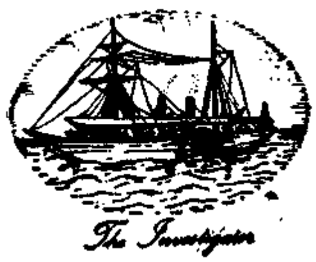
PROCEEDINGS OF THE SYMPOSIUM ON COASTAL AQUACULTURE

Held at Cochin

From January 12 to 18, 1980

PART 1: PRAWN CULTURE

(Issued on 25th February 1982)



MARINE BIOLOGICAL ASSOCIATION OF INDIA

POST BOX NO. 1244, COCHIN 682 011, INDIA

Price : Rs. 400.00

SYMPOSIUM SERIES 6

Abbreviation

Proc. Symp. Coastal Aquaculture, Pt. 1.

PRINTED IN INDIA BY K. G. JOHN AT THE DIOCESAN PRESS, MADRAS 7 AND PUBLISHED BY E. G. SILAS ON BEHALF OF THE MARINE BIOLOGICAL ASSOCIATION OF INDIA, COCHIN-682 011.

Proc. Symp. Coastal Aquaculture, 1982, **1** : 117-122

OXYGEN CONSUMPTION, AMMONIA EXCRETION AND RANDOM ACTIVITY IN *PENAEUS SEMISULCATUS, MACROBRACHIUM MALCOLMSONII* AND *PARATELPHUSA HYDRODROMUS* WITH REFERENCE TO AMBIENT OXYGEN

A. LAXMINARAYANA AND M. N. KUTTY*

Central Marine Fisheries Research Institute, Cochin 682018, India

ABSTRACT

Oxygen consumption, ammonia excretion and random activity in relation to ambient oxygen have been investigated in a marine prawn, *Penaeus semisulcatus*, a freshwater prawn, *Macrobrachium malcolmsonii* and a freshwater crab, *Paratelphusa hydrodromus*. At normoxia, *P. semisulcatus* maintained an ammonia quotient (A.Q.= volume or mole ; mole relation of ammonia excreted to oxygen consumed) of about 0.06, *M. malcolmsonii* maintained an A.Q. of about 0.08 and *P. hydrodromus* an A.Q. of about 0.25. Under hypoxic conditions all these three crustaceans showed high ammonia quotients. The 2 to 5 fold increase in A.Q. values in hypoxic conditions indicates increased protein degradation and may be of value in combating acid base balance as in the case of fishes. The random activity increased in hypoxic conditions in the case of *P. semisulcatus* and *M. molcolmsonii* whereas in the case of *P. hydrodromus* the activity decreased in hypoxic conditions indicating a dichotomy in behaviour which appears to have ecological significance. The metabolic rate decreased in hypoxic conditions in all the three species.

INTRODUCTION

INFLUENCE of environment on the energy metabolism of poikilotherms has been reviewed by Fry (1971), Wolvekamp and Waterman (1960), Kinne (1970-72) and Vernberg and Vernberg (1972). Oxygen consumption of crustaceans has been studied by several workers (Lofts, 1956 ; Subrahmanyam, 1957, 1962 ; Rao, 1958 ; Rajabai, 1961, 1963 ; King, 1965 ; Kutty 1969 ; Kutty *et al.*, 1971 ; Reeve 1969 ; Ramamurthi and Sainath Janak, 1973), but there are fewer studies combining oxygen consumption and nitrogen excretion (Reeve, 1969). In most of these cases spontaneous random activity as a factor has not been investigated. Comparison of routine metabolism can be valid only when a measure of activity is available as otherwise energy requirements can be widely different even in the resting animals at different levels of random activity (Spoor, 1946 ; Fry, 1947 ; Beamish and Mookerji, 1964 ; Kutty, 1968).

In the present study simultaneous measurements of oxygen consumption, ammonia excretion and random activity of a marine prawn, *Penaeus semisulcatus*, a freshwater prawn, *Macrobrachium malcolmsonii* and a fresh water crab, *Paratelphusa hydrodromus* exposed to various concentrations of ambient oxygen below air saturation have been investigated. Besides providing basic information on the influence of ambient oxygen on metabolism and activity of crustaceans this study gives supplementary information of value in the aquaculture of the two commercially important prawns.

MATERIALS AND METHODS

P. semisulcatus were collected from Palk Bay off Mandapam. They were kept in full sea water (salinity 33‰) in a rectangular tank

* Fisheries College, Tamil Nadu Agricultural University, Tuticorin-682 003, India.

fitted with a biological filter through which water was recirculated. *M. malcolmsonii* were collected from the river Cauvery off Tiruchirapally. They were also kept in fresh water in a rectangular tank fitted with a biological ammonia filter. Oxygen concentration of the water present in these tanks was always kept near air-saturation. The water in these tanks was partially changed once in a week. The prawns were fed *ad lib* with earthworms. The uneaten food and faeces were removed everyday by siphoning.

Field crabs *P. hydrodromus* were collected from paddy fields around Madurai and were maintained in freshwater. They were also fed *ad lib* with earthworms.

P. semisulcatus used for the experiments were of 13.9±2.07 g. in weight (n = 3) and 128± 4.62 mm in total length. *M. malcolmsonii* used for the study were of 31.94±0.48 g. in weight (n=5) and 194.4±0.18 mm in total length. *P. hydrodromus* used for experiment were of 36.6±0.18 g. in weight (n=3) and 50.00±0.58 mm in carapace width. The water temperature in the acclimation tanks was 29±1°C and the animals were tested in the same temperature. All the three crustaceans were acclimated at least for two weeks before experiment and tested under acclimation conditions. The animals were starved for 24 hours (Fromm, 1963; Beamish, 1964) before experiment.

Apparatus

The apparatus used for the present study has been described by Kutty *et al.* (1971). Mainly it consisted of two units, an electronic counter and a transparent plastic perspex respirometer.

Experimental procedure

These experiments were done using modified Fry's respirometer. The duration of an experiment lasted for 60 minutes except the last one in which the ambient oxygen was allowed to reduce until the animal was aspyxiated (loss of equilibrium).

The focus lights beamed at the photocells were switched on at least 30 minutes before starting a day's experiment. At the start of the experiment, initial samples were collected and the circulation of water through the respirometer was cut off. After an interval of 60 minutes, final samples were collected. In each sampling time (initial and final of each run), two separate water samples were collected for analysis of dissolved oxygen and ammonia. The size of each sample was 30 ml for oxygen and 15 ml for ammonia (25 ml collected first for rinsing was discarded). Care was taken during sampling to compensate the sampling water by allowing water to flow into the respirometer. The figure in the activity counter was recorded immediately after sampling (initial and final sampling of all the runs).

After sampling the final samples of Run I, the respirometer was not opened to the circulating water but approximately 70 ml of the crustacean medium was circulated once or twice through the respirometer for mixing it with the 'respired' water remaining unflushed in the respirometer. Then the initial samples of next run (as described above) were collected. The overall time for sampling and adding water was about 2 minutes. To avoid using the correction factor for the initial oxygen concentration of second and the successive runs, the above mentioned procedure was followed by taking initial samples. During the last run, the final samples were collected only after the animal reached the asphyxial oxygen level, as indicated by the beginning of the equilibrium loss of the animal. Then the respirometer was flushed with the air-saturated water to revive the animal. The concentrations of oxygen and ammonia were determined in the samples acquired at the beginning and at the end of each closure period. The activity was counted by the difference between the initial and final figure of the activity counter, which was noted immediately after each sampling.

Methods of Water Analysis :

(i) *Dissolved oxygen*: The unmodified Winkler method was followed (American Public Health Association, 1965). The size of the sample used for titration was 25 ml.

(ii) *Ammonia* : Ammonia concentration in the water samples was estimated by an improved Phenol hypochlorite method (Harwood, 1970). The size of the sample used for estimation was 10 ml. and the ammonia contents in the water samples were determined colorimetrically using Spectronic 20 at a wavelength of 630 ml.

RESULTS

The results of the experiments on oxygen consumption, NH_3 excretion, A.Q. and random activity in *P. semisulcatus, M. malcolmsonii* and *P. hydrodromus* subjected to a hypoxic phase until the animals were asphyxiated in a closed respirometer are represented graphically in Fig 1. The ambient oxygen concentrations were categorised into three levels (high, medium and low) (Table 1). In high ambient oxygen concentration *P. semisulcatus* showed the highest rate of oxygen consumption followed by *M. malcolmsonii* and *P. hydrodromus. P. semisulcatus* showed the highest rate of ammonia excretion in high ambient oxygen concentration followed by *P. hydrodromus* and *M. malcolmsonii.* In high ambient oxygen concentration *P. hydrodromus* showed the highest random activity and *P. semisulcatus* the least.

The trends in oxygen consumption decreased with decrease in ambient oxygen in all the three species tested. The decrease in the rate of oxygen consumption was most significant in *P. semisulcatus* and less significant in *P. hydrodromus.* The rate of ammonia excretion increased with decrease in ambient oxygen in all the three species. The random activity increased in *P. semisulcatus* and *M. malcolmsonii* with decrease in ambient oxygen but in the case of *P. hydrodromus* the random activity decreased with decrease in ambient oxygen concentration.

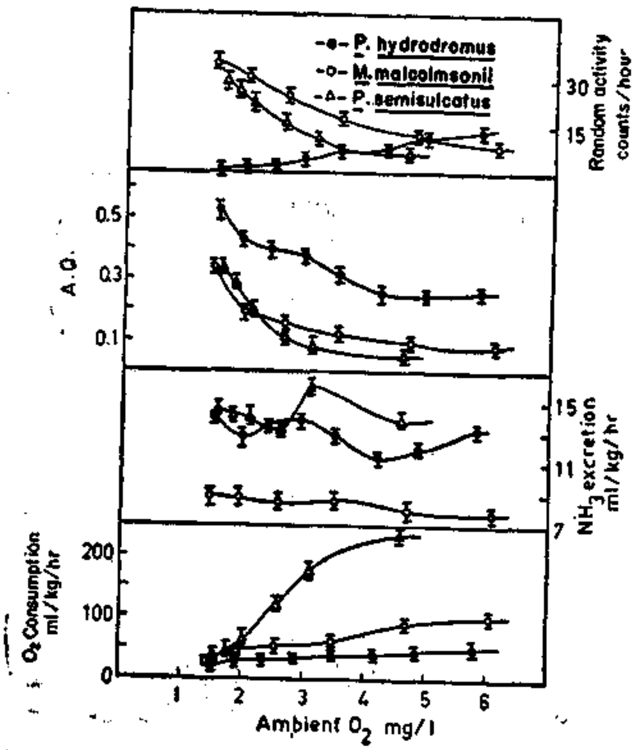


Fig. 1. Oxygen consumption, NH_3 excretion, A.Q. and random activity in relation to ambient oxygen in *P. semisulcatus, M. malcolmsonii* and *P. hydrodromus* acclimated to and tested at 29± 1°C. Each value plotted is a mean of (± S.E.) 5 determinations in the case of *M. malcolmsonii* and 3 determinations each in the case of *P. hydrodromus*.

TABLE 1. *Oxygen consumption, NH_3 excretion, A. Q. and random activity in* P. semisulcatus, M. malcolmsonii *and* P. hydrodromous *at* 29± 1°C

Species	Ambient (O_2 mg/l)	Random activity (counts/hr)	Rate of O_2 consumption (ml/kg/hr.)	Rate of NH_3 excretion (ml/kg/hr.)	A.Q.	Remarks
P. semisulcatus	High (4.55—4.63) (4.60± 0.04)	5± 0.58	232.3± 1.62	13.9± 0.11	0.06± 0.0001	Acclimated to and tested in full sea-water (33‰)
	Medium (2.01—3.49) (2.7± 0.20)	16.3± 1.62	125.4± 16.13	14.5± 0.53	0.13± 0.017	,,
	Low (1.62—1.81) (1.70± 0.04)	27.3± 0.88	46.1± 1.64	14.2± 0.30	0.31± 0.100	,,
M. malcolmsonii	High (6.05—6.24) (6.10± 0.03)	8.8± 0.92	99.5± 0.42	7.8± 0.18	0.08± 0.001	Acclimated to and tested in fresh-water.
	Medium (2.53—4.79) (3.60± 0.23)	18.3± 1.50	73.1± 3.86	8.4± 0.15	0.12± 0.001	,,
	Low (1.39—1.86) (1.70± 0.06)	33.1± 0.78	36.3± 3.56	8.8± 0.15	0.27± 0.025	,,
P. hydrodromus	High (5.02—5.80) (5.60± 0.19)	13.0± 0.41	48.7± 3.44	12.3± 0.81	0.25± 0.013	Acclimated to and tested in fresh-water.
	Medium (2.78—4.30) (3.80± 0.23)	7.20± 0.80	41.3± 1.55	12.6± 0.40	0.31± 0.016	,,
	Low (1.52—2.48) (1.90± 0.12)	1.4± 0.38	30.2± 1.01	13.5± 0.35	0.46± 0.024	,,

Discussion

The present study shows that in the case of crustaceans as well, the relative ammonia excretion, as evident from the A.Q. is increasing under hypoxic conditions, in agreement with earlier observation on fishes, *Tilapia mossambica* (Kutty, 1972) *Rhinomugil corsula* (Kutty and Peer Mohamed, 1975) and in gold fish and *Barbus sarana* (Peer Mohamed, 1974). Thus it appears that under anaerobic conditions induced by hypoxia there is increase in protein degradation and N-excretion in crustaceans as was suggested earlier (Kutty, 1972). It would appear that the ammonia produced may be of value in combating acidosis caused due to hypoxia and also perhaps in Na^+ conservation. In the two prawns tested there was clear increase in random activity under hypoxia but for the crab a decrease in activity was observed. This again suggests, as observed earlier in the case of teleosts *Chanos chanos* (Ameer Hamsa and Kutty, 1972) and *T. mossambica* (Peer Mohamed, 1974) that there is a dichotomy in behavioural evolution as evident from the two distinct paths in random-activity-ambient oxygen relation. Both kinds of behaviour can expected to be of value to the species concerned for survival, for increase in activity might allow the animal to escape from a hypoxic environment and decrease in activity might help the animal in conserving the limited source of oxygen available.

References

AMEER HAMSA, A. K. M. S. AND M. N. KUTTY. 1972. Oxygen consumption in relation to spontaneous activity in five marine teleosts. *Indian J. Fish.*, **19** : 76-85.

American Public Health Association 1965. Standard methods for the examination of water and waste water. *12th ed. A. P. H. A. Enc. New York.*

BEAMISH, F. W. H. 1964. Respiration of fishes with special emphasis on standard oxygen consumption, III. Influence of oxygen. *Can. J. Zool.*, **42** : 355-366.

——— AND MOOKERJI 1964. Respiration of fishes with special emphasis on standard oxygen consumption. I - Influence of weight and temperature on respiration of gold fish, *Carassius auratus* L. *Ibid.*, **42** : 161-175.

FRY, E. E. J. 1947. Pubs. Ont. *Fish. Res. Lab.* **68** : 1.

——— 1971. The effect of environmental factors on the physiology of fish, p. 1-98. *In* : W. S. Hoar and P. J. Randall (Eds.) *Fish Physiology*, Chapter, I. Vol. VI, Academic Press, New York and London.

FROMM, P.O. 1963. Studies on renal and extrarenal excretion in freshwater teleost, *Salmo gairdneri. Comp. Biochem. Physiol.*, **10** : 121-128.

HARWOOD, J. E. AND A. L. KUHN 1970 *Water research*, **4** : 805-811.

KING, E. N. 1965. The oxygen consumption of intact crabs and excised gills as a function of decreased salinity. *Comp. Biochem. Physiol.*, **15** : 93-103.

KINNE, O. (Ed.) : *Marine Ecology*, Wiley—*Interscience*, 1970-72. Vol. 1. London.

KUTTY, M. N. 1967. Oxygen consumption in the prawns, *Penaeus indicus* and *Penaeus semisulcatus. FAO Fish. Rep.*, **57** (3) : 957-969.

——— 1968. Respiratory quotients in gold fish and rainbow trout. *J. Fish. Res. Bd. Can. adv.*, **25** (8) : 1689-1728.

——— 1969. Oxygen consumption of mullet *Liza macrolepis* with special reference to swimming velocity. *Mar. Biol.*, **4** (3) :239-243.

——— G. MURUGABOOPATHY AND T. S. KRISHNAN 1971. Influence of salinity and temperature on the oxygen consumption in young juveniles of the Indian prawn *Panaeus indicus. Mar. Biol.*, 2(2) : 125-131.

——— PEER MOHAMED, M., K. THIAGARAJAN AND A. N. LEONARD. 1971a. Modification of Fry's Fish Activity Counter and Respirometer. *Indian J. exp. Biol.* **9** : 218-222.

——— 1972. Respiratory quotient and ammonia excretion in *Tilapia mossambica. Mar. Biol.*, **16** : 126-133.

——— and M. PEER MOHAMED 1975. Metabolic adaptations of mullet, *Rhinomugil corsula* (Hamliton) with special reference to energy utilisation. *Aquaculture*, **5** : 253-270.

LOFTS, B. 1956. The effect of salinity changes on the respiration of the prawn, *Palaemonetes varians* (LEECH) *J. exp. Biol.*, **33** : 730-736.

PEER MOHAMED, M. 1974. Influence of hypoxia on fish metabolism and activity ; *Ph. D. Thesis, Madurai University*, Madurai.

RAJABAI, K. G. 1961. Studies on the oxygen consumption in tropical poikilotherms, VI. Effect of starvation on the oxygen consumption of the freshwater field crab, *Paratelphusa* sp. *Proc. Indian Acad. Sci.*, **54 B** (6) : 276-80.

——— 1963. Studies on the oxygen consumption in tropical poikilotherms VII. Effect of starvation on temperature response of metabolism in the fresh water crab, *Paratelphusa*, sp., *Ibid.* **58** : 207-214.

RAMAMURTHI, R. AND A. T. SAINATH JANAK 1973. Metabolism of fresh water crab, *Paratelphusa hydrodromus* (Herbst) in relation to size, sex, season and dirunal rhythm. *Ibid.*, **78** B, 6, 275-281.

RAO, K.P. 1958. Oxygen consumption as a function of size and salinity in *Metapenaeus monoceros* from marine and brackishwater environments. *J. Exp. Biol.*, **35** : 307-313.

REEVE., M. R. 1969. The Laboratory culture of the prawn *Palaemon serratus. Fishery Investigations, Series* II, **26** (i) : 1-38.

SPOOR, W. A. 1946. A quantitative study of the relation between the activity and oxygen consumption of the gold fish and its implications to the respiratory metabolism in fishes. *Biol. Bull.*, **91** : 321-325.

SUBRAHMANYAM, C. B. 1957. Relationship between the body weight and the oxygen consumption in *Emerita asiatica* (Milne-edwards). *Curr. Sci.*, **26** : 155-156.

——— 1962. Oxygen consumption in relation to body weight and oxygen tension in the prawn *Penaeus indicus* (Milne-edwards). *Proc. Indian Acad. Sci.* (Sect. B), **55** : 152-161.

VERNBERG, F. J. AND W. B. VERNBERG 1972. *Environmental physiology of marine animals* : New York : Shinger-verlag. 346 pp.

WOLVE KAMP, H. P. AND T. H. WATERMAN 1960. Respiration. *In* : T. H. Waterman (Ed.) *The Physiology of Crustacea* Vol. I, pp. 35-100. Academic Press, New York.