Mercury Toxicity in Two Intertidal Tropical Marine Molluscs*

A. E. EKANATH** and N. R. MENON***

College of Fisheries, University of Agricultural Sciences, Mangalore-575 002

Lethal and sub-lethal effects of mercury have been studied in *Perna viridis* and *Modiolus carvalhoi*. For *P. viridis* LC30 is 1.0 p.p.m. at 48 h and 0.23 p.p.m. at 96 h. Recorded LC50 values for *M. carvalhoi* are 0.5 p.p.m. and 0.19 p.p.m. at 48 h and 96 h respectively. The results document that these two species, although inhabiting the same area in the tidal belt, exhibit clear differences in mercury resistance. It is further shown that the duration of exposure affects mortality rates. In sub-lethal concentration, between 0.01 and 0.10 p.p.m. decrease in pedal-gland activity is conspicuous in *P. viridis*. At concentrations much below LC50 values (at 96 h), although some animals are alive, pedal-gland activity is totally suspended, supporting the assumption that shell-closure ability plays a minor role in byssus thread production. In *M. carvalhoi* total cessation of pedal gland activity occurred at 0.09 p.p.m. of mercury.

The toxicity of metal in general is associated with the inhibition or retardation of enzyme reactions. The review of Vallee & Ulmer (1972) gave details of biochemical effects of mercury, cadmium, and lead on marine organisms. Bryan (1976) opines that the form of the metal, environmental factors, condition of the animal, acclimation and acclimatization to the metals are important factors which influence metal toxicity. Information on lethal toxicity by way of LC50 definitions probably indicate the toxicity of the metal as well as its rate of entry (Corner & Sparrow, 1956).

Mercury introduced into the marine environment in the divalent inorganic form or as phenyl mercury acetate, is first incorporated into the bottom sediment. From the sediments it can be mobilized by the formation of soluble complexes such as $HgCl_2$ or by biological methylation. The methylated mercury will evaporate to form dimethyl mercury or accumulate in organisms in the form of monomethyl mercury (Jernelov, 1972). During the present investigation the acute and sub-acute toxicity effects of mercury given in an inorganic form, on the life and activity of *Perna viridis* and *Modiolus carvalhoi* have been elucidated.

*Abstract presented at the 14th European Symposium on Marine Biology.

** Present address: Department of Oceanography, Dalhousie University, Canada

*** Present address: School of Marine Sciences. University of Cochin, Cochin

Materials and Methods

The test animals, *Perna viridis* (20–24 mm shell length) and *Modiolus carvalhoi* (12–14 mm shell length) from the same community and population, from the low tide belts at Someswar rocky shore, Mangalore (12°47′ N; 74°51′E) were employed. Large number of these animals were transported to the laboratory in polyethylene buckets, 24 h before the commencement of experiments. The unfed test animals were kept under constant aeration. Mercuric chloride was dissolved in distilled water and added to aged sea water (Salinity *ca* 32‰ and pH 8.21) to prepare the test solutions. The experiments were carried out at room temperature (30 ± 0.5°C).

Lethal toxicity assessed by death of the test organisms lasted for 96 h. Valve gaping beyond 5 mm in the case of *P. viridis;* 2 mm in the case of *M. carvalhoi* and inability to valve closure, under mechanical stimulus were the indices employed to pronounce the test individuals dead.

Byssus thread formation was calculated as the number of threads secreted by one mussel. Readings were taken at 12 h intervals (0600 and 1800 h). Since the majority of the threads formed, developed adhesive discs, these discs were counted and then the whole byssal mass (stem and threads) was cut-off flush with valves and the test

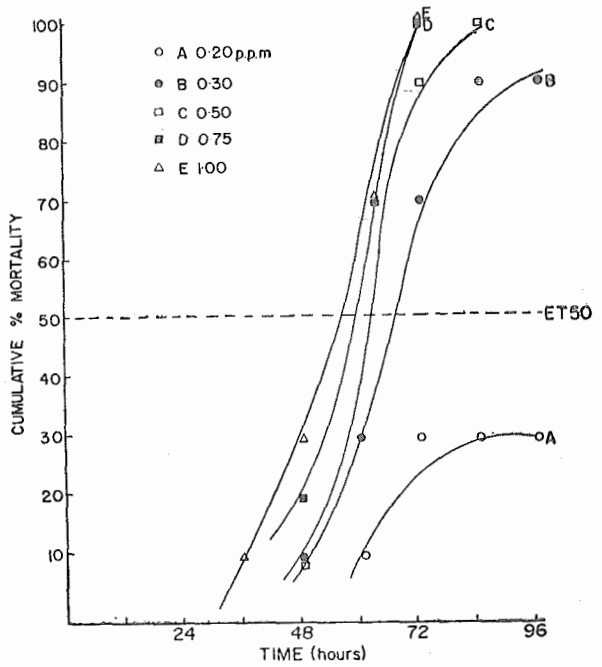

Fig. 1a. Mortality rates of *Perna viridis* in different concentrations of mercury

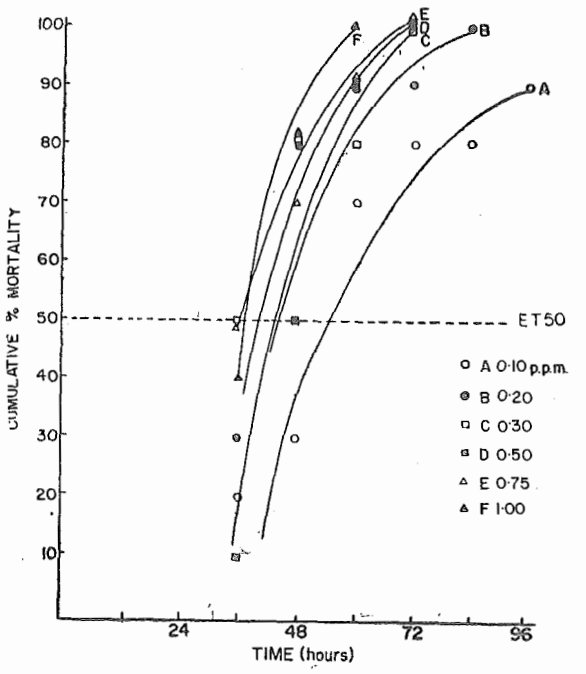

Fig. 1b. Mortality rates of *Modiolus carvalhoi in* different concentrations of mercury

animals were left in the test solution for further observation. Removal of byssus threads did not affect further secretion.

Results

Mortality

The results on the cumulative mortality rates of *Perna viridis* exposed to various concentrations of mercury are presented in

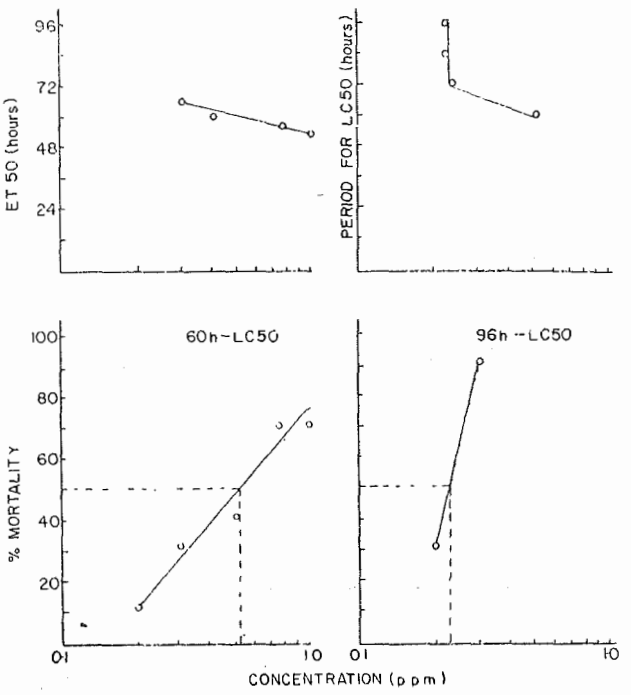

Fig. 2a. Toxicity curves of *Perna viridis* when exposed to mercury

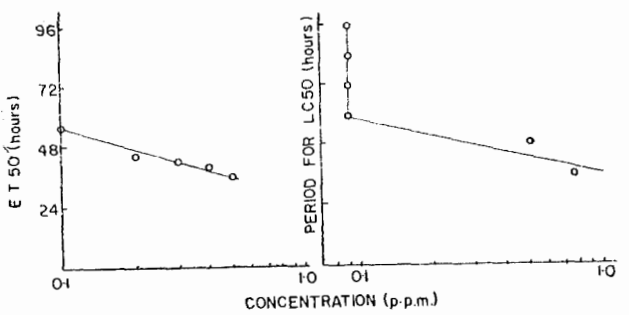

Fig. 2b. Toxicity curves of *Modiolus carvalhoi* when exposed to mercury

Fig. 1a. Among the concentrations employed, 0.1 p.p.m. did not bring out death to any organism until 96 h. 100% mortality within the experimental duration occurred only in 0.5, 0.75 and 1.00 p.p.m. concentrations. 48 h LC30 was 1.00 p.p.m, 60 h LC50 was 0.52 p.p.m. and 96 h LC50 was 0.23 p.p.m. The 5% confidence limits are 0.2 to 0.4 p.p.m. for 96 h organisms. The time taken for the death of 50% of the test organisms (ET-50) is 67.2 h in 0.3 p.p.m. and 56.2 in 1.00 p.p.m. (Figs. 1a and 2a).

In *Modiolus carvalhoi* the results are drastically different from that registered for *P. viridis*. The LC50 for this bivalve is 0.19 p.p.m. at 96 h (Fig. 1b).

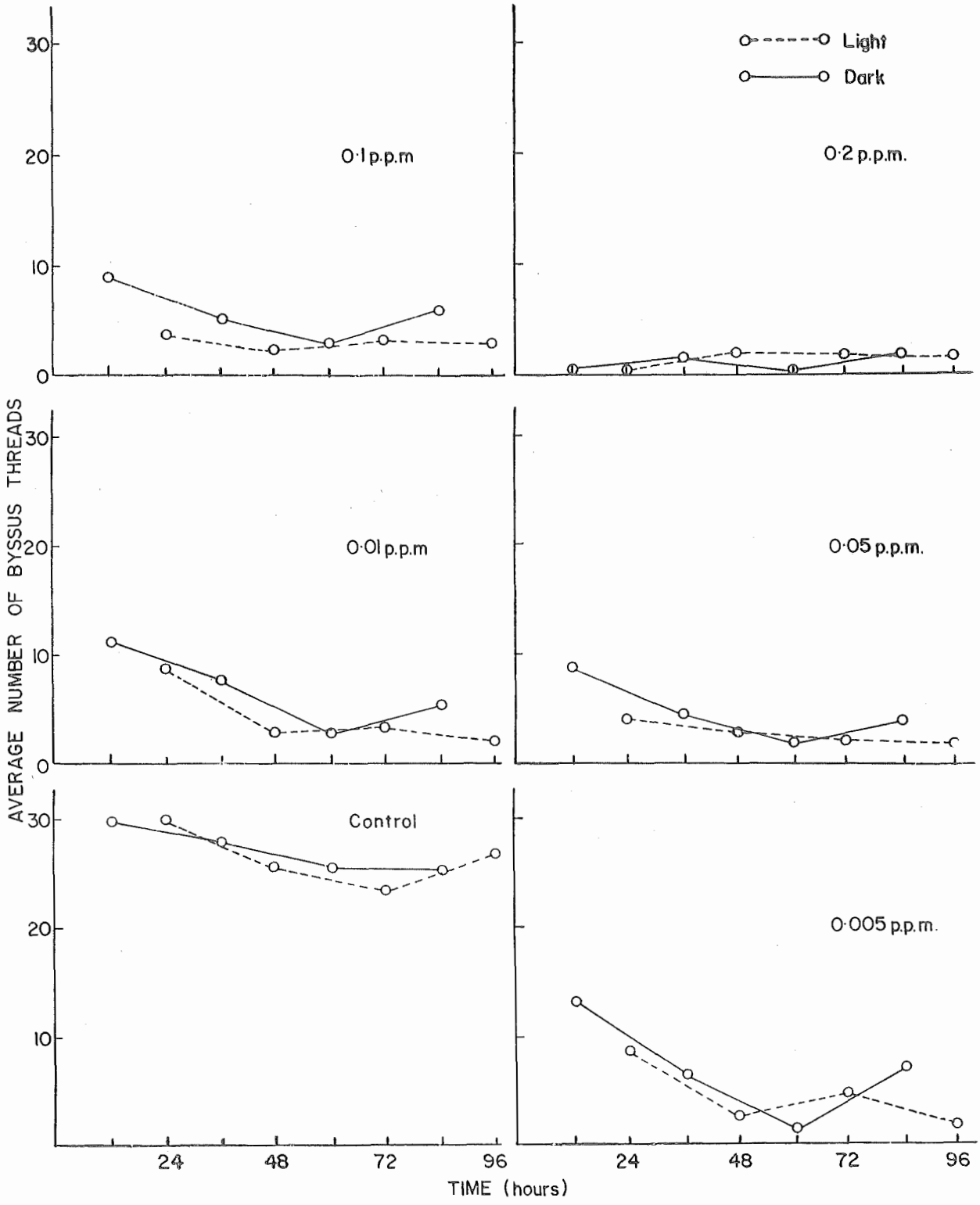

Fig. 3. Effect of mercury concentration on byssogenesis in *Perna viridis*.

Byssogenesis

It is obvious from the results that increase in concentration of mercury in the test media resulted in decrease in the number of byssus threads produced (Fig. 3). Production of byssus threads nearly ceased in mercury at 0.001 p.p.m. The mercury dependent variation in byssogenesis was found to be highly significant (p. 0.01).

The total number of threads produced by all the test animals in their respective concentrations, within the experimental duration give an index of the overall activity. It is evident that exposure to higher concentrations will ultimately, result in considerable reduction in the number of byssus threads produced or may even lead to cessation (Fig. 3).

Although *Modiolus carvalhoi* also uses byssus threads as mooring lines, considerable amount of morphological variations exist between the threads of this species and those of *Perna viridis*. The threads of former are thinner, less tanned and the byssal stem is more bushy.

In the case of this species the number of byssus threads produced was minimum in 0.075 p.p.m. of mercury. However, the differences in the number produced are not very conspicuous as a function of increase in the mercury concentration of the test media. (Fig. 4.)

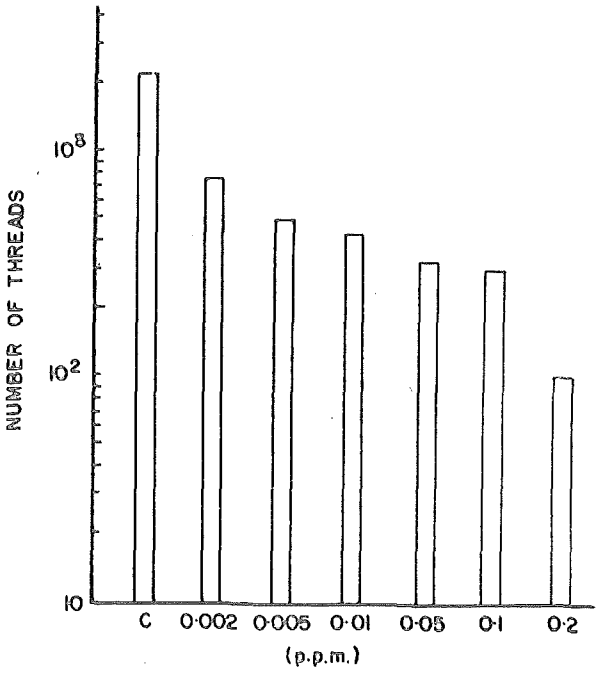

Fig. 4. Total byssus threads reduction on *Perna viridis*

Discussion

Korringa (1952) suggested that the mucus covering the free surfaces of the marine organisms could perform as an agent for collection of mercury from sea water. After incorporation into the body, the organomercuric compound may undergo a biotransformation yielding inorganic mercury. Irukayama *et al.* (1967) exposing *Venus japonica* to mercury, both in inorganic and organic forms for 12 days, found considerable accumulation of this heavy metal in the tissue. However, they failed to find out organic forms of mercury in the tissues, when the animals were exposed to inorganic mercury which lead to the assumption that the source of organic mercury must be directly from the sea. Yoshida *et al.* (1967) working on the accumulation of mercury on the various organs and tissues of *Venerupis phillippenera* exposed to phenyl mercuric chloride and mercuric chloride, found that the muscles accumulate the least, and the gills the maximum, when the animals came into contact with phenyl mercury; whereas the mid-gut gland stored maximum when the organisms were exposed to mercuric chloride. Rothstein (1970) stated that the polar mercuric chloride is not greatly soluble in the cellular membranes, but it has a high affinity for all molecules containing sulphydral groups and hence most of the enzymes. Therefore it is possible that these strong bonds would reduce greatly, the mobility of the mercury within the animal. Wisely & Blick (1967) testing on the tolerance of larvae of bryozoans, worms, molluscs and brine shrimps to mercuric chloride found that the larvae of *Mytilus edulis* has a 2 h LC50 value of 13.0 p.p.m. Their studies showed that molluscs have comparatively lower tolerance to mercuric chloride. The present studies have shown that *P. viridis* is very sensitive to mercury (96 h LC50 0.23 p.p.m.). However, *M. carvalhoi,* which co-habits with *P. viridis* proved to be highly sensitive to mercury (96 h LC50 0.19 p.p.m.). It is of interest to record here that *M. carvalhoi* occupies a position in the sub-tidal belt of Someswar beach,

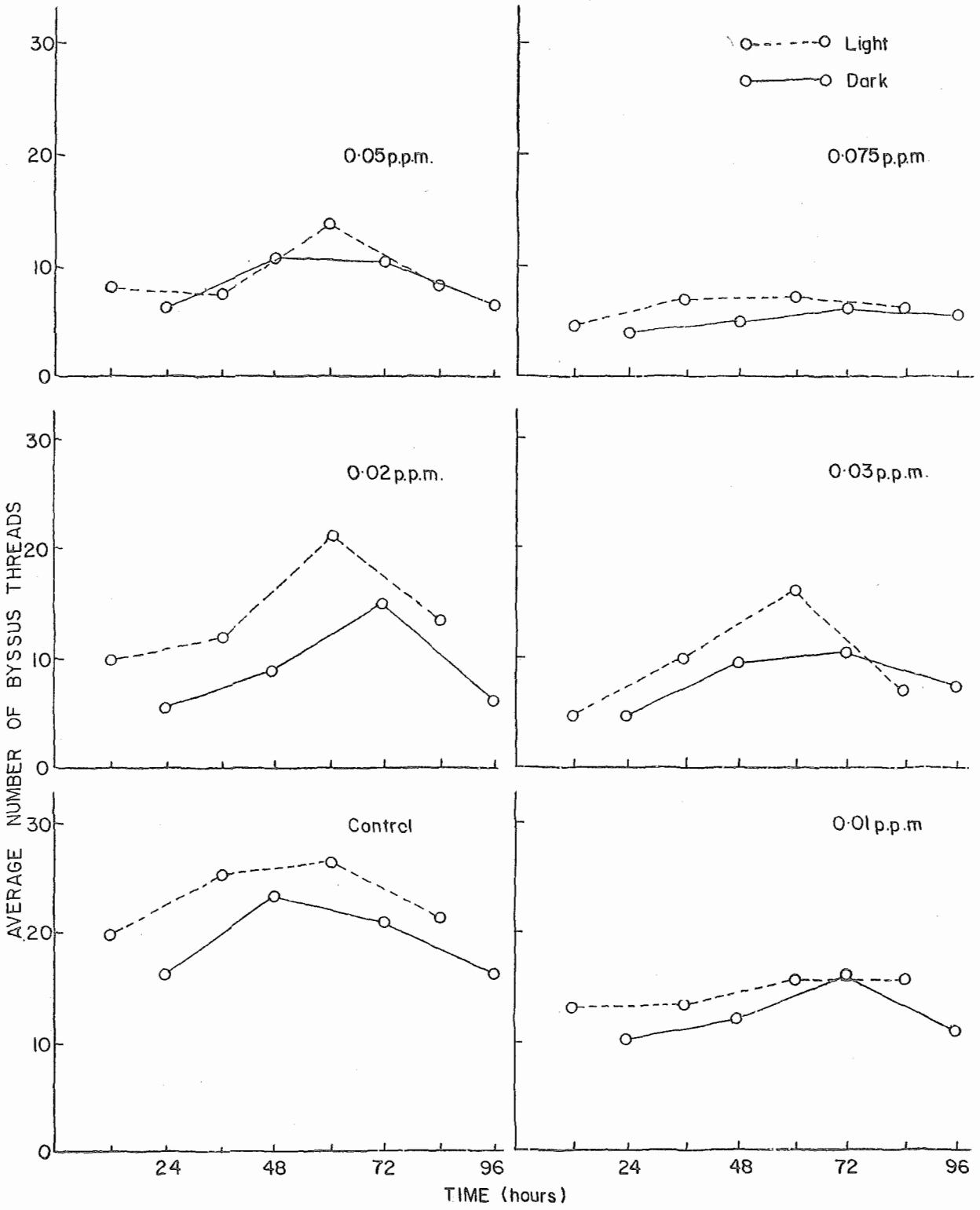

Fig. 5. Effect of mercury concentration on byssogenesis in *Modiolus carvalhoi*

whereas *P. viridis* is inter-tidal in distribution.

Miettinen *et al.* (1972) found that 20% of the total mercury that gets into the pedal muscle of the Mediterranean representative of *M. galloprovincialis* gets depurated quickly. Previous studies have shown that 50% of the test population of the estuarine clam *Meretrix casta* died when the mercury level of the test medium reached a concentration of 0.042 p.p.m. (Eknath, 1978). These results along with those of Calabrese & Nelson (1974) on another clam, show that the benthic clams in general have a lower tolerance than inter-tidal or sub-tidal bivalves.

The number and nature of byssus threads secreted by mytilids are influenced by various environmental factors. These include water movement, salinity, the position occupied by the mussels in the inter-tidal region, dissolved oxygen concentration, temperature, oil, detergents, ammonia and mercury salts (Van Winkle, 1970; Roberts, 1975; Reddy & Menon, 1979; 1980). Roberts (1976) stated that the number of byssus threads produced by *M. edulis* decreases considerably when the mercury concentration in the test media ranged from 0.5 to 1.0 p.p.m. Here the number of threads produced, decreased considerably above 0.05 p.p.m. of Hg. It is clear that at these concentrations which are considerably below the 96 h LC50, pedal gland activity and other rate functions connected with byssogenesis are impaired with in the case of *P. viridis*

Thanks are due to Prof. H.P.C. Shetty, Director of Instruction for constant encouragement and facilities. The help rendered by Prof. Dr. O. Kinne and Dr. Karl Klockner, Biologische Anstalt Helgoland, Hamburg, F.R.G. to improve the manuscript is gratefully acknowledged.

References

Bryan, G. W. (1976) *Marine Pollution* (Johnston, R., Ed.) Academic Press, New York and London, p. 185

Calabrese, A. & Nelson, D. A. (1974) *Bull. Environ. Contam. toxicol.* **11**, 92

Corner, E. D. S. & Sparrow, B. M. S. (1956) *J. mar. biol. Ass. U. K.* **35**, 531

Ekanath, A. E. (1978) *Studies in the Bioassay of a Few Marine Organisms Employing Various Industrial Effluents.* p. 272, *M.F. Sc. Thesis, Univ. Agric. Sci. Mangalore*

Irukayama, K. (1967) *Adv. wat. Pollut. Res.* **3**, 153

Jernelov, A. (1972) In *Environmental Mercury Contamination* (Hartung, R. & Dinman, B. D. Eds.) Ann Arbor Science Publishers, Michigan, 167

Korringa, P. (1952) *Quart. Rev. Biol.* **27**, 266

Miettinen, J. K., Heyrand, M. & Keckes, S. (1972) In *Marine Pollution and Sea Life* (Ruivo, M. Ed.) Fishing News (Books) Ltd., London, 295

Reddy, N. A. & Menon, N. R. (1979) *Mar. Ecol. Progr. Ser.* **1**, 315

Reddy, N. A. & Menon, N. R. (1980) *Symp. Environ. Biol.* UGC, 314

Roberts, D. (1975) *Environ. Pollut.* **8**, 214

Rothstein, A. (1970) In *Current Topics in Membranes and Transport* (Vronner, F. & Kleinzeller, A. Eds.) Academic Press, New York & London, 135

Van Winkle, W. Jr. (1970) *Mar. Biol.* **7**, 143

Vallee, B. L. & Ulmer, D. D. (1972) *Ann. Rev. Biochem.* **41**, 91

Wisely, B. & Blick, R. A. P. (1967) *Aust. J. Mar. freshwater Res.* **18**, 63

Yoshida, T., Kawabata, T. & Matsue, Y. (1967) *J. Tokyo Univ. Fish.* **53**, 73