ASPECTS ON THE ECOLOGY OF *BARBUS KIMBERLEYENSIS* AND *BARBUS HOLUBI* IN THE VAAL RIVER

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ABSTRACT

From the summarized data presented in the present paper several factors contributing to the paucity of *Barbus kimberleyensis* were illuminated. Soil erosion causes extremely turbid conditions in the waters of the Vaal River for almost the whole year and therefore restricts the ability of the predatory species to see its prey. Another factor which is most certainly one of the major causes of the limited reproduction is the slow growth-rate and the age at which both sexes reach sexual maturity. With the increasing angling pressure this may give rise to a critical situation in the near future.

In contrast to *Barbus kimberleyensis*, *Barbus holubi* is abundant in the Vaal River probably due to its omnivorous feeding habits which make it more adaptable to turbid water conditions. In addition both sexes reach sexual maturity at a younger stage than those of the large-mouth yellowfish.

INTRODUCTION

In 1969, following complaints by anglers on deteriorating angling conditions in the Vaal River, a project on the ecology of the main angling species was initiated by the Nature Conservation Division of the Transvaal Provincial Administration. The main object of the study was to provide a background for future management practices by the Fisheries section. Important ecological parameters such as age and growth, reproduction and distribution were investigated and special attention was paid to the ecology of *Barbus kimberleyensis* as the common belief was that there was a decline in the numbers and distribution thereof. The present paper includes a report on aspects of the ecology of *Barbus kimberleyensis* and *Barbus holubi*.

SAMPLING LOCALITIES AND METHODS

For the four seasonal surveys which were conducted June, September (1969), January and April (1970), twenty-five sampling localities were selected. Sites were chosen to represent all habitat types and special care was taken to assure the maximum effective use of the seine nets. In a supplementary study samplings were undertaken on a monthly basis and only five localities were visited viz. 5, 7, 10, 13 and 18 (Figure 1). Detailed descriptions of the individual sampling are included in the original report by the author (Mulder 1972). Sampling was done by means of a seine net (122 m × 5,5 m × 25 mm) and gill nets (15 m × 3 m × 120 mm). The latter was used only to supplement the number of large specimens and was mainly restricted to localities where sampling with the seine net proved extremely difficult. A mosquito net (15,2 m × 0,9 m × 2,5 mm) was used for sampling in the marginal vegetation and shallow pools.

DISTRIBUTION

The principal method in which an estimation of the population number is made by marking and tagging and subsequent recapture was practically impossible in the present study. The large

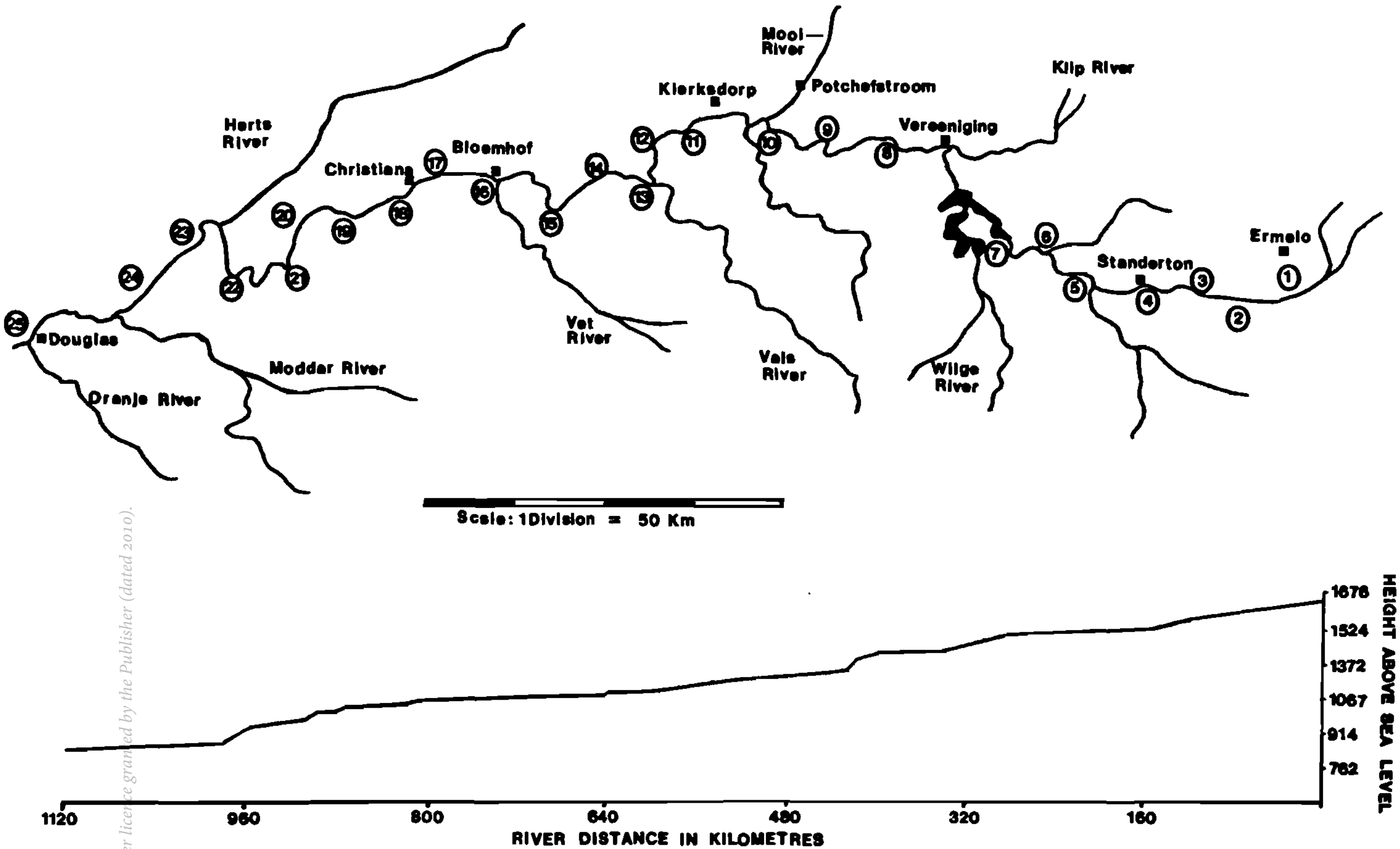


FIGURE 1
Sampling localities and profile of the Vaal River.

bodies of water, the number and widely spaced sampling localities and the time factor eliminated the use of this method. To serve as an indication of the species composition at each given locality the number of each species was recorded for the first two seine attempts. *Barbus kimberleyensis* and *Barbus holubi* both seemed to prefer clear, fast-flowing waters with sandy or rocky substrate. Stomach content analyses revealed that this phenomenon was to a certain extent coupled with food preference. *Barbus kimberleyensis*, as a predator, relied on the visibility in the clear water in these areas to see its prey while *Barbus holubi* fed on the large numbers of *Corbicula* (mussels) found here. This was particularly evident at sampling localities 10 and 14 which were both situated at the base of rapids. The water of the far western regions of the river, below the Vaalharts weir, is much clearer than that above the weir. An interesting observation was that *Barbus kimberleyensis* specimens found in these two regions differed in colour. In the more turbid upper part of the river the fish were typically silver-coloured while in the clearer parts this changed to a yellowish copper-colour. This change in colour was also noticed after four months when some silver specimens were transferred to breeding ponds at the Fisheries Institute at Lydenburg where the water is absolutely clear. In Table 1 the mean percentages based on the total number of fish caught per season are presented to serve as an indication of the species composition during the survey.

TABLE 1

PERCENTAGE COMPOSITION OF CATCHES FOR THE SEASONAL SURVEYS IN THE VAAL RIVER JULY 1969 – APRIL 1970

	Winter		*Spring*		*Summer*		*Autumn*		
	number	%	*number*	%	*number*	%	*number*	%	*Mean*
B. kimberleyensis	283	4,7	196	5,7	205	4,7	105	3,2	4,6
B. holubi	2339	38,9	928	28,3	885	20,5	718	22,0	27,4
L. capensis	2710	45,2	1873	54,5	1848	42,7	1083	33,2	43,9
L. umbratus	511	8,5	305	8,9	1152	26,6	1274	39,1	20,8
C. carpio	110	1,8	44	1,3	203	4,7	54	1,1	2,4
C. gariepinus	53	0,9	52	1,4	32	0,7	26	1,1	1,0

LENGTH/MASS RELATIONSHIP

Length/mass relationships for each species were determined on a seasonal basis and for two length groups (Tables 2 and 3). The division at 25 cm was an arbitrary decision based on field observations that there seemed to be an increase in body depth above 20 cm length. In the case of *Barbus holubi* the division also separated the mature and immature fish. To determine the validity of using the combined male and female data for the length/mass relationship of the species involved, a simple statistical evaluation was made in which the mean mass of different length groups was compared (Tables 4 and 5). The results thereof indicate no significant difference.

TABLE 2

VALUES OF LOG C AND CONSTANT n FOR *Barbus kimberleyensis* COMPUTED FROM THE LENGTH/MASS RELATIONSHIP W= LOG C + n (LOG L)

	CENTIMETRE GROUPS					
	7–25 centimetre			25 centimetre and larger		
SEASON	Log C	n	N	Log C	n	N
Winter 69	−1,7223	2,8537	253	−1,8971	3,0161	44
Spring 69	−1,8033	2,9171	184	−2,1347	3,1775	29
Summer 70	−1,7493	2,8853	179	−2,4610	3,3789	26
Autumn 70	−1,7231	2,8606	82	−2,2789	3,2530	31

TABLE 3

VALUES OF LOG C AND CONSTANT n FOR *Barbus holubi* COMPUTED FROM THE LENGTH/MASS RELATIONSHIP W= LOG C + n (LOG L)

	CENTIMETRE GROUPS					
	7–25 centimetre			25 centimetre and larger		
SEASON	Log C	n	N	Log C	n	N
Winter 69	−1,7595	2,9220	1057	−1,9711	3,0821	86
Spring 69	−1,7742	2,9347	678	−1,8650	3,0264	66
Summer 70	−1,8239	2,9944	667	−2,4724	3,4021	70
Autumn 70	−1,7872	2,9468	502	−2,2554	3,2665	27

TABLE 4

SIGNIFICANCE OF DIFFERENCES IN MEAN MASS FOR MALES AND FEMALES OF *Barbus kimberleyensis*. MEANS COMPUTED FOR FOUR CENTIMETRE LENGTH INTERVALS

Length groups (cm)	*FEMALES*			*MALES*			
	N	$\bar{x}$	*Sx*	*N*	$\bar{x}$	*Sx*	*t,05*
25–28	36	239,5	62,3	24	237,5	31,6	0,1134
30–33	29	394,8	66,2	11	392,2	50,4	0,4641
37–40	15	779,3	87,6	12	809,3	48,3	1,0609
41–44	13	1100,8	142,8	16	1100,4	109,5	0,0085
45–48	22	1362,6	134,1	20	1374,4	148,1	0,2710

TABLE 5

SIGNIFICANCE OF DIFFERENCES IN MEAN MASS FOR MALES AND FEMALES OF *Barbus holubi*. MEANS COMPUTED FOR FIVE CENTIMETRE INTERVALS

Length groups (cm)	*FEMALES*			*MALES*			
	N	$\bar{x}$	*Sx*	*N*	$\bar{x}$	*Sx*	*t,05*
30–34	17	512,1	62,1	24	499,0	64,9	0,6477
38–42	39	1021,8	118,6	34	994,8	141,8	0,8731
43–47	61	1460,6	194,9	26	1384,6	194,4	1,6670

AGE AND GROWTH

Age determinations were carried out on scales collected on the latero-dorsal region of the body, anterior to the dorsal fin. The formula of Schaefer (1965) was employed for back calculations.

$$\mathrm{Ln} = \mathrm{C} + \frac{\mathrm{Sn}\,(\mathrm{Lt} - \mathrm{C})}{\mathrm{St}}$$

Ln = Length at annulus n
Lt = Length at capture
Sn = Distance from nucleus to annulus n
St = Scale Radius
C = X-axis intercept of body/scale relationship

In the present study scale radius (16× magnification) was measured as the furthest distance on the axis from the nucleus to the laterodorsal "shoulder" of the scale. In this area the annuli were more easily identified than on the frontal region.

The mean fork lengths based on the back calculations are summarized in Tables 6 and 7. From Table 6 it is evident that there seems to be no considerable difference in the mean lengths for males and females of *Barbus kimberleyensis* up to an age group of 9 years. The increasing differences thereafter can be coupled with longevity as is clearly illustrated in Figure 3.

Table 6

EMPIRICAL AND BACK CALCULATED MEAN FORK LENGTHS FOR *Barbus kimberleyensis* FROM THE VAAL RIVER

	YEAR CLASSES														
	N	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*
	76	(8,2)												
*	130	8,1	(13,5)											
	115	8,3	13,8	(18,9)										
FEMALES	49	8,3	14,2	19,3	(24,1)									
	25	8,4	14,0	19,9	25,6	(30,9)								
	15	8,3	13,3	18,5	24,2	30,0	(34,8)							
	6	8,8	14,3	19,2	24,3	29,8	34,6	(39,6)						
	18	8,5	13,3	18,4	23,7	28,8	34,1	38,8	(43,9)					
	3	8,2	13,0	17,9	23,1	28,0	33,9	39,2	43,2	(46,9)				
	7	8,0	12,4	17,9	21,8	26,5	31,3	36,0	40,5	45,3	(49,7)			
	12	7,8	12,7	17,3	22,1	27,0	32,2	36,5	41,2	45,8	50,7	(55,1)		
	1	7,9	13,8	18,0	24,8	29,6	33,6	38,1	43,1	48,5	54,3	58,8	(64,3)	
	1	8,4	13,3	18,2	23,5	28,1	34,2	39,6	43,7	48,4	53,5	57,1	62,2	(65,9)
MALES	22	8,2	13,7	18,8	(23,7)									
	7	8,6	14,4	19,6	24,7	(29,3)								
	5	8,2	13,3	18,9	24,7	30,6	(34,6)							
	9	8,3	13,4	18,6	24,1	29,4	34,0	(38,4)						
	12	7,7	12,2	17,0	22,0	26,9	31,1	36,5	(40,2)					
	5	8,0	12,6	17,3	22,1	27,4	32,8	37,4	42,0	(45,0)				
	1	8,0	12,7	17,1	21,9	25,6	30,5	35,0	38,5	42,5	46,3	(47,7)		
	519													

* Sexes not discernible.

( ) Empirical mean lengths based on lengths of fishes that had completed growth for the season.

TABLE 7

EMPIRICAL AND BACK CALCULATED MEAN FORK LENGTHS FOR *Barbus holubi* FROM THE VAAL RIVER

		YEAR CLASSES												
	N	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*
	42	(8,4)												
*	39	8,5	(13,4)											
	48	9,4	14,9	(20,0)										
	33	10,0	16,6	22,6	(27,5)									
FEMALES	7	9,1	14,8	20,5	26,5	(31,2)								
	7	10,1	15,7	21,3	27,0	31,8	(36,2)							
	6	9,7	15,5	20,5	25,5	30,9	37,0	(41,8)						
	5	9,3	14,5	20,0	24,6	29,8	35,6	40,2	(44,7)					
	7	9,0	13,5	18,3	23,1	28,4	33,2	37,7	42,0	(46,1)				
	7	9,0	13,8	18,6	23,8	28,4	33,8	36,9	43,3	48,8	(50,1)			
MALES	5	9,6	14,1	20,7	26,0	(31,2)								
	8	9,3	15,5	20,4	26,0	31,6	(36.6)							
	3	9,9	14,9	20,9	26,8	32,7	38,0	(42,6)						
	3	9,2	15,7	20,0	23,8	28,2	32,0	36,4	(39,4)					
	Σ220													

* Sexes not discernible.
( ) Empirical mean lengths based on lengths of fishes that had completed growth.

Mathematical descriptions of growth in length (Von Bertalanffy 1938) for males and females of ***Barbus kimberleyensis*** were computed as:

$$Lt = 66,7 \ (1-e^{-0,124\ (t-0,27)} \ \text{(males)}$$
$$Lt = 130,9 \ (1-e^{-0,1115\ (t-0,36)} \ \text{(females)}$$

The hypothetical maximum lengths were derived from Walford graphs (Walford 1946) but in the case of the females it was obvious that the lack of sufficient data on the 13+ age groups had an effect on the reliability thereof. In the computation of both growth-curves the mean lengths of the first year classes were disregarded as it was felt that they were affected by net selectivity.

In the case of ***Barbus holubi*** a growth-curve based on the combined data for males and

TABLE 8

EMPIRICAL AND CALCULATED GROWTH RATES FOR MALES OF *Barbus holubi* IN THE VAAL RIVER

Year class	*Mean length (cm)*	**Calculated length (cm)*	*Yearly increment (cm)*	*†Calculated mass (gm)*	*Yearly increment (gm)*
1	8,4	6,6	—	4,8	—
2	13,4	13,5	6,9	35,3	30,5
3	20,0	19,8	6,3	109,2	73,9
4	27,5	25,5	5,7	224,8	115,6
5	31,2	30,5	5,0	398,4	173,6
6	36,4	35,1	4,6	623,9	225,5
7	41,8	39,2	4,1	888,2	264,3
8	44,7	42,9	3,7	1185,1	296,9
9	46,1	46,3	3,4	1511,3	326,2
10	50,1	49,3	3,0	1846,2	334,9

* Von Bertalanffy.
† Length/mass relationship.

TABLE 9

EMPIRICAL AND CALCULATED GROWTH RATES FOR MALES OF *Barbus kimberleyensis* IN THE VAAL RIVER

Year class	*Mean length (cm)*	**Calculated length (cm)*	*Yearly increment (cm)*	*†Calculated mass (gm)*	*Yearly increment (gm)*
1	8,2	5,8	—	2,8	—
2	13,5	12,9	7,1	28,1	25,3
3	18,9	19,1	6,2	86,9	58,8
4	23,7	24,7	5,6	187,4	100,5
5	29,3	29,6	4,9	334,7	147,3
6	34,6	34,0	4,4	522,0	187,3
7	38,4	37,8	3,8	733,1	211,1
8	40,2	41,2	3,4	966,3	233,2
9	45,0	44,1	2,9	1201,3	235,0
10	46,3	46,8	2,7	1452,4	251,1

* Von Bertalanffy.
† Length/mass relationship.

females was computed because of the small difference in the mean fork lengths of the respective age groups (Table 7).

$$Lt = 76{,}5\ (1 - e^{-0{,}105\ (t-0{,}15)}$$

Growth rates in length and mass are summarized in Tables 8 and 9 using the computed growth curves and length/mass relationships.

Tables 10 and 11 illustrate the considerable overlapping of the year classes of both species. This was mainly attributed to the difference in individual growth-rates as well as the occurrence of several spawning periods within a season as was established for *Barbus holubi*.

REPRODUCTION

A sex ratio (females/males) of 1,8 was determined for both species; a phenomenon which can be explained by the obvious differences in life span for the sexes (Figure 2). Investigations revealed that *Barbus kimberleyensis* males attain sexual maturity at an age of six years (35 cm) while the females reproduce at an age of eight years (46 cm). This can be regarded as one of the major reasons for the decline in numbers of the species. *Barbus holubi* males were found to be sexually mature after four years and the females after five years.

To clarify certain aspects of the reproductive cycle six phases in the gonad development were distinguished by visual examination (Nikolsky 1963). They were:

1. Resting
2. Developing
3. Well-developed
4. Ripe-running
5. Spawned but more than 50% ova still in ovaries
6. Spawned, ovaries empty.

From the above-mentioned data it was found that after a short pause in May the gonads of both species start developing in June. In the case of *Barbus kimberleyensis* the "well-developed" stage was reached in late October (males) and November (females) whereas for *Barbus holubi* males were ripe-running as early as August and the first spawning took place in early October.

A second spawning period was evident in January, an observation which was substantiated by the length intervals of the fry collected in spawning areas and similar observations on the breeding stock at the Fisheries Institute. Although in some cases the gonads of females of both species revealed signs of incomplete spawning it could not be established if this was a natural phenomenon. A personal opinion, based on field observation and the findings that 99% of the ova stripped from females were ultimately fertilized, is that one spawning seems the natural event although disturbance could result in several spawnings within a certain time interval. Fry were often noticed in ponds where stripped females were kept and as the females were, as a

Table 10

AGE AND CORRESPONDING LENGTHS OF *Barbus kimberleyensis* IN THE VAAL RIVER

	YEAR CLASSES											
Length (*cm*)	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
5	1											
6	13											
7	22											
8	16											
9	16											
10	7	12										
11	1	11										
12		34										
13		37										
14		24	3									
15		21	8									
16		2	18									
17			16									
18			13									
19			19									
20			16	4								
21			11	9								
22			6	4								
23			4	16								
24			1	16								
25				8	1							
26				10	2							
27				3	3							
28				1	3							
29					5	1						
30					6	3						
31					3	2						
32					3	1	1					
33					2							
34					2	1	1					
35					2	3	1					
36						1	3	2				
37						4	3	1				
38						3		3				
39						1		2				
40								2				
41							1	2				
42							2	5	1			
43							2	5				
44								3	1			
45							1	1				
46							1	1	1	1		
47								1	2	2	1	
48								1	1			
49									1	1	2	
50									1	1		
51											1	
53										1		
54									1	1	1	
55											1	
56											1	
58											2	
59											2	
61											1	
62												1
63												1
64												1

TABLE 11

AGE AND CORRESPONDING LENGTHS OF *Barbus holubi* IN THE VAAL RIVER

	YEAR CLASSES											
Length (cm)	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
6	4											
7	12											
8	15											
9	8											
10	3	4										
11		5										
12		7										
13		8										
14		7										
15		8										
16		1	1									
17		1	9									
18			11									
19			4									
20			6									
21			5									
22			3									
23			4	1								
24			2	2								
24			2	2								
25			2	6	1							
26				6	2							
27				3								
28				7								
29				4	1							
30					2							
31				1								
32						1						
33				2	4	1						
34					1	2						
35						3						
36						3						
37					1	1	1					
38						2	1	1				
39						2		1				
40							1	1				
41							2	1				
42							1					
43										1		
44							1		1			
45							1	2	1	1		
46							1	1	1			
47							1					
48								1				
49									1	1		
50									1	2		
51										1		
52									1			
54									1			
59										1		

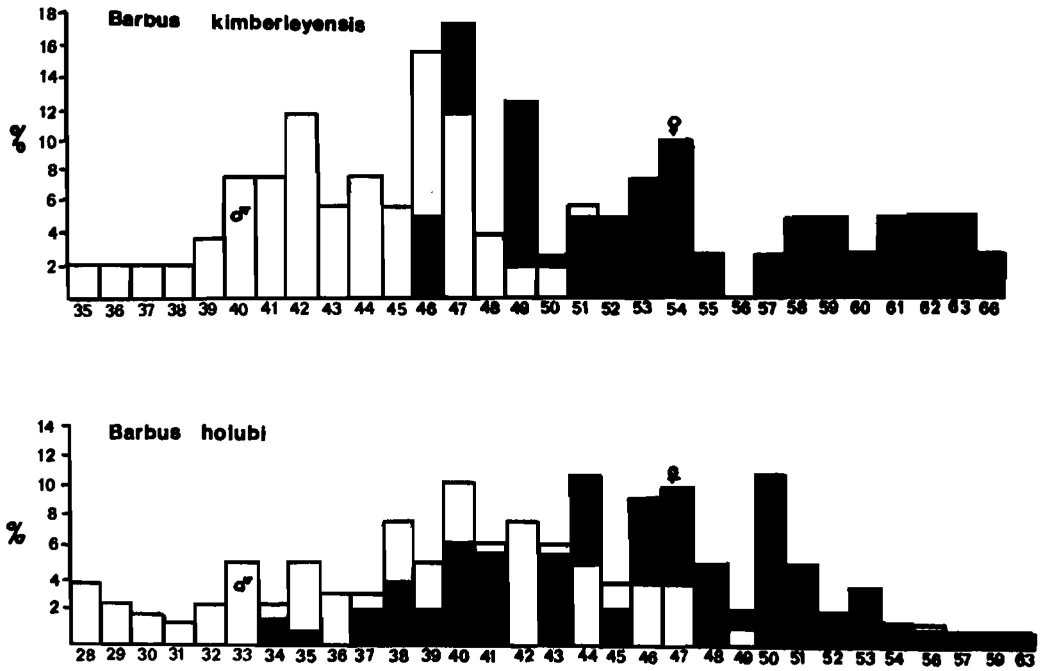


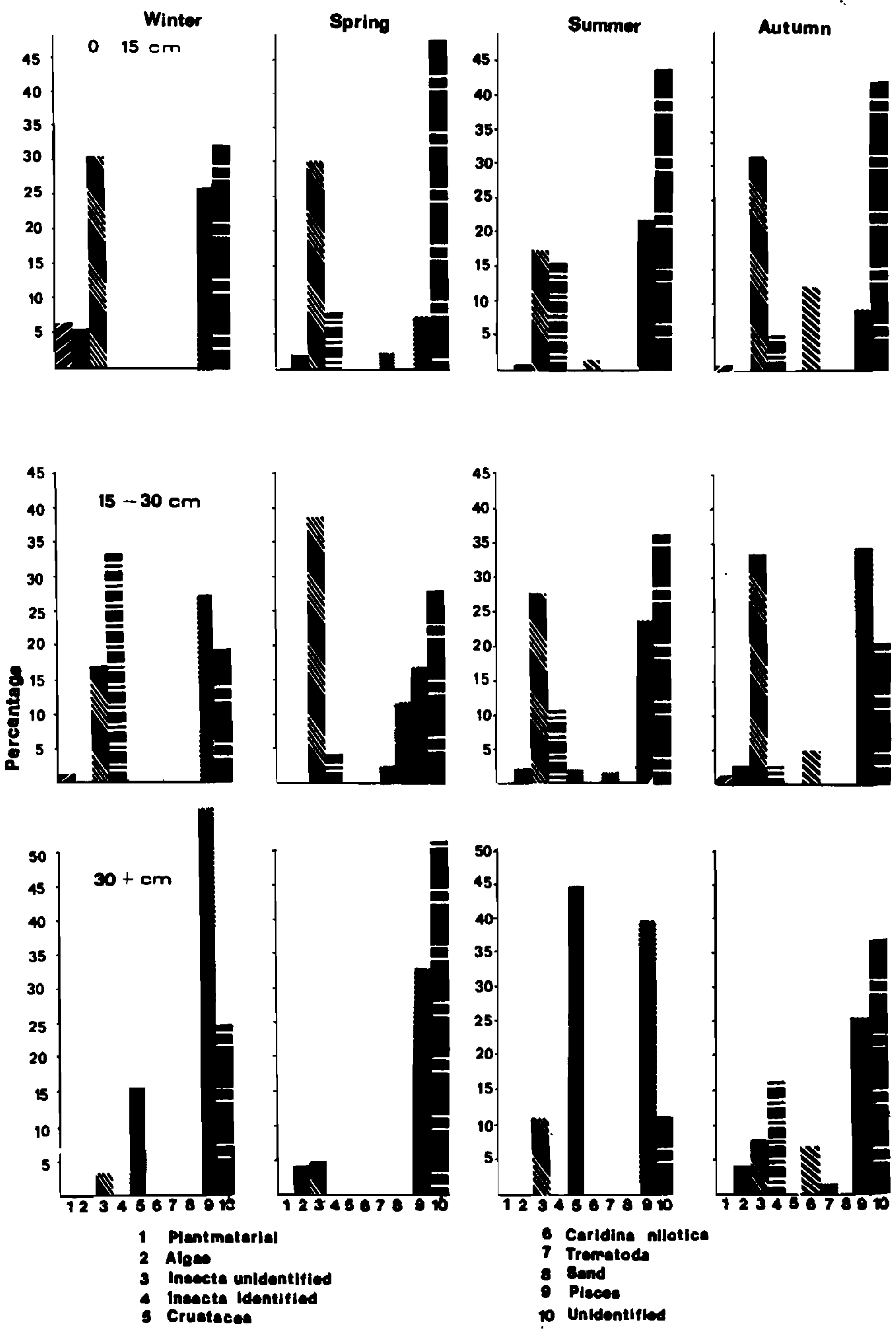
FIGURE 2

Length frequencies of mature males and females of *Barbus kimberleyensis* and *Barbus holubi*. Data expressed as percentages of total for each sex.

precautionary measure, not stripped of all ova in fear of damage this indicated resumed spawning. In the case of *Barbus holubi* it is known that spawning takes place in gravel nests constructed by the fish but for *Barbus kimberleyensis* the actual spawning was never observed. The occurrence of fry and larvae in identical habitats as found for *Barbus holubi* does, however, indicate similar breeding habits. For neither species does there seem to be a positive correlation between ova production and fork length, and the number of ova produced varied between 16 000 and 52 000.

FIGURE 3 (*Opposite*)

Percentage composition of the stomach contents of *Barbus kimberleyensis*. Percentages based on volumetric determination of individual items.


Winter
Spring
Summer
Autumn
0 15 cm
15 – 30 cm
30 + cm
Percentage
1 Plantmaterial
2 Algae
3 Insecta unidentified
4 Insecta identified
5 Crustacea
6 Caridina nilotica
7 Trematoda
8 Sand
9 Pisces
10 Unidentified

FOOD HABITS

According to Groenewald (1957) and Enslin (1966) *Barbus holubi* is an omnivorous feeder and they found that in the younger stages the fish relied mainly on plankton, insects and insect larvae whereas in the older fish (20 cm +) the diet consisted mainly of algae and aquatic vegetation The above-mentioned findings as well as the sporadic occurrence of *Corbicula* in the stomach contents were underlined in the present study. Although *Barbus kimberleyensis* was always known to be a predator detailed data were not available in the literature. In this study the stomach contents of all specimens of this species were examined and the results thereof are given in Figure 3. From the figure it is obvious that *Barbus kimberleyensis* is a predator from the juvenile stages with increasing piscivorous tendency with increasing age.

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