Drift of invertebrates in an intermittent stream draining marshy terrain of west-central Alberta

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Seven 24-h drift samples were taken with a plankton net (pore size: 76 μ) over a 1-year period from an intermittent stream that drains marshy, muskeg-type terrain of west-central Alberta, Canada. The drift was mainly composed of planktonic and benthic animals originating in the marsh. The only abundant lotic taxon in the drift was simuliid larvae. Rotifers and cyclopoid nauplii were numerically the most important taxa. Drift densities for the fauna as a whole tended to decrease as the ice-free season progressed, but there was no consistent correlation between drift densities and flow. However total daily drift across a point varied directly with flow. All the abundant taxa drifted more during the day than at night, and nematodes, harpacticoids, simuliid larvae, chironomid larvae, chydorids, and rotifers were found in significantly ($P < 0.05$) greater numbers in the daytime drift. Drift rates of taxa caught in the plankton net were compared with drift rates of the same taxa caught in a 320-μ drift net. Rotifers, entomostracans (especially the immature stages), and even small simuliid and chironomid larvae would have been seriously underestimated using only the 320-μ net. The marshy areas via drift through the intermittent tributaries contribute a very large number of small organisms to the main stream. Draining the wetlands might have a pronounced detrimental effect on the main stream's ecosystem.

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On a recueilli sept échantillons de dérive de 24 h, répartis sur une période de 1 an, au moyen d'un filet à plancton (ouverture de maille de 76 μ), dans un ruisseau temporaire drainant un terrain marécageux de type "muskeg" du centre-ouest de l'Alberta, Canada. Les échantillons comprennent surtout des organismes planctoniques et benthiques provenant du marécage. Les larves de simulies représentent le seul groupe lotique important. Les rotifères et les larves nauplii de cyclopoïdes sont les organismes les plus nombreux. La densité de la faune totale impliquée dans la dérive tend à diminuer graduellement après la fonte des glaces, mais il n'y a pas de corrélation directe entre la densité de la dérive et l'écoulement. Cependant, la dérive quotidienne totale en un point donné est directement proportionnelle à l'écoulement. Toutes les espèces abondantes dérivent plus le jour que la nuit; toutefois, le nombre de nématodes, d'harpacticoïdes, de larves de simulies, de larves de chironomides, de chydorides et de rotifères est significativement ($P < 0.05$) plus grand dans la dérive de jour. On a comparé l'intensité de la dérive des espèces capturées au filet à plancton avec celle des mêmes espèces capturées au moyen de filets à dérive à maille de 320 μ. En utilisant seulement le filet à maille de 320 μ, le nombre de rotifères, d'entomostracés (surtout les stades immatures) et même des petites larves de simulies et de chironomides se trouve grandement sous-estimé. Par la dérive dans les tributaires temporaires, les régions marécageuses fournissent un grand nombre de petits organismes au cours d'eau principal. L'assèchement des marais pourrait nuire à l'écosystème du cours d'eau principal.

Introduction

Poorly drained marshy, muskeg-type terrain is characteristic of much of the northern boreal forest. Permanent streams flowing through these marshy areas are fed by vast numbers of very small, usually intermittent, tributaries draining the extensive marshy regions. These tributaries usually consist of very short definitive channels connecting the lentic marshes to permanent streams. In west-central Alberta one such tributary has been under observation since 1966, mainly in respect to the movements of *Leptophlebia cupida* (Say) (Ephemeroptera) nymphs, which move into the tributary from a permanent, brown-water stream, the Bigoray River (53°24′ N, 115°07′ W). In 1970 a 1-year drift study of the main stream was initiated (see this issue), and this afforded an opportunity to study the drifting animals of the small tributary as well. This particular tributary was the only tributary in the study area where a drift study could be carried out. Most of the small streams draining the marshy terrain are very slow moving; there is not sufficient current to operate a drift net. But just before the tributary in question empties into the Bigoray River, it flows over a waterfall. A drift net was placed near the top of the fall catching all the water of the stream, the fall providing sufficient current for the drift net.

The goals of the tributary drift study were (1) to determine the magnitude and composition of the drifting animals entering the main stream over a 1-year period; (2) to detect possible diel periodicities in the drifting animals from this type of aquatic habitat; and (3) to compare the number of animals caught in a net having a pore size of 320-μ with numbers caught in a 76-μ net (a number 20 plankton net).

Description of the Study Area

The tributary drains a large marshy, muskeg-type (or bog) area of approximately 15 000 m². The floral association of this wetland is mainly *Carex*, *Equisetum*, and *Sphagnum*. In certain areas of the marsh, water might be a meter or more in depth during the ice-free season, but generally the water is no more than 30 cm in depth. The tributary proper has, from its confluence with the main stream to where it blends imperceptibly with the water of the marsh, a definitive lotic channel of about 50 m in length. Depending on the amount of rainfall, the tributary may or may not contain flowing water during the entire ice-free season, which extends usually from late April through October. In most years the tributary is completely dry by early September. During the drift study, the channel dried up in late August 1970. There is never water in the tributary during the winter; any water that might be in the stream when freeze-up occurs will eventually freeze into the substrate. Water could always be found in the marsh during the ice-free season, even when the tributary was dry. In winter, water of the marsh also freezes into the substrate in most areas. Except for flow and temperature, the general physical and chemical features of the tributary are similar to those of the Bigoray River (Clifford 1969). The water usually has a pH above 7; the color of the water is dark brown, and dissolved oxygen in the lotic channel and lentic marsh is always near saturation during the ice-free season. During the drift study, flow at the waterfall ranged from 0 in September 1970 to 10 liters/s during the high water of April 1971. After the spring break-up in late April, the water of the tributary proper and the main stream exhibit about the same mean daily temperatures, but the daily fluctuations are greater in the tributary. Usually by the middle of May, water temperatures are higher in the main stream than in the tributary, and they remain so for the rest of the ice-free season. For five sampling intervals between May 21 and August 19, 1970, the average daily water temperatures of the tributary and the main stream were 8.8 and 12.5°C, respectively.

Methods

Five meters before emptying into the Bigoray River, the water of the tributary flows over a waterfall about 1.5 m in height. There was an undercut area about 30 cm beneath the top of the fall. A wide mouth plankton net (diameter: 24 cm) having a mesh size of 76 μ (number 20 net) was placed in the undercut area, and the entire flow of the tributary passed through the net. Seven samples of 20-min duration were taken at evenly spaced intervals (i.e., 0800, 1200, 1600, ... 0800 h) during the 24-h period. The plankton net was positioned at 20 min to the hour; for example the 0800 sample represents the sampling time between 0740 and 0800 h. Except for the April and May 1971 samples, drifting animals were also collected with a 320-μ net, the same mesh size as used in the main stream study. After the plankton net was removed the 320-μ net was positioned for a 1-h sampling interval. The flow of the tributary and hence the flow passing through the drift nets was measured by placing a large bucket of known volume beneath the fall and recording the bucket's

TABLE 1

Total drift rates (numbers per 20 min) of the tributary drift taxa for the seven sampling dates, May 21, 1970 to May 15, 1971

Taxa	Total numbers (20 min)	Taxa	Total numbers (20 min)
Diptera		Crustacea	
Chironomidae larvae	16 326	Nauplii	93 848
Chironomidae adults and pupae	868	Cyclopoida	35 499
Simuliidae	537	Harpacticoida	8 005
Culicinae	1 997	Ostracoda	7 824
Ceratopogonidae	906	*Ceriodaphnia reticulata*	12 750
Dixidae	366	Chydoridae	3 667
Other Diptera	62	*Scapholeberis kingi*	1 728
Ephemeroptera		Other Cladocera	179
Leptophlebia cupida	366	Rotifera	103 014
Trichoptera	213	Nematoda	26 473
Coleoptera adults	26	Oligochaeta	5 438
Coleoptera larvae	199	Gastropoda	19
Collembola	22	Terrestrial invertebrates	324
Hydracarina	3 118	Others	7 541

NOTE: Except where otherwise indicated, the insects are all larvae; the other taxa (except nauplii) include both mature and immature forms.

filling time. The nets filtered the entire flow of the tributary on all occasions except during the high water of April 1971, at which time both total flow of the tributary and the flow through the nets were roughly estimated by photographs of the nets in place beneath the fall.

In the laboratory each sample was washed through a coarse net (pore size: 720-μ) and the filtrate was caught. The material retained by the coarse net was examined at × 16 magnification, with the appropriate identification and counts being made. The filtrate was made up to a known volume and the number of animals in the filtrate fraction was estimated by counting at × 100 magnification the number of animals in several "strips" of known volume of a Sedgwick–Rafter cell. Depending on the number of animals, three to five strips for each of three Sedgwick–Rafter cells were counted, making the appropriate corrections for the volume of the filtrate. Except where otherwise indicated, the following presentation pertains only to data obtained with the plankton net (the 76-μ net).

Results

Composition and Seasonal Changes

The drifting animals were a mixture of benthic (both lentic and lotic species) and planktonic

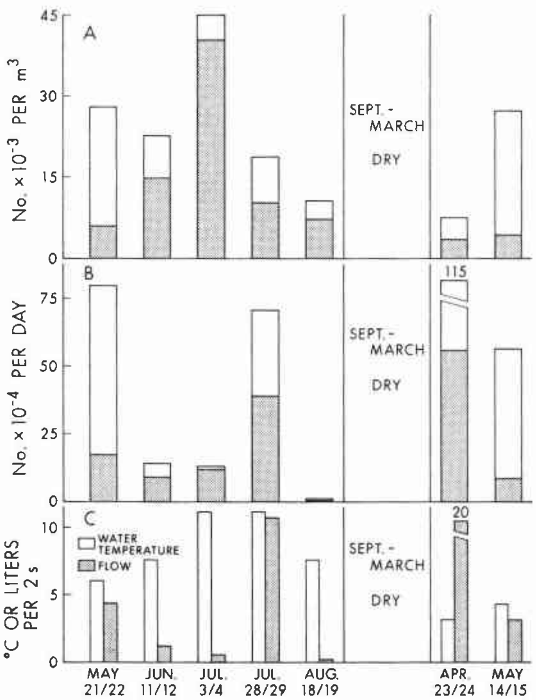

FIG. 1. A, total drift densities of the seven 20-min sampling intervals for each 24-h period. B, calculated total drift going over the fall per 24 h. C, average water temperature and flow. The unshaded areas of A and B indicate the combined nauplii and rotifer fraction of the samples; the shaded areas represent all other taxa.

species, with planktonic organisms predominating (Table 1). Some of the common genera of rotifers were *Dicranophorus*, *Brachionus*, *Lepadella*, and *Platyias*. Two species of cyclopoids have been tentatively identified as *Cyclops magnus* Marsh and *Cyclops venustoides* Coker. Simuliids consisted almost entirely of *Simulium venustum* Say; ceratopogonids were mainly *Bezzia* sp. The chironomids in the drift were not identified, although a taxonomic study has begun on this important group for both the tributary and the Bigoray River. Trichopteran larvae were all limnephilids, mainly *Limnephilus* and *Glyphotaelius*; coleopterans included several species of Dytiscidae, especially *Laccophilus*.

Changes in Drift Densities and Total Daily Drift

Except for the early July sample, total drift densities, i.e., total number of animals per m^3 of water for the combined seven sampling intervals of each sampling date, tended to decrease during the ice-free season (Fig. 1A). But there was no consistent correlation with flow (Fig. 1C). The numerical importance of the microscopic nauplii and rotifers is evident from these data. Total daily drift (Fig. 1B) is the calculated total number of drifting animals passing over the fall of the ditch for the entire 24-h period. As would be expected, the total number per 24-h period was dependent on the flow, the greater the flow the more animals drifting across a width transect.

Percentage Composition throughout the Year

The drifting animals were composed of 15 abundant taxa, making up about 97% of the total number of drifting animals (Table 2). Planktonic rotifers and copepod nauplii were numerically the two most abundant groups in the drift throughout most of the study. Adult and late stage copepodites of both cyclopoids and harpacticoids were collected in the April 23–24 drift sample, which was taken shortly after the tributary and its surrounding marshy area had thawed. No nauplii were collected at this time, indicating that the copepods overwinter in the marsh as adults or more likely, as has been described by Watson and Smallman (1971) for cyclopoids in temporary ponds, as late stage copepodites in arrested development. However, all cladocerans of the marsh overwinter in the egg stage.

Generally the tributary drift fauna is composed of planktonic and benthic animals that originate in the lentic marshy area. The only abundant lotic species, restricted to the tributary proper, were the simuliid larvae and some of the chironomid species.

Because some of the taxa are large heterogeneous groups, it is difficult to discern precise seasonal trends of the drifting animals. Of the entomostracans and disregarding the microscopic nauplii, the cyclopoids are most important during the early part of the ice-free season; the cladoceran population builds up in late July and then over-winters as ephippia. Just before the stream dried up in early autumn the cyclopoid population again was numerically important. Probably these cyclopoids of August are the ones that over-winter in a late copepodite stage. Both terrestrial insects and emerging imagines of aquatic species other than the chironomids were rare in the drift. Compared with the main stream drift study, there were large numbers of oligochaetes and nematodes caught in the plankton net of the tributary; but these

TABLE 2

Percentage composition of the abundant taxa found in the tributary drift samples for the period May 21, 1970 to May 15, 1971

Taxa	May 21–22	June 11–12	July 3–4	July 28–29	August 18–19	April 23–24	May 14–15
Nauplii	49	23	0	36	13	0	52
Cyclopoida	10	26	5	13	9	13	2
Harpacticoida	0	6	6	1	12	4	2
Ostracoda	1	3	3	1	2	3	5
Ceriodaphnia reticulata	1	T	0	17	0	0	T
Scapholeberis kingi	0	0	0	3	0	0	0
Chydoridae	1	1	1	4	0	0	0
Chironomidae larvae	3	16	38	8	20	1	1
Chironomidae adults and pupae	1	1	1	T	1	0	T
Culicinae larvae	T	0	0	T	0	2	T
Ceratopogonidae larvae	T	0	T	1	0	0	T
Hydracarina	T	T	0	T	T	3	T
Rotifera	30	12	10	9	20	50	32
Nematoda	4	4	20	1	19	17	4
Oligochaeta	T	T	15	5	2	T	T
Others	0	8	1	1	2	7	2

NOTE: T = less than 1%.

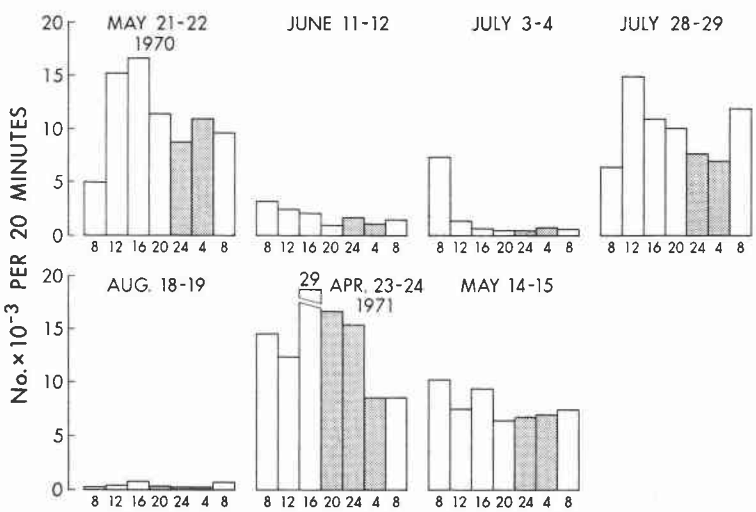

FIG. 2. Total drift per 20-min sampling interval for the seven sampling dates. The shaded bars indicate night-time sampling intervals.

relatively larger numbers were probably due in part to the small mesh size of the drift net used in the tributary study.

TABLE 3

Average daytime and nighttime drift rates and average number of taxa for the period May 21, 1970 to May 15, 1971

Sampling date	Average drift rate, number/20 min		Average number of taxa, number/20 min	
	Day	Night	Day	Night
May 21–22	11 403	9 875	12	10
June 11–12	2 056	1 443	9	7
July 3–4	2 117	680	9	7
July 28–29	10 799	7 319	18	17
August 18–19	162	66	5	6
April 23–24	16 067	13 551	13	14
May 14–15	8 263	6 860	13	11

NOTE: Averages are total values per daytime (or nighttime) sampling intervals divided by number of daytime (or nighttime) sampling intervals.

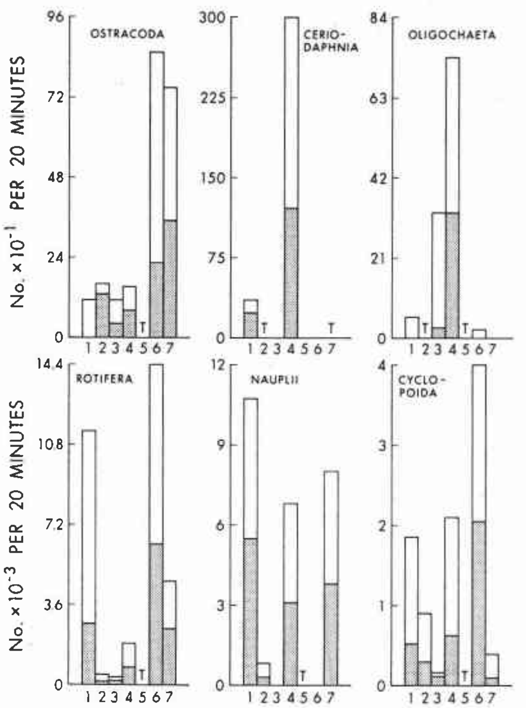

FIG. 3. Average daytime (unshaded) and nighttime (shaded) drift rates for each of the seven sampling dates. Averages are total drift rates per daytime (or nighttime) sampling intervals divided by number of daytime (or nighttime) sampling intervals. Abscissa numbers are (1) May 21–22, (2) June 11–12, (3) July 3–4, (4) July 28–29, (5) August 18–19, (6) April 23–24, (7) May 14–15. T's are trace values.

Daily and Seasonal Drift Patterns

Twenty-four-hour Patterns for the Fauna as a Whole

Although there were no discernible seasonal trends in the hourly values for the fauna as a whole, the maximum numbers always occurred during the daylight hours (Fig. 2). Average total daytime drift exceeded average total nighttime drift for every sampling date, regardless of season and environmental condition, e.g., the low water of August 1970 to the high water of April 1971 (Table 3). This is different from the results of the main stream drift study, where drift for the fauna as a whole was generally greatest at night. Although drift was greatest during the day, there was no apparent correlation with daily changes in water temperatures. With the exception of the August sample, the average number of taxa in the drift was also highest during the daylight hours (Table 3).

Daily Drift Patterns of Individual Taxa

All the abundant species exhibited a propensity to drift more during the day than at night (Figs. 3 and 4). The mayfly *Leptophlebia cupida*,

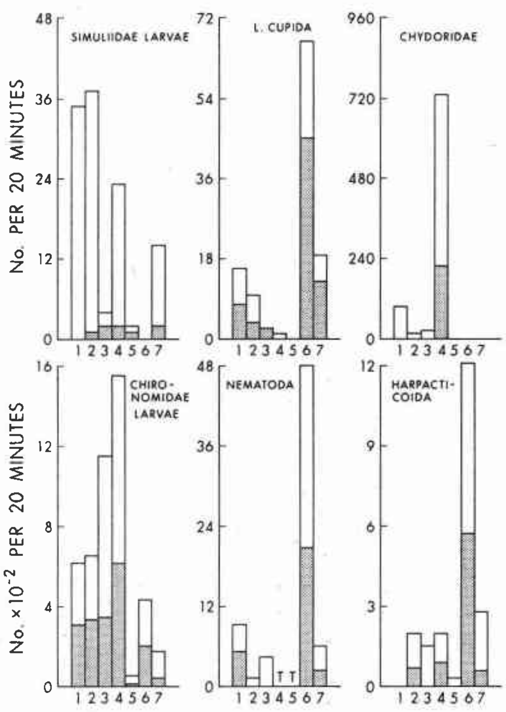

FIG. 4. Average daytime and nighttime drift rates for each of the seven sampling dates. See Fig. 3 for explanation.

which migrates into the tributary from the main stream after the ice breaks up in the spring, was the only species with a night-active drift pattern; and its pattern in the tributary, because of the daytime migratory activity (Hayden and Clifford, in preparation), was not as pronounced as its night-active pattern in the main stream. For each taxon of Figs. 3 and 4, the daytime and nighttime values of each sampling date were transformed into their log forms and then, treating each taxon throughout the entire study period, statistical comparisons between daytime and nighttime drift were made using the paired variate t-test. At $P < 0.05$ (one-sided test), the following taxa were found in significantly larger numbers in the daytime drift: nematodes, harpacticoids, simuliid larvae, chironomid larvae, chydorids, and rotifers. Nymphs of *L. cupida*, although exhibiting a night-active pattern, did not drift in significantly larger numbers at night in the tributary.

The number of taxa exhibiting day-active patterns is surprising. And the day-active patterns of Chironomidae and Simuliidae larvae are perplexing since both taxa were found in significantly larger numbers in the night samples of the main stream. Chironomidae is a heterogeneous taxon and it is possible that species-specific patterns account for the differences between the tributary and main stream. However, for both the tributary and the main stream, there was only one abundant simuliid, *S. venustum*. There was the possibility that very small larvae accounted for the day-active pattern in the tributary, being caught by the 76-μ net of the tributary but passing through the 320-μ net of the main stream. However, as indicated previously, a 320-μ net was also used in the tributary study during 1970, and the drifting simuliid larvae caught by this net also exhibited a day-active pattern. An examination of *S. venustum*'s total hourly drift values for the entire study, as obtained with the 76-μ net, reveals the following: 372(0800), 140(1200), 15(1600), 6(2000), 8(2400), 8(0400), and 3(0800). Most of the larvae were caught during the first sampling interval, the first 0800 sample; and a substantial number was caught during the second sample interval. It is possible that the significantly larger number of simuliid larvae in the daytime drift was due to the sampling procedure. The plankton net as it was initially being positioned for the first 0800 sample might have brushed off the larvae from submerged overhanging vegetation and hence into the net. However there was no evidence that more animals of the other taxa were consistently being caught at 0800 of day 1 than at 0800 of day 2 (for the fauna as a whole see Fig. 2). And of course the phenomenon would be restricted to animals, such as simuliid larvae, that can remain attached to submerged vegetation in strong current.

Comparison of the Catch in the 76-μ and 320-μ Nets

The composition of the tributary drift would have been interpreted in an entirely different way by using a 320-μ net instead of the 76-μ net (Table 4). Only large specimens, i.e., *L. cupida* nymphs, adult coleopterans, and the gastropods (mainly *Physa* and *Lymnaea*), were not underrepresented in the 320-μ-net samples. For the main stream study, a comparison was made between the catch in drift nets having 320-μ mesh and a coarser net having a 720-μ mesh; it was shown that the 320-μ nets caught per unit volume of water many more animals of almost all taxa than did the 720-μ net. Disregarding the entomostracans and considering only the taxa

TABLE 4

Total number of drifting animals caught in the 76-μ net and 320-μ net for all 20-min sampling intervals, May 21 through August 19, 1970

	76-μ net	320-μ net
Nauplii	65 488	5
Rotifera	32 788	6
Cyclopoida	20 522	193
Chironomidae larvae	14 235	162
Ceriodaphnia reticulata	12 595	148
Nematoda	6 363	1
Oligochaeta	5 366	4
Chydoridae	3 667	11
Harpacticoida	2 370	1
Ostracoda	1 930	237
Scapholeberis kingi	1 728	5
Chironomidae adults and pupae	863	234
Ceratopogonidae larvae	740	19
Simuliidae larvae	472	29
Dixidae larvae	365	14
Terrestrial invertebrates	320	10
Trichoptera larvae	202	15
Coleoptera larvae	190	51
Hydracarina	147	18
Culicinae larvae	93	5
Leptophlebia cupida	87	92
Coleoptera adults	18	16
Gastropoda	18	24

that are usually thought of as being representative of stream faunas, it is still obvious that pore size of the net is very important when interpreting data within streams or comparing data between streams. For example, chironomid and simuliid larvae are important components of most stream faunas, and these two taxa were found in the drift of both the tributary and main stream. The ratios of the 320-μ net catches to the 720-μ net catches in the main stream for chironomid larvae and simuliid larvae were 23:1 and 8:1, respectively; the ratios of the 76-μ net to 320-μ net catches in the tributary for chironomid and simuliid larvae were 88:1 and 16:1, respectively. Obviously even a 320-μ net misses many of the larvae of these two important stream groups. One might think that a net with a 0.3-mm opening would retain even the smallest larvae, but shape and projecting appendages are very important when dealing with small animals and small pore sizes. The disparities in the catches between the three nets also point up the danger of comparing in terms of absolute numbers the drift features of different streams when mesh size of the drift nets are not the same.

Discussion

The drifting animals of the small intermittent tributary consist of benthic and planktonic species originating in the lentic marshy region and lotic species of the tributary proper. It is evident that these small tributaries, when they are flowing, contribute a very large number of animals to the main stream. And in the marshy, muskeg-type terrain of much of the boreal forest, there are thousands of these small tricklets draining into a particular permanent stream. For example, in the study area of the Bigoray River, there are four tributaries draining into a 50-m stretch of the main stream. Regardless of the drifting animals' fate once they have entered the main stream, they occur in such large numbers that they become a significant component of the brown-water stream's ecosystem. There is as yet no empirical data on the fate of the planktonic animals once they enter the Bigoray River other than the work of Bond (1972), who studied the food habits of the white sucker (*Catostomus commersonii*) fry in the Bigoray River. Bond found that 50% of the food items in the stomachs of young fry, from 11 to 40 mm in length, consisted of ostracods, copepods, cladocerans, and rotifers. Draining the wetlands to develop farmland, build roads, etc. might have a pronounced detrimental effect on the permanent stream's ecosystem.

Acknowledgments

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BOND, W. A. 1972. Spawning migration, age, growth, and food habits of the white sucker, *Catostomus commersonii* (Lacépède), in the Bigoray River, Alberta. M.Sc. Thesis, Dept. of Zoology, Univ. of Alberta, Edmonton, Alberta.

CLIFFORD, H. F. 1969. Limnological features of a northern brown-water stream, with special reference to the life histories of the aquatic insects. Am. Midl. Nat. **82**: 578–597.

WATSON, N. H. F., and B. N. SMALLMAN. 1971. The role of photoperiod and temperature in the induction and termination of an arrested development in two species of freshwater cyclopid copepods. Can. J. Zool. **49**: 855–862.