

# Population abundance and body size of *Calanus sinicus* in marginal habitats in the coastal seas of south-eastern Hong Kong

G.-T. ZHANG<sup>1</sup> AND C.K. WONG<sup>2</sup>

<sup>1</sup>Jiaozhou Bay Marine Ecosystem Research Station, Institute of Oceanology, Chinese Academy of Sciences, Qingdao, China, <sup>2</sup>School of Life Sciences, The Chinese University of Hong Kong, Shatin, Hong Kong, China

*The species range of Calanus sinicus along the Chinese coast extends from the Bohai Sea and the Yellow Sea in the north to the northern part of the South China Sea in the south. The subtropical seas along the southern coast of China mark the southern edge of the range of C. sinicus. In coastal seas off eastern Hong Kong, C. sinicus appears first in December, but densities comparable to those in the Yellow Sea and the East China Sea are reached only in January and February when temperature is <15°C. Density decreases in March as temperature increases. No individuals remain after May when temperature is >25°C. The average prosome length of females collected in February is comparable to that of females from the Yellow Sea, but females collected after mid-March are smaller than the smallest females from the Yellow Sea. Reproduction occurred mainly between January and March. Rapid decline of the population in April and the absence of a summer population suggest that the local population is derived from individuals advected from the north by ocean currents. Eggs produced locally probably did not hatch or develop into adults.*

**Keywords:** *Calanus sinicus*, population abundance, body size, subtropical coastal waters

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## INTRODUCTION

*Calanus sinicus* is a calanoid copepod with wide distribution in continental shelf waters of the north-west Pacific Ocean (Hulsemann, 1994). Along the Chinese coast, the range of *C. sinicus* extends from the Bohai Sea and the Yellow Sea in the north to the northern part of the South China Sea in the south (Chen, 1992). In the temperate waters of the Bohai Sea, the Yellow Sea and the East China Sea, *C. sinicus* occurs throughout the year and is a dominant member of the mesozooplankton in terms of numerical abundance and ecological importance (Chen, 1992; Wang *et al.*, 2003). In subtropical seas along the coast of southern China, *C. sinicus* occurs seasonally from late autumn to early spring (Chen, 1992; Hwang & Wong, 2005). While *C. sinicus* is considered one of the key species of planktonic copepods in the coastal waters of China and Japan (Chen, 1964), most previous studies on the seasonal dynamics and life history of *C. sinicus* have focused on populations in temperate oceans (Uye, 2000; Zhang *et al.*, 2005; Xu & Chen, 2007; Zhang *et al.*, 2007). Far less information is available on populations in the subtropical waters near the southern edge of the species range.

Hong Kong is located in the southern part of the Chinese coast. A plume of estuarine water from the Zhujiang River covers the western side of Hong Kong during the rainy

season from April to September. Oceanic conditions, characterized by high salinities, prevail on the eastern side of Hong Kong. The eastern side of Hong Kong consists of two semi-enclosed bays in the north and open sea area in the south (Figure 1). Tolo Harbour, a landlocked bay opens into Mirs Bay via a narrow tidal channel. Mean water depth in Tolo Harbour varies from ~10 m in the inner shallow basin to about 20 m in the channel. Because of the semi-enclosed topography, Tolo Harbour is characterized by low current velocity and is poorly flushed (Oakley & Cripps, 1972). Bordered by Hong Kong on the west and mainland China on the north and east, Mirs Bay has an average water depth of about 25 m and is fully exposed to water currents from the South China Sea.

Results of a previous study revealed that the occurrence of *Calanus sinicus* in coastal oceans around Hong Kong and Taiwan is limited by temperature to winter and spring (Hwang & Wong, 2005). It was hypothesized that *C. sinicus* is carried into the subtropical oceans in the southern part of the species range every winter from population centres in the north by the China Coastal Current when the north-eastern monsoon is blowing (Chen, 1992). Understanding the life history of *C. sinicus* in marginal habitats near the southern edge of its geographical range is important to researchers of the ecosystem dynamics of the South China Sea. In this study, seasonal variations in population structure and body size of *C. sinicus* are investigated along a transect extending from the inner part of Tolo Harbour to the outer part of Mirs Bay. The objectives are to: (i) investigate the population structure of *C. sinicus* in subtropical coastal oceans; (ii) identify factors that influence the seasonal and

**Corresponding author:**  
C.K. Wong  
Email: chongkimwong@cuhk.edu.hk

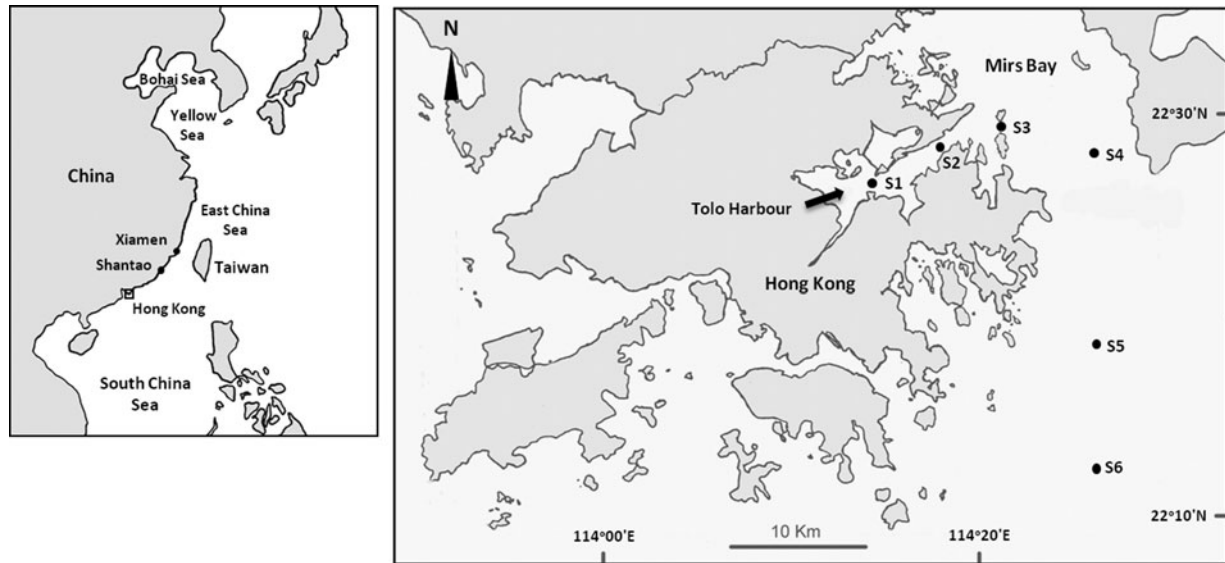


Fig. 1. Map of Hong Kong showing the locations of Tolo Harbour, Mirs Bay and the six sampling stations.

spatial distribution patterns of *C. sinicus*; and (iii) provide preliminary information on the recruitment mechanisms of *C. sinicus* in marginal habitats in the northern part of the South China Sea.

## MATERIALS AND METHODS

Zooplankton was collected approximately semi-monthly from September 2003 to July 2004 at 6 sampling stations. Two stations, S<sub>1</sub> (22°26'725"N, 114°14'566"E) and S<sub>2</sub> (22°28'539"N, 114°18'034"E) were located inside Tolo Harbour. Two stations, S<sub>3</sub> (22°29'468"N, 114°21'588"E) and S<sub>4</sub> (22°26'670"N, 114°26'920"E) were located in Mirs Bay. Two stations, S<sub>5</sub> (22°17'560"N, 114°26'920"E) and S<sub>6</sub> (22°13'000"N, 114°26'920"E) were located in the coastal sea of south-eastern Hong Kong outside Mirs Bay (Figure 1). Water depths ranged from 15 m at S<sub>1</sub>, the innermost station, to ~30 m at S<sub>5</sub> and S<sub>6</sub>, the two outermost stations. At each station, duplicate zooplankton samples were taken

by hauling a conical plankton net (0.5 m mouth diameter; 125 µm mesh) vertically from ~2 m above bottom to the surface. All zooplankton samples were immediately preserved in 4% formalin seawater. Water temperature and salinity were measured at the surface (0.5 m) using a Hydrolab H20 water quality monitoring system (Austin, USA). Chlorophyll-*a* concentration in seawater samples collected at the surface (0.5 m) with a Van Dorn type bottle was measured fluorometrically using a Turner Designs 10-AU-000 Fluorometer (Sunnyvale, USA) (Strickland & Parsons, 1968).

In the laboratory, *C. sinicus* in different developmental stages (eggs, nauplii (NI–NVI), copepodites (CI–CV), adult males and adult females) were identified and sorted under a stereomicroscope according to the descriptions of Li & Fang (1983). Densities were determined by counting 25–100% of each sample under a stereomicroscope. Prosome lengths, from the anterior end of the cephalosome to the posterior lateral edge of the last metasome segment, of CVs, adult males and adult females were measured. At least 10 individuals of each developmental stage were measured for each sample.

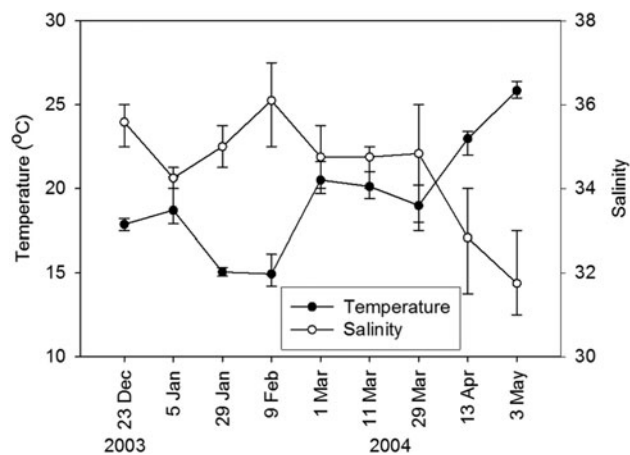


Fig. 2. Temporal variations in water temperature and salinity in the study area during the period when *Calanus sinicus* was present. Values represent average of six sampling stations. Error bars denote the range.

## RESULTS

### Environmental conditions

Similar seasonal trends in temperature and salinity were observed at all sampling stations (Figure 2). Surface water temperature ranged from ~15°C in late January and early February to >25°C in May. Salinity ranged from a maximum of 37 at S<sub>2</sub> in February to a minimum of 31 at S<sub>1</sub> and S<sub>3</sub> in early May (Figure 2). Salinity decreased markedly after March, especially in Tolo Harbour, with the approach of the rainy season.

Chlorophyll-*a* concentration was much higher in Tolo Harbour than in Mirs Bay (Figure 3). In Tolo Harbour, values spanned widely from 2.67 to 20.30 µg l<sup>-1</sup> at S<sub>1</sub> and from 0.84 to 8.70 µg l<sup>-1</sup> at S<sub>2</sub>. In comparison, values recorded at the four stations outside Tolo Harbour varied from 0.17 to 4.36 µg l<sup>-1</sup>.

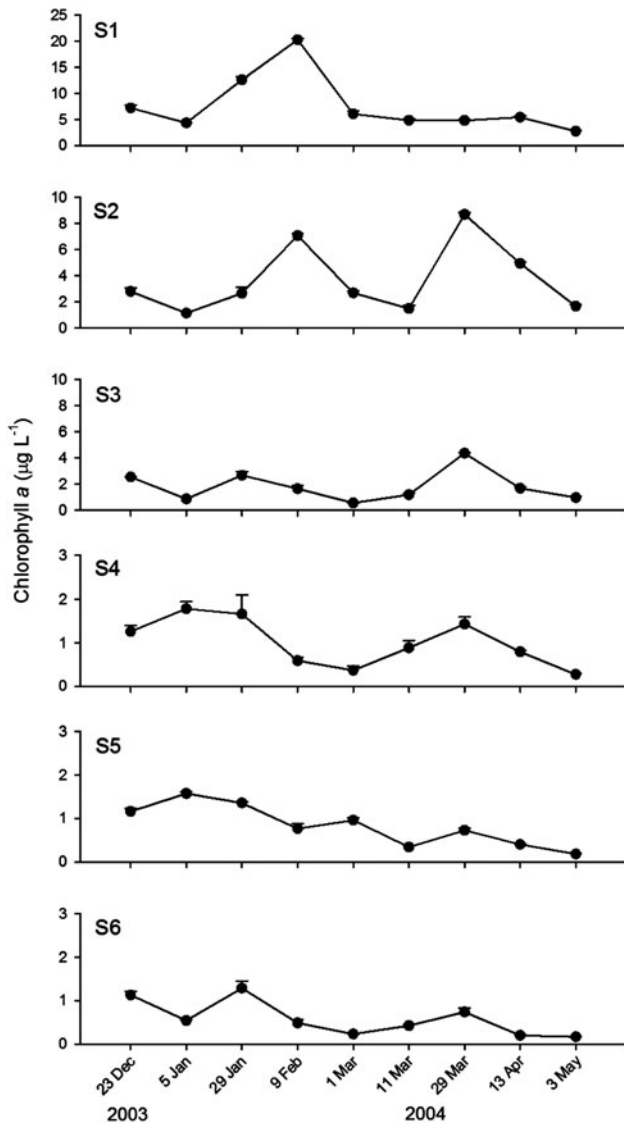


Fig. 3. Temporal variations in mean chlorophyll-*a* concentrations (error bars: standard deviation) at six sampling stations during the period when *Calanus sinicus* was present.

### Population abundance and structure

*Calanus sinicus* was found only in samples collected between late December and early May (Figure 4). The highest densities were recorded in January and February. Averaged across all sampling stations, the density of adults increased from 1.1 ind.  $m^{-3}$  in late December to 78.8 ind.  $m^{-3}$  in early February, then decreased to 13.2 ind.  $m^{-3}$  in early March and  $<1.6$  ind.  $m^{-3}$  in April. No adults were found in samples taken in May. Copepodites also appeared first in December and remained relatively abundant until early March. The maximum average density of 402 ind.  $m^{-3}$  was recorded in late January. Average density dropped abruptly from 384 ind.  $m^{-3}$  in early March to 38.3 ind.  $m^{-3}$  at the end of March. Samples collected in April and May contained  $<30$  ind.  $m^{-3}$ . Only a few nauplii of *C. sinicus* were found in samples collected in December. Average density increased markedly from  $<30$  ind.  $m^{-3}$  in early January to  $>1100$  ind.  $m^{-3}$  at the end of January, and then decreased more or less continuously to  $<10$  ind.  $m^{-3}$  in samples taken

in April and May. Eggs of *C. sinicus* appeared first in samples collected in December but did not become abundant until late January. The maximum average density of 485 ind.  $m^{-3}$  was recorded in early February. No eggs of *C. sinicus* were found in samples collected in May.

*Calanus sinicus* exhibited spatial variations in abundance throughout the study period (Figure 4). Adults, copepodites, nauplii and eggs appeared at S5 and S6, the outermost stations in December, but did not reach Tolo Harbour until January. Adults and copepodites appeared at S5 and S6 in December, reached S3 and S4 in Mirs Bay in early January, and were found in Tolo Harbour at the end of January. Throughout January and February, the density of adults was much lower at S1 and S2 than at the four outer stations. A similar trend of shoreward decrease was observed in the density of nauplii and copepodites in January. Samples collected in Tolo Harbour in early January contained no nauplii. A few eggs were found in S2 in early January when the average density of eggs in the entire study area was still  $<50$   $m^{-3}$ , but samples collected in Tolo Harbour in late January did not contain eggs even though egg density at S6, the outermost station, had reached a maximum of  $>1400$   $m^{-3}$ . While the density of adults was always highest in the open waters outside Tolo Harbour, samples collected in March showed that eggs, nauplii and copepodites were often abundant at S2 in the outer part of Tolo Harbour and S3 in the inner part of Mirs Bay than at the other stations. Eggs and nauplii disappeared from Tolo Harbour before adults and copepodites. No eggs and nauplii were found in Tolo Harbour after March. In contrast, adults and copepodites remained at S1 until April and at S2 until early May.

### Sex-ratio and female fecundity

The ratio of female:male was highest in December when the density of adults in the study area was still very low (Figure 5). Sex-ratio decreased after December. Females were outnumbered by males only in samples taken in early March. The number of eggs per female increased from  $<15$  in December to a peak of 111 in early March. The number of eggs per female decreased markedly after March and no ovigerous females were found in samples taken in May.

### Prosome length

Temporal and spatial changes in the prosome lengths of adults and copepodites of *C. sinicus* are shown in Figure 6. The prosome length of females, males and CV varied significantly among stations and with time (2-way analysis of variance,  $P < 0.001$ ). The overall pattern was that individuals from January and February were bigger than individuals from March, April and May (Tukey's multiple comparison tests,  $P < 0.05$ ), and individuals from S3, S4, S5 and S6 were bigger than individuals from S1 and S2 (Tukey's multiple comparison tests,  $P < 0.05$ ). Averaged across all stations, the prosome length of female increased from 2.29 mm in December to 2.34 mm in early February, and then decreased gradually to 1.98 mm in early May (Figure 7). Similarly, the average prosome length of male increased from 2.03 mm in December to 2.18 mm at the end of January, and then decreased to 1.86 mm in May (Figure 7). Only one CV individual was found in samples taken in December. The average prosome

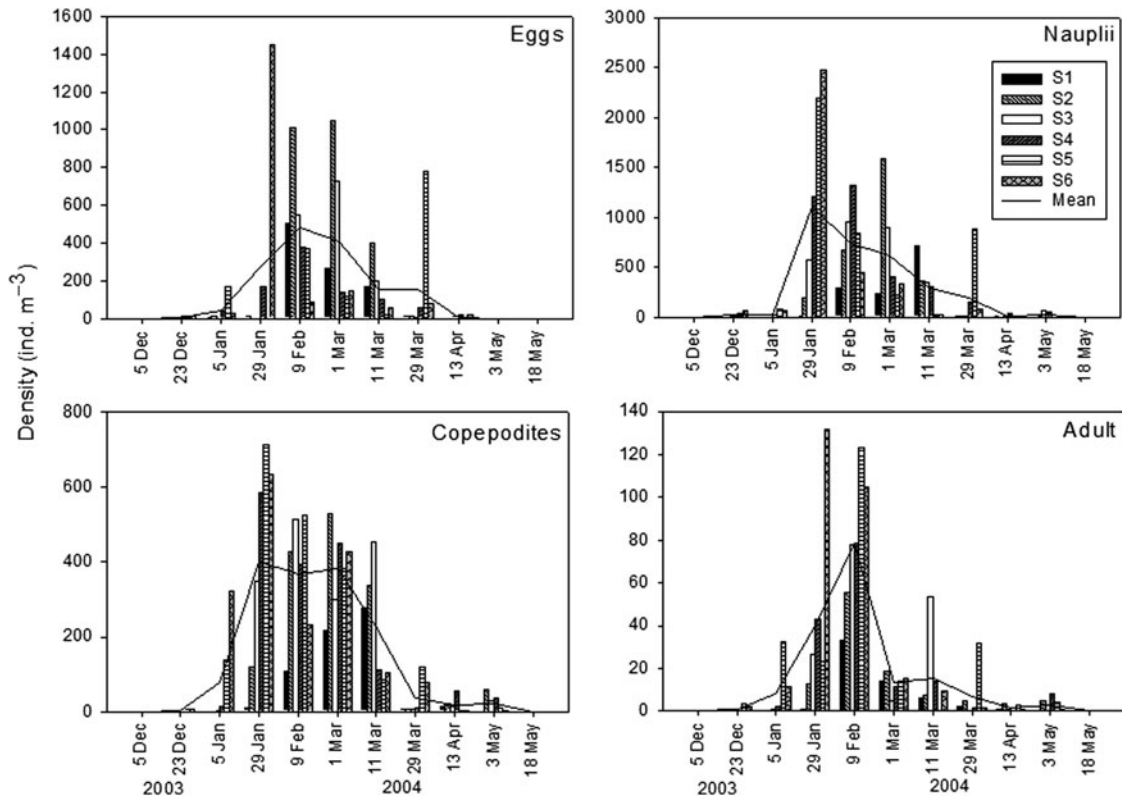


Fig. 4. Temporal variations in the density of *Calanus sinicus* of different developmental stages at six sampling stations. Solid lines connect average densities of six sampling stations.

length of CV was 1.87 mm in early January, 1.99 mm at the end of January, and 1.67 mm in May (Figure 7).

## DISCUSSION

### Population dynamics

*Calanus sinicus* appears in the subtropical coastal waters of eastern Hong Kong in winter and early spring. Adults and juveniles first appear in the open waters of south-eastern Hong Kong and Mirs Bay at the end of December. Density

increases rapidly in January. By the end of January, individuals of all developmental stages can be found in the innermost station in the shallow waters of the semi-enclosed Tolo Harbour. The highest density is recorded in late January and early February, when average water temperature has dropped to  $<15^{\circ}\text{C}$ . Densities recorded in January and February are comparable to those encountered in the population centres in the Yellow Sea (Liu *et al.*, 2003; Wang *et al.*, 2003). Overall, observations from this study and an earlier study (Hwang & Wong, 2005) confirm that the occurrence of *C. sinicus* in coastal seas of southern China coincides with the north-eastern monsoon period in winter, when cold water masses carrying *C. sinicus* from the Yellow Sea and East China Sea are driven into the South China Sea through the Taiwan Strait (Hwang *et al.*, 2004, 2006).

Data presented in this study and in many previous studies suggest that temperature is an important factor regulating the distribution of *C. sinicus*. In the Inland Sea of Japan, the biomass of *C. sinicus* reaches a maximum at  $\sim 20^{\circ}\text{C}$  (Uye, 2000). The upper thermal limit of *C. sinicus* in laboratory cultures is considered to be  $\sim 23^{\circ}\text{C}$  (Huang & Zheng, 1986; Uye, 1988). In Xiamen Harbour, *C. sinicus* disappears in June when water temperature reaches  $24^{\circ}\text{C}$  (Lin & Li, 1984). Zooplankton surveys conducted along the Chinese coast and the Taiwan Strait have generally confirmed that *C. sinicus* disappears when water temperature exceeds  $26\text{--}27^{\circ}\text{C}$  (Wang *et al.*, 2003; Hwang *et al.*, 2009). In a more recent study, *C. sinicus* is found to be abundant in western and north-eastern Taiwan, but absent in eastern Taiwan where the main branch of the Kuroshio Current warms the surface water to  $23.5^{\circ}\text{C}$  in January to  $29.2^{\circ}\text{C}$  in July (Hsiao *et al.*, 2011). Results presented here show that temperature

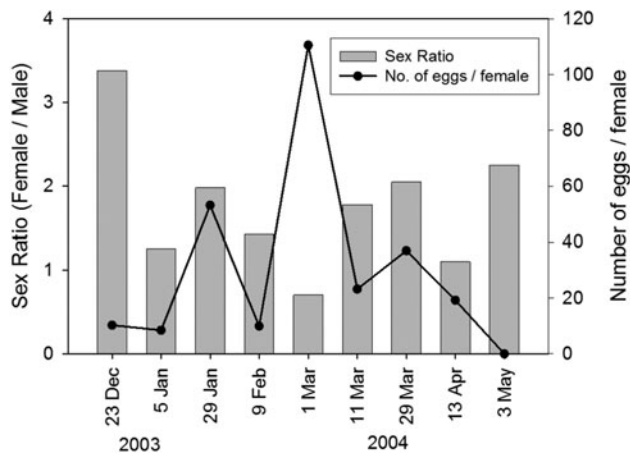


Fig. 5. Temporal variations in the sex-ratio and the number of eggs per female in *Calanus sinicus*. Values represent average of six sampling stations.



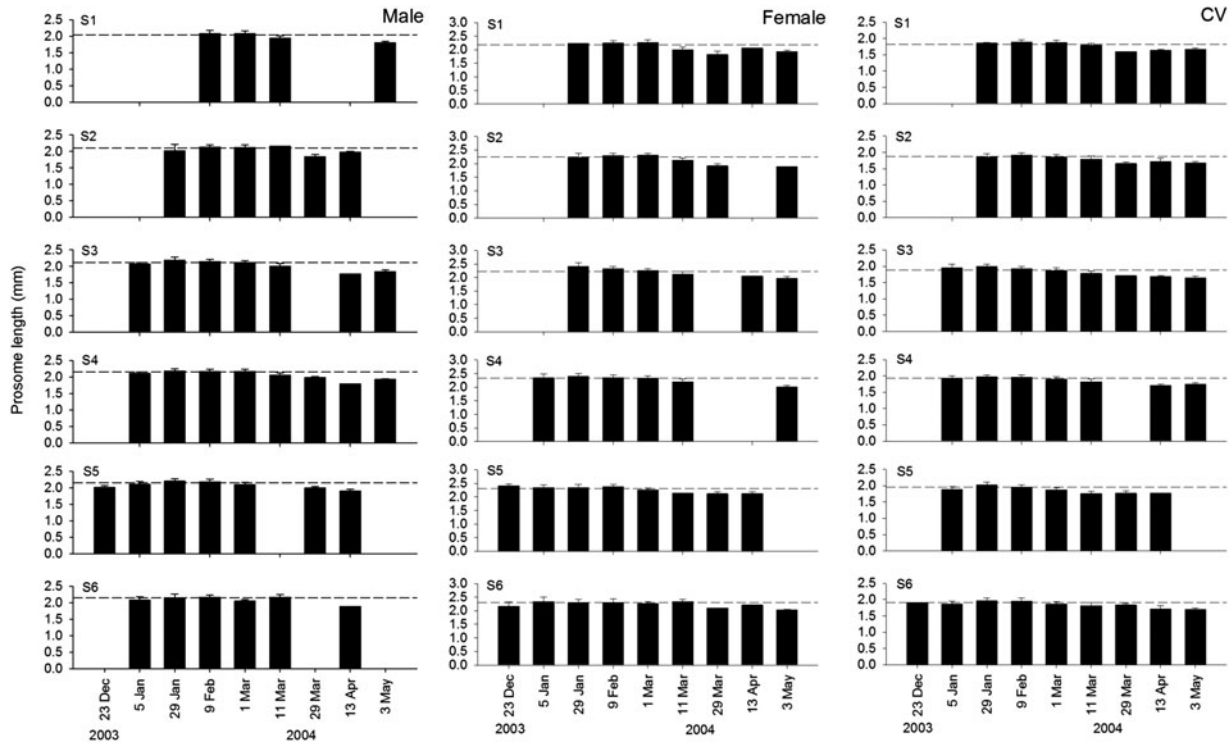


Fig. 6. Temporal variations in the average prosome length of males, females and copepodites (CVs) at six sampling stations. Vertical bars denote the standard deviation. Broken horizontal lines mark the average prosome length at each sampling station.

influences the occurrence of *C. sinicus* in the coastal waters of eastern Hong Kong. There is a negative correlation between temperature and density in *C. sinicus* nauplii and adults (Table 1). The only increasing trend in the density of *C. sinicus* of all developmental stages occurs between December and early February when water temperature is <math><20^{\circ}\text{C}</math> and decreasing. Decline in the density of all developmental stages begins in February when water temperature is just starting to increase. Very few individuals remain in the water column in May when water temperature approaches

*C. sinicus* increases when temperature is

Temperature probably also influences the size of the *C. sinicus* population that can be established in the subtropical coastal seas around Hong Kong. Densities recorded in this study were much higher than those recorded in a study conducted between 2000 and 2002 in an area near S5 and S6 (Hwang & Wong, 2005). While the previous study was conducted in an area nearer to the shore than S5 and S6, the lowest temperature encountered was also

In temperate regions, from the Bohai Sea to the East China Sea, population size of *C. sinicus* decreases abruptly after June, when water temperature goes up to C. sinicus has been known to survive the summer in cold waters in the thermally stratified deep areas (Wang *et al.*, 2003; Zhang *et al.*, 2007). The duration of the occurrence of *C. sinicus* also increases northward along the Chinese coast. In Hong Kong, *C. sinicus* occurs from

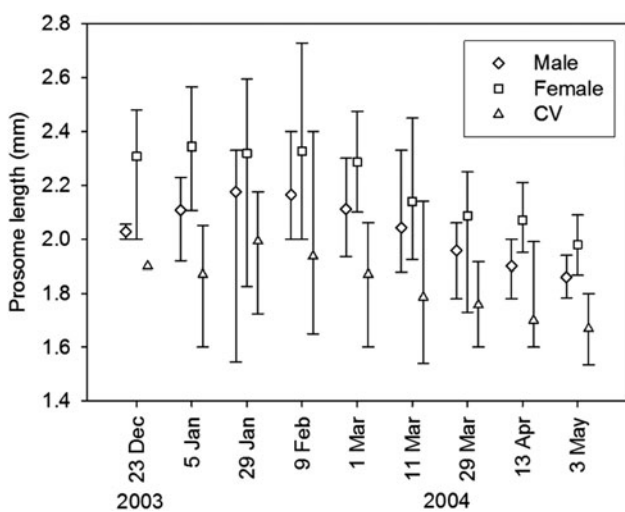


Fig. 7. Temporal variations in the prosome length of males, females and copepodites (CVs). Values represent average of six sampling stations. Vertical bars denote the range.

Table 1. Pearson correlation coefficients between the abundance and prosome length of *Calanus sinicus* of different developmental stages and various environmental parameters. Statistically significant correlations (

	Chlorophyll- <i>a</i>	Temperature	Salinity
Density of eggs	0.21	-0.23	0.17
Density of nauplii	-0.12	-0.43*	0.18
Density of copepodites	-0.27	-0.27	0.29
Density of adults	-0.06	-0.62*	0.57*
Prosome length of copepodites	-0.01	-0.69*	0.36
Prosome length of females	-0.13	-0.36	0.19
Prosome length of males	-0.13	-0.46*	0.36

December to May. Further north in Xiamen Harbour in the Taiwan Strait, *C. sinicus* occurs between November and early June (Lin & Li, 1984; Dur *et al.*, 2007; Hsiao *et al.*, 2011). In the coastal seas of northern Taiwan, the East China Sea and the Yellow Sea, *C. sinicus* occurs throughout the year (Chen, 1992; Wang *et al.*, 2003; Hwang & Wong, 2005; Xu & Chen, 2007). The north and middle parts of the Taiwan Strait are considered to be the southern limit for the perennial occurrence of *C. sinicus* (Chen, 1964; Huang *et al.*, 2002). Outside Xiamen Harbour, *C. sinicus* disappears completely between June and late November from nearshore areas, but persists in deep offshore waters (Huang *et al.*, 2002). The population is able to reproduce and recruit rapidly when temperature becomes more favourable during autumn. Shantou is located 200 km south-west of Xiamen and 300 km north-east of Hong Kong (Figure 1). Temperature in the coastal areas outside Shantou drops to  $<22^{\circ}\text{C}$  in November and reaches a minimum of  $16.4^{\circ}\text{C}$  in January (Jiang *et al.*, 2002). *Calanus sinicus* can be found in Shantou from late November to April (Huang, personal communication). The time of first appearance in Shantou is almost similar to that in Xiamen and approximately one month earlier than that in Hong Kong.

Correlation between salinity and density in *C. sinicus* adults is positive (Table 1). Nevertheless, the distribution of *C. sinicus* may not be strongly influenced by salinity. In Hong Kong, beginning of the rainy season and a gradual decrease in surface salinity coincide with the rise in temperature in spring (Figure 2). *Calanus sinicus* can tolerate a wide range of salinity (Huang & Zheng, 1986). In the Yellow Sea, *C. sinicus* is well adapted to salinities  $>29$ , but its distribution is probably not limited by salinity (Wang *et al.*, 2003; Zhang *et al.*, 2007; Hwang *et al.*, 2009). Surface water in the western part of Hong Kong is strongly influenced by fresh water discharged from the Zhujiang River during the summer. In estuarine water with salinity  $<30$ , *C. sinicus* has been found to occur in densities comparable to those recorded in this study (Wong *et al.*, 2000).

No significant correlation is found between chlorophyll-*a* concentration and the abundance of *C. sinicus* (Table 1). In the Yellow Sea, non-phytoplankton food such as ciliates formed a significant portion of the diet of *C. sinicus* (Huo *et al.*, 2008), suggesting that the abundance of *C. sinicus* is not necessarily related to the supply of phytoplankton. On the other hand, the egg production rate of *C. sinicus* in the Inland Sea of Japan declined when chlorophyll-*a* concentration in phytoplankton  $>5\ \mu\text{m}$  was  $<0.5\ \mu\text{g l}^{-1}$  (Uye & Murase, 1997). Chlorophyll-*a* concentrations at the two stations in the south-eastern corner of Hong Kong dropped below  $0.5\ \mu\text{g l}^{-1}$  in April and May, therefore decline in chlorophyll-*a* concentrations may contribute to the rapid disappearance of *C. sinicus* after March.

### Prosoma length

Seasonal changes in prosoma length suggest that the body size of *C. sinicus* may be influenced by temperature. Between December and early March, the average prosoma length of adult females varies between 2.29 and 2.34 mm, and is comparable to the 2.22–2.38 mm recorded for populations in the Yellow Sea (Zhang *et al.*, 2005). The average prosoma length of females decreases to 2.14 mm in the middle of March when water temperature is rising but still

$<23^{\circ}\text{C}$ . In May, when water temperature averages  $>25^{\circ}\text{C}$ , the average prosoma length of the few surviving females decreases to 1.98 mm. For comparison, it is worth noting that the prosoma length of most females in the Yellow Sea is  $>2.1\ \text{mm}$ , although small individuals with prosoma length as short as 1.90 mm have also been recorded (Zhang *et al.*, 2005).

In regions with a wide temperature range, the body size of copepods may be affected by water temperature (Hirche, 1992; Ban, 1994). The body size of calanoid copepods has been known to correlate negatively with temperature, with the smallest individuals occurring at the highest temperature (Halsband & Hirche, 2001; Halsband-Lenk *et al.*, 2002). Data presented here show a significant negative correlation between prosoma length and temperature in *C. sinicus* CVs and adult males (Table 1). Prosoma length of all developmental stages fluctuates between December and February, but follows a clear decreasing trend in March as water temperature begins to increase. In both CVs and adults, the smallest individuals appear in May when water temperature is high and the population is just about to disappear from the water column.

Size selective predation is known to play an important role in controlling the size composition of zooplankton communities (Brooks & Dodson, 1965). Dense schools of the larval and juvenile fishes appear in Tolo Harbour in spring. Copepods form an important part of the diet of these small fishes (Nip *et al.*, 2003). Planktivorous fishes rely on vision to capture the biggest and most conspicuous prey (O'Brien, 1979). In shallow areas where *C. sinicus* cannot rely on vertical migration to avoid fish predators, size selective predation may favour individuals with smaller body size.

### Recruitment

*Calanus sinicus* is carried into the coastal seas around Hong Kong from population centres in the Yellow Sea and the East China Sea every winter by the China Coastal Current (Hwang & Wong, 2005). In the eastern part of Hong Kong, *C. sinicus* first appears in the open waters outside Mirs Bay in December and reaches the inner part of Tolo Harbour approximately one month later in January. This sequence of appearance suggests that *C. sinicus* in the northern part of the South China Sea was first recruited to the open seas around Hong Kong, and then to the shallow, semi-enclosed waters of Mirs Bay and Tolo Harbour. The delay in the appearance of *C. sinicus* in Tolo Harbour is probably due to the low level of water exchange between the semi-enclosed bay and the adjacent sea areas. The copepod community in Tolo Harbour is marked by a scarcity of large species (Zhang & Wong, 2011). *Calanus sinicus* is a prominent member of the zooplankton community in Tolo Harbour and Mirs Bay because of its large size. *Calanus sinicus* adults and copepodites that enter into the shallow waters of Tolo Harbour are probably removed rapidly by small fishes which make their appearance in early spring (Nip *et al.*, 2003). Indeed, there is a shoreward decrease in abundance of *C. sinicus* even during the period of peak densities in late January and early February, and this could be caused by patterns of the current as well as predation.

The presence of ovigerous females suggests that reproduction occurs between January and March. The maximum clutch size of 111 eggs per female was comparatively higher than those recorded for populations in the Yellow Sea

(Zhang *et al.*, 2005) and the Inland Sea of Japan (Uye, 2000). Since clutch size increases with prosome length (Zhang *et al.*, 2005), it is surprising to note that females produce their biggest clutches in early March when average prosome length is already decreasing. On the other hand, high food concentrations in February may allow females to increase their reproductive effort in March. At 20°C, eggs take 14 hours to hatch (Zhang *et al.*, 2005) and develop into adults in 16 days (Uye, 1988). While there is sufficient time for eggs spawned locally to develop into nauplii and copepodites, study of the effect of mud on the survival of *C. sinicus* egg by Uye (2000) suggests that most eggs would die very quickly as they sink and come into contact with the sediment in the shallow waters of Tolo Harbour and Mirs Bay. Experiments in the Yellow Sea revealed that high temperature is detrimental to the hatching of *C. sinicus* (Zhang *et al.*, 2007). Continual decline in the density of nauplii after March also suggests that most eggs do not hatch into nauplii.

Decrease in the prosome length of *C. sinicus* begins in March and the smallest females appear in May, just before the disappearance of the species from the study area. While selective predation by visual predators may favour smaller individuals, the observed seasonal pattern in body size suggests that environmental conditions, particularly high temperature, in the subtropical seas around Hong Kong are detrimental to *C. sinicus* after March. Change in the direction of the monsoon winds, discontinuation in the intrusion of cold water masses from the north, and influx of warm water masses from the South China Sea cause a rapid increase in surface water temperature in the northern part of the South China Sea. No over-summer populations of *C. sinicus* have been reported in the coastal seas of southern China. Copepods can retreat to the bottom when the water temperature at the surface becomes stressful. In the southern part of the Yellow Sea, *C. sinicus* retreats to the cold bottom waters during summer (Wang *et al.*, 2003). A similar situation occurs in the Taiwan Strait, where *C. sinicus* disappears completely between June and late November from nearshore areas outside Xiamen Harbour, but persists in deep offshore waters (Huang *et al.*, 2002). At present, no data are available to suggest that *C. sinicus* populations can survive in deeper areas in the northern part of the South China Sea. In eastern Taiwan where surface water is warmed by the Kuroshio Current, *C. sinicus* is absent even in areas with water depth up to 800 m (Hsiao *et al.*, 2004).

## CONCLUSIONS

In conclusion, the occurrence of *C. sinicus* in the coastal seas of eastern Hong Kong is restricted to the period between December and May. Densities comparable to those recorded in population centres in the Yellow Sea and East China Sea (Wang *et al.*, 2003) are encountered only in late January and early February when water temperature drops to ~15°C. Females with eggs appear between December and April, but most eggs probably do not hatch into nauplii. Prosome length and clutch size decrease after March when water temperature begins to rise. The absence of a summer population and the observed seasonal change in prosome length, with individuals collected in March and April, just before the disappearance of the population, being much smaller than those collected in January when the population

first appears, indicate that *C. sinicus* in the coastal waters of Hong Kong is recruited from populations in the northern part of the species range. The shallow seas of eastern Hong Kong provide only marginal habitats for *C. sinicus* populations which have been transported into subtropical oceans on the southern edge of the species range during winter and early spring by water currents.

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**Correspondence should be addressed to:**

C.K. Wong  
 School of Life Sciences,  
 The Chinese University of Hong Kong,  
 Shatin, Hong Kong, China  
 email: chongkimwong@cuhk.edu.hk