JOURNAL OF CRUSTACEAN BIOLOGY, 12(4): 655–660, 1992

BREEDING PERIODICITY OF THE PADDY FIELD CRAB *OZIOTELPHUSA SENEX SENEX* (FABRICIUS) (DECAPODA: BRACHYURA), A FIELD STUDY

Y. Dayakar and K. V. Ramana Rao

ABSTRACT

The breeding periodicity of the paddy field crab *Oziotelphusa senex senex* was determined by direct field observations, by calculating the percentage of ovigerous females, and by histological studies on the nature of the ovary in the crab population of Allur (Nellore District, A.P., India) for three years. The female of this crab is an annual breeder, showing a single peak in June. Vitellogenesis occurs from December to April, spawning from May to July, brooding from July to September, and release of juveniles from September to November. This coincides with northeast monsoons. The smallest ovigerous crab had a carapace width of 3.0 cm (245 eggs), and the largest crab a carapace width of 5.2 cm (445 eggs). The mean incubation period is 47 ± 4 days. The different phases of the reproductive cycle synchronizes with seasonal variations such as temperature, humidity, and rainfall.

The success of brachyurans in varied environments is attributed to the diversity of their life-history patterns and reproductive strategies (Sastry, 1983). Biotic and abiotic environmental factors influence distribution, physiology, reproduction, and behavior of brachyurans (Powers and Bliss, 1983; Dunham and Gilchrist, 1988; Hartnoll, 1988; Wolcott, 1988).

Information on the reproductive biology of crabs is mostly confined to marine and estuarine forms (Knudsen, 1964; Hartnoll, 1969; Haefner, 1976, 1977; Seiple, 1979; McConaugha *et al.*, 1980; Goy *et al.*, 1985; Salmon, 1987). We find very little work on reproductive biology in fresh-water crabs. Different species of fresh-water potamonids are distributed in different parts of peninsular India (McCann, 1937). Earlier studies on these crabs were mainly on gametogenesis and on endocrine regulation (Adiyodi, 1988). Such studies do not furnish enough information on breeding periodicity of these crabs. The environmental factors operating in the respective habitats influence the breeding periodicity of the species (Kinne, 1964). Temperature and salinity are the prime factors in determining the breeding periodicity of marine and estuarine forms (Giese and Pearse, 1974). The environmental factors responsible for the control of breeding periodicity in fresh-water forms are quite different. Rainfall and temperature appear to influence breeding periodicity in fresh-water crabs. Therefore, the influence of these parameters on the breeding periodicity of the Allur populations of the paddy field crab *Oziotelphusa senex senex* was studied for three years.

These crabs are abundantly available in the paddy fields of the Allur village (14°54′N, 80°03′E, Nellore District, A.P., India (Fig. 1)). They live in burrows located along the bunds of the paddy fields. The crabs are rarely seen in the open fields. The Allur reservoir has an area of 800 hectares. It is the main catchment and storage reservoir for fresh water in Allur. The northeast monsoon lasts from September to November each year. The paddy fields with fine clay soil, standing waters, abundant microflora and fauna, and a bottom rich in organic matter offer an ideal habitat for these crabs (Dayakar, 1985).

MATERIALS AND METHODS

Minimum and maximum air temperatures (°C) and relative humidity (RH) (% saturation) of the fields were recorded daily directly with a graduated centigrade thermometer and hygrometer (No. 17/50; range 0–100%) twice a day (0830 and 1730). Rainfall recordings were taken from the India Meteorological Department (IMD) at Allur station. IMD recorded rainfall using the Self-Recording Rain Gauge (No. 1212/90) which computes cumulative values for every 24 h.

The percentage of ovigerous condition was determined from 20 female crabs (carapace width > 3.0 cm) on a monthly basis. Carapace width was measured with vernier calipers (accurate to 0.1 mm). For histological studies, ovarian tissues were fixed in Bouin's fluid, sectioned, and stained with Ehrlich's haematoxylin and eosin, and observed under a trinocular microscope (GTR IIA, Getner Instruments) available in our laboratory.

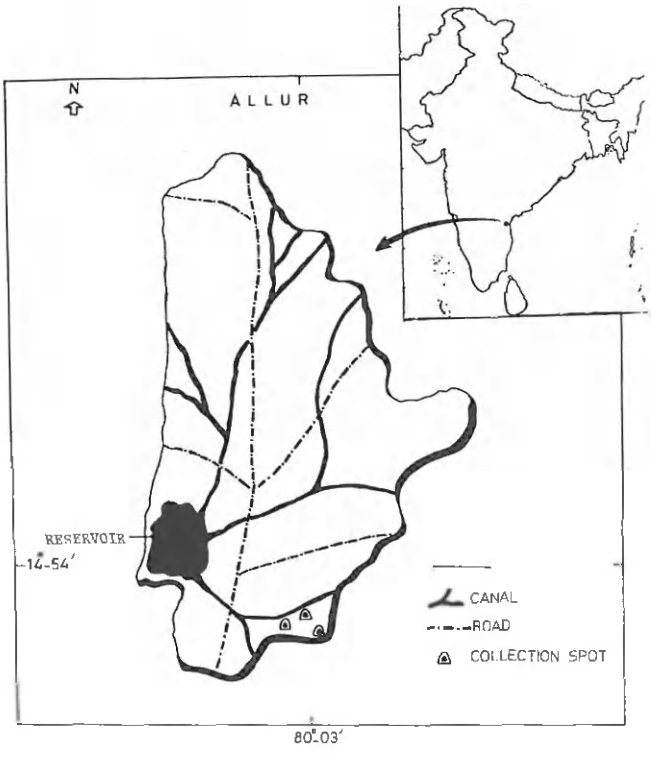

Fig. 1. The study area. Upper right: outline of India with approximate location of Allur village. Center, Allur showing the reservoir, canals, and crab collection spots. Scale: = 2 km.

Results

Temperatures ranged from 19.9–41.0°C throughout the period of study (Fig. 2). High temperatures were recorded in April, May, and June and low temperatures in December and January. Relative humidity ranged from 46–91%. Highest RH was observed from October–January and lowest from May–June. Rainfall varied immensely with the season, from 0–841.9 mm. Maximum rainfall was recorded from October–January. Lowest rainfall was recorded from February–May (Fig. 2).

Breeding Activity.—Reproductively active females with a carapace width ranging from 3.0–5.5 cm ($N = 84$ observations) were collected from May–November (1986, 1987) and from May–October (1988) (Table 1). The smallest ovigerous crab had a carapace width of 3.0 cm (245 eggs) and the largest, a carapace width of 5.2 cm (445 eggs). There is a positive correlation between the number of eggs spawned and the size of the crab as indicated by carapace width (Fig. 3). The first spawning was observed in the second week of May and extended until the first week of August in 1986 and 1987. However, in 1988 samples, spawning was limited to three months (May–July). Maximum spawning was observed in June during the entire period of study (Table 1).

Ovarian Cycle.—Vitellogenesis occurs from December–April (spring), when a steady rise in the temperature and a decrease in humidity and rainfall were observed. During this period, temperature ranged from 19.9–39.3°C, RH from 61–91%, and rainfall from 0–242 mm. At the beginning of vitellogenesis, the ovary is transparent, slender, and the ovarian wall is thin. As vitellogenesis proceeds, the ovary becomes milky white and large. Both previtellogenic and vitellogenic oocytes are pushed to the peripheral region of the ovary. At the end of vitellogenesis the matured oocytes have yolk globules scattered around the ooplasm. The ovary appears yellow in color. Spawning commences soon after the completion of vitellogenesis from May–July (summer), when the temperature is at its maximum. During this period the field temperature increases by +2°C, RH decreases by 40% with occasional rains. Crabs settle to the bottom of the burrow before beginning the deposition of eggs (spawning). At this time the ovary increases further in size. It is orange in color and is ready for deposition of eggs.

During ovulation the eggs are protected by a brooding chamber formed by the inflexed abdomen. After spawning, the ovary size is reduced. It is pale white in color. Incubation and hatching of eggs takes place from July–August (autumn). The period of incubation is 47 ± 4 days. During this period the fields are dry, but occasional rainfall may occur. After incubation, the newly hatched juveniles are not released, but are retained in the brood chamber until the onset of favorable conditions. The actual release of juveniles from the brood chamber into the field takes place when the fields are inundated with rain water. Inundation takes place during the peak monsoon period from September–November every year (Fig. 2). Maximum rainfall is observed during these months (841.9 mm), RH increases from 58–86% and the temperature falls from 36.3–21.1°C. The spent ovary is transparent and threadlike (Table 2).

Discussion

The breeding periodicity of crab species inhabiting different environments is influ-

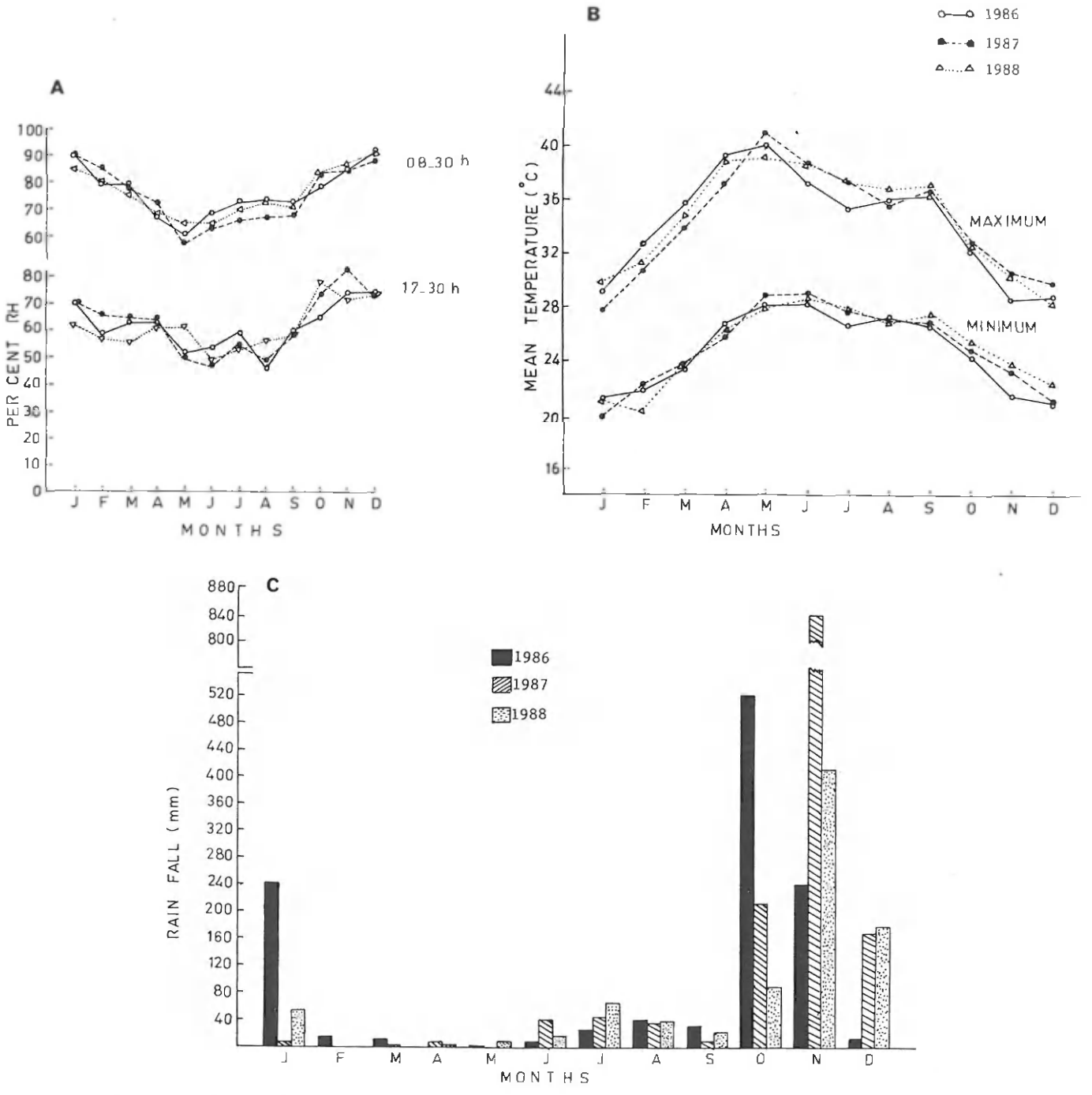

Fig. 2. Meteorological conditions at the study area. A, percentage relative humidity; B, mean temperature (in °C) at monthly intervals for the study period; and C, total rainfall at monthly intervals for the study period.

Table 1. Spawning activity (a) and ovigerous condition (b) of *Oziotelphusa senex senex* during different months of the breeding season. (Data compiled from a three-year study.)

Months	Number examined	1986		1987		1988	
		a	b	a	b	a	b
May	20	3	1	3	2	3	2
June	20	14	3	16	3	15	4
July	20	5	3	8	6	9	5
August	20	—	5	1	9	—	6
September	20	—	10	—	14	—	17
October	20	—	17	—	15	—	13
November	20	—	4	—	2	—	—

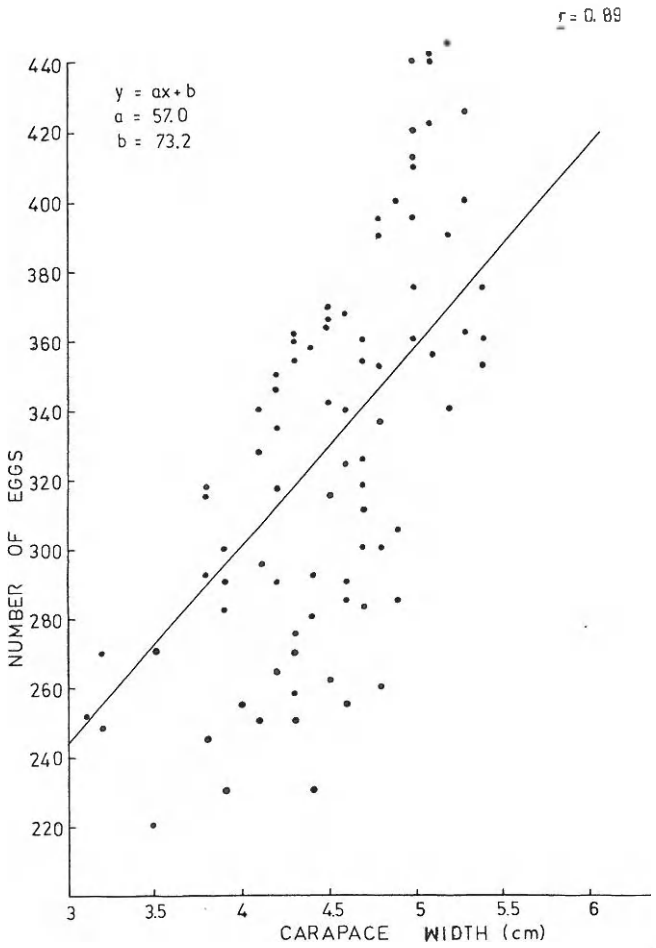

Fig. 3. Regression line showing correlation between carapace width and number of freshly spawned eggs in *Oziotelphusa senex senex* in India.

enced by factors prevailing in their respective habitats. The factors influencing the breeding periodicity of marine invertebrates is well understood (Giese and Pearse, 1974). Orton (1920) realized the importance of sea temperature as the prime factor in determining the breeding periodicity of marine invertebrates. However, temperature is not the only factor that influences breeding periodicity. Other factors, such as salinity, day length, food availability, and competition between congeneric species also influence breeding (Kinne, 1964; Booloo-tian, 1965; Steele and Steele, 1975).

Marine invertebrates have a saline environment in which to breed, while estuarine forms avoid rainy months for breeding to overcome salinity changes (Christensen and Costlow, 1975). That is why the mud crab *Scylla serrata* migrates to the sea for breeding (Hill, 1975). The Atlantic rock crab *Cancer irroratus* breeds from October–August in the mid-Atlantic Bight (Haefner, 1976). The tropical crab *Portunus pelagicus* and the fiddler crab *Uca annulipes* found on the west coast of India breed during non-monsoon months, owing to the influence of the southwest monsoon (Pillay and Nair, 1971). The terrestrial crabs *Cardisoma guanhumi* and *Gecarcinus lateralis* have solved the problem of release and dispersal of young by migrating to salt water (Gifford, 1962; Bliss, 1968).

The paddy field crab *O. senex senex* has no connections to the sea or to esturaries. Therefore, it depends on rain water for the release and dispersal of juveniles. The Allur population of *O. senex senex* has modulated its breeding periodicity in such a way as to release the juveniles from its brood cham-

Table 2. Breeding periodicity of *Oziotelphusa senex senex* in the Allur paddy fields, India.

Event	Period	Weather condition	Ovary condition
Vitellogenesis	December–April	Steady rise in temperature, humidity and rainfall decrease.	Ovarian proliferation. Ovary gradually increases in size. First milky white and later turns into yellow. Yolk globules visible in mature oocytes.
Spawning	May–July	Temperature at maximum, humidity and rainfall further decrease, dry conditions.	Ovary orange in color ready for deposition of eggs (peak period).
Incubation, hatching, and retention of juveniles in brood chamber	July and August	Occasional rains, field generally dry.	Egg development in brood chamber. Ovary pale white and reduced in size.
Release of juveniles from brood chamber into field	September–November	Monsoon rains, flooded fields, temperature declines, humidity increases.	Spent ovary transparent and threadlike (lean period).

ber immediately after the onset of the northeast monsoon (September–November).

From these data, it is clear that the Allur population of *O. senex senex* is an annual breeder with a single spawning period extending from May–July. The breeding pattern is dependent on temperature and rainfall. Vitellogenesis occurs during warm conditions and spawning during high temperatures and dry field conditions. The conditions favorable for vitellogenesis and spawning are not suitable for incubation and release of juveniles. Accordingly, there is a steady fall in temperature and an increase in rainfall, prior to the release of juveniles from the brood chamber into the field. The release of juveniles is particularly synchronized with the onset of monsoon rains; until then the juveniles are retained in the brood chamber. Though consistency in vitellogenesis and spawning was observed during the study period, the time spent in the brood chamber from spawning to the release of juveniles is variable and monsoon-dependent. Monsoon-dependent breeding was also reported in other potamonid crabs, namely, *Barytelphusa cunicularis* (see Diwan and Nagabhushanam, 1974) and *Paratelphusa hydrodromous* (see Pillai and Subramoniam, 1984), and in the fresh-water prawn *Macrobrachium malcolmsonii* (see Rajyalakshmi, 1980).

Acknowledgements

The authors are thankful to Prof. K. Sasira Babu for his encouragement and Mr. Dayanand Y. Pudi for drawing the figures.

Literature Cited

Adiyodi, R. G. 1988. Reproduction and development.—*In:* W. W. Burggren and B. R. McMahon, eds., Biology of land crabs. Pp. 139–185. Cambridge University Press, Cambridge, England.

Bliss, D. E. 1968. Transition from water to land in the decapod crustaceans.—American Zoologist 8: 355–392.

Boolootian, R. A. 1965. Aspects of reproductive biology in the striped shore crab, *Pachygrapsus crassipes.*—Bulletin of the Southern California Academy of Sciences 64: 43–49.

Christensen, M. E., and J. D. Costlow. 1975. The effect of salinity and cyclic temperature on larval development of the mud crab *Rhithropanopeus harrisii* (Brachyura: Xanthidae) reared in the laboratory.—Marine Biology 32: 215–221.

Dayakar, Y. 1985. Habitat physiology of three brachyurans, *Scylla serrata, Oziotelphusa senex senex* and *Ocypode platytarsis*—with reference to nitrogen metabolism.—M.Phil. dissertation, S. V. University, Tirupati, India.

Diwan, A. D., and R. Nagabhushanam. 1974. Reproductive cycle and biochemical changes in the gonads of the freshwater crab, *Barytelphusa cunicularis.*—Indian Journal of Fisheries 21: 164–176.

Dunham, D. W., and S. L. Gilchrist. 1988. Behaviour.—*In:* W. W. Burggren and B. R. McMahon, eds., Biology of land crabs. Pp. 97–138. Cambridge University Press, Cambridge, England.

Giese, A. C., and J. S. Pearse. 1974. Introduction: general principles.—*In:* A. C. Giese and J. S. Pearse, eds., Reproduction of marine invertebrates, Vol. I. Pp. 1–49. Academic Press, New York, New York.

Gifford, C. A. 1962. Some observations on the general biology of the land crab, *Cardisoma guanhumi* in South Florida.—Biological Bulletin 123: 207–225.

Goy, J. W., S. G. Morgan, and J. D. Costlow. 1985. Studies on the reproductive biology of the mud crab, *Rhithropanopeus harrisii.* Induction of spawning during the non-breeding season.—Crustaceana 49: 83–87.

Haefner, P. A. 1976. Distribution, reproduction and molting of the rock crab, *Cancer irroratus,* in the mid-Atlantic Bight.—Journal of Natural History 10: 377–397.

———. 1977. Aspects of the biology of the Jonah crab, *Cancer borealis,* in the mid-Atlantic Bight.—Journal of Natural History 11: 303–320.

Hartnoll, R. G. 1969. Mating in Brachyura.—Crustaceana 16: 161–181.

———. 1988. Evolution, systemics and geographical distribution.—*In:* W. W. Burggren and B. R. McMahon, eds., Biology of land crabs. Pp. 6–54. Cambridge University Press, Cambridge, England.

Hill, B. J. 1975. Abundance, breeding and growth of the crab, *Scylla serrata* in two South African estuaries.—Marine Biology 32: 119–126.

Kinne, O. 1964. The effect of temperature and salinity on marine and brackish water animals. 2. Salinity and temperature combinations.—Oceanography and Marine Biology 2: 281–339.

Knudsen, J. W. 1964. Observations on the reproductive cycles and ecology of the common Brachyura and crablike Anomura of Puget Sound, Washington.—Pacific Science 18: 3–33.

McCann, C. 1937. Notes on the common land crab, *Paratelphusa guerini* of Salsette islands.—Journal of the Bombay Natural History Society 39: 531–542.

McConaugha, J. R., K. McNally, J. W. Goy, and J. D. Costlow. 1980. Winter-induced mating in the stone crab, *Menippe mercenaria.*—Proceedings of the World Mariculture Society 11: 544–547.

Orton, J. H. 1920. Sea temperature, breeding and distribution in marine animals.—Journal of the Marine Biological Association of the United Kingdom 12: 339–366.

Pillai, C. K., and T. Subramoniam. 1984. Monsoon-dependent breeding in the field crab, *Paratelphusa hydrodromous.*—Hydrobiologia 119: 7–14.

Pillay, K. K., and N. B. Nair. 1971. The annual reproductive cycles of *Uca annulipes, Portunus pelagicus* and *Metapenaeus affinis* (Crustacea: Decapoda) from the south-west coast of India.—Marine Biology 11: 152–166.

Powers, L. W., and D. E. Bliss. 1983. Terrestrial adaptations.—*In:* F. J. Vernberg and W. B. Vernberg,

eds., The biology of Crustacea, Vol. 8, Environmental adaptations. Pp. 271–333. Academic Press, New York, New York.

Rajyalakshmi, T. 1980. Comparative study of the biology of the freshwater prawn, *Macrobrachium malcolmsonii* of Godavari and Hoogly river system.—Proceedings of the Indian National Science Academy, Section IB: 72–89.

Salmon, M. 1987. On the reproductive behavior of the fiddler crab, *Uca thayeri,* with comparisons to *U. pugilator* and *U. vocans*: evidence for behavioral convergence.—Journal of Crustacean Biology 7: 25–44.

Sastry, A. N. 1983. Ecological aspects of reproduction.—*In:* F. J. Vernberg and W. B. Vernberg, eds., The biology of Crustacea, Vol. 8, Environmental adaptations. Pp. 179–254. Academic Press, New York, New York.

Seiple, W. 1979. Distribution, habitat preference and breeding periods in the crustaceans *Sesarma cinereum* and *S. reticulatum* (Brachyura: Decapoda: Grapsidae).—Marine Biology 52: 77–86.

Steele, D. H., and V. J. Steele. 1975. The biology of *Gammarus* (Crustacea, Amphipoda) in the northwestern Atlantic. XI. Comparison and discussion.—Canadian Journal of Zoology 53: 1116–1126.

Wolcott, T. G. 1988. Ecology.—*In:* W. W. Burggren and B. R. McMahon, eds., Biology of land crabs. Pp. 55–96. Cambridge University Press, Cambridge, England.

RECEIVED: 10 September 1991.
ACCEPTED: 14 February 1992.

Address: Department of Zoology, S. V. University P. G. Centre, Kavali 524 202, A. P., India.

ANNOUNCEMENT

"Zoosystematica Rossica," a new journal in English, is being published by the Zoological Institute, Russian Academy of Sciences, St. Petersburg, and East Palaearctic section of the International Organization for Biological Control of noxious animals and plants, Moscow. The journal focuses on descriptions of new taxa, taxonomic revisions, synonymic notes, phylogenetic reconstructions, and most interesting new faunistic records in all groups of animals from all parts of the world. The journal is mainly a forum for zoologists working in Russia and neighboring countries.

The journal will be published quarterly, with each issue about 160 pages. The annual individual subscription price is US $102.00.

Order forms, manuscripts, and other correspondence should be sent to:

Elena Markhaseva
Zoological Institute
Russian Academy of Sciences
St. Petersburg 199034
Russia
(Tel. 218 1311, fax (812) 218 0011)

Payment for subscription should be sent to:

Account No. 18000885
Secretariat East Palaearctic Section
IOBC (EPS MOBB) VO SOJUSVALUTRASCHET
VNESH-ECONOMBANK
Serpukhovskii val 8
Moscow, Russia