adjacent Canadian waters, in spite of the intensive commercial fishery in that area. It was the only specimen seen so that it is impossible to say now whether it is a stray or whether a small population has already been established in the Point Pelee area.

The shallow waters from western Lake Erie to Lake St. Clair have contributed most of the limited number of records of freshwater fishes that have moved north into Canadian waters over the past 25 yr. Catches in those waters should be carefully scrutinized and all unusual items reported.

The specimen has been added to the reference collection of the Royal Ontario Museum (ROM Cat. No. 34561).

We thank Rudy Krause for his care in recognizing that the fish was different, and for taking the trouble to turn it over to the Ontario Ministry of Natural Resources.

Literature Cited

Hubbs, C. L. and **K. F. Lagler.** 1964. Fishes of the Great Lakes Region. University of Michigan Press, Ann Arbor, Michigan. 213 pp.

Trautman, M. B. 1957. The fishes of Ohio. Ohio State University Press, Columbus, Ohio. 683 pp.

Received 2 October 1978
Accepted 4 December 1978

Earthworm Cocoons as a Drift Component in a Southern Ontario Stream

DONALD P. SCHWERT[1] and KENNETH W. DANCE[2]

[1]Geology Department, Stevens Hall, North Dakota State University, Fargo, North Dakota 58105
[2]Ecologistics Limited, 309 Lancaster Street West, Kitchener, Ontario N2H 4V4

Schwert, D. P. and K. W. Dance. 1979. Earthworm cocoons as a drift component in a southern Ontario stream. Canadian Field-Naturalist 93(2): 180–183.

Cocoons representing at least six species of Lumbricidae were isolated from drift subsamples of a stream in Waterloo County, Ontario in the wpring of 1976. Of the 308 cocoons, 92% were viable. We present arguments to support cocoon drift as a potentially important mechanism in lumbricid dispersal.

Key Words: cocoons, Lumbricidae, Oligochaeta, biological drift, dispersion, Ontario, geographical distribution.

In southern Ontario, as in many other regions of North America, large populations of lumbricid earthworms often occur in moist lowlands adjacent to streams and lakes. When temperature, moisture, and light conditions permit, a number of the lumbricid species in these areas are active on or just below the soil surface. Significant activity combined with surface runoff from rainstorms and snowmelt can result in large numbers of earthworms and their cocoons becoming trapped in waterways. Their subsequent downstream drift might be expected to be a significant factor in lumbricid dispersal, but this mechanism has remained poorly studied. Bouché (1972) hypothesized that stream drift had an important influence on the distribution of some hygrophilic lumbricid species in France, and Ward (1976) applied a similar hypothesis to explain the recolonization of a riffle area by the lumbricid *Eiseniella tetraedra* in a Colorado stream. No published observations of the drift of lumbricid cocoons exist, however, probably because these might be easily confused with plant seeds during sorting.

During the latter 5 mo of a 13-mo stream drift study in southern Ontario (Dance and Hynes, *in press*), sorting of earthworm cocoons from freshly collected drift samples was initiated. We present here data on this component and suggest its possible significance with respect to lumbricid dispersal.

The Study Area

All of the examined cocoons were obtained from drift samples of two headwater branches of Canagagigue Creek in a predominantly agricultural region immediately north of Floradale in Waterloo County, Ontario (43°39′N, 80°35′W). Stations 1 and 2 were located on the permanent, spring-fed east branch of the creek. Stations 3 and 4 were located on the west branch, an intermittent stream which flowed continuously during the five months of this study. Station 1 was a gravelly riffle, in a treeless pasture 350 m downstream from a White Cedar (*Thuja occidentalis*) woods. Station 2 was a cobble and boulder riffle at the downstream margin of an extensive American Beech (*Fagus grandifolia*) and Sugar Maple (*Acer saccharum*) stand. Station 3 was at the downstream edge of a short, silty riffle in a treeless pasture. The streambank at Station 4 was lined with herbs and *Salix* spp., and the bed consisted of boulders and cobbles resting on silts.

Methods

Drift was subsampled continuously using a specially designed apparatus of 253 μm Nitrex cloth net mounted over an aluminum and steel frame (Dance et al., *in press*). Water flowed without wave interference through a vertical opening 1 cm wide and 100 cm high into a long sample bag. The contents of the trap were placed weekly into a plastic bag and frozen until sorting. Under a binocular microscope, cocoons were sorted from thawed samples which had been collected between February and June 1976 and placed into labelled vials of 70% ethanol.

Attempts at placing generic or specific names on the cocoons were inhibited by distortions in the cocoon shape resulting from the sample procedures and by the frequent absence of the diagnostic end "tufts" which had apparently broken off during the turbulence of drift. Names could, therefore, be placed on only a small number of the cocoons through comparison with a cocoon reference collection and with the cocoon descriptions in Evans and Guild (1947) and Gerard (1964).

Mean monthly discharge volumes during the study period for each of the sample stations were calculated from data on the creek provided by the Canada Water Survey and the School of Engineering at the University of Guelph. Utilizing this information and the calculated average component of the total discharge continuously subsampled by each trap (for detailed procedure, see Dance et al., *in press*), a multiplication factor was derived estimating the total monthly number of cocoons passing each sample point.

Results

A summary of the mean monthly discharge values for the four Canagagigue Creek sample stations is presented in Table 1. Discharge volumes fluctuated widely for each station during the study period but for all four were maximal in March and minimal in June.

Monthly summaries of the actual cocoon content of the drift samples and of the estimated total cocoons flowing past each station are presented in Table 2. Cocoons were absent from all February samples, but maximum numbers were recorded in March at the east branch stations and in April at the west branch stations; the west branch stations were inoperable during most of March because of flooding. Except for a sharp increase in June numbers at Station 2, the incidence of cocoons generally decreased into the early summer.

TABLE 1—Estimated mean 1976 monthly discharge (L/s) for four Canagagigue Creek drift sample sites (Waterloo County, Ontario)

	Station			
Month	1	2	3	4
Feb.	202	455	3174	3398
Mar.	901	1126	3066	6089
Apr.	271	410	394	446
May	151	275	220	298
June	148	241	47	87

TABLE 2—Summary of the 1976 monthly totals of earthworm cocoons per drift trap (and estimated total cocoons flowing past each sample station) for four Canagagigue Creek drift sample sites in Waterloo County, Ontario, and their percent viability

	Number of cocoons (estimated total) Station					
Month	1	2	3	4	Cocoon total	Numbers of viable cocoons (% of monthly total)
Feb.	0 (0)	0 (0)	0 (0)	0 (0)	0	— (—)
Mar.	52 (17 731)	42 (22 105)	Flood	Flood	94	88 (93.6)
Apr.	34 (5964)	33 (9167)	10 (1149)	52 (11 556)	129	110 (85.3)
May	22 (4000)	6 (1875)	1 (88)	8 (2963)	37	36 (97.3)
June	18 (3529)	29 (13 809)	0 (0)	1 (345)	48	48 (100.0)
Total					308	282 (91.8)

Nearly 92% of the cocoons were found to contain sperm and albumen, or some stage in the development of the embryonic mass, and these were termed "viable," or potentially capable of hatching.

All cocoons resembled in general form those of the Lumbricidae. A qualitative examination of the undistorted component yielded cocoons resembling the following taxa in the family: *Aporrectodea* spp., *Dendrodrilus rubidus*, *Eisenia fetida*, *Eiseniella tetraedra*, *Lumbricus terrestris*, *Octolasion teyrtaeum*.

We have collected adults of each of the above species from sites in Waterloo County, and all of the species have been recorded from southern Ontario by Reynolds (1977). One adult *Eisenia fetida* and one adult *Eiseniella tetraedra* were also collected from the drift samples.

Discussion

Fluctuations in the monthly totals of the observed cocoons undoubtedly reflect both the physical state of the environment and the cocoon production of the local fauna. The absence of cocoons from the February samples would be expected because of the frozen condition of the soil, but the March and April cocoon peaks are probably the result of both the high rate of surface runoff from snowmelt and rain and a high degree of surface activity and cocoon production by the earthworm fauna. The precise distances which any of the cocoons drifted to the trap sites remains unknown, although presumably none of the cocoons were derived from sources greater than 2–3 km upstream, the area of the upper Canagagigue watershed.

The small size (< 6 mm) and tough, spheroidal outer walls of lumbricid cocoons are ideally suited for long and rigorous transport in streams. Individuals of several lumbricid species have been shown to be capable of prolonged submersion (Roots 1956; Edwards and Lofty 1972), and the successful hatching and growth while submerged of the lumbricid *Allolobophora chlorotica* has been demonstrated by Roots (1956). From these studies and from the remarkably high viability of the drift cocoons of the present study, successful hatching of cocoons could be expected in areas of a stream where the cocoons had been deposited near the margin or in the bottom sediments of pools. A major consequence, therefore, would be the establishment of the transported species in lowland areas along the stream.

Because cocoons have subsequently been obtained from random drift samples in other streams of southern Ontario and of Newfoundland, the phenomenon of cocoon drift appears to be widespread. We have also collected large immature and adult Lumbricidae from other streams in Ontario, as well as in Newfoundland, New York, and Pennsylvania. Although these worms survived submergence in rigorous environments, the battered nature of many of the specimens indicates that these large, soft-bodied stages have difficulty in physically surviving prolonged transport. In addition, this stage is particularly susceptible to predation by fish; the palatability of cocoons to fish is unknown, but presumably low.

The successful drift of cocoons may be of considerable importance in explaining the modern distribution of many lumbricid species in North America. All of the species identified from Canagagigue Creek are of taxa hypothesized by Gates (1970) and Reynolds (1974) as having been introduced into North America from Europe. The widespread distribution of many of these species across Canada and the United States is attributed by Gates (1976) as being primarily due to transport by human activity. While man has undoubtedly influenced earthworm distribution, he cannot, as Ball (1975) argues, logically claim responsibility for the entire distribution of lumbricid earthworms across the continent. Transport of cocoons, however, from one point of intensive lumbricid establishment upstream to other points downstream could result in the subsequent colonization of the lower watershed by these species. Although further investigation is needed to support this mechanism, stream drift may be as important to the dispersal of earthworms as it is to many other groups of invertebrates.

Acknowledgments

We are grateful to those property owners near Floradale, Ontario, who granted us access to Canagagigue Creek for sampling. We also appreciate the useful suggestions of A. D. Harrison of the University of Waterloo regarding the manuscript. Funding for publication of this paper was provided by Ecologistics Limited and by North Dakota State University.

Literature Cited

Ball, I. R. 1975. Nature and formulation of biogeographical hypotheses. Systematic Zoology 24(4): 407–430.

Bouché, M. B. 1972. Lombriciens de France, écologie et systématique. Institut National de la Recherche Agronomique, Paris. 617 pp.

Dance, K. W. and **H. B. N. Hynes.** *In press.* A continuous study of the drift in adjacent intermittent and permanent streams. Archiv für Hydrobiologie.

Dance, K. W., H. B. N. Hynes, and **N. K. Kaushik.** *In press.* Seasonal drift of solid organic matter in two adjacent streams. Archiv für Hydrobiologie.

Edwards, C. A. and **J. R. Lofty.** 1972. Biology of earthworms. Chapman and Hall, Ltd., London. 283 pp.

Evans, A. C. and **W. J. McL. Guild.** 1947. Cocoons of some British Lumbricidae. Annals and Magazine of Natural History, Series 11, 14: 714–719.

Gates, G. E. 1970. Miscellanea megadrilogica VII. Megadrilogica 1(2): 1–14.

Gates, G. E. 1976. More on earthworm distribution in North America. Proceedings of the Biological Society of Washington 89(40): 467–476.

Gerard, B. M. 1964. Synopses of the British fauna. Number 6. Lumbricidae (Annelida) with keys and descriptions. Linnaean Society of London. 58 pp.

Reynolds, J. W. 1974. Are oligochaetes really hermaphroditic organisms? Biologist 56(2): 90–99.

Reynolds, J. W. 1977. The earthworms (Lumbricidae and Sparganophilidae) of Ontario. Life Sciences Miscellaneous Publications, Royal Ontario Museum. x + 141 pp.

Roots, B. I. 1956. The water relations of earthworms. II. Resistance to desiccation and immersion, and behaviour when submerged and when allowed a choice of environment. Journal of Experimental Biology 33: 29–44.

Ward, J. V. 1976. Lumbricid earthworm populations in a Colorado mountain stream. Southwestern Naturalist 21(1): 71–78.

Received 29 September 1978
Accepted 27 December 1978

Flowering Plant Phenology at Sheep Mountain, Southwest Yukon Territory

MANFRED HOEFS

Yukon Game Branch, P.O. Box 2703, Whitehorse, Yukon Territory Y1A 2C6

Hoefs, M. 1979. Flowering plant phenology at Sheep Mountain, southwest Yukon Territory. Canadian Field-Naturalist 93(2): 183–187.

The dates of initiation of flowering of 60 vascular plant species in the Kluane Lake area, Yukon Territory, are presented for the 1970, 1971, and 1972 seasons. The altitudinal advance of plant development is determined, using *Carex filifolia* as the indicator species.

Key Words: phenology, flowering plants, subarctic botany, *Carex filifolia*, Kluane Lake, Yukon Territory.

The data presented here are part of a larger investigation carried out on Dall Sheep (*Ovis dalli dalli*) and their range in the Kluane Lake area of the Yukon Territory since 1969. The specific study area is "Sheep Mountain," an important winter range of a Dall Sheep population located at the southeast shore of Kluane Lake near the mouth of the Slims River (61°00′N, 138°30′E). For details on the vegetation, climate, geology and soil of the area, the reader is referred to Hoefs et al. (1975) and for details on the sheep population, their range use patterns, and forage selection, to Hoefs (1975).

During this investigation it became clear that a number of activities of sheep, for instance forage selection, use of various plant communities, and vertical migration, were closely linked to plant phenological phenomena. A number of these were investigated.

My studies (Hoefs 1974) have demonstrated that the flowers of certain plant species are preferred forage items for Dall Sheep. This paper deals with the dates of initiation of flowering of 60 vascular plants on Sheep Mountain.

A number of factors have been used to explain the vertical seasonal movements of ungulates; these include snow conditions and other weather factors, avoidance of blood-sucking insects, protection of winter ranges, and advantages with respect to forage (Dixon 1938; Murie 1944; Blood 1963; Egorov 1967; Hebert 1972). Some indications of the vertical march of phenology can be obtained from the dates of first flowering of plant species at different altitudes. A more accurate quantification, however, is possible by observation of the performance of the same species of plant at various altitudes. This study determined altitudinal advance using *Carex filifolia* as the indicator species. *Carex filifolia* was selected because it is (*a*) a fairly abundant plant in all dry grassland associations in the boreal, subalpine, and alpine biogeoclimatic zones of the study area (Hoefs et al. 1975); (*b*) one of the most preferred Dall Sheep forage plants (Hoefs 1975); (*c*) an "early bird" in a phenological sense, flowering earlier and reaching the annual maximum of growth before any of the other important forage plants (Figure 1).

Methods

Sixty species of flowering plants, known to be used by sheep (Hoefs 1975), were mapped and marked by wooden stakes on Sheep Mountain in 1969. The dates