

means of immunological defence of fish against cadmium may be attributed to our present observation. It is interesting to note the disaggregation of thrombocytes in the blood of fish treated with higher concentrations of $CdSO_4$ (figure 2) when compared to that of normal fish (figure 1). The *in vitro* observations^{1,2} on the platelet disaggregating action of $CdCl_2$ strongly support our *in vivo* observation on the thrombocyte disaggregating capacity of cadmium in the fish.

The cytological shift in lymphocytes in mice and rats³ towards an increase in lymphocytes as a means of immunological defense explains the leucocytic response to cadmium observed in the fish *Badis buchanaani*. The dose response increase in lymphocytes and a corresponding decrease in thrombocytes may be related to an increase in the body defense or immunological competency of the fish against cadmium. Differential blood cell counts could usefully indicate early detection of adverse environmental effect of cadmium on fish.

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BIMODAL OXYGEN UPTAKE AND SOME BLOOD PARAMETERS IN THE BUEBLE NEST BUILDER, *TRICHOGASTER PECTORALIS* (REGAN)

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TRICHOGASTER pectoralis is an exotic species introduced in Tamil Nadu by the State Fisheries department. A native of Thailand and Cambodia, the species established itself in almost all the freshwaters of the state. The air breathing modifications of this fish include the so-called labyrinth organs and the well vascularized epithelium covering the labyrinth organs and the supra branchial chamber. The air breathing habit of the fish was first mentioned by Bader¹. But no information is available on the bimodal oxygen consumption and blood parameters of this fish. In the present investigation an attempt has been made to study the bimodal oxygen uptake and the respiratory adaptations of the blood in *T. pectoralis* and the results are reported here.

Specimens of *T. pectoralis* weighing 10–15 g collected from local freshwater sources were maintained in plastic aquaria at $29 \pm 1^\circ C$ and fed with boiled eggs and earthworms alternatively, every two days. Feeding was discontinued one day before the fish were used in the experiments. The aquatic oxygen consumption of the fish was studied by measuring the loss of oxygen and the rate of flow of water through the respiratory chamber, in a continuous flow system as adopted by Job². Oxygen content of water samples was estimated using Winkler's method. The aerial oxygen uptake by the fish was measured with a simple respirometer using manometric techniques. Oxygen uptake from air and water was also measured simultaneously, when the fish was in water with access to air using respiratory chambers designed by Reddy and Natarajan³. Oxygen consumption from water was determined by estimating the loss of oxygen using Winkler's method and oxygen consumed from the air was determined using a manometer connected to the gas phase. In all manometric measurements, pressure changes in the gas phase of the respiratory chamber due to extraneous factors were corrected by a thermobarometer. The respiratory chambers were thermostated by immersion in a temperature controlled bath throughout the period of experimentation. All measurements were made at $29 \pm 1^\circ C$ and sex was considered only for blood analyses.

Blood samples were collected by cardiac puncture using a heparinised needle and processed for the estimation of haemoglobin (Hb), haematocrit (Hct), mean corpuscular haemoglobin concentration (MCHc), oxygen capacity and standard bicarbonates following Lenfant and Johansen⁴. Red cell count was

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made with Neubauer Crystalline counting chamber.

Undisturbed *T. pectoralis* under laboratory conditions surfaced to breathe approximately once every 3.5 min with a mean apnoea length of 3.8 ± 1.2 min. The respiratory act consisted first of breaking the water surface with the mouth, followed immediately by the expiration of gas from the suprabranchial chambers. After rapidly inspiring the fish left the surface, the entire process of labyrinth ventilation requiring less than 1/3 sec. If prevented from reaching the surface, the fish struggles violently and prolonged prevention from air breathing is known to kill it. Under laboratory conditions, the major proportion of oxygen requirement of *T. pectoralis* was met by the air breathing organs, and gills play a minor role to the tune of about 36% in the gaseous exchange (table 1). Greater participation of air breathing organs under bimodal conditions (upto 80%) has been recorded in *Anabas scandens*³, *Channa gachua* (75%)⁵ and *Osphromenus olfax* (69%)⁶.

TABLE 1

Oxygen consumption of *T. pectoralis*
(cc/kg/h ± S.E.) N = 15

Oxygen consumption	Water	Air	Total oxygen consumption
From air	—	110.68	—
	De 4.21		
From water with access to air	55.26 ± 1.97 (36%)	99.74 ± 3.83 (64%)	155.00 ± 5.20
From water without access to air	68.14 ± 2.91	—	—

There is a marked difference in the blood values of two sexes (table 2). Generally, they are higher in the male than in the female. Yadav *et al.*⁷ have also reported significant differences in blood parameters between sexes of fishes. When compared with other freshwater fish⁸, the blood values are higher in both the sexes. The level of Hb in *Trichogaster* varies from 12.96–14.50 g/100 ml. Some of the values of Hb g/100 ml mentioned for other airbreathing fishes are: 11.58 for *Anabas*, 9.5 for *Ophiocephalus* and 6.1 for *Mystus*⁹. The higher concentration of Hb appears to be an adaptation to the obligatory air breathing habit and habitat in water of low oxygen content. The high oxygen capacity reflects an adaptation towards oxygen deficient ambient conditions.

TABLE 2

Blood characteristics

Blood parameters	Male + female	Male	Female
Haemoglobin (Hb) (g/100 ml)	13.21 ± 0.80	14.50 ± 1.02	12.96 ± 0.90
Mean corpuscular haemoglobin concentration (McHc) (%)	31.34 ± 1.32	33.50 ± 1.57	30.17 ± 1.48
Haematocrit (Hct) (%)	37.60 ± 1.70	39.02 ± 1.98	36.23 ± 1.22
Oxygen capacity (Vol. %)	15.48 ± 0.62	14.32 ± 0.43	13.90 ± 0.31
Red blood corpuscle (RBC) (× 10 ⁶ m/cmm)	4.80 ± 0.60	4.76 ± 0.91	4.21 ± 0.23
Standard bicarbonates (mm/l) pH = 7.6	33.26 ± 1.41	34.90 ± 1.19	32.73 ± 1.02

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

The Mchc is also considered as a valuable parameter to correlate the degree of dependency on atmospheric gas exchange in air breathing fish. In the present study, both male and female fish showed a high percentage of Mchc, compared to that of *Ophiocephalus gachua* (28.5%) and *Mystus vittatus* (22.8%)⁹, indicating a better adaptation correlated with their greater dependency on aerial gas exchange. The mean Hct ranges from 36.23–39.20%. Figures given for other air breathing fishes are: 60–70% for *Ophiocephalus*⁸, 50–61.76% for *Lepidocephalus*⁷ and 46.62–48.86% for *Osphromenus*⁶. The number of red blood corpuscles in *Trichogaster* is well within the limits given by Mott¹⁰ in general. It ranges in teleostean fish from 0.61 to 6.13 millions/mm. Values for some other air breathing fish are: 2.70–3.40 for *Osphromenus*⁶ and 4.95 for *Anabas*⁹.

The bicarbonate level (32.73–34.90 mM/l) is generally high and is similar to that found in other air breathing fishes, such as the African lung fish, *Protopterus aethiopicus* (30 mM/l)⁴ and *Osphromenus olfax* (33.80–35.52 mM/l)⁶. Fish 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. With aerial respiration, however, such carbon dioxide limits no longer apply and in fact should be considerably higher. An adaptive increase in buffering capacity with increased importance of air breathing in fishes is also reported and bicarbonates acting as buffering

agents in blood are demonstrated for air breathing fishes *Anabas* and *Ophiocephalus*¹.

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BLOOD VOLUME OF A FRESHWATER FIELD CRAB AS A FUNCTION OF SALINITY ADAPTATION

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HAEMOLYMPH volume measurements in crustaceans were restricted only to marine amphipods^{1, 2} and cryfish³. No information on blood volume is available with reference to crabs. In this study, an attempt has been made to note the haemolymph volume in a freshwater field crab with reference to sex and salinity adaptation.

Paddy field crabs, *Oziotelphusa senex senex* were adapted to full strength artificial seawater⁴ for 3 months as described earlier⁵. Haemolymph of the adult crabs (about 15 g size) was drawn into hypodermal syringe through arthroal membrane for biochemical analysis. Protein was estimated according to Lowry *et al.*⁶ and the total amino acid content was estimated colorimetrically⁷. For the determination of haemolymph volume 0.5 ml containing 5 μ Ci of ¹⁴C-sucrose (supplied by BARC, Bombay) was injected into a crab, and after a known time, the blood was drawn,

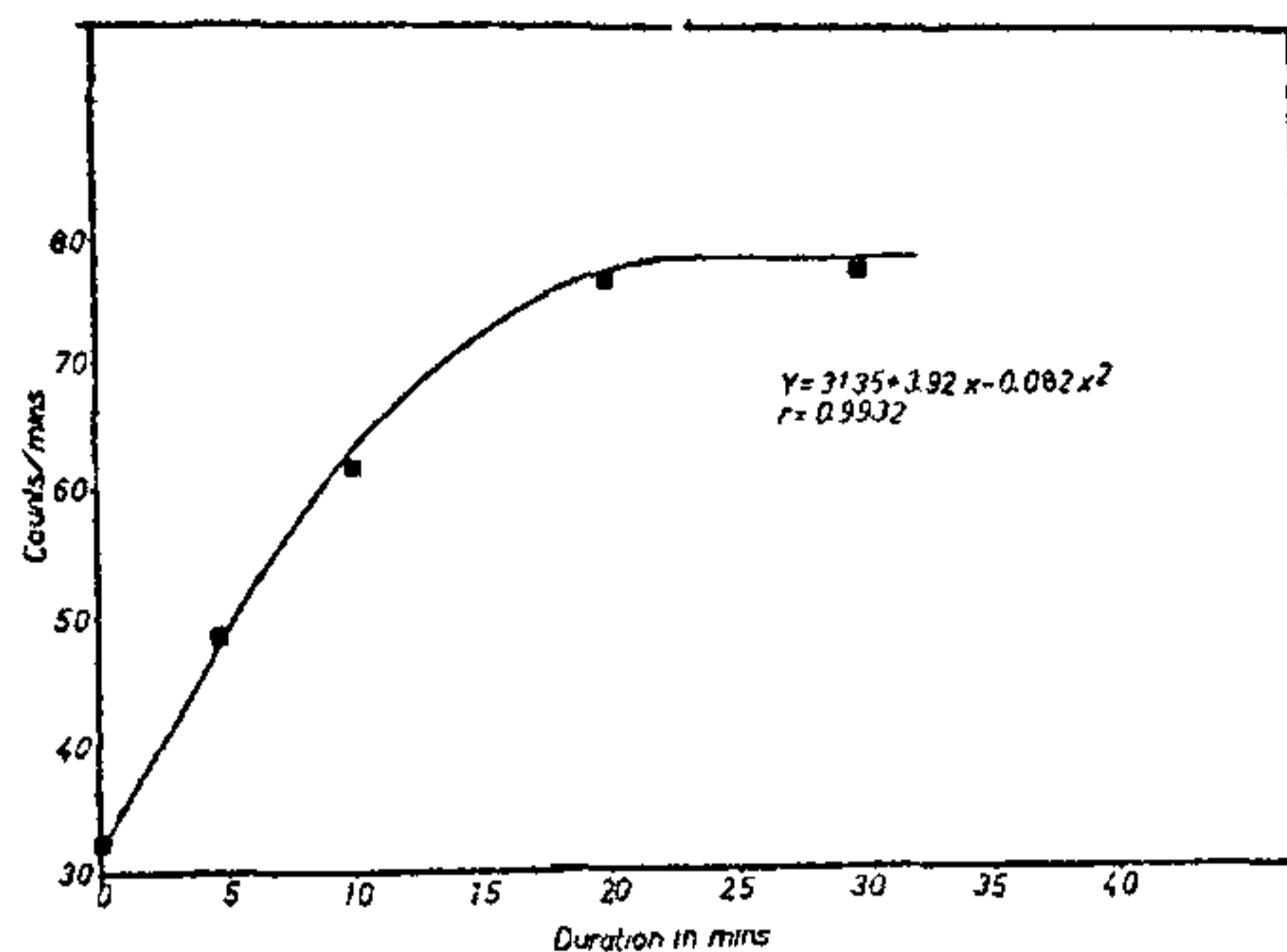


Figure 1. Circulation time taken by ¹⁴C-sucrose to reach equilibration in blood.

TABLE I

Blood volume changes in the crab, *Oziotelphusa senex senex* on account of salinity adaptation

Crab	No. of crabs used	ml blood/100 g body weight
Freshwater male	7	46.3 ± 5.95
Seawater male	7	21.2 ± 2.0
Freshwater female	11	42.1 ± 3.28
Seawater female	11	20.3 ± 5.3

dried in a desiccator and the radioactivity of the flake was estimated using a glass flow counter (Burshane, Trombay Electronics). By this isotope dilution, the haemolymph volume of the adult crab in relation to sex and salinity was estimated.

Figure 1 demonstrates the total equilibrium time of the isotope in the circulating fluids of the crab. It is clear from this graph, that within 20 min, the equilibration is reached. In subsequent experiments this time was taken to draw blood and to estimate the radioactivity. Blood volume was significantly ($P < 0.001$) reduced in both male and female crabs on adaptation to higher salinity (table 1).

The protein content of the haemolymph increased significantly ($P < 0.001$) on adaptation to higher salinity, whereas the total amino acid content remained unaltered (table 2).