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Influence of Ambient Oxygen on Respiratory Quotient and Survival of Some South Indian Snakes

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Routine O_2 consumption and CO_2 production of four South Indian snakes at 28–30°C in general showed dependence on ambient oxygen, eventhough CO_2 production was less influenced by oxygen. With reduction in ambient oxygen the respiratory quotient (RQ) increased above unity in all cases. Routine RQ's of one-week starved *Echis carinatus, Eryx johnii, Argyrogena fasciolatus* and *Eryx conicus* under adequate oxygen conditions, were 0.91, 0.86, 0.85 and 0.74 respectively. Anaerobic capacity was high for *E. conicus* and *A. fasciolatus*, which displayed high R Q's under hypoxia and longer survival times (7 and 5 hr respectively) under an atmosphere of nitrogen. *Echis carinatus*, the only poisonous snake tested, displayed lowest hypoxic RQ's and anoxic survival time 15 min.

Key Words: **RQ, Anoxia, PO_2, Snakes,** *Eryx conicus, Eryx johnii, Argyrogena fasciolatus, Echis carinatus,* **Anaerobic metabolism**

Introduction

Apart from the early references (Aubert 1881, Pfluger 1875) recent studies have brought anaerobic metabolism and anoxic survival of lower vertebrates into focus (Blazka 1958, Bellamy & Peterson 1968, Kutty 1968, Hochachka et al. 1972). There does not appear to be any study on the metabolism and survival of snakes under hypoxic and anoxic conditions. However, there are several reports on the normoxic metabolism of snakes especially with reference to O_2 consumption (Baldwin 1930, Vinegara, Hutchinson & Dowling 1970, Rebach 1973). We are reporting here our observations on respiratory quotient (RQ) of two species of sand boas, *Eryx conicus* (Schneider), *Eryx johnii* (Russel), banded racer, *Argyrogena fasciolatus* (Shaw) and saw-scaled viper, *Echis carinatus* (Schneider) under different oxygen concentrations and

**Present address*: School of Biological Sciences, Madurai University, Madurai 625021 their survival under an atmosphere of nitrogen.

Materials and Methods

Among the four species included in this study the saw-scaled viper is deadly poisonous. The snakes were collected from Madurai and Palayamkottai (Tamil Nadu) during the month of February 1978 and the experimentation was continued up to August 1980. The animals starved for one week were put in respirometers of sizes ranging from 180 ml to 16 L. depending on the size of the snakes. Various ambient oxygen conditions were obtained by filling the respirometers in different ratios of nitrogen to air. Metabolic rates were obtained 12 hr after the test animal was put in respirometer. Gas samples were taken from the closed respirometer and analysed for oxygen and carbon dioxide in a modified Fry gas analyser (Fry et al. 1949). Anoxic survival of the snakes were tested by obtaining the time of asphyxiation in an atmosphere of nitrogen (commercial quality, Indian Oxygen Limited—no attempt was made to purify the nitrogen). During the period of experimentation the ambient temperature ranged from 28.5 to 31.0°c.

Results and Discussion

Routine values of O_2 consumption and CO_2 production of the four species of snakes at various partial pressures of ambient oxygen (PO_2) are shown in (figure 1). In general O_2 consumption is dependent on ambient oxygen while CO_2 production is less so. In all the species a higher CO_2 production than O_2 consumption at lower PO_2 is evident as indicated by the hatched areas between the smoothed lines drawn through the O_2 consumption and CO_2 production values, as again could be judged from the RQ plots (figure 2).

Table 1 *Routine O_2 consumption and RQ of snakes in ambient PO_2 near that of atmosphere and 29 ± 1°L. Numbers in brackets indicate the number of determinations*

Snake-species	O_2 consumption ml/kg/hr	RQ
Saw-scaled viper (*Echis carinatus*)	83.2 ± 34.1	0.91 ± 0.04 (3)
Banded racer (*Argyrogena fasciolatus*)	630.7 ± 58.1	0.86 ± 0.14 (3)
John's sandboa (*Eryx johnii*)	82.6 ± 14.5	0.85 ± 0.05 (4)
Russel's sandboa (*Eryx conicus*)	357.9 ± 38.1	0.75 ± 0.04 (6)

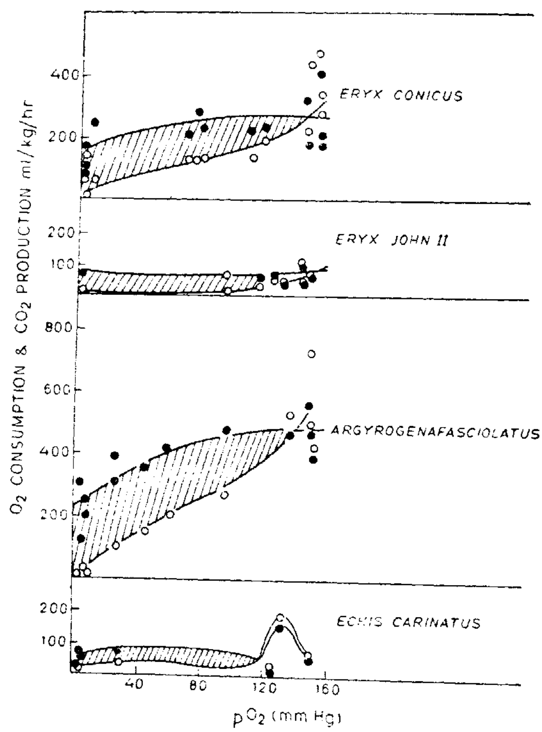

Figure 1 Routine oxygen consumption (open circles) and carbon dioxide production (closed circles) in sand boas, *Eryx conicus* (281.5 g) and *Eryx johnii* (30.5 g), banded racer, *Argyrogena fasciolatus* (32.2 g; 12.4 g) and saw-scaled viper, *Echis carinatus* (14.1 g; 28.5 g) at various partial pressures of ambient oxygen. Each point denotes a single determination of metabolic rate. All measurements were made at room tempearture, 29 ± 1°C

There is almost an 8 fold difference in the levels of routine O_2 consumption of the different species of snakes in relatively high oxygen (figure 1, table 1). Size effect cannot account for the differences in metabolic rates as, for example, the smaller *E. johnii* (31 g) had a much lower metabolic rate than the larger *E. conicus* (282 g). From general observations the banded racer appeared to be most agile; this snake had the highest metabolic rate as well. The metabolic rates, however, need not be taken entirely as species-specific, since the routine rates would be related to the levels of random activity of the snakes corresponding to the periods of metabolism measurement (Fry 1947).

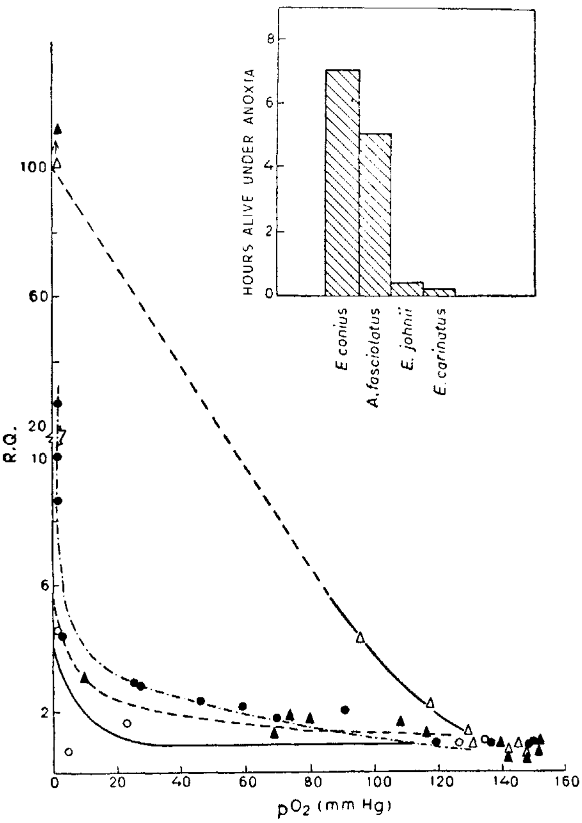

Figure 2 Respiratory quotients of *Eryx conicus* (closed triangles), *E. johnii* (open tiriangles), *Argyrogena fasciolatus* (closed circles) and *Echis carinatus* (open circles), Values correspond to data presented in figure 1. The inset shows survival times (times to asphyxiation) of the various snakes in nitrogen for the same snakes used for metabolism measurements

Routine RQ's of the snakes tested at PO_2 near that of atmosphere (135 to 160 mm Hg) are close to unity (table 1). At lower PO_2 the RQ increases over unity, the nature of the rise in RQ with decrease in PO_2 being different for the various species tested. Thus the curves in figure 2 can be taken as characteristic of the species concerned as has been shown in other lower vertebrates (Kutty 1972, Mohamed 1974). Assuming an average aerobic RQ value near unity, the higher the elevation of the RQ curve over unity, the higher is the intensity of anaerobic metabolism, but the total anaerobic ability can be estimated only with the information on time for which the high RQ is sustained. The RQ's reported were measured over periods of closure (ca. 1 hr) of the respirometer. However, survival times under 'complete' anoxia are available (inset, figure 2). Considering the values available, *Echis carinatus* has the lowest intensity of anaerobic metabolism, hypoxic RQ's being close to unity down to almost 20 mm PO_2; this snake survived for the shortest time under an atmosphere of nitrogen. The curves for hypoxic RQ of *A. fasciolatus* and *E. conicus* are more elevated than that of *Echis*. Both *E, conicus* and *A. fasciolatus* survived for fairly long periods in an atmosphere of nitrogen (7 and 5 hr respectively). *Eryx conicus* has evidently better capacity for anaerobiosis, for it recovered after asphyxiation, but *A. fasciolatus* did not. The most highly elevated RQ—PO_2 curve is that of *E. johnii*, the point of elevation from an RQ of unity being about a PO_2 of 140 mm. *Eryx johnii* sustains perhaps the highest intensity of anaerobiosis, but its capacity for survival without oxygen was found to be small. It must, however, be pointed out that the 6 month-old snake tested was reared in captivity from its birth.

The RQ's near unity (table 1) observed in snakes tested at PO_2 levels near that of atmosphere are indicative that they are oxidising a mixture of substrates. Since all the test animals were starved for a week these can be generally expected to use more of fat and protein, but the value for *E. conicus* only provides evidence for this. The extra CO_2 released in snakes under low PO_2 must have obviously been displaced from the alkaline (bicarbonate) reserve by the acid produced from glycolysis. But it is likely that other systems of organic carbon dioxide release which are more efficient than glycolysis in energy liberation, are also involved (Blazka 1968, Hochachka & Somero 1973, Kutty & Mohamed 1975).

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