BLOOD ANALYSES OF SOME ANTARCTIC FISH

By INIGO EVERSON *and* R. RALPH

THE blood of Antarctic fish is of particular interest because it is now well known that species of the family Chaenichthyidae are without erythrocytes, haemoglobin or any other respiratory pigment in their blood (Matthews, 1931, p. 36; Ruud, 1954, 1959, 1965). Martsinkevich (1958) cast some doubt on the absence of erythrocytes in these fish, and Hureau (1966) has definitely confirmed their presence in the blood of *Chaenichthys rhinoceratus*; however, they are very fragile and few in number, and it is clear from the work of Ruud (1959) that chaenichthyids carry oxygen in their blood in physical solution and the erythrocytes that Hureau described are functionally insignificant.

Several workers have examined the blood of other Antarctic fish and they have drawn attention to the lower concentrations of haemoglobin and the reduced numbers of erythrocytes present compared with fish from tropical and temperate waters (Tyler, 1960; Kooyman, 1963; Hureau, 1966).

During a study on the respiratory metabolism of a chaenichthyid, *Chaenocephalus aceratus*, and some other nototheniid fish, blood analyses were made on some Antarctic fish for which no previous data are available. The results of these analyses are given in this paper. Some results are also given for fish caught north of the Antarctic Convergence, at Port Stanley in the Falkland Islands.

MATERIALS AND METHODS

Fish were caught at the following localities in British Antarctic Territory during the Antarctic summer 1966–67: Signy Island, Argentine Islands, Deception Island, Port Lockroy, Admiralty Bay and King Edward Point (South Georgia). In addition, a small number of fish was caught in the Falkland Islands.

The fish were caught on long lines, hand lines and in traps, but only trap-caught and lively, lip-hooked specimens were used for these analyses. At Signy Island some of the fish were kept in tanks for several weeks before samples were taken but at the other stations the fish were used on capture. Blood samples were taken directly from the heart, using disposable syringes, and they were mixed with anti-coagulant (3·8 per cent sodium citrate) in the ratio 6 : 1 by volume. A correction was applied to the results for this dilution. For the erythrocyte count the blood was diluted 1 : 200 in a Thoma red-cell pipette using Young's marine teleost saline (Hale, 1958, p. 92), and the cells were counted on a Thoma haemocytometer. The haemoglobin concentration was estimated by the Sahli acid haematin method. This method has the disadvantage that the observed readings are high because fish erythrocytes are nucleated and the nuclei increase the turbidity of the sample. To overcome this, the readings were corrected using the factor proposed by Larsen and Snieszko (1961) for fish blood, i.e. true concentration $= (0{\cdot}534 \times \text{observed concentration}) + 2{\cdot}44$. A centrifuge was available at Signy Island and haematocrits were measured on blood samples taken from fish there. Erythrocyte size was measured with an eyepiece micrometer.

RESULTS

The results of the blood analyses of fish from south of the Antarctic Convergence are shown in Table I, and Table II gives results for fish from north of the Convergence. In this paper there has been no attempt to relate variations in blood composition with the sex or stage of maturity of the fish.

DISCUSSION

The results given agree generally with the published values for other Antarctic fish (Tyler, 1960; Kooyman, 1963; Hureau, 1966). Some of these values are given in Table III. The two specimens of *Parachaenichthys georgianus* from South Georgia were notable in having very low haemoglobin levels and low erythrocyte counts. An indication of this was obvious in the

TABLE I. HAEMOGLOBIN CONCENTRATION, HAEMATOCRITS, ERYTHROCYTE COUNTS AND ERYTHROCYTE SIZES OF THE BLOOD OF SOME ANTARCTIC FISHES
(Results are expressed as means followed by the standard deviations. The number of fish in each sample is given in brackets; when fewer than four fish were caught, the individual results are given.)

Locality	*Position* lat.	long.	*Species*	*Haemoglobin concentration* (g./ 100 ml. blood)	*Haematocrits*	*Erythrocyte count* ($\times 10^5$/mm.^{3})	*Erythrocyte size* (μm.)
Signy Island	60°43′S.	45°38′W.	*Notothenia neglecta*	5·0±0·65 (16)	25·2±5·3 (16)	693±157 (16)	15×10
Signy Island	60°43′S.	45°38′W.	*N. rossii*	4·7±1·89 (5)	24·0±5·4 (5)	428±45 (5)	15×10
King Edward Point, South Georgia	54°17′S.	36°30′W.	*N. neglecta*	6·9±1·26 (10)	—	757±58 (10)	16×10
King Edward Point, South Georgia	54°17′S.	36°30′W.	*N. rossii*	6·6±1·43 (25)	—	713±130 (20)	16×11
King Edward Point, South Georgia	54°17′S.	36°30′W.	*Parachaenichthys georgianus*	0·8, 0·8 (2)	—	225, 200 (2)	20×14
Argentine Islands	65°15′S.	64°17′W.	*N. neglecta*	5·7±1·67 (9)	—	735±213 (9)	17×10
Argentine Islands	65°15′S.	64°17′W.	*Trematomus bernacchii*	5·0 (1)	—	883 (1)	15×10
Deception Island	62°57′S.	60°38′W.	*N. neglecta*	6·0±1·2 (7)	—	718±22 (7)	15×13
Deception Island	62°57′S.	60°38′W.	*N. gibberifrons*	5·9, 5·0 (2)	—	570, 748 (2)	17×9
Deception Island	62°57′S.	60°38′W.	*P. charcoti*	5·4 (1)	—	945 (1)	12×10
Goudier Island, Port Lockroy	64°50′S.	63°31′W.	*N. gibberifrons*	5·9 (1)	—	660 (1)	15×11
Admiralty Bay, King George Island	62°07′S.	58°27′W.	*T. bernacchii*	5·0, 5·6, 5·5 (3)	—	940, 750, 830 (3)	16×11

TABLE II. HAEMOGLOBIN CONCENTRATION, ERYTHROCYTE COUNTS AND ERYTHROCYTE SIZE OF THE BLOOD OF FISH CAUGHT AT PORT STANLEY, FALKLAND ISLANDS

Species	*Haemoglobin concentration* (g./100 ml. blood)	*Erythrocyte count* ($\times 10^3$/mm.^{3})	*Erythrocyte size* (μm.)
Eleginops maclovinus	8·4	1,975	12×10
	8·1	1,825	12× 8
Notothenia wiltoni	3·1	1,000	16×10
	5·9	1,150	16× 8
	5·3	1,300	12×10
N. sima	3·9	1,125	—
	8·0	1,950	16×12
	5·9	1,075	14× 8
	—	2,425	16× 9

TABLE III. HAEMOGLOBIN CONCENTRATION AND ERYTHROCYTE COUNTS OF ANTARCTIC FISH

Species	*Haemoglobin concentration* (g./100 ml. blood)	*Erythrocyte count* ($\times 10^3$/mm.^{3})	*Authority*
Trematomus borchgrevinki	3·5–4·0	660–800	Tyler (1960)
T. borchgrevinki	7·0	1,190	Kooyman (1963)
T. bernacchii	3·5	740	Kooyman (1963)
T. loennbergii	4·6	830	Kooyman (1963)
T. hansoni	3·9	750	Kooyman (1963)
T. hansoni	2·6–6·7	620	Hureau (1966)
Notothenia larseni	3·5	380–390	Tyler (1960)

living fish from the pale pink colour of the gills. However, the other bathydraconid examined, *Parachaenichthys charcoti* (from Deception Island), did not show this extreme reduction. All the species examined, except the fish from the Falkland Islands, possess fewer erythrocytes and less haemoglobin than is normal in other teleost fish. Such small quantities are common in cyclostomes and elasmobranchs, but among higher fish a normal erythrocyte count would be $1-2\times10^6$/mm.^{3}, with haemoglobin 7—12 g./100 ml. blood, e.g. the values found in *Eleginops maclovinus*. This fish is found off the coasts of Argentina and the Falkland Islands, and not south of the Antarctic Convergence (Norman, 1937). The nototheniids from the Falkland Islands have higher erythrocyte counts than their more southerly relatives, although their haemoglobin levels are approximately the same, except for one specimen of *Notothenia sima*.

It seems clear that there is a tendency for Antarctic fish to reduce the number of erythrocytes and the amount of haemoglobin in their blood. This is clearly seen in the bathydraconid, *Parachaenichthys georgianus*, and it reaches the extreme condition in the chaenichthyids. Further work is needed on those nototheniids found north of the Convergence to determine whether their blood haemoglobin and erythrocyte levels are significantly higher than their truly Antarctic relatives, as is partially indicated here.

MS. received 10 August 1967

REFERENCES

HALE, L. J. 1958. *Biological laboratory data*. 1st edition. London, Methuen & Co. Ltd. [Methuen's Biological Monograph Series.]

HUREAU, J. C. 1966. Biologie de *Chaenichthys rhinoceratus* Richardson, et probleme du sang incolore des Chaenichthyidae, poissons de mers australes. *Bull. Soc. zool. Fr.*, **91**, No. 4, 735–51.

KOOYMAN, G. L. 1963. Erythrocyte analysis of some Antarctic fishes. *Copeia*, 1963, No. 2, 457–58.

LARSEN, H. N. *and* S. F. SNIESZKO. 1961. Comparison of various methods of determination of haemoglobin in trout blood. *Progve Fish Cult.*, **90**, No. 2, 139–42.

MARTSINKEVICH, L. D. 1958. Kletochnyĭ sostav krovi belokrovnykh ryb (Chaenichthyidae) Antarktiki [Cellular composition of the blood of white-blooded fish (Chaenichthyidae) from the Antarctic]. *Inf. Byull. sov. antarkt. Eksped.*, No. 3, 67–68. [*English translation:* Cellular makeup of the blood of white-blooded fish (Chaenichthyidae) from the Antarctic. (*In Soviet Antarctic Expedition Information Bulletin, Vol. I.* Amsterdam, London, New York, Elsevier Publishing Company, 1964, 137–38.)]

MATTHEWS, L. H. 1931. *South Georgia: the British Empire's sub-Antarctic outpost*. Bristol, John Wright and Sons Ltd.; London, Simpkin Marshall Ltd.

NORMAN, J. R. 1937. Coast fishes. Part II. The Patagonian region. '*Discovery*' *Rep.*, **16**, 3–150.

RUUD, J. T. 1954. Vertebrates without erythrocytes and blood pigment. *Nature, Lond.*, **173**, No. 4410, 848–50.

————. 1959. Vertebrates without blood pigment: a study of the fish family Chaenichthyidae. *Proc. 15th Int. Congr. Zool., London, 1958*, Sect. 6, Paper 32, 526–28.

————. 1965. The ice fish. *Scient. Am.*, **213**, No. 5, 108–14.

TYLER, J. C. 1960. Erythrocyte counts and haemoglobin determinations for two Antarctic notothenioid fishes. *Stanford ichthyol. Bull.*, **7**, No. 4, 199–201.