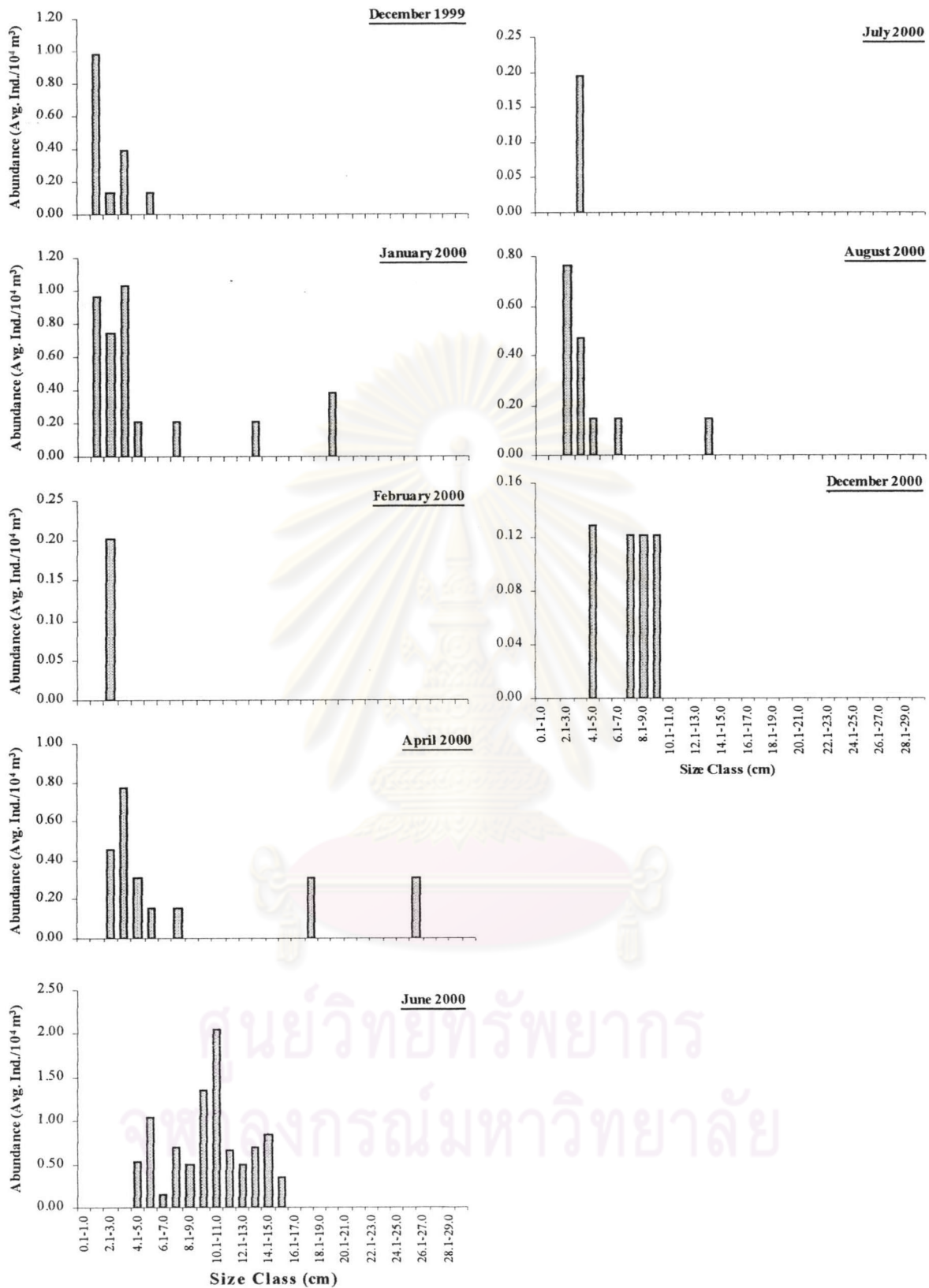


Figure 24. Size class distribution of *Cassiopea andromeda* at Phetchaburi Province from December 1999 to December 2000.

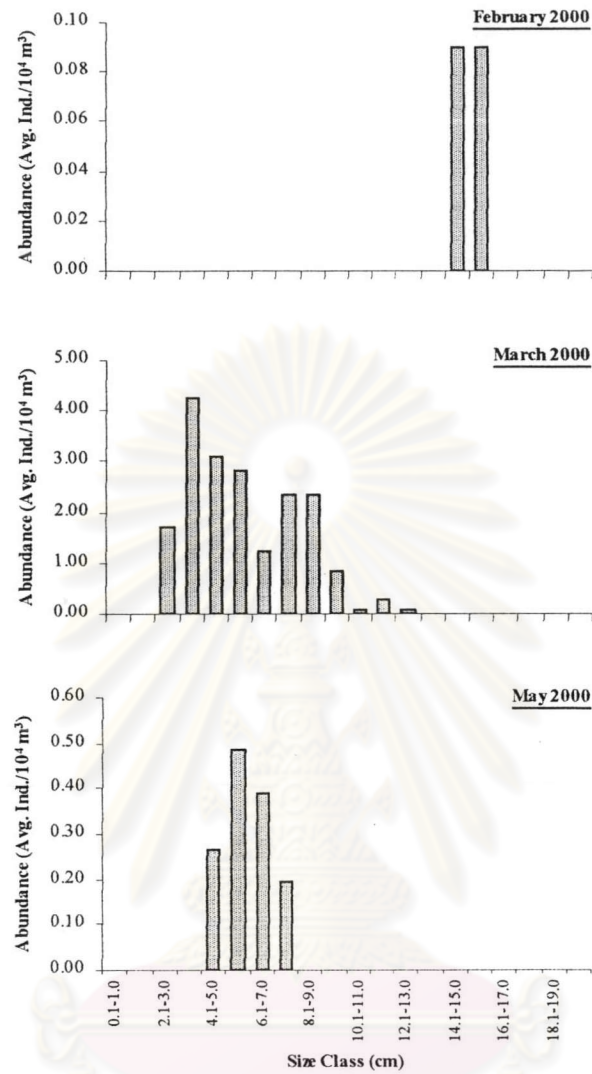


Figure 25. Size class distribution of *Acromitus flagellatus* at Chon Buri Province from December 1999 to December 2000.

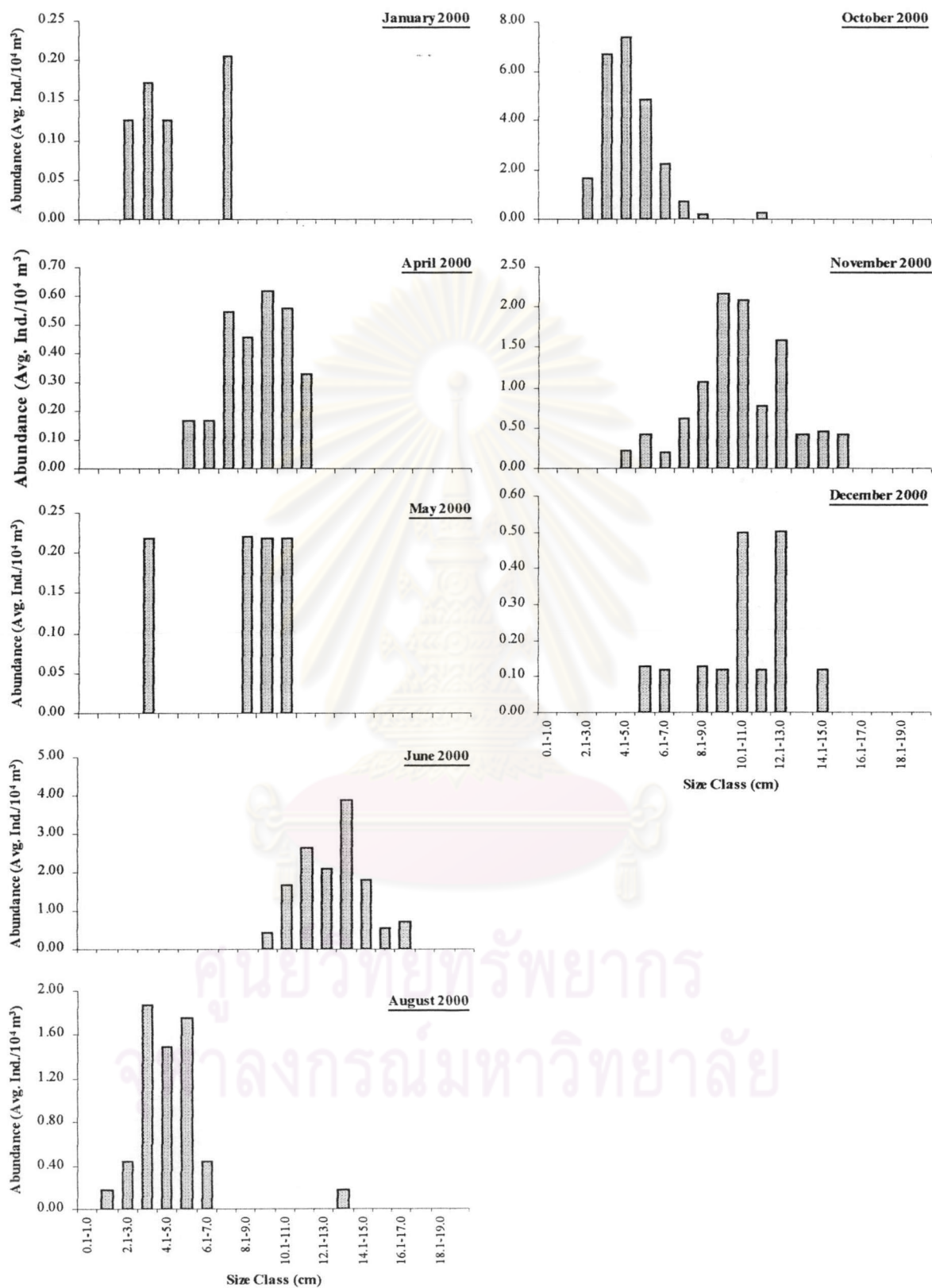


Figure 26. Size class distribution of *Acromitus flagellatus* at Phetchaburi Province from December 1999 to December 2000.

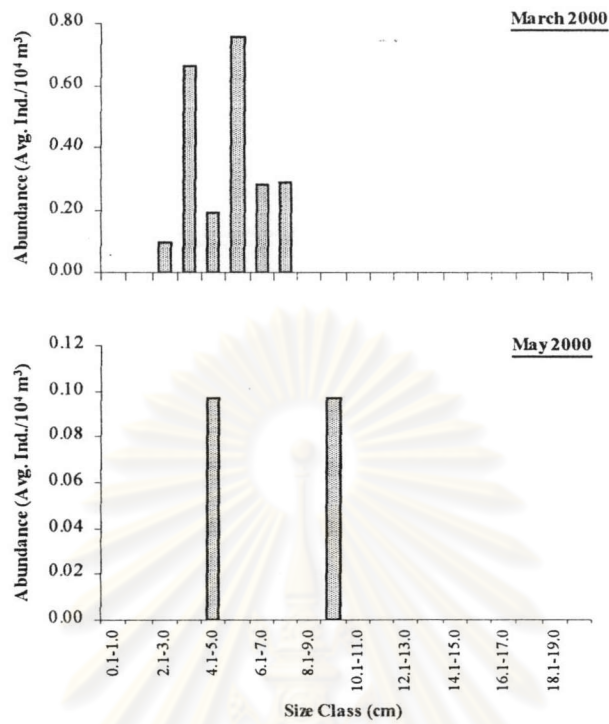


Figure 27. Size class distribution of *Acromitus hardenbergi* at Chon Buri Province from December 1999 to December 2000.

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June 2000. Smaller specimens (2-7 cm) were obtained again in August and October 2000. By November and December 2000, there was an increase in diameter of specimens to larger size classes (8-12 cm) (Figure 28).

Catostylus townsendi, only found in Phetchaburi Province, established a shift in size classes throughout the sampling period. In January and February 2000, sizes of specimens were between 4-8 cm in diameter. Sizes had increased to larger size classes (7-12 cm) in April and May 2000. Medium sizes disappeared in June 2000 and only larger sizes (10-12 cm) were obtained. Interestingly, in August 2000, specimens that were found displayed a wide range in sizes. The smallest specimens found in August 2000 were approximately 2 cm in diameter while the largest found were 10 cm in diameter. However, the majority of the specimens found in this month were between 4-6 cm (Figure 29).

Lobonema smithii, an economic species, also found only in Phetchaburi Province, were obtained only in June and July 2000. Within these two months, specimens that were found shifted from smaller sizes (24 cm and 32 cm) to relatively larger sizes (28-53 cm) by July 2000, which coincided with jellyfish fishery season. The majority of the specimens found were between 36-45 cm in diameter (Figure 30).

At Chon Buri Province, *Rhopilema hispidum* was not found within the regular sampling area. However, an additional sampling was conducted south of the regular sampling area in August 2000 and specimens were obtained. *R. hispidum* that were obtained from this area ranged from 16.1 cm to 54 cm in diameter. Specimens that were 30 cm in diameter were found in highest abundant while the second most abundant were specimens with bell diameter of 39 cm (Figure 31). At Phetchaburi Province, *R. hispidum* were found only in July 2000 and specimens were 15 cm in diameter (Figure 32).

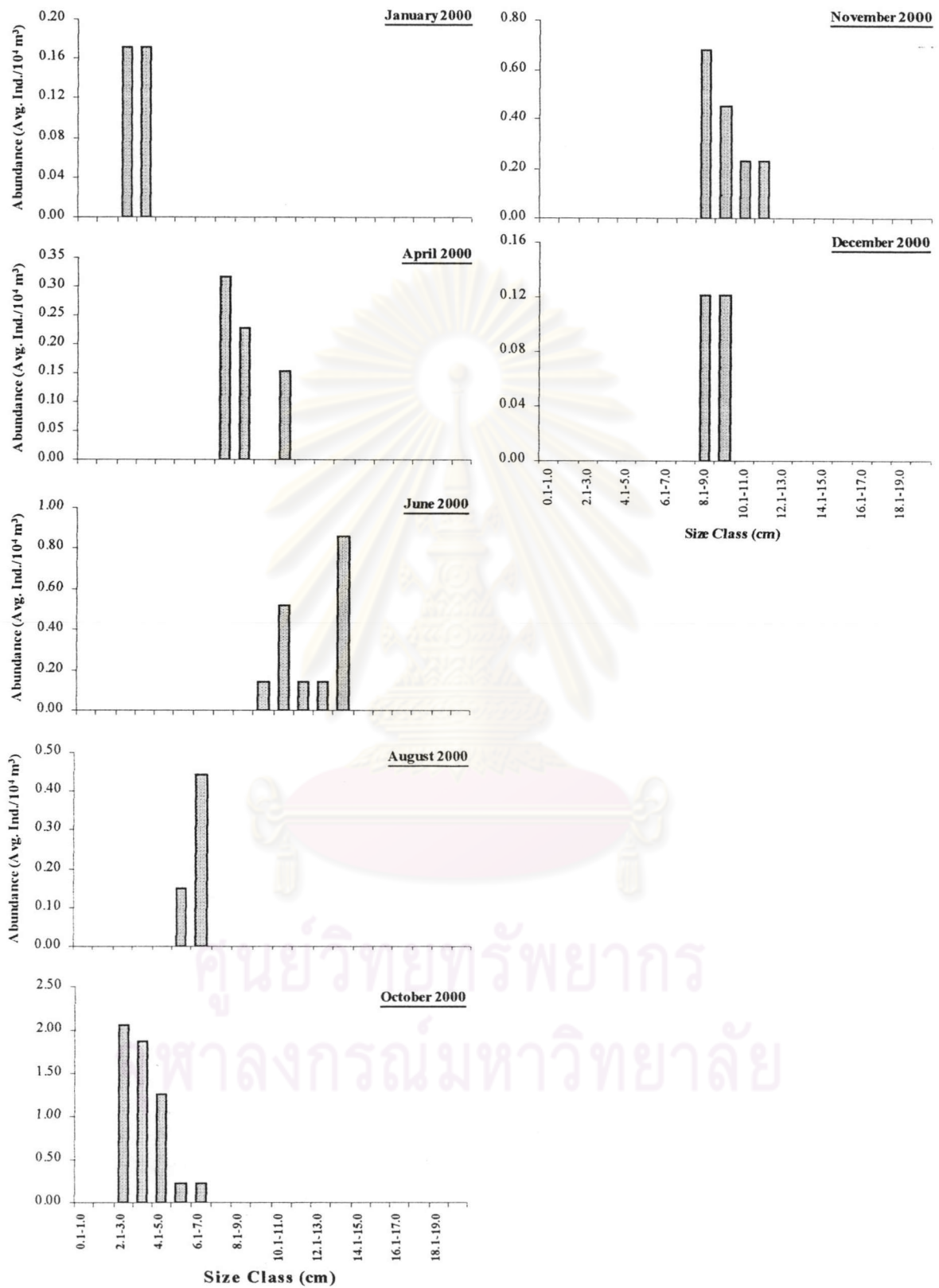


Figure 28. Size class distribution of *Acromitus hardenbergi* at Phetchaburi Province from December 1999 to December 2000.

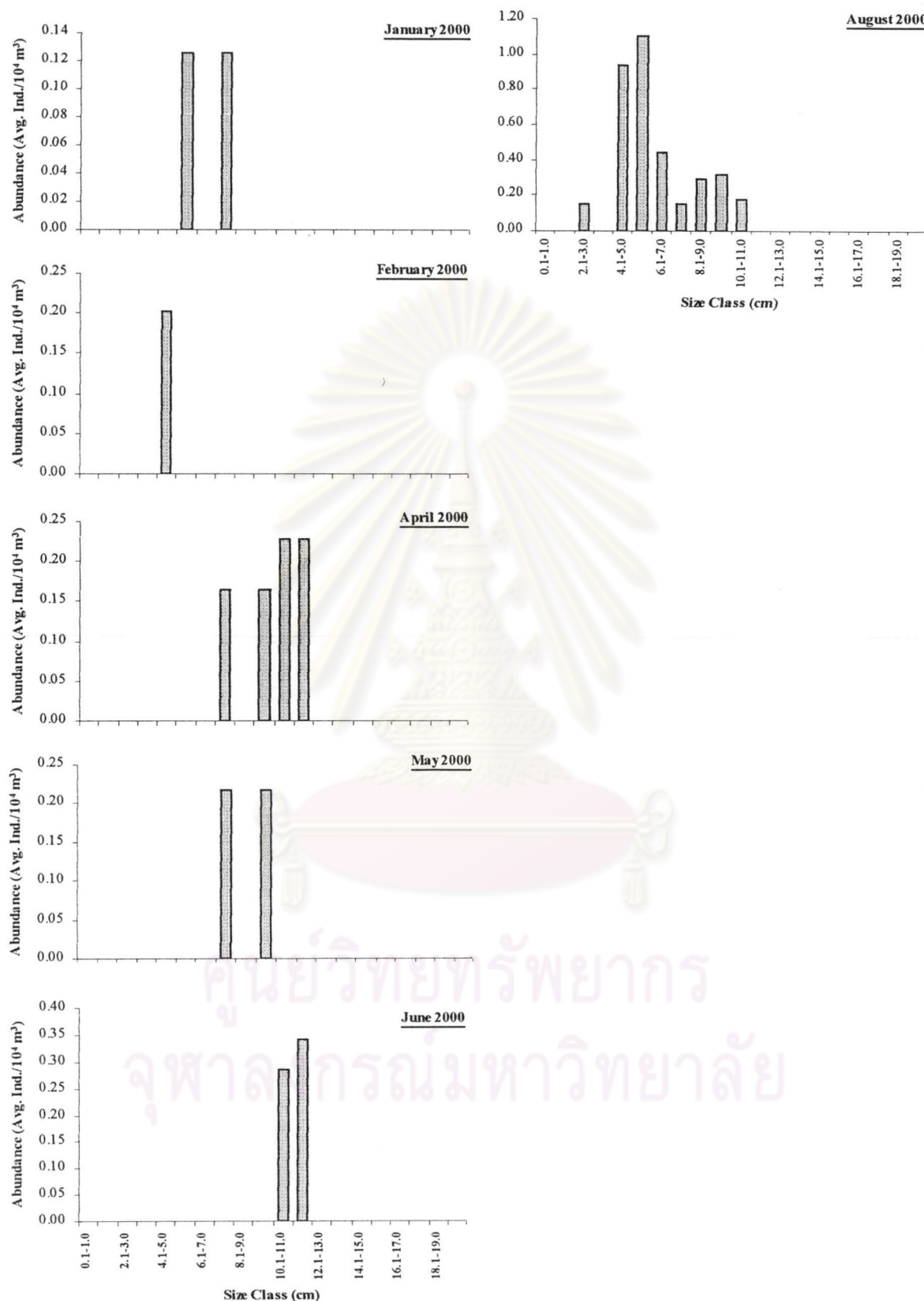


Figure 29. Size class distribution of *Catostylus townsendi* at Phetchaburi Province from December 1999 to December 2000.

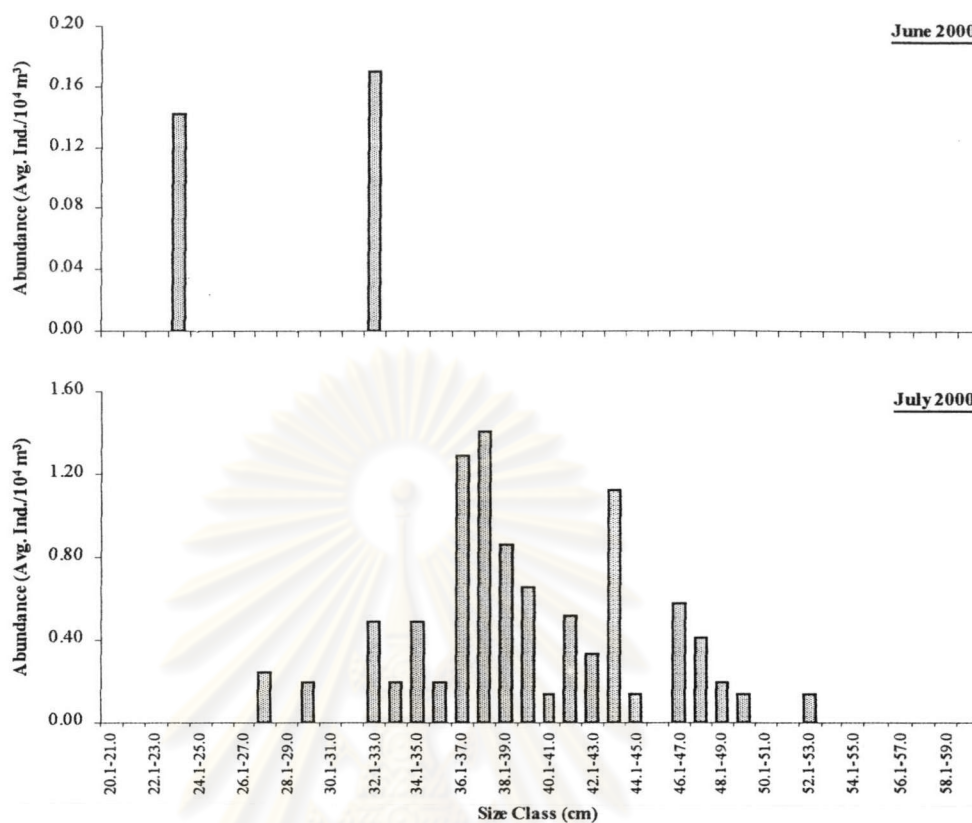


Figure 30. Size class distribution of *Lobonema smithii* at Phetchaburi Province from December 1999 to December 2000.

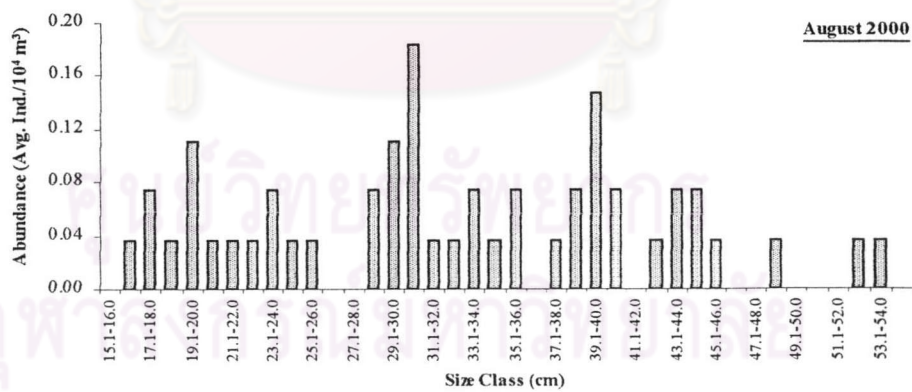


Figure 31. Size class distribution of *Rhopilema hispidum* at Chon Buri Province in August 2000.

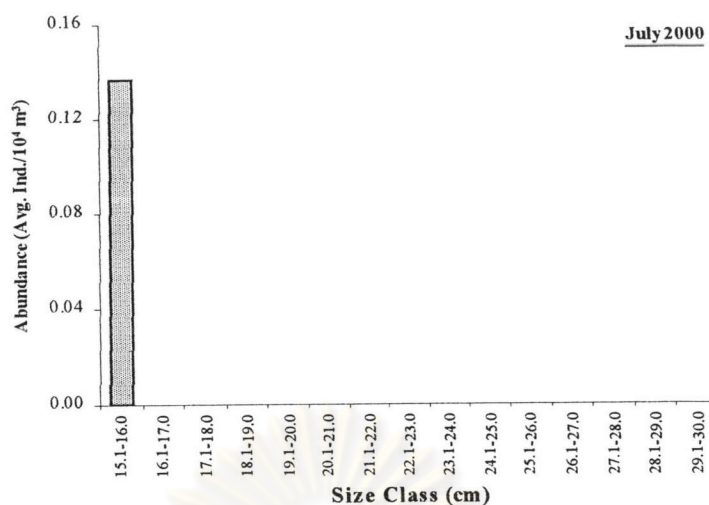


Figure 32. Size class distribution of *Rhopilema hispidum* at Phetchaburi Province from December 1999 to December 2000.

IV. Gonads

The data of gonad development of varying sizes of rhizomedusae suggested that each species reached sexual maturation at different sizes (Figure 31-36). This can be summarized as follows (Table 9):

Table 9. Sexual maturation stages of 6 species of rhizomedusae obtained from this study.

Species	Bell Diameter (cm)
<i>Cassiopea andromeda</i>	15, 26
<i>Acromitus flagellatus</i>	8, 14
<i>Acromitus hardenbergi</i>	7
<i>Catostylus townsendi</i>	6, 12
<i>Lobonema smithii</i>	> 24
<i>Rhopilema hispidum</i>	> 15

In *Cassiopea andromeda* (Figure 33), sexual maturation was not observed in small-size individuals of 1-10 cm (Figure 33A-F). However, at the size of approximately 15 cm, oocytes, testes, and sperms were observed (Figure 33G, H, and I). The blastula stage was observed in specimens the size of approximately 18 cm (Figure 33J), suggesting internal fertilization. The second sexual maturation was observed in specimens that were larger than 20 cm (Figure 33K and L).

Similar to *C. andromeda*, sexual maturation of *Acromitus flagellatus* occurred twice, at the sizes of 8 and 14 cm, where the oocytes were clearly visible (Figure 34E and K). In contrast, the oocytes of *Acromitus hardenbergi* were visible at the size of approximately 7 cm, indicating sexual maturation (Figure 35D).

In *Catostylus townsendi*, first sexual maturation was observed at the size of 6 cm (Figure 36A). Thereafter, the blastula stage was observed indicating that the fertilization occurred internally (Figure 36B, C, and D). The second sexual maturation was observed in samples obtained from specimens larger than 12 cm in diameter (Figure 36E).

Since specimens of *Lobonema smithii* and *Rhopilema hispidum* obtained from the field were large specimens, sexual maturation was observed in the smallest size obtained. In *L. smithii* and *R. hispidum*, oocytes were observed in specimens larger than 24 cm and 15 cm in diameter, respectively (Figure 37 and 38).

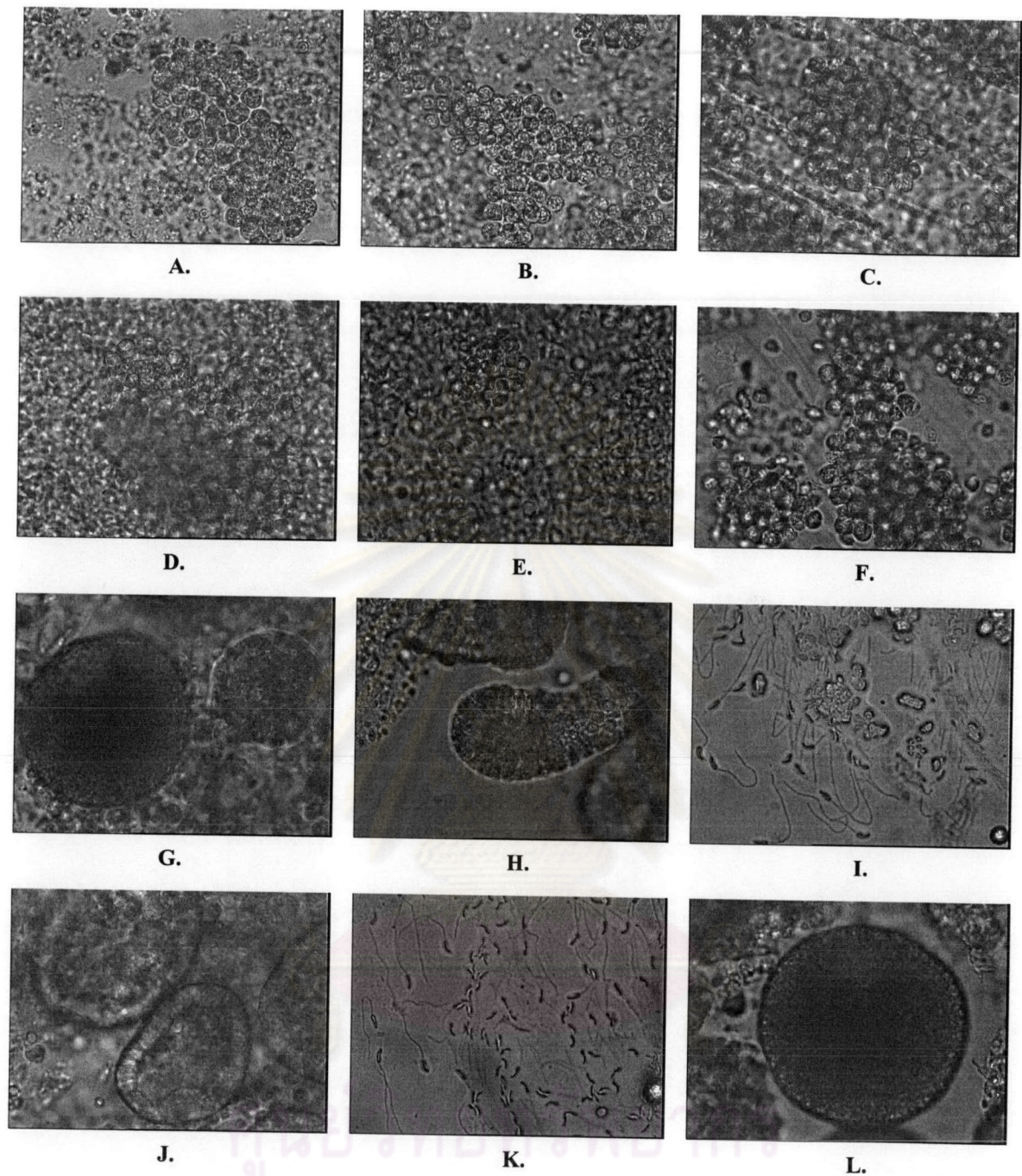


Figure 33. Gonad development of *Cassiopea andromeda*; (A) 1.5 cm, (B) 3 cm, (C) 4 cm, (D) 7 cm, (E) 8.5 cm, (F) 10.5 cm, (G) 15 cm, (H) 15 cm (spermatocytes), (I) 15 cm (sperms), (J) 18 cm, (K) 21 cm (sperms), and (L) 26 cm in diameter.

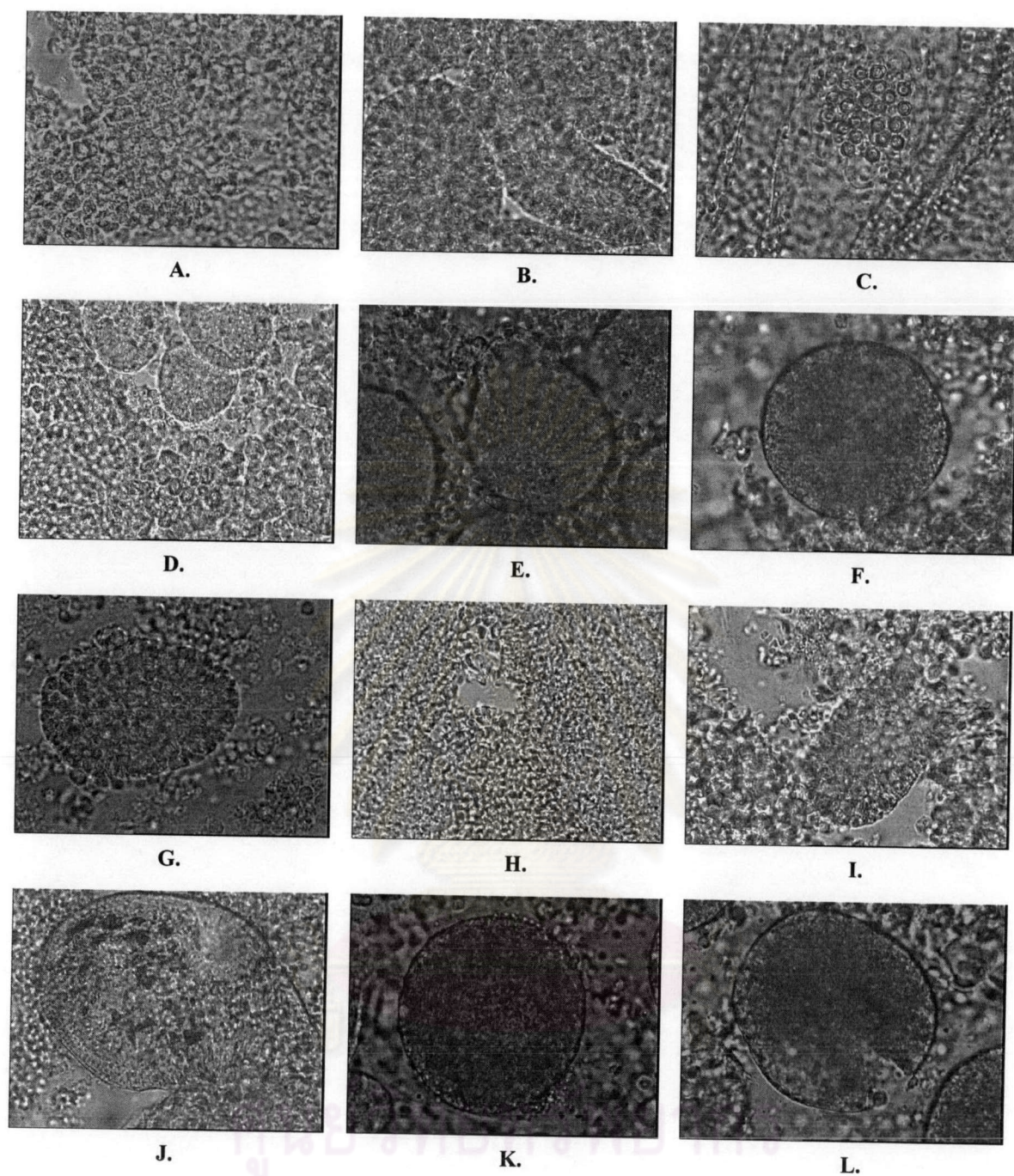


Figure 34. Gonad development of *Acromitus flagellatus*; (A) 2 cm, (B) 3.5 cm, (C) 4.5 cm, (D) 6.5 cm, (E) 8 cm, (F) 9 cm, (G) 9 cm, (H) 10 cm, (I) 10.5 cm, (J) 12.5 cm, (K) 14 cm, and (L) 15.5 cm in diameter.

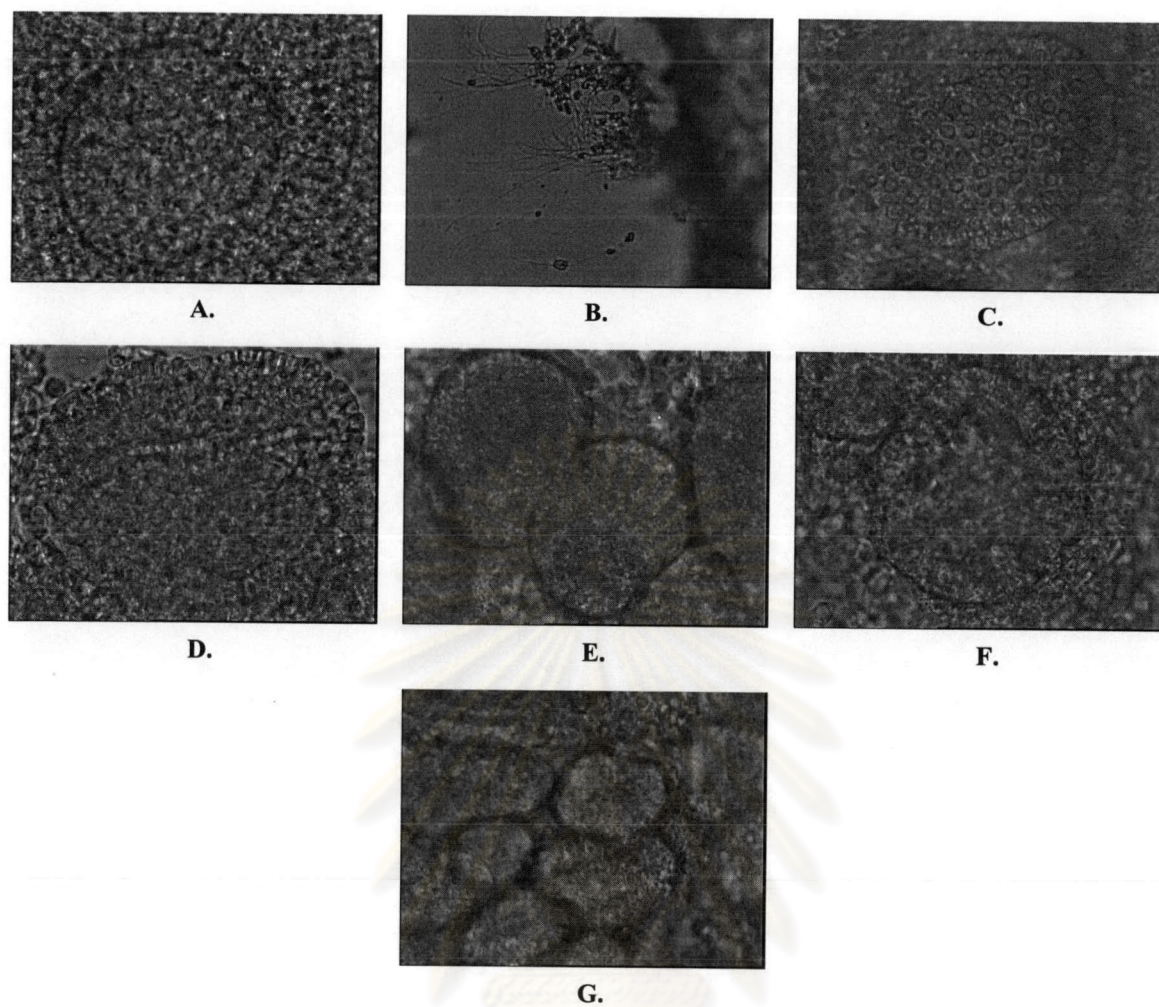


Figure 35. Gonad development of *Acromitus hardenbergi*; (A) 4.5 cm, (B) 6.5 cm (sperms), (C) 6.5 cm, (D) 7.5 cm, (E) 8.5 cm, (F) 10 cm, and (G) 11 cm in diameter.

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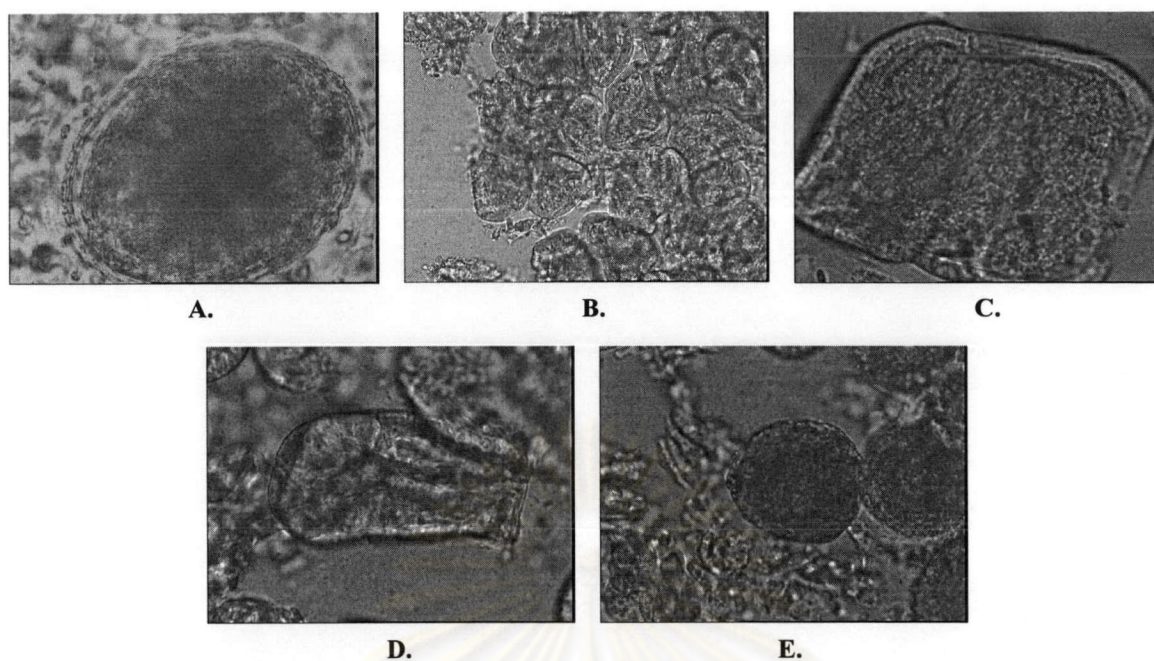


Figure 36. Gonad development of *Catostylus townsendi*; (A) 6 cm, (B) 8 cm, (C) 8.5 cm, (D) 10 cm, and (E) 12.5 cm in diameter.

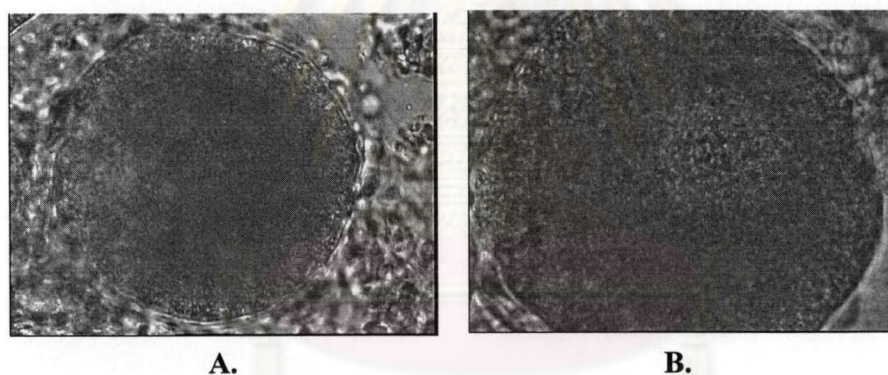


Figure 37. Gonad development of *Lobonema smithii*; (A) 24 cm and (B) 33 cm in diameter.

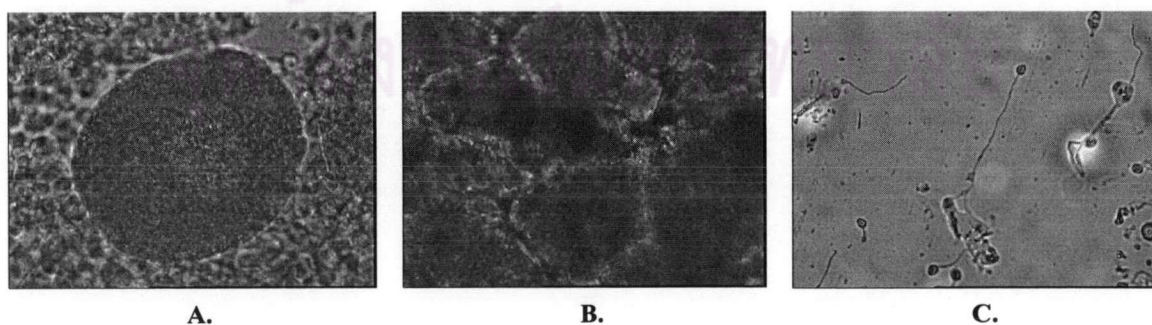


Figure 38. Gonad development of *Rhopilema hispidum*; (A) 15.5 cm, (B) 37 cm, and (C) 46 cm (sperms) in diameter.

V. Environmental Parameters

The average salinity at Chon Buri Province fluctuated severely through out the sampling period. The highest average salinity was observed in February (31.5 ± 0.1 psu) and the lowest was observed in June (0.3 ± 0.0 psu). At Phetchaburi Province, on the other hand, the highest value was observed in March (32.2 ± 0.1 psu) and the lowest in October 2000 (19.9 ± 0.9 psu) (Figure 39).

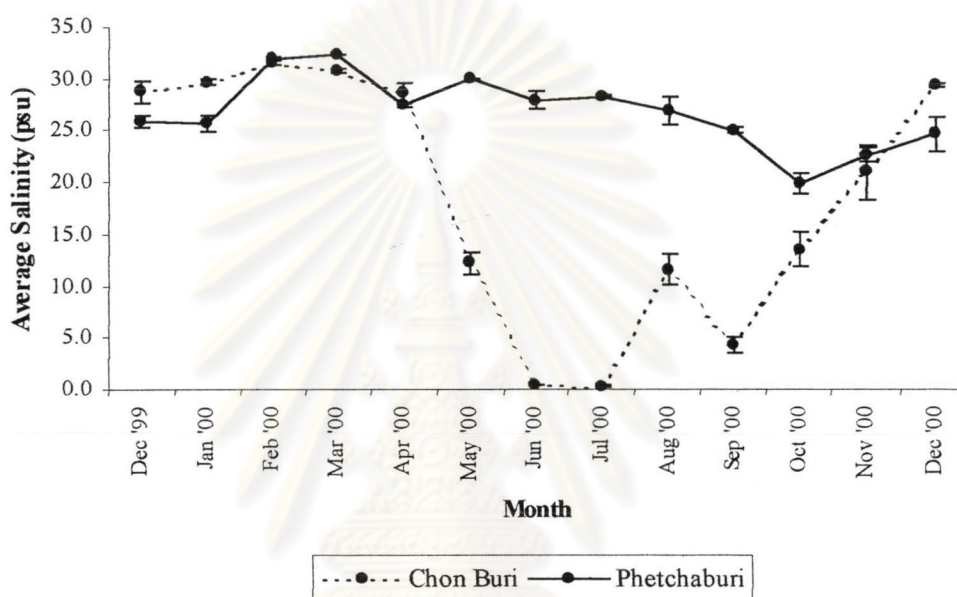


Figure 39. Average salinity at Chon Buri and Phetchaburi Province from December 1999 to December 2000.

The average pH values fluctuated through out the sampling period. At Chon Buri Province, the highest value was observed in December (8.31 ± 0.08) and the lowest in June 2000 (6.96 ± 0.08). At Phetchaburi Province, the highest value was observed in July (8.59 ± 0.08) and the lowest value was observed in December 2000 (7.52 ± 0.09) (Figure 40).

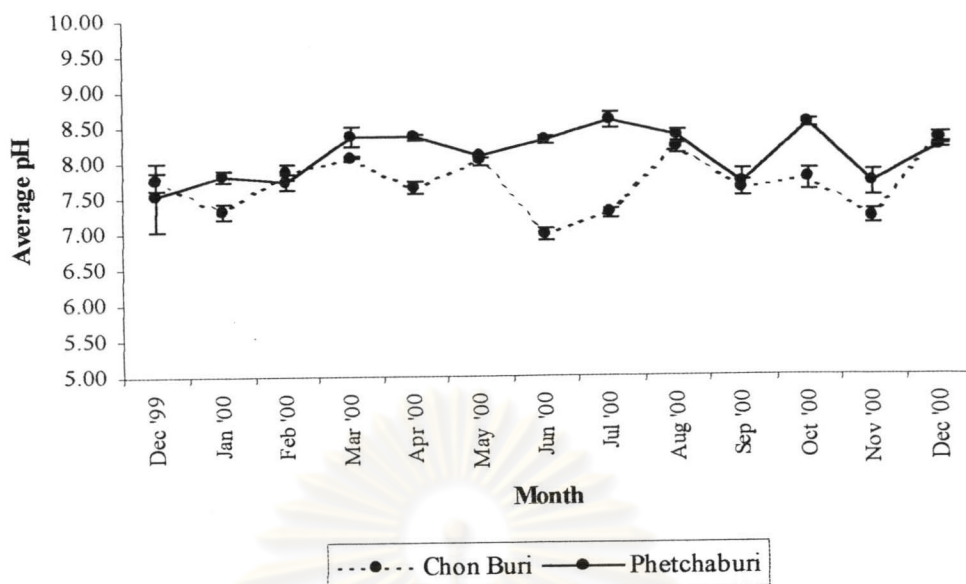


Figure 40. Average pH at Chon Buri and Phetchaburi Provinces from December 1999 to December 2000.

Evidently, the values for dissolved oxygen concentration varied throughout the sampling period. For both Chon Buri and Phetchaburi Provinces, the lowest values were observed in September. These values are 2.70 ± 0.15 mg/l for Chon Buri Province and 2.62 ± 0.18 mg/l for Phetchaburi Province (Figure 41). Comparatively, average temperature at both locations did not vary much throughout the sampling period. The lowest values were observed in the winter, December 2000, for both locations. The highest values were observed in June for Chon Buri Province (31.6 ± 0.1 °C) and in August for Phetchaburi Province (31.6 ± 0.4 °C) (Figure 42).

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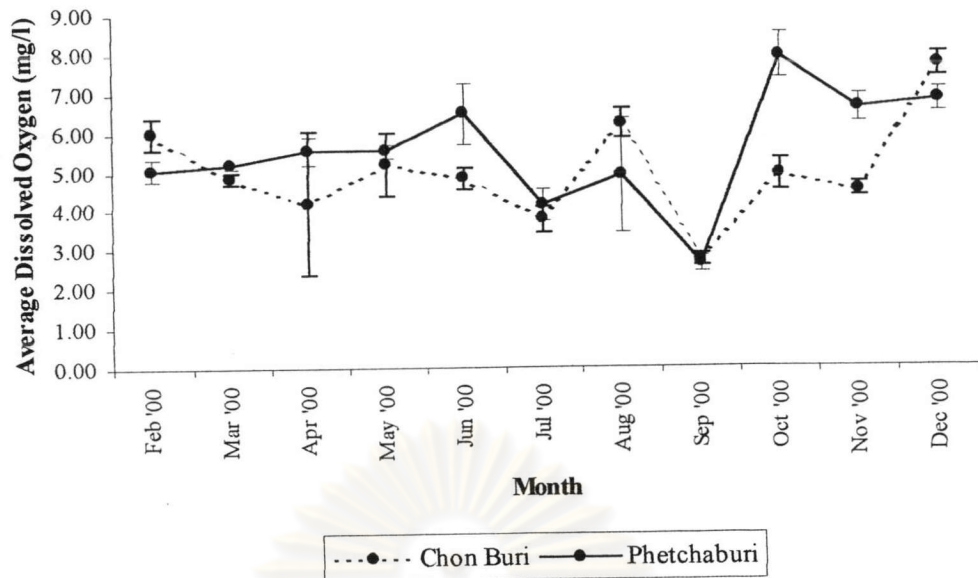


Figure 41. Average dissolved oxygen content at Chon Buri and Phetchaburi Provinces from February 2000 to December 2000.

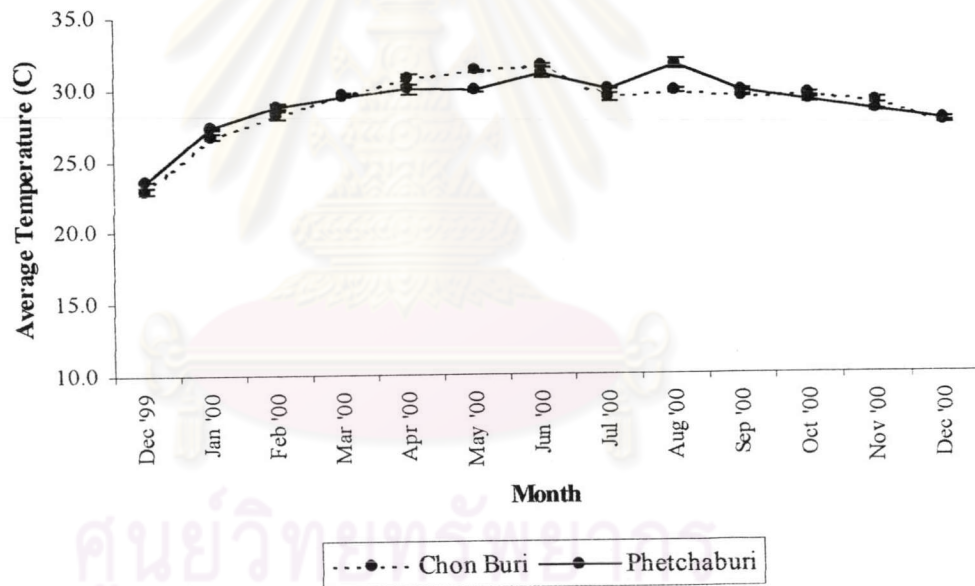


Figure 42. Average temperature at Chon Buri and Phetchaburi Provinces from December 1999 to December 2000.

At Chon Buri Province, the highest zooplankton concentration occurred during the months of November 2000 ($716,569 \text{ individuals} \cdot 10^2 \text{ m}^{-3}$), where the major fraction of zooplankton were copepods, while the lowest concentration was observed October 2000 ($71,703 \text{ individuals} \cdot 10^2 \text{ m}^{-3}$) (Figure 43A). In comparison, at Phetchaburi Province, the highest concentration was observed during October 2000 ($2,734,438 \text{ individuals} \cdot 10^2 \text{ m}^{-3}$),

where the majority of the zooplankton were decapod larvae and copepods. The lowest concentration was observed during September 2000 ($80,781 \text{ individuals} \cdot 10^2 \text{ m}^{-3}$) (Figure 43B).

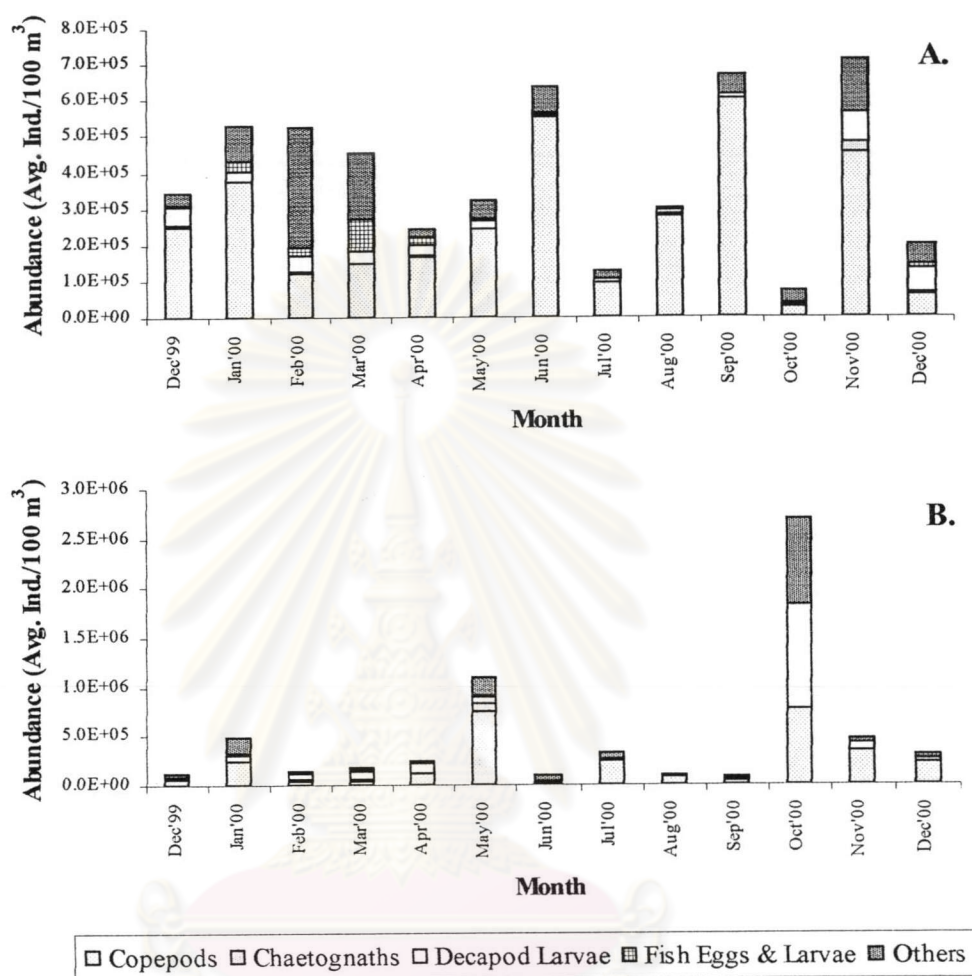


Figure 43. Average zooplankton concentration and composition at (A) Chon Buri and (B) Phetchaburi Provinces from December 1999 to December 2000.

The abundance hydromedusae at Chon Buri Province was highest in November 2000 ($> 29,000$ individuals $\cdot 10^2 \text{ m}^{-3}$) while the highest abundance ($> 51,000$ individuals $\cdot 10^2 \text{ m}^{-3}$) at Phetchaburi Province was observed in October 2000 (Figure 44). The highest abundance of scyphozoan larvae was observed in July 2000 for both Chon Buri (> 100 individuals $\cdot 10^2 \text{ m}^{-3}$) and Phetchaburi (> 300 individuals $\cdot 10^2 \text{ m}^{-3}$) Provinces (Figure 45).

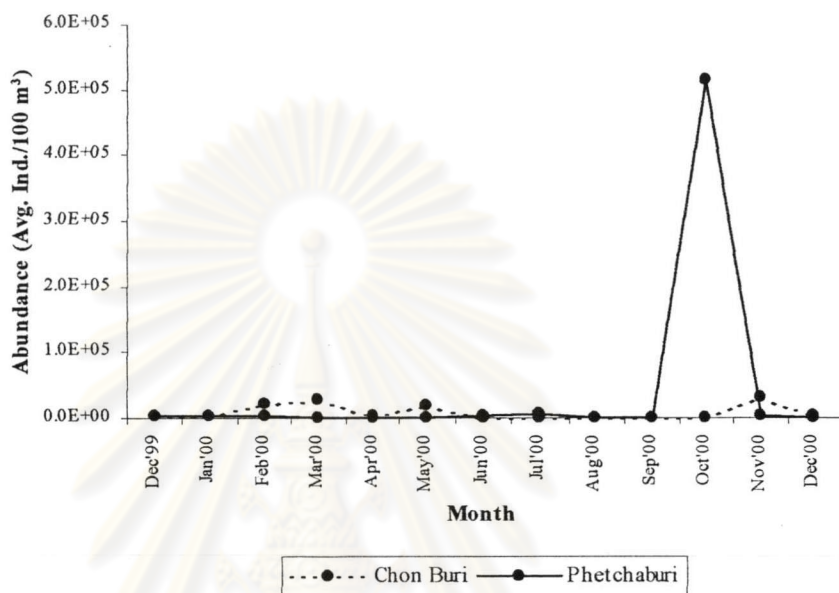


Figure 44. Abundance of hydromedusae at Chon Buri and Phetchaburi Provinces from December 1999 to December 2000.

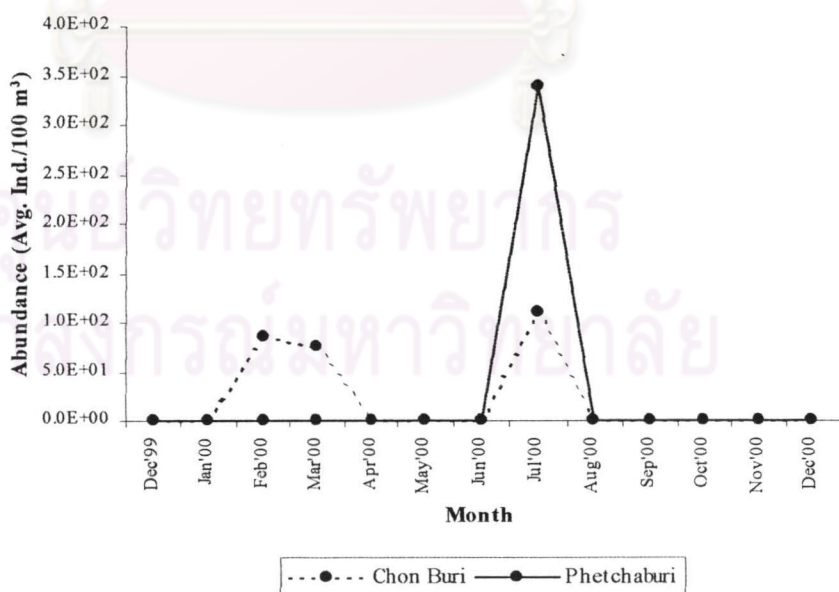


Figure 45. Abundance of scyphozoan larvae at Chon Buri and Phetchaburi Provinces from December 1999 to December 2000.

The abundance of ctenophores at was highest in November 2000 ($> 32,000$ individuals $\cdot 10^2 \text{ m}^{-3}$) and October 2000 ($> 67,000$ individuals $\cdot 10^2 \text{ m}^{-3}$) at Chon Buri and Phetchaburi, respectively (Figure 46). At Chon Buri Province, the highest abundance of polychaetes was observed in February 2000 ($> 9,000$ individuals $\cdot 10^2 \text{ m}^{-3}$) and in October 2000 ($> 23,000$ individuals $\cdot 10^2 \text{ m}^{-3}$) at Phetchaburi Province (Figure 47).

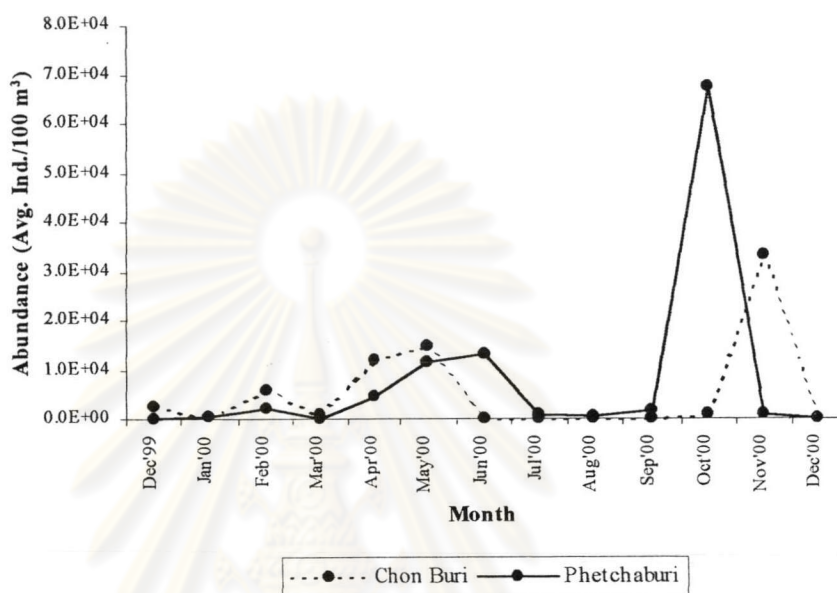


Figure 46. Abundance of ctenophores at Chon Buri and Phetchaburi Provinces from December 1999 to December 2000.

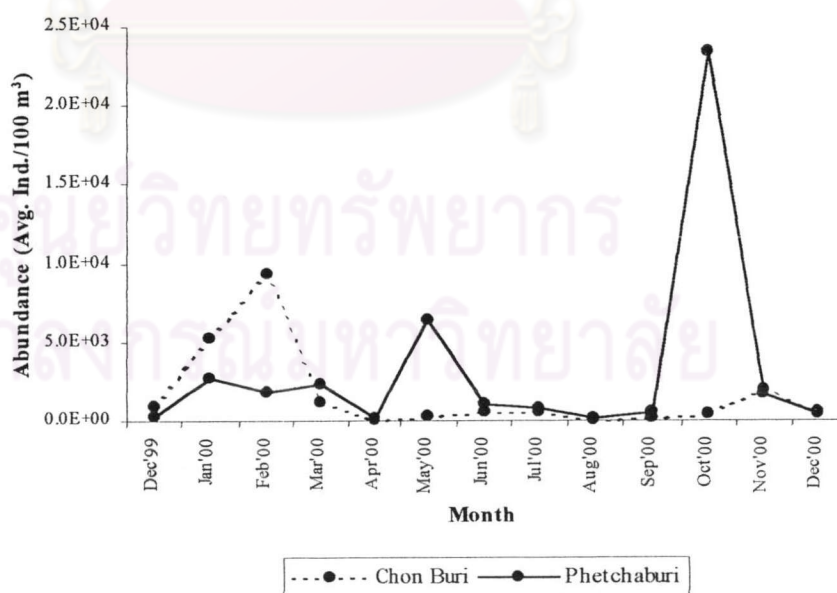


Figure 47. Abundance of polychaetes at Chon Buri and Phetchaburi Provinces from December 1999 to December 2000.

The highest abundance of barnacle larvae was observed in February 2000 ($> 250,000$ individuals $\cdot 10^2$ m $^{-3}$) and October ($> 230,000$ individuals $\cdot 10^2$ m $^{-3}$) for Chon Buri and Phetchaburi, respectively (Figure 48). At Chon Buri Province, the highest abundance of cladocerans was observed in June 2000 ($> 27,000$ individuals $\cdot 10^2$ m $^{-3}$) while, at Phetchaburi Province, it was observed in January 2000 ($> 37,000$ individuals $\cdot 10^2$ m $^{-3}$) (Figure 49).

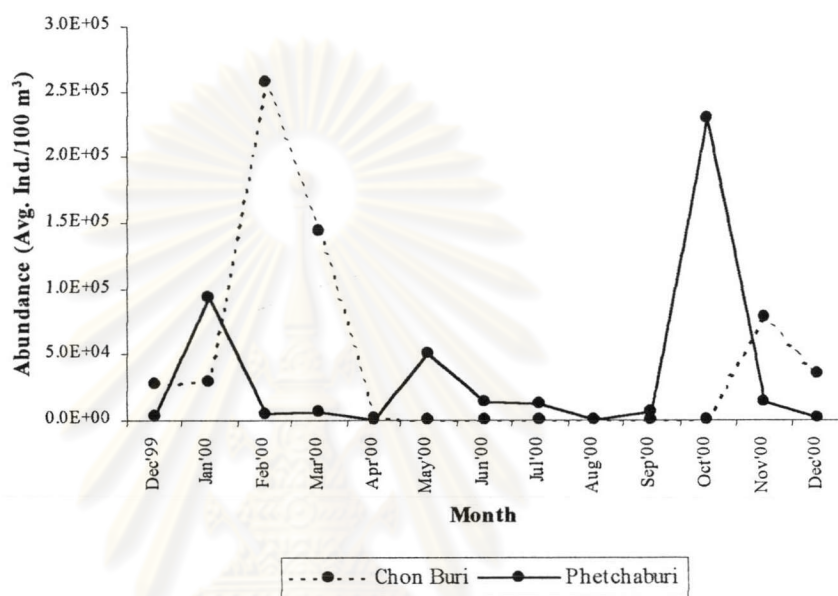


Figure 48. Abundance of barnacle larvae at Chon Buri and Phetchaburi Provinces from December 1999 to December 2000.

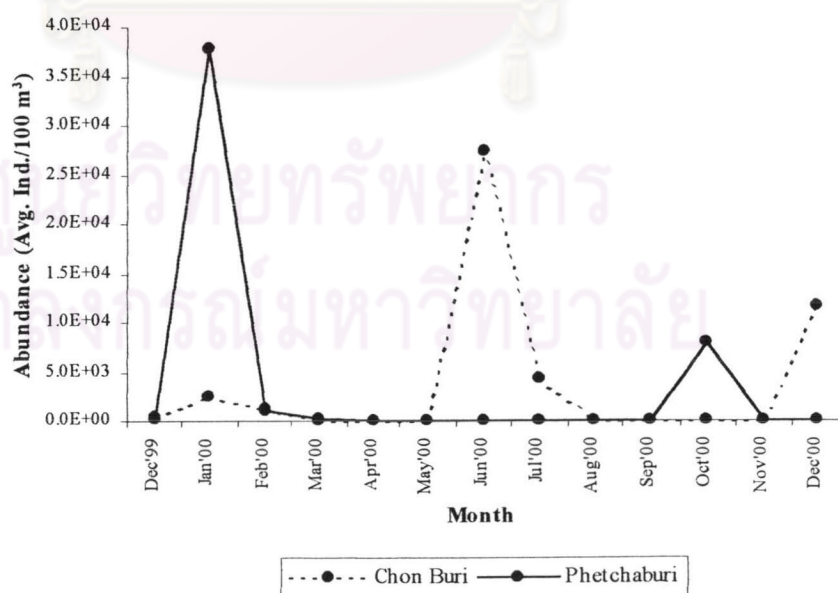


Figure 49. Abundance of cladocerans at Chon Buri and Phetchaburi Provinces from December 1999 to December 2000.

At Chon Buri Province, the highest abundance ($> 11,000$ individuals $\cdot 10^2$ m $^{-3}$) of amphipods was observed in September 2000. On the other hand, at Phetchaburi Province, the highest abundance ($> 6,000$ individuals $\cdot 10^2$ m $^{-3}$) was observed in December 2000 (Figure 50). The highest abundance of gastropods was observed in February 2000 and May 2000 for Chon Buri ($> 12,000$ individuals $\cdot 10^2$ m $^{-3}$) and Phetchaburi ($> 2,800$ individuals $\cdot 10^2$ m $^{-3}$), respectively (Figure 51).

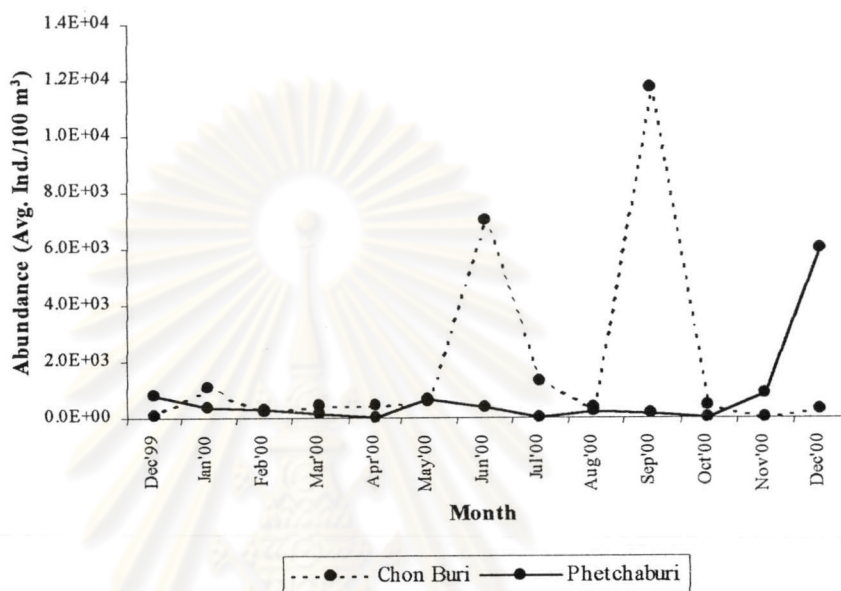


Figure 50. Abundance of amphipods at Chon Buri and Phetchaburi Provinces from December 1999 to December 2000.

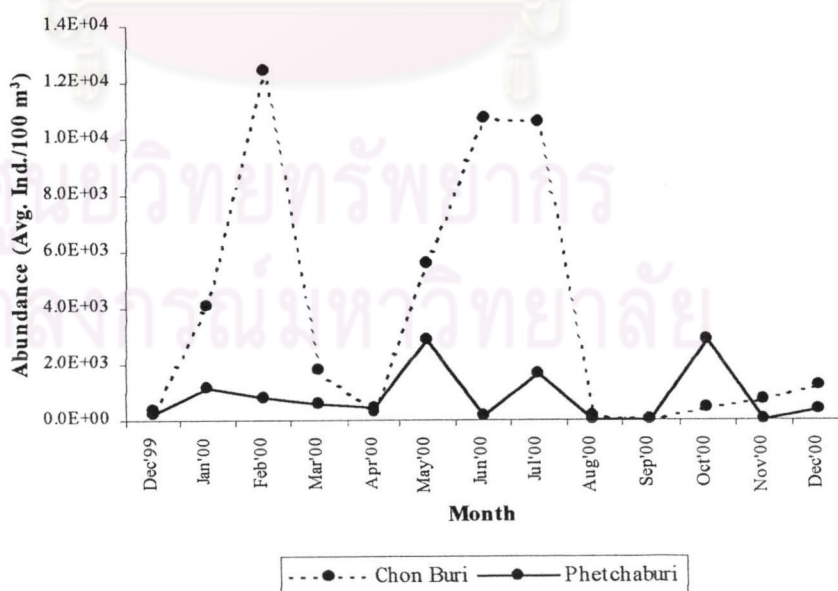


Figure 51. Abundance of gastropods at Chon Buri and Phetchaburi Provinces from December 1999 to December 2000.

The highest abundance of bivalves was observed in October 2000 ($> 25,000$ individuals $\cdot 10^2 \text{ m}^{-3}$) and November 2000 ($> 11,000$ individuals $\cdot 10^2 \text{ m}^{-3}$) for Chon Buri and Phetchaburi, respectively (Figure 52). For copepods, the highest abundance at Chon Buri Province was observed in September 2000 ($> 600,000$ individuals $\cdot 10^2 \text{ m}^{-3}$) and in October 2000 ($> 760,000$ individuals $\cdot 10^2 \text{ m}^{-3}$) at Phetchaburi Province (Figure 53).

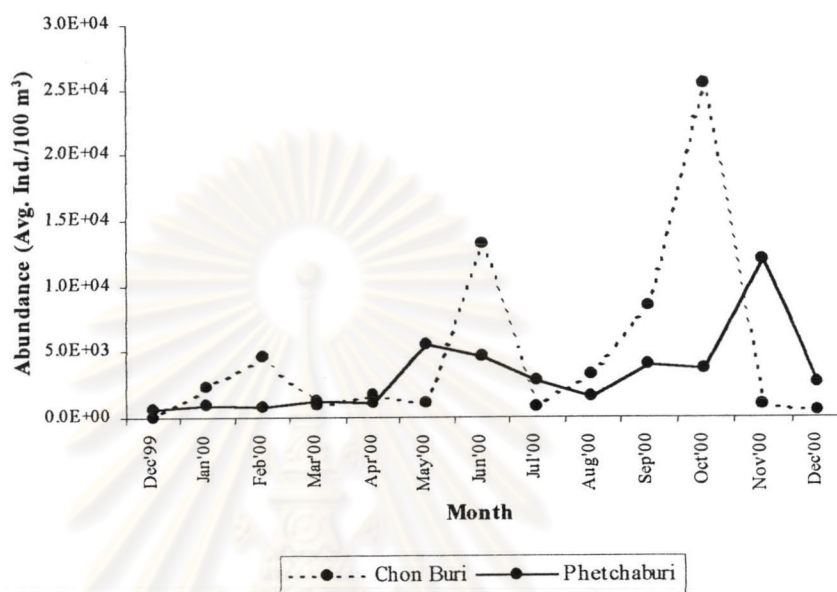


Figure 52. Abundance of bivalves at Chon Buri and Phetchaburi Provinces from December 1999 to December 2000.

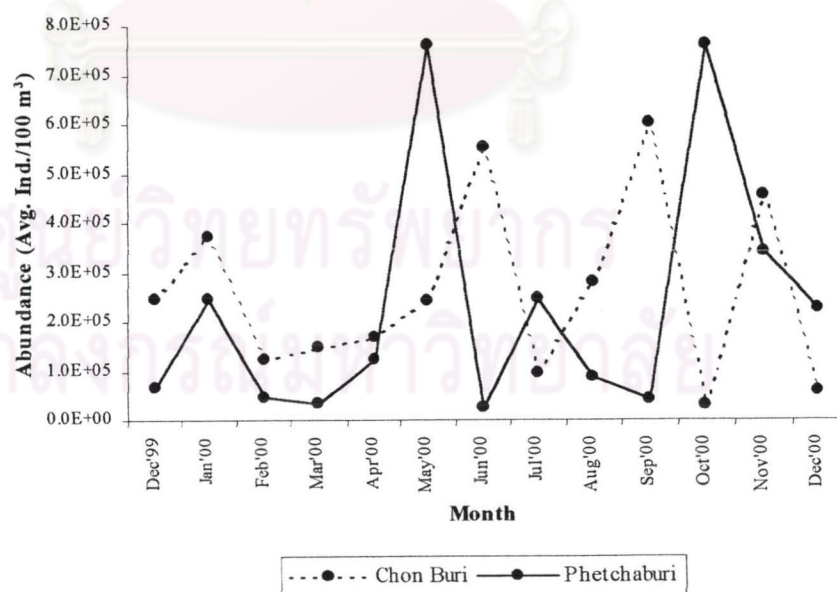


Figure 53. Abundance of copepods at Chon Buri and Phetchaburi Provinces from December 1999 to December 2000.

The highest abundance of lucifers and lucifer larvae was observed in November 2000 at Chon Buri Province ($> 59,000$ individuals $\cdot 10^2$ m $^{-3}$). At Phetchaburi Province, the highest abundance ($> 27,000$ individuals $\cdot 10^2$ m $^{-3}$) was observed in May 2000 (Figure 54). Similarly, the highest abundance of shrimps and shrimp larvae was observed in November 2000 ($> 3,500$ individuals $\cdot 10^2$ m $^{-3}$) and May 2000 ($> 12,000$ individuals $\cdot 10^2$ m $^{-3}$) for Chon Buri and Phetchaburi, respectively (Figure 55).

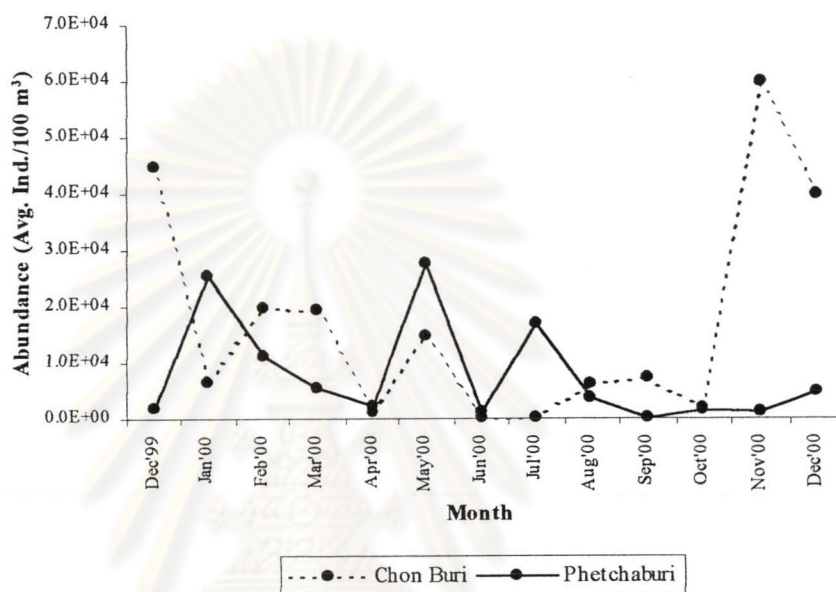


Figure 54. Abundance of lucifers and lucifer larvae at Chon Buri and Phetchaburi Provinces from December 1999 to December 2000.

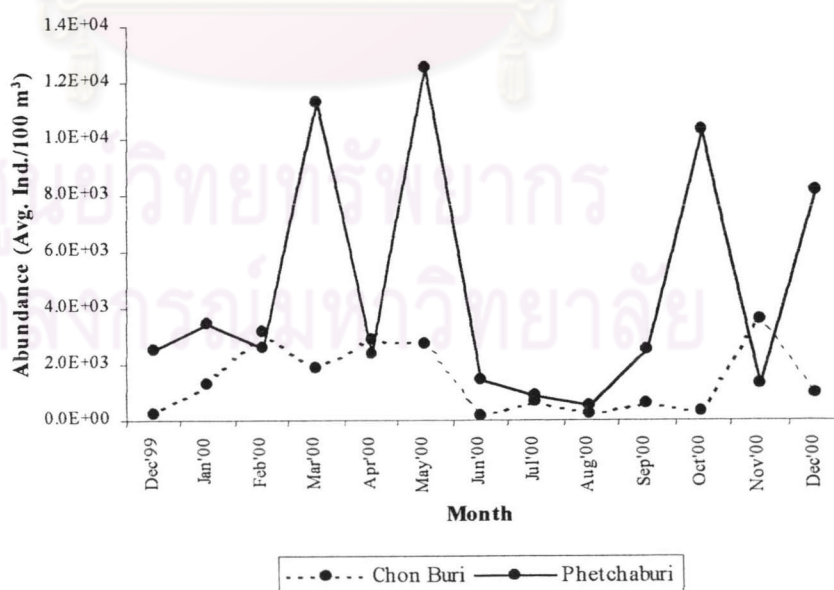


Figure 55. Abundance of shrimps and shrimp larvae at Chon Buri and Phetchaburi Provinces from December 1999 to December 2000.

In December 2000 and October 2000, the highest abundance of juvenile crabs and crab larvae was observed for Chon Buri ($> 27,000$ individuals $\cdot 10^2 \text{ m}^{-3}$) and Phetchaburi ($> 1,000,000$ individuals $\cdot 10^2 \text{ m}^{-3}$), respectively (Figure 56). The highest abundance of larvaceans was observed in December 1999 ($> 14,000$ individuals $\cdot 10^2 \text{ m}^{-3}$) at Chon Buri and October 2000 ($> 28,000$ individuals $\cdot 10^2 \text{ m}^{-3}$) at Phetchaburi (Figure 57).

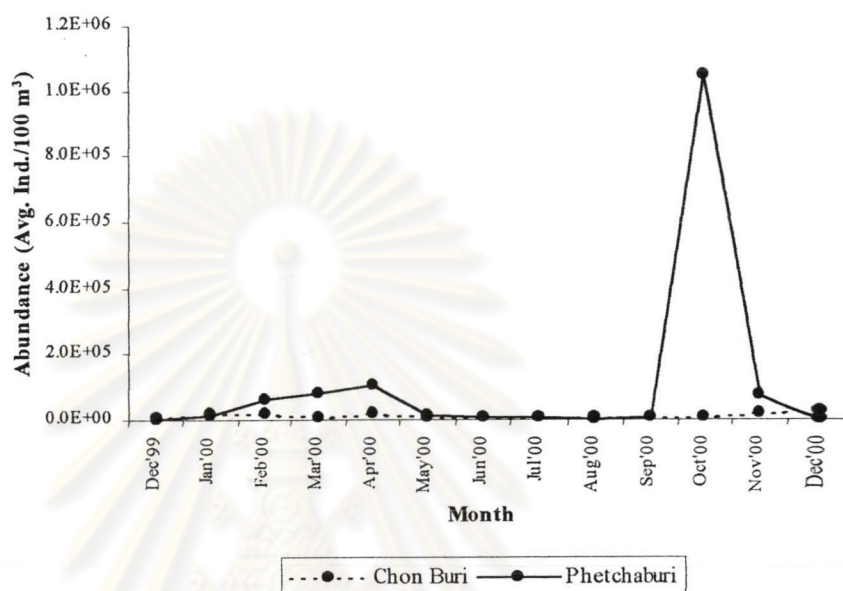


Figure 56. Abundance of juvenile crabs and crabs larvae at Chon Buri and Phetchaburi Provinces from December 1999 to December 2000.

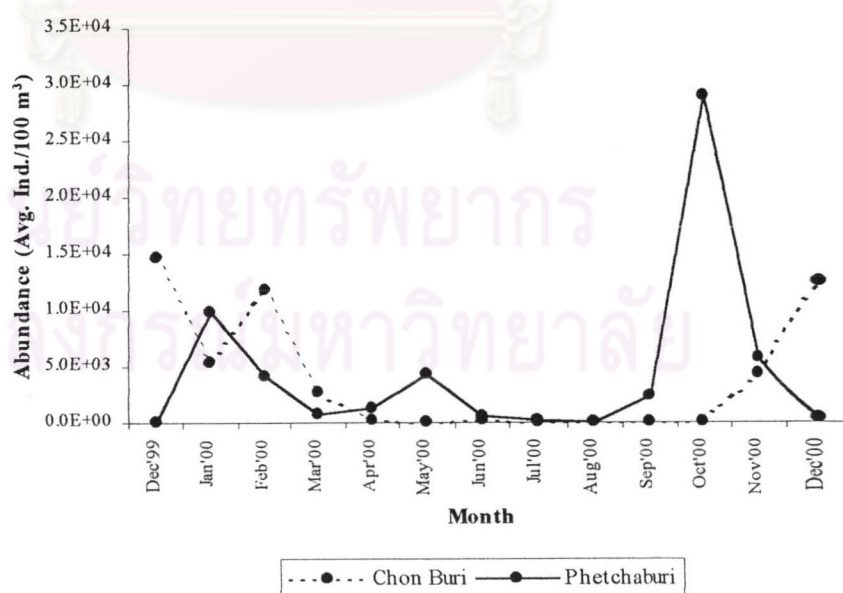


Figure 57. Abundance of larvaceans at Chon Buri and Phetchaburi Provinces from December 1999 and December 2000.

At Chon Buri and Phetchaburi Provinces, the highest abundance of juvenile fish and fish larvae was observed in February 2000 ($> 3,500$ individuals $\cdot 10^2$ m $^{-3}$) and October 2000 ($> 2,300$ individuals $\cdot 10^2$ m $^{-3}$), respectively (Figure 58). The highest abundance of planktonic eggs was observed in March 2000 ($> 91,000$ individuals $\cdot 10^2$ m $^{-3}$) at Chon Buri Province and in May 2000 ($> 21,000$ individuals $\cdot 10^2$ m $^{-3}$) at Phetchaburi Province (Figure 59).

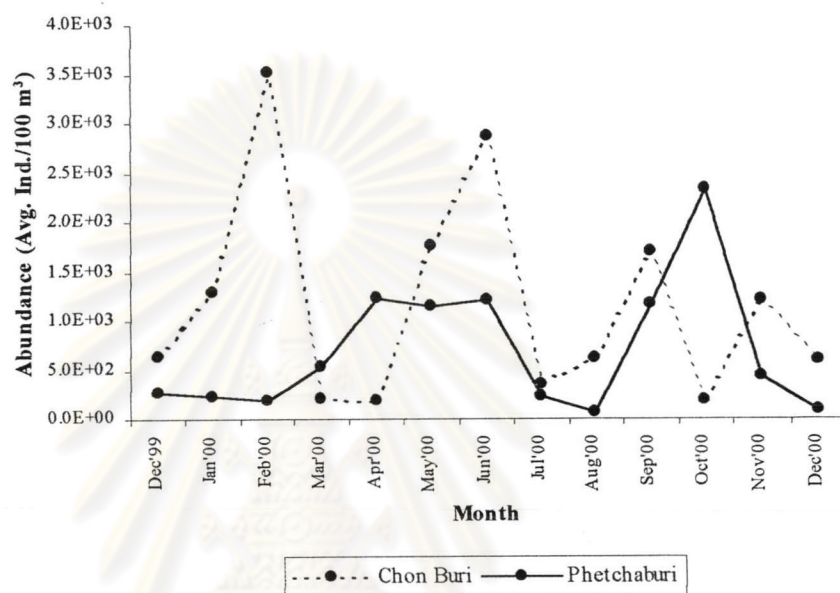


Figure 58. Abundance of juvenile fish and fish larvae at Chon Buri and Phetchaburi Provinces from December 1999 to December 2000.

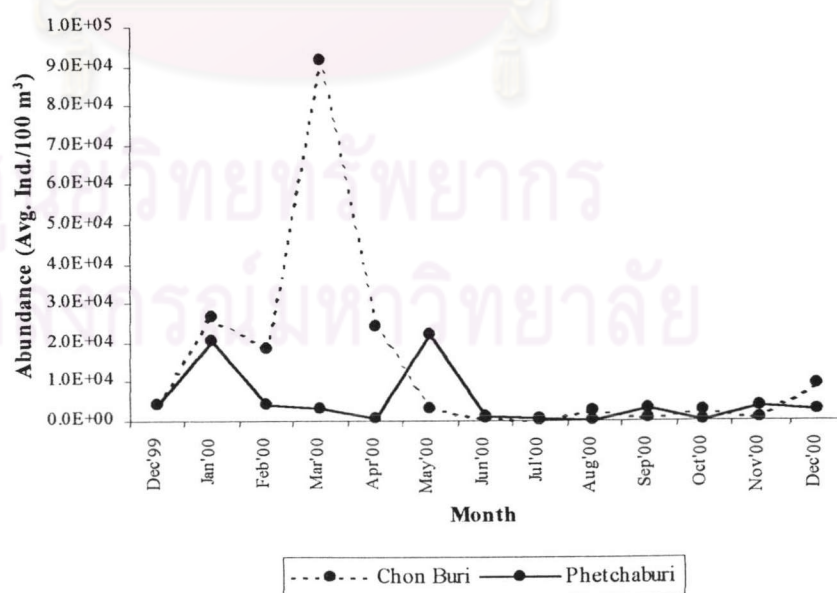


Figure 59. Abundance of planktonic eggs at Chon Buri and Phetchaburi Provinces from December 1999 to December 2000.

The highest abundance of chaetognaths was observed in November 2000 ($> 23,000 \text{ individuals} \cdot 10^2 \text{ m}^{-3}$) and May 2000 ($> 70,000 \text{ individuals} \cdot 10^2 \text{ m}^{-3}$) for Chon Buri and Phetchaburi, respectively (Figure 60).

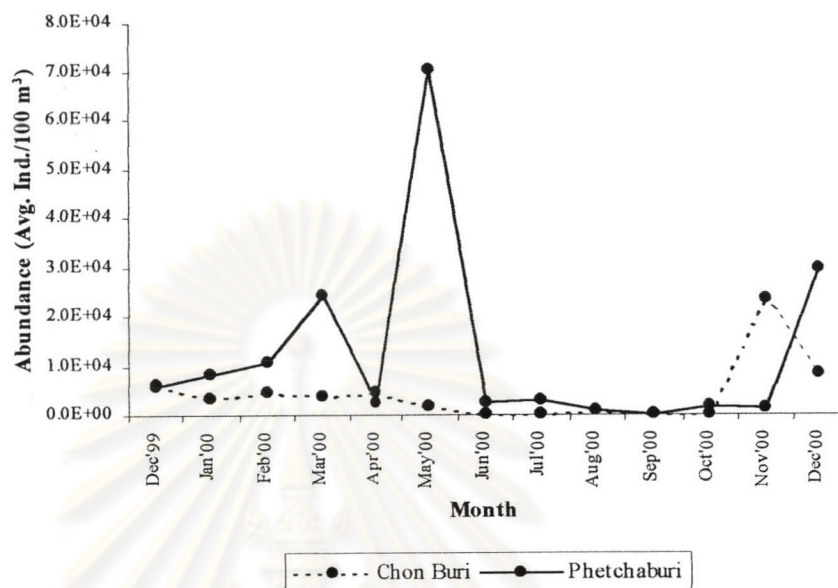


Figure 60. Abundance of chaetognaths at Chon Buri and Phetchaburi Provinces from December 1999 to December 2000.