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OBSERVATIONS ON CRAYFISH IN THE EVERGLADES, FLORIDA, U.S.A.

BY

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The crayfish, *Procambarus alleni* (Faxon), ranges throughout central and southern Florida, U.S.A., inhabiting most aquatic habitats including intermittently-flooded flatwoods, ponds, lakes, ditches, streams and canals (Hobbs, 1942). It is particularly common in the vast marsh ecosystem of southern Florida, including the Everglades, where it is subjected to seasonal changes in water depth during the annual cycle of alternating wet and dry seasons. This note reports on several aspects of the little known biology of crayfish in the Everglades, particularly responses of the population to seasonal and annual variation in the hydrologic regime.

Most of the data were collected as part of a seven-year sampling program, 1966-1972, directed by A. L. Higer and M. C. Kolipinski of the U.S. Geological Survey under contract to the U.S. National Park Service. The area studied was in the southern Everglades of Everglades National Park. Samples were taken at ten permanent sites on each of two consecutive days generally once per month with a Higer pull-up trap, a 1.5 $\times$ 3 m rectangular sheet of netting supported along its edges by pipes and brought rapidly from the bottom to the surface (Kushlan, 1974). Samples were taken after dark when crayfish are generally most active (Roberts, 1944). Additional samples of standing crop were taken with 1 m^2 throw traps. Energy content was determined with a Parr adiabatic calorimeter. Years used in calculations run from the beginning of the wet season in June through May.

Water levels in the Everglades showed yearly variation during the study period. In a typical year water levels fall during the dry season in winter (February) and spring to a low point below ground level in May or June. By this time surface water has disappeared from most of the marshes and remains only in scattered ponds. Such typical fluctuations occurred at the beginning of the study in 1966-67 (fig. 1). A somewhat similar but lessened fluctuation occurred in 1967-68. The fluctuation dampened out over the following three years as water levels remained elevated because of high rainfall and surface discharge. The typical fluctuating pattern returned in 1970-71 and 1971-72.

The standing crop of crayfish in the Everglades varied from location to location in the Everglades depending in part on water depth. Standing crop in marshes achieves an average maximum of about 1.6 kcal/m^2 in water about 25 cm deep (fig. 2). Highest standing crops found in Everglades marshes were 4.0 kcal/m^2.

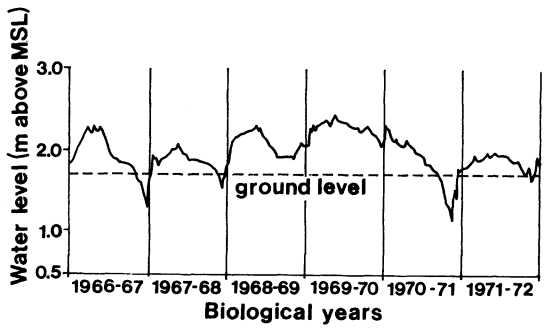

Fig. 1. Changes in water levels in the Everglades over the 1966-72 study period.

In the Everglades, other mobile aquatic organisms tend to move into ponds and similar deep locations when the water table lowers during the dry season (Kushlan, 1976). Although some movement probably occurs in Everglades crayfish, as has been demonstrated in other species (Camougis & Hichar, 1959; Momot, 1966; Mobberly & Pfrimmer, 1967), crayfish do not become concentrated in ponds during the dry season. Cambarine crayfish have well adapted burrowing habits that enable them to survive loss of surface water in many types of fluctuating habitats (e.g., Williams, Williams & Hynes, 1974). *Procambarus alleni* is a facultative

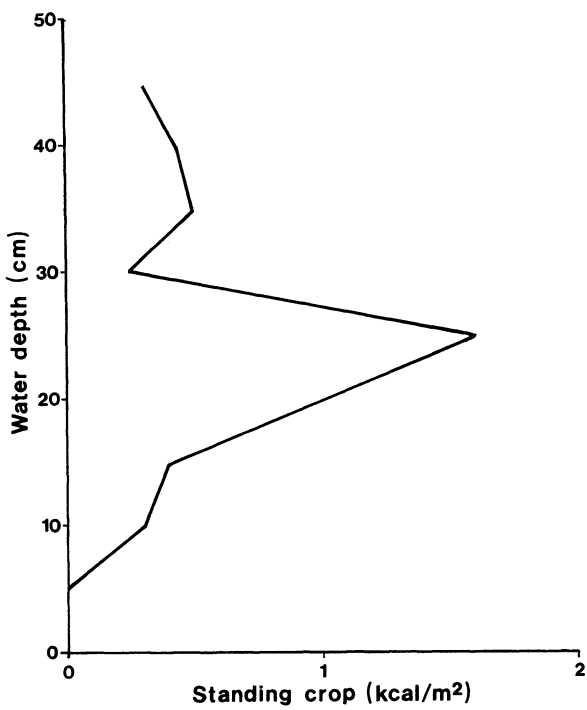

Fig. 2. Standing crop of crayfish in the Everglades marshes in locations of different water depths.

burrower and thus probably survives by burrowing in the marsh rather than migrating to ponds during the dry season.

The abundance of crayfish varied over the study period (fig. 3). Annual average biomass and density were high in 1966-67 and 1967-68 when water levels fluc-

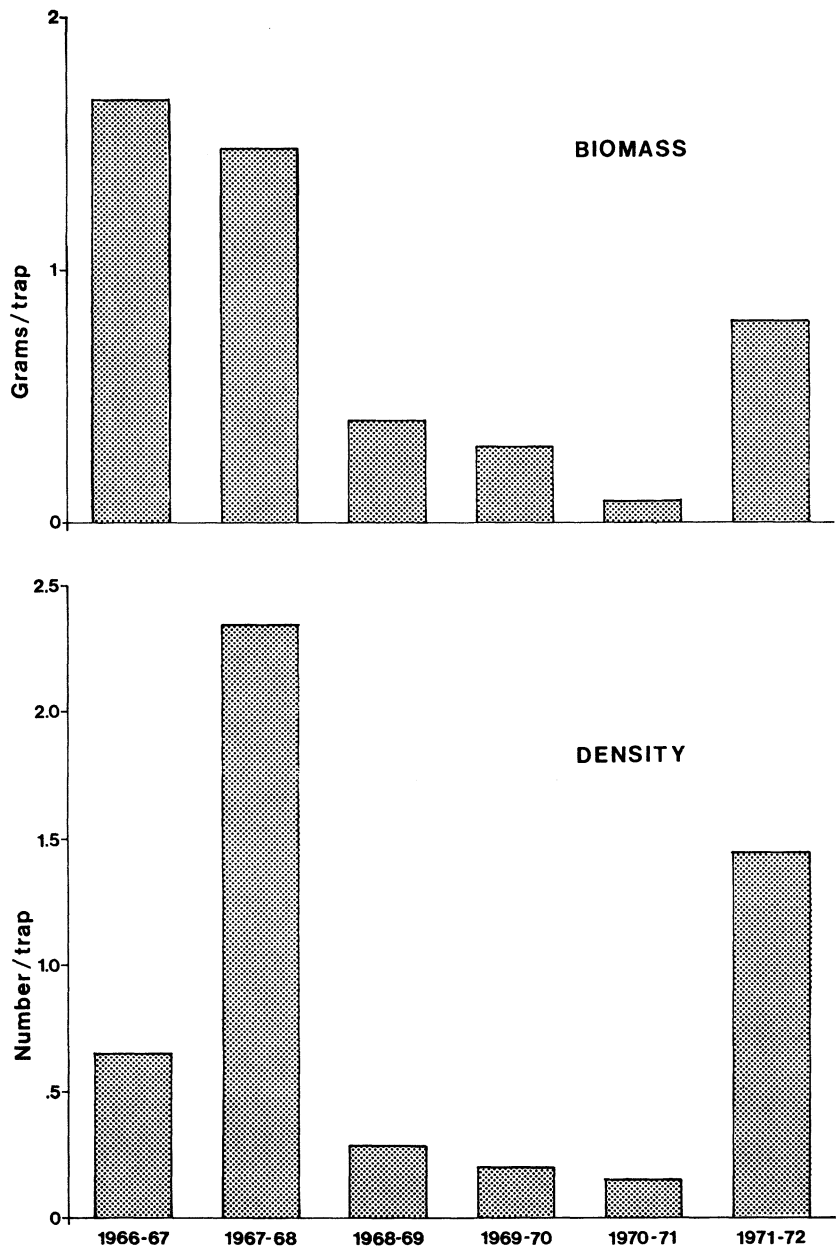

Fig. 3. Annual mean biomass and density of crayfish in the Everglades.

tuated typically. However biomass and density fell during the period of extended high water. The return of fluctuating conditions restored higher values with a delay of one year. During 1970-71, the first year water levels fell after the period of extended high water, crayfish abundance continued at its previous low level, reflecting the antecedent conditions. Thus crayfish biomass and density were higher in fluctuating than stabilized water conditions. During the period of continued high water fish populations in the Everglades also underwent marked changes, increasing in the diversity, number of species, and size of larger predatory fish (Kushlan, 1976a). This probably resulted in increased predation pressure on crayfish which may have caused their decrease in abundance. Return of a drying season in 1970-71 eliminated the larger predators permitting return of more typical populations the following year. Fluctuating water levels are therefore necessary for maintenance of high population levels of crayfish in the Everglades.

No ovigerous females were encountered in the trap samples. This suggests that females remained secluded during their ovigerous period. Such maternal inactivity and general trap shyness has been found in other species (Mason, 1970). The time of breeding can be determined by the entrance of juveniles into the trapable poulation, as shown by declines in the average size of crayfish trapped. Pooled data for the 1966-72 study period show two periods of low average size, May-June and January (fig. 4). This suggests that there are two breeding seasons in the Everglades. Considering a delay between juvenile hatching and becoming trapable, hatching may occur in April and, if growth slows in the winter, somewhere between September and November. It is possible that some breeding in the Everglades occurs year-round with twice annual peaks of activity in spring and fall.

Momot (1967) found that crayfish in a marl-depositing, periphyton dominated system were primarily scavengers and grazers on aufwuchs. This is also probably the case in the Everglades. Crayfish probably also consume selected plant material (Seroll & Coler, 1975). Since crayfish achieve standing crops of 4.0 kcal/m^2, they represent a potentially important source of food for other organisms. Everglades crayfish are prey for large fish, bullfrogs (*Rana grylio* Stejneger), American bitterns (*Botaurus lentiginosus* (Montagu)), pied-billed grebes (*Podilymbus podiceps* (L.)), white ibis (*Eudocimus albus* (L.)), racoons (*Procyon lotor* (L.)), river otters (*Lutra canadensis* (Schreber)) and alligators (*Alligator mississippiensis* (Daudin)). Crayfish comprise 75% by volume of the food of the Everglades bullfrog (Ligas, 1960), 32% by volume of the food of juvenile alligators (Fogarty & Albury, 1968) and 51% by weight of the food consumed by white ibis (Kushlan & Kushlan, 1975). This means for example, that white ibis required 470 tonnes of crayfish in the 1972 nesting season. Thus the crayfish is an important link in the pathway of energy flow in the Everglades. More needs to be known about the biology of this species and its role in the ecology of the Everglades marsh. It is apparent, however, that the maintenance of fluctuating water levels is necessary for high standing crops and therefore availability of crayfish to other components of the food web.

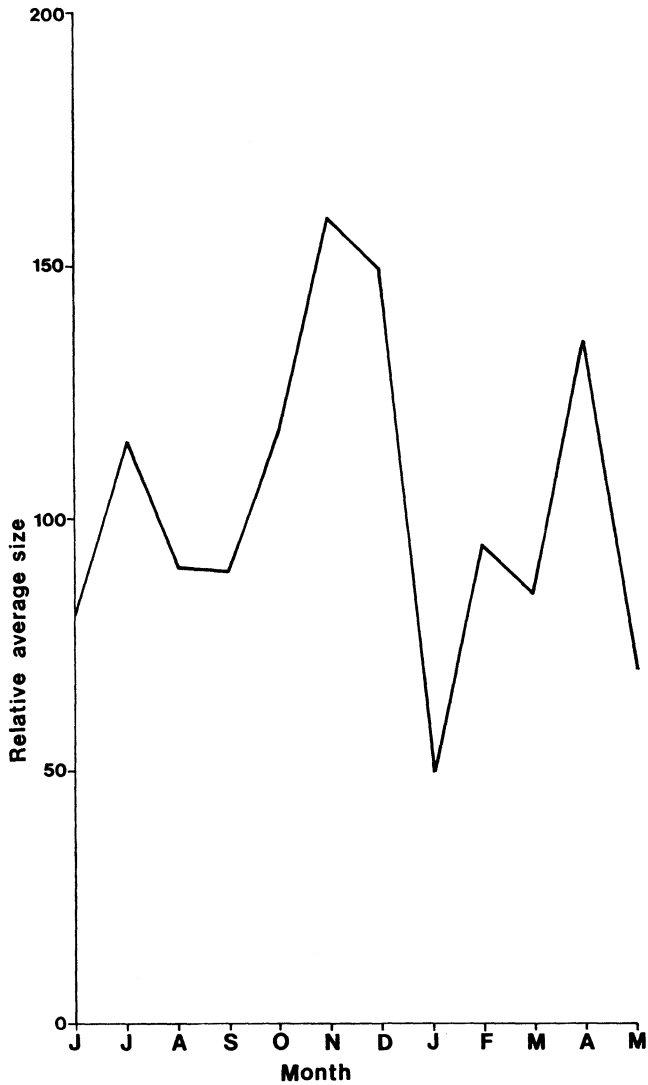

Fig. 4. Average size of crayfish in different months showing small average size in May-June and January indicating entrance of juveniles into the trapable population. Data plotted are averages for the six year study period expressed as a percent of the average size of crayfish each year.

REFERENCES

CAMOUGIS, G. & J. K. HICHAR, 1959. Some studies on crayfish distribution in a small pond. American Midland Natural., **62**: 227-231.

FOGARTY, M. J. & J. D. ALBURY, 1968. Late summer foods of young alligators in Florida. Proc. S. E. Assoc. Game Fish Comm., **21**: 220-222.

HOBBS, H. H., Jr., 1942. The crayfishes of Florida. Univ. Florida Publ., (Biol. Sci. Ser.) **3** (2): 1-179.

KUSHLAN, J. A., 1974. Quantitative sampling of fish populations in shallow fresh-water environments. Trans. American Fish Soc., **103**: 348-352.

——, 1976. Wading bird predation in a seasonally-fluctuating pond. Auk, **93**: 464-476.
——, 1976a. Environmental stability and fish community diversity. Ecology, **57**: 821-825.
KUSHLAN, J. A. & M. S. KUSHLAN, 1975. Food of the white ibis in southern Florida. Florida Field Natural., **3**: 31-38.
LIGAS, F. J., 1960. The Everglades bullfrog, life history and management: 1-79. (Florida Game and Fresh Water Fish Commission).
MASON, J. C., 1970. Maternal-offspring behavior of the crayfish, Pacifastacus trowbridgi (Stimpson). American Midland Natural., **84**: 463-473.
MOBBERLY, W. C., Jr. & R. J. PFRIMMER, 1967. Distribution of crayfish in a roadside ditch. American Midland Natural., **78**: 82-88.
MOMOT, W. T., 1966. Upstream movement of crayfish in an intermittent Oklahoma stream. American Midland Natural., **75**: 150-159.
——, 1967. Populations dynamics and productivity of the crayfish Orconectes virilis in a marl lake. American Midland Natural., **78**: 55-81.
ROBERTS, T. W., 1944. Light, eyestalk, chemical and certain other factors as regulators of the community activity for the crayfish Cambarus virilis Hagen. Ecol. Monog., **14**: 359-392.
SEROL, A. & R. A. COLER, 1975. Demonstrated food preferences of Orconectes immunis (Hagen) (Decapoda, Astacidea). Crustaceana, **29**: 319-320.
WILLIAMS, D. D., N. E. WILLAMS & H. B. N. HYNES, 1974. Observations on the life history and burrow construction of the crayfish Cambarus fodiens (Cottle) in a temporary stream in southern Ontario. Canadian Journ. Zool., **52**: 365-370.

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