action by which parasitic infection affects enzymatic activity must be speculated at this time. It is known that the liver is affected in schistosomiasis when the young parasite is migrating to the mesenteric vessels and later when egg and toxic metabolic products are passed by the mature worms[3]. In Rhesus monkeys infected with *S. mansoni*, a change of serum protein occurred 6 to 7 weeks following the initial infection and about the time that eggs appeared in the feces[6]. Associated with this change of serum protein was a fall of total body and intravascular albumin. The same authors[6] mention that similar protein changes have been observed with malaria, trypanosomiasis, trichenelliasis, trichostrongylosis and fascioliasis. In analogous studies with *S. matheei* in sheep[7,8], a more detailed account of the sequential changes of albumin degradation associated with the parasitic disease has been reported. These authors[8] state that 'the underlying cause of increased albumin degradation is due to an abnormal loss of plasma into the gastrointestinal tract'.

In the present study, it would appear that enzymatic function as measured by serum ChE was reduced at a time coincident with schistosome egg production of a patent infection. There was, however, no significant liver damage as indicated by additional clinical blood chemistry[1]. Therefore, it might be suspect that with egg passage into the gastrointestinal tract, a loss of plasma fluids would reduce the serum ChE activity faster than its replacement by the liver.

Fasciola hepatica is another trematode parasite which markedly affects the liver and its associated functions. A recent report[9] has shown that in infected rats, the ChE activity was reduced within 2 weeks of infection with metacercariae. In this case, however, tissue destruction during the time of parasite migration in the liver would be a more probable cause for the reduction of ChE activity. Egg production by mature flukes would not be found until many weeks later, and the eggs would follow a different pathway via the bile ducts as a means of entering the intestinal tract.

From the foregoing information, it is suggested that parasitic trematode infections are associated with a variety of pathological effects which include a reduction of ChE activity. This reduction of enzymatic function may be a result of tissue destruction by the parasite or the parasite's eggs. In the present study, loss of plasma protein associated with egg perforation of the intestinal wall is thought to be responsible for the reduction of plasma ChE activity in schistosome infected monkeys.

[4] S. Frankel, S. Reitman and A. C. Sonnenwirth, *Gradwahl's Clinical Laboratory Methods and Diagnosis* (The C. V. Mosby Company, St. Louis 1963), p. 142.
[5] M. H. Shakir, M. Saif and F. Abdel-Fattah, J. Egypt. med. Ass. *47*, 122 (1964).
[6] S. R. Smithers and P. J. Walker, Expl Parasit. *11*, 39 (1961).
[7] J. D. Dargie, J. M. MacLean and J. M. Preston, J. comp. Path. *83*, 543 (1973).
[8] J. M. Preston, J. D. Dargie and J. M. MacLean, J. comp. Path. *83*, 401 (1973).
[9] G. Lämmler and J. Schuster, Zbl. Vet. Med. B *20*, 715 (1973).

In situ Accumulation of Marine Algal Exudate by a Polychaete Worm (*Schizobranchia insignis*)[1,2]

P. V. Fankboner and L. D. Druehl

Bamfield Marine Station, Bamfield, British Columbia VOR 1BO (Canada), and Department of Biological Sciences, Simon Fraser University, Burnaby, British Columbia V5A 1S6 (Canada), 21 April 1976.

Summary. For the first time, heterotrophic accumulation of dissolved carbon by a soft-bodied marine invertebrate under in situ conditions has been demonstrated. The polychaete worm *Schizobranchia insignis* Bush concentrated ^{14}C-labelled dissolved carbon (DC) exudated by the large brown alga, *Macrocystis integrifolia* Bory, 14 times over the killed controls. Our evidence suggests that algal exudate may be a significant nutritional supplement to some invertebrates cohabitating with *M. integrifolia*.

Heterotrophic utilization of dissolved organic carbon (DOC) compounds in seawater, resulting predominately from algal primary production, has been the basis of much speculation[3–8], since Pütter's hypothesis[9] was put forward near the turn of the century. Recent reviews[8,10,11] indicate that some cyclostome fishes and a wide range of marine invertebrates accumulate DOC and that this material provides a nutritional supplement to these organisms.

Exudation of significant amounts of photosynthetically produced DOC has been reported for many unstressed, actively growing algae, including both benthic macrophytes and phytoplankton[12–14]. To date, however, accumulation of DOC by freeliving invertebrates has been demonstrated solely in the laboratory using either synthetically prepared substrates or algal hydrolysates. Such conditions are not experienced in toto by the organisms in their natural environment and lead to inconclusive results. In the following, we have conducted experiments which establish, for the first time, heterotrophic accumulation in situ of algal extracellular products by a free-living marine invertebrate.

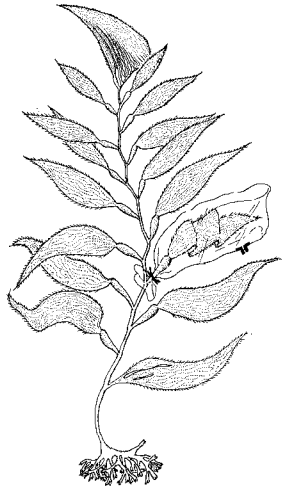
[1] This study was supported by Operating Grant No. A6966 to PVF from the National Research Council of Canada.
[2] We are grateful to Mr G. F. Cota, Dalhousie University, Halifax, for his contributions to the field experiments.
[3] R. E. Johannes, S. J. Coward and K. L. Wegg, Comp. Biochem. Physiol. *29*, 283 (1969).
[4] A. Krogh, Biol. Rev. *6*, 412 (1931).
[5] A. Krogh, Ecol. Monogr. *4*, 421 (1934).
[6] A. Krogh, Ecol. Monogr. *4*, 430 (1934).
[7] G. C. Stephens, in *Estuaries* (Ed. G. H. Lauff; Am. Ass. Adv. Sci., Washington, D. C., 1967).
[8] G. C. Stephens, Am. Zoologist *8*, 95 (1968).
[9] H. U. Sverdrup, M. W. Johnson and R. H. Flemming, *The Oceans – their Physics, Chemistry and General Biology* (Prentice-Hall, Inc., Englewood Cliffs, New Jersey 1942).
[10] Yu. I. Sorokin and D. I. Wyshkwarzev, Aquaculture *2*, 414 (1973).
[11] G. C. Stephens, in *Nitrogen Metabolism and the Environment* (Ed. J. W. Campbell and L. Goldstein; Academic Press, New York 1972).
[12] M. Brylinsky, PhD Thesis, University of Georgia, Athens (1971).
[13] J. A. Hellebust, in *Algal Physiology and Biochemistry* (Ed. W. D. P. Stewart; Univ. Calif. Press, Berkeley and Los Angeles, California 1974).
[14] K. Moebus and K. M. Johnson, Mar. Biol. *26*, 117 (1974).

In situ accumulation of kelp exudation products by *Schizobranchia insignis*

Sample Type	Sample number	^{14}C-Activity Accumulation ($\bar{x} \pm$ SD)	Concentration factor
Experimental worms	30	188.6 ± 141.8 dpm/mg wet wt.	9.9
Control worms Killed in 70% ethanol	10	13.0 ± 12.7 dpm/mg wet wt.	0.7
Algal blades	10	1930 ± 12.7 dpm/mg wet wt.	101.6
Incubation waters	10	19 ± 12.7 10^4 dpm/ml	100.0

Concentration factors were calculated on the basis of activity per unit volume of an organism (10^3 mg/ml) divided by the ambient activity per unit volume remaining in the incubation waters at the termination of the experiments.

Material and methods. We investigated the transfer of photosynthetically produced ^{14}C-labelled organic compounds originating from the large kelp, *Macrocystis integrifolia* Bory, to a cohabitating sabellid polychaete, *Schizobranchia insignis* Bush. Experiments were conducted in situ via SCUBA at inshore kelp beds adjacent to Bamfield, Vancouver Island, B.C. 5 unencrusted, non-necrotic fronds of *M. integrifolia* were selected for each experiment and treated as follows: For tracing the course of algal exudate, a ^{14}C-labelled source for photosynthesis was made available to *M. integrifolia* via an adaptation of a plastic bagging technique originated by PARKER[15]. Single blades from each algal frond were enclosed with 2.0 l of ambient seawater in a clear, polyethylene bag fitted with a serum cap (Figure 1). The bags were sealed at the base of the blades' pneumatocyst and 1.0 mCi of $Na_2{}^{14}CO_3$ (Atomic Energy of Canada) was injected through the serum cap into each bag. The algae were incubated in this labelled medium for 48 h. Following incubation, the plastic bags were removed, and the blades were washed in fresh seawater to remove sorbed isotope. A second incubation period of 24 h was initiated whereby each blade was then replaced in a new bag containing 10 adult specimens of *S. insignis*, intact in their tubes, to allow for the heterotrophic transfer of ^{14}C-labelled products, exudated by *M. integrifolia*, to the polychaetes. Next, blade tissue samples plus 5 specimens of *S. insignis* were taken from each bag. The worms were carefully drawn from their tubes, rinsed in fresh seawater, blotted, weighed, solubilized in 2.0 ml NCS Tissue Solubilizer (Amersham/Searle), neutralized with glacial acetic acid, and counted in 15.0 ml of Liquiflour toluene cocktail (New England Nuclear). Solubilizing of blade tissue samples for scintillation counting proceeded according to LOBBAN[16]; all other samples were counted in 10.0 ml of Scintiverse cocktail (Amersham/Searle). All counting results were corrected for background quenching by the external standard method, and converted to disintegrations per minute (dpm). Control worms were killed by fixation in 70% ethanol.



An in situ specimen of the 'Large Kelp' *Macrocystis integrifolia* Bory with an experimental plastic bag containing an algal blade plus $Na_2{}^{14}CO_3$ incubation waters. Stipe lenghth is approximately 3 m.

Results and discussion. Data on accumulation of algal exudation products in situ by *Schizobranchia insignis* indicate that a), extracellular products, in the form of dissolved carbon, were released by *Macrocystis integrifolia* into the incubation waters of the plastic bags, and b), in all cases, specimens of *S. insignis* from the experimental groups were able to accumulate ^{14}C-labelled algal exudated material by approximately 14 times over the killed controls.

Establishing the heterotrophic transfer of an algal exudate in situ to a cohabitating polychaete is intriguing, but what is the nutritional significance of this phenomenon in the natural habitat of these organisms? The canopies and holdfasts of *Macrocystis pyrifera* (a species which in its northern range overlaps *Macrocystis integrifolia*) are covered by numerous attached foraminiferans, crustaceans, molluscs, ectoprocts, hydroids, turbellarians, nematodes, and polychaete worms[17]. In addition, soft bodied macro-invertebrate species, which do not actually live upon *Macrocystis pyrifera*, but which are permanent members of the kelp bed community, number over 500 and, of these, 12% are habitual residents[18]. Since all soft bodied marine invertebrates examined to date possess the ability to accumulate DOC, we presume that those invertebrates who live amongst *Macrocystis* exploit similar nutritional resources in the form of kelp exudation products.

Addendum. It has recently come to our attention[19] that under the conditions of our experiments, kelp exudated ^{14}carbon may be available to *Schizobranchia insignis* as both dissolved carbon and suspended particulate carbon. Hence, our data for accumulation by the worms would reflect exploitation of one or both phases of ^{14}carbon present in the exudation waters.

[15] B. R. PARKER, J. Phycol. *1*, *41* (1965).
[16] C. S. LOBBAN, Limnol. Oceanogr. *19*, 356 (1974).
[17] B. L. WING and K. A. CLENDENNING, in *The Biology of Giant Kelp Beds (Macrocystis) in California* (Ed. W. J. NORTH; Verlag J. Cramer, Lehre 1971).
[18] W. J. NORTH, in: *The Biology of Giant Kelp Beds (Macrocystis) in California* (Ed. W. J. NORTH; Verlag J. Cramer, Lehre 1971).
[19] P. V. FANKBONER and M. E. DE BURGH, unpublished.