

EFFECTS OF FEEDING ON METABOLIC RATE OF THE CRAB *Chasmagnathus granulata* (DECAPODA, BRACHYURA).

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ABSTRACT

Metabolic rates of adult males of the intertidal crab *Chasmagnathus granulata* (Dana, 1851) were determined in relation to feeding. A feeding frequency of 3-4 days was suitable to maintain a constant energy metabolism for at least during two months. Commercially available pellets of rabbit food have proven to be a suitable energy source for crabs. During starvation, a lower (51 % less than fed crabs), but constant metabolic rate should be maintained by crabs, at least during a seven week period. On the other hand, a SDA of a single meal was estimated as 78 % over the metabolic rate of 2 wk starved crabs. These crabs showed a peak metabolic rate between 6 and 40 h after the meal, metabolic rate fell to a resting level about 64 h later.

Keywords: Metabolic rate, Crabs, Feeding, Starvation

INTRODUCTION

Changes in metabolic rate have been used as indicators of the physiological responses of aquatic animals to various environmental conditions. For example, in crabs, metabolic rate has been measured to evaluate the physiological effects of temperature (Leffler, 1972; Dezi *et al.*, 1987), air exposure (Veerannan, 1972), salinity (Dehnel, 1960) and pollution (Rodríguez and Monserrat, 1991). Metabolic rates of decapod crustaceans have also been studied in relation to starvation and feeding (Wallace, 1973; Aldrich, 1975a, 1975b; Dall and Smith, 1986) or diet composition (Koshio *et al.*, 1992).

This work evaluates the effects of feeding and starvation on the metabolic rate of the intertidal crab *Chasmagnathus granulata* (Dana, 1851), in order to improve the standardization of the acclimation period previous to experimental assays, and to obtain information for the planning of physiological experiments.

MATERIALS AND METHODS

Adult male crabs were collected at Faro San Antonio beach, Samborombón Bay (36°18'S, 56°47'W), Argentina, during June 1994. Intermoult crabs, who

were typified according to Drach and Tchernigovtzeff (1967) and Aiken (1973), were used for the experiments (carapace width: 28.15 ± 0.22 mm, wet weight: 14.00 ± 0.32 g, $n=30$). Once in the laboratory, crabs were initially held for 4 days in glass aquarium containing wet mud collected at sampling site. Temperature was maintained at 20 ± 1 °C and photoperiod at 14L:10D.

After the 4-d acclimation period, ten animals were assigned to each of three glass aquaria of 40x30x20 cm, free of mud, to be used for the experiments. Each aquarium contained 2 l of 12 ‰ salinity water, made by adding artificial salt (HW Marinemix) to dechlorinated tap water. The crabs could choose between remaining in the water or exposing themselves to the air. Once the experimental groups were defined, a first measurement of aerial oxygen consumption was made on all animals (initial respirometry).

Standard metabolic rate was measured as oxygen consumption, using a device made up of twelve constant pressure respirometers. Each respirometer comprised an air chamber of 200 cm³ capacity, connected to a graduate glass pipe filled with a manometric fluid. The entire device was submerged into a water bath; water was used to maintain a constant temperature of 20 ± 1 °C, and besides as manometric fluid. Ten of these respirometers contained crabs (one crab per respirometer) while the other two were used as controls (without animals). Locomotion of crabs was precluded by the small size of the respirometers used. KOH 10 % was used as the CO₂ absorbent in all the respirometers used, so that a continuous reduction of gas volume due to the oxygen consumption of crabs could be measured on graduate pipes. Changes of volume eventually recorded from the control respirometers, because of slight variations of temperature and/or atmospheric pressure, were used to correct the values taken from the crab-containing respirometers. Measurements on all respirometers were made simultaneously each 5 minutes during 90 minutes. All measurements were made between 10:30 AM and 03:30 PM, to reduce possible variability associated with diurnal cycles of metabolic rates.

Rates of oxygen consumption of the crabs were then estimated from the slope of the linear regression of cumulative oxygen consumption vs. time, during the 90 minutes measurement period. All crabs were weighed (0.0001 g) at the end of that period, in order to calculate the specific rate of oxygen consumption (%l O₂/min/g). Oxygen volume was always referred to the standard conditions of pressure and temperature (760 mmHg and 273 °K).

During the experiments, the crabs were given pellets of rabbit food, with the following composition (in relation to wet weight): protein 17 %, fat 3 %, fiber 15 %, digestible energy 2700 kcal/kg. The pellets which were 0.5 cm diameter x 1 cm long were readily accepted by the crabs. Crabs were fed in excess and each feeding session lasted 6 h.

First experiment: effect of periodical food supply

One group of ten crabs was fed on pellets twice a week. Following a meal, the remaining food was removed and the water in the aquarium replaced. A second group of ten crabs was held without food, but water was replaced

following the same schedule as for fed crabs. Oxygen consumption was measured at weekly intervals for both groups of crabs, measurements being made two days after a feeding day. The experiment lasted 8 weeks.

Second experiment: effect of a single meal

A group of 10 crabs was deprived of food for 13 days, and oxygen consumption was then measured. The crabs were then provided with an excess of food pellets for a feeding session of 6 h duration. Measurements of oxygen consumption were then carried out 6, 16, 40, 64 and 122 h after the start of feeding.

Oxygen consumption rate was analyzed by means of either a two way (first experiment) or one way (second experiment) ANOVA for repeated measures (Winner, 1971), with time as one factor, and feeding condition as the other. Student-Newman-Keuls procedure was applied for multiple comparisons between means (Winner, 1971).

RESULTS

The metabolic rates of the fed and food-deprived crabs held for 8 wk (Exp. 1) are shown in Fig. 1. There were significant differences (p) in metabolic rates between fed and food-deprived crabs from week 1 onwards, the interaction between factors (feeding condition and time) also being significant (p). Fed crabs showed after one week a significantly higher metabolic rate than they had at the beginning (initial respirometry). This rate was maintained rather constant throughout the remaining 7-wk feeding period (24 % higher on average than the initial value). Oxygen consumption of food-deprived crabs decreased significantly (p) during the 1st wk, and then remained stable for 7 wk (27 % lower on average than the initial value). Another significant drop (p) in metabolic rate of food deprived crabs was detected during the eighth week of experiment (see Fig. 1). None of the fed crabs died; 90 % of food-deprived crabs were alive after 7 weeks and 60 % at the end of the experiment.

The results obtained in the second experiment are shown in Fig. 2. Following 13 d of food deprivation, the rate of oxygen consumption decreased significantly (p) from the initial level and had reached the same level as observed for the food-deprived animals in the first experiment. Following a single feeding, there was a significant increase in metabolic rate (60 % after 6 h). A peak was observed after 16 h (78 % higher than during starvation, 32 % higher than the initial value). This maximum percentage of 78 % was considered as the best estimation of the "Specific Dynamic Action" (SDA). After 64 and 122 h, the rates of oxygen consumption were not significantly different ($p > 0.05$) from the initial values.

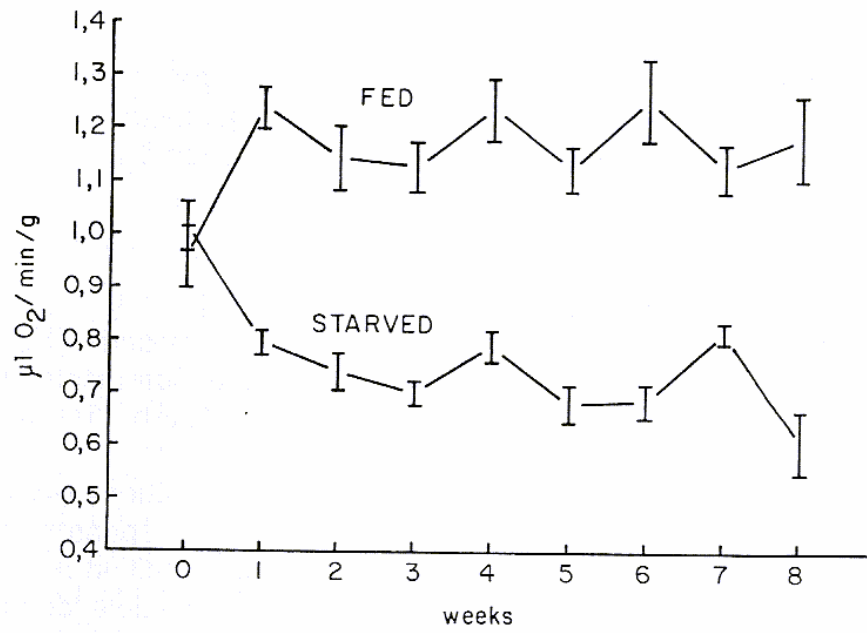


Figure 1. Oxygen consumption of periodically fed and starved crabs. Vertical bars: standard errors.

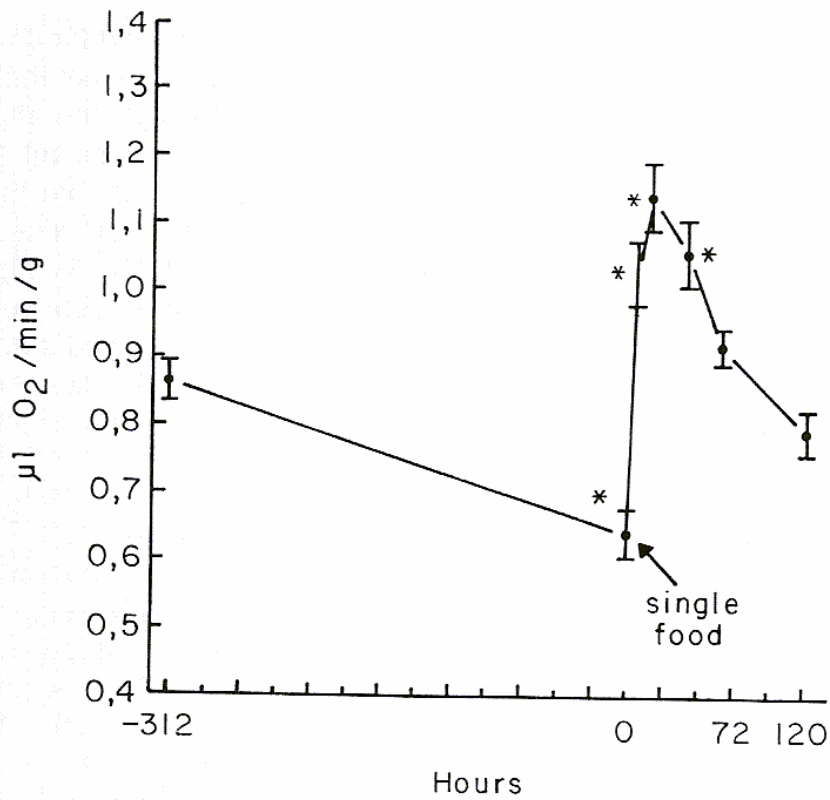


Figure 2. Oxygen consumption after a single food. Hours before food supply are indicated with negative sign. IR: initial respirometry, SV: starved value. Vertical bars: standard errors.

DISCUSSION

After the first week of starvation, *C. granulata* maintained its metabolic rate at a constantly low level during six weeks; during the 8th wk, another significant drop occurred, accompanied by increasing mortality. A decrease in metabolic rate during starvation was observed also in other crabs species. It was reduced by 50 % and 40 % in *Uca pugnax* and *Carcinus maenas*, respectively (Vernberg, 1959; Wallace, 1973), following one week of food deprivation. *C. maenas* (a crab in similar weight than *C. granulata*), also showed a further decrease of metabolic rate after prolonged starvation (Wallace, 1973). During starvation, there is probably an efficient mobilization and utilization of long-term energy reserves, such as lipids and proteins (Wallace, 1973; Dall and Smith, 1986). Utilization of lipids as a main energy substrate probably occurred also in the natural habitat during fall, when crabs were sampled, according to previous studies on *C. granulata* (Kucharski and Da Silva, 1991b).

In crabs that were periodically fed, a constant and high metabolic level was maintained during the entire assay, with a 100 % survival. These results from periodically fed crabs qualify the assayed diet and feeding frequency as suitable for maintaining stocks of crabs in the laboratory. Besides, the "feeding metabolic level" was significantly higher than the metabolic rate of collected crabs (initial respirometry). This result shows that the quality of the diet given was higher than that merely obtained from mud (given before the experiment). A great proportion of mud or sediments has been reported from the analysis of stomachal content of *C. granulata* sampled at natural sites (Olivier et al., 1972; Botto and Irigoyen, 1979; D'Incao et al., 1990). In a previous work on *C. granulata*, Kucharski and Da Silva (1991a) found an increment in hepatopancreatic and muscle lipids after administration of a diet having protein levels similar to the ones employed in this work.

The relatively high percentage of vegetable fibers in the pellets given here as food, may have approached the natural diet of *C. granulata* as this was found to include up to 34 % of vegetable fibers, mainly from halophyte plants of the genus *Spartina* and *Salicornia* (Botto and Irigoyen, 1979; D'Incao et al., 1990). However, the pellets used in this work had lower protein levels than those used for other crustaceans, especially penaeids (Cuzon et al., 1994). Further studies on growth and reproduction of the studied species are needed to check the suitability of different food sources during long-term starvation.

Since no binders were included in the pellet formulation, their stability in water was low. Thus they were placed in the dry zone of the aquarium, to reduce dissolution. They were finally dispersed by the crabs through the aquarium, but no fermentation seemed to occur during the 6 h of feeding. Replacement of water after each feeding session always guaranteed a suitable water quality during the experiments.

Results of single a food supply clearly confirm our conclusions from the first experiment, with respect to increasing metabolic rate after food uptake. The second experiment also showed that provided food caused a SDA of about 78

% over the starved metabolic rate of crabs. Higher values of SDA were reported for other crustaceans (up twofold range over the metabolic rate of *Daphnia magna*: Lampert, 1986). The duration of the digestive cycle has been estimated as about 12 h in two decapod crustaceans (Barker and Gibson, 1977, 1978); this is in agreement with the time elapsed in our experiment from the beginning of feeding to maximum oxygen consumption (16 h). After 64 h, a return to the initial value took place. These results should be considered in physiological experiments concerning the effect of a single feeding.

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