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BIMODAL GAS EXCHANGE AND SOME BLOOD PARAMETERS IN THE INDIAN AIR-BREATHING FISH, *OSPHROMENUS OLFAX* (DAY)

Osphromenus olfax is an exotic species introduced in Madras in 1886. Its air-breathing habit was first mentioned by Day[1]. No information is available on the respiratory patterns and blood parameters of this fish. An attempt has been made to study the bimodal gas exchange and respiratory adaptations of the blood in *O. olfax* and the results are reported here.

O. olfax weighing 10 to 15 g were collected from local fresh water sources and acclimated to the laboratory conditions for 10 days at 28 ± 1° C. The fishes were fed every other day and water in the aquaria was renewed once a week. Feeding was stopped a day before the fishes were used in the experiments. Each fish was transferred from the acclimation tank to the respirometer at least 12 h before the experiment and kept in running water overnight. The oxygen consumption of the fish in air was measured with a simple respirometer using manometric techniques (Umbreit *et al.*[14]). The oxygen consumption with no access to air was studied using the method of Job[3]. The aerial and aquatic respirations were measured when fishes were in water with access to air using the apparatus described in an earlier publication[8]. Oxygen consumption from water was found by estimating the loss of oxygen using Winkler's method (Welsh and Smith[16]) and oxygen consumed

TABLE I

Oxygen consumption of O. olfax (*cc/kg/h* ± *S.E.*)
N = 20

Oxygen consumption	Water	Air	Total oxygen consumption
From air	..	148·40 ± 4·66	..
From water with access to air	68·10 ± 3·72 (31%)	152·30 ± 5·20 (69%)	220·40 ± 8·46
From water without access to air	74·68 ± 3·80	..	..

TABLE II

Blood characteristics

Blood parameters	Male + female	Male	Female
Haemoglobin (Hb) (gm%)	16·60 ± 0·782	17·80 ± 1·020	15·87 ± 0·670
Mean corpuscular haemoglobin concentration (MCHC) (%)	30·20 ± 1·20	31·06 ± 1·16	29·64 ± 1·30
Haematocrit (Hct) (%)	48·6 ± 1·28	48·60 ± 1·34	46·82 ± 0·932
Oxygen capacity (Vol %)	17·32 ± 0·575	18·82 ± 0·463	16·30 ± 0·394
Red blood corpuscle (RBC) (× 10⁶ m/c mm)	3·20 ± 0·630	3·40 ± 0·542	2·70 ± 0·460
Standard bicarbonates (mM/l) pH = 7·60	34·20 ± 1·40	35·52 ± 1·20	33·80 ± 1·00

Values expressed are mean ± S.D. for 6 individual observations.

from air was determined using a manometer connected to the gas phase. All measurements were made at $28 \pm 1°$ C. Sex was taken into consideration only for blood analyses.

For analysis, blood was collected by cardiac puncture in heparinised vials and processed for the estimation of haemoglobin (Hb), haematocrit (Hct), mean corpuscular haemoglobin concentration (MCHC), oxygen capacity and standard bicarbonates following Lenfant and Johansen[5]. Red cell count was made with Neubauer crystalline counting chamber.

O. olfax is an obligate air breather coming to the surface at irregular intervals to gulp air. Intervals between air breaths vary between 5 and 25 minutes, depending on the oxygen content of the water and of the air. If prevented from reaching the surface, the fish struggle violently and prolonged prevention from air breathing is known to kill it. Under laboratory conditions, the major proportion of the oxygen requirement of *O. olfax* was met by the air breathing organs, and gills play a minor role to the tune of about 31% in the gaeous exchange. The present results can be compared with those from other bimodal breathers. At about 29° C, the climbing perch, *Anabas scandens*[8], an obligate air breather with degenerate gills, shows about 20% of the oxygen uptake *via* gills and 80% by the air breathing organs. In *Channa gachua*[9], the gills contribute 21% to the oxygen uptake at 29° C. The gills in *Osphromenus* based at 28° C contribute about 31% to the total oxygen uptake.

With regard to the blood parameters, there is a clear-cut difference in the two sexes. Generally, they are higher in male fishes than in females. The level of haemoglobin in *Osphromenus* varies from 15·87–17·80 gm%. Some of the values of Hb gm% mentioned for other air-breathing fishes are: 12–20 for *Ophiocephalus*[11], 10–19·8 for *Anabas*[2], and 14·30–19·0 for *Lepidocephalus*[16]. The higher concentration of Hb appears to be its obligatory air breathing habit and habitat in water of low oxygen content. The high oxygen capacity reflects an adaptation towards oxygen deficient ambient conditions.

The haematocrit ranges from 46·82–48·60%. Figures given for other air-breathng fishes are: 50–61·76% for *Lepidocephalus*[16], and 60 to 70% for *Ophiocephalus*[11].

The number of red blood corpuscles in *Osphromenus* is well within the limits given by Mott[7] in general. It ranges in teleostean fishes from 0·61 to 6·13 millions/mm^3[3–12]. Values for some other air breathing fishes are: 3·34–7·06 for *Anabas*[2], 2·15 for *Heteropneustes*[10], 1·71 for *Amphipnous*,[13] and 1·45–2·06 for *Lepidocephalus*[16].

The bicarbonate level (33·80–35·52 mM/l) is generally high and is simlar to that found in other air breathing fishes, such as the African lung fish *Protopterus aethiopicus* (30 mM/l)[5], and the electric eel, *Electrophorus electricus* (12·5–33·5 mM/l)[6]. Fishes which depend only upon water breathing have low carbon dioxide tension and plasma bicarbonate concentration. This is necessitated by the low solubility of oxygen in water compared with that of carbon dioxide. With aerial respiration, however, such carbon dioxide limits no longer apply and in fact should be considerably higher.

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