BREEDING AND GROWTH OF THE BURROWING PRAWN *CALLIANASSA KRAUSSI* STEBBING (CRUSTACEA: DECAPODA: THALASSINIDEA)

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ABSTRACT

1. *C. kraussi* in the Swartkops river estuary in South Africa has a major breeding period in winter–spring (May–July/August) and a minor breeding period in summer (November–January).

2. A maximum of 43 per cent of ovigerous mature females was recorded. Females in the 8 and 9 mm carapace-size classes make the major contribution to the breeding effort.

3. Recruitment is very marked with 60–80 per cent of the population consisting of juveniles at times.

4. Both sexes live for about two years. Females hatching in winter–spring may breed first in summer at an age of about 16–18 months and then again in the following winter at an age of about two years. Females hatching in summer breed first in winter at an age of about 18 months and some in the following summer at an age of about two years.

5. Breeding and growth in *C. kraussi* is compared with that in other known callianassids, and discussed in relation to estuarine eco-systems and conservation measures.

INTRODUCTION

Although species of *Callianassa* have a world-wide distribution very few studies of their breeding and growth have been carried out, possibly because individuals are inconspicuous and it is frequently difficult to obtain regular large samples. On the east and west coasts of North America species of this genus are common and a number of ecological studies have been done (Lunz 1937; MacGinitie 1934; Pohl 1946) but the only population studies have been done in the southern hemisphere. Hailstone & Stephenson (1961) investigated *C. australiensis* which is abundant and readily obtainable along the coasts of New South Wales and Queensland. Devine (1966) made a similar study of *C. filholi* in New Zealand.

C. kraussi is the dominant macrobenthic species in many South African closed estuaries (Scott *et al.* 1952; Millard & Scott 1953; Forbes 1973a) and is also abundant in sheltered sandy areas at many estuary mouths (Day *et al.* 1952; Day 1958; Macnae 1957). It is widely exploited as a bait organism by anglers but its biology and significance in estuarine systems is little known. Knowledge of the life cycle is important for an understanding of both these aspects and also in framing conservation measures. The biology of the larval stages has already been described (Forbes 1973b) and this paper presents the results of investigations of breeding and growth.

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METHODS

Samples of *Callianassa kraussi* were collected in the Swartkops estuary (33°52′S/25°37′E) near Port Elizabeth, South Africa, using a 'prawn pump', an instrument very similar to the 'yabby pump' described by Hailstone & Stephenson (1961). The prawn pump was used to collect 100 prawns each month from subtidal sand-banks over the period July 1971 to January 1972.

After January 1972 collections with the prawn pump were carried out in 0,5–1 m depth of water and the contents of the pump expelled into a sieve (2 mm bar mesh). The sieve was then agitated in the water so that the substrate passed through and the prawns could be picked out. Sieving facilitated recovery of young prawns which could otherwise not be separated from the pump spoil, and specimens as small as 10 mm total length were obtained. From February 1972 until October 1973, 200 prawns were collected every month in this way.

Prawns were sexed and weighed and the carapace length of each specimen measured mid-dorsally from the tip of the rostrum to the posterior end of the carapace – the area referred to by Biffar (1971) as the 'dorsal oval'. The measurements were sorted into 1 mm carapace-length size classes. Specimens with a carapace length of 3 mm or less were difficult to sex and hence were classified as unsexed juveniles. Numbers of juveniles were expressed as a percentage of the total numbers in the sample. Estimates of the recruitment of juveniles to the population would be exaggerated if concomitant deaths of older animals occurred. In order to obviate this possibility an index of fluctuations in population density was obtained by recording the number of prawns collected per 100 pump strokes at each monthly sampling, and this was correlated with the percentage of juveniles in the sample. A size frequency analysis was made of specimens with a carapace length greater than 3 mm and growth rates determined by inspection of the rates of progression of the modes in successive samples. Females were examined for the presence of eggs and counts of the number of eggs were carried out on females collected both in the Swartkops estuary and in other Eastern Cape estuaries. The state of development of the ovary, which is easily visible through the transparent abdominal tergites in *C. kraussi*, was also noted.

RESULTS

Breeding

Of the 122 ovigerous females recorded from the Swartkops River (Table 1) all save one had a carapace length of 7 mm or more; this was therefore taken as the size at sexual maturity. The percentages of mature females which were ovigerous at different times of the year are shown in Figure 1. There appear to be two peaks of breeding activity each year, firstly a major peak in winter (May to July/August) and secondly a smaller peak in late spring and summer (November to January). The proportion of adult females which were ovigerous was never large (maximum 43 per cent) and there was a suggestion of a decline in the maximum values recorded over the 2½-year sampling period. The increasing proportions of females carrying eyed eggs towards the end of each breeding peak indicate that egg production occurred mainly during April/May to June in the winter season and October to December in the summer season. Forbes (1973b) has shown that the egg development period is about 30 days at 20°C; the approximate one-month lag and subsequent convergence between the figures for ovigerous females and those carrying eyed eggs suggest further that females only produce one batch of eggs per breeding peak.

The number of eggs carried by females of different sizes is indicated in Table 1. With increase in carapace length from 6 to 9 mm there is a marked increase in the mean number of eggs produced. With further increase in size this number declines, although this result may have been biased by the low number of females obtained and by damage during collection. Table 1 also shows the contribution of females of different sizes to total egg production. It is clear that females in the 8 and 9 mm carapace-length size class made the major contribution to egg production.

TABLE 1

Contribution of different size classes to egg production in the Swartkops estuary. Numbers in brackets are standard deviations.

Size class (mm carapace)	*Total no. ovigerous females obtained*	*Mean no. eggs/female*	*No. of eggs produced by each size class (no. of females x mean no. of eggs)*	*% age egg contribution by each size class*
6	1	40	40	<1
7	36	88 (50)	3 168	21
8	40	114 (84)	4 560	31
9	30	193 (121)	5 790	39
10	11	95 (70)	1 045	7
11	4	76 (19)	304	<1
	n = 122		14 907	

Recruitment

The number of prawns obtained per 100 pump strokes using both pump and sieve over the period March 1972 until October 1973 had a mean of 205 (n = 20; $\sigma = 85$; range 62–344). There was a significant correlation ($r = 0{,}67$, $p < 0{,}005$) between the yield per 100 pump strokes and the percentage of juveniles in the population (Figure 2). This indicates that the high proportions of juveniles recorded (up to 75 percent of the population) represent real additions to the population and are not merely the result of deaths in the older size classes. There were three peaks in the percentages of juveniles in the population (Figure 1) representing three distinct periods of recruitment to the population. A major peak occurred in November to December 1972, and two minor ones in May to June 1972 and 1973. These peaks probably represent recruitment from the preceding breeding peak. Thus juveniles recorded in November to December 1972 would have resulted from the extrusion of eggs in May to June; similarly the smaller peaks in May to June of 1972 and 1973 would have resulted from egg production in October to December of the previous years. The magnitude of recruitment

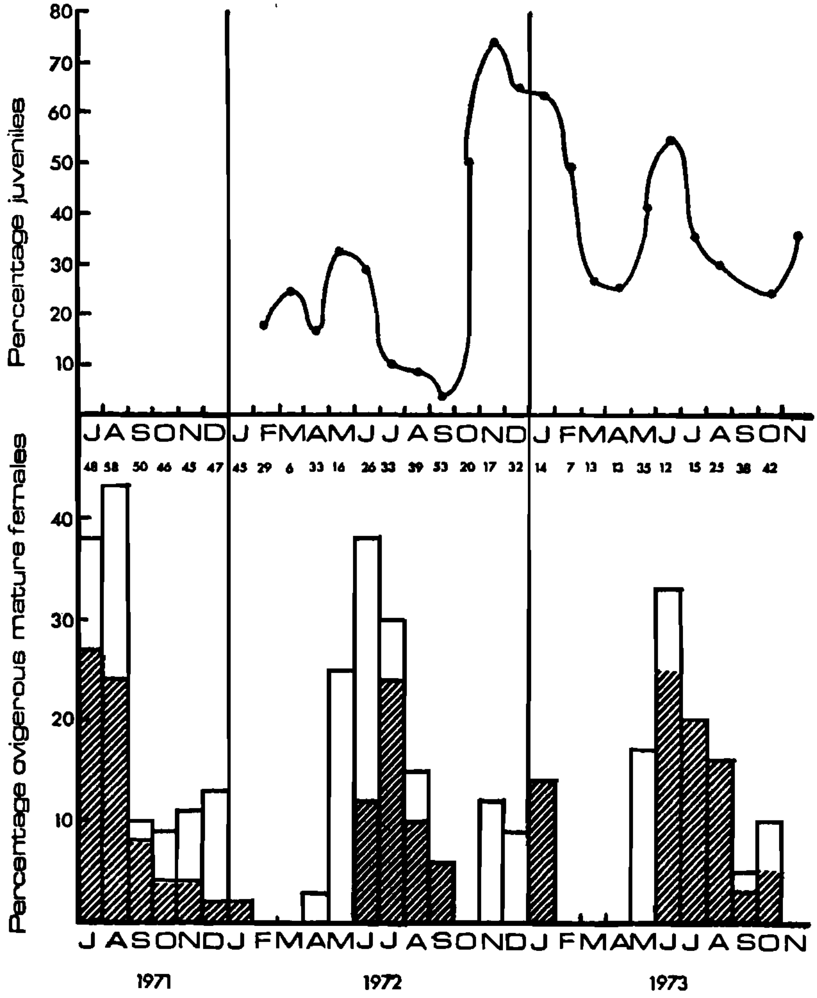

Figure 1

The percentage ovigerous females and juveniles in the population of *C. kraussi* in the Swartkops River estuary each month over the period July 1971–November 1973. In lower section, figures above histogram indicate actual number of mature females collected; cross-hatching in the histograms indicates percentage of females carrying eyed eggs.

is large; in November 1972 75 per cent, and in June 1973, 55 per cent of the population consisted of juveniles.

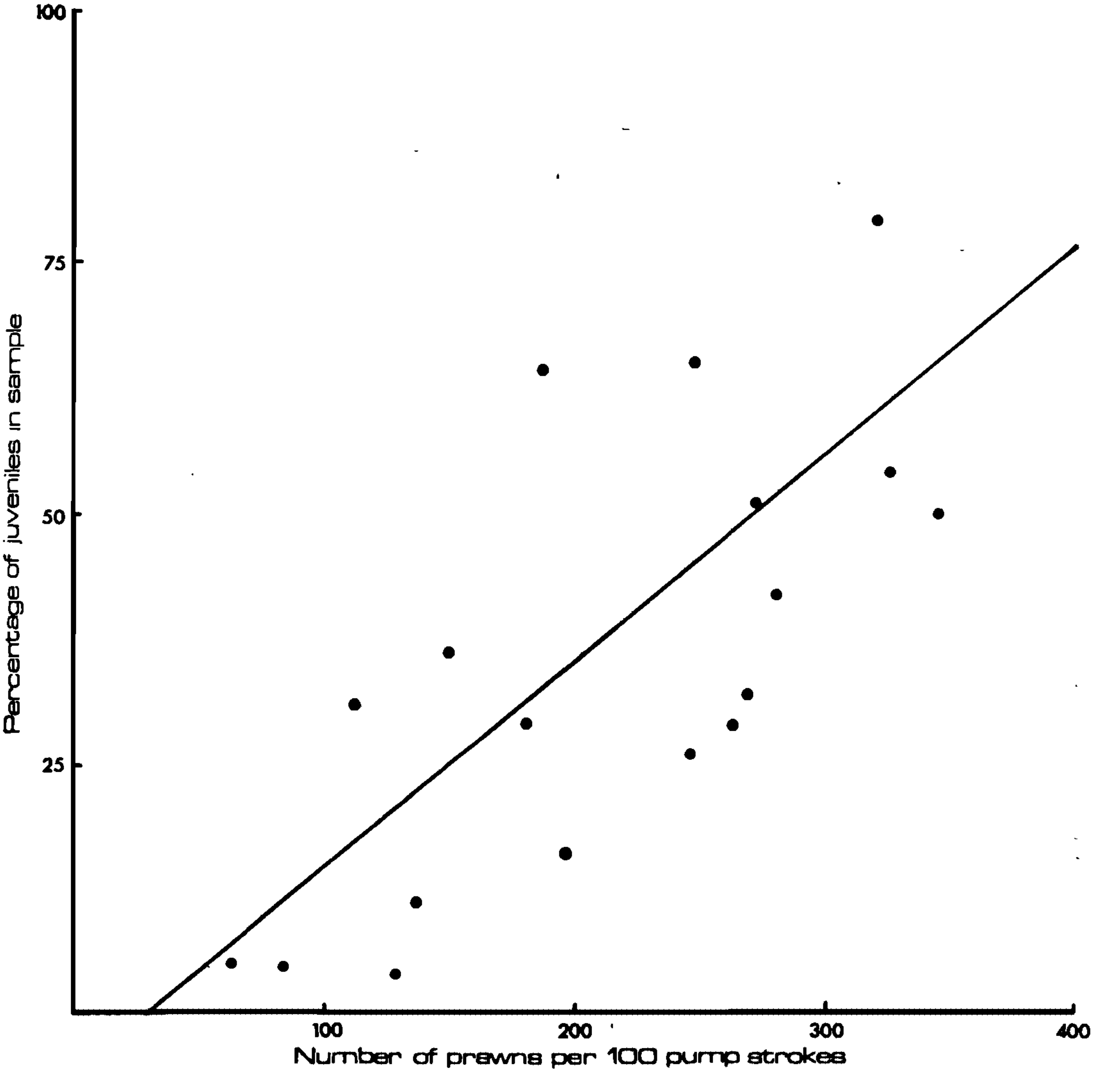

FIGURE 2

Relation between numbers of prawns obtained per 100 pump strokes and percentage of juveniles in the population. Regression equation y = 0,19x — 5,3.

Growth

Size frequency histograms of the population are shown in Figure 3. Not all samples have been shown because many were similar. In addition the study period was not long enough to follow one generation from hatching to death so the picture given is a composite one. Figure 3 shows that in September 1972 there were very few juveniles (2–3 mm carapace length) present in the population but this size class increased markedly in October and November. With

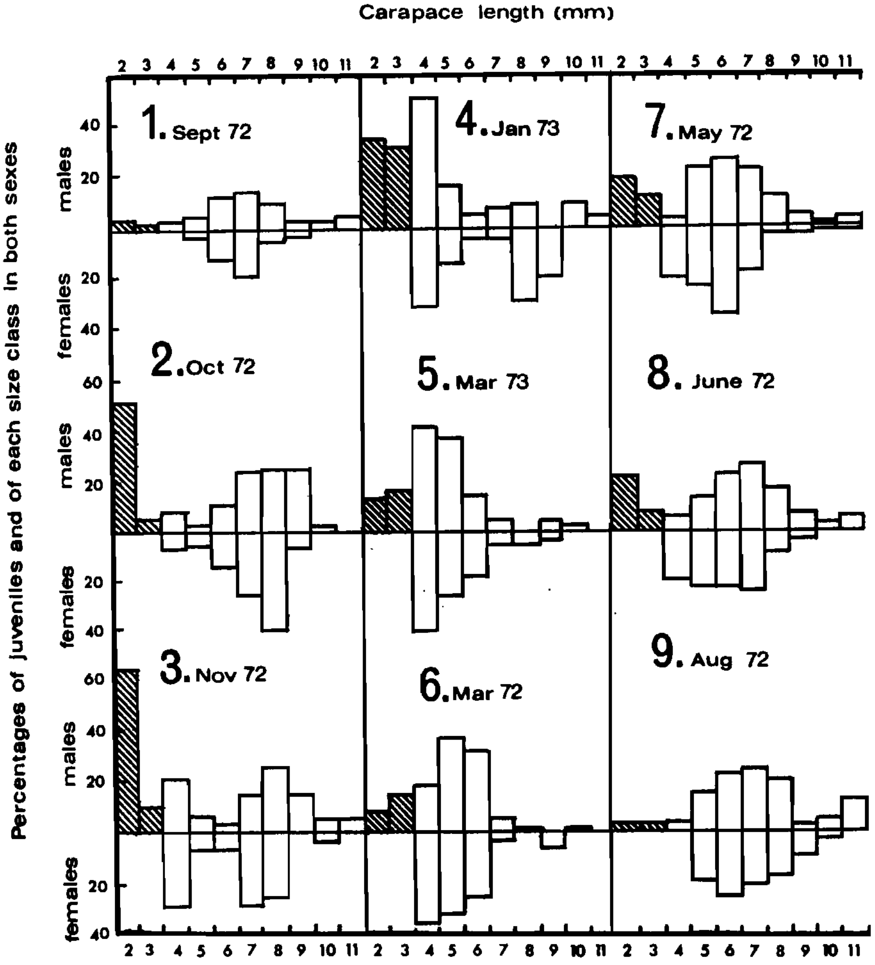

FIGURE 3

Combined results from 1972 and 1973 to illustrate movement of modal sizes in the population of *C. kraussi* in the Swartkops River estuary. Cross-hatching indicates percentage of unsexed juveniles; other percentages calculated separately within each sex. For further explanation see text.

further growth over summer a modal size of 4 mm carapace length was attained. With continued recruitment and further growth, carapace length of this generation varied from 4 to 6 mm by March. Data from March 1972 (Histogram 6) onwards show that growth was maintained over winter with the carapace-length range increasing from 5–7 mm in May to 6–8 mm in August. This generation was now about one year old. Histograms 7 and 8 also show recruitment of juveniles during May and June but by August (Histogram 9) these had merged with the preceding size classes and it was no longer possible to follow them as a particular generation. From September onwards (Histogram 1) growth of females slowed and they tended to accumulate in the 7–8 mm size classes. The males continued to grow and, as shown in Figure 4, this led to a marked change in sex ratio at carapace lengths above 9 mm while the length/weight curves for the two sexes (Figure 5) tended to separate, although the differences were not statistically significant. A final increase in size of the females occurred between November and January (Figure 3; Histograms 3, 4) when there was an increase in the modal sizes from 7–8 mm to 8–9 mm. Few females attained sizes greater than 9 mm carapace length.

The growth pattern indicated by the progression of the modes shown in Figure 3 was then combined with the breeding information shown in Figure 1 to give the post-larval life diagram shown in Figure 6.

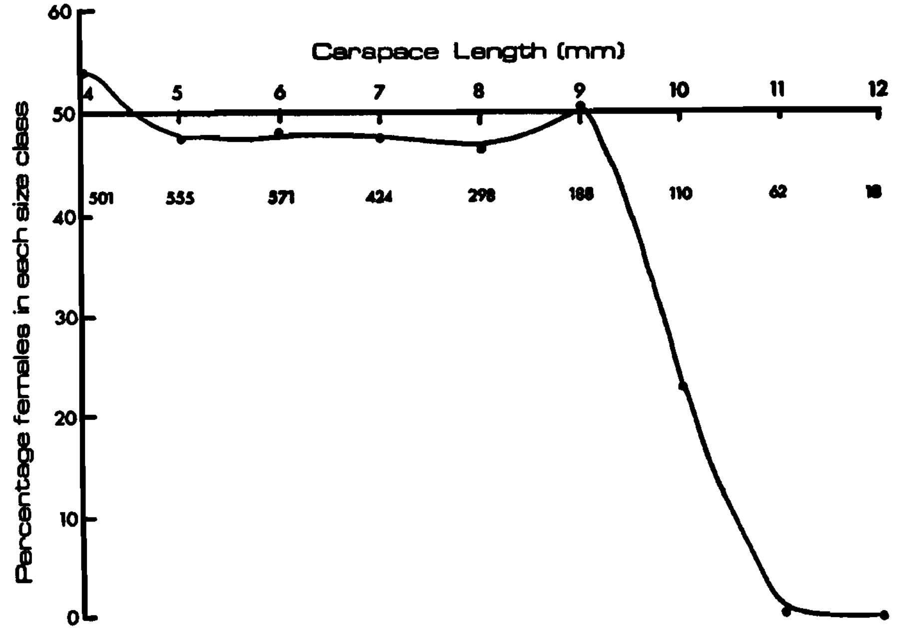

FIGURE 4

Changes in proportions of females in each size class with increasing size. Figures indicate total numbers (male and female) obtained.

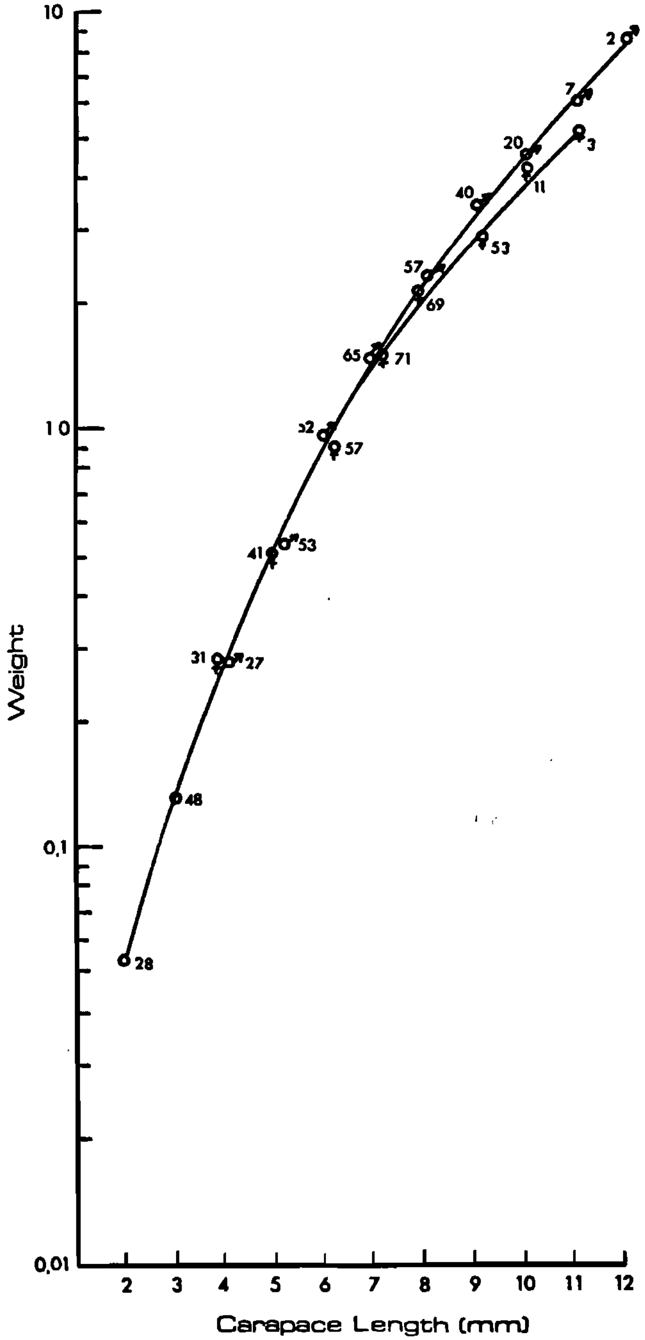

FIGURE 5
Length/wet-weight (g) curve for *Callianassa kraussi;* 2 and 3 mm size classes not sexed, otherwise sexes indicated. Figures indicate numbers of prawns measured.

Two generations of juveniles appear every year due to the winter-spring and summer breeding peaks; these two generations are designated A and B respectively in Figure 6. Males and females have been separated because of different growth rates.

Growth of Males. Males appear to grow continually until their maximum size is achieved. Males hatched in winter-spring (A) reach a carapace length of 8–9 mm after one year's growth. Growth continues during the following summer and the maximum carapace length of 11–13 mm is attained by early autumn at an age of about 18 months. This is followed by death in winter at an age of nearly two years.

Males which hatch in summer (B) merge with males of Generation A at an age of about one year when they are about six months younger than males of Generation A. The maximum carapace length of 11–13 mm is attained after about 15 months and this generation then survives the second winter before dying in spring at an age, as in the males of generation A, of nearly two years.

Growth of Females. Females which hatch in winter-spring (A) initially grow at a similar rate to the males and by the end of their first autumn (age about 9 months) have reached a carapace length of 6–7 mm. A period of ovary development then follows (Figure 6) and growth slows. There is a brief resumption of growth in spring and a carapace length of 8 mm is attained before summer breeding occurs at an age of about 16 months. It is uncertain what proportion of females of this generation is involved in summer breeding. The ovary then re-develops over summer and growth again slows although there is some further growth in autumn so that a carapace length of 8–9 mm is attained before they breed for a second time in the following winter at an age of about two years. A subsequent decrease in the numbers of large females indicates that the life span is probably slightly over two years.

In those females which hatch in summer (B), growth is again initially similar to that of males and a carapace length of about 8 mm is attained by the end of spring (age about 10 months) and the females of this generation then merge with those of Generation A. This merging of the size classes suggests that growth of B females is not slowed by ovary development and hence that they are not involved in summer breeding; this would agree with the smaller proportion of females showing winter ovary development prior to summer breeding (Figure 6) and also with the smaller peak of ovigerous females at this season. Growth of Generation B slows during summer and from the large proportion of females showing ovary development (Figure 6) this would appear to involve females of both generations which then contribute to the major winter-spring breeding season. The females of Generation B are now about 18 months old and have attained a carapace length of about 9 mm. Assuming a life span of about two years, as suggested for Generation A, this would mean that most of Generation B would survive through the following summer. This appears to be the case because declines in the numbers of large females were noted both at the end of spring and also at the end of summer. The contribution of these large females (carapace length 10–11 mm) to the summer breeding season is summarized in Table 2, which illustrates the size composition of females during peak winter and summer breeding months.

The months chosen were those in which the highest absolute number of ovigerous females

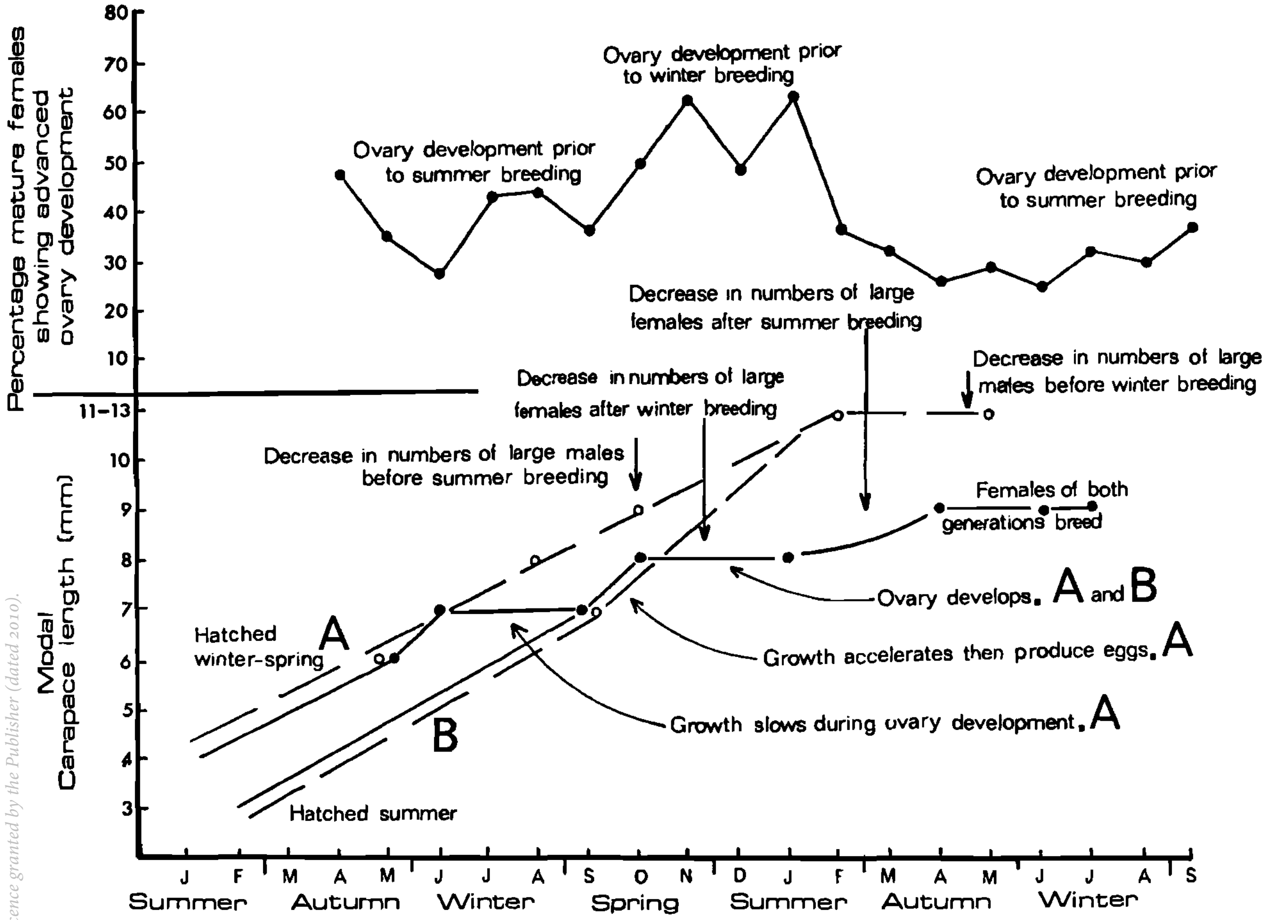

FIGURE 6
Growth of generations hatching in winter–spring (A) and summer (B). Males shown by open circles and dashed lines; females by solid circles and continuous lines. Ovary development associated with periods of slower growth in females shown in upper graph. For further explanation see text.

was obtained. Although the numbers involved, especially in summer, are small, the available evidence indicates that females breeding in summer are predominantly large (carapace length 8 mm or more) and supports the suggestion that summer breeding involves two-year-old females of Generation B (summer hatch) (females of this generation would not be able to attain a carapace length of 8 mm in one year) and probably also 18-month-old females of Generation A although the relative proportions are uncertain. These results also show that the recruitment from summer breeding is reduced because fewer females breed (Figure 1) but also because the very large females that contribute most of the breeding effort (Table 2) are beyond the size at which maximal egg production occurs (Table 1).

TABLE 2

Size distribution of ovigerous females during peaks of winter and summer breeding seasons.

Sizes	*August 1971, 1972, 1973*		*December 1971, 1972*	
7 mm	39%	Combined: 72%	0%	Combined: 33%
8 mm	33%		33%	
9–11 mm	24%	n = 33	66%	n = 9

DISCUSSION

Comparison of the life cycle of *C. kraussi* with the only other reasonably known callianassid, *C. australiensis* of the eastern coast of Australia (Hailstone & Stephenson 1961), indicates basic similarities. Both species are common in sheltered sandy or muddy sand substrates, both have spring and summer generations although *C. australiensis* has retained the planktonic larval stage which has been lost in *C. kraussi* (Forbes 1973b), and both are extensively exploited as bait organisms. Marked depletion of *C. australiensis* has occurred in certain areas (Hailstone & Stephenson 1961), although no measurable effects of bait exploitation have yet been noted in South Africa, despite increasing collecting pressure (personal observations) since the advent of the 'prawn pump'. This suggests that recruitment to the population is strong despite comparatively low rates of egg production and the involvement of smaller proportions of the mature females in breeding than in other known species. Pohl (1946) recorded 8 170 eggs on a specimen of *C. major* from North Carolina and Devine (1966) found 660–1500 in *C. filholi* of New Zealand. Production of large numbers of eggs is usually associated with small egg size. Thus Pohl (1946) recorded egg measurements of 0,88 × 0,74 mm (n = 45 from one female) in *C. major*. *C. gilchristi* from False Bay in South Africa had eggs 0,6 mm in diameter while eggs of *C. kraussi* were 1,2 mm in diameter (Forbes 1973b). The maximum proportion of ovigerous mature females recorded in *C. kraussi* was only 43 per cent. Hailstone & Stephenson (1961) recorded up to 90 per cent of mature females ovigerous at any one time in *C. australiensis* and Devine (1966) up to 80 per cent in *C. filholi*. Despite this low level of breeding and the smaller number of eggs the population of *C. kraussi* in the Swartkops estuary at times consisted of 60–80 per cent juveniles as compared to a maximum of 40–50 per cent in *C. australiensis*. This high rate of recruitment indicates low larval mortality and demonstrates the numerical success of the loss of the planktonic phase (Forbes 1973b) and the adoption of a non-pelagic lecithotrophic form of larval development (Thorson 1950; Vance 1973). This type of larval development is typically associated with an increase in the egg size and a reduction in the number of eggs produced by an individual female.

The significance of *C. kraussi* in South African estuaries is virtually unknown. The abundance of this species in many areas combined with a comparatively short life span and a high recruitment rate and the absence of energy loss from the population in the form of planktonic larvae suggests a rapid turnover of energy and nutrients within a restricted area. Despite the demonstration of the trophic significance of *C. major* faecal pellets on the east coast of the U.S.A. by Frankenberg *et al.* (1967), the role of *C. kraussi* in energy flow patterns in South African estuaries, through its ability to make submerged detritus available to surface feeders both in the form of faecal pellets and also as prey species for fish, is unknown.

Rapid turnover of generations and strong recruitment from a small proportion of mature females indicate that *C. kraussi* populations could probably recover rapidly from exploitation. Reduction in numbers would, however, reduce possibilities of contact between individuals with obvious effects on breeding effort. It is noteworthy here that the results suggest a decline in the maximum numbers of ovigerous females in successive years which has coincided with increasing use of 'prawn pumps'. In view of the possible significance of *C. kraussi* in estuarine systems it is possible that drastic reductions in numbers, as has been shown to be possible in Australia (Hailstone & Stephenson 1961), could reduce the breeding population beyond the point where recruitment is sufficient to balance losses. This could in turn disrupt energy flow patterns with resultant broad repercussions. Conservation measures should thus be designed so as to ensure the continued existence of stocks above and beyond those required simply for bait purposes.

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