Aspects of the biology of a rare redfin minnow, *Barbus burchelli* (Pisces, Cyprinidae), from South Africa

J.A. Cambray and C.T. Stuart
Albany Museum, Grahamstown

Burchell's redfin, *Barbus burchelli* is endemic to the Breede River and adjacent smaller river systems in the Cape Province. Negative human influences have led to a drastic decline in numbers of this medium-sized minnow, especially agricultural demand on the water resource and the introduction of exotic predatory fish. The breeding season is extended, from September to February, with a peak in December. The absolute fecundity of a 123 mm FL specimen was 10 678, which includes both mature and recruitment ova. Females grow larger (123 mm FL), and live longer (6 + years), than males (113 mm FL and 4 + years). *B. burchelli* grow rapidly in their first year attaining a length of between 40 and 50 mm FL. Pronounced conical tubercles of sexually mature males erupt in spring, begin to show signs of wear in November and by March are worn or sloughed off. The survival of this species is dependent upon proper management of the Breede River system.

S. Afr. J. Zool. 1985, 20: 155 – 165

Burchell se rooivlerkie, *Barbus bruchelli* is endemies tot die Breederivier en die aanliggende kleiner rivierstelsels in die Kaapprovinsie. Negatiewe menslike invloede het gelei tot 'n drastiese vermindering in die getalle van hierdie middelgrootte kleinvissie, veral die aanvraag na water vir landboudoeleindes en die invoer van uitheemse roofvissoorte. Die broeiseisoen is verleng, van September tot Februarie, met die hoogtepunt in Desember. Die totale vrugbaarheid van 'n individu met 'n VL van 123 mm was 10 678, wat ryp asook rekruteerbare eiers insluit. Die wyfies word groter (123 mm VL), en lewe langer (6 + jaar), as die mannetjies (113 mm VL en 4 + jaar). *B. burchelli* groei vinnig in hul eerste jaar en bereik 'n lengte van tussen 40 en 50 mm VL. Skerp kegelvormige knoppies op geslagsrype mannetjies breek in die lente deur, vertoon tekens van afslyting in November, en teen Maartmaand is die knoppies verslete of heeltemal weg. Die oorlewing van hierdie vissoort is afhanklik van die behoorlike bestuur van die Breederivierstelsel.

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J.A. Cambray and C.T. Stuart
Albany Museum, Somerset Street, Grahamstown, 6140 Republic of South Africa

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Andrew Smith described *B. burchelli* (Figure 1) in 1841 but only recorded his collection sites as various rivers of the Cape Colony with no further details (Jubb 1967). It is now known

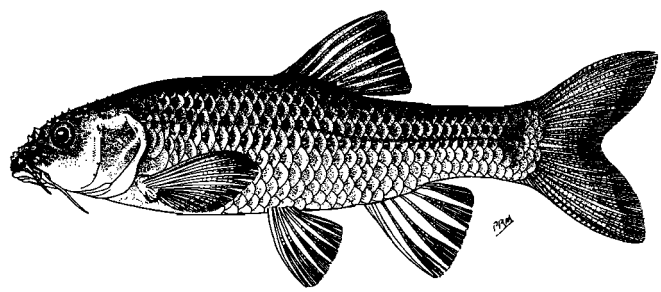

Figure 1 Male *B. burchelli* from Duiwenhoks River (80 mm SL), note conical tubercles on head. (Drawn by P. Meakin.)

that *B. burchelli* are endemic to the southern Cape and occur in the Breede, Kafferkuils, Duiwenhoks, Heuningnes and Sout River Systems (Figure 2). Its taxonomy (Skelton 1980) and distribution (Gaigher, Hamman & Thorne 1980) have recently been updated.

Esterhuizen (1978) completed the first biological study on Burchell's redfin and since his work remains unpublished some of his findings are incorporated into the present study. Surveys of the fish populations in the Breede River system, undertaken by the Cape Department of Nature and Environmental Conservation and the present study show the widespread distribution of predatory exotic fish species within the system, the most important being bass of the genus *Micropterus*. The presence of intensive agriculture with resultant high nutrient and often toxic runoff, along most of the Breede River and its tributaries, contributes to the general deterioration of the natural aquatic environment. Channelling of river beds to prevent flooding and to facilitate the pumping of water for irrigation purposes is probably having an adverse effect on this redfin minnow. Because of these environmental changes *B. burchelli* is listed in the South African Red Data Book — Pisces (Skelton 1977, in prep.) and it is classified as rare.

The objective of this study was to investigate selected aspects of the biology of *B. burchelli* with the aim of conserving this minnow species.

Methods

Collections, using a 5 m × 1 m funnelled seine-net, with a stretched mesh size of 1 mm, were made over the periods

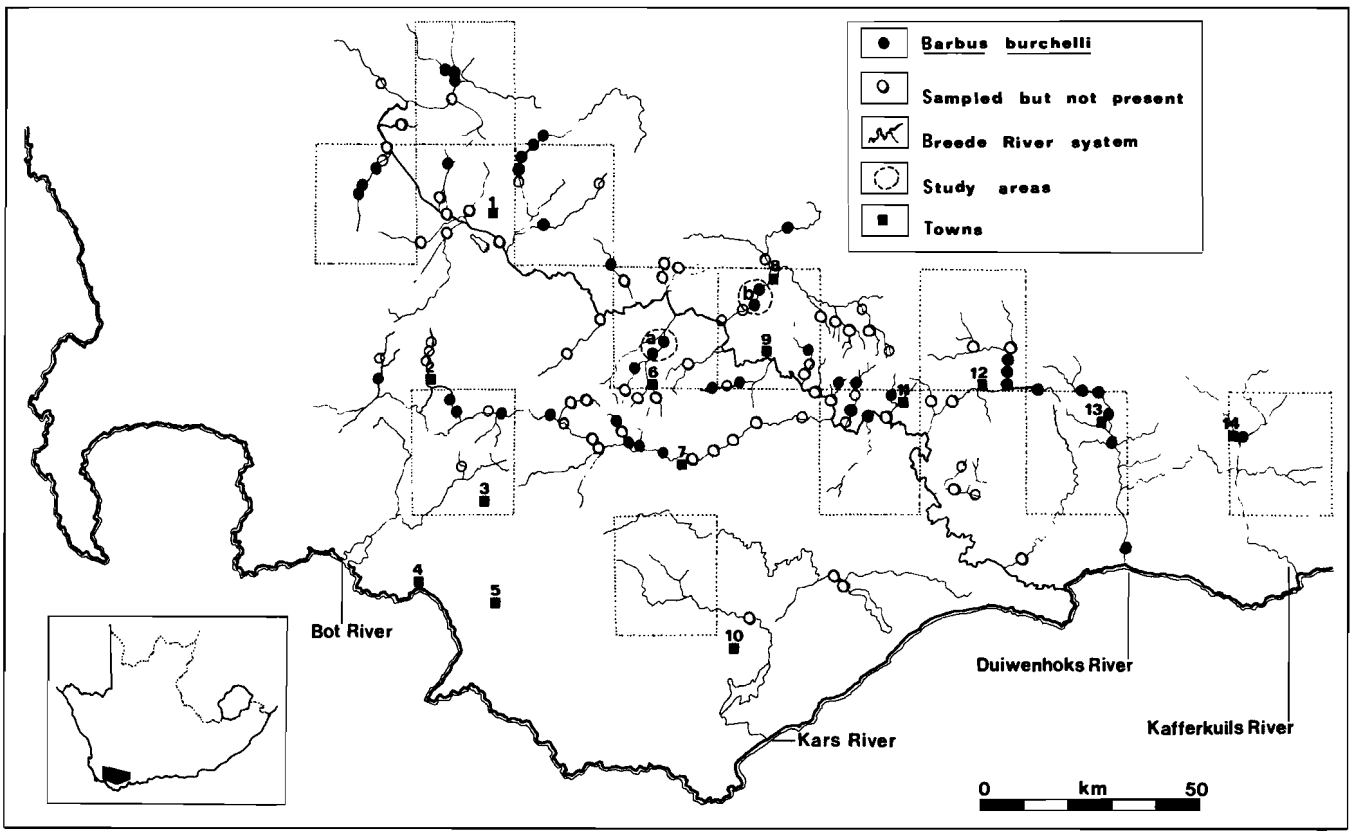

Figure 2 Distribution records of *B. burchelli*. The quarter-degree squares are after Gaigher (1978), which includes C.P.A. material records (post 1967) and pre 1968 records, mainly from Barnard (1943). Study areas, a — Keiser's River, b — Kogmanskloof River. Towns 1. Worcester, 2. Villiersdorp, 3. Caledon, 4. Hermanus, 5. Stanford, 6. McGregor, 7. Riviersonderend, 8. Montagu, 9. Bonnievale, 10. Bredasdorp, 11. Swellendam, 12. Suurbrak, 13. Heidelberg, 14. Riversdale.

November to April 1977/78 (Esterhuizen 1978) in the Keiser's River near McGregor, and also January to December (1980) in the Kogmanskloof River near Montagu. Distribution records were determined by examination of the literature, Cape Department of Nature and Environmental Conservation records and surveys by one of the authors (C.T.S.).

Relatively small samples were collected because of the threatened status of the species. Specimens were fixed in 10% formalin and then preserved in 50% n-propyl alcohol. All fish were catalogued in the Albany Museum. The mass of preserved specimens was recorded to the nearest 0,01 g and the fork length (FL) was measured to the nearest mm. The fish were sexed and the mass of both gonads was recorded to the nearest 0,01 g. A gonado-somatic index (GSI) was calculated for each fish using the equation

$$GSI = \frac{\text{Gonad mass}}{\text{Fish mass}} \times 100.$$

To determine the seasonality of mature ova the diameter of 10 of the largest ova from 10 or more females were measured on a monthly basis using an eye-piece micrometer in a stereoscopic microscope (Gaigher 1975). These measurements were taken from preserved material and do not represent live ova sizes. Ovaries were placed in Gilson's solution and shaken to separate the ova from the ovarian tissue. Ova were divided into four groups: < 0,2 mm; 0,2 – 0,4 mm; 0,5 – 1,1 mm and > 1,1 mm in diameter. The small oocyctes in the first group were not counted because they did not contain any yolk. Ova greater than 1,1 mm were classified as mature, while the next two size groups were probably recruitment stock, both containing yolk. All the eggs of one fish were measured to obtain these groupings. The number of modes in a size distribution of ova are often considered to represent the number of spawnings individual females are capable of within a season (Bagenal & Braum 1978). Absolute fecundity was determined by counting all the mature and recruitment ova (i.e. yolked ova) from fish collected in September, November and December. Even after using Gilson's solution many of the smaller ova had to be mechanically separated from the others. This, combined with the relatively few yolked ova in most females, made direct counting more applicable than subsampling (Cambray 1982). The objective of grouping the eggs was to follow the abundance of mature to recruitment ova on a seasonal basis.

Conical tubercle formation was monitored on a monthly basis for both males and females. Conical tubercles on the heads of five of the largest males and females were counted, and the largest measured with regard to height and basal diameter. The eruption of tubercles and their wear was also noted.

Scales were collected from immediately above the lateral line. The first scale was taken below the origin of the first dorsal ray and the remaining scales were removed posteriorly from this point. Four to six scales per fish were removed and mounted on a microscope slide, with a cover slip. Scales were taken from 109 fish (♂♂ = 55, ♀♀ = 46 and 8 juveniles) collected in January, February and March and from 78 fish (♂♂ = 29, ♀♀ = 49) collected in August, September and November. Scales were examined with a microfiche reader at a magnification of 48×. Annuli were identified by cutting over or crowding of circuli.

The contents of 32 foreguts were examined of which 12 were empty. Items were classified into major groupings with no attempt to determine species level.

Figure 3 Keiser's River, Breede River system. (Photo C.T. Stuart.)

Study area

The Breede River system contributes 4,2% of South Africa's total mean annual runoff and is classified as a clean acidic river, with low dissolved solids on Table Mountain sandstones (Noble & Hemens 1978). In the lower reaches of the river dissolved solids can be greater than 400 mg/ℓ and the biotic features reflect low productivity, and a diverse fauna with many endemic groups (Noble & Hemens 1978).

The two tributary systems in which samples were collected were the Keiser's (Figure 3) and the Kogmanskloof Rivers (Figure 4). The former rises in the Riviersonderend Mountains above the village of McGregor and flows through the Riviersonderend valley. The Kogmanskloof River rises in the Waboomsberge and after passing through the Kogmanskloof enters the Breede River near Goudmyn, Ashton. Both streams are perennial and relatively short with shallow altitudinal drops.

The Keiser's River sampling site was situated on the Vrolijkheid Nature Conservation Station. At this point the west bank is bounded by a low scrub-covered hill and the east bank is lined with cultivated lands for most of its length. During the 1980 study period the substratum was made up of water-washed rocks and pebbles, with the bedrock exposed in places. Several pools had a rock/sand/silt mix. The turbidity increased during periods of irrigation and land clearing on farms upstream from the study area. However, for much of the year the water was clear.

The Keiser's River runs in a series of narrow channels opening regularly into small, shallow pools. For much of the year water flow is sluggish to non-existent. During the winter rainy season periodical floods of short duration occur. In places large beds of *Phragmites communis* and smaller beds of *Typha capensis* extend from the banks into the pools. *Acacia karoo* and the exotic *Acacia longifolia* line both banks.

The Kogmanskloof River study site is situated in the Montagu Mountain Reserve. Both banks are bounded by rock outcrops and cliffs, with shrub *Acacia karoo* dominating the vegetation. During the dry season pools of varying size remain in the river bed; during the rains these are linked by narrow channels. The silt load is relatively high, emanating from agricultural development near Montagu. The pools are bounded by beds of *Phragmites communis*, with limited aquatic growth of other species. The major sampling pools were over 2 m deep in places, but as shallow as 30 cm in the vicinity of exposed bedrock. The substratum consisted of silt/sand with some small stony patches.

Figure 4 Collection site, Kogmanskloof River, Breede River system. (Photo C.T. Stuart)

Weather records were obtained from the station maintained at the Vrolijkheid Nature Conservation Station.

Both sites occur within the winter rainfall region, with the majority of rainfall between May and August (Figure 5). Rain occurs mostly in relatively soft showers, with occasional thunderstorms, with snow falling in the Riviersonderend Mountains during winter. Air temperatures for 1980 are provided in Figure 6.

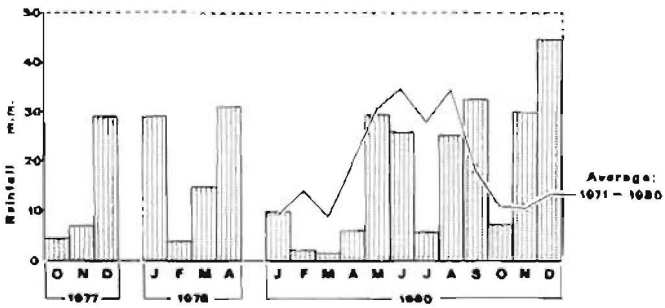

Figure 5 Monthly rainfall record, October 1977 to April 1978 and January to December 1980 and the ten-year average 1971 – 1980, for Vrolijkheid Nature Conservation Station.

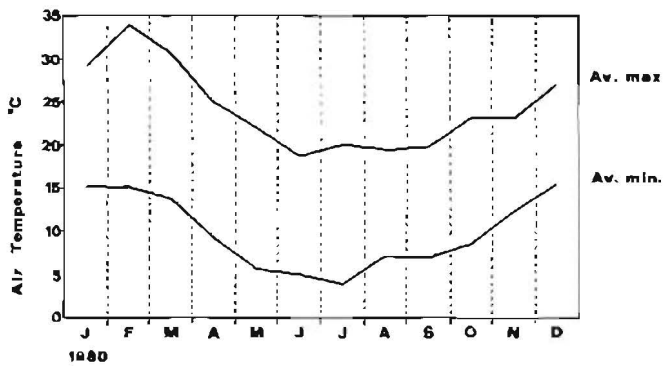

Figure 6 Air temperature records, January to December 1980, at Vrolijkheid Nature Conservation Station.

Floods in January 1981 destroyed the natural habitats of *B. burchelli* in the Kogmanskloof (Figure 7) and Keiser's Rivers (Hamman, Thorne & Scott 1982). Sand and silt filled many of the rock pools and the *B. burchelli* populations were probably washed into the Breede River main course, where survivors would be exposed to heavy predation by exotic species (Hamman *et al.* 1982). During the survey *B. burchelli* were not collected in either the Keiser's or the Kogmanskloof Rivers. The area east of Montagu, including streams in the Barrydale district and the Duiwenhoks and Kafferkuils Rivers fell outside the flood-stricken areas, with the result that *B. burchelli* survived in these areas (Hamman *et al.* 1982). In March 1983, *B. burchelli* were collected at one out of the three sites sampled in the Kogmanskloof River (C.P.A. distribution records), indicating that the river is being recolonized by this species.

Results

Distribution

Between 30 August 1978 and 16 November 1983, 136 sites were sampled in the Breede River system (Table 1). *B. burchelli* were collected in 41 localities, but were only taken from the Breede River mainstream at one site. *Micropterus* spp. were often collected in the mainstream. Two other

Figure 7 Natural flood damage to *B. burchelli* habitats during the January 1981 floods. (Photo C.T. Stuart.)

indigenous fish, *Sandelia capensis* and *Galaxias zebratus*, were frequently encountered. *S. capensis* occurred at 37 of the 41 localities in which *B. burchelli* was found (Table 2).

Length frequency

Fish of less than 30 mm FL were only collected in January (smallest 23 mm FL) and in February (smallest 24 mm FL) (Figure 8). No young-of-the-year specimens were collected at the sampling site during the period March to June. In the July/August collection, 12 of the 0^+ cohort (39 – 54 mm FL) were collected. Unfortunately, only a few juveniles were collected at the sampling site with the result that the rapid growth in their first year could not be followed on a monthly basis. The length frequency of the total collection ($n = 373$) is shown in Figure 9. The largest female was 123 mm FL and the largest male 113 mm FL. The majority of the fish, both males and females were between 70 and 100 mm FL.

On December 22, 1977, *B. burchelli* of 23 mm FL were collected in the Keiser's River (Esterhuizen 1978), indicating a spawning in November. The largest specimen collected in the study area was a 101 mm FL female. The majority of the fish collected were between 61 – 80 mm FL.

Growth rate

Annuli formed between August and September were very clear on many of the scales examined. Figures 10 & 11 show that *B. burchelli* grew quickly in their first year, attaining a length of 40 – 50 mm FL. Thereafter growth slowed down. The oldest specimen was a 6^+-year-old female of 120 mm FL, while

Table 1 Number of times that fish species have been collected in tributaries and the mainstream of the Breede River system (Cape Dept of Nature and Environmental Conservation distribution records, 30/8/78 – 16/11/83)

Species	Breede — mainstream	Bakoonds	Boesmans	Boesmanspad	Bruintjies	Buffelsjags	Dipka	Dwars	Groot	Haartbees	Hex	Holsloot	Huiswater	Jan Dutoit	Keisers	Keurbooms	Klip	Kluitjieskraal	Kogmanskloof	Kruis	Leeu	Modder	Nuy	Olifantsdoorn	Riet	Riviersonderend	Romans	Slang	Smalblaar	Tradou	Wit	Total times collected
Indigenous																																
Barbus andrewi	1										2	1																				4
Barbus burchelli	1	1	1			1		3			3			1	3	2			4		2		1			10				5	3	41
Galaxias zebratus	3							1	1		2			1	1	3			1		1					11			1		4	30
Sandelia capensis	5	1	1			2		4	2		2			1	3	3	1		9		2		2		1	10			1		3	53
Exotic																																
Cyprinus carpio								1																								1
Lepomis macrochirus	6					5		1																		4				1		17
Micropterus dolomieu	3					1						1														1						6
Micropterus salmoides	1																									1						2
Micropterus spp.	5			1																										2		8
Salmo gairdneri											1												1			3						5
Tilapia sparrmanii						1																								1		2
Tinca tinca																										1						1
No catch	2			1	1	4	2		3	1	2		1		2		1	1		2		1	2	1		8	1	3		2		41

Table 2 Frequency of other fish species occurring together with *B. burchelli* in the Breede River system. Cape Department of Nature and Environmental Conservation distribution records, lodged at the Albany Museum, 30/8/78 – 16/11/83

Species	Frequency of occurrence with *B. burchelli*
Indigenous	
Barbus andrewi	0
Galaxias zebratus	22
Sandelia capensis	37
Exotic	
Cyprinus carpio	1
Lepomis macrochirus	1
Micropterus dolomieu	0
Micropterus salmoides	0
Micropterus spp.	0
Salmo gairdneri	0
Tilapia sparrmanii	2
Tinca tinca	0

the oldest male measured 113 mm FL and was 4^+ years old. Length frequency graphs of the total population (Figure 9) indicate that the majority of the specimens were between 70 to 100 mm FL, giving ages of 2^+ and 3^+ years as shown in Figure 11.

Esterhuizen (1978) calculated that *B. burchelli* attained an average length of between 40 to 62 mm SL (mean 49 mm) at the end of their first year. He aged fish from his November to April collections, i.e. fish collected over six months, which might explain some of his size variability. The oldest fish in his study was 4^+ (90 mm SL).

Sex ratio, spawning and fecundity

Forty-one per cent of the *B. burchelli* which were sexed ($n = 319$) were males (Tables 3 & 4). There were more males

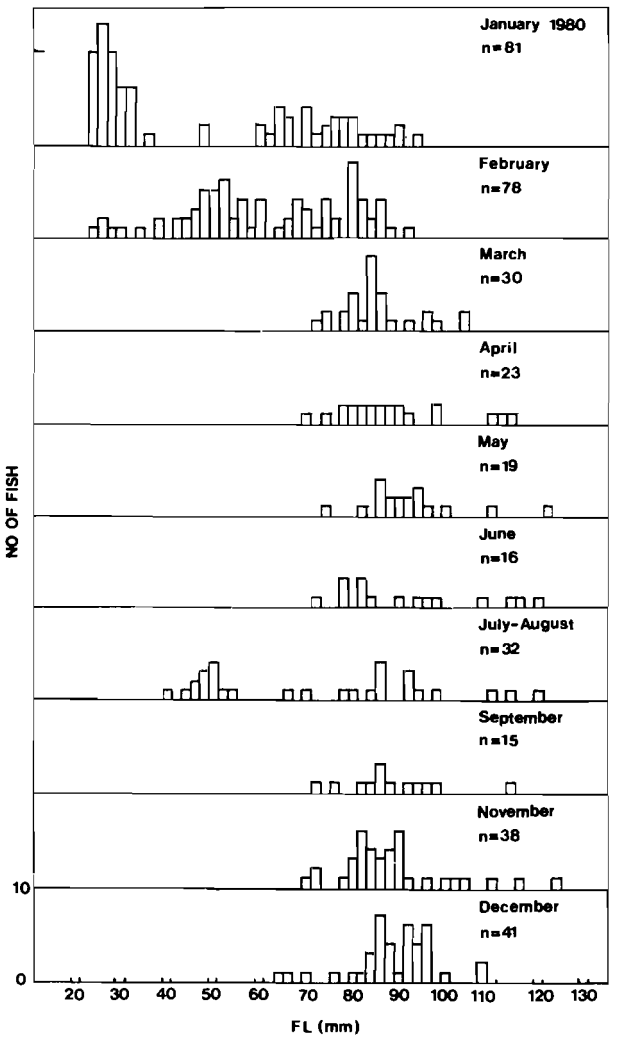

Figure 8 Length frequency distribution of *B. burchelli* (n = 373) from the Kogmanskloof River, January to December 1980.

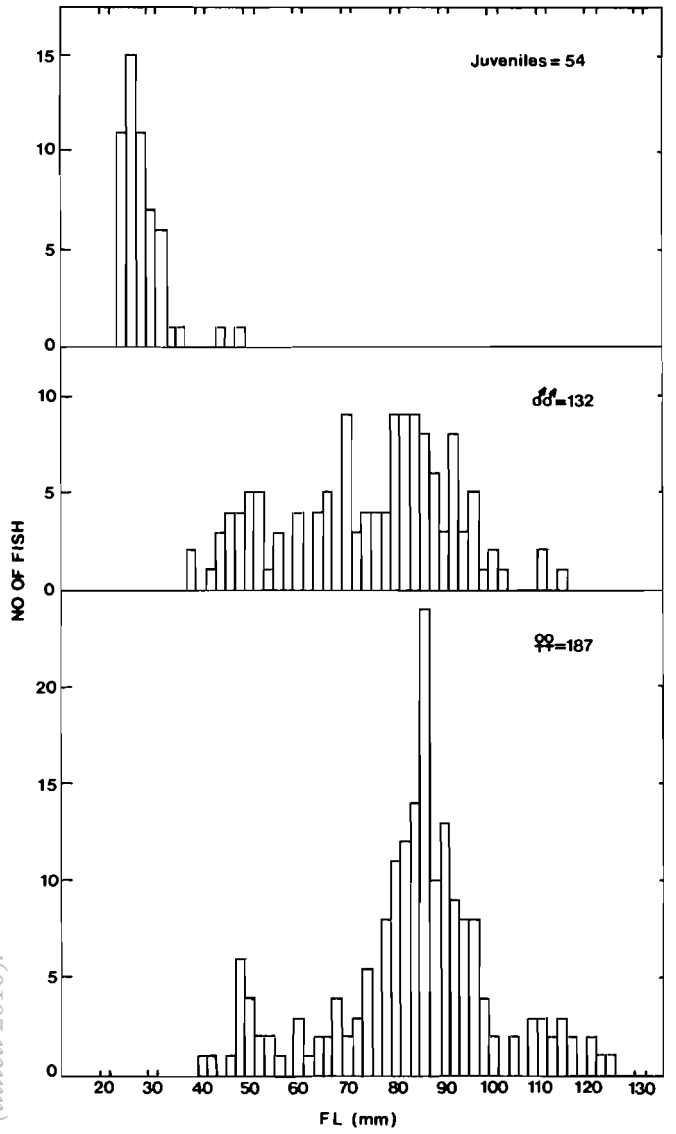

Figure 9 Length frequency distribution of *B. burchelli* collected from the Kogmanskloof River, January to December 1980.

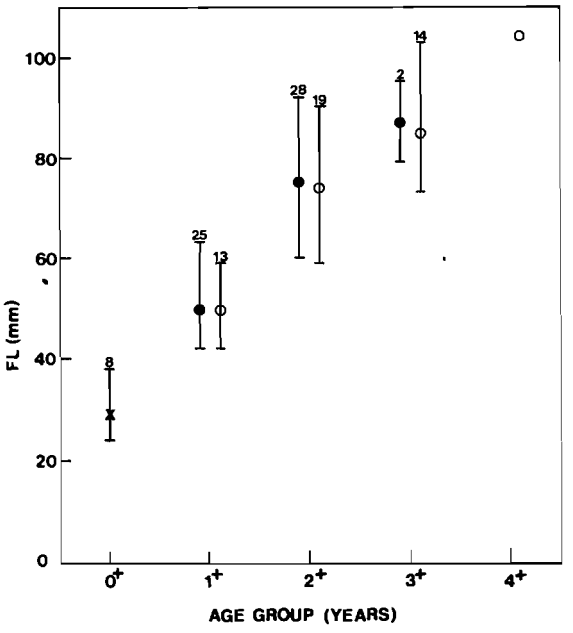

Figure 10 Growth rate of *B. burchelli* collected from the Kogmanskloof River in January, February and March 1980. Cross = not-sexed, closed circles = males, open circles = females.

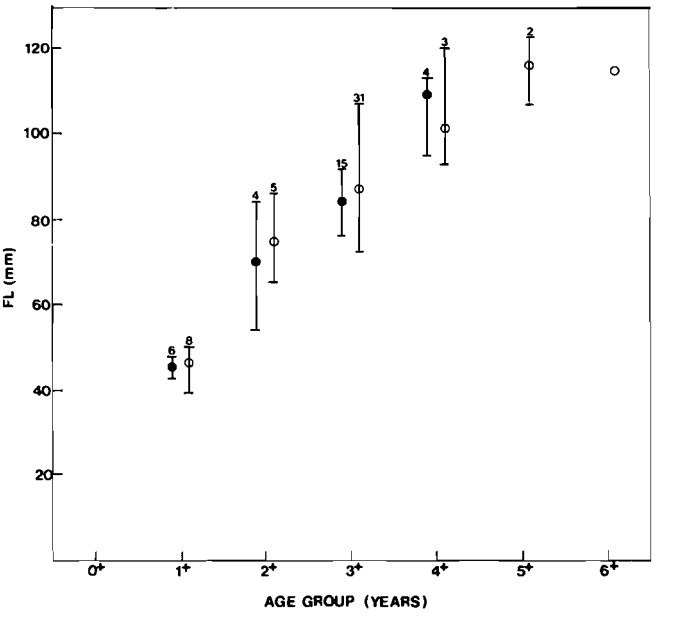

Figure 11 Growth rate of *B. burchelli* collected from the Kogmanskloof River in August, September and November 1980. Closed circles = males, open circles = females.

Table 3 *B. burchelli* collected from the Kogmanskloof River, Breede River system, January to December 1980

Sex	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Nov.	Dec.	Total
♂♂	16	37	16	8	8	6	2	9	5	14	11	132
♀♀	19	35	14	15	11	10	2	17	10	24	30	187
Not sexed	46	6	0	0	0	0	0	2	0	0	0	54
Total	81	78	30	23	19	16	4	28	15	38	41	373

Table 4 Percentage of male *B. burchelli* in different groups. Fish collected from Kogmanskloof River, January to December 1980

Fork length (mm)	Sample size	% ♂♂
0 – 50	31	58
51 – 70	51	59
81 – 90	165	36
> 90	72	33
Total	319	41

(58 – 59%) in fish under 70 mm FL; however for fish larger than 71 mm FL there were more females and in fish over 90 mm FL only 33% were males (Table 4). Esterhuizen's (1978) study also showed a similar trend in fish over 51 mm in length. Overall Esterhuizen (1978) calculated a 1 ♂: 1,5 ♀♀ ratio compared to the 1♂: 1,4♀♀ ratio of the present study (Table 4).

The gonado-somatic index (GSI) indicates that gonads begin to increase in mass during August and reach a peak in late September (Figures 12 & 13). While no sampling was carried out during October, the November GSI values indicate that some spawning had occurred. After December the values continue to decrease, reaching a minimum value during the winter months. These data show that *B. burchelli* have an extended

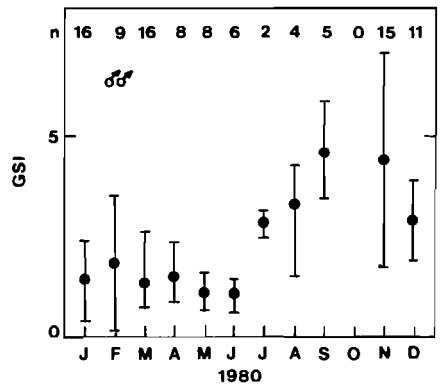

Figure 12 Mean and range of monthly gonado-somatic indices (GSI) of male *B. burchelli* from the Kogmanskloof River, January to December 1980.

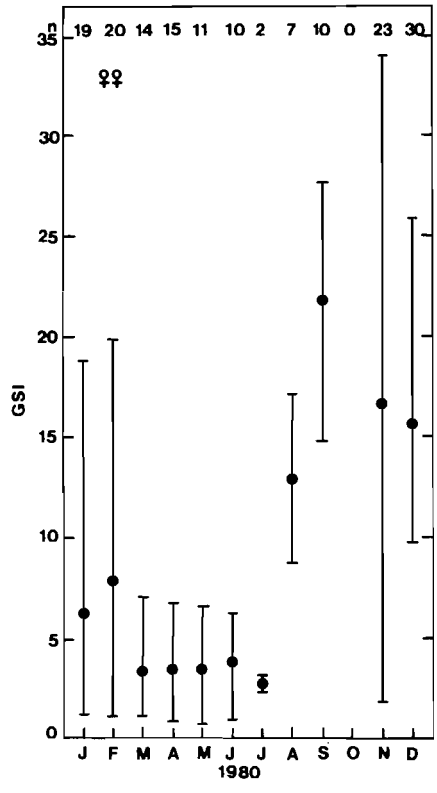

Figure 13 Mean and range of monthly gonado-somatic indices (GSI) of female *B. burchelli*, from the Kogmanskloof River, January to December 1980.

breeding season from September to February, with the major spawning possibly occurring between December and January. Esterhuizen (1978) also found that the major GSI decrease occurred from December to January and continued to decline to a low in February.

During January and February and between August and December 1980 large mature ova were found in the ovaries (Table 5). This is further evidence of an extended breeding season. A few large ova were also present in specimens collected during March and April.

All the ova in a 95 mm FL specimen were measured, which gave three ova size categories as mentioned under methods (Figure 14). The absolute fecundity (all yolked ova) of *B. burchelli* collected in September ($n = 10$), November ($n = 22$) and December ($n = 10$) is shown in Figures 15, 16, & 17. While there were too few fish to analyse the September results, the

Table 5 Largest ova diameter of *B. burchelli* January to March and August to December 1980

Month	No. of fish	No. of ova measured	Mean diameter of ova (mm)	*S.D.*
January	12	120	1,4	0,01
February	13	130	1,4	0,01
March	13	130	1,0	0,05
April	10	100	1,3	0,04
August	9	90	1,5	0,01
September	10	100	1,5	0,0
November	16	160	1,5	0,01
December	12	120	1,5	0,01

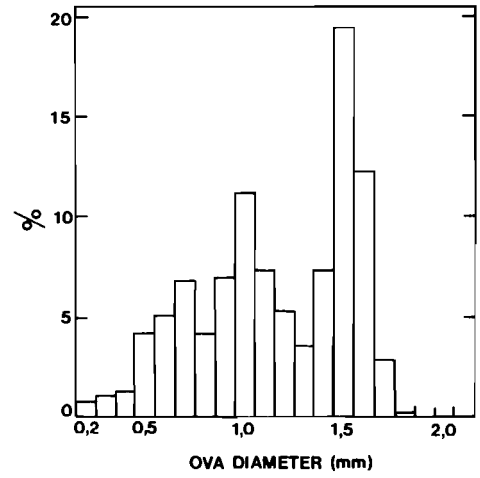

Figure 14 Ova size frequency of a 95 mm FL *B. burchelli* collected from the Breede River system, 25 September 1980, absolute fecundity 3 939 yolked ova.

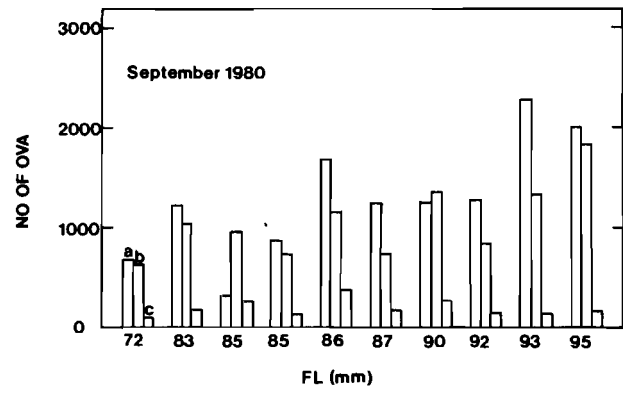

Figure 15 Frequency of yolked ova in three size classes for *B. burchelli*, of different lengths, collected during September 1980, Kogmanskloof River. Ova size classes: a = > 1,1 mm; b = 0,5 – 1,1 mm; c = 0,2 – 0,4 mm in diameter.

November GSI values indicate that some spawning activity had taken place. Fecundity to length or mass relationships have not been calculated owing to small sample size, but it is clear that the larger fish carry more ova than the smaller specimens. In November a 123 mm FL *B. burchelli* had a total of 10 678 yolked ova (> 0,2 mm in diameter), with 7 433 ova in the largest size category (Figure 16). By comparison, a 71 mm FL female had only 986 yolked ova of which 509 were in the largest category (Figure 16). For an increase of 52 mm in fork length there was a 10,8-fold increase in absolute fecundity and a 14,6-fold increase of mature ova.

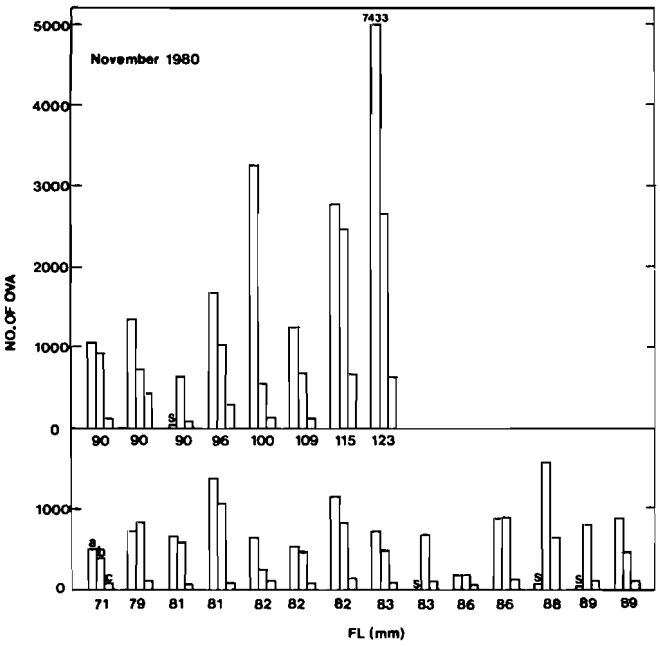

Figure 16 Frequency of yolked ova in three size classes for *B. burchelli*, of different lengths, collected during November 1980, Kogmanskloof River. Key as in Figure 15 and S indicates that the fish has spawned.

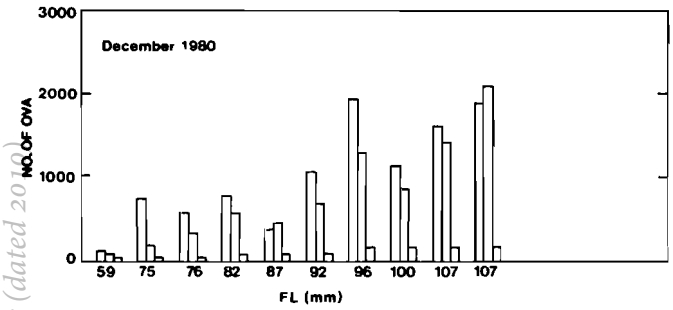

Figure 17 Frequency of yolked ova in three size classes for *B. burchelli* of different lengths, collected during December 1980, Kogmanskloof River. Key as in Figure 15.

It is evident from the November sample that some of the fish (e.g. 88 mm FL, Figure 16) had already spawned the largest eggs and that some of the second size group were probably being recruited. The December data suggests that in fish less than 90 mm FL there are less mature ova, however owing to extreme variability and small sample size no definite conclusions can be made. The bigger fish still have a large percentage of mature and recruitment ova, for example the ovaries of a 107 mm FL specimen contained 4 244 yolked ova of which 1983 were mature ova (Figure 17). Segments of the population possibly spawn at different times. More information is required to establish whether *B. burchelli* spawn in their first year.

Tubercle formation

The formation, wear and size of the conical tubercles on the heads of both male and female *B. burchelli* were observed throughout the study period (Tables 6 & 7). The large conical tubercles on the snout and head of males (> 80 mm FL) began to erupt through the bases of the tubercles of the previous season in May, and by August some of the conical tubercles were well formed. The first signs of wear occurred in November, which coincided with the spawning season. This wearing and/or sloughing off of the larger conical tubercles continues until April when only the base of the tubercle remains. This seasonal cycle adds further support to the suggestion (Skelton 1980) that the tubercles are associated with reproduction. Some tubercles on both sexes remain pointed from one breeding season to the next, which was more evident on the smaller (< 70 mm FL) males. Generally the larger males (Figure 1) have more conical tubercles, up to 132 on a 100 mm FL specimen. The smallest male in the study with large (base > 0,5 mm, height > 0,4 mm) conical tubercles was 69 mm FL. Females also showed a seasonal pattern of tubercle formation, but not as pronounced as the males (Table 7). The greatest number of conical tubercles on a female was 20 on a 95 mm FL specimen. A marked difference was also noted in tubercle size, the largest conical tubercle on a female was 0,5 mm high with a basal diameter of 0,9 mm in comparison to a male with measurements of 1,5 mm and 1,8 mm respectively.

Table 6 Seasonal formation, wear and size of conical tubercles on the heads of male *B. burchelli*

Month	No. of fish examined	Fish FL (mm) range	No. of conical tubercles on head (min. – max.)	Size of the largest tubercles: base diameter (mm)	Size of the largest tubercles: height (mm)	Remarks
1980						
January	5	70 – 75	12 – 16	0,2 – 0,7	0,2 – 0,3	pointed, several worn
February	5	79 – 85	20 – 30	0,7 – 1,1	0,3 – 0,4	on some fish all large tubercles are worn away
March	5	86 – 95	14 – 22	0,5 – 1,0	0,1 – 0,3	mainly worn
April	5	81 – 97	12 – 24	0,3 – 0,7	0,1 – 0,2	mainly worn
May	5	87 – 110	13 – 30	0,7 – 0,8	0,2 – 0,3	few pointed
June	5	77 – 95	4 – 22	0,3 – 1,1	0,1 – 0,3	tubercle bases left, several still pointed
July	2	78 – 91	12 – 26	0,5 – 1,1	0,1 – 0,2	tubercles erupting through old bases
August	4	84 – 110	10 – 17	0,8 – 1,3	0,1 – 0,4	some erupting, some well-developed
September	5	72 – 113	4 – 68	0,8 – 1,8	0,5 – 1,5	well-developed, pointed
November	5	87 – 102	30 – 83	1,0 – 1,7	0,6 – 1,1	some of larger tubercles are worn – smallest male with conical tubercles 69 mm FL
December	5	84 – 100	8 – 132	0,8 – 1,3	0,3 – 0,7	most of large tubercles are worn

Table 7 Seasonal formation, wear and size of conical tubercles on the heads of female *B. burchelli*

Month	No. of fish examined	Fish FL (mm) range	No. of conical tubercles on head (min. – max.)	Size of the largest tubercles: base diameter (mm)	Size of the largest tubercles: height (mm)	Remarks
1980						
January	5	80 – 94	0 – 8	0,2	0,05	white bases like males
February	5	85 – 91	2 – 6	0,1	< 0,05	very small; pointed
March	5	95 – 104	2 – 7	0,05 – 0,1	< 0,05	pointed
April	5	90 – 114	2 – 9	0,1 – 0,2	0,05	some worn
May	5	90 – 122	0 – 3	0,1	< 0,05	bases, no points
June	5	98 – 120	0 – 8	0,2 – 0,4	< 0,05	all worn
July	2	86 – 98	0	–	–	none
August	5	86 – 120	0 – 5	0,1 – 0,2	0,1	pointed
September	5	85 – 95	0 – 20	0,1 – 0,3	0,05 – 0,2	pointed
November	5	96 – 123	6 – 15	0,2 – 0,9	0,05 – 0,5	pointed
December	5	95 – 107	6 – 11	0,1 – 0,4	0,05 – 0,1	pointed

Table 8 Food items in the foreguts of 20 *B. burchelli* from the Kogmanskloof River, Breede River System

Food item	% Frequency of occurrence
Crustacea	
Cladocera	5
Copepoda	45
Ostracoda	35
Insecta	
Chironomidae larvae	45
Filamentous algae	5
Detritus	70
Sand particles	25

Food habits

Thirty-two guts were examined of which 12 were empty. Analysis of the remaining 20 indicated that *B. burchelli* were feeding off the substratum (Table 8). The sub-inferior orientation of the mouth confirms the method of food procurement (Figure 1). There was a high percentage of both sand particles and detritus in the guts, though.

Ostracods, copepods and chironomid larvae were well represented (Table 8). Gaigher (1978) noted that *B. burchelli* feeds mainly on diatoms and algae. In fishes the length of the gut usually reflects the diet (Nikolsky 1963); usually the shorter the gut the more carnivorous the feeding habits and the longer, the more herbivorous. Skelton (1980) determined that the intestine of *B. burchelli* was moderately long, up to 2,8 times the standard length of the fish, compared to other redfin species. This relatively long gut indicates a more herbivorous diet, which might explain the high percentage of detrital matter. Such a limited sample must be treated with some reserve as many factors influence the feeding pattern of barbine minnows throughout the year (Cambray 1983a).

Discussion

Although the Breede and adjacent river systems have been influenced by negative human interference, healthy populations of *B. burchelli* are still to be found in several tributaries (Gaigher *et al.* 1980). Sections of the mainstream were found to be devoid of indigenous freshwater fishes. One of us (C.T.S.) has established that the times of spawning and hatching of *B. burchelli* fry coincide with the drawing-off of the greatest quantities of water for irrigation and in addition fertilizers and pesticides are being applied at this time. Being extremely vulnerable at this time, the death of embryos and larval fish is probably high. An additional and probably a detrimental factor is the increased salinity of the Breede River and many of its tributaries as a result of the drawing-off of large quantities of water for irrigation. Skelton (1977) noted that specimens in the Albany Museum, which had been collected from the Breede River system, had a high incidence of helminth parasites, indicating poor environmental conditions. Stream modification such as channelization, and bulldozing stretches of the river, are also having a detrimental impact on remaining *B. burchelli* habitats. The adverse impact of the January 1981 floods on the Kogmanskloof River populations of *B. burchelli*, as reported by Hamman *et al.* (1982), are largely the result of poor catchment management.

Both Skelton (1977) and Gaigher *et al.* (1980) have recorded that *B. burchelli* are rare, owing to predation by exotic fish species, such as *Micropterus* spp. and *Salmo gairdneri*. In recent surveys no *B. burchelli* have been collected at the same site as either bass or trout in the Breede River system (Albany Museum and Cape Dept of Nature and Environmental Conservation records). This minnow was collected once in the main channel and all the other collections were from the tributaries of this river system. Hamman *et al.* (1982) note that *B. burchelli* which get washed into the main Breede River channel during floods probably have, owing to predation by exotic fish, little chance of survival and therefore of recolonizing the tributaries.

In comparison to the exotics, the two indigenous species, *S. capensis* and *G. zebratus* frequently occurred together with *B. burchelli*. Predation on *B. burchelli* by *Xenopus laevis* has been witnessed by one of us (C.T.S.). Five piscivorous bird species were recorded on the Keiser's River, namely reed cormorant (*Phalacrocorax africanus*), grey heron (*Ardea cinerea*), little egret (*Egretta garzetta*), giant kingfisher (*Megaceryle maxima*) and the malachite kingfisher (*Corythornis cristata*) (Stuart, Palmer & Munnik 1978). At the Kogmanskloof River study site the grey heron, giant kingfisher and malachite kingfisher (*Corythornis cristata*) were regularly recorded (Stuart pers. obs.). These predators possibly have less of an impact on *B. burchelli* populations than exotic fishes, since they have long co-existed together.

There have been very few biological studies on the numerous African barbine minnows, (Cambray 1982) and there are no other ecological studies on the redfin *Barbus* species with which to make comparisons. The majority of the small *Barbus* species which have been studied grow rapidly and attain sexual maturity in their first year (Cambray & Bruton 1985). *B. burchelli* attain a fork length of between 40 – 50 mm in their first year. This is approximately 35 – 44% of the males' and 33 – 41% of the females' final fork length, using the largest fish in this collection as an example (male 113 mm FL, female 123 mm FL). Gaigher (1975) also determined that *B. trevelyani* attain a fork length of between 40 – 50 mm in their first year of growth. This rapid growth rate in the first year is important for relatively short-lived minnow species (Cambray & Bruton 1985).

Like most other small *Barbus* species studied, *B. burchelli* have an extended breeding season (Cambray & Bruton 1984). This allows for multiple spawning which is a possible adaptation to an unstable environment, and also allows the small abdominal volume of the female to carry more mature eggs during a breeding season. Although it was determined indirectly, through following ova size classes, it appears that an individual female has the potential to spawn more than once in a season. Cambray (1982) found that periods of steady rainfall were probably the ultimate trigger to initiate the spawning of another minnow, *B. anoplus*. This occurs in a summer rainfall region, unlike *B. burchelli* of the winter rainfall area. However, heavy rains did fall in November and December 1980 when spawning took place (Figure 5). In Esterhuizen's (1978) study there was relatively good rainfall during December and January (Figure 5) again coinciding with spawning. The average rainfall pattern for the area indicates that from October to March (the breeding season) there is little rainfall (Figure 5). The possibility of rain still exists during these months and further studies on *B. burchelli* should determine if rainfall is the ultimate trigger for spawning. If so it would provide a definite time to monitor spawning sites. Possible impact of excessive fertilizer or pesticide levels, water abstraction, exotic predation etc., could be noted and steps taken to rectify these problems in the declared conservation areas for this species.

One of the most noticeable characters of sexually mature male *B. burchelli* are the large conical tubercles which appear on their heads during spring (Figure 1), and are more highly developed than most other small *Barbus* species (Skelton 1980). Males of many species of the family Cyprinidae develop excrescences, generally on the head and forepart of the body at breeding time (Breder & Rosen 1966). Tubercles probably originally evolved to enable spawning individuals to maintain contact in fluviatile environments and may also be used by some species for defence of nests and territories and possibly the stimulation of females to breed (Wiley & Collette 1970; Collette 1977). The fact that the tubercles of *B. burchelli* become more worn as the breeding season progresses suggests their use in defending a territory. Smaller tubercles also occur on the fins and scales of *B. burchelli* and are only well developed on sexually mature males.

B. burchelli are protected under the Cape Provincial Nature Conservation Ordinance. In addition, the Holsloot River in the Breede River system is a Project Aqua site 2 (Noble 1974), but Skelton (1977) noted there are no museum records of *B. burchelli* from this tributary. In the more recent collections *B. andrewi* and bass were collected in this river, but no museum records of *B. burchelli* presently exist for this area. Conservation measures proposed by Skelton (1977) included the establishment of sanctuary stream(s) from which exotic predatory fish species are excluded. He also recommended that breeding populations be established at provincial fish hatcheries for restocking purposes. Bok & Heard (1982) and Cambray (1983a) have demonstrated the feasibility of artificially propagating small *Barbus* species. However, the greatest need is for sanctuary streams in which existing populations are properly protected.

Gaigher (1975) considered that the reasons for the decline of *B. trevelyani* in the Keiskamma River cannot be halted, as these are part of agricultural and industrial development. This also applies to sections of the Breede River system. Gaigher's (1975) conservation recommendations for *B. trevelyani* are also applicable to *B. burchelli*, including proclaimed conservation areas and an intensive study of all aspects of the biology of this threatened fish species. The measures outlined by Gaigher *et al.* (1980) for fish conservation management in the Cape Province, are important guidelines to prevent the extinction of endangered fish species.

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