

CHAPTER 3

RESULTS

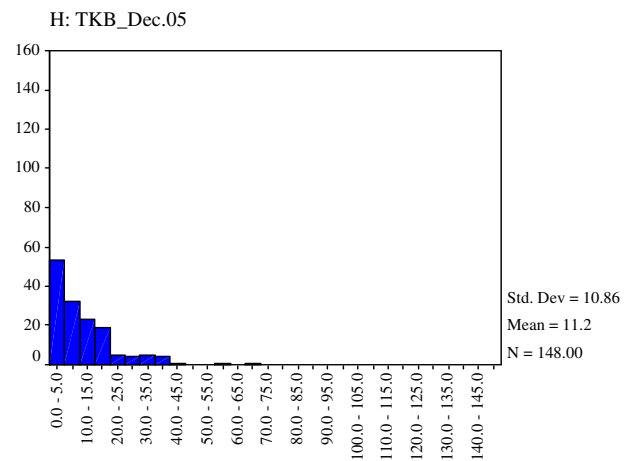
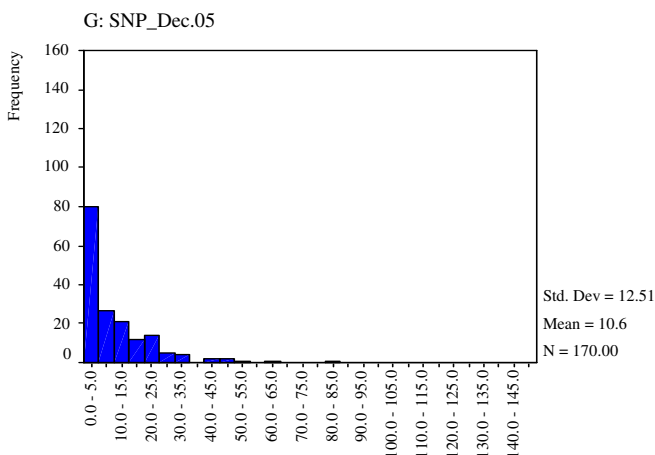
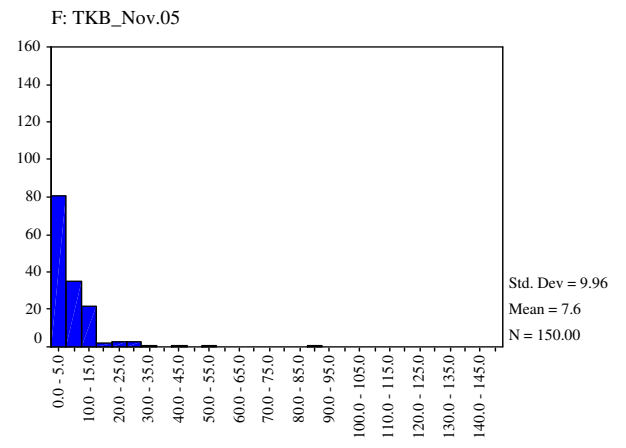
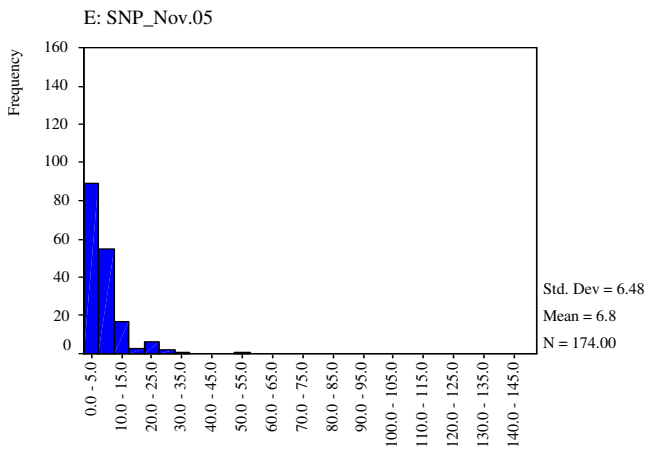
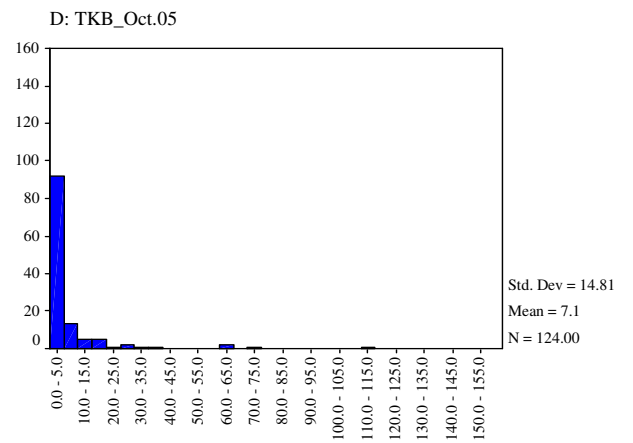
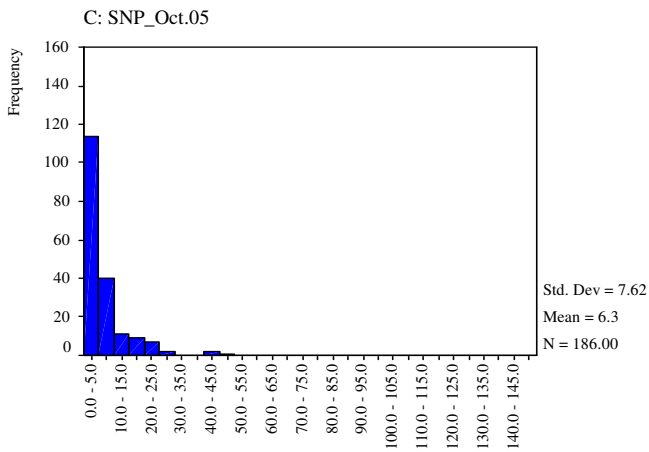
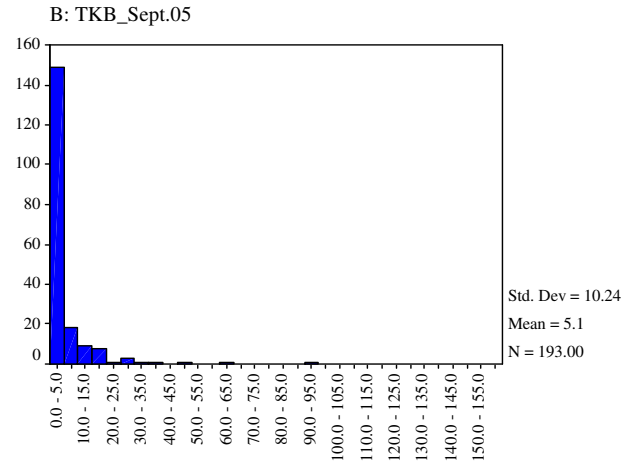
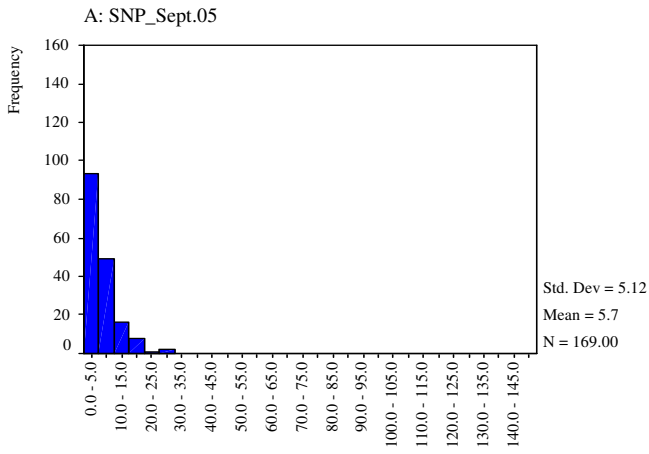
Size structure and reproductive potential

Padina populations were dynamic throughout the year (Figures 11A-X). The surface area distributions were skewed to the left, with many small individuals and few large ones in every month. The range of the surface area at SNP was from 2.3 to 22.5 cm² (Table 2). They showed the largest surface area in June 2006 (Figure 11S) and the smallest in February 2006 (Figure 11K). The range of the mean surface area was from 5.1 to 31.1 cm² at TKB (Table 2). At TKB the largest surface area was in February 2006 (Figure 11L) and the smallest in September 2006 (Figure 10B). The mean surface area of specimens varied from one month to another and they also varied between sites (Table 3). The range of mean of surface area was wider at TKB than at SNP.

P. boryana released spores throughout the year (Figure 12, Table 4). The number of released spores also varied at both sites. The number of released spores varied throughout the year at both sites and was significantly different between the two sites (Table 4, $P < 0.05$). The average number of released spores was higher at SNP than TKB. There were two peaks of spores released, first in November 2005 (Table 4; $n = 172$, 1533.50 ± 351.82 spores), and second in May 2006 (Table 4; $n = 145$, 8069.21 ± 1456.75 spores) through August 2006 at SNP. At TKB the average number of released spores

occurred in February (Table 4; $n=120$, 9522.11 ± 9522.11 spores) and started again in July 2006 (Table 4; $n=34$, 4399.10 ± 4399.10 spore) through August 2006.

Figure 11, A-H.



surface area (cm2)

surface area (cm2)

Figure 11, I-P.

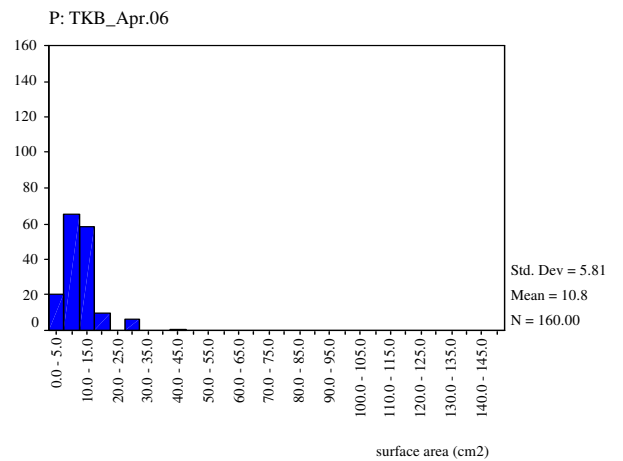
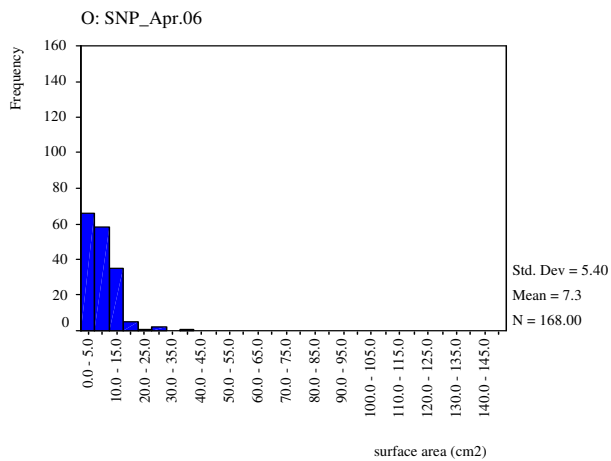
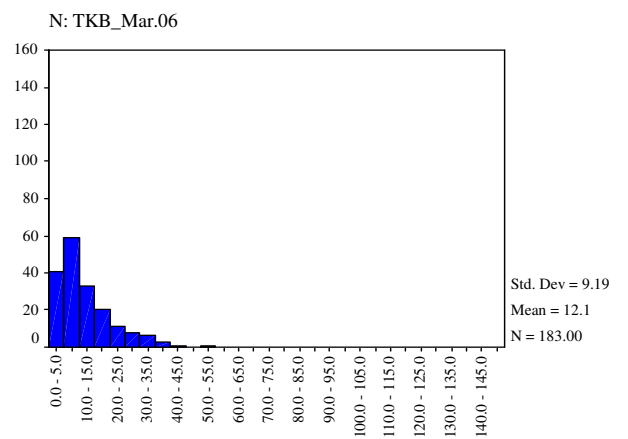
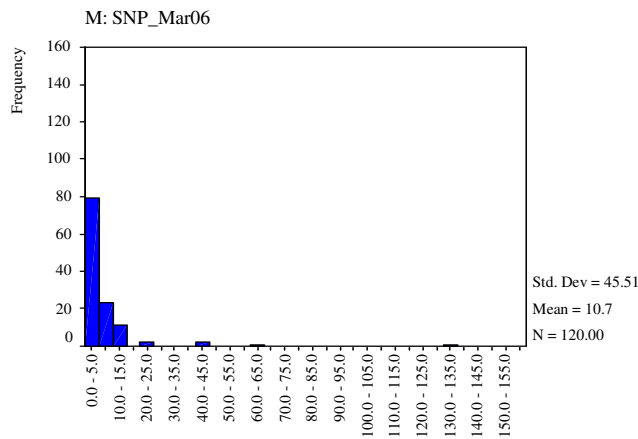
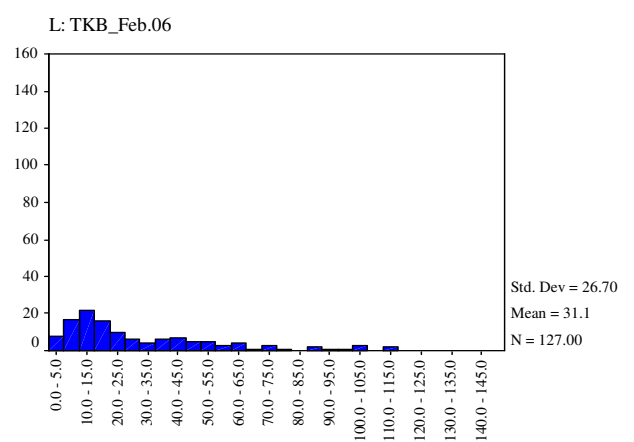
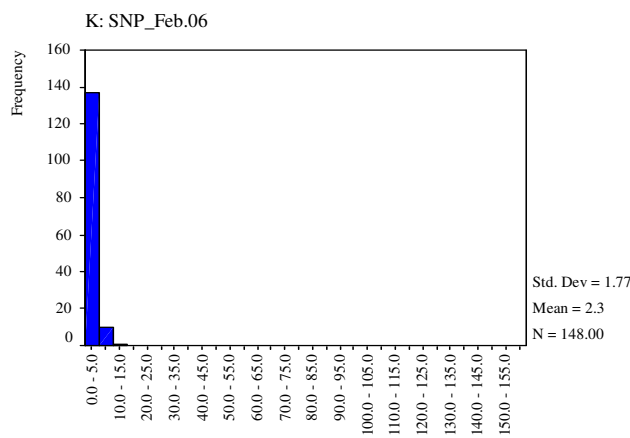
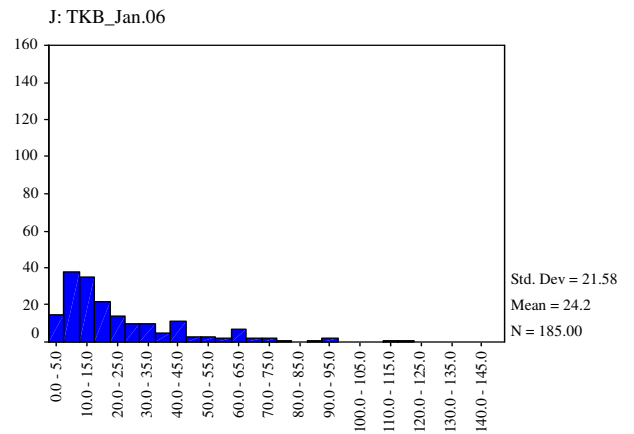
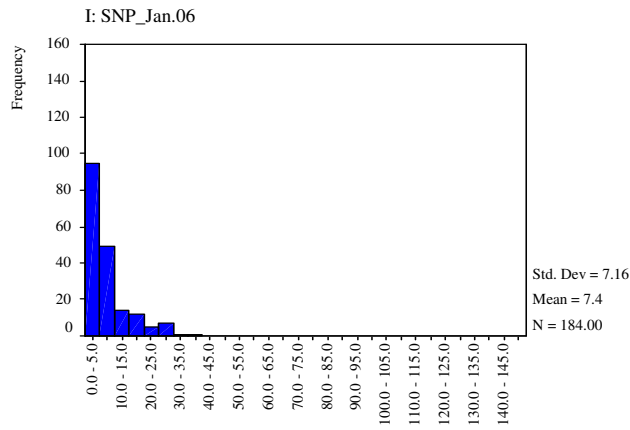


Figure 11, Q-X.

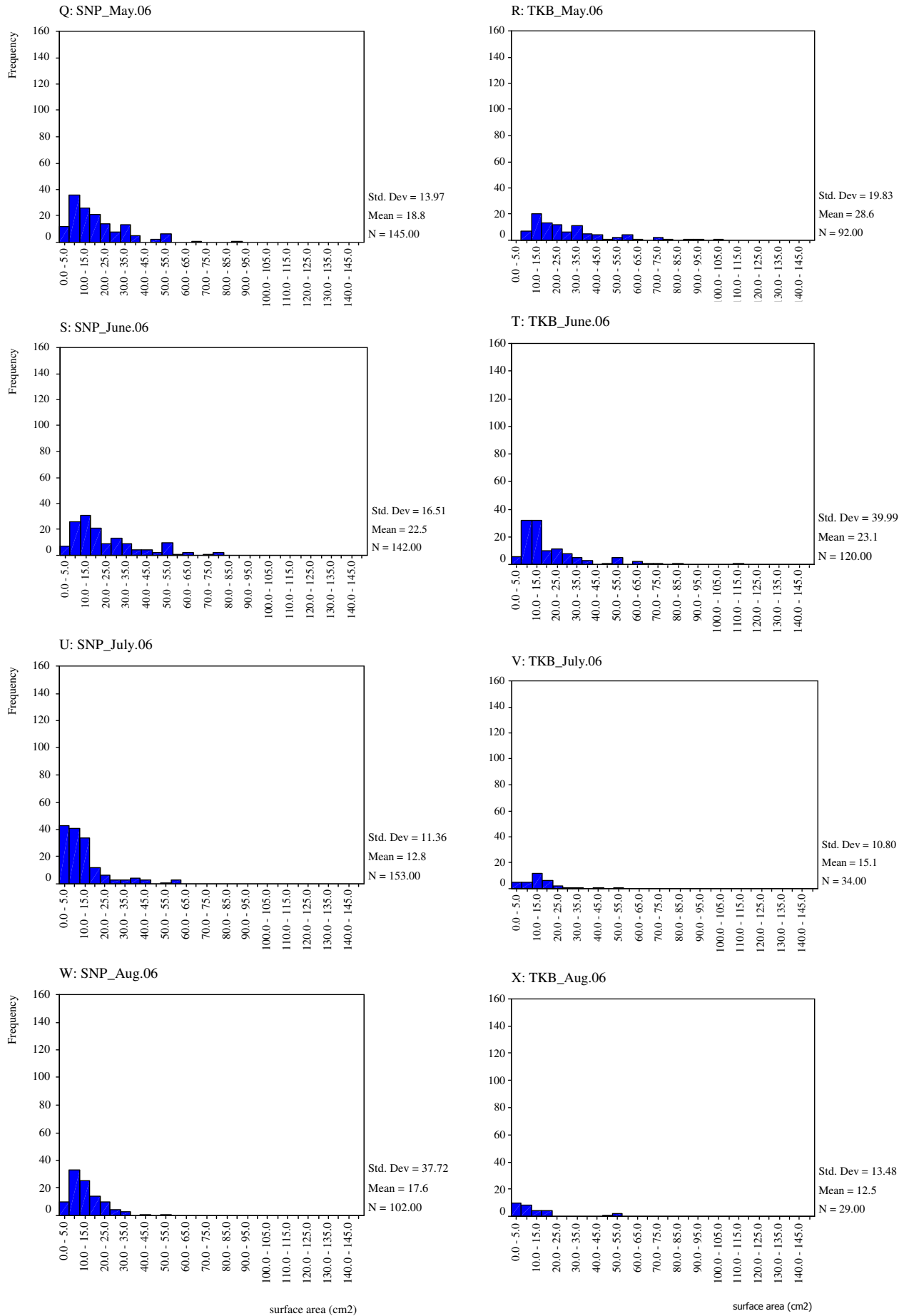


Figure 11. Size class of *P. boryana* populations from September 2005 to August 2006 comparing Sirinart National Park and Tang Khen Bay.

Table 2. A comparison of mean surface areas of *P. boryana* blade at Sirinart National Park and Tang Khen Bay from September 2005 to August 2006.

month	N		mean±SE	
	SNP	TKB	SNP (cm)	TKB (cm)
Sept-05	169	199	5.7±0.39	5.1±0.72
Oct-05	186	123	6.3±0.56	7.1±1.34
Nov-05	174	149	6.8±0.49	7.6±0.82
Dec-05	170	147	10.6±0.096	11.2±0.9
Jan-06	184	184	7.4±0.53	24.2±1.6
Feb-06	148	126	2.3±0.15	31.1±2.38
Mar-06	120	182	10.7±4.15	12.1±0.68
Apr-06	168	160	7.3±0.42	10.8±0.46
May-06	145	92	18.8±1.16	28.6±2.07
June-06	142	120	22.5±1.39	23.1±3.65
July-06	153	34	12.8±0.92	15.1±0.65
Aug-06	102	29	17.6±3.74	12.5±0.53

Table 3. A comparison of size class distribution at Sirinart National Park and Tang Khen

Bay from September 2005 to August 2006; otherwise, * $P < 0.05$, ** $P < 0.01$,

*** $P < 0.001$; ns = not significant.

month	N		X^2	P
	SNP	TKB		
Sept-05	169	199	3.321	<0.001***
Oct-05	186	123	1.264	0.082 ns
Nov-05	174	149	0.682	0.741 ns
Dec-05	170	147	1.472	0.026*
Jan-06	184	184	5.161	<0.001***
Feb-06	148	126	7.316	<0.001***
Mar-06	120	182	4.171	<0.001***
Apr-06	168	160	7.115	<0.001***
May-06	145	92	4.498	<0.001***
June-06	142	120	1.931	0.053 ns
July-06	153	34	11.49	<0.001***
Aug-06	102	29	13.409	<0.001***

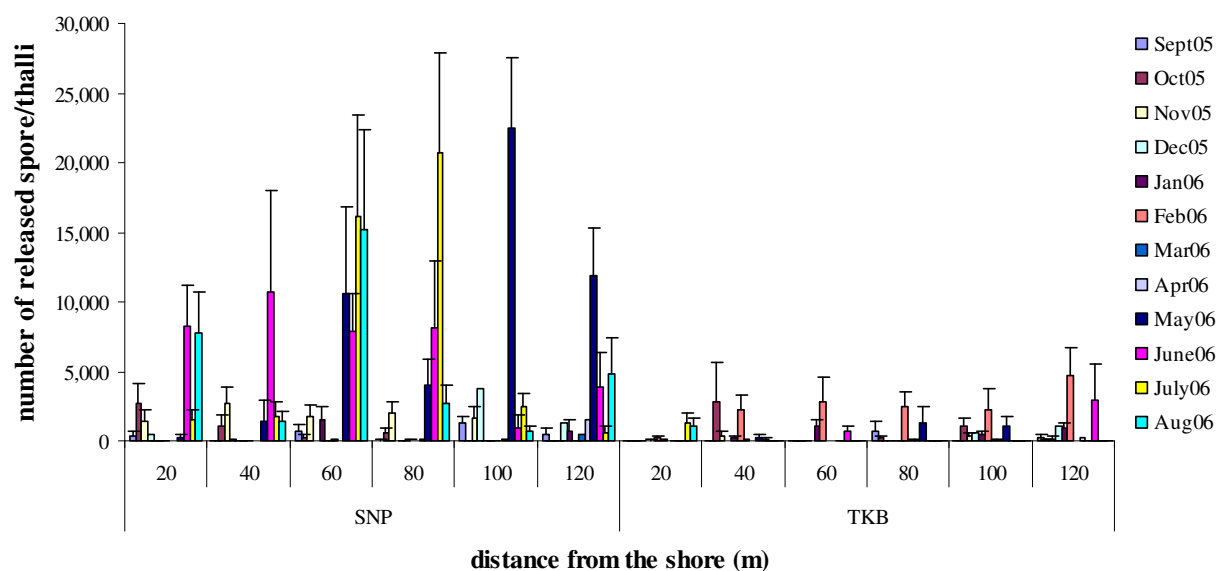


Figure 12. Comparison of the average number of released spores/thalli from September 2005 to August 2006 at Sirinart National Park and Tang Khen Bay.

Table 4. The average number of released spores at Sirinart National Park and Tang Khen Bay from September 2005 to August 2006; otherwise, * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$; ns = not significant.

month	N		mean \pm SE		X^2	P
	SNP	TKB	SNP (spores)	TKB (spores)		
Sept-05	161	188	459.23 \pm 146.20	510.77 \pm 404.61	2.362	0.018*
Oct-05	185	121	775.80 \pm 298.51	2,717.43 \pm 1,853.30	0.155	0.877 ns
Nov-05	172	148	1,533.50 \pm 351.82	516.49 \pm 269.42	3.265	0.001**
Dec-05	167	141	861.94 \pm 332.45	1,397.17 \pm 532.04	1.935	0.053 ns
Jan-06	184	174	367.79 \pm 206.57	1,675.71 \pm 494.53	3.637	<0.001***
Feb-06	148	120	6.82 \pm 5.62	9,522.11 \pm 2,245.58	6.735	<0.001***
Mar-06	120	178	124.57 \pm 93.05	244.78 \pm 111.03	0.645	0.519 ns
Apr-06	313	160	3,897.25 \pm 715.92	386.79 \pm 131.08	2.125	0.034*
May-06	145	92	8,069.21 \pm 1,456.75	2,217.74 \pm 1,221.68	4.372	<0.001***
June-06	142	120	6,092.80 \pm 1,506.24	1,543.9 \pm 824.73	3.921	<0.001***
July-06	153	34	6,303.18 \pm 1,628.21	4,399.06 \pm 2,618.45	1.822	0.068 ns
Aug-06	104	29	3,840.52 \pm 875.95	4,400.48 \pm 2,119.39	0.572	0.567 ns

The reproductive cycle and the time of production of new individuals

The percentage of reproduction of *P. boryana* varied at both SNP and TKB and was significantly different (Table 5, $P < 0.05$) between the two sites throughout the year of study. Both sites had two peaks of the reproduction per year. The SNP populations had peaks of reproduction between September 2005 to January 2006 and May to August 2006. The lowest was between February to April 2006 (Figure 13, Table 5). The TKB populations showed the same pattern but with a different periodicity (Figure 13, Table 5). For example, those populations peaked from December 2005 to February 2006 and May to June 2006. They were not significantly different among months ($P > 0.05$).

Moreover, both sites showed the same percentages of the various life phases. Sporophytes showed the highest percentage throughout the year. There were, in fact, only a few female gametophytes in some months (Figure 13, Table 6). The percentage of male gametophytes was even lower and were observed only 3 times in the year: May (2.46%) to June (0.69%) to July (0.69%) 2006 in SNP, and April (2.24%) to May (4.44%) to June (8.3%) 2006 in TKB (Figure 13, Table 6).

P. boryana can be reproductive throughout the year. The percentage of maturation stages 3-5 was calculated to assess the reproductive potential of the populations and was found to be significantly different between months and sites (Figure 14, Table 7, $P < 0.05$). Reproductive potential is a function of the number of spores and gametes produced. However, since the sporophyte generation was overwhelmingly dominant at both SNP and TKB, the data reflect the reproductive potential based on spore

production. The data showed the same trend as the percentage of reproduction. Likewise, the peak of maturity was in September 2005 by $40.91 \pm 7.35\%$ and May 2006 by $72.87 \pm 9.09\%$ at SNP, and February 2006 by $34.28 \pm 3.62\%$ and May 2006 by $59.18 \pm 10.49\%$ at TKB (Table 7). Both sites showed significantly different peaks (Table 7, $P < 0.05$). The percentage of maturation was higher in the end of the year at both sites. Statistical analysis supported the significant difference between months at the two sites in the January to February and July to August periods. However, it was greater at SNP than at TKB during the two peaks period and less from January to April 2006.

The averages of number of spores (Figure 15, Table 8) at SNP were greater than at TKB throughout the year. However, *P. boryana* showed the same phenomenon of producing more spores from May to August before the plants died. The number of spores varied throughout the year and showed significant differences (Table 8, $P < 0.05$) between levels (distance from the shore) at both sites.

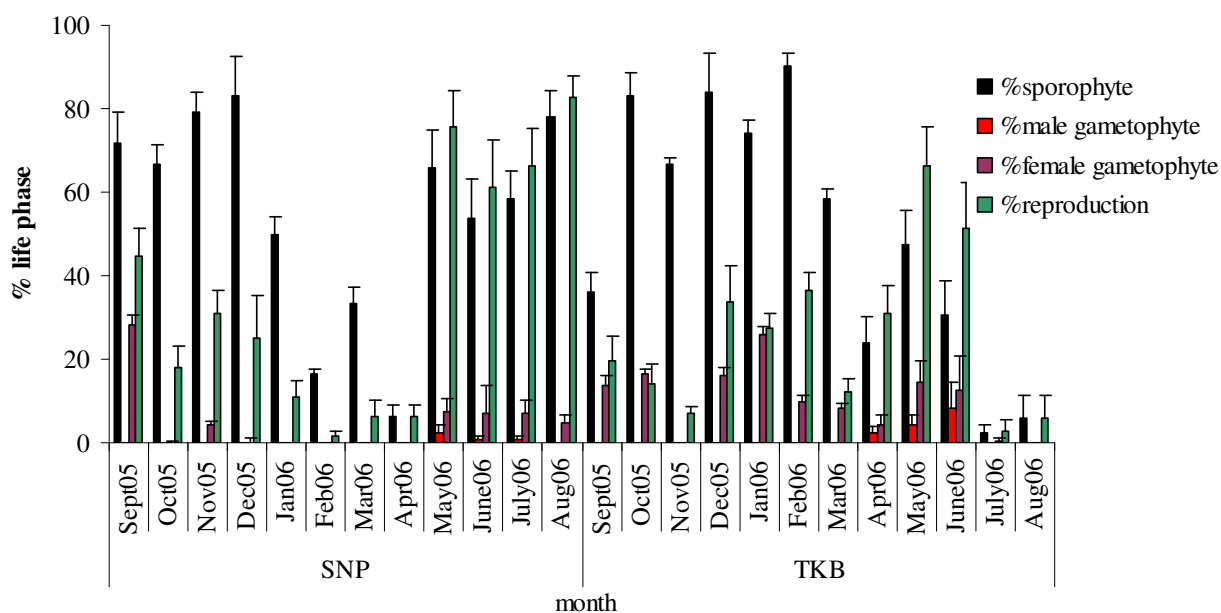


Figure 13. Comparison of percentages of life phases of *P. boryana* from September 2005 to August 2006 at Sirinart National Park and Tang Khen Bay.

Table 5. The average percentage of reproductive stages at Sirinart National Park and Tang Khen Bay; otherwise, * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$; ns = not significant.

month	mean \pm SE		X^2	P
	SNP	TKB		
Sept-05	44.64 \pm 6.59	19.60 \pm 5.97	2.082	0.037*
Oct-05	18.05 \pm 4.93	13.96 \pm 5.04	0.481	0.63 ns
Nov-05	30.92 \pm 5.49	7.09 \pm 1.56	2.722	0.006**
Dec-05	25.24 \pm 9.96	33.55 \pm 8.80	0.961	0.337 ns
Jan-06	10.90 \pm 4.15	27.39 \pm 3.70	2.491	0.013*
Feb-06	1.67 \pm 1.13	36.66 \pm 4.02	2.934	0.003**
Mar-06	6.43 \pm 3.84	11.98 \pm 3.14	1.292	0.196 ns
Apr-06	6.11 \pm 3.03	30.81 \pm 6.95	2.58	0.01**
May-06	75.50 \pm 8.70	66.29 \pm 9.56	0.561	0.575 ns
June-06	61.30 \pm 11.08	51.31 \pm 11.07	0.48	0.631 ns
July-06	66.33 \pm 8.92	2.78 \pm 2.78	2.989	0.003**
Aug-06	82.65 \pm 5.30	5.75 \pm 5.75	2.989	0.003**

Table 6. Summary of percentages of each life stage varied throughout the year from September 2005 to August 2006 at Sirinart National Park and Tang Khen Bay.

month	SNP			TKB		
	%sporophyte	%female gametophyte	%male gametophyte	%sporophyte	%female gametophyte	%male gametophyte
Sept-05	71.63±7.71	28.37±2.22	0	36.11±4.62	13.89±2.25	0
Oct-05	66.67±4.75	0±0.48	0	83.33±5.47	16.67±1.11	0
Nov-05	79.17±4.79	4.17±1.11	0	66.67±1.56	0	0
Dec-05	83.33±9.37	0±1.19	0	84.03±9.29	15.97±2.02	0
Jan-06	50±4.15	0	0	74.31±2.77	25.69±2.22	0
Feb-06	16.67±1.14	0	0	90.12±3.13	9.88±1.52	0
Mar-06	33.33±3.84	0	0	58.33±2.57	8.33±1.1	0
Apr-06	6.11±3.03	0	0	24.1±5.95	4.46±2.05	2.24±1.65
May-06	65.73±9.16	7.31±3.44	2.46±1.7	47.31±8.37	14.54±4.88	4.44±2.38
June-06	53.66±9.39	6.94±6.94	0.69±0.69	30.59±8.32	12.42±8.39	8.3±6.17
July-06	58.43±6.68	7.2±2.99	0.69±0.69	2.22±2.22	0.56±0.56	0
Aug-06	78.02±6.38	4.62±2.1	0	5.75±5.75	0	0

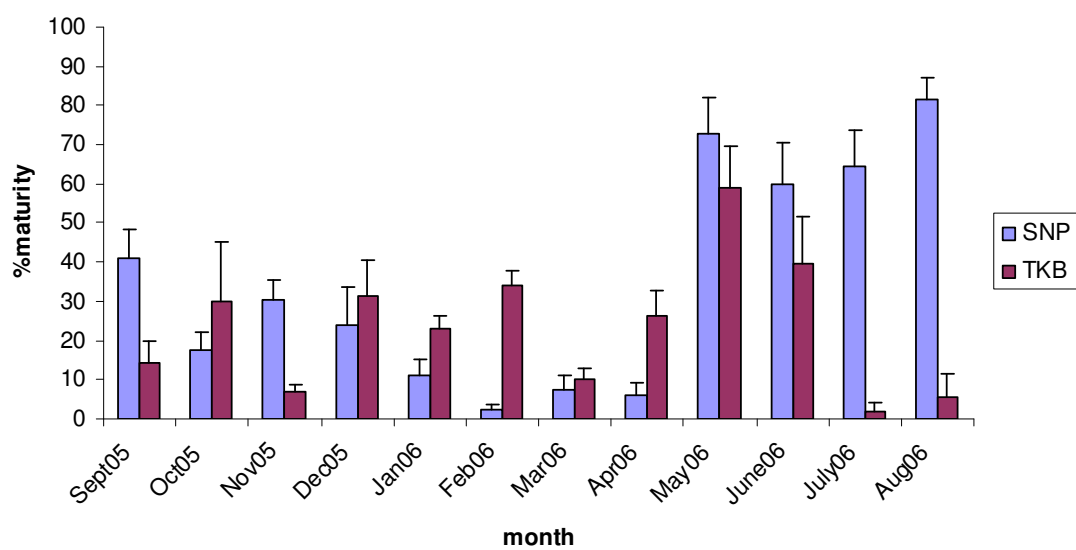


Figure 14. Comparison of the percentages of mature (stages 3-5) thalli from September 2005 to August 2006 at Sirinart National Park and Tang Khen Bay.

Table 7. The average of percentage of maturation stages at Sirinart national Park and Tang Khen Bay; otherwise, * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$; ns = not significant.

month	mean \pm SE		X^2	P
	SNP	TKB		
Sept05	40.91 \pm 7.35	14.51 \pm 5.1	2.402	0.016*
Oct05	17.51 \pm 4.54	30.18 \pm 14.86	0.48	0.631 ns
Nov05	30.33 \pm 5.09	7.11 \pm 1.55	2.722	0.006**
Dec05	23.99 \pm 9.71	31.56 \pm 8.98	0.962	0.336 ns
Jan06	10.9 \pm 4.15	23.22 \pm 3.07	2.085	0.037*
Feb06	2.22 \pm 1.41	34.28 \pm 3.62	2.939	0.003**
Mar06	7.22 \pm 3.85	10.07 \pm 2.68	0.646	0.518 ns
Apr06	6.11 \pm 3.03	26.12 \pm 6.78	2.096	0.036*
May06	72.87 \pm 9.09	59.18 \pm 10.49	0.961	0.337 ns
June06	60.12 \pm 10.48	39.66 \pm 12.02	1.043	0.297 ns
July06	64.59 \pm 8.98	2 \pm 2.3	2.989	0.003**
Aug06	81.54 \pm 5.66	5.75 \pm 5.75	2.989	0.003**

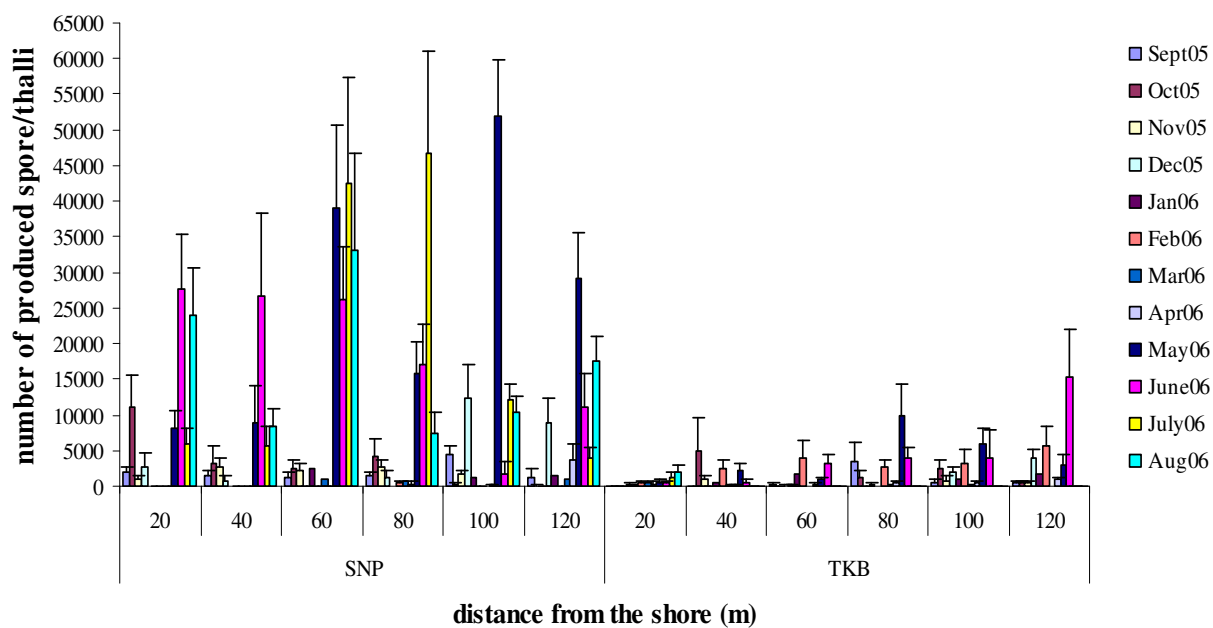


Figure 15. Comparison of the average number of spores/thalli from September 2005 to August 2006 at Sirinart National Park and Tang Khen Bay.

Table 8. The average number of spores produced at Sirinart National Park and Tang

Khen Bay from September 2005 to August 2006; otherwise, * $P < 0.05$,

** $P < 0.01$, *** $P < 0.001$; ns = not significant.

month	N		mean \pm SE		χ^2	P
	SNP	TKB	SNP	TKB		
Sept-05	161	188	2,116.51 \pm 351.06	2,735.31 \pm 1557.12	5.627	<0.001***
Oct-05	185	121	3,696.93 \pm 984.15	5,527.91 \pm 3,232.80	2.104	0.035*
Nov-05	172	148	3,274.67 \pm 662.55	1,259.37 \pm 643.86	5.026	<0.001***
Dec-05	167	141	4,068.28 \pm 1,017.70	5,379.35 \pm 1,448.90	1.87	0.062 ns
Jan-06	184	174	914.36 \pm 345.37	3,278.02 \pm 848.61	2.97	0.003**
Feb-06	148	120	89.69 \pm 58.56	21,491.68 \pm 4,930.35	6.845	<0.001***
Mar-06	120	178	507.18 \pm 248.99	773.83 \pm 272.78	0.535	0.593
Apr-06	168	160	737.57 \pm 431.81	1,863.76 \pm 392.73	5.179	<0.001***
May-06	145	92	24,168.07 \pm 2,928.41	17,603.17 \pm 4,618.63	2.867	0.004**
June-06	142	120	17,175.31 \pm 2,800	12,069.97 \pm 2,894.51	2.511	0.012*
July-06	153	34	17,659.22 \pm 3,358.72	4,488.47 \pm 2,658.53	4.817	<0.001***
Aug-06	102	29	14,724.92 \pm 1,818.80	8,205.52 \pm 3,681.07	4.086	<0.001***

Recruitment study

Algal recruitment in this study followed a typical successional pattern. In the early stages filamentous green algae were dominant followed by taxa with more complex morphologies. After clearing the permanent plots, filamentous green and red algae appeared as the pioneer species. After that *Gelidium* spp., *Gracilaria* spp., *Turbinaria ornata*, followed. The green algae, *Ulva*, *Boodlea* and *Chlorodesmis*, were observed at both sites. Filamentous red algae such as *Champia*, *Gelidium*, and *Ceramium* were observed at SNP and crustose algae were also abundant at TKB. The prostrate thalli of *Padina*, *Dictyosphaerota*, grew in the plots after 1 month. The percentages of filamentous algae were high at both sites and they grew throughout the year (Table 9-10). In addition, the filamentous algae were higher in the lower intertidal, 61-120 m. from shoreline than in the upper zone, while *Padina* was found in higher numbers on the upper shore. Some plots were covered by the sediment at both sites.

New individuals of *Padina* were first noticed in October 2005, a month after the substrates were cleared. The prostrate *Dictyosphaerota* stage appeared first and was observed throughout the year at both sites. The foliose stage of *Padina* were first observed in the plots in November 2005. The foliose blade can develop from the *Dictyosphaerota* stage and form a canopy throughout the year. When the growth of *Padina* in the plot was at its peak in the May 2005 (Table 11-12; $n=6\pm 3.46$, height= 5.33 ± 0.41 cm. at 41-60 m. at SNP, $n=9.33\pm 5.21$, height= 4.29 ± 0.39 cm. at 61-80 m. at TKB), *P. boryana* showed the highest percentage cover and also its greatest height in May and June 2005. After that, the blade was torn due to the tissue lost and the thalli became soft and easily

damaged by water movement. *Padina* started to die off in June 2005. New individuals were recruited in the area in October 2005. In this study, *Padina* was mostly absent in the last two months, July and August 2006, at both sites.

The recruitment of *Padina* on the monitoring plots changed throughout the year (Figure 16-17). There were significant differences in percentage cover between TKB and SNP from December 2005 to June 2006 (Table 11, $P < 0.05$). A higher percentage cover of both the *Dictyerpa* stage and foliose blades was found at TKB at all distances from the shore and during all months. The percentage cover of *Padina* was greater than 40% at TKB, and less than 40% at SNP.

There was no clear pattern of *Padina* recruitment and growth at SNP. For example, there was no recruitment at all in some plots. Higher recruitment occurred in the zone nearest to the shore throughout the year. There was significantly higher recruitment at the 0-20 meter level ($P < 0.05$). However, there were no significant differences in percentage cover among other shore levels. At 101-120 meters, there was no recruitment of *Padina* at all throughout the study, also sediment approximately 0.5 mm thick, was observed. The highest percentage cover of *Padina* was found at the uppermost shore levels during March and June 2006 at $76.67\% \pm 14.53\%$ and $75\% \pm 17.56\%$ respectively. Most of percentages cover of *Padina* were the *Dictyerpa* stage in March 2006 with only a few foliose thalli 1 cm. in height (Table 11-12; $n=10$). Foliose thalli showed the highest percentage cover in June 2006 with an average height of 4.18 ± 0.37 cm. at the upper level (Table 11-12; $n=15 \pm 1.53$). *Padina* started to die off after the peak month then the percentage cover decreased. The percentage cover of *Padina* was $23.33\% \pm 12.02\%$ in June and $33.33\% \pm 24.04\%$ in August (at the 0-20 m.), however, some of the foliose thalli

were still in the plots (Table 11-12).

The percentage cover at TKB (Figure 17) revealed the dynamics of recruitment in the area. The percentage cover varied depending on the distance from the shore. There was higher recruitment at all shore levels at TKB resulting in the percentage cover being more than 40%, except at the 81-100 meters where there was no recruitment. There were significant differences ($P < 0.05$) between the early period of the study and the later, November 2005-May 2006 and June 2006-August 2006. Early in the study a large canopy was formed, whereas at the end of the study the populations disappeared due to senescence. The growth and development cycle was dynamic at TKB. The highest percentage cover of *Padina* was reached in May (Table 11-12; $n=9.33 \pm 5.21$, 4.29 ± 0.39 cm. at the 61-80 m.). Then it started to drop in June 2006 and the foliose thalli disappeared in August 2006, the last month of this study. In the permanent plots, the *Dictyosphaerota* stage thalli were observed throughout the year. This caused the percentage cover to be high after the peak of growth in January to February 2006 by almost 100% even though there were no foliose thalli in the plots.

The data of measurement of surface area and number of released spores support an understanding of the recruitment of *P. boryana* in the manipulated permanent plots. The percentage covers were high after the peak of releasing spores, another source of recruitment. Foliose thalli were visible within one month of spore release.

Physico-chemical parameters such as salinity, seawater and air temperature were subjected to correlation tests. The ranges of the physical parameters at both sites were only slightly different. The range of the average seawater temperature was 26°C-34°C at SNP and 25°C-38°C at TKB (Figure 18). The range of the average air

temperature was 24°C-31°C at SNP and 23°C-37°C at TKB (Figure 19). The range of the average salinity was 24-34 ppt at SNP and 20-35 ppt at TKB (Figure 20). However, at SNP, there was a correlation between air temperature and surface area (Table 13, Figure 21; $r = -0.24$). At TKB, there were significant correlations between air temperature and average percentage of female gametophytes (Table 13, Figure 22; $r = 0.237$), water temperature and average percentage of female gametophytes (Table 13, Figure 23; $r = 0.334$). Moreover, there were correlations between salinity and average percentage of male gametophytes (Table 13, Figure 24; $r = 0.235$), average percentage of sporophytes (Table 13, Figure 25; $r = 0.235$), average percentage of mature sporophytes (Table 13, Figure 26; $r = 0.339$), average percentage of reproduction (Table 13, Figure 27; $r = 0.348$), the average number of produced spores (Table 13, Figure 28; $r = 0.43$), the average number of released spores (Table 13, Figure 29; $r = 0.253$), and average surface area (Table 13, Figure 30; $r = 0.507$).

Table 9. A comparison of the percentage of filamentous greens, filamentous reds and *P. boryana* at all levels in the permanent plots at Sirinart National Park from October 2005 to August 2006.

month	% filamentous green						% filamentous red						% <i>Padina</i>					
	Upper (m.)		Middle (m.)		Lower (m.)		Upper (m.)		Middle (m.)		Lower (m.)		Upper (m.)		Middle (m.)		Lower (m.)	
	0-20	21-40	41-60	61-80	81-100	101-120	0-20	21-40	41-60	61-80	81-100	101-120	0-20	21-40	41-60	61-80	81-100	101-120
Oct-05	40±20	63.33±8.82	5±2.89	40±25.17	66.67±8.82	100	0	0	13.33±6.67	3.33±3.33	0	0	36.67±13.33	36.67±8.82	1.67±1.67	0	33.33±8.81	0
Nov-05	33.33±16.67	50	55±27.54	66.67±8.82	60±10	91.67±1.67	0	0	11.67±6.01	20±11.55	23.33±14.53	6.67±3.33	33.33±16.67	52±0.58	0	0	16.67±16.67	0
Dec-05	50	20±20	35±15	0	50	66.67±8.82	50	0	58.33±8.33	0	50	30	0	0	6.67±6.67	0	0	0
Jan-06	60±30	46.67±23.33	85±7.64	0	75.33±7.97	3.33±3.33	1.67±1.67	20±10	13.33±8.33	0	21.67±8.33	3.33±3.33	3.33±3.33	0	1.67±1.67	0	0	0
Feb-06	76.67±14.53	46.67±23.33	88.33±9.28	100	75.33±7.97	3.33±3.33	0	20±10	11.67±9.28	0	22.33±7.67	3.33±3.33	16.67±16.67	0	0	0	0	0
Mar-06	23.33±14.53	66.67±3.33	88.33±9.28	100	78.67±6.33	3.33±3.34	0	20±10	11.67±9.28	0	22.33±7.67	3.33±3.33	76.67±14.53	0	0	0	0	0
Apr-06	36.67±18.56	66.67±3.33	20±20	60	66.67±11.67	3.33±3.35	16.67±16.67	31.67±1.67	43.33±6.67	0	23.33±14.53	3.33±3.33	40±5.78	0	6.67±3.33	13.33±13.33	5±2.29	0
May-06	23.33±13.02	6.67±6.67	63.33±6.67	5±5	28.33±10.14	60±5.77	8.33±8.33	0	16.67±16.67	13.33±13.33	55±15	0	56.67±12.02	23.33±14.53	20±10	13.33±13.33	10±5	0
June-06	0	0	0	50	83.33±16.67	60±5.77	15±12.58	0	0	50	0	0	75±17.56	0	10±5.77	0	16.67±16.67	0
July-06	36.67±19.22	0	0	50	100	100	15±15	0	0	50	0	0	23.33±12.02	3.33±3.33	11.67±6.01	0	0	0
Aug-06	33.33±20.28	33.33±33.33	100	50	100	100	15±15	0	0	50	0	0	33.33±24.04	3.33±3.33	13.33±6.67	0	0	0

Table 10. A comparison of the percentage of filamentous greens, filamentous reds and *P. boryana* at all levels in the permanent plots at Tang Khen Bay from October 2005 to August 2006.

month	% filamentous green						% filamentous red						% <i>Padina</i>					
	Upper (m.)		Middle (m.)		Lower (m.)		Upper (m.)		Middle (m.)		Lower (m.)		Upper (m.)		Middle (m.)		Lower (m.)	
	0-20	21-40	41-60	61-80	81-100	101-120	0-20	21-40	41-60	61-80	81-100	101-120	0-20	21-40	41-60	61-80	81-100	101-120
Oct-05	100	95±2.89	80±5.77	46.67±23.33	36.67±6.67	93.33±1.67	0	0	0	0	0	0	0	5±2.89	20±10	20±17.32	0	6.67±2.89
Nov-05	6.67±1.67	88.33±9.28	30±30	0	20±10	83.33±4.41	6.67±6.67	0	0	0	0	0	10±5.77	11.67±9.28	13.33±2.89	53.33±46.19	26.67±5.77	16.67±7.64
Dec-05	28.33±9.28	51.67±4.41	15±5.20	10±2.89	33.33±11.67	20.83±7.95	8.33±6.01	0	0	0	0	6.67±6.67	28.33±16.41	43.33±3.33	65±18.03	53.33±42.52	20±34.64	56.67±5.77
Jan-06	35±2.89	90	1.33±0.67	0	0	0	0	0	0	0	0	0	23.33±8.33	33.33±12.02	98.67±1.15	66.67±57.74	0	100
Feb-06	85±5	0	1.33±0.68	0	78.33±7.33	13.33±8.82	0	0	0	0	0	0	11.67±6.01	81±10.54	98.67±0.06	66.67±33.33	0	30
Mar-06	58.33±24.21	38.33±20.48	31.67±7.26	0	0	0	0	0	0	0	0	0	11.67±6.01	45±24.66	64.33±8.09	66.67±33.33	0	43.33±6.67
Apr-06	46.67±8.82	21.67±13.02	25±12.58	13.33±6.67	0	26.67±3.33	0	0	0	0	0	6.67±6.67	24.67±13.48	48.33±21.67	66.67±8.82	53.33±26.67	0	66.67±8.82
May-06	30±22.55	90	0	60±10	56.67±6.67	26.67±3.33	0	0	0	0	42.67±6.36	6.67±6.67	63.33±21.67	36.67±26.67	80±20	26.67±14.53	0.67±0.67	66.67±8.82
June-06	20±5.77	46.67±8.82	46.67±27.28	46.67±24.04	100	26.67±3.33	10±10	0	0	0	0	6.67±6.67	70±15.28	40±5.77	53.33±27.28	20±11.55	0.67±0.67	66.67±8.82
July-06	15±2.89	0	65±15	65±15	56.67±28.48	0	5±5	0	33.33±16.67	33.33±16.67	0	0	80±5.77	61.67±14.24	0	0	0	0
Aug-06	0.67±0.67	20±15	0	0	0	0	0	0	0	0	0	0	99.33±0.67	50.33±25.69	0	0	0	0

Table 11. The average percentage of *P. boryana* recruitment at all shore levels at Sirinart National Park and Tang Khen Bay from October 2005 to August 2006; otherwise, * $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$; ns=not significant.

month	SNP						TKB						X^2	P
	Upper (m.)		Middle (m.)		Lower (m.)		Upper (m.)		Middle (m.)		Lower (m.)			
	0-20	21-40	41-60	61-80	81-100	101-120	0-20	21-40	41-60	61-80	81-100	101-120		
Oct-05	36.67±13.33	36.67±8.82	1.67±1.67	0	33.33±8.81	0	0	5±2.89	20±10	20±17.32	0	6.67±2.89	0.914	0.361 ns
Nov-05	33.33±16.67	52±0.58	0	0	16.67±16.67	0	10±5.77	11.67±9.28	13.33±2.89	53.33±46.19	26.67±5.77	16.67±7.64	1.299	0.194 ns
Dec-05	0	0	6.67±6.67	0	0	0	28.33±16.41	43.33±3.33	65±18.03	53.33±42.52	20±34.64	56.67±5.77	4.822	<0.001***
Jan-06	3.33±3.33	0	1.67±1.67	0	0	0	23.33±8.33	33.33±12.02	98.67±1.15	66.67±57.74	0	100	4.235	<0.001***
Feb-06	16.67±16.67	0	0	0	0	0	11.67±6.01	81±10.54	98.67±0.06	66.67±33.33	0	30	3.946	<0.001***
Mar-06	76.67±14.53	0	0	0	0	0	11.67±6.01	45±24.66	64.33±8.09	66.67±33.33	0	43.33±6.67	2.62	0.009**
Apr-06	40±5.78	0	6.67±3.33	13.33±13.33	5±2.29	0	24.67±13.48	48.33±21.67	66.67±8.82	53.33±26.67	0	66.67±8.82	2.96	0.003**
May-06	56.67±12.02	23.33±14.53	20±10	13.33±13.33	10±5	0	63.33±21.67	36.67±26.67	80±20	26.67±14.53	0.67±0.67	66.67±8.82	2.114	0.034*
June-06	75±17.56	0	10±5.77	0	16.67±16.67	0	70±15.28	40±5.77	53.33±27.28	20±11.55	0.67±0.67	66.67±8.82	2.421	0.015*
July-06	23.33±12.02	3.33±3.33	11.67±6.01	0	0	0	80±5.77	61.67±14.24	0	0	0	0	0.931	0.352 ns
Aug-06	33.33±24.04	3.33±3.33	13.33±6.67	0	0	0	99.33±0.67	50.33±25.69	0	0	0	0	0.698	0.485 ns

Table 12. The average length (cm.) of *P. boryana* in the permanent plots at Sirinart National Park and Tang Khen Bay from October 2005 to August 2006; D: *Dictyarpa* stage found.

month	SNP						TKB					
	Upper (m.)		Middle (m.)		Lower (m.)		Upper (m.)		Middle (m.)		Lower (m.)	
	0-20	21-40	41-60	61-80	81-100	101-120	0-20	21-40	41-60	61-80	81-100	101-120
Oct-05	1	D	D	D	D	D	0	0.5	0	2	0.95±.14	0
Nov-05	D	D	D	D	0.5	0	0.85±0.05	1	1.07±0.02	1.77±0.07	0.5	2.09±0.22
Dec-05	D	D	1.5	D	D	0	0.82±0.05	0.61±0.04	1±0.05	1.56±0.1	0	3.32±0.17
Jan-06	0.5	D	D	D	D	0	1.07±0.06	0.68±0.08	1.32±0.11	1.82±0.14	0	2.9±0.14
Feb-06	0.5	D	D	D	D	0	1	1	1.33±0.12	1.82±0.14	0	0.5
Mar-06	1	D	D	D	D	0	1	1.67±0.4	1.02±0.26	1.9±0.2	0	2.54±0.13
Apr-06	0.95±0.06	D	1.44±0.22	D	0.89±0.11	0	1.31±0.08	1.35±0.1	1.22±0.08	1.82±0.13	0	2.79±0.17
May-06	2.167±0.18	0.50	5.33±0.41	0.50	0.96±0.13	0	2.79±0.19	1.66±0.15	1.88±0.29	4.29±0.39	0	2.79±0.17
June-06	4.18±0.37	D	4.2±1.55	D	1	0	1.8±0.1	1.11±0.09	1.83±0.14	1.55±0.58	0	2.79±0.17
July-06	2.90±0.33	4±.58	4.67±1.33	D	0	0	3.23±0.11	1.53±0.1	0	0	0	0
Aug-06	5.33±0.3	4±0.58	4.75±0.67	0	0	0	1	0	0	0	0	0

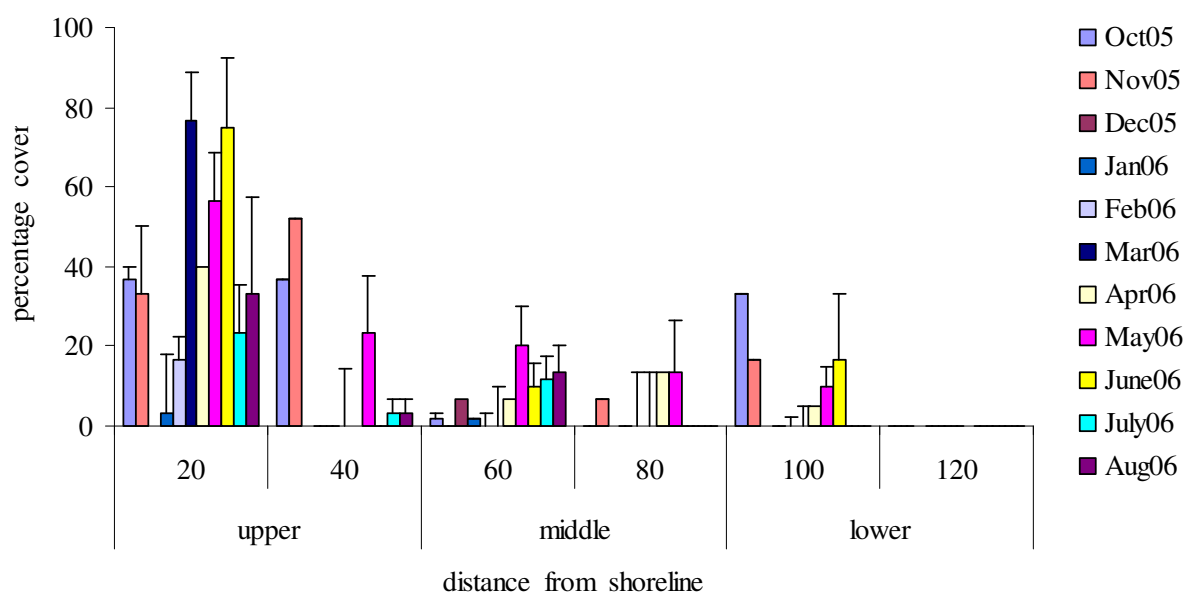


Figure 16. Percentages cover of *P. boryana* from October 2005 to August 2006 at Sirinart National Park.

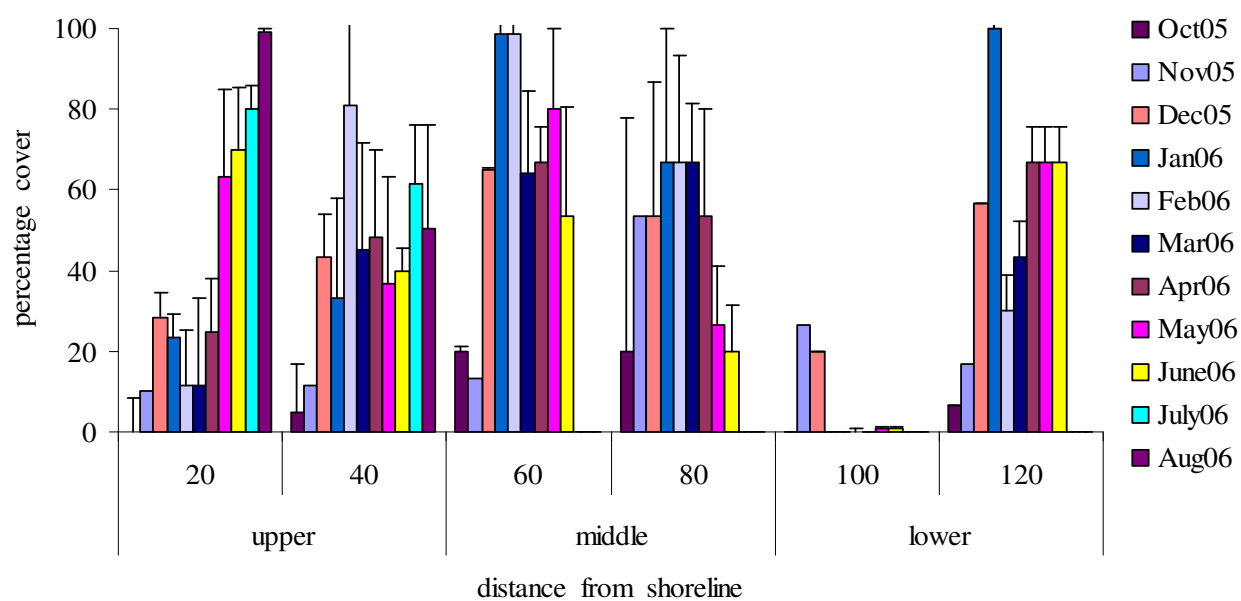


Figure 17. Percentages cover of *P. boryana* from October 2005 to August 2006 at Tang Khen Bay.

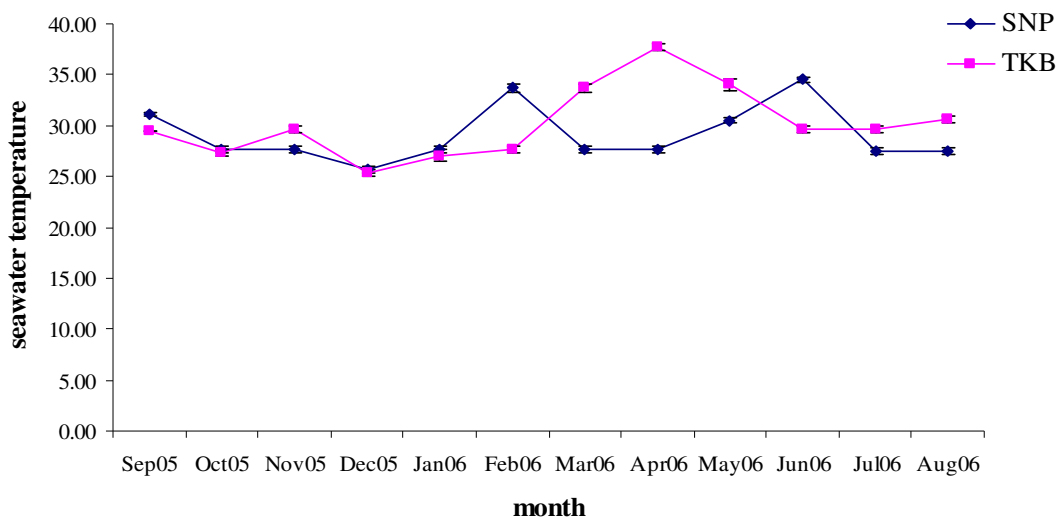


Figure 18. Comparison of seawater temperatures from September 2005 to August 2006 at Sirinart National Park and Tang Khen Bay.

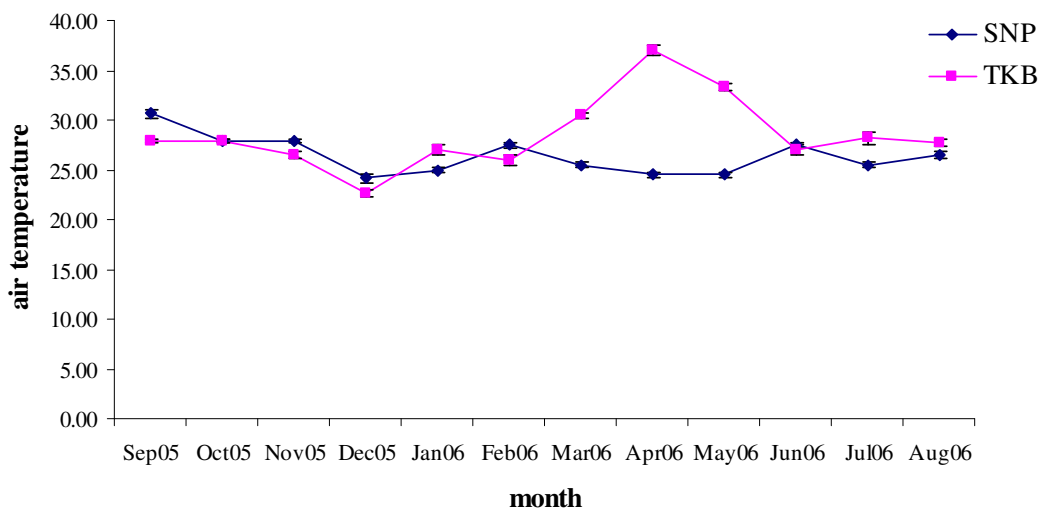


Figure 19. Comparison of air temperatures from September 2005 to August 2006 at Sirinart National Park and Tang Khen Bay.

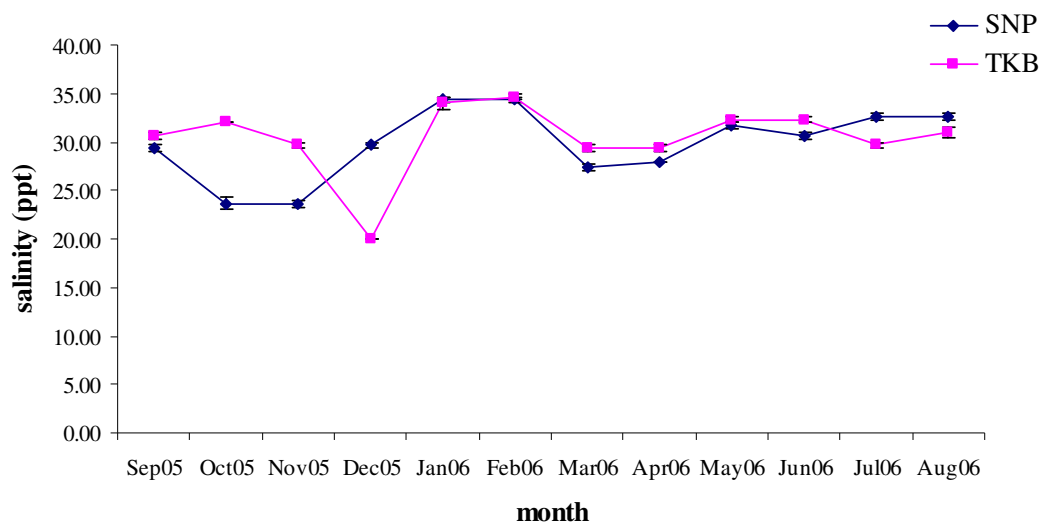


Figure 20. Comparison of salinity (ppt) from September 2005 to August 2006 at Sirinart National Park and Tang Khen Bay.

Table 13. The correlation coefficient value of physico-chemical parameters and biological characteristics of *P. boryana*.

Biological parameters	SNP			TKB		
	Temperature		Salinity	Temperature		Salinity
	Air	Water		Air	Water	
Surface area	-0.24	-0.117	0.158	-0.091	-0.028	0.507
%female gametophyte	-0.128	0.12	0.114	0.237	0.334	0.13
%male gametophyte	-0.006	-0.089	0.114	0.111	0.047	0.235
%sporophyte	0.094	-0.085	0.143	-0.102	-0.072	0.302
%mature sporophyte	0.088	-0.072	0.147	-0.086	-0.109	0.339
%reproduction	0.084	-0.065	0.145	-0.063	-0.029	0.348
Number of spore produced	-0.008	-0.035	0.062	-0.137	-0.088	0.43
Number of spore released	0.018	0.13	-205	0.227	-0.22	0.253
%cover of <i>Padina</i>	0.115	0.13	-0.205	-0.052	0.018	0.083

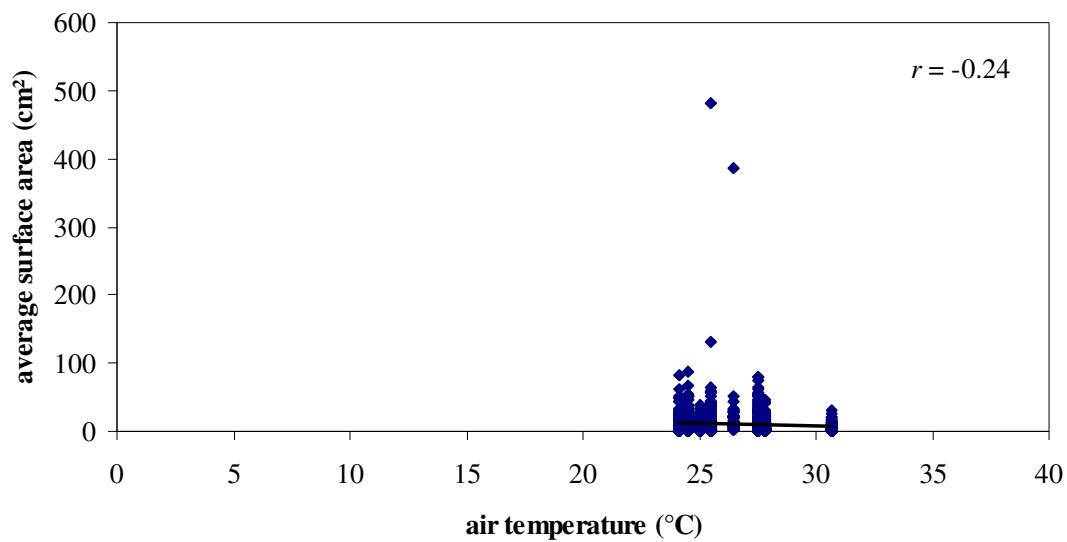


Figure 21. The correlation of average surface areas and air temperature from September 2005 to August 2006 at Sirinart National Park.

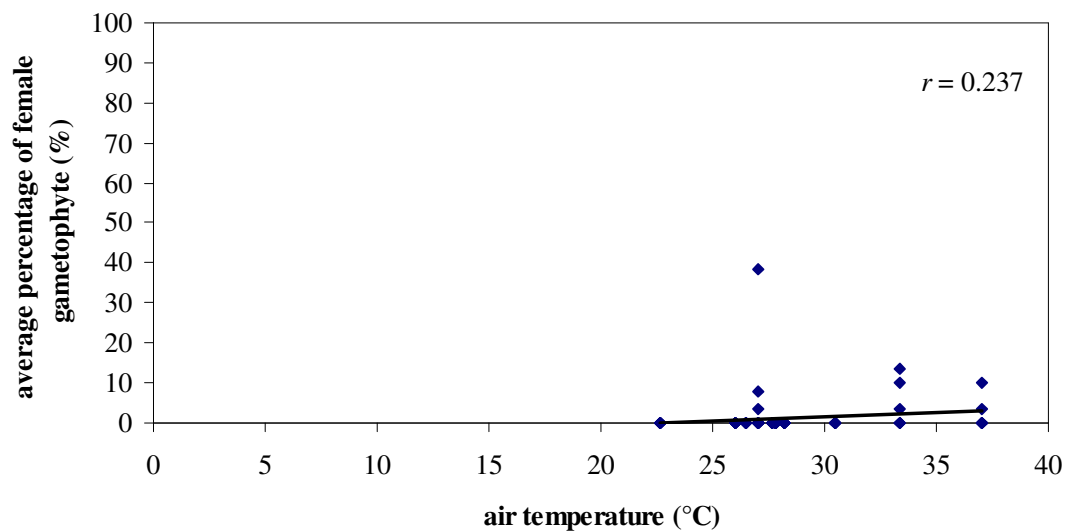


Figure 22. The correlation of average percentages of female gametophytes and air temperature from September 2005 to August 2006 at Tang Khen Bay.

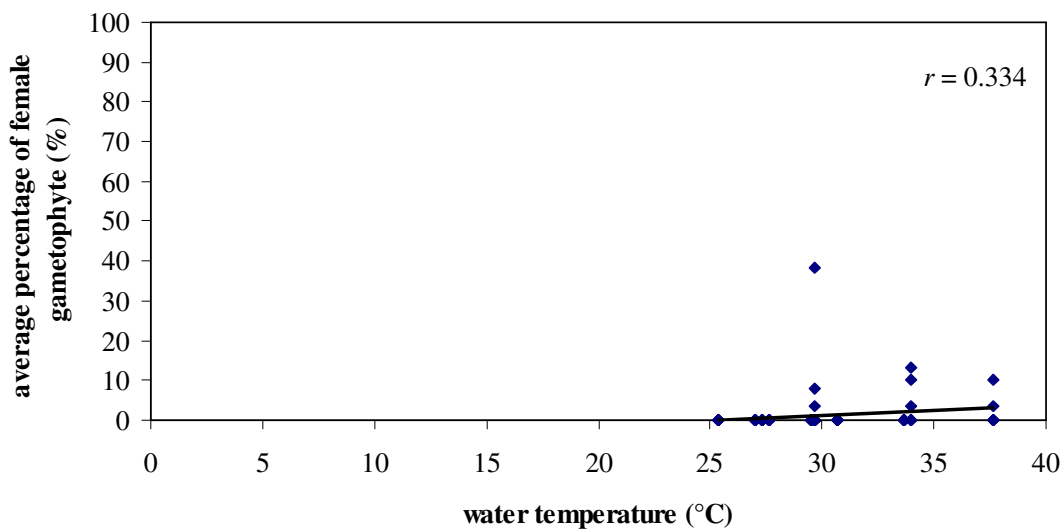


Figure 23. The correlation of average percentages of female gametophytes and water temperature from September 2005 to August 2006 at Tang Khen Bay.

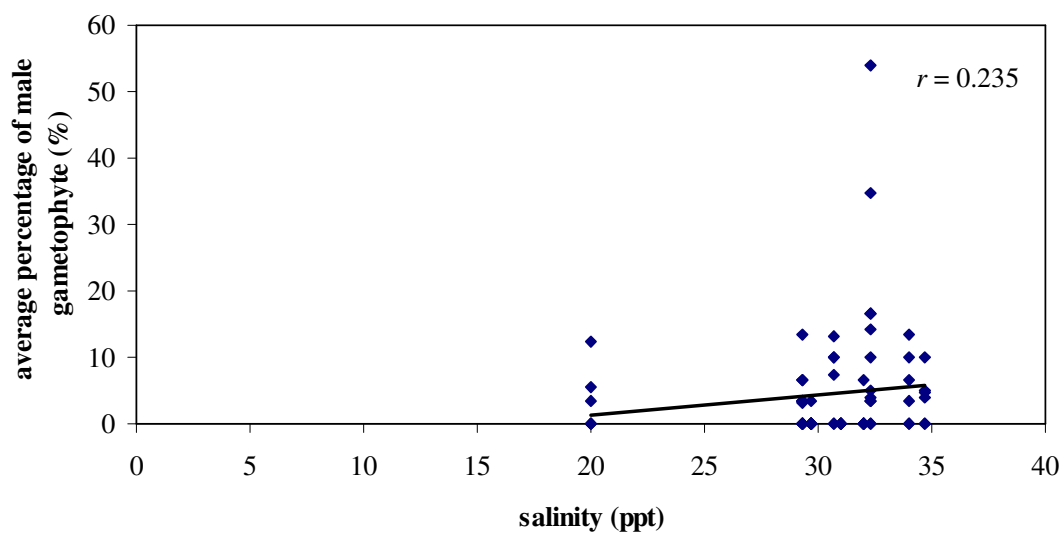


Figure 24. The correlation of average percentages of male gametophytes and salinity from September 2005 to August 2006 at Tang Khen Bay.

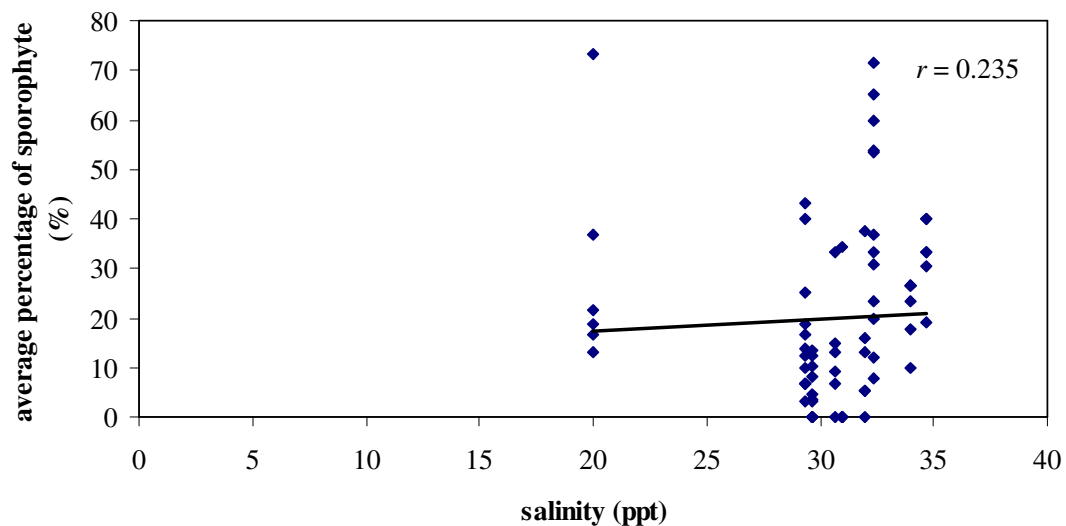


Figure 25. The correlation of average percentages of sporophytes and salinity from September 2005 to August 2006 at Tang Khen Bay.

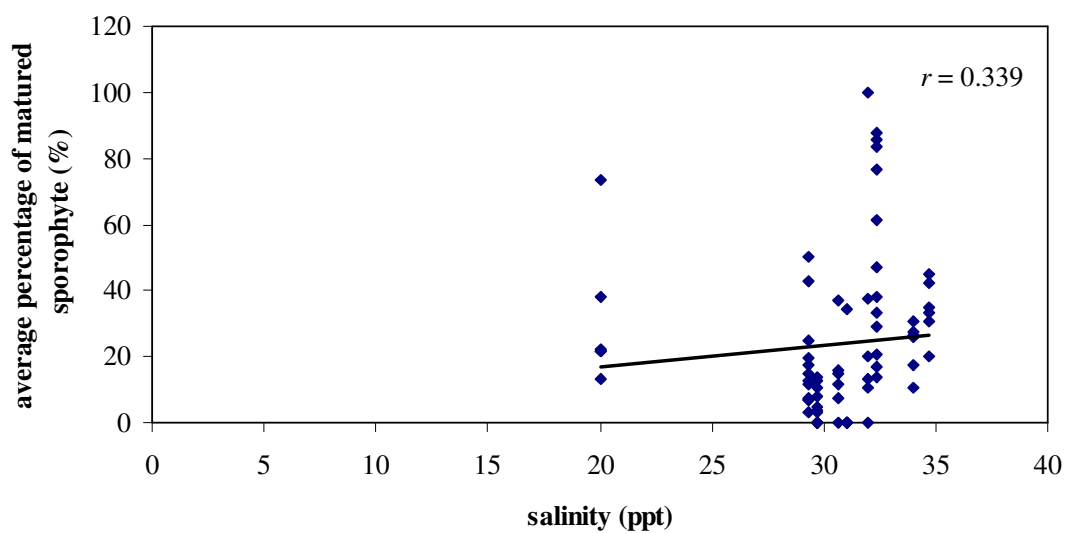


Figure 26. The correlation of average percentages of mature sporophytes and salinity from September 2005 to August 2006 at Tang Khen Bay.

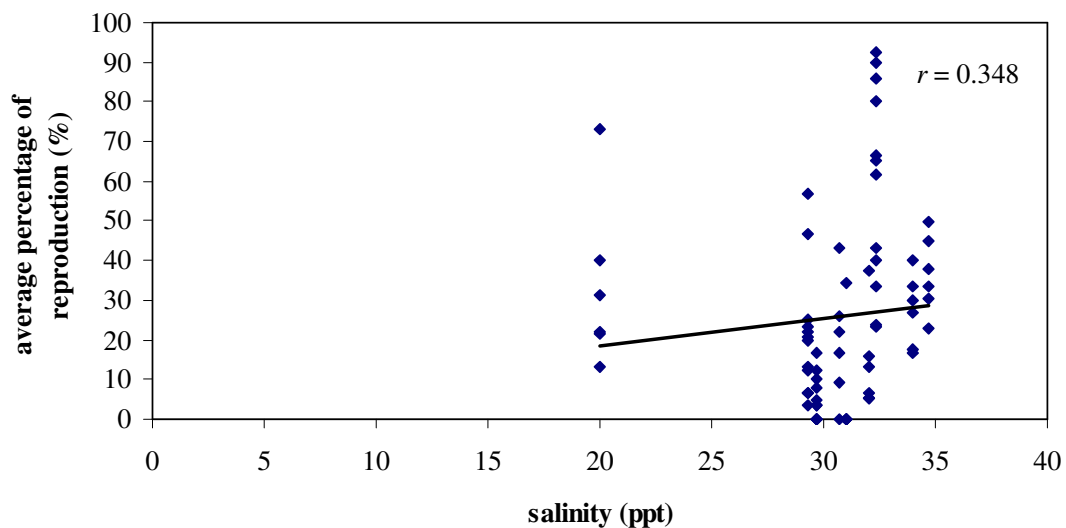


Figure 27. The correlation of average percentages of reproduction and salinity from September 2005 to August 2006 at Tang Khen Bay.

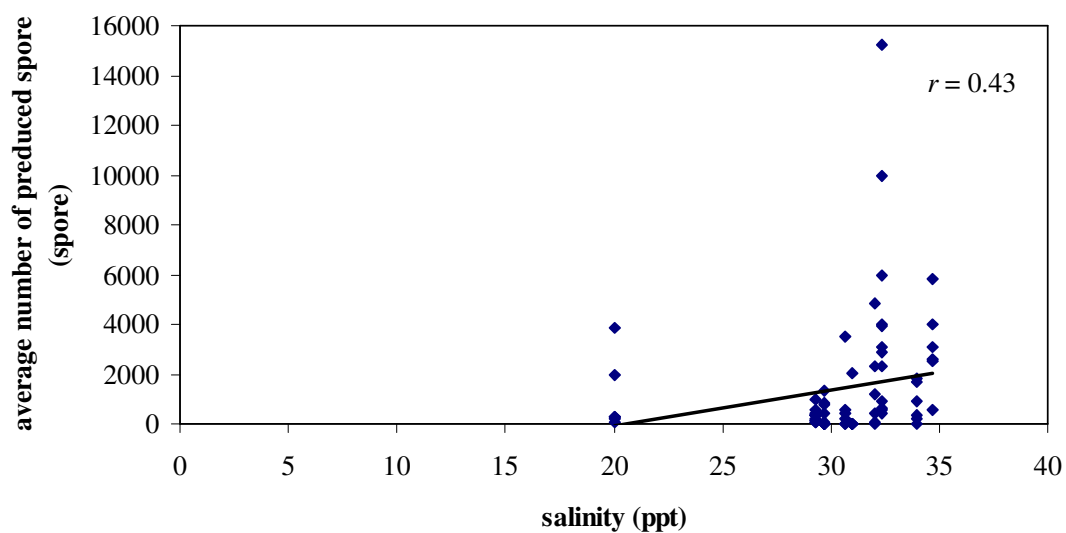


Figure 28. The correlation of average numbers of spores produced and salinity from September 2005 to August 2006 at Tang Khen Bay.

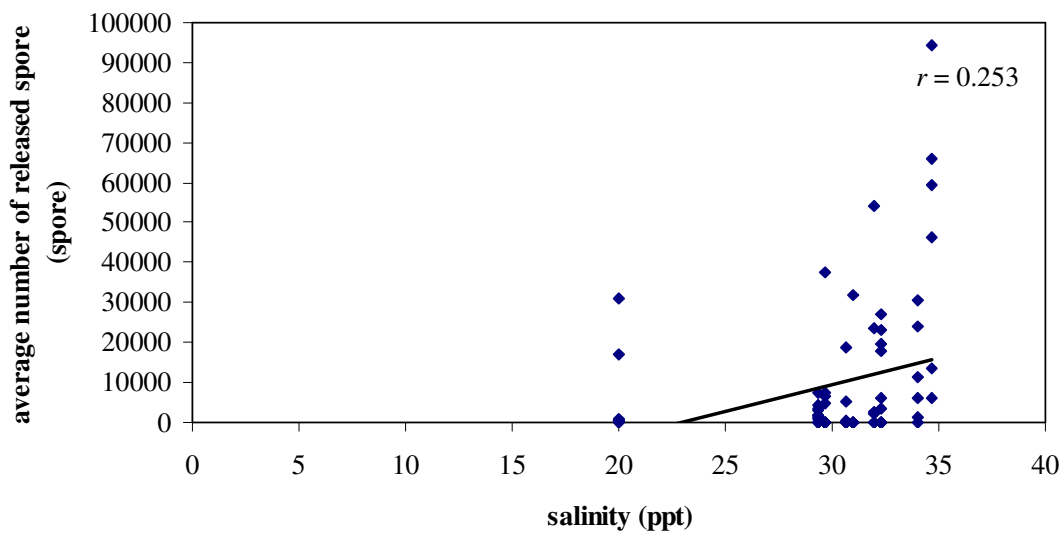


Figure 29. The correlation of average numbers of spores released and salinity from September 2005 to August 2006 at Tang Khen Bay.

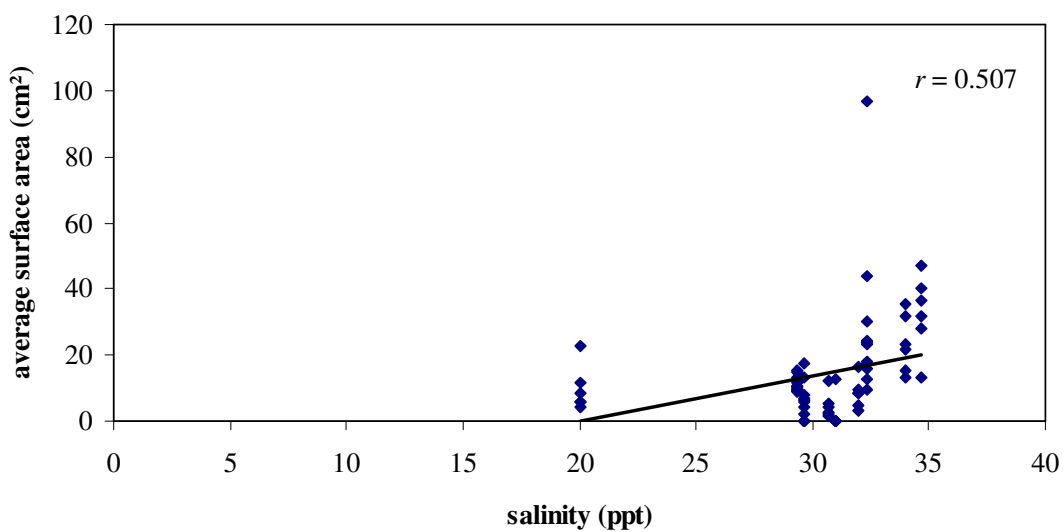


Figure 30. The correlation of average surface area and salinity from September 2005 to August 2006 at Tang Khen Bay.