l that, in sandy areas, primary production increases from HW to UW. In muddy areas, however, highest primary production occurred at LW with a considerable decrease towards UW, probably due to turbidity.

There is little data on primary production of estuarine sand or, indeed, of sandy beaches in general. Steele & Baird (1968) estimated a production of 6,5 g C/m²/y at an ambient temperature of 10°C in a Scottish beach. This is approximately a tenth of the production measured in the present study and this may be partly due to the low temperature and the fact that the measurements were made on an exposed beach and not in an estuary. As far as the muddy stations are concerned, more comprehensive data are available. Hargrave (1969) estimated production to be 40,4 g C/m²/y, Biggs & Flemmer (1972) obtained a value of 72,0 g C/m²/y and Riznyk & Phinney (1972) found production rates of 80 to 300 g C/m²/y in estuarine mud flats. The present findings compare well with these published data.

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YELLOWFISH AND TIGERFISH HAEMATOLOGY

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No previous physiological studies have been made on the large-mouth yellowfish and the tigerfish in South Africa. Difficulties were originally encountered in obtaining healthy specimens, and high mortality rates occurred during and after transportation, problems which have now been overcome (Hattingh *et al.* 1975). It is known that the environment plays an important role in the physiology of a fish and haematological ranges will give an indication of the blood physiological state (Blaxhall & Daisley 1973; Bouck & Ball 1966). The present report concerns basic haematological values for these two species.

Barbus kimberleyensis (yellowfish) was obtained from Scandinaviadrif near Potchefstroom with the

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help of the Provincial Fisheries, and specimens were transported to the laboratory where they were left for several weeks to acclimatize (Hattingh *et al.* 1975). *Hydrocynus vittatus* (tigerfish) was studied in the field at Komatipoort directly after seining as the fish could not be transported to the laboratory within three days. All the fish were sexually mature and in good health. Due to their scarcity only eight individuals of each species, including both sexes, were investigated. The methods used for anaesthetization, blood sampling and determination of mass, length, pH, haematocrit (Hc), haemoglobin concentration (Hb), plasma protein concentration (P. Prot), red blood cell counts (Rb), white blood cell counts (Wb), mean corpuscular volume (MCV), average corpuscular haemoglobin (ACH) and mean corpuscular haemoglobin concentration per cent (MCHC) have been described elsewhere (Hattingh 1973*a*). Determination of dimensions was done with an optical micrometer on dry films of blood. Gel electrophoresis was carried out on the plasma proteins and haemoglobin on a 5 per cent gel (Hattingh 1973*b*).

Table I presents the mean values and standard deviation (SD) obtained for the haematological parameters of both species. Mass and pH values were not determined for *H. vittatus*. The haematocrit values were very high in both cases. The haemoglobin concentration was 9,03 g per cent for *B. kimberleyensis* and 9,98 g per cent for *H. vittatus*, which is high for freshwater fish (Hattingh 1973*a*). A high plasma protein concentration was found in *H. vittatus*. The density of erythrocytes and leucocytes was 1,20 x 10^6/mm^3 and 6,79 x 10^3/mm^3 respectively for *B. kimberleyensis*. The erythrocyte and leucocyte values of *H. vittatus* were 2,84 x 10^6/mm^3 and leucocyte values of *H. vittatus* were 2,84 x 10^6/mm^3 and 9,11 x 10^3/mm^3 respectively. The haematocrit was 42,33 per cent for *B. kimberleyensis* and 43,46 per cent for *H. vittatus*.

The electrophoretic separations of the plasma are reproduced in Figure 1. The plasma proteins of *B. kimberleyensis* migrated in certain cases further than those of *H. vittatus*. A standard separation into 18 fractions was found for *H. vittatus* and the percentage protein of each fraction was very constant. The plasma proteins of *B. kimberleyensis* showed variation in the percentage of several fractions in the different fish. The number of fractions was very constant. The haemoglobin was separated

TABLE I

Haematological values for *Barbus kimberleyensis* and *Hydrocynus vittatus*

Haematological parameters	*Barbus kimberleyensis*			*Hydrocynus vittatus*		
	Mean	±	SD	Mean	±	SD
(pH)	7,34		0,12	—		—
Mass (g)	979,98		160,37	—		—
Length (cm)	42,60		1,90	39,26		5,15
Haematocrit (%)	42,33		8,40	43,46		5,40
Haemoglobin (g%)	9,03		1,99	9,98		0,94
P. Prot (mg/ml)	37,50		13,90	50,44		2,79
Rb (x 10^6/mm^3)	1,20		0,09	2,84		0,53
Wb (x 10^3/mm^3)	6,79		2,44	9,11		4,58
Erythrocyte dimension (μ)	15,1 x 10,7		0,04 x 10,07	10,0 x 6,4		0,08 x 0,21
MCV (μ^3m)	354,43		77,43	153,89		21,83
ACH (ng)	76,96		19,79	35,91		5,02
MCHC (%)	22,24		6,20	23,13		2,41

in the met-form and five haemoglobin fractions were found in the blood of *B. kimberleyensis*. Fraction four was the most prominant (Figure 2). The haemoglobin of *H. vittatus* was not investigated electrophoretically.

It is known (Manwell 1957) that sexual maturity as well as age influences erythrocyte numbers, thus affecting the haematocrit and haemoglobin concentration as well. This influence has not yet been investigated for other haematological parameters of South African freshwater fish. All the fish used in this study were sexually mature. This parameter could thus not have had any effect on the values obtained.

The present values can only be taken as an indication of what the real status may be. The values obtained for *Barbus holubi, Cyprinus carpio, Labeo umbratus, Labeo capensis, Clarias gariepinus* and *Sarotherodon mossambicus* (Hattingh 1972, 1973*a*) were in most cases lower than those for *B. kimberleyensis* and *H. vittatus*. The higher values probably reflect a higher metabolic activity in the last two species. The amount of erythrocytes and leucocytes may have been influenced by stress during capture. The MCV, ACH and MCHC values were affected by the values of the haematocrit, the amount of erythrocytes and the haemoglobin concentration. The size of erythrocytes of both species may have had an effect on the other parameters, especially on the number of erythrocytes and the haemoglobin content. It is not certain that the haemoglobin content of each cell is related to its size. The high values obtained for the two species were most likely due to two factors; firstly both species are predators and thus more active and with a higher metabolic activity, and secondly stress during capture has had an effect.

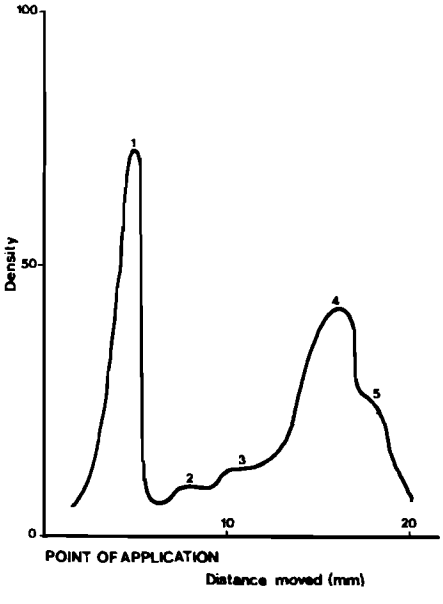

FIGURE 1
Polyacrylamide gel electrophoresis of the plasma of *Barbus kimberleyensis* and *Hydrocynus vittatus*.

The constancy of the electrophoretogram of the plasma proteins of *H. vittatus* is remarkable. This can be one of the most reliable methods for establishing a possible protein taxonomy as suggested by Nyman (1965), provided that the study be carried out directly after capture. The electrophoretogram of the plasma proteins of *B. kimberleyensis* was erratic. The number of protein fractions found in the plasma of *B. kimberleyensis* corresponds with that found in *B. holubi* (Hattingh 1973*b*) and *H. vittatus*. *B. kimberleyensis* refused to feed in captivity and this may have influenced the plasma protein concentration affecting the concentration of each fraction as well. The haemoglobin of *B. kimberleyensis* displayed five fractions which corresponds with the results of Hattingh & Du Toit (1973) who found six haemoglobin fractions for *B. holubi* with one to the anode. All the present fractions migrated to the positive terminal. No experiments were conducted towards the negative terminal. The number of fish is clearly too small for any significant results, but nevertheless it gives an indication of the general haematology. A shortcoming is that the study was conducted only during the spring, whereas a survey over a period of a whole year, including all seasons, would reveal the complete haematological cycle.

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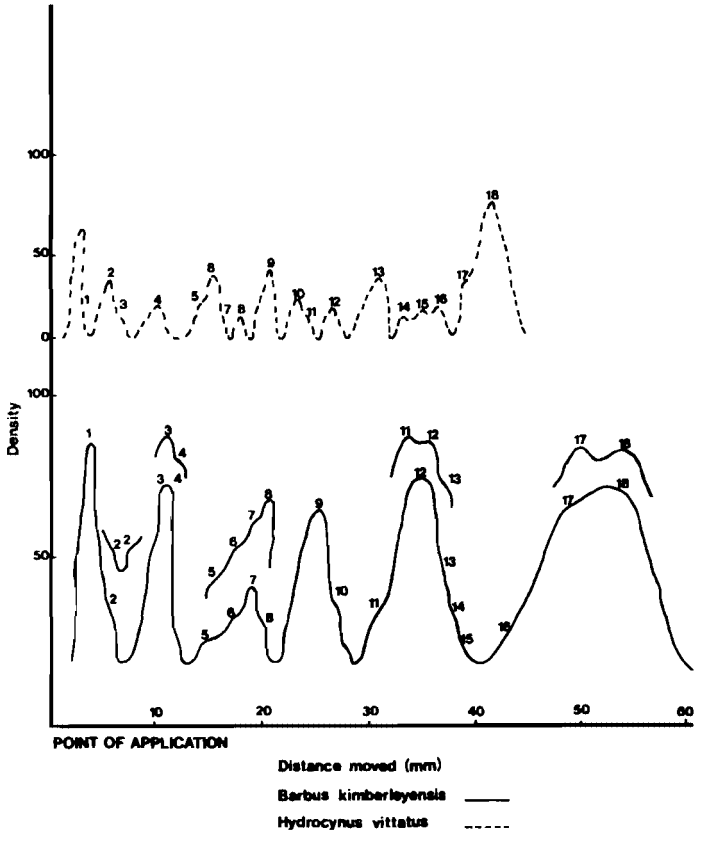

FIGURE 2
The electrophoretic pattern of the haemoglobin of *Barbus kimberleyensis*.

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