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TAGGING AND MARKING CRAWFISH *(Procambarus clarkii)* IN A POPULATION ESTIMATION STUDY

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ABSTRACT

Crawfish *(Procambarus clarkii)* were tagged with enumerated plastic streamers and released in 0.1-ha ponds to observe recapture frequency in stand-up traps. Also, crawfish were marked by a uropod punch, released and recaptured in 0.1-ha ponds for population estimation.

Survival of streamer-tagged crawfish in indoor tanks averaged 46.7% after 25 days, indicating that tagging caused stress leading to mortality, especially during molt. Recapture frequencies of tagged crawfish indicated sampling bias which obviated use of the tagging method in population assessments.

Short term (3-day) survival of marked crawfish (92%) and retention of the mark after molt indicated potential application in population assessment studies. Population estimates in two ponds were calculated using two methods: mark-recapture data and quadrant sampling. For both methods, crawfish were collected by seining. Population estimates using quadrant sampling averaged 25% lower than those using mark-recapture data. This discrepancy may have been due to escape during seining, which would lead to population under-estimation with quadrant sampling.

INTRODUCTION

Crawfish population assessments can be used as a management tool to indicate relative abundance, total biomass, growth rates, and other crawfish production parameters in various systems. Accurate population estimates allow the crawfish producer to approximate future harvesting times and yields, food input and other management requirements. Population estimationwith certain crawfish species can be accomplished in deep, clear waters by visual observations (Capelli, 1975); population assessments in clear, shallow streams can be conducted using electro-fishing (Hopkins, 1967). In the southeastern United States, however, most crawfish *(Procambarus spp.)* culture occurs in open, shallow ponds in which some type of vegetation is available for crawfish forage. Under these conditions, small crawfish (<5 cm) are typically sampled by dipnet to obtain data on their relative abundance, and larger crawfish are commonly captured in traps (Huner, 1978).

In several studies, larger crawfish have been individually marked by clipping or excision of non-vital appendages (Hopkins, 1967; Romaire, 1974; Momot and Gowing, 1977). However, analysis of population assessment data for coolwater crawfish *(Orconectes spp.)* indicates that trapping may be biased, selecting for crawfish based on size, sex and breeding state, rather than reflecting true population densities (Capelli and Magnuson, 1975; Malley and Reynolds, 1979). In addition, trapping studies have shown that certain animals become "trap-shy" or "trap-happy", thereby biasing population estimates from recapture frequencies (Eberhardt, 1969).

Additional population assessment research will help provide valuable management and research methods in estimating crawfish populations in warmwater ponds. The dual purpose of this study was 1) to observe the recapture frequency of tagged crawfish *(P. clarkii)* in baited traps, using enumerated streamer tags to estimate populations and 2) to compare population estimates obtained with mark-recapture data and quadrant sampling data in two crawfish ponds, using crawfish collected by seine sampling.

METHODS AND MATERIALS

In May and June of 1984, plastic streamer Floy (Floy Tag and Manufacturing, Inc., Seattle, WA) shrimp tags, individually enumerated, were inserted in crawfish *(P. clarkii)* in a tag retention and recapture frequency study. Crawfish were collected from several ponds by seining with a 4.6-m net with 4-mm mesh. The seine was weighted at the lead line with a heavy chain to prevent the lead line from floating over the submerged rice stubble in each pond. Crawfish that were >80 mm total length, retained all appendages and demonstrated normal activity levels were selected for tagging. The 80 mm criteria was selected based on Huner's (1978) observation that crawfish of that size were fully vulnerable to trapping using 1.9-cm mesh traps.

Streamer tags were inserted in the crawfish according to the manufacturer's suggestions for use in shrimp. Each streamer was inserted into anterior abdominal muscle until equal portions of the streamer extended from each side of the abdominal segment. All tagged crawfish were observed for injury trauma for five minutes prior to use in the studies. Streamer tags were brown in color to approximate the exoskeleton color, thus reducing tagged crawfish losses due to predation. The tags have a sharply indented middle portion to reduce slippage of the tag through entry or exit holes. This method of tag insertion in shrimp has resulted in tag retention exceeding 1000 km of shrimp travel in open ocean conditions (Floy Tag and Manufacturing, Inc., personal communication).

In the indoor tag retention study, 30 crawfish were tagged and then held in indoor tanks for 25 days to observe retention and survival rates. These rates were factors of consideration during assessment of recapture frequencies in ponds.

In the (1984) pond study of recapture frequencies, forty (40) tagged crawfish were randomly dispersed in each of three 0.1-ha ponds. During the next 32 days, crawfish harvested from 1.9-cm (0.75-in) mesh double-funnel standup traps in each pond were closely observed for the presence of streamer tags. Tag numbers were recorded and all captured, tagged crawfish were returned immediately to their respective ponds and randomly dispersed. Untagged crawfish were not returned, using the assumption that recruitment approximated loss from capture. Six traps per pond (60 traps/ha) were harvested daily, with approximate 24-hour sets.

In the 1985 crawfish marking study, crawfish were randomly collected from two 0.1-ha ponds by the seining method described for 1984. On May 10 crawfish were marked by punching a hole (approximately 6-mm in diameter) with a paper punch in a uropod of each animal. As naturally-occurring injuries on uropods may occasionally be mistaken for clip marks, or the clip marks may not be observed (personal observation), the punch hole is advantageous in leaving a distinctive mark that is easily made. Wilder (1953) found that similar marks in lobsters were still recognizable after two molts, thus suggesting that punch marks

Tagging and Marking Crawfish *(Procambarus clarkii)* in a Population Estimation Study

would be sufficiently durable for short-term studies in crawfish. Minimum total length of crawfish marked was arbitrarily chosen at 70 mm as smaller crawfish often did not have uropods of sufficient area to leave an intact punch hole. The overall physical condition of crawfish selected for marking was identical to that of crawfish in the 1984 tagging study.

An indoor survival study was conducted to observe possible acute injury effects on crawfish marked by punch holes over a 72-hour period. Survival at 24 and 48 hours was not recorded so as not to disturb the marked crawfish. The post-marking observation period (3 days) was shorter than the post-tagging observation period (25 days), as the mark (in contrast to the tag) was regarded as relatively permanent and occurred on a non-vital appendage.

In the 1985 marking study in ponds, crawfish were collected by seining, marked and released by random dispersal into two 0.1-ha ponds on May 10 (Day 0). Seine samples were taken in each pond on May 13, 16 and 20 (Day 3, 6, and 10, respectively). These intervals were arbitrarily selected to allow marked crawfish to disperse themselves with the ponds. Each seine sample consisted of three seine sweeps, 27.9 m² (300 ft²) per sweep, at random quadrants in each pond. During sampling, crawfish with marks were recorded, and all other healthy crawfish larger than 70 mm were marked in a similar fashion. All crawfish were immediately and randomly dispersed in their respective ponds. Pond population assessments were calculated by two methods: 1) total counts on quadrant plots (Seber, 1973) and 2) analysis of marked crawfish recaptures, using the Peterson Weighted Mean estimate (Begon, 1979). The latter estimate, to reduce effects of recruitment and mortality, assumes that all individuals have an equal chance of capture, that marking has no effect on capture or death and that sampling periods are short in relation to total time (Begon, 1979).

Table 1. Survival of Crawfish Tagged with Plastic Streamers (N = 30 per treatment)

	Tagged		Non-Tagged (Control)	
Day	No. Alive	Survival (%)	No. Alive	Survival (%)
0	30	100	30	100
1	29	96.7	30	100
2	29	96.7	29	96.7
3	29	96.7	29	96.7
7	28	93.3	27	90.0
14	25	83.3	26	86.7
21	21	70.0	25	83.3
25[1]	14	46.7	22	73.3

[1]Many Crawfish experienced a molt during Day 24.

RESULTS

1984 Tagging Study

Indoor Survival and Tag Retention — The results of the indoor tagging survival study are listed in Table 1. Survival of tagged crawfish over a 25-day period was 46.7%, compared to 73.3% survival of non-tagged (control) crawfish under similar conditions. One-third (7/21 = 33%) of the tagged crawfish that survived to Day 21 died prior to Day 25. A simultaneous molt by many crawfish on Day 24 appeared to cause most of the mortalities, as most dead tagged crawfish on Day 25 were found to be in the process of molting. Four of the 14 tagged crawfish alive on Day 25 were soft-shelled, indicating that streamer tagging can be relatively permanent and not necessarily lethal for crawfish. However, the stress of molting, perhaps combined with indoor conditions and streamer tagging, can lead to a high incidence of mortality. The only tag losses observed in the indoor study were from dead crawfish.

Recapture Frequency — The numbers of tagged (as well as untagged) crawfish that were captured (trapped) tended to increase with time between early May and June (Fig. 1), perhaps reflecting increased crawfish activity with increasing pond water temperatures. In Pond No. 32, most captured, tagged crawfish (39/69 = 57%) were trapped more than once (from Table 2 and Figure 1), indicating little or no negative effect of capture on trap re-entry in that pond. More tagged individuals

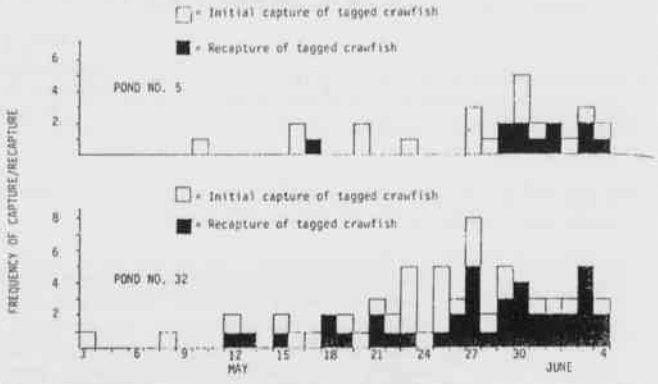

Figure 1. Capture/recapture frequencies of tagged crawfish in two 0.1-ha ponds, using traps.

Table 2. Capture frequency of Tagged Crawfish in Traps During May 3-June 4, 1984

Pond No.	Total no. of trapped crawfish (tagged and untagged	Total no. of tagged crawfish trapped	No. of tagged individual crawfish trapped at least once	No. of tagged individual crawfish never trapped
3	1090	13	12	28
5	3621	28	17	23
32	2538	69	30	10
Totals	7249	110	59	61

entered traps in Pond No. 32 than in Pond No. 3 and 5 combined (30 vs 29), although total numbers of (tagged and untagged) crawfish captured during the study do not reflect a similar disparity among the ponds (Table 2). However, most tagged crawfish (61/120 = 51%) initially released into the three ponds were never observed to be recaptured.

1985 Marketing Study

Indoor Survival and Mark Retention — The survival of crawfish marked with punch holes, under indoor conditions, averaged 92% over 72 hours (data not included). This percentage compared favorably with non-marked (control) crawfish, which averaged 86% survival under similar conditions. Marked crawfish that had molted retained the mark. Marking appeared to have no adverse effect on crawfish survival during molt.

Population assessments — The pond area sampled by the three seine sweeps in each sample was 83.6 m² (900 ft²). As the total water area of each pond is 1067 m², 7.84% of the total pond area was swept during each sample period. Calculations based on the percentage of pond area seined should yield an under-estimate of total crawfish numbers (>70 mm) in each pond, since this method assumes 100% capture in the seined area, and a certain percentage of crawfish will escape seining in burrows or depressions. Using total counts on quadrant

Table 3. Crawfish Population Estimates Utilizing Seine Sampling Area[1] in Two 0.1-Ha Ponds

	Pond No. 3		Pond No. 4	
Sampling Period	No. of seined crawfish	Pond population estimate	No. of seined crawfish	Pond population estimate
Day 0	119	1518	105	1339
Day 3	131	1671	65	829
Day 6	105	1339	68	867
Day 10	132	1684	82	1046
Average	121.8	1553	80	1020

[1]In each case, seine sample area = 83.6 m², = 7.84% of total pond area.

plots, based on the four seine samples in each pond, average population estimates (crawfish >70 mm) are 1553 for Pone No. 3 (C.V. = 8.7%) and 1020 for Pond No. 4 (C.V. = 10.7%) (Table 3).

The numbers of previously-marked ('old marks') and newly-marked crawfish in these ponds during these four seine sample periods are listed in Table 4. The Peterson Weighted Mean estimate of the crawfish population in Pond No. 3 is 1756 (C.V. = 15.3%), while the population estimate in Pond No. 4 is 1687 (C.V. = 21.2%). No significant differences (P = 0.05) exist between pond population estimates derived from the quadrant-plot and mark-recapture methods.

Table 4. Seine Captures of Marked and Unmarked Crawfish in Two 0.1-Ha Ponds

Mark Type [1]	Day	Pond No. 3		Pond No. 4	
New Marks	0	119		105	
Old Marks	3		9		5
New Marks	3	122		60	
Old Marks	6		20		7
New Marks	6	85		61	
Old Marks	10		15		11
Non-Marked	10	117		71	
Total old marks			44		23
Total new marks		443		297	

[1] 'New marks' and 'Non-Marked' signify previously uncaptured and unmarked crawfish.
'Old marks' signify recaptured marked crawfish.

DISCUSSION

The frequency of recapture of streamer-tagged crawfish in this study indicated that one or more basic assumptions required in the capture-recapture method of population assessment (Begon, 1979) may not have been met: 1) taggs may have been lost during the study, 2) all individuals may not have had an equal chance of capture or 3) all individuals, whether tagged or not, may not have had an equal chance of dying. The indoor tagging survival experiment demonstrated that less than half of tagged crawfish survived to Day 25 under tank conditions, and that molting affected tagged crawfish survival. A high mortality rate was also observed for tagged brown shrimp in indoor tanks (Howe and Hoyt, 1982). Survival of tagged crawfish in ponds may be different from that in confined tanks. However, the increased movement of crawfish in ponds may also affect tag retention; for example, in open-water release of 27,324 tagged shrimp in Texas, only one tagged shrimp was recovered after one year, but 839 tags were found washed ashore within 10 days of release (Cody and Avent, 1980). The fact that 51% of tagged crawfish released into the three study ponds were never recognized as being caught, while 57% of captured tagged crawfish in Pond No. 32 wre trapped more than once, also indicates that at least one of the three required assumptions in capture-recapture studies was not met. The tagged crawfish were perhaps differentially affected by mortality, were more trap-shy or trap-happy than crawfish not previously trapped, and/or tag loss occurred. Therefore, the tags were not considered suitable for population estimation studies, and no population assessments were conducted using data from the tagging study.

In conducting the marking (punch hole) study in ponds, there was no apparent violation of the assumptions required in mark-recapture; the mark was relatively permanent, did not appear to affect mortality, and animals were captured by random seining of quadrants rather than by trapping. Seber (1973) indicates that, in density estimates for closed populations using total counts on sample plots, 5-10% of the population area should be sampled. In this study 7.8% of the pond area was seined during each sample period, and the 10-day duration of the study appears adequately short to assume closed populations in the ponds.

Combined population estimates (for crawfish >70 mm) using quadrant sampling, of 1553 (Pond No. 3) and 1020 crawfish (Pond No. 4), average 25% lower than those obtained using the Peterson Weighted Mean estimate (1756 and 1687 crawfish, respectively). This discrepancy may be at least partially explained by crawfish escaping from the seine. However, few crawfish were seen to escape to the side of the net during seining (the water was clear), and in each case the seine sweep was terminated at the pond bank, reducing loss by escape. Other crawfish may have escaped in burrows or depressions, the net having passed over them. Such loss of crawfish would decrease population estimates using quadrant sampling, but would not affect mark-recapture population estimates (assuming the mark does not affect the ability of crawfish to escape seining).

Based on these preliminary studies, the mark-recapture approach, utilizing a punch-hole mark, appears to be a fairly easy tool to approximate crawfish populations, at least in small ponds. The mark can be varied by using different uropods, allowing for a variety of assessment estimates. Based on research information to date, seining may have less inherent bias than trapping in assessing populations of larger crawfish. Streamer tags, as used in this study, do not appear to meet population assessment requirements, are more expensive and difficult to use, and therefore are not recommended for assessing crawfish populations in ponds.

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