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A comparative study of hematology of three air-breathing fishes

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Abstract. The blood parameters like haemoglobin level, hematocrit value and erythrocyte count were estimated in the three air-breathing fishes, *Anabas scandens* (Cuvier), *Ophiocephalus gachua* (Hamilton-Buchanan) and *Mystus vittatus* (Bloch). *A. scandens* possesses a higher haemoglobin level than the other two. Hematocrit values also follow the same trend. Maximum erythrocyte count is also obtained for *A. scandens*.
The higher values of haemoglobin content, hematocrit and erythrocyte counts in *A. scandens* and *O. gachua* are suggested to serve as rich oxygen stores simulating diving syndromes among higher vertebrates, besides reflecting an adaptation to the mixed condition of systemic arterial blood.

Keywords. Hematology; *Anabas scandens; Ophiocephalus gachua; Mystus vittatus.*

1. Introduction

Studies on blood parameters like haemoglobin content, hematocrit, erythrocyte count, mean erythrocyte haemoglobin content, oxygen capacity have revealed adaptive features correlated with the relative importance of air- and water-breathing. Purely aquatic breathers have been shown to possess generally lower levels of haemoglobin content and oxygen capacity in contrast to the air-breathing fishes (Lomholt and Johansen 1976). A definite tendency for haemoglobin content and oxygen capacity to be higher in air-breathing teleosts has been disclosed by the studies of Lenfant and Johansen (1972).

The number of species of air-breathing fishes, so far explored on this aspect, is too small compared to the large number of about 140 extant species. Attempts have, therefore, been made in the present investigation to estimate the blood haemoglobin content, oxygen capacity, hematocrit, erythrocyte count and mean erythrocyte haemoglobin content in the three air-breathing fishes, *Anabas scandens* (Cuvier), *Ophiocephalus gachua* (Hamilton-Buchanan) and *Mystus vittatus* (Bloch) and also to correlate these parameters with their air-breathing habits.

2. Materials and methods

Samples of *A. scandens* (size range: 16–30 g), *O. gachua* (size range: 16–35 g) and *M. vittatus* (size range: 9-16 g), collected from local ponds were maintained in separate cement cisterns at 28±1°C and fed with boiled eggs and earthworms alternatively, every two days. Feeding was stopped one day before the fishes were used in the experiments.

2.1. *Blood sampling*

Fishes were taken from the cement cisterns and the required amount of blood was collected by cardiac puncture using a heparinized syringe.

2.2. *Estimation of haemoglobin content of blood*

Haemoglobin content in blood was estimated using Sahli Hemometer (Superior, Germany) with permanent coloured glass comparison standards.

2.3. *Estimation of hematocrit*

Hematocrit value of blood was determined by centrifuging blood in heparinised hematocrit tubes (Germany) at 7,000 rev/ min for 20 min. From the volume of blood taken and the cell volume after centrifugation, hematocrit percentage was calculated.

2.4. *Estimation of percentage mean erythrocyte haemoglobin content*

The percentage mean erythrocyte haemoglobin content was computed using the values of haemoglobin content and hematocrit as follows:

$$= \frac{\text{Haemoglobin (g/100 ml)}}{\text{Hematocrit percentage}} \times 100 \text{ (Seiverd 1964)}$$

2.5. *Estimation of oxygen capacity of blood*

Oxygen capacity of blood has been computed by multiplying the haemoglobin content with the oxygen combining power of 1·25 ml of oxygen per gram of haemoglobin (Johansen 1970).

2.6. *Erythrocyte count*

For enumeration of erythrocytes, hemocytometer (Hellige, West Germany) with improved Neubauer ruling was used. The number of erythrocyte was counted and represented in million of cells per cubic mm of blood.

3. Results

The values of various blood parameters obtained for the air-breathing fishes, *A. scandens*, *O. gachua* and *M. vittatus* are given in table 1. It could be noted that *A. scandens* possesses normally a higher haemoglobin level of 11·58±0·370 gm/100 ml of blood compared to 9·5±0·61 gm/100 ml of blood in *O. gachua* and 6·1±0·21 gm/100 ml of blood in *M. vittatus*. Higher values of hematocrit (34·30±1·678%) and

Table 1. Values of some blood parameters of *A. scandens*, *O. gachua* and *M. vittatus* (number of observations in parentheses).

Species	Haemoglobin content g/100 ml of blood ± S.E.	Hematocrit %± S.E.	Erythrocyte count. million cells/ cubic mm of blood	Computed mean erythrocyte haemoglobin content (%)	Computed oxygen capacity vol. %
A. scandens	11·58 ± 0·370 (18)	34·30 ± 1·678 (12)	4·95 ± 0·50 (10)	33·7	14·48
O. gachua	9·5 ± 0·61 (12)	33·33 ± 1·64 (12)	4·79 ± 0·56 (11)	28·5	11·88
M. vittatus	6·1 ± 0·21 (12)	26·69 ± 1·13 (12)	3·61 ± 0·14 (12)	22·8	7·63

erythrocyte count (4·95±0·50 million cells/cubic mm of blood) recorded in *A. scandens* were, however, not significantly different ($P>0{\cdot}05$) from the values obtained for *O. gachua*. Hematocrit values and erythrocyte counts were 33·33±1·64% and 4·79±0·56 million cells/cubic mm of blood, respectively in *O. gachua* (table 1). Mean erythrocyte haemoglobin content was found to be higher in *A. scandens* (33·7%) compared with *O. gachua* (28·5%) and *M. vittatus* (22·8%). The computed values of oxygen capacity also revealed higher value for *A. scandens* (14·48 vol %) compared to *O. gachua* (11·88 vol%) and *M. vittatus* (7·63 vol%).

4. Discussion

Based on the hematological studies of various workers on water- and air-breathing fishes, Dubale (1963) concluded that air-breathing fishes, particularly teleosts, possessed a higher oxygen-holding capacity than the non-migratory water-breathing fishes. Lenfant and Johansen (1972) have also shown that there is a tendency for haemoglobin concentration to be higher in those fishes which get their oxygen from air.

The results obtained in the present investigation lend support to the above conclusions. The three species investigated here, show a correlation between the haemoglobin content and the degree of dependency on atmospheric gas exchange. *A. scandens*, with maximum dependency on atmospheric air to the tune of 80% of its oxygen requirement (Reddy and Natarajan 1970), showed maximum haemoglobin content (11·58±0·370 g/100 ml) in contrast to *M. vittatus* depending on aerial gas exchange to the tune of about 33% (Ramaswamy and Reddy 1977) which contains only 6·1±0·21 g Hb/100 ml of blood. *O. gachua*, which is intermediate, extracting 71% of its total oxygen requirement from air (Ramaswamy and Reddy 1978), has been shown to possess 9·5±0·61 mg Hb/100 ml of blood.

The erythrocyte count is higher in the two predominantly air-breathing species, *A. scandens* and *O. gachua* compared to *M. vittatus*, which is a poor air-breather. The erythrocyte counts of *A. scandens* and *O. gachua*, however, did not reveal any significant difference. The lack of difference in erythrocyte count appears to be compensated by *A. scandens* with a higher percentage of mean erythrocyte haemoglobin content (33·7%), compared to that of *O. gachua* (28·5%), indicating a better adaptation correlated to its greater dependency on aerial gas exchange.

The catfish, *M. vittatus*, a facultative air-breather, with no specialised accessory respiratory organs, showed relatively low values of haemoglobin content (6·21±0·21 gm/100 ml of blood). Similar low values were reported by Haws and Goodnight (1962) for the two catfishes, *Ictalurus punctatus* (6·6 g/100 ml) and *Ictalurus nebulosus* (6·9 g/100 ml). The lower values of haemoglobin content together with lower values of erythrocyte count (3·61±0·41 million cells/cu. mm of blood) in *M. vittatus* could be suggested to reflect its predominant water-breathing nature.

The tendency for oxygen capacity to be higher in air-breathing teleosts, has been considered by Krogh and Leitch (1919) to reflect the habitats of the fishes, particularly the degree of oxygen deficiency of the ambient medium. The higher values of haemoglobin content and oxygen capacity of obligate air-breathers may not suggest an adaptation towards oxygen-deficient ambient conditions as they use the atmosphere as the main source of oxygen. However, these tendencies suggest a comparison with the diving animals among higher vertebrates which, owing to their high oxygen capacities, increase their oxygen stores and consequently extend the time between surfacings (Johansen 1970).

Johansen *et al* (1968), working on *Electrophorus*, also suggested that the high oxygen capacity of blood is an adaptation to the mixed condition of systemic arterial blood resulting from the huge shunting of oxygenated blood to the systemic veins. In such a situation the arterial blood would never get fully saturated, reducing the efficiency of gas transport system. High haemoglobin content and oxygen capacity could then prove to be of great adaptive significance. In *A. scandens* and *O. gachua*, the efferent vessels from air-breathing organs are connected to systemic veins as in the case of *Electrophorus*, resulting in arterial perfusion with mixed blood (Johansen 1970). Higher values of haemoglobin and oxygen capacity obtained for these two species may, therefore, be suggested to be an adaptation to the mixed condition of systemic arterial blood, as suggested for *Electrophorus* by Johansen *et al* (1968) and Johansen (1970).

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