

Investigations of the Troglotic Crayfish *Orconectes inermis testii* (Hay) in Mayfield's Cave, Monroe County, Indiana

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SUMMARY

Mark-recapture studies of some aspects of the biology of the cavernicolous crayfish, *Orconectes inermis testii* (Hay), were conducted from December, 1969 to March, 1970, in Mayfield's Cave, Monroe County, Indiana. Population size was estimated to be 66 ± 9 (95% C.L.) for the 300 m study area, but because of the small sample size, this is undoubtedly a deflated value. Size of animals, expressed as total length, indicates that the population was comprised primarily of adults. Seventy-four percent of the marked crayfish moved no more than 10.5 m away (total upstream and downstream distances) from the tagging site. Hence, this species appears to restrict its activities to a specific area ("home range") of up to 10.5 m of stream passage. Form I males traveled greater distances than did Form II (15.1 and 3.0 m, respectively), possibly in search of mates. Adult females moved less than juveniles, and males appeared to move greater distances than females (means of 12.9 and 5.9 m, respectively). Upstream movements were more commonly observed than downstream (mainly Form I males), indicating a possible restocking mechanism following floods. Distances traveled were not related to the size of individuals or to elapsed time.

INTRODUCTION

Packard (1888) made the earliest reference to *Orconectes inermis testii* (Hay) when he reported that C.H. Bollman had visited Mayfield's Cave, Monroe County, Indiana, and found "*Cambarus pellucidus*" in its stream. In 1891 Hay introduced the varietal name for the troglotic crayfish in Mayfield's and Truett's caves. In 1907 Banta conducted an exhaustive study of the biota in Mayfield's Cave, and his observations concerning this subspecies are still heavily quoted. Hobbs et al. (1977) reported that this crayfish is currently known from 21 localities in "Monroe, Owen, and Greene (?) counties, Indiana. It intergrades with the typical subspecies [*O. i. inermis* Cope] in the more southern counties of the State".

A brief visit to Mayfield's Cave on 20 September 1969 convinced me that it would be an excellent site for a short-term study of the stream-dwelling *O. i. testii*. Not only was it conveniently located (4.8 km west of Bloomington), but it was one of the few caves for which past faunal data were available. Thus, data collected 71 years after Banta's (1907) work could allow a comparative study, and perhaps enable an assessment of human impact on even a supposedly "isolated" environment.

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Studies were conducted from September 1969 to March 1970, but during March the owner of the cave, concerned with safety and his liability in the event of an accident, "closed" the cave.

STUDY AREA

The entrance to Mayfield's Cave is in the northeast side of an abandoned quarry about 4.8 km northwest of Bloomington, Indiana, Section 26, Township 9N, Range 1W SW $\frac{1}{4}$, NE $\frac{1}{4}$, SW $\frac{1}{4}$, at an elevation of 260 m (Fig. 1). The cave is developed in the Ste. Genevieve limestone and is approximately 550 m long. A stream flows from the rear and emerges at the surface as a small spring, approximately 230 m from the entrance. The stream passage is 4 to 6 m wide and 1 to 2 m high. Occasional areas near the entrance and rear have ceiling heights of approximately 4 m. Small intermittent pools lie along the length of the stream (Fig. 1), which meanders along the passage and pe-

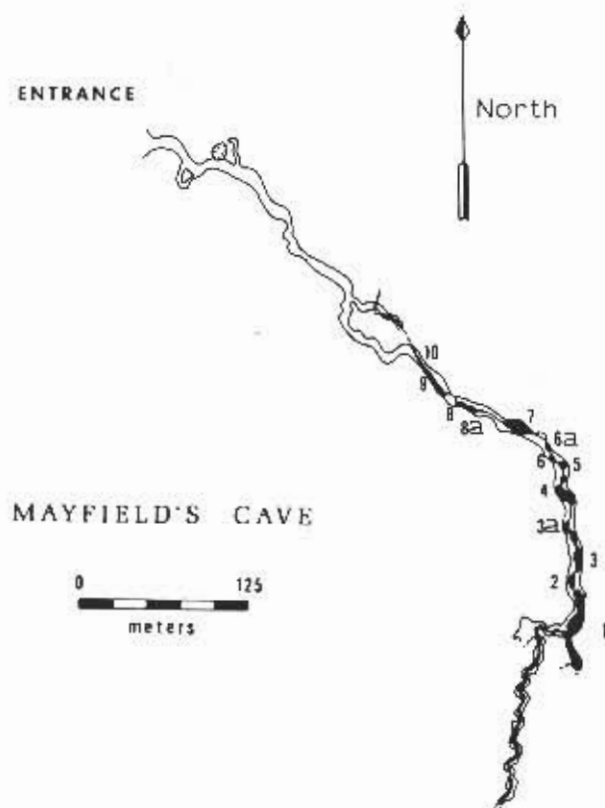


Fig. 1. Map of Mayfield's Cave showing the location of stations along the study area (after Banta, 1907: Plate 2).

riodically undercuts the walls and disappears. The pooled areas range in depth from less than 1 cm to approximately 60 cm and are up to 9 m long and 2 m wide. The stream flows continually throughout all months of the year, although velocity is greatly reduced during summer and fall. Normally the water is clear, but becomes turbid as flow increases following precipitation. The substrate is variable, consisting of silt, sand, gravel, small rocks, and "breakdown."

Approximately 300 m of the stream passage was divided into stations, based primarily on the location of pools, to facilitate study (Fig. 1).

Two species of crayfishes, representing two genera, were sympatric in the stream. *Orconectes inermis testii* and *Cambarus (Erebicambarus) laevis* (Faxon). They occurred in all portions of the stream and were more often observed in pools than in shallow, faster flowing sections. *Orconectes i. testii* greatly exceeded *C. (E.) laevis* in numbers. Four species of entocytherid ostracods were present as commensals on the crayfishes: *Sagittocythere barri* (Hart and Hobbs), *Donnaldsoncythere donnaldsonensis* (Klie), *Uncinocythere xania* (Hart and Hobbs), and *Dactylocythere susanae* Hobbs III. Large numbers of the isopod *Caecidotea stygius* (Packard) and the amphipod *Cran-gonyx gracilis* Smith frequented primarily the pooled areas of the stream. Numerous Diptera, Coleoptera, plethodontid salamanders, and other taxa were observed throughout the cave (see Banta, 1907, for a detailed description of the cave, its fauna, and the environs at that time). One of the organisms reported by Banta to occur in the cave, *Amblyopsis spelaea* DeKay (Southern cavefish), has not been observed in recent years. Eigenmann introduced this species into the cave in the summer of 1901, and in 1907 Banta reported that it was abundant and "breeding freely." No cavefish occur naturally north of the East Fork of White River.

METHODS

Air and water temperatures were recorded on each visit to the cave. Records of surface air temperatures and precipitation for the period were obtained from a nearby weather station. Water levels, velocity, turbidity, relative abundance of organisms, and available food (leaves, detritus, dead organisms) were also noted at each station (Hobbs, 1973b). Crayfish were captured by hand or with the aid of a small net, marked, and released at the point of capture.

Various tagging methods were tested in the laboratory (Hobbs III, 1981), but work began before they had been evaluated. Crayfishes here were marked externally with blue and red Magic Marker as a temporary tag. The first crayfish was marked on 21 December 1969. The surface of the exoskeleton was dried and the appropriate station number marked on the dorsum of the carapace. Individuals were marked using combinations of the two colors on the telson, uropods, and abdominal segments (Fig. 2). Marking a crayfish and recording data took approximately five minutes per individual. The following information was recorded for each: sex (form in males; ovigerous,

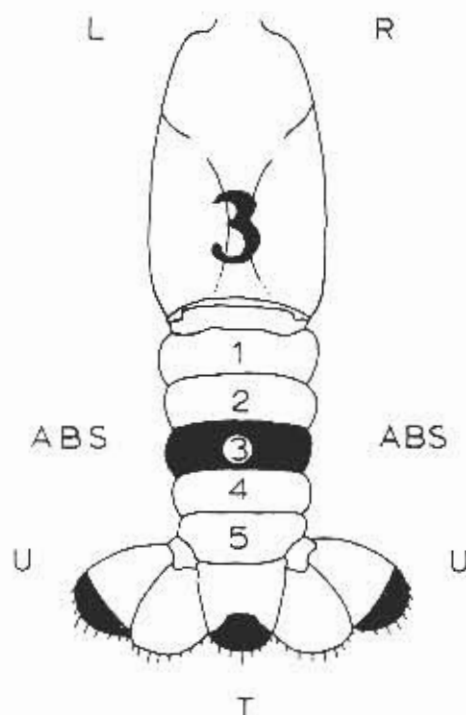


Fig. 2. Dorsal view of generalized crayfish, showing system of tagging individuals in Mayfield's Cave. Shown is individual R3UTU (3) ABS. R = color (red); 3 = station; UTU = uropods and telson; (3) ABS = 3rd abdominal segment.

and with or without eggs or cement glands, in females), length (tip of rostrum to tip of telson), relative position in molt cycle, location where tagged, injuries and regenerated appendages, and responses to light. Total counts were made of all specimens observed on each trip. On occasion, crayfishes were removed from the cave and examined for symbionts.

The flexibility of the crayfish abdomen makes total length (TL) a less reliable absolute measurement than the more standard carapace length (CL). However, since TL was the datum obtained in the first two tagging efforts, and since exclusion of this information would have meant too great a loss, TL was retained as the expression of size throughout the study. Although the carapace and abdomen are approximately subequal in length in cambarid crayfishes, conversion of TL to CL involves potentially substantial error.

RESULTS

Banta (1907) reported two species of crayfishes, *O. i. testii* (his *C. pellucidus*) and *C. (E.) laevis* (his *C. bartonii*), from this locality. Seventeen specimens of both species were observed on the first trip along the stream passage in 1969, the majority of them *O. i. testii*.

Size: Forty-nine crayfishes were tagged from 21 December 1969 to 5 March 1970 (all captured specimens tagged). *Orconectes i. testii* was represented by 19 ♂ I, 6 ♂ II, 1 ♂ J, 17 ♀, and 6 ♀ J, suggesting that the population consisted mostly of adults (86%), although several individuals less than 20 mm long were observed on two occasions in January 1970. Males ranged in total length from 27 to 58 mm and females from 20 to 61 mm, with individuals of each sex evenly distributed over its size range.

Temperature: Only slight variations in temperature within the cave occurred during the study. Observed extremes for water temperature were 11.1 and 13.1°C, and 11.7 and 13.2°C for air temperature.

Numbers (or population size): of the 49 crayfishes (*O. i. testii*) tagged and released, 23 were recovered at least once, resulting in a 47% recovery rate. The greatest number of recaptures for any individual was four, and that for only one crayfish. Hobbs (1973a) reported the population in the cave to be 128 ± 33 (95% C.L.) in the 300 m study area. Further analysis of data and use of the Schumacher-Eschmeyer Index (Schumacher and Eschmeyer, 1943) yielded the more accurate figure of 66 ± 8.9 (95% C.L.), or two crayfish per 10 m of stream passage.

Movements: Natural movements of 23 individuals of *O. i. testii* are given in Table 1. All individuals recaptured at least once are included. Some of the apparently short distances recorded (0.3 and 0.6 m) occurred 60 and 56 days, respectively, between recaptures. This does not imply that these individuals did not move greater distances. Some of the greater movements recorded (35 and 42 m) also occurred over short periods of time (1 and 20 days, respectively). The minimum and maximum distances that individuals moved from the point of marking lie between 0 and 42 m. Although, no crayfish were recorded as moving 0 meters, some individuals were subsequently observed in the same location within a small area of stream passage.

The time elapsed between markings and recaptures varied considerably (Fig. 3), and this and the distances traveled on any one occasion impose constraints on interpreting these data. Consequently, the range of distances moved between recaptures, regardless of direction, was divided into quartiles: 0–10.5 m (Quartile 1 = Q_1), 10.5–21.0 m (Q_2), 21.0–32.3 m (Q_3), and 32.3–42.0 m (Q_4). For *O. i. testii*, 80.4% of the total movements

$$\left(\frac{\text{\# of movements within 0 - 10.5 m between recaptures} - Q_1}{\text{Total \# of movements}} \right)$$

fell within Q_1 , 7.8% in Q_2 , 2.0% in Q_3 , and 9.8% in Q_4 . The large percentage of Q_1 movements suggests that individuals of this species tend to restrict their

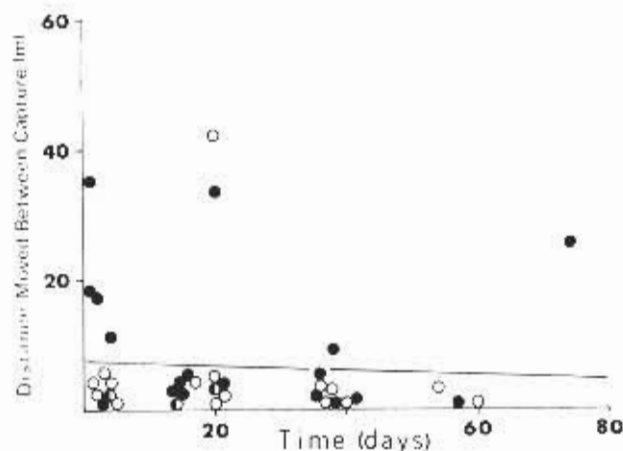


Fig. 3. Plot of distances moved by *O. i. testii* as a function of time (days). Open circle = ♀, closed circle = ♂I, half-filled circle = ♂II.

activity to a specific area, probably somewhere between 0 and 10.5 m (Fig. 4, 5).

For *O. i. testii*, 74% of the individuals

$$\left(\frac{\# \text{ of individuals moved } 0 - 10.5 \text{ m total range of movements}}{\text{Total } \# \text{ of individuals}} \right)$$

moved no more than 10.5 m away from their original marking site, 8.7% moved 10.5 to 21.0 m, 4.4% moved from 21.0 to 32.2 m, and 13.0% moved from 32.3 to 42.0 m. The percentages are based on the total range of movements (distance traveled between maximum upstream and downstream positions).

Upstream movements seem to dominate over downstream in *O. i. testii* (mainly Form I males) in this cave (Table I, Fig. 6). Fifteen individuals (65%) moved upstream and 8 (35%) downstream, based on their final position relative to the location where marked.

The movements of two crayfishes are noteworthy. Individual 3E of *O. i. testii* (a Form I male) moved upstream 35.4 m in a 24-hour period. This compares with an individual of *O. juvenilis* (Hagen) reported by Merkle (1967) that moved at least 95.6 m in 48 hours. Individual 6A of *O. i. testii* (also a Form I male) was recovered 4 January at station 6. Two days later it was found at station 5, 17.1 m upstream. To get here it had to travel at least 8.9 m out of the water over gravel and stone, as the stream was at low level and pools 5 and 6 were not connected. Additional data concerning the biology of this species may be found in Hobbs (1972, 1975a, b).

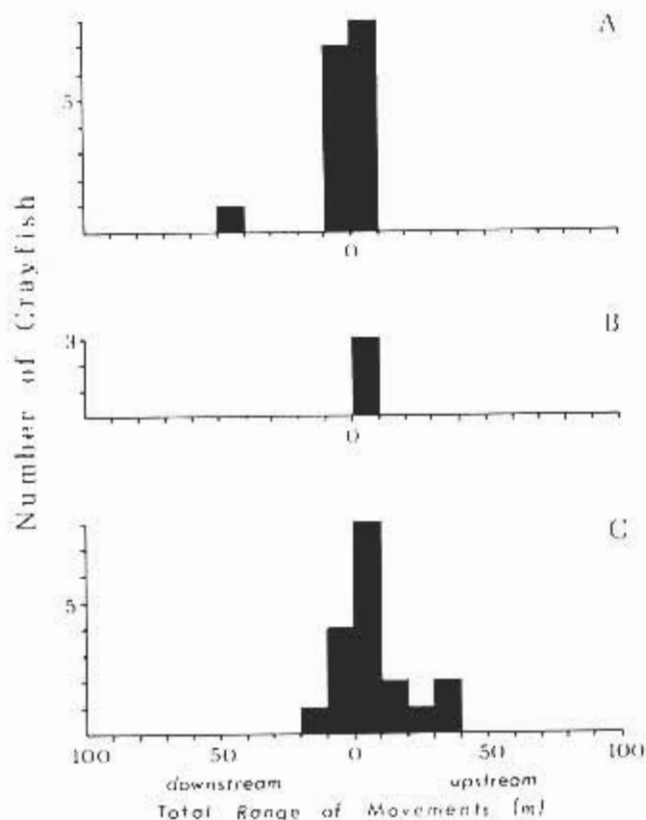


Fig. 4. Histogram of distances and directions moved by tagged *O. i. testii* between captures. A. females; B. Form II males; C. Form I males.

DISCUSSION AND CONCLUSIONS

During the seven-month study period the subterranean water and air temperatures were very stable, varying only a maximum of 2.5 and 2.6°C, respectively. Variations as small as these are common in caves. The noticeable drop in water temperature during the month of March is attributed to snow and ice melt.

Twenty-three marked *O. i. testii* crayfish were recovered at least once for a 47% recapture rate. This percentage is relatively high when compared with most other studies: Camougis and Hichar (1959) reported only 12.5% recovery, Black (1963) 17.5%, Momot (1966) about 25%, and Mobberly and Pfirmer (1967) better than 19% recovery for both males and females. Merkle

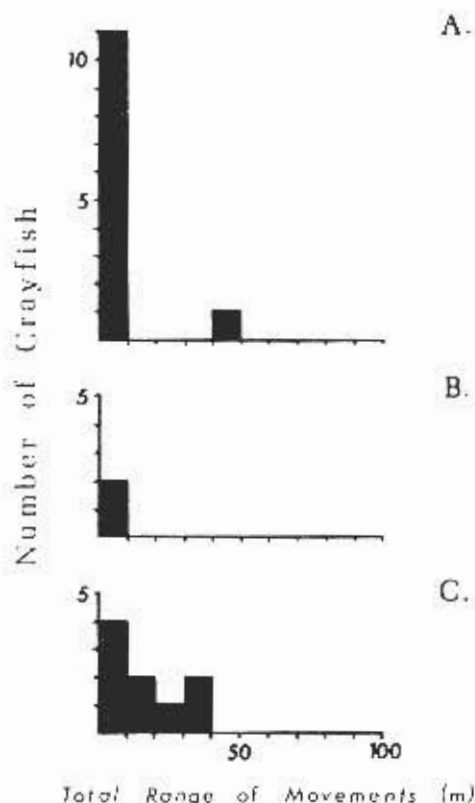


Fig. 5. Histogram of the total range of movements (distance between farthest upstream and downstream positions) of tagged *O. i. testii*. A. females, B. Form II males, C. Form I males.

(1967), however, reported 47.1% total recovery in her study of *Orconectes juvenilis*. An estimate of *O. i. testii* population size in the 300 m study area was determined to be 66 ± 8.9 (95% C.L.). The size of the specimens indicates that the population was comprised primarily of adults.

Since 74% of *O. i. testii* moved no more than 10.5 m away (total upstream and downstream distance) from the tagging site, this species apparently tends to restrict its activities to a specific area (home range) of up to 10.5 m. Form I males traveled greater distances than did Form II, possibly in search of mates. Adult females showed less movement than juveniles, and males appeared to move greater distances than females, means of 12.9 and 5.9 m, respectively. Upstream movements were predominate (mainly Form I males), indicating a possible restocking mechanism following floods. These

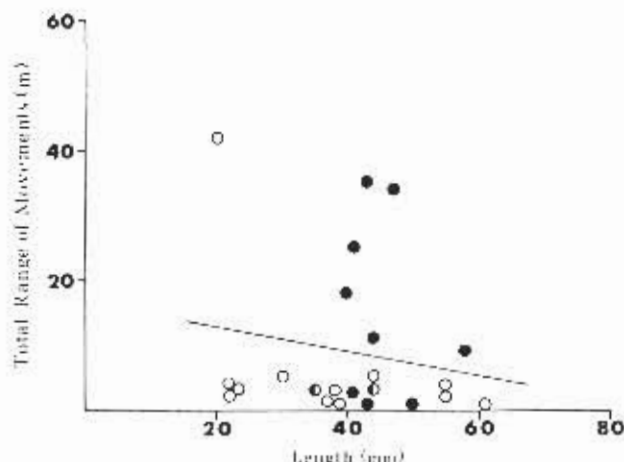


Fig. 6. Plot of total range of movements (m) of *O. i. testii* as a function of total length (mm). Open circle = ♀, closed circle = ♂I, half-filled circle = ♂II.

data partially support those of Minckley (1964), Momot (1966), and Elliott (1971) that certain aquatic invertebrates exhibit extensive upstream movement, although not necessarily as a compensatory movement for downstream displacement following floods. Although some flooding occurred during the study period (rains did affect and increase the volume of flow through the stream passage), no major spates took place. No evidence from this study supports the proposal of Momot (1966) and Waters (1961) that flooding results primarily in downstream displacement. This undoubtedly occurs to some degree during heavy flow. It is difficult to postulate reasons for the net upstream movements without some data concerning the environment (i.e., food availability and fluctuation, water chemistry, flooding) and further information on the animals (e.g., reproductive cycles).

If total range of movements is compared with size, it is apparent that smaller crayfish have a larger "home range" than do adults (Fig. 6). However, the size of this range for *O. i. testii* in Mayfield's Cave is not related to animal size, *per se*, but does seem to be related to sex and stage of reproduction. Using the values of total range of movements upstream and downstream (Fig. 5), it is clear that Form I males are more active and travel greater distances than do Form II males (means 15.1 and 3.0 m total range of movements, respectively), and also seem to move upstream more than downstream. Form I males are in breeding state and probably travel greater distances in search of mates than do Form II males. The latter most likely move in search for food, during intraspecific interactions, or to escape predation. Comparing the movements of all males and females, those of males (12.9 m)

are greater than those of females (5.9 m). The distances traveled are not directly dependent on the time elapsed, and hence time was not an important factor (Fig. 3).

RÉSUMÉ

Certains aspects de la biologie de l'écrevisse cavernicole *Orconectes inermis testii* (Hay) ont été étudiés par la méthode de marquage et de recapture, entre décembre 1969 et mars 1970, à la grotte de Mayfield, Comté de Monroe, Indiana. L'effectif de la population a été estimé à 66 ± 9 (probabilité de 95%), pour les 300 mètres du cours d'eau étudié, mais par suite du faible nombre d'individus échantillonnés, cet effectif est sans doute sous-estimé. La taille des animaux, exprimée par leur longueur totale, indique que la population est composée essentiellement d'adultes. Soixante quatorze pour cent des écrevisses marquées ne se sont pas déplacées au delà de 10,5 mètres (total des distances vers l'amont et vers l'aval) à partir du site de marquage. Ainsi, cette espèce semble limiter ses activités à une aire restreinte ("home range") qui ne dépasse pas une longueur de 10,5 mètres du cours de la rivière. Les mâles de la forme I se déplacent à de plus grandes distances que ceux de la forme II (respectivement 15,1 et 3,0 mètres), vraisemblablement en quête d'accouplement. Les femelles adultes se déplacent moins que les juvéniles, tandis que les mâles semblent se déplacer plus loin que les femelles (moyennes respectives de 12,9 et 5,9 mètres). Des déplacements vers l'amont furent observés plus fréquemment que vers l'aval, indiquant la possibilité d'existence d'un mécanisme de repeuplement compensant les dérives dues aux crues. Les distances de déplacement n'ont paru fonction, ni de la taille des individus, ni du temps écoulé.

LITERATURE

- BANTA, A.M. 1907. The fauna of Mayfield's Cave, Carnegie Inst. Wash. Publ. 67:1-114.
- BLACK, J.E. 1963. Observations on the home range of stream-dwelling crayfishes. *Ecology* 44:592-595.
- CAMOUGIS, G., and J.K. HICHAIR 1959. Some stues on crayfish distribution in a small pond, *Am. Midl. Nat.* 62:227-231.
- ELLIOTT, J.M. 1971. Upstream movements of benthic invertebrates in a Lake District stream. *J. Anim. Ecol.* 40:235-252.
- HAY, W.P. 1891. Two new subterranean crustaceans from the United States, *Proc. Biol. Soc. Washington* 14:179-180.
- HOBBS, H.H., Jr., H.H. HOBBS III, and M.A. Daniel. 1977. A review of the troglobitic decapod crustaceans of the Americas, *Smithson. Contrib. Zool.* 244:1-183.
- HOBBS, H.H., III, 1972. The distribution and population dynamics of the cave crayfishes of southern Indiana. 14th Annu. Rep. Cave Res. Found. 37-41.
- HOBBS, H.H., III, 1973a. Movement and ecology of troglobitic crayfishes from southern Indiana caves. *NSS '73 Prog. (30th Ann. Conv.)*, 16-17.
- HOBBS, H.H., III, 1973b. The population dynamics of cave crayfishes and their commensal ostracods from southern Indiana. Ph. D. Dissertation, Department of Zoology, Indiana University, Bloomington.
- HOBBS, H.H., III, 1975a. Observations on the cave-dwelling crayfishes of Indiana. *Proc. 2nd Int. Crayfish Symp., Louisiana State Univ.*, 405-414.
- HOBBS, H.H., III, 1975b. Distribution of Indiana cavernicolous crayfishes and their ectocommensal ostracods. *Int. J. Speleol.* 7:273-302.
- HOBBS, H.H., III, 1981. Studies of the cave crayfish, *Orconectes inermis inermis* Cope (Decapoda, Cambaridae). Part IV: Mark-recapture procedures for estimating population size and movements of individuals. *Int. J. Speleol.* 10:303-322.
- MERKLE, E.L. 1967. The home range and homing ability of the crayfish *Orconectes juvenalis* in a permanent Kentucky stream. M.S. Thesis, Univ. Kentucky, Lexington.
- MINCKLEY, W.L. 1964. Upstream movements of *Gammarus* (Amphipoda) in Doe Run, Meade County, Kentucky. *Ecology* 45:195-197.

- MOBBERLY, W.C., Jr., and R. PFRIMMER. 1967. Distribution of crayfish in a roadside ditch. *Am. Midl. Nat.* 70:82-88.
- MOMOT, W.T. 1966. Upstream movement of crayfish in an intermittent Oklahoma stream. *Am. Midl. Nat.* 75:150-159.
- PACKARD, A.S. 1888. The cave fauna of North America with remarks on the anatomy of the brain and origin of the blind species. *Mem. Nat. Acad. Sci.* 4:1-156.
- SCHUMACHER, F.X., and R.W. ESCHMEYER. 1943. The estimation of fish population in lakes or ponds. *J. Tenn. Acad. Sci.* 18:228-249.
- WATERS, T. 1961. Standing crop and drift of stream bottom organism. *Ecology* 42:532-537.