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Effects of Water Soluble Crude Oil Fractions on Cirral Beat Frequency in *Balanus balanoides*

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Many previous investigations on the effect of crude oil on animals considered rates of survival. More important are studies of sublethal effects of oil on physiological processes especially in long-term pollution with low quantities of oil. Crude oil may reduce food intake and growth (BAYNE et al. 1980; Widdows 1985), rates of oxygen consumption (Ponat 1975; Edwards 1978), and motile behavior such as swimming and burrowing (Percy and Mullin 1977). Degradation in sensory acuity and in behavioral responses to sensory cues have also been reported (Olla et al. 1980a). Chemosensory disruption by pollutants may also prevent detection of food and avoidance of predators (Olla et al. 1980b).

In the present preliminary investigation the influence of water-soluble fractions of crude oil from Venezuela (Cabimas) and Saudi Arabia (Arabian-light) on cirral activity of Balanus balanoides was studied. Cirral beat reflects the general metabolic level of the barnacle (Southward 1964) and may be a suitable indicator for sublethal pollution effects on the organism.

MATERIAL AND METHODS

Balanus balanoides attached to stones were collected at the North Sea coast near the isle of Nordstrand. Fresh filtered water from the Kiel Bay was adjusted to the requisite salinity with a commercial sea salt mixture. The animals were maintained at 15°C and 25°/oo S under constant artificial dimmed light. All experiments were performed at these conditions.

Two stones with about 50 balanids on each were maintained seperately in a glass aquarium (175 mm x 120 mm x 170 mm) in 1 L of sea water. In preliminary experiments the animals were observed for 10 days (7-9 times every day) and active balanids were selected as suitable individuals for the experiments.

Cirral beat frequency of the balanids was measured by recording the time in seconds for 20 beats with a stop-watch. From these values beats per minute were calculated. Beat frequency of each individual was counted four times on every experimental day. Chemical as well as mechanical stimulation resulting from changing the water may affect cirral activity. To avoid errors due to this, recording of beat frequency always began 30 min after the water was changed.

There is a considerable variation of cirral beat frequency between individuals. Older barnacles beat more slowly than younger specimens (Southward 1955). Prior to the contamination experiments the cirral activity of the selected balanids of each cobble was recorded on 5 days to determine the average activity of the animals. Each individual had its own frequency of beats which remained relatively constant on all the experimental days. Control values presented in Figure 1 and 2 are the values of the day before the contamination experiment.

For these experiments water-soluble fractions of Cabimas oil from Venezuela and Arabian-light from Saudi Arabia were prepared. A mixture of 1,5 mL crude oil and 1,5 L sea water was slowly stirred (250 U/min) by a magnetic stirrer for 20 h in a closed bottle. After stirring the mixture was kept undisturbed for 2 h to separate insoluble components of the crude oil from the solution. Then 1 L of the solution was decanted into the experimental container and the animals were transferred to this.

A slow water current assists the maintenance of regular beating while high current speeds stop beating (Southward 1955). To avoid differences in cirral activity caused by irregular water currents the test solution was not aerated while counting the beat frequency of the balanids. After 3 h in the contaminated water the animals were transferred to fresh sea water and cirral activity was again observed.

Results of the experiments are compiled in Figure 1 and 2. Only animals active on all the days of the experiments were considered in the results. The significance of the data was checked by the U-test of Wilcoxon, Mann and Whitney (Sachs 1974).

RESULTS AND DISCUSSION

The experiments were conducted in early summer where <u>Balanus balanoides</u> shows the greatest cirral activity (Southward 1955). The mean cirral beat frequency of the animals on the days before the contamination experi-

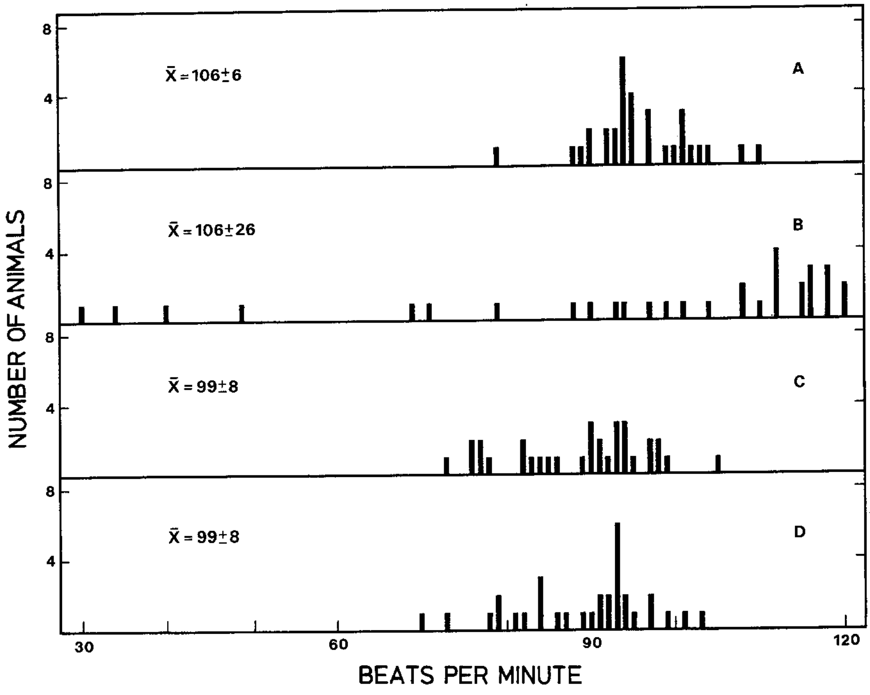

Figure 1. Balanus balanoides. Influence of water-soluble fraction of Cabimas crude oil on cirral beat frequency.
A. Normal beat frequency.
B. Beat frequency in the water-soluble fraction of crude oil.
C. Recovery of beat frequency after 3 h in fresh sea water.
D. Recovery after 1 day in fresh sea water.

ments varied between 95 and 106 beats/min. Both cirral activity and recovery time of Balanus balanoides were influenced by the water-soluble fractions of Arabian-light and Cabimas crude oil. Effects differed according to oil type.

The water-soluble fraction of Cabimas oil did not change the mean value of cirral activity of the balanids, but the standard deviation increased since some animals became more active and others diminished their cirral activity (Figure 1). After 3 h in clean sea water most of the balanids showed again normal cirral activity. Concomitantly the standard deviation returned to approximately the same values as before the experiment. One day after the end of the contamination complete recovery and normal cirral beat frequency were observed.

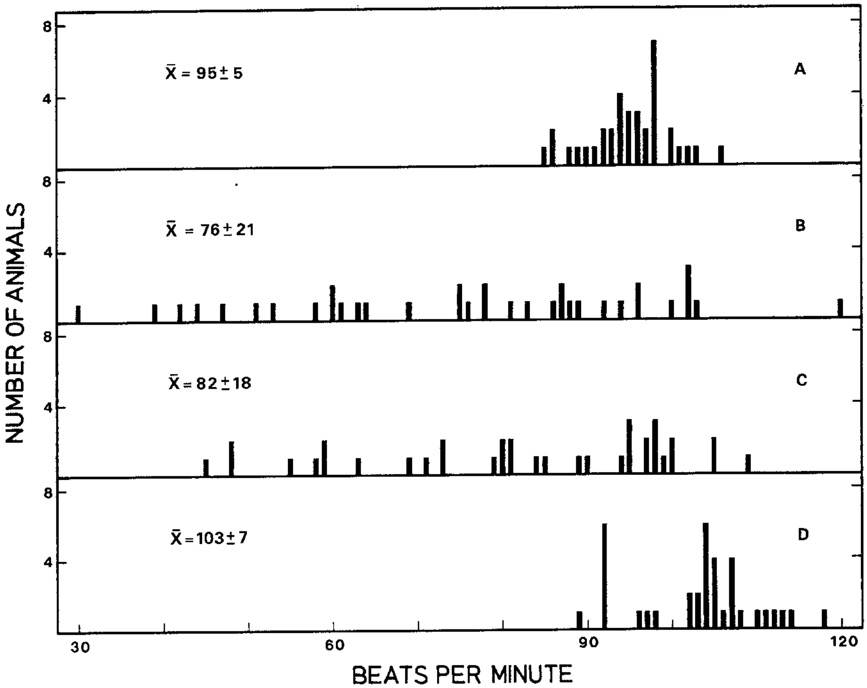

Figure 2. <u>Balanus balanoides</u>. Influence of water-soluble fraction of Arabian-light crude oil on cirral beat frequency.

A. Normal beat frequency.
B. Beat frequency in the water-soluble fraction of crude oil.
C. Recovery of beat frequency after 1 day in fresh sea water.
D. Recovery after 5 days in fresh sea water.

By contrast Arabian-light oil reduced cirral activity of the balanids (Figure 2). The difference between normal cirral activity and activity during exposure to the water-soluble crude oil fraction is statistically significant ($p < 0{,}001$). Again the influence on beat frequency of the individuals was variable. Although some balanids increased their cirral activity, most of them reduced it. The standard deviation was again higher than under normal conditions. The balanids had a longer recovery period after return to uncontaminated sea water than by exposure to Cabimas oil. One day after contamination hardly any recovery was recognizable. After a recovery time of 5 days beat frequency was the same as before contamination.

The experiments indicate that cirral beat frequency and consequently food intake are inhibited by water-soluble crude oil components.

Since infrared and gas chromatographic methods were not available; it was not possible to determine the concentration and composition of the water-soluble crude oil fractions. In general, slow stirring gives a reproducible aqueous extract that contains mostly aromatic compounds as benzenes and naphthalenes (Boylan and Tripp 1971). Water-soluble fractions from different oils will vary not only in terms of total hydrocarbon concentration but also in hydrocarbon composition (Anderson et al. 1974).

Cabimas oil from Venezuela is a heavy (0,940 g mL^{-1}) naphthen-basic oil of high viscosity. A water-soluble fraction of Cabimas crude oil had no irreversible toxic effect on the balanids when these were brought back to uncontaminated sea water after 3 h exposure. The fact that the water-soluble fraction of Cabimas crude oil is almost without smell implies that only small quantities of the crude oil are dissolved in the water.

Arabian-light from Saudi Arabia is a thin-bodied oil (0,858 g mL^{-1}) and belongs to the paraffin-basic type. The strong odor of the Arabian-light water-soluble fraction indicates that greater parts of the oil components are soluble. Therefore the solution will be more toxic and the recovery time of balanids exposed to the water-soluble fraction is very long.

The crude oils are the same as used by Moigis (1983) for his experiments on the influence of crude oil on plankton-productivity. In his investigations Cabimas oil was more toxic than Arabian-light. Since he used oil in water dispersions the effects are perhaps due to the emulsified oil components. Furthermore animals exhibit different reactions to the crude oil and not all species are influenced by the same components. Moigis (1983) observed that diatoms are more sensitive to crude oil than flagellates.

This preliminary investigation on <u>Balanus balanoides</u> indicates that balanid cirral activity is affected by water pollution. Balanids are widely distributed, available all times of the year and easy to maintain in the laboratory. Moreover cirral beat frequency is easy to measure. Cirral activity of balanids may be a suitable indicator for studying sublethal pollution effects. For further investigations in this field, teamwork with chemists is desirable for determination of the composition of the water-soluble crude oil fractions. Experiments with single oil components are also necessary to clarify the mechanisms of the effects of water-soluble fractions of crude oils on the balanids.

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