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Aspects of the ecology of *Tylodiplax indica* Alcock (Brachyura: Ocypodidae) on a Kuwait mudflat

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ABSTRACT

A mudflat in Sulaibikhat Bay, Kuwait was sampled every six weeks from May 1988–March 1989 at mean high tide level and mean high water neap for the Ocypodid crab *Tylodiplax indica*. The sexes were in similar total numbers (1167♂, 1180♀) and carapace width ranges (2.5–11 cm), and carapace width frequency data indicated that instar number was either variable, or fixed with overlapping size ranges. Sex ratios differed from 1 : 1 in only one sampling period, but there was a significant female bias in the main ovigerous classes (7–8 mm CW) and a male bias in the larger classes.

Density, biomass and the percentage of juveniles were significantly higher in winter (November–March), which was therefore the more ecologically-active season, contrary to the cycle normally associated with waters of similar latitude. This was related to Kuwait's climate, and associated water temperatures.

INTRODUCTION

Ocypodid crabs are conspicuous members of the macrofauna of tropical and subtropical particulate shores. In Kuwait, there are 18 species (Jones 1986) and nine inhabit the extensive mudflats in the north of the country (Clayton 1986). Very little is known of their ecology.

Jones & Clayton (1983) and Collins *et al.* (1984) described distribution, zonation and feeding in *Cleistostoma* spp. and *Uca sindensis*, Clayton (1988) examined social spacing in *C. kuwaitense* and Snowden *et al.* (1991) described the population biology of *Ilyoplax stevensi*. There has been no work on any of the other species.

Tylodiplax indica Alcock is one of the smallest of Kuwait's ocypodids and is frequently the numerically-dominant macroscopic organism on mudflats above mean tide level (MTL) (Al Taher 1990). Although it has long been known from the Arabian Gulf, the Gulf of Oman (Stephensen 1949) and Pakistan (Alcock 1900), it has not

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been studied before. Indeed there appears to have been no previous ecological work on any *Tylodiplax* species.

MATERIALS AND METHODS

Every six weeks between May 1988 and March 1989, fifteen $0.05\,m^2 \times 20\,cm$ quadrats were extracted at each of six stations in western Sulaibikhat Bay, Kuwait (29°21.5′N, 47°49.25′E). Preliminary studies (Al Taher 1990) showed that an excavation depth of 20 cm was sufficient to collect all specimens. The stations were mean high tide level (MHTL) and mean high water neap (MHWN) along three transects, 200 m apart. The substrate was transported to the laboratory and washed through sieves of 2 and 1 mm mesh and the residues on the sieves were stored in 5% formyl seawater. *Tylodiplax indica* individuals were subsequently removed, counted and sexed on the basis of abdomen size and in smaller individuals the presence in males of the reflected first pleopod (see Stephensen 1949). This is undeveloped in those of < 2.5 mm carapace width which were classed as juveniles. Maximum (CW) was measured to the nearest 0.1 mm using an eyepiece micrometer under 60× magnification, and in mature females the presence

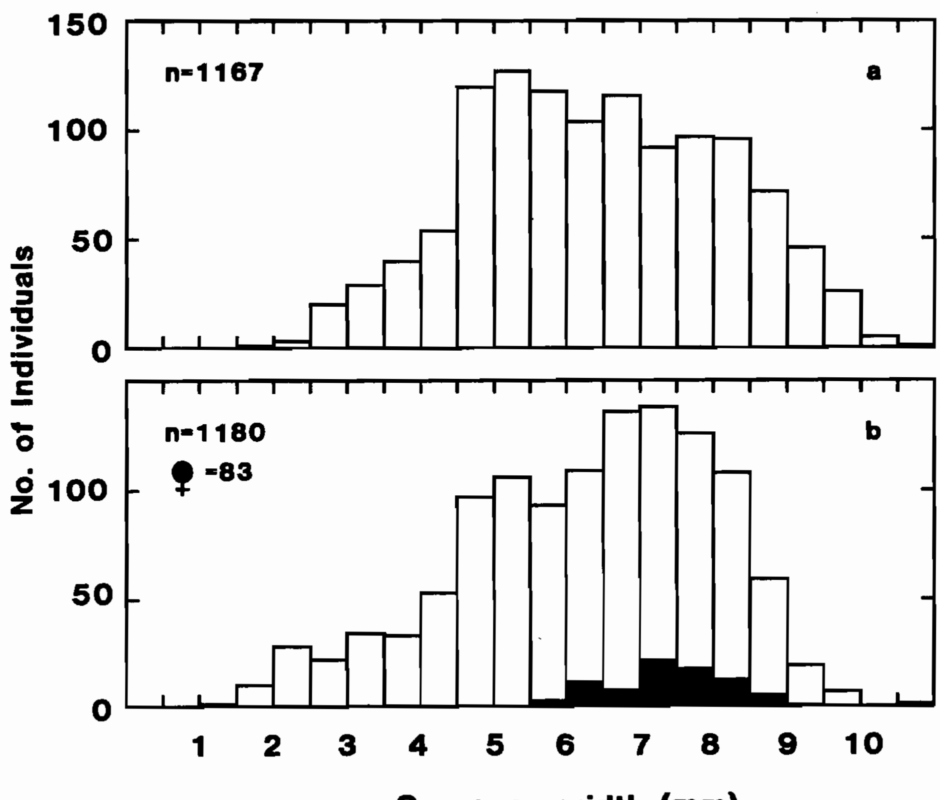

Fig. 1. Carapace width frequency distributions of *Tylodiplax indica* (a) males, (b) females (black = ovigerous females) and juveniles (cross hatched).

of absence of eggs was noted. Intact individuals were dried at 80°C for 48 h and weighed. At the sampling site surface water temperature and salinity were recorded at high water at approximately monthly intervals. Specimens of *Tylodiplax* collected from the study area on 27 Nov 1989 are lodged with The Natural History Museum (London).

RESULTS

POPULATION DYNAMICS

The CW frequency distribution (Fig. 1) show that the sexes were present in similar numbers (1167 males, 1180 females) with identical size ranges (2.5–11 mm). Both distributions were unimodal, and skewed slightly to the right in males (mode 5.25 mm, Fig. 1a) and the left in females (mode 7.25 mm, Fig. 1b). Mean CW's were very similar (♂: 6.41 ± 1.71 mm, ♀: 6.27 ± 1.72 mm), and a *Z*-test (Siegel 1956) showed that the median CW's (♂: 6.45; ♀: 6.61 mm) were not significantly different from each other ($Z = 0.82, P = 0.41$).

There were ovigerous females in all CW classes between 5.5 and 9.5 mm, where they comprised between 3 and 16% of the females per class (Fig. 2a). *X* tests showed that there were significantly more females than males in the 7–8 mm size classes and significantly more males than females between 9 and 10.5 mm (Fig. 2b). In the remaining 12 CW classes and for the total population, sex ratios did not differ significantly from 1 : 1 ($P > 0.10$).

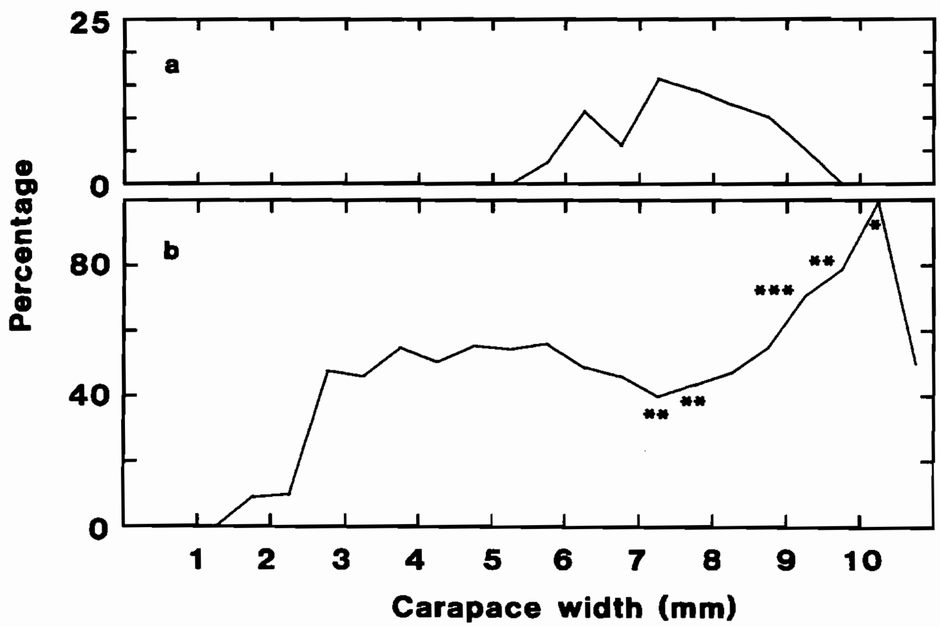

Fig. 2. *Tylodiplax indica.* (a) Ovigerous females as a percentage of total females in each CW class, (b) males as a percentage of total no. of individuals in each CW class. Asterisks indicate significant departures from 1 : 1 sex ratio (* = $P < 0.05$, ** = $P < 0.01$, *** = $P < 0.001$).

The CW frequency distributions of males and females during each of the eight sampling periods (Fig. 3) contained varying numbers of modes of different degrees of clarity, few of which can be followed with the confidence through successive samples. There were similar numbers of males and females in most periods and the sex ratio differed significantly from 1 : 1 only in November 1988 when the sample was male-biased ($X^2 = 4.95, P < 0.05$).

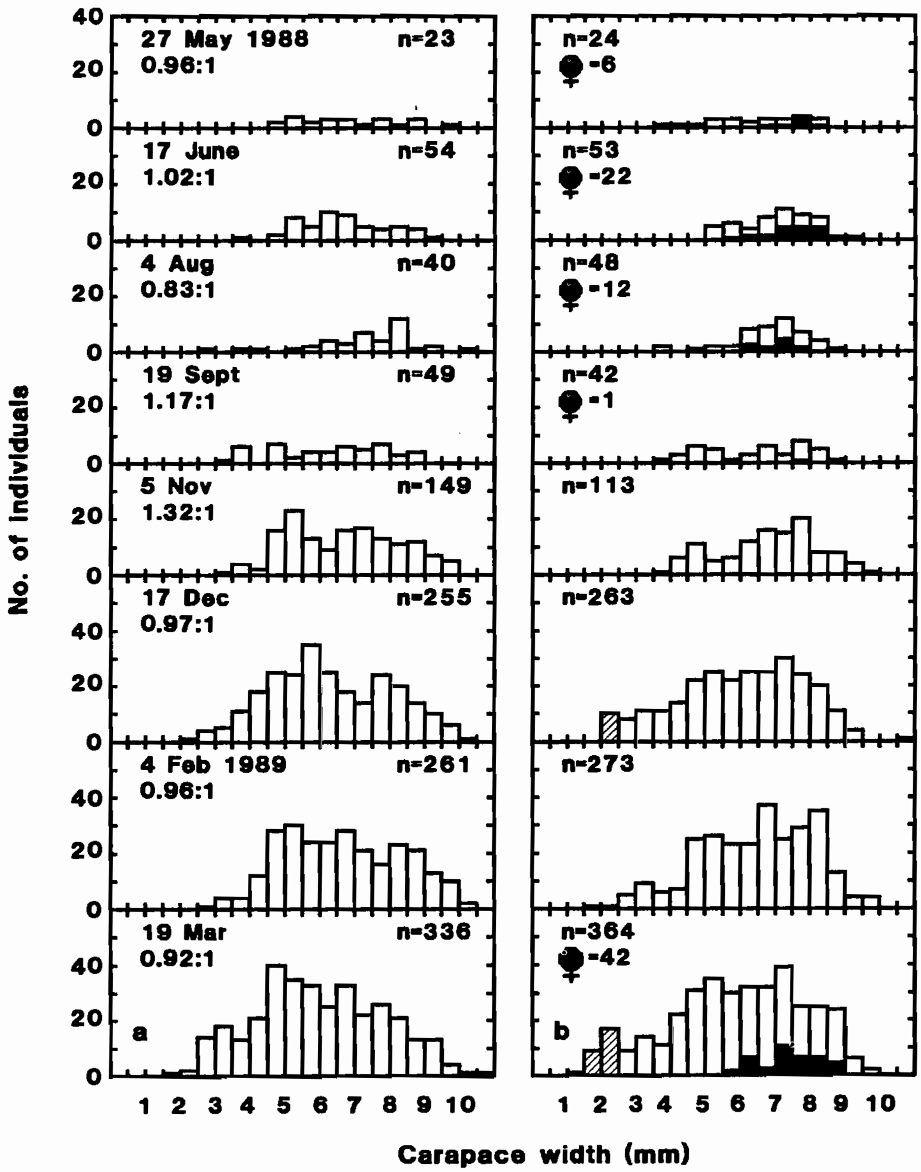

Fig. 3. Carapace width frequency distributions of *Tylodiplax indica* (a) males, (b) females (black = ovigerous) and juveniles (< 2.5 mm CW, cross-hatched), during each sampling period. Ratios = males : females.

TEMPORAL VARIATIONS

Salinity at the sampling site was 40% at the beginning and end of the survey and 42% between July and October 1988 (Fig. 4a). Surface water temperature (Fig. 4b) were above 30°C from mid-May to mid-September and at a maximum of 32.5–33.5°C between June and August. Temperatures then declined to the annual minimum of 14°C in February 1989, and rose again to 22°C in March.

Tylodiplax indica densities (Fig. 5) remained below 75 individuals m^{-2} from May to September 1988 then rose to maxima of 150–300 m^{-2} in March 1989. Exceptions were Transect 3 MHWN where the peak occurred in December 1988, and Transect 1 MHTL where densities remained below 10 individuals m^{-2} throughout.

There were ovigerous females in the population between May and September 1988 (Fig. 6a) and they comprised a maximum of 45% of the mature females (> 5.5 mm CW, Fig. 1) in June. By September this had fallen to 4% and there were no egg-bearing females between November 1988 and February 1989. Ovigerous individuals were present again in March 1989, at 20% of the mature female population. Juveniles (< 2.5 mm CW) only occurred during the last three sampling periods, reaching a maximum in March 1989 (Fig. 6b).

The regressions of $\log_{10}$ dry weight against $\log_{10}$ CW for the dried and weighed males, non-ovigerous and ovigerous females all gave significant relationships ($P < 0.001$, Fig. 7). The equations were applied to the raw data of Fig. 3 showing the number of each type of individual present during each sampling period and their biomass throughout the year was calculated. The cycle of biomass (Fig. 8) closely resembled that of density, with low values (around 0.5 g m^{-2}) from May to September 1988, followed by large increases to a peak of 2.2 g m^{-2} in March 1989. Males and females each contributed around 50% to the total biomass throughout the year and

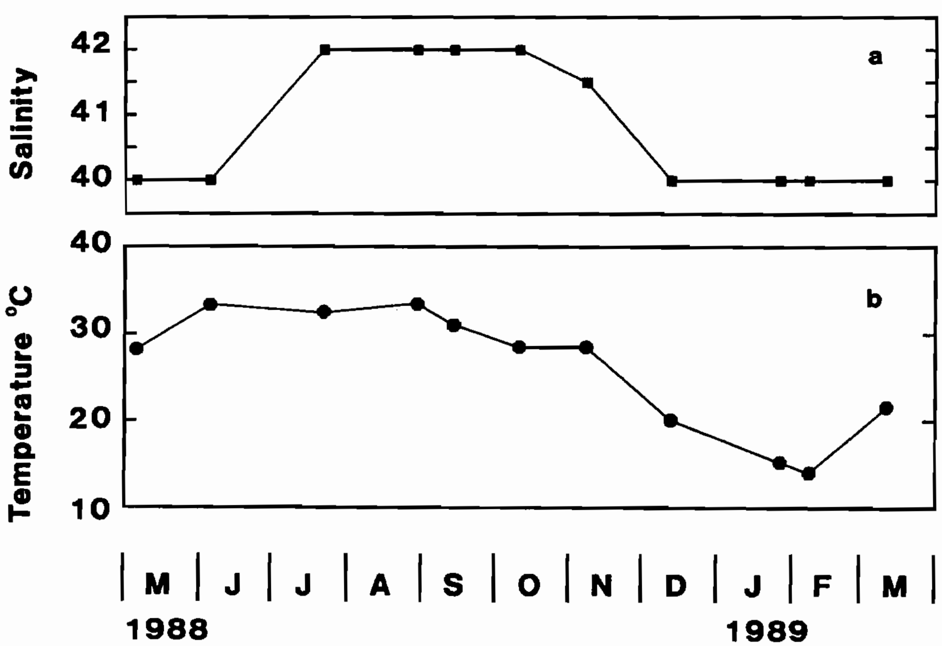

Fig. 4. (a) Salinity, (b) temperature at high water in western Sulaibikhat Bay, May 1988–March 1989.

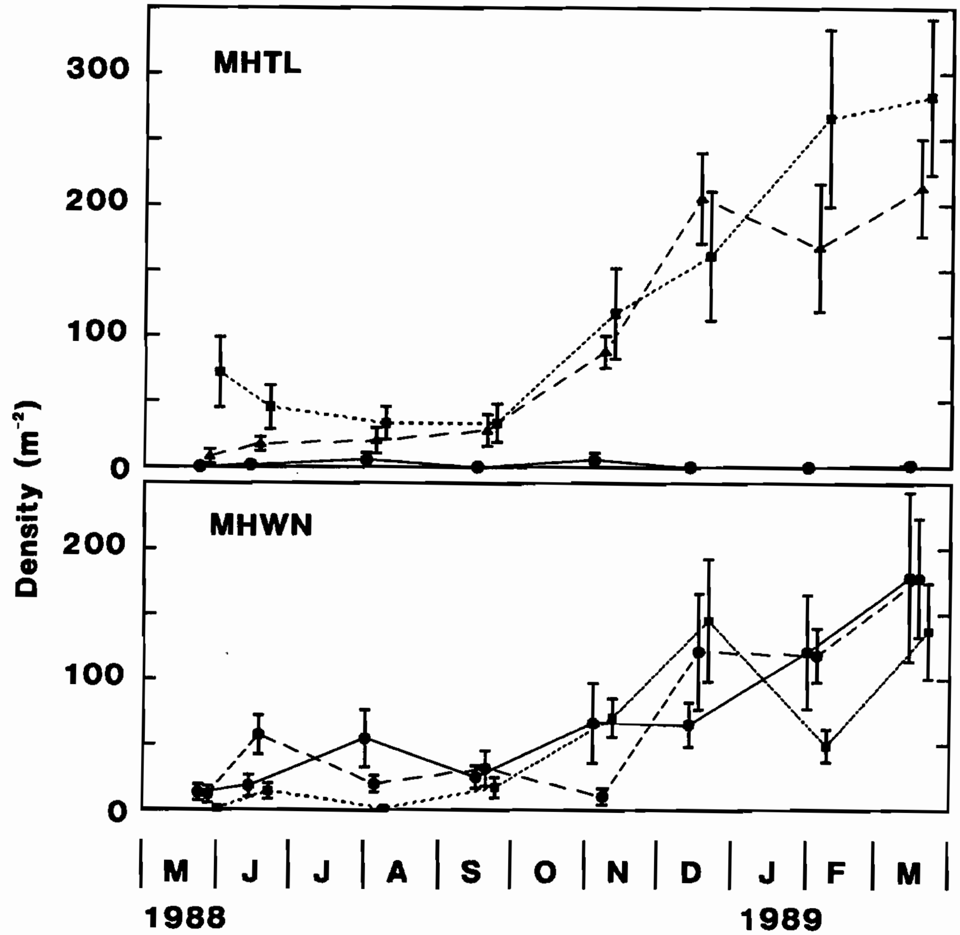

Fig. 5. Population density of *Tylodiplax indica* (m^{-2}), May 1988–March 1989. ●——● = Transect 1, ▲– – –▲ = Transect 2, ■······■ = Transect 3; vertical bars indicate standard errors.

there was a very small contribution by ovigerous females (maximum $0.2\,g\,m^{-2}$ in March 1989).

Mann-Whitney U-tests indicated that total densities, biomass and the percentage of juveniles were all significantly higher from November 1988 to March 1989 than from May to September 1988 ($n_1, n_2 = 4$, $U = 0$, $P < 0.05$). Although the ovigerous percentage was numerically higher during the first half of the survey, it was not significantly higher ($n_1, n_2 = 4$, $U = 0$, $P < 0.05$). Density, biomass and the percentage of juveniles were all negatively correlated with water temperature (Spearman rank correlation tests, $n = 8$: density $r_S = 0.810$, $P < 0.05$; biomass $r_S = 0.738$, $P = 0.05$; juveniles $r_S = -0.764$, $P < 0.05$), and the percentage of ovigerous females was positively correlated ($r = 0.805$, $P < 0.05$). There were no significant correlations with salinity (density $r_S = 0.498$, $P > 0.10$; biomass $r_S = 0.498$, $P > 0.10$; juveniles $r_S = 0.702$, $P > 0.05$; ovigerous $r_S = 0.131$, $P > 0.10$.

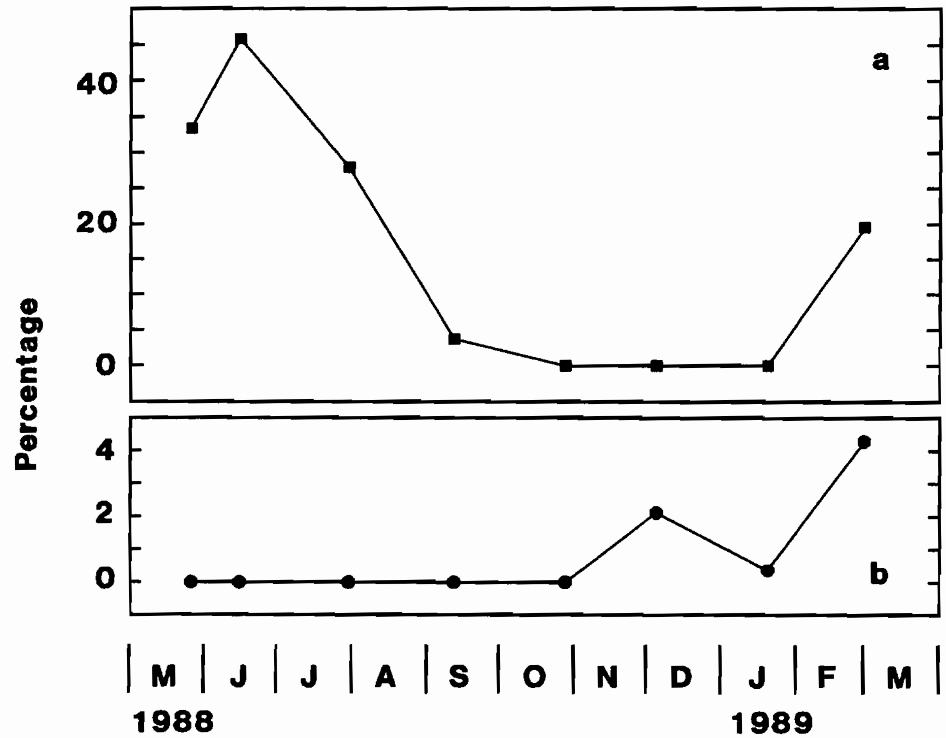

Fig. 6. *Tylodiplax indica* (a) Ovigerous females as a percentage of mature females (> 5.5 mm CW), (b) juveniles (< 2.5 mm CW) as a percentage of total individuals, May 1988–March 1989.

DISCUSSION

The lack of clearly discernible modes in the total male and female CW frequency histograms indicates that there is no clear size definition of moulting and that the number of instars is either variable, or fixed about occurring over wide size ranges (Hartnoll 1982; Bellwood & Perez 1989). Although sex ratios differed from 1 : 1 in only one of the eight sampling periods and five of the 17 post-juvenile size classes, the

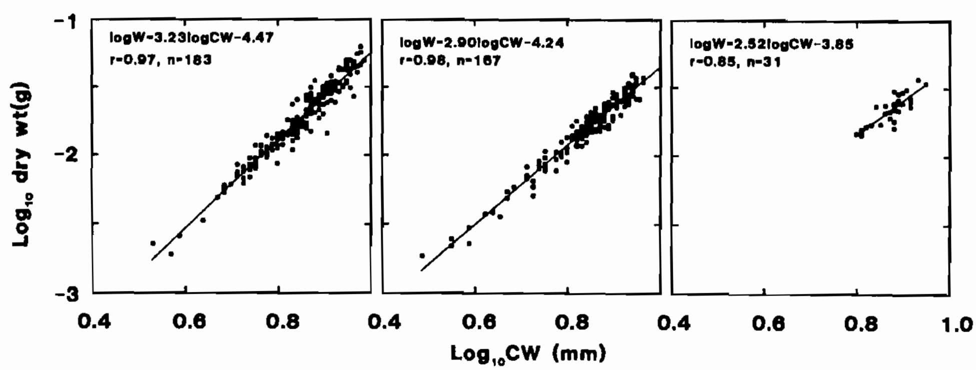

Fig. 7. Regressions of Log_{10} dry weight against log_{10} carapace width of *Tylodiplax indica* for (a) males, (b) non-ovigerous females, (c) ovigerous females.

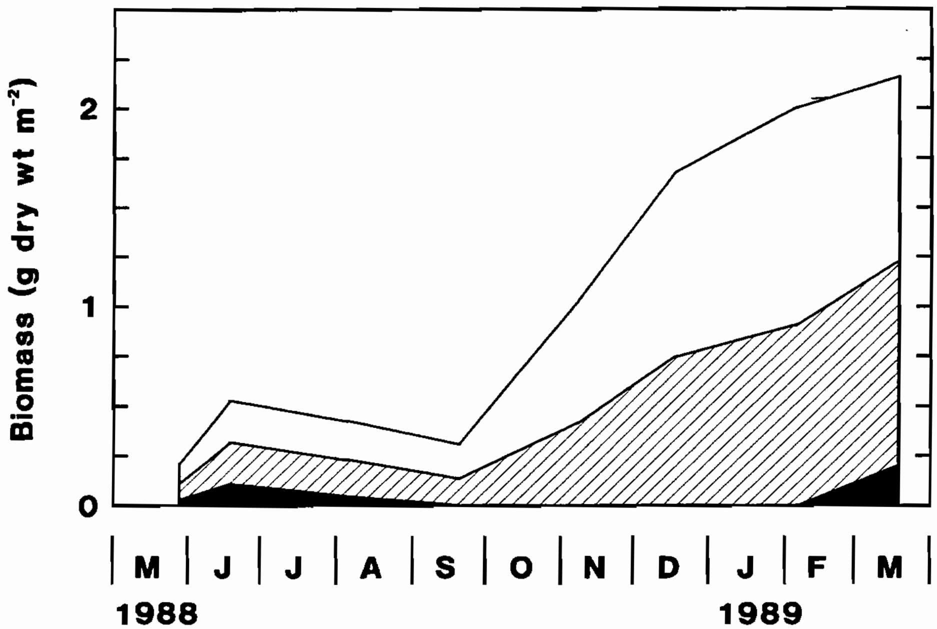

Fig. 8. Biomass of *Tylodiplax indica* (g dry wt m^{-2}), May 1988–March 1989. Males = white, non-ovigerous females = cross hatched, ovigerous females = black.

plot of percentage males against CW produced the J-shaped curve characteristics of the 'anomalous' pattern (Wenner 1972) recorded in brachyurans by Conde & Diaz (1989) and others. Females outnumbered males at the centre of the reproductive range and this is generally thought to result from reproductively-active females deferring somatic growth (Colby & Fonseca 1984; Conde & Diaz 1989; Diaz & Conde 1989). Consequently there was a significant male bias in the larger classes. This produced slight variations in the form of the two histograms, but there were insufficient to cause large differences in mean CW or significant differences in medians.

Density, biomass and the percentage of juveniles were also significantly higher in winter, which is therefore the mean ecologically-active season, contrary to the cycle normally associated with warm-temperature waters (Levinton 1982; Raymont 1983). Similar fluctuations have been reported for *Ilyoplax stevensi* at MHTL in Sulaibikhat Bay (Snowden *et al.* 1991) and Al-Taher (1990) has recorded several other high shore species in which densities are consistently higher in winter. Without further sampling it is not clear if the data on density (Fig. 5) and biomass (Fig. 8) reflect normal seasonal variations in the population of *T. indica*. Further sampling during the critical period of April may help clarify if the population is crashing as the mild winter temperatures return to high summer levels. Additionally, sampling at lower levels on the shore, may show if the crab is simply relocating to a more favourable position on the shore as has been demonstrated for other Ocypodid crabs, *Scopimera globosa* and *Ilyoplax pusillus* by Wada (1983a, 1983b). No explanation is currently available for the low densities of *Tylodiplax indica* at MHTL at Transect 1.

The higher densities in winter for both *Ilyoplax stevensi* and *Tylodiplax indica* suggests that this unusual cycle may be common amongst elements of Kuwait's upper eulittoral benthos. In *I. stevensi* this is related to the harsh climate, resulting from Kuwait's location at the northwestern end of the warm, shallow, semi-enclosed Arabian Gulf and at the northeastern edge of the Arabian Desert. Although of a warm-temperate latitude, sea temperatures are those of the tropics in summer and the subtropics in winter (Fig. 4, c.f. Kinne 1970), and the annual range of air temperatures is 0.50°C (Al-Kulaib 1975). In *I. stevensi* only the percentage of juveniles was correlated with water temperature, and air temperatures, which rise above 45°C for several hours per day between June and September and severely curtail surface activity, are a more important factor (Snowden *et al.* 1991). In *T. indica* water temperature is of greater significance, as it was negatively correlated with density, biomass and the percentage of juveniles, and positively correlated with the percentage of ovigerous females. Variation between species, as a result of physiological, behavioural and other differences, is to be expected. Clearly the controlling factors are complex and require further elucidation. At present the evidence suggests that the cycle may be widespread in Kuwait's upper eulittoral zone and that both water and air temperature are important. When further studies are possible, these will examine the significance of these and other factors.

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REFERENCES

Alcock, A. 1900. Materials for a carcinological fauna of India. No. 6. The Brachyura Catametopa, or Grapsoidea. Journal of the Asiatic Society of Bengal **69:** 280–456.

Al-Kulaib, A.M. 1975. Weather and climate of Kuwait. Director General of Civil Aviation, Meteorological Section, State of Kuwait, 120 pp.

Al-Taher, E.Y. 1990. The impact of the Doha West Power Station effluent on the upper eulittoral benthos of western Sulaibikhat Bay, Kuwait. M.Sc. thesis, University of Kuwait.

Bellwood, D.R. & Perez, O.S. 1989. Sexual differences in the absolute growth pattern of the Indo-Pacific sandy shore crab Matuta lunaris. Journal of Zoology, London **218:** 603–8.

Clayton, D.A. 1986. Ecology of the mudflats with particular reference to those of the northern Arabian Gulf. In: **Halwagy, R., Clayton, D.A. & Behbehan, M.** (Eds.). *Proceedings of the First Arabian Gulf Conference on Marine Environment and Pollution.* Kuwait University, Faculty of Science, pp. 83–96.

Clayton, D.A. 1988. Hood construction as a spacing mechanism in *Cleistostoma kuwai tense* (Crustacea: Ocypodidae). *Marine Biology* **99:** 57–61.

Colby, D.R. & Fonseca, M.S. 1984. Population dynamics, spatial dispersion and somatic growth of the sand fiddler crab *Uca pugilator. Marine Ecology Progress Series* **16:** 269–79.

Collins, M.J., Jones, D.A. & Clayton, D.A. 1984. Redescription of *Uca sindensis* (Alcock, 1900) (Brachyura: Ocypodidae) with notes on the ecology of a population from Kuwait. Journal of Crustacean Biology **4:** 318–28.

Conde, J.E. & Diaz, H. 1989. The mangrove tree crab *Aratus pisonii* in a tropical estuarine coastal lagoon. *Estuarine, Coastal and Shelf Science* **28:** 639–50.

Diaz, H. & Conde, J.E. 1989. Population dynamics and life history of the mangrove crab *Aratus pisonii* (Brachyura, Grapsidae) in a marine environment. Bulletin of Marine Science **45:** 148–63.

Hartnoll, R.G. 1982. Growth. In: **Abele, L.G. (Ed.).** The biology of Crustacea. 2. Embryology, Morphology and Genetics. pp. 111–96. Academic Press, New York.

Jones, D.A. 1986. A field guide to the seashores of Kuwait and the Arabian Gulf. University of Kuwait, 192 pp.

Jones, D.A. & Clayton, D. 1983. The systematics and ecology of crabs belonging to the genera *Cleistostoma* De Haan and *Paracleistostoma* De Man on Kuwait mudflats. Crustaceana **45:** 183–99.

Kinne, O. 1970. Temperature; Animals; Invertebrates. In: **Kinne, O. (Ed.).** Marine Ecology, A Comprehensive, Integrated Treatise on Life in Oceans and Coastal Waters 1, Wiley Interscience. pp. 407–514. London.

Levinton, J.S. 1982. Marine Ecology. Prentice-Hall, New Jersey.

Raymont, J.E.G. 1983. Plankton and Productivity in the Oceans (2nd edn.). Pergamon Press, Oxford.

Siegel, S. 1956. Non parametric statistics for the behavioral sciences. McGraw Hill, New York, 312 pp.

Snowden, R.J., Clayton, D.A. & Al-Taher, E.Y. 1991. Population biology of *Ilyoplax stevensi* (Brachyura: Ocypodidae) on a Kuwait mudlfat. Marine Ecology Progress Series **71:** 219–25.

Stephensen, K. 1949. The Brachyura of the Iranian Gulf. Danish Scientific Investigations in Iran, 57–235.

Wada, K. 1983a. Temporal changes of spatial distributions of *Scopimera globosa* and *Ilyoplax pusillus* (Decapoda: Ocypodidae) at co-occuring areas. Japanese Journal of Ecology **33:** 1–9.

Wada, K. 1983b. Movement of burrow location in *Scopimera globosa* and *Illyoplax pusillus* (Decapoda: Ocypodidae). Physiological Ecology Japan **20:** 1–21.

Wenner, A.M. 1972. Sex ratio as a function of size in marine crustacea. The American Naturalist **106:** 321–50.

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بعض المظاهر البيئية لسرطان البحر تايلوديبلاكس إنديكا على المسطحات الطينية لشواطىء الكويت

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خلاصة

تم جمع عينات سرطان **تايلوديبلاكس إنديكا** كل ستة أسابيع خلال الفترة من مايو ١٩٨٨ إلى مارس ١٩٨٩م عند متوسط المد العالي MHTL من المسطحات الطينية في جون الصليبيخات ـ الكويت. وكان مجموع أعداد الجنسين متقارب (١١٧٦♂ و ١١٨٠♀) وكان عرض الدرع فيهايتراوح من (١-١١ ملم) وقد دل تردد بياناتCW على أن عدد الأطوار كانت إما متغيرا أو ثابتا مع بعض التداخل من حيث الأحجام.

وإختلفت نسبة الجنس من ١ : ١ مرة واحدة خلال فترة تجميع العينات، لكن الإنحراف الملحوظ كان في إناث الأصناف البيوضة الرئيسة (٧-٨ ملم CW)، وكانت الذكور منحرفة إلى الأصناف الأكبر.

أما الكثافة والكتلة البيولوجية والنسبة المئوية لليوافع فقد كانت نسبيا أعلى في الشتاء (نوفمبر ـ مارس)، ويمثل ذلك الموسم نشاطاً بيئياً متميزاً لليوافع، بخلاف نشاطها خلال الدورة الطبيعية مقارنة بالمياه التي تتبع نفس خطوط العرض، والتي تتبع نفس الظروف المناخية للكويت من حيث درجة حرارة الماء.

*عنوان المراسلة: قسم العلوم البيئية ـ السير ويليام هالكرو وشركاه المحدودة سويندون ـ المملكة المتحدة.