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The influence of a short-termed flood on a springbrook community

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With plate 8, 3 figures and 1 table in the text

Abstract

The spring, Rold Kilde, was seriously affected by a short-termed flood. Frequency values and relative abundance for the most numerous species were estimated before and after the flood. It has not been possible by these methods to demonstrate any permanent change in the fauna although it is living under very constant ecological conditions and very seldom exposed to floods.

Introduction

Most watercourses are more or less characterized by fluctuations in water-flow. Although this is very often emphasized in studies on running waters, our knowledge of its effect on the bottom fauna is limited. It is to be expected, that large fluctuations, eventually connected with a complete drying up in the dry season followed by a flood, will eliminate several species from the stream in question. But if this happens regularly, it can be impossible from a study of such a stream to analyze the effect on the fauna. HYNES (1958) describes the influence of an exceptional drought on a small stream. He concludes, that many animals are able to survive, but further, that some insect nymphs are killed, whereas the eggs of several insects are resistant to drying up. Bexause of this, the effect of drought depends very much on the time of occurrence in relation to the insects life-cycle. In a later paper (HYNES 1968) the same author studied the influence of a long-termed spate on the fauna. He found that the fauna was reduced by the spate, but most populations were rebuilt before the next breeding season and, therefore, must have survived in the bottom of the stream. An exception from this was *Baetis rhodani*, which together with other ephemeroptera was completely eliminated and did not reappear until the next generation had hatched. In 1966 the present author had an opportunity to study the influence of a short-termed flood on a springbrook community. The results of this study are given below.

Description of the locality

Through several years the present author has studied the fauna of a spring, Rold Kilde, in the northern part of Jutland. A description of this spring is given by NIELSEN (1942, p. 330). The locality is characterized by a high degree of constancy regarding water-current, water-flow, substrate, and

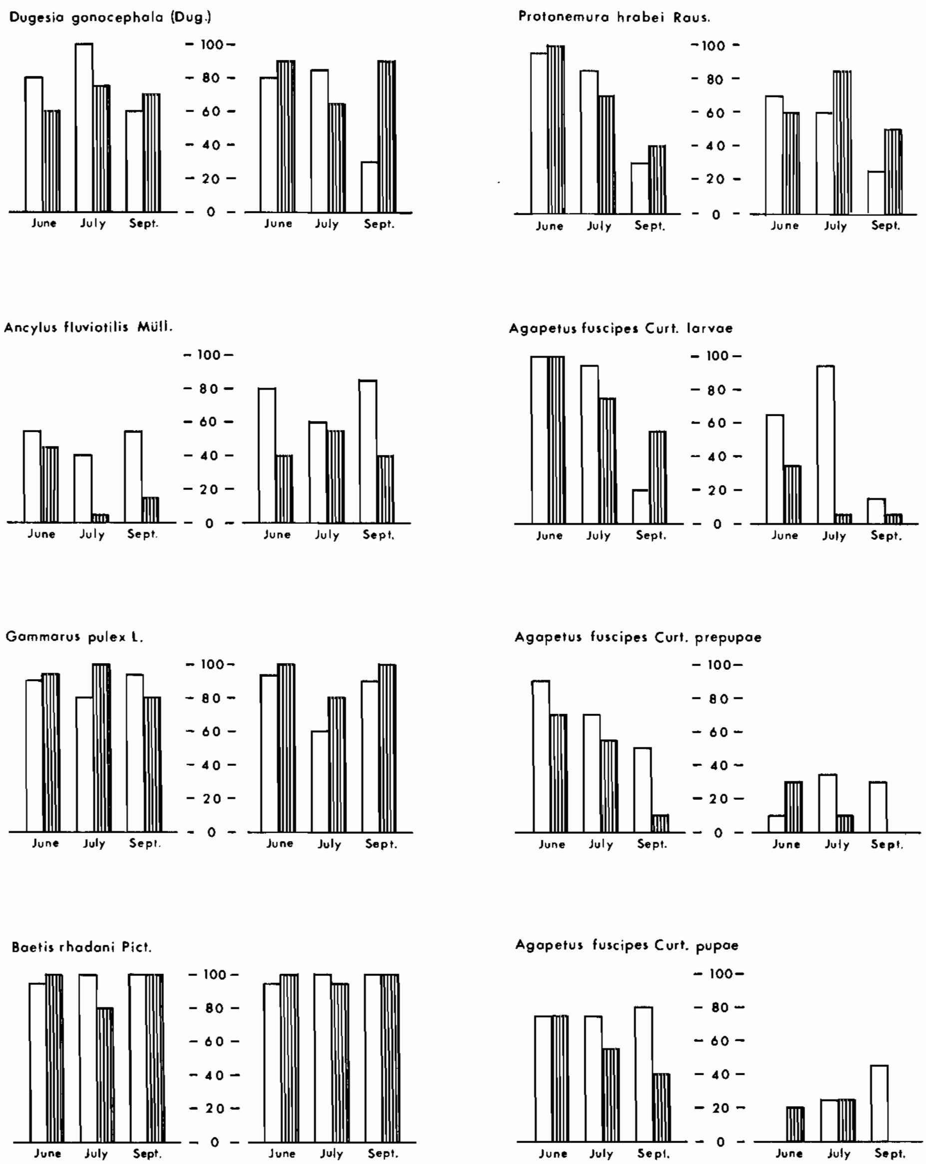
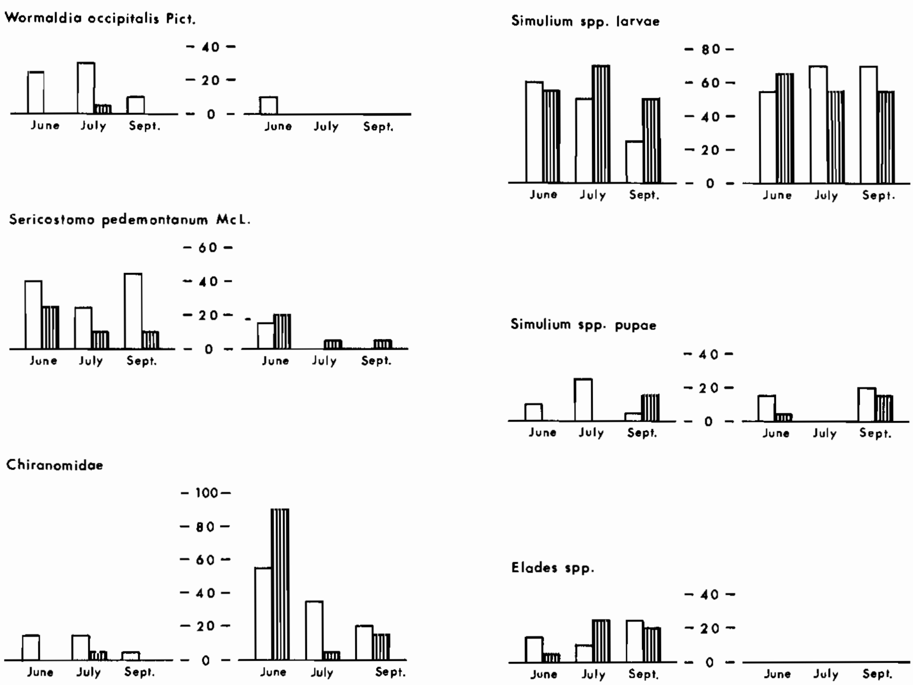


Fig. 2. Frequency values for the most important species. Left: Station A, right:

chemical conditions. On July 6th, 1966, the area in which the spring is situated was exposed to a heavy thunder-shower. It is difficult to give exact measures of the velocity of the rain, as it was very locally distributed. But on the day in question the nearest meteorological station, 3 km east of the locality, measured 69.7 mm precipitation, which fell partly as hail. This is more than the average July precipitation of 60 mm for the region. (Information from The Danish Meteorological Institute.) When the locality was visited about three weeks later, the appearance of the spring and the springbrook was completely altered. It was observed, that the rainwater had come pouring down through the gully, in the bottom of which the spring is situated, and into the spring. Everywhere the springbrook was eroded very vigorously in the bottom. At some places the stream-bed was lowered more than 20 cm and the greater part of the original bottom was dried out (Plate 8, Fig. 1 A and B). The violence of the water-flow was evident from the fact, that boulders, which earlier dammed up the water, had been moved 10—20 m downstream. There was hardly a stone in the springbrook which hat not been turned about. On the face of it, one would expect that such an influence on a watercourse would have serious consequences for the fauna.



Station B. Open and hatched bars represent results from 1965 and 1966 respectively.

Methods

During the two-year period prior to this event the fauna had been studied, especially with respect to species composition and the relative abundance of each species. Therefore, an opportunity was presented to ascertain the effect of such a strong fluctuation in water-flow on the bottom fauna, especially those animals associated with the stones on the bottom.

The part of the springbrook studied was about 300 m in length. On this stretch the fauna was analyzed at five stations, but in the following only the results from the two most comparable stations in relation to substrate are presented. These stations, referred to as Station A for the upstream and Station B for the downstream, were about 200 m apart. Station A, situated in the forest but in a clearing, is regarded to be somewhat less exposed than Station B which lies in open land. The substrate of both stations was constituted of stony bottom with sand and gravel between the stones. In the vicinity of Station B there were mats of phanerogams prior to the flood. Unpublished studies by the present author seem to indicate that this is only of minor importance for the stone-fauna, for which reason it will be ignored herein. Otherwise the substrate on both stations seemed to be similar before and after the flood.

The fauna was analyzed by two mutually independent methods. These will be described elsewhere together with an estimate of confidence limits. The one method gives an estimate of the frequency value of the species. The other gives a measure for relative abundance or dominance of each species. Both methods consider only the species found on or below the stones. Therefore, the animals living in the detritus beneath and behind the stones are included. The frequency measurements were carried out once a month, whereas the estimates of dominance values were taken with greater intervals, approximately once in three months. At the time of the flood frequency measurements had been carried out through two years, whereas the sampling for density studies had been taken through 18 months.

Results

In Fig. 2 some results of the frequency measurements are given. The exact sampling dates are as follows:

		1965	1966
Station A	June	30	29
	July	29	27
	Sept.	16	28
Station B	June	29	28
	July	28	26
	Sept.	15	27

Note that the September sample in 1966 was taken nearly a fortnight later than in 1965.

Looking first at the results from Station A it is seen, that the values for July as a main rule are lower in 1966 than in the preceeding year. However, the differences are significant ($P < 0.05$) only for the following species: *Wormaldia occipitalis*, *Simulium* spp. pupae, and *Ancylus fluviatilis*. In addition the frequency values are lowered, but not significantly, for the following species: *Dugesia gonocephala, Baetis rhodani, Protonemura hrabei, Agapetus fuscipes* larvae and prepupae, and *Sericostoma pedemontanum.* In the following cases the values are higher, but not significantly: *Gammarus pulex, Simulium* spp. larvae, and *Helodes* spp.

Looking at the results for the month of September, it is seen that most of the drops in frequency values now are adjusted. An exception from this is *Wormaldia occipitalis,* which is not yet found by the frequency measurements. Further, *Agapetus fuscipes* prepupae and pupae, *Sericostoma pedemontanum,* and *Ancylus fluviatilis* are still lower, for the last mentioned species even significantly lower than the June-value.

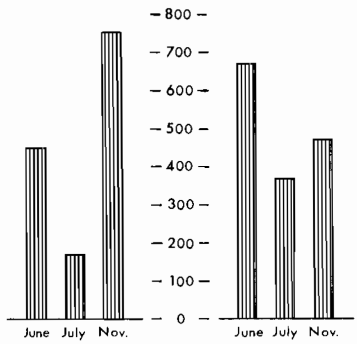


Fig. 3. Total number of individuals in the samples for estimate of relative abundance. Left: Station A, right: Station B.

At the lower station only *Agapetus fuscipes* larvae and Chironomidae in July 1966 show frequency values significantly lower than in the same month in 1965. Not significantly lower are the July-values for *Dugesia gonocephala, Agapetus fuscipes* prepupae, and *Simulium* spp. larvae. On the contrary, the values for *Gammarus pulex* and *Protonemura hrabei* are increased.

In September the frequency values for *Agapetus fuscipes* prepupae and pupae are still lower than the corresponding July-values and the September-values from 1965. Compared to this the value for *Dugesia gonocephala* is increased very much in this month.

In Fig. 3 and 4 the results from the population estimates are given. As these samples were taken in more irregular intervals, comparable samples from the year before are not available. The exact dates for sampling were as follows: June 28—29, July 27 and November 1.

From Fig. 3 it appears, that the absolute number of individuals in the sample are exceptionally low for July at both stations. Even though the samples are only relative estimates it may be assumed, that these values are significantly lower than the June-values. Furthermore, the increase in the figures in November would indicate that the community has recovered.

From Fig. 4, representing more than 75 % of the individuals in each sample, it is possible to make a further analysis of the high water-flow's influence on the more common species. Drops in the relative abundance for July are only found for the following species for both stations: *Baetis rhodani*, *Simulium latipes*, Chironomidae, and *Ancylus fluviatilis*. For *Dugesia gonocephala* a drop at Station A is accompained by an increase at Station B, whereas the opposite is the case for *Agapetus fuscipes* and *Simulium ornatum*. In the rest of the illustrated species an increase is found at both localities and in many cases the increase is biggest at station B.

Discussion

It is noted, that there are some discrepancies between the results from the two methods. This, however, is to be expected, as the two methods measure two different qualities of the community. The frequency value can in some cases be a rough measure for the magnitude of the population, but does not tell anything about the number of individuals at a certain locality. On the contrary, together with some measure of population size, it can give information about dispersion pattern of the animals at the locality. It means that if the animals are very uniformly distributed at the locality, a high frequency value can be connected with a low number of individuals. On the contrary, if a species is aggregated, a low frequency value can be combined with a high number of individuals. Therefore, if a decrease in frequency-value coincides with an increase in absolute number it shows that the animals are aggregated, i. e. there are not so many places within the locality which meet the animal's ecological requirements. This is the case for *Dugesia gonocephala* and *Gammarus pulex* at Station B, where relative as well as absolute numbers increase in July (Fig. 4 and Table 1).

Table 1. Absolute numbers of four species at the two stations.

	Station A			Station B		
	June	July	Nov.	June	July	Nov.
Dugesia gonocephala	28	11	28	41	61	35
Gammarus pulex	76	41	12	53	155	39
Protonemura hrabei	74	44	0	8	43	0
Agapetus fuscipes	52	46	25	35	0	4

The relative quantitative samples do not give any measure of population size either, but only a measure of the relative abundance of the species at different times and places. An increase of relative abundance may coincide

Fig. 4. Relative abundance for the most common species. Left: Station A, right: Station B.

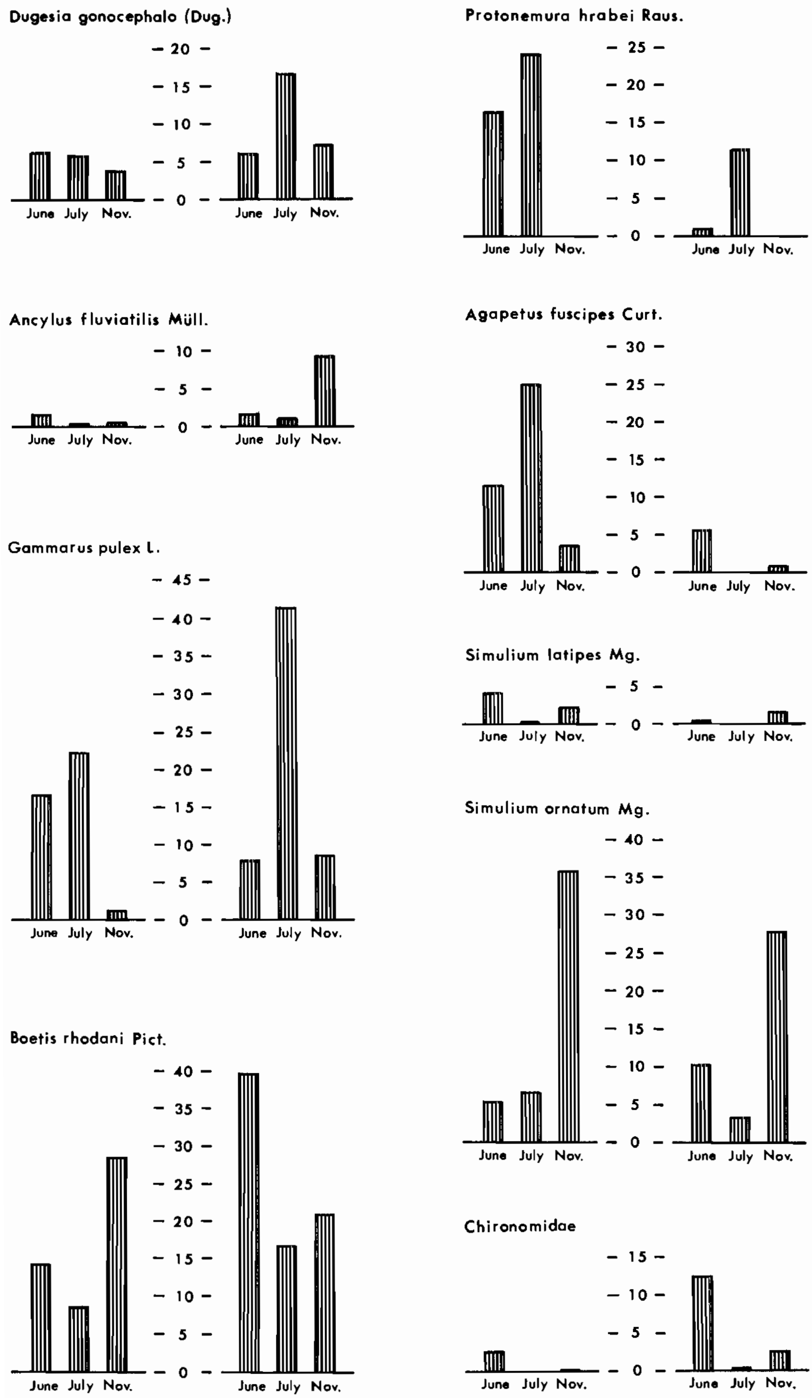

Dugesia gonocephala (Dug.)
Protonemura hrabei Raus.
Ancylus fluviatilis Müll.
Agapetus fuscipes Curt.
Gammarus pulex L.
Simulium latipes Mg.
Simulium ornatum Mg.
Boetis rhodani Pict.
Chironomidae
June
July
Nov.

Fig. 4.

with a decrease of absolute abundance in case the total number of individuals at the station is decreased at the same time. The following species: *Dugesia gonocephala, Gammarus pulex, Protonemura hrabei,* and *Agapetus fuscipes* show an increase in relative abundance for one or both of the stations. In most cases, however, this is a result of the decrease in absolute number in the sample (Table 1). This may be taken as an indication, that these species are better adapted to the extraordinary conditions than the rest of the species.

In situations where an increase in the relative number seems to be due to an increase in absolute number a further explanation is needed. In some cases this only takes place at Station B, whereas there is a decrease in relative number and in some cases also in absolute number at Station A. The explanation for this seems to be, that the population is moved somewhat downstream by the flood. This applies to *Dugesia gonocephala, Gammarus pulex,* and *Protonemura hrabei* (also indicated by frequency values for the two last mentioned species). For *Gammarus pulex* and *Protonemura hrabei* there is an increase in relative abundance at the upper station, but this is relatively small and related to a serious decrease in absolute number, whereas the increase in absolute number at Station B is important (Table 1). Normally frequency values for *Dugesia gonocephala* have a minimum at Station B in September. This is demonstrated in 1964 as well as in 1965. It is presumed to be due to upstream migration connected with the breeding period in late summer. The number of egg-capsules is very scarce in the lower section of the brook (Station B) and very common in the upper section. In 1966 this minimum is hardly visible. *Protonemura hrabei* has its flying period in July. This can explain the July-decrease at Station A but not the increase at Station B.

Agapetus fuscipes is exceptional in that frequency values as well as relative and absolute numbers are decreased significantly at Station B but not at Station A. However, yet unpublished studies of the spring show that at Station B the larvae migrate to areas with lower water-level just before pupation. This means, that at Station B they must move towards the banks, whereas at Station A the water level normally is low enough for pupation in the middle of the stream. Therefore, no migration is necessary at this station. At Station A larval frequency for September is higher in 1966 than in 1965, whereas the opposite is the case at Station B. This is due to the facts, that the new generation starts in the upper part of the stream and later on spreads downstream and that the September analysis was delayed about two weeks in 1966. Therefore in 1965 the old generation is counted at both stations whereas in 1966 the young generation is only counted at Station A. Normally this generation is not found at Station B until about a month later than at Station A. The delay in sampling date in 1966 is also responsible for the lower values of prepupae and pupae at both stations in September.

As a main result it may be stated, that the exceptionally high water-flow had not as originally expected any catastrophic effect on the fauna of the springbrook. It is true that a number of the species show a decrease in the July measurements either in frequency value or in the relative abundance value, as well as a significant decrease occurs in total number of individuals at both stations. But many of these decreases in frequency and relative abundance are insignificant and for most of the species the value has reached normal size in September or November for the two methods respectively. Further, some of the July-minima can be explained by the animals life-cycle. Many species have their flying period in July, resulting in a decrease in abundance of nymphs and larvae during this period. This applies to *Baetis rhodani, Protonemura hrabei, Agapetus fuscipes,* and *Simulium ornatum.* The life-cycle can also explain the frequency value for *Ancylus fluviatilis,* since earlier studies (THORUP 1963) indicate that the older generation dies out at this time. Nevertheless it seems true, that this species is seriously damaged by the flood. *Ancylus* is strongly attached to the stones, and when these stones are rolling downstream the snails are crushed between them.

Just at the time of the flood most *Wormaldia occipitalis* had pupated. As their pupae usually are fixed between two stones, it is evident, that when all the stones are moved downstream most of the pupae are damaged.

Thus *Ancylus fluviatilis* and *Wormaldia occipitalis* are the only two species that with any certainty can be said to have been seriously influenced by the exceptionally high water-flow. The *Ancylus* population was in some degree rebuilt by November, but not until a year later had the population regained the original size. All through the following year *Wormaldia* was very scarce in the brook, but in 1968 it again was as common as earlier.

It is also true that a good deal of the less common species, which have not been dealt with in this paper, are seriously affected. However, most of these are found again a few months later and the next year the fauna seems to be completely rebuilt.

The conclusion must be, that even a biotope, which through a long period seems to be very constant in ecological conditions, now and then is exposed to sudden changes. Even if these changes influence the fauna directly and even if it alters the brook completely for a while, it has not been possible to demonstrate any permanent change in the fauna. After some months the original conditions seem to be re-established.

The extent to which sampling on a small locality influences the results obtained by further sampling has often been discussed. MACAN (1966) showed, that introduction of a top-predator into a community did not change its structure substantially. The observations in the present paper seem to show, that a very serious disturbance of the substrate does not change the community bound to this substrate, not even when the biotope in question is characterized by a high degree of constancy. In watercourses, that regularily are exposed to floods related to certain seasons, it is to be expected, that the communities connected to the biotopes in such watercourses are adapted to these conditions. This can not be expected at a locality such as Rold Kilde described herein, but nevertheless the fauna seems to be able to stand at least short-termed extreme conditions.

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Summary

In July, 1966, the spring Rold Kilde, Jutland, was seriously affected by a very heavy thunder-shower.

Studies on the brook fauna were carried out before and after the flood by using two independent methods. One of these gave an estimate of the frequency value for each species. The second gave an estimate of relative abundance or dominance.

Both methods showed that the fauna was influenced during and shortly after the flood. However, in a few months the populations of most species in the brook were restored.

Two species, *Ancylus fluviatilis* and *Wormaldia occipitalis,* were seriously affected and their populations did not reach normal level until one and two years later respectively.

The less numerous species occurring in the brook, were not regarded in this study, but all of these have been refound again after the flood.

Zusammenfassung

Im Juli 1966 wurde die Quelle Rold Kilde, Jütland, durch einen heftigen Gewitterregen stark beeinflußt. Untersuchungen über die Bachfauna wurden vor und nach der Überschwemmung mit Hilfe zweier verschiedener Methoden durchgeführt, wovon die eine zur Bestimmung der Häufigkeitswerte der einzelnen Arten führte, während die zweite eine Schätzung der relativen Abundanz oder Dominanz erlaubte. Beide Methoden ergaben, daß die Fauna während und kurz nach der Überschwemmung beeinflußt wurde, innerhalb weniger Monate aber die Populationen der meisten Arten bereits wieder in alter Frequenz auftraten.

Zwei Arten, *Ancylus fluviatilis* und *Wormaldia occipitalis* wurden stark beeinflußt, und ihre Populationen erreichten erst nach ein und zwei Jahren das ursprüng-

liche normale Niveau. Die weniger häufigen Organismenarten des Baches blieben in dieser Untersuchung unberücksichtigt, jedoch wurden sie alle nach dem Abflauen der Flut wiedergefunden.

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A

B

Fig. 1 A and B. Rold Kilde at two places between Station A and Station B three weeks after the flood. Fig. 1 A. The stones with mosses and the gravel area was covered with water before the flood. Fig. 1 B. The gravel area was covered with water before the flood. Note the stones with pupal cases of *Agapetus*, which originally was situated just at the water surface.

J. T h o r u p : The influence of a short-termed flood on a springbrook community.