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# On the Nature and possible Utility of Epilithic Detritus

by

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Abstract

Epilithic detritus is recognized as a rich and potentially useful form of detrital material in aquatic habitats. It forms an adherent cover to the light-shaded, under-sides of submerged stones. Compared with other aquatic detrital materials it was found to be rich in organic material, protein and total potential energy content. It probably represents a primary seral stage in community succession which is prevented from maturing further by the absence of light. The potential usefulness of epilithic detritus, as food to aquatic detrivores, is discussed.

## Introduction

The surface coverings of stones submerged in the littoral regions of freshwater bodies or in lotic habitats are not homogeneous. They may show lateral heterogeneities as a result of water flow and vertical heterogeneities as a result of changes in light intensity. The points of contiguity between adjacent stones represent critical boundaries. Above these regions light conditions allow autotrophy but current intensity may be limiting whereas below the critical boundaries current intensity is reduced and light alternatively becomes limiting. Here heterotrophy is dominant and detrital particles collect and adhere to the stone surfaces. The purpose of the following note is to discuss the nature and possible utility of this, relatively ignored detrital accumulation.

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## Methods

Samples of epilithic detritus were obtained from stones derived from the littoral region of a fairly rich, oligotrophic, mountain lake (i.e. Malham Tarn, Yorks., England; Grid ref. 34897666). Twenty stones were removed haphazardly from the Tarn and their bottom-coverings were scrubbed into one volume (5L) of distilled water. The resultant suspension was concentrated by filtration. This procedure was repeated on 4 occasions throughout a 10 month interval in 1971—72 (i.e. December, March, June and September). During the March sampling period, comparative detrital samples were taken from loose sediments surrounding the littoral stones and also from the sedge-beds which occur at Malham (see HOLMES, 1965).

Biochemical analysis of the detrital samples was carried out according to the scheme summarized in Table I. Special points of note in the sequence are numbered (in square parentheses) and refer to the following details:

1. A 450°C maximum was used because at higher temperatures the contained salts may deliquesce (GROVE et al., 1961).
2. Carbohydrate determination followed the method of BOCOCK (1963). Two fractions were distinguished, i.e. cold-water soluble forms (mono- and disaccharides together with some unbranched, short chain polysaccharides) and hot-water soluble forms (long chain and branched polysaccharides). The cold-water fraction was extracted first.
3. Lipid estimation was by the method of SIEFKEN & ARMITAGE (1968).
4. Protein estimation was by the method of PRICE (1965).
5. Lignin was assessed by 12 hr digestion with hot conc HCL. The resultant residue was assumed to be lignin although other substances may have been included (e.g. tannins and keratins). For further discussion see BRAUNS, (1952).
6. Cellulose estimation followed the technique of NORMAN & JENKINS (1933) which extracts CROSS & BEVAN cellulose (CROSS & BEVAN, 1911).

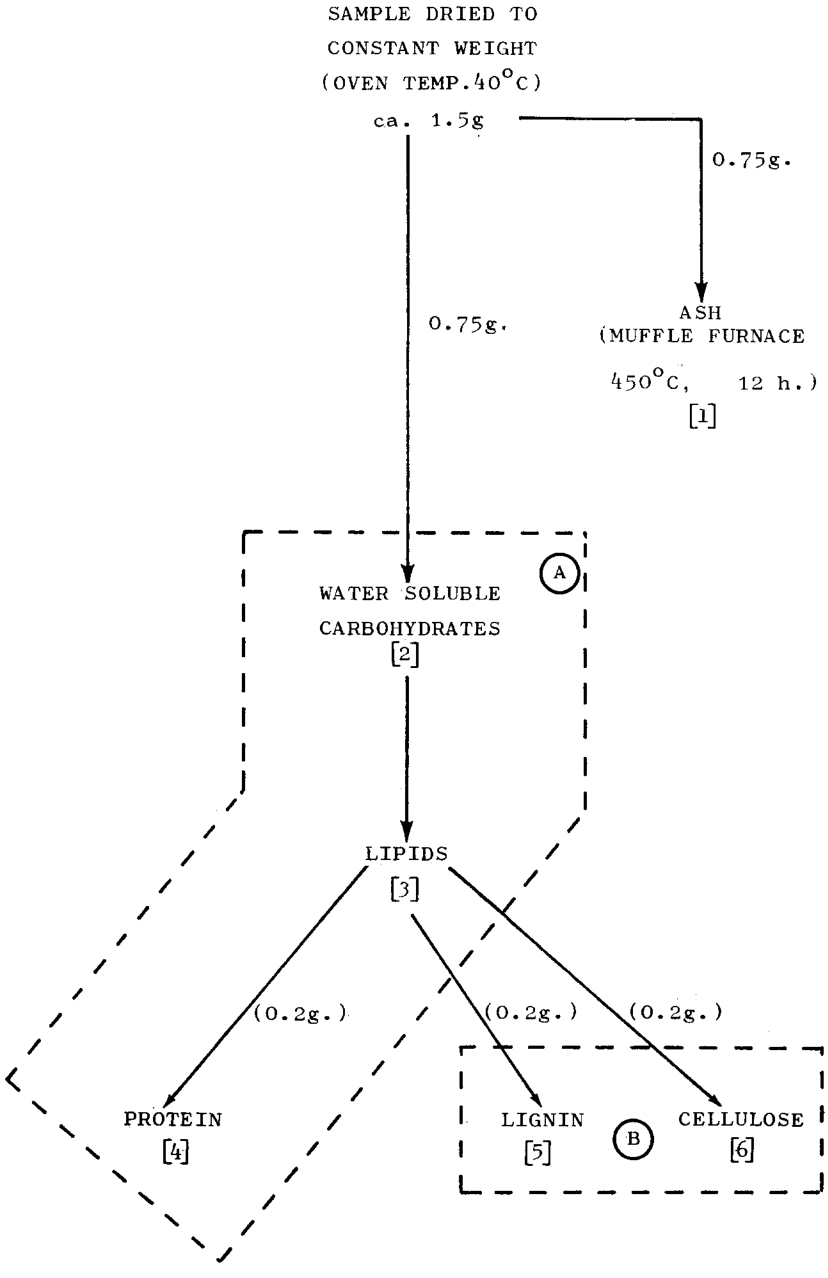
Caloric densities of the detrital materials were estimated using a micro-bomb calorimeter (PHILLIPSON, 1964) with cellulose acetate as a packing substance (COMITA & SCHINDLER, 1963).

## Results

On the stones, the epilithic detritus formed a thin, chocolate brown cover which was strongly adherent. It was densest on the

TABLE I

*Procedure and sequence for the analysis of detritus. Techniques A involve removal of the substance estimated, whereas Techniques B involve removal of the extraneous material.*



## Table II

*Biochemical constitution of detrital materials obtained from various sources in Malhalm Tarn. Samples were obtained in March, 1970.*

| Detrital Source / Detrital Fraction | Epilithic | Between-stones | Around sedge+ |
|---|---|---|---|
| % ASH | 37.34++ | 55.61 | 90.45 |
| CARBOHYDRATES | * | * | * |
| Cold-water soluble | 6.28 | — | — |
| Hot-water soluble | 2.29 | 0.01 | 1.89 |
| Total | 8.57 | 0.01 | 1.89 |
| LIPIDS | 0.80 | 0.01 | 2.47 |
| PROTEIN | 6.75 | 0.90 | 5.56 |
| LIGNIN | 69.32 | 71.06 | 61.96 |
| CELLULOSE | 12.56 | 25.63 | 27.31 |
| Unaccounted | 2.00 | 3.20 | 0.81 |

\+ Carex rostrata (Stokes) - the sediment is Kalkschlammer (Seekreide).

++ this figure is over-estimated since the sampling procedure (by scrubbing) inevitably removed particles of grit from the stone surface.

* figures in terms of % ash-free dry weight.

## Table III

*Calorific equivalents of detrital materials obtained from various sources in Malhalm Tarn. Samples were obtained in March, 1970.*

| Source of detritus | Kcal/g dry weight * | Kcal/g ash-free dry weight * |
|---|---|---|
| Sedge bed | $0.450 \pm 0.043$ | $4.715 \pm 0.311$ |
| Between-stones | $1.732 \pm 0.121$ | $3.416 \pm 0.470$ |
| Epilithic | $2.571 \pm 0.195$ | $4.101 \pm 0.390$ |

* confidence limits = $t.s/\sqrt{n}$ where t = 3.182 for 3(n-1) degrees of freedom at the 95% level of probability.

ventral stone surfaces becoming less dense on the lateral aspects and merging into the algal cover at the points where stones were contiguous with their neighbours. Table II presents the results of the biochemical analyses and the caloric densities are given in Table III. The former accounted for at least 97% of the total organic materials present. This information was taken from the March sample and includes comparative data from the intra-stone, and sedge-bed sediments. The extend of seasonal variations in the relative biochemical constitution and caloric density of the epilithic detritus is summarized in Figs. 1 & 2 respectively.

When compared with the other sediments, epilithic detritus is rich in terms of organic matter, protein and total potential energy. Lignin and cellulose make up the greatest proportion of the organic fraction of all sediments. Lipids generally contribute the least,

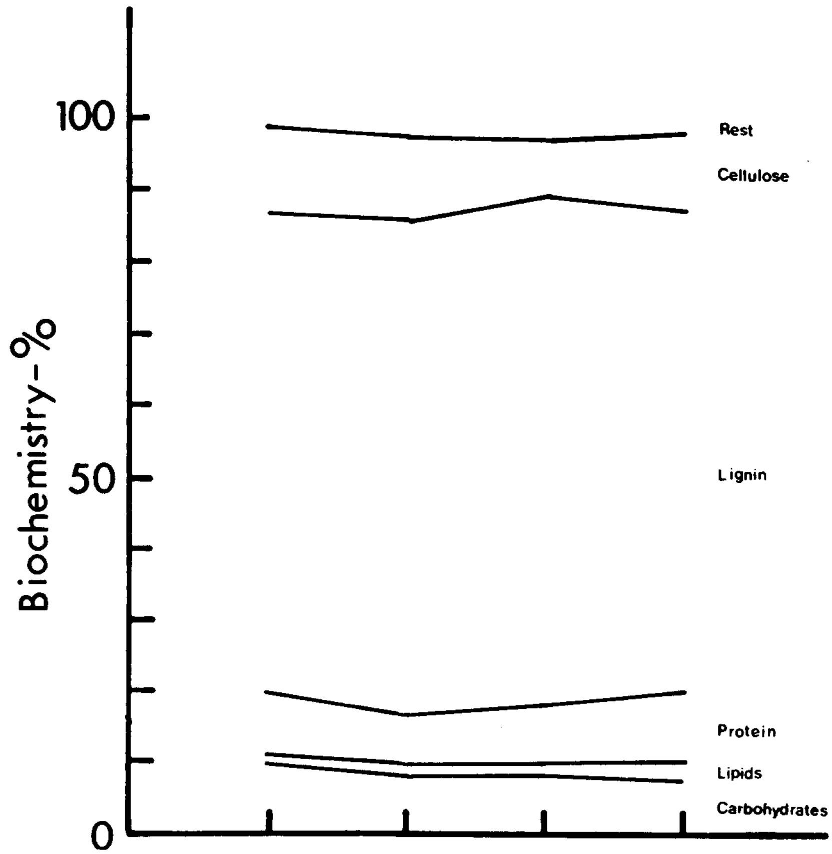



Fig. 1. Seasonal variations in the biochemical constitution of epilithic detritus expressed in terms of the relative proportions (%) of the various constituents.

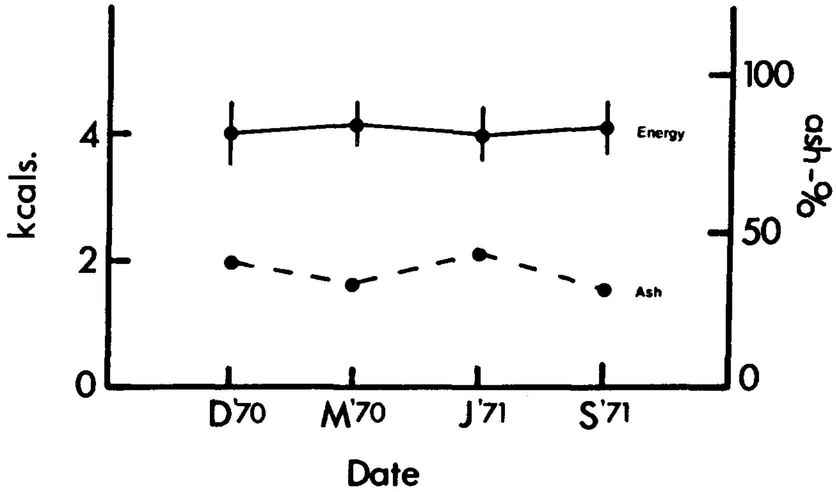



Fig. 2. Seasonal variations in the caloric density (K cal/g ash-free dry weight) and ash content (%) of epilithic detritus.

except in the sedge-bed materials where the higher proportion results in an elevated caloric density (i.e. per g ash-free dry weight). The relatively high protein content of the epilithic sample probably reflects a high bacterial standing crop. Gram positive coccoid forms were apparently dominant (CALOW, 1972). The calorific equivalent of epilithic detritus is greater than that of the other sediments when expressed in terms of dry weight. In the marine situation suspended detritus generally has a higher equivalent than sedimented materials (KENCHINGTON, 1970) and the calorific equivalent of epilithic detritus falls more closely into the former category.

Figs. 1 & 2 show that both the relative proportions of biochemical constituents comprising epilithic detritus and its caloric content remain relatively constant throughout the year.

## DISCUSSION

Detrital cover on the under-sides of submerged stones probably represents a primary seral stage in aufwuch community succession. which is prevented from maturing further by the poor light conditions. It is well established that the primary fouling film which develops on submerged surfaces consists of a bacterial slime cover which attracts algal and other suspended organic particles (SECHLER & GUNDERSON, 1971). Further algal developments cannot occur in the absence of light. Detrital particles are usually hydrophilic and carry a negative micellar charge which facilitates their adhesion to solid objects (Fox, 1950). Attraction of suspended particles, and dead or dying algal cells to the bacterial film will obviously result in characteristics more typical of the dead organic suspension than the sedimented detritus. The ultimate source of epilithic detritus is unknown and will, almost certainly, vary with habitat. In Malham Tarn, however, the high lignin content is suggestive of allochthonous material.

Egglishaw (1969) has distinguished two sources of food which are available to bottom feeding, stone-dwelling invertebrates i.e. algal epilitha and the between-stone sediments. Results presented here, however, suggest a third potential food-source, epilithic detritus, which is generally richer than the sedimented equivalent and may, therefore, be more important. In this context it is interesting to note that in the marine environment suspended, dead, organic particles may provide a reasonable food supply (Gavard, 1927; Bond, 1933) whereas sedimented materials are usually unsatisfactory (Loosanoff et al., 1951). The high lignin content, however, may mitigate against the nutritional value of the epilithic material although the bacterial component may be of value. For example in Malham Tarn *Planorbis contortus* Linn. lives on the under-sides of submerged stones in the littoral region and ingests epilithic detritus (Calow, 1972). It digests this material with low efficiency ($< 10\%$ of the detritus ingested is absorbed; unpublished). Nevertheless, it can make more effective use of the associate bacteria (assimilation efficiency ca. 90%; Calow & Fletcher, 1972) and this appears to be its most important food source.

Other observations on the ecology of *P. contortus* at Malham have suggested that it is intolerant to sediment accumulations (Calow, 1972). Since it requires detritus (or the bacterial fraction) as food it is, in a sense, compromised. Here epilithic detritus provides the necessary food-source in a compact condition (i.e. attached to stones) so that food can be obtained without concomitant fouling. Many littoral invertebrates seem to be adversely affected by loose sediment (Krecker & Lancaster, 1933) so that attached,epilithic detritus may be of general importance as a non-fouling food source for aquatic detritivores.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## ADDENDUM

After submitting this paper my attention was drawn to an article by MADSEN (1972) on detritus on stones in small streams. Here, unlike in the littoral region of Malham Tarn, epilithic detritus formed the major component of both upper and lower stone surfaces. MADSEN gives information on the gross structural form of this material but not on biochemical composition so that in this respect comparison is not possible. The mechanism used to account for the development of the detrital layer, however, is similar to that proposed in the present paper though no specific mention is made of the involvement of bacterial "slime" and of the possibility that the process is a protracted part of normal aufwuch succession. In considering the potential trophic utility of epilithic detritus, though, we both come to the same conclusion; i.e. that the material is probably not utilized directly by animals but indirectly through the agency of associated bacteria. It is encouraging that working independently and in different habitats we have come to much the same conclusions regarding the form and potential trophic importance of epilithic detritus.

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