WALKER, C. F. 1946. The amphibians of Ohio. Part I. The frogs and toads. Ohio State Mus. Sci. Bull. 1(3):1-109.

WELLS, K. D. 1977a. The social behaviour of anuran amphibians. Anim. Behav. 25:666-693.

———. 1977b. Territoriality and male mating success in the green frog *(Rana clamitans)*. Ecology 58:750-762.

Accepted: 21 August 1984.

Journal of Herpetology, Vol. 19, No. 3, pp. 436-438, 1985

Dispersal Patterns of Translocated *Cryptobranchus alleganiensis* in a Maryland Stream

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Cryptobranchus alleganiensis is generally declining throughout its range and is listed as endangered in Maryland (Williams et al., 1981b; Gates et al., 1984). Cultural stream habitat alteration, including artificial impoundments and excess sediment loading, is apparently a primary cause for the reduced range. Williams et al. (1981b) suggested that C. *alleganiensis* might be reintroduced to restored stream habitat where it was formerly extirpated. To assess the probability of success of reintroductions, we proposed monitoring dispersal patterns of radio-equipped individuals translocated from the Allegheny River drainage in Pennsylvania to a specific Maryland stream location.

The study was conducted in a 2.5 km section of Bear Creek, Garrett County, Maryland, located 7 km west of the intersection of Route 219 and Bear Creek Road. Bear Creek is a spring-fed stream, 5-8 m wide, that drains westward into the Youghiogheny River at Friendsville, Maryland. The study section ranges from white water riffles to small pools up to 2.0 m deep. This area was chosen because of suitable water quality and habitat (see Hillis and Bellis, 1971; Nickerson and Mays, 1973a).

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Adult *Cryptobranchus alleganiensis* were collected (see Williams et al., 1981a) on 1 July 1981 and on 18 May 1982 from French Creek, Allegheny River drainage, at the Hayfield Township line bridge, near the Abex Corporation on Route 19/Route 6, Crawford County, Pennsylvania. Individuals ranged from 280-385 mm snout-vent length (i = 338 ± 11 SE, N = 10) and from 445-820 gin weight (i = 701 ± 41 SE, N = 10). They were transported to a holding pen in Bear Creek at the Maryland Department of Natural Resources Fish Rearing Station and allowed to acclimate to the local stream conditions for 7-28 days prior to surgical implantation of transmitters (Stouffer et al., 1983). Five animals were implanted with radiotransmitters in each year and marked with floy T-tags. They were then placed in the holding pen for 3-23 days of post-operative observation before being released at the study site. Five were monitored from August through mid-December 1981 and the remaining five from June through September 1982. All individuals were located with hand-held Yagi beam and/or "ping-pong" paddle loop antennas. Individuals were identified by the use of different frequencies (150-151 MHz) and pulse rates.

Dispersal during both study periods was predominantly downstream, but appeared more rapid in 1981 than in 1982, suggesting a possible seasonal aspect to dispersal (Fig. 1). The distances moved by our individuals ranged from 0-2340 m (f= 1026 ± 289 SE, N = 10). One C. *alleganiensis* did move downstream 460.8 m, and then proceeded upstream for 146.4 m. Another did not leave the area of release throughout the entire monitoring period. The greatest and most rapid unidirectional movements occurred during periods of high stream discharge associated with storms. However, a high discharge rate did not necessarily result in movement (Fig. 1).

Most translocated C. *alleganiensis* did eventually establish home ranges around one or more rock dens. Flat rocks 56-109 cm in diameter seem to be required as dens (Hillis and Bellis, 1971). Hillis and Bellis (1971) noted that the dispersion pattern of C. *alleganiensis* was associated with the distribution of large, flat rocks and swift, shallow water. Bishop (1941) stated that C. *alleganiensis* is most abundant in sections of the stream where the current is swift and the water is 61 cm deep and where large slabs of rock, sunken logs, or boards are present. The abundance of den sites is known to influence C. *alleganiensis* density (Nickerson and Mays, 1973a). Generally, only one individual is found at a den, indicating that these sites are defended (Smith, 1907; Hillis and Bellis, 1971; Nickerson and Mays, 1973a). Lack of suitable shelter was probably not a factor in dispersal, because several of our animals did move through areas that later were occupied by others.

Nickerson and Mays (1973a, b) observed that the greatest unidirectional movement in *Cryptobranchus a. bishopi* was 990 m over a 28-day interval. Another C. *a. bishopi* traveled 525 m down-

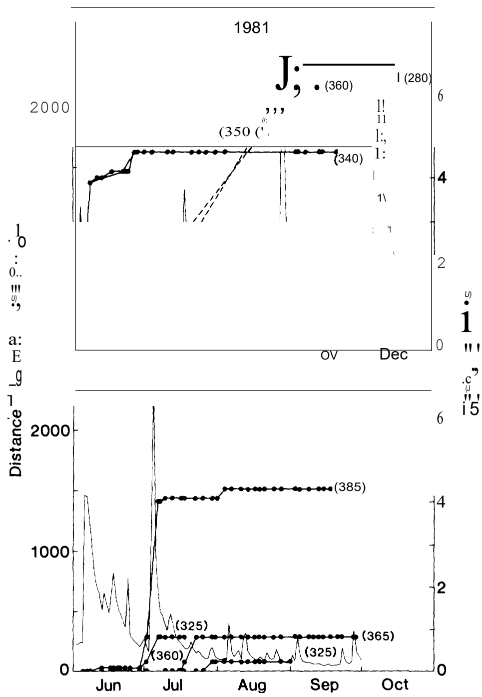

FIG. 1. The effect of stream discharge on dispersal in ten translocated C. *alleganiensis*. Dots connected by solid lines indicate movements over time, while dashed lines indicate time intervals during which radio contact was lost. Spikes in stream discharge rates resulted from storms. Snout-vent length (mm) of each individual is in parentheses.

stream and then 525 m upstream, a round trip distance of 1050 m, during a 48-day period from June to August. Although C. *alleganiensis* are quite capable of lengthy movements under normal circumstances, Nickerson and Mays (1973b) observed that most individuals (70%) were recaptured less than 30 m from the tagging site. Hillis and Bellis (1971) stated that once C. *alleganiensis* were released at their capture sites they rarely moved more than 10-20 m before seeking cover. We found no obvious differences in movement among individuals within our size range (Fig. 1). This agrees with the findings of Hillis and Bellis (1971).

Four of our translocated individuals plus the one that did not disperse were found within the 990 m maximum unidirectional dispersal distance recorded by Nickerson and Mays (1973b). In fact, these five individuals were all located in less than 315 m of stream habitat. Five other translocated individuals appeared to move considerably greater distances than that associated with normal movement patterns. However, several did remain close enough to one another so that the probability of encounters between the sexes would be relatively high. This result would be important during the late August mating season (Bishop, 1941).

If a reintroduction of a small number of individuals {:S30) is planned, we would recommend that translocated individuals from the same drainage be released during months with low stream discharge rates and prior to the mating season. An early spring release should minimize dispersal, thereby maximizing contact between the sexes, and provide sufficient time for individuals to secure suitable den sites for nesting. This approach should maximize recruitment and aid in establishing a stable population. If several small releases or a large release (> 30) is planned, dispersal may not be considered a problem. In fact, releases during periods of high stream discharge would help to spread individuals throughout the stream system, thereby more quickly establishing a stable population. Although dispersal tends to occur more quickly in late summer, possible related to mating activity (Bishop, 1941), we would recommend that releases not take place from August through November to avoid possible disruptions during the mating and incubation periods (Bishop, 1941).

Acknowledgments.-We thank C. Shiffer, G. J. Taylor, J. R. Lebo, and T. J. Welch for their support and help throughout the study. Personnel at the Bear Creek Fish Rearing Station allowed us to maintain hellbenders at the facility. F. P. Younger prepared the figure. Typing was done by K. A. Twigg and E. S. Kirk. Funds for this research were provided by the Maryland Forest, Park, and Wildlife Service, and the U.S. Fish and Wildlife Service through the Maryland Endangered Species Program. This is Scientific Series No. 1542-AEL, Center for Environmental and Estuarine Studies, University of Maryland.

LITERATURE CITED

BISHOP, S. C. 1941. The salamanders of New York. New York State Mus. Bull. 324:1-356.

GATES, J.E., C. H. HOCUTT, AND J. R. STAUFFER, JR. 1984. The status of the hellbender *(Cryptobranchus alleganiensis)* in Maryland. Proceedings of a symposium on threatened and endangered plants and animals of Maryland, September 3-4, 1981. Towson State Univ., Towson, Maryland.

HILLIS, R. E., AND E. D. BELLIS. 1971. Some aspects of the ecology of the hellbender, *Cryptobranchus alleganiensis alleganiensis,* in a Pennsylvania stream. J. Herpetol. 5:121-126.

NICKERSON, M. A., AND C. E. MAYS. 1973a. The hellbenders: North American "giant salamanders." Pub!. Biol. Geo!., Milw. Pub!. Mus. 1:1-106.

--. 1973b. A study of the Ozark hellbender *Cryptobranchus alleganiensis bishopi.* Ecology 54: 1164-1165.

SMITH, B. G. 1907. The life history and habits of *Cryptobranchus al/eganiensis.* Biol. Bull. 13:5-39.

STOUFFER, R. H., JR., J. E. GATES, C. H. HOCUTT, AND J. R. STAUFFER, JR. 1983. Surgical implantation of a transmitter package for radio-tracking endangered hellbenders. Wild!. Soc. Bull. 11:384-386.

WILLIAMS, R. D., J. E. GATES, AND C. H. HOCUTT. 1981a. An evaluation of known and potential sampling techniques for hellbender, *Cryptobranchus alleganiensis.* J. Herpetol. 15:23-27.

-- AND G. J. TAYLOR. 1981b. The hellbender: A nongame species in need of management. Wild!. Soc. Bull. 9:94-100.

Accepted: 29 June 1984.

LINKED CITATIONS

Dispersal Patterns of Translocated Cryptobranchus alleganiensis in a Maryland Stream
J. Edward Gates; Ronald H. Stouffer, Jr.; Jay R. Stauffer, Jr.; Charles H. Hocutt
Journal of Herpetology, Vol. 19, No. 3. (Sep., 1985), pp. 436-438.
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http://links.jstor.org/sici?sici=0022-1511%28198509%2919%3A3%3C436%3ADPOTCA%3E2.0.CO%3B2-Q

Literature Cited

Some Aspects of the Ecology of the Hellbender, Cryptobranchus alleganiensis alleganiensis, in a Pennsylvania Stream
Robert E. Hillis; Edward D. Bellis
Journal of Herpetology, Vol. 5, No. 3/4. (Dec. 15, 1971), pp. 121-126.
Stable URL:
http://links.jstor.org/sici?sici=0022-1511%2819711215%295%3A3%2F4%3C121%3ASAOTEO%3E2.0.CO%3B2-H

A Study of the Ozark Hellbender Cryptobranchus Alleganiensis Bishopi
Max A. Nickerson; Charles E. Mays
Ecology, Vol. 54, No. 5. (Sep., 1973), pp. 1164-1165.
Stable URL:
http://links.jstor.org/sici?sici=0012-9658%28197309%2954%3A5%3C1164%3AASOTOH%3E2.0.CO%3B2-R

An Evaluation of Known and Potential Sampling Techniques for Hellbender, Cryptobranchus alleganiensis
R. David Williams; J. Edward Gates; Charles H. Hocutt
Journal of Herpetology, Vol. 15, No. 1. (Mar. 15, 1981), pp. 23-27.
Stable URL:
http://links.jstor.org/sici?sici=0022-1511%2819810315%2915%3A1%3C23%3AAEOKAP%3E2.0.CO%3B2-Z