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The Distribution of Centroptiloides bifasciata (E.-P.) (Baëtidae: Ephem.) in Southern Africa, with Ecological Observations on the Nymphs

by

J. D. AGNEW

(National Institute for Water Research, South African Council for Scientific and Industrial Research, Pretoria, South Africa.)

(with 1 fig.)

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INTRODUCTION

The first baëtids known from South Africa were described by ESBEN-PETERSEN in 1913: one of his new species, *Centroptilum bifasciatum*, was later placed in the new genus *Centroptiloides* by LESTAGE (1918). To date, this has remained a monotypic genus. The nymph was unknown until the description by CRASS appeared in 1947. The full synonymy of this species is given below (references marked with an asterisk have not been seen in the original):

Centroptiloides bifasciata (E.-P.) 1913

Centroptilum bifasciatum ESBEN-PETERSEN 1913+. Ann. S. Afr. Mus. 10, 182. (Figs. 4—7).
Centroptiloides bifasciatus PETERS, LESTAGE 1918. Rev. Zool. Afr. 6 (1) 108.
? *Haplobaëtis umbratus* NAVAS 1922+. Treb. Mus. Ci. Nat. Barcelona. 4, 115.
Centroptiloides bifasciata E.-P., LESTAGE 1924. Rev. Zool. Afr. 12 (3) 341.
Centroptiloides marginata LESTAGE. Rev. Zool. Afr. 12 (3) 341.
Centroptiloides collarti NAVAS 1930+. Rev. Zool. Bot. Afr. 19, 319.

Centroptiloides bifasciatum (E.-P.), BARNARD 1932. Trans. Roy. Soc. S. Afr. 20 (3) 226 (Fig. 16).
Centroptiloides bifasciatum (E.-P.), BARNARD 1940. Ann. S. Afr. Mus. 32 (6) 626.
Centroptiloides bifasciatum (E.-P.), CRASS 1947. Ann. Natal. Mus. 11 (1) 91—93 (Figs. 29—30).
Centroptiloides bifasciata (ESBEN-PETERSEN), DEMOULIN 1957. Bull. Ann. Soc. Roy. Ent. Belg. 93 (9—10) 259—260 (Fig. 1).
A reference by ULMER (1920) to this species has been omitted from the above list, as this paper has not been available for study and the actual name used by ULMER cannot be found in the above references.

DISTRIBUTION

The type locality of this species, given in the original description, is Mfongosi, Zululand (Natal) (see Fig. 1). The distribution was later considerably extended by the authors listed above: LESTAGE (1924) writes, "Cette espèce existe, d'après ULMER dans toute l'Afrique, du Cameroun jusque dans l'Afrique du Sud". BARNARD (1932) records it from the Kunene River, Ovamboland (South West Africa), while *Centroptiloides collarti* was recorded from Stanleyville, Congo. All these records, with the exception of those of CRASS (1947), were based on material consisting of imagines. The nymphs recorded by CRASS came from various rivers and streams in Natal. KIMMINS (1948, 1955, 1956 and 1960) in his excellent studies on the Ephemeroptera of Uganda and Nyasaland, has not recorded this species.

Recently many new records have become available as a result of hydrobiological work carried out by members of this Institute. A few of these have already been published (OLIFF 1960). New records are arranged below in Table I, with the catalogue numbers of the specimens of nymphs in this Institute, dates of collection, localities and type of habitat from which the specimens were collected. Where available, pH and current speed readings are given. These are based on snap readings in the field, taken while the samples were being collected.

Fig. 1 depicts the known distribution of this species and suggests a southerly limit beyond which it does not penetrate (it is not possible to include on the map the Central African records given in the literature). The catchment area of the Great Berg River in the South-Western Cape has been the subject of a detailed study by HARRISON & ELLSWORTH (1958), and it was found that *C. bifasciata* was absent from this river system. Later work by HARRISON & AGNEW (1962, in press) on the acid streams of the Southern Cape revealed that it

TABLE I

New Records of Centroptiloides bifasciata (E.-P.)

Catalogue No.	Date	Locality and Province	Long. E.	Lat. S.	Alt.(m)	Habitat and remarks.
GEN 34D	15.ix.54	Komati River at Badplaas, E. Transvaal.	30° 38′	25° 54′	1070	Stones in current and marginal vegetation (A. D. HARRISON)
GEN 133E	6.vii.59	Zeekoespruit at Badplaas, E. Transvaal.	30° 35′	25° 57′	1070	Stones in current.
GEN 150B	9.vii.59	Olifants River near Mica, E. Transvaal.	30° 50′	24° 11′	457	Marginal reeds *(?Phragmites)* in current. pH = 8.4.
GEN 152A	10.vii.59	Letaba River at Tzaneen, N. E. Transvaal.	30° 10′	23° 48′	700	Stones in current. pH = 7.4.
GEN 162C	10.vii.59	Stream just S. of Wylliespoort, N. Transvaal.	29° 56′	22° 57′	915	Stones in current.
	10.vii.59	Limpopo River at Beit Bridge, N. Transvaal.	30° 00′	22° 14′	450	Stones in current. pH = 8.4.
GEN 243B	19.xi.59	Mlumati (Lomati) River, 21 km S. of Hectorspruit, E. Transvaal.	31° 40′	25° 36′	300	Marginal vegetation in current. pH = 7.0.
GEN 307C	18.xi.59	Sabie River at Lower Sabie, E. Transvaal.	31° 55′	25° 07′	150	Marginal vegetation in current.
GEN 308A	24.xi.59	Sabie River at Lower Sabie, E. Transvaal.	31° 55′	25° 07′	150	Marginal vegetation in current.
	24.xi.59	Sabie River at Lower Sabie, E. Transvaal.	31° 55′	25° 07′	150	Stones in current.
GEN 345C	4.v.60	Mooi River at Mooi River, Natal.	30° 01′	29° 12′	1220	Stones in current.
GEN 390A	26.vi.60	Crocodile River at Karino, E. Transvaal.	31° 07′	25° 29′	610	Stones in current.
	28.vi.60	Olifants River at Old Gorge Rest Camp, E. Transvaal.	31° 50′	23° 59′	150	Marginal vegetation in current, and stones in current.
GEN 420B	25.viii.60	Crocodile River at Schagen, E. Transvaal.	30° 48′	25° 26′	732	Stones in current. pH = 7.7 Current speed = 95 cm/sec.
	25.viii.60	Elands River just before confluence with Crocodile River, E. Transvaal.	30° 42′	25° 30′	825	Stones in current. pH = 7.7 Current speed = 78 cm/sec.
	25.viii.60	Crocodile River just above confluence with Elands River, E. Transvaal.	30° 40′	25° 27′	825	Stones in current. pH = 7.6 Current speed = 87 cm/sec.
	23.viii.60	Crocodile River, at Rietvly 27, E. Transvaal.	30° 34′	25° 24′	975	Stones in current. pH = 7.7. Current speed = 97 cm/sec.
GEN 536A	1.vii.60	Sabie River at Lower Sabie, E. Transvaal.	31° 55′	25° 07′	150	Marginal vegetation in current.
GEN 538C	11.xii.60	Orange River at Prieska, Cape Province.	22° 46′	29° 40′	950	Small stones in current, on shallow bottom.
GEN 569C	4.vii.60	Komati River at Komatipoort, E. Transvaal.	31° 57′	25° 27′	150	Marginal vegetation in current.
GEN 668G	25.vi.61	Stream between Shire River and Mwanza, Nyasaland.	34° 37′	15°40′	1220	Aquatic *Hydrostachys polymorpha* KLOTSCH in current.
FRW 169A	8.iii.60	Krom River at Assegaaibosch, S. Cape Province.	24° 19′	33° 57′	300	Stones in current, with heavy growth of brown gelatinous ?*Pyrobotrys* and other algae on stones and vegetation.
VAL 390C	29.v.58	Vaal River at Lindeques Drift, Transvaal-Orange Free State border.	27° 35′	26° 45′	1370	Stones in current (F. M. CHUTTER). Specimens from the same locality, but not retained, collected on 27.ii.58 and 31.iii.58
	25.iv.57	Vaal River just below Vaal Barrage, Transvaal-Orange Free State border.	27° 40′	26° 47′	1375	Stones in current. *(F. M. Chutter)*
	14.i.59	Klip River at Memel, Orange Free State.	29° 35′	27° 41′	1750	Stones in current (F. M. CHUTTER).
VAL 1053A	23.iii.60	Vaal River at Gladdedrif, Transvaal-Orange Free State border.	28° 44′	27° 00′	1525	Stones in current (F. M. CHUTTER).
	11.viii.60	Wilge River at Frankfort, Orange Free State.	28° 29′	27° 18′	1500	Stones in current (F. M. CHUTTER).

N.B. Where no catalogue numbers are entered, specimens were not retained. All records are those of the author, except where otherwise stated.

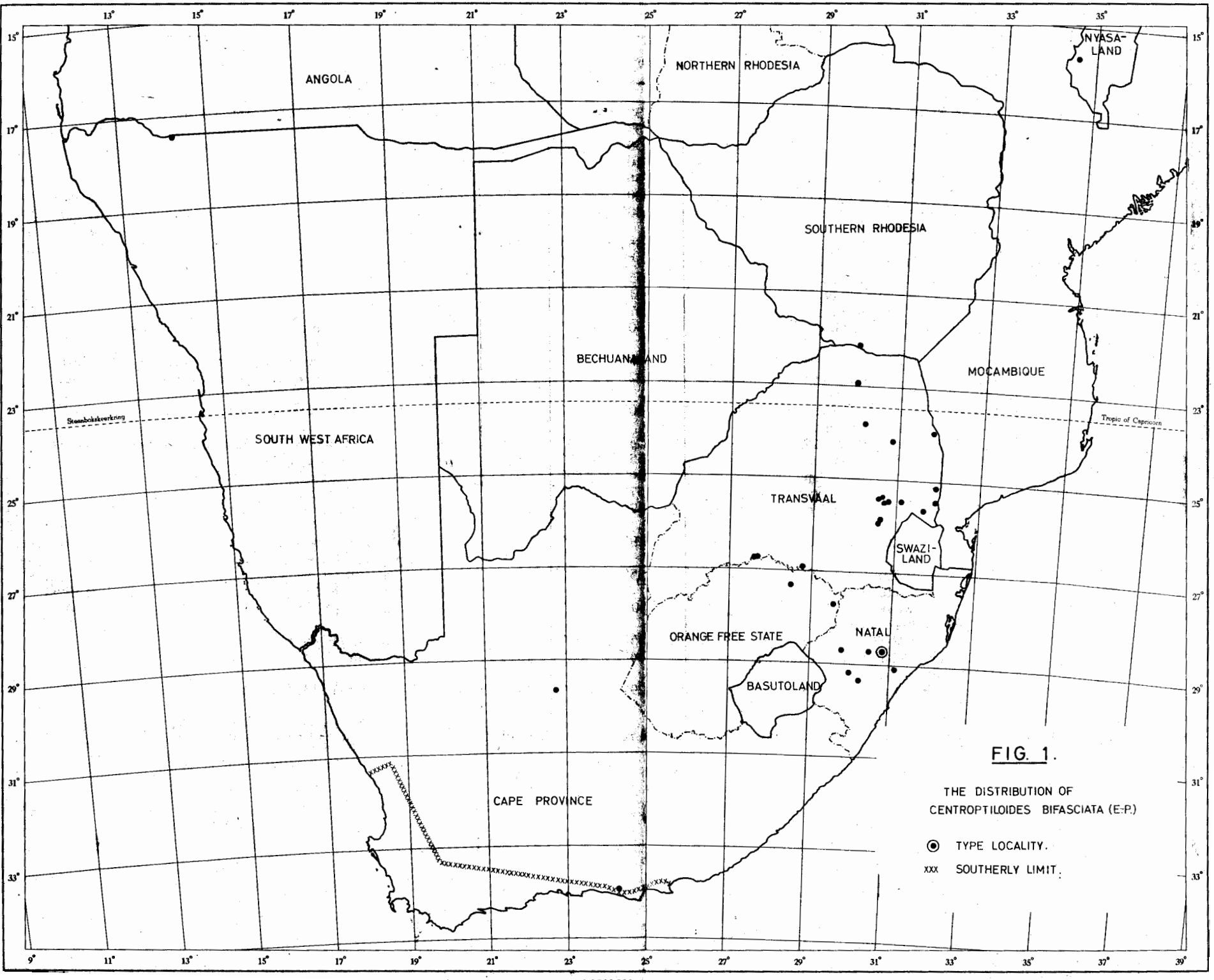
ANGOLA
NORTHERN RHODESIA
NYASA-LAND
SOUTHERN RHODESIA
BECHUANALAND
MOCAMBIQUE
Steenbokkeerkring
Tropic of Capricorn
SOUTH WEST AFRICA
TRANSVAAL
SWAZI-LAND
ORANGE FREE STATE
NATAL
BASUTOLAND
CAPE PROVINCE
FIG. 1.
THE DISTRIBUTION OF
CENTROPTILOIDES BIFASCIATA (E.P.)
TYPE LOCALITY.
xxx SOUTHERLY LIMIT.

TABLE II.

Analysis of the gut-content of 7 nymphs.

	A	B	C	D	E	F	G
Baetid nymph head capsules	?1	—	—	—	—	—	—
Baetid head + thorax united	—	1	—	—	2	—	—
Baetid abdomen	—	1	—	—	1	—	—
Simulium head capsules	8	8	1	11	—	2	—
Simulium anal extremity	3	1	—	—	—	1	—
Simulium whole larvae	6	2	—	2	—	—	—
Chironomid head capsules	—	7	—	—	—	15	6
Unidentified head capsules	—	2	—	—	—	—	—
Total probable number of whole larvae	14	17	1	13	2	17	6

was also absent from these streams and they classified this baëtid under "temperate species which appear to prefer alkaline water". OLIFF (1960) in his study of the Tugela River, Natal, found that this species did not occur in the upper river (i.e. source, waterfall, mountain torrent and foothill torrent zones) but was present in the sand bed zone and disappeared again in the estuarine zone. A detailed survey of the Vaal Dam catchment area by Mr. F. M. CHUTTER of this Institute revealed that this species was rather rare and had a very patchy distribution. Occasionally a few nymphs were found at five out of the fifty points at which he has taken samples (the results of this survey are still to be published). The altitude of this catchment area lies uniformly above 1525 m, and it is clear that in this area the species is barely maintaining itself. At lower altitudes along the same system (e.g. at Prieska, see Table I) the nymphs were much more plentiful.

ECOLOGY OF THE NYMPHS

As outlined above, nymphs of *C. bifasciata* are not inhabitants of the cold mountain or high altitude streams, and the species is probably also limited by the low pH of the acid streams in the Southern and Western Cape. There are doubtless also other factors which limit this species locally, of which silt seems to be the most important. In the rivers and streams of the Eastern Transvaal, for example, extensive agricultural activity (and ? mild pollution) seems to have altered the lower Crocodile River and made it unsuitable for the nymphs as they are not found here but do occur higher up the Crocodile River and in

the nearby Sabie River which lies at an altitude slightly lower than that of the Crocodile River. The Sabie River appears to be not as disturbed by human activity as the Crocodile River.

Some factors which appear to limit the distribution of this species have been discussed above, but very little is known about the individual biology of this baëtid and nothing about the imaginal phase.

Fully grown nymphs attain a length of 15 mm, and they are thus by far the largest baëtid nymphs found in Southern Africa. BROWN (1960, 1961a and 1961b) has recently made a detailed study of the morphology and functioning of the mouthparts of two baëtids, *Chloëon dipterum* and *Baëtis rhodani*, and has correlated this with the diet of these nymphs. He found that the food of both these species consisted mainly of detritus, but that algae were also ingested, and that some types of algae were efficiently utilized. He also found that there were differences in the diet according to the size of the larvae, and that differences in the food ingested by different populations reflected differences in the food available in the habitats. His work disproved earlier speculations that nymphs of Ephemeroptera in general were carnivorous because of the strong development of the mouthparts. Recently Miss J. KING of this Institute has reported that nymphs of *C. bifasciata* are carnivorous. I have examined the contents of the alimentary canal in seven nymphs, and the results are given in Table II. The nymphs are lettered A to G, and the lengths of the nymphs, together with the numbers of the catalogued tubes from which they were taken (see Table I) are as follows:

GEN 307C	Nymph A,	10 mm	(Lower Sabie, Eastern Transvaal)
	Nymph B,	10 mm	(Lower Sabie, Eastern Transvaal)
GEN 308A	Nymph C,	11 mm	(Lower Sabie, Eastern Transvaal)
	Nymph D,	10 mm	(Lower Sabie, Eastern Transvaal)
GEN 668G	Nymph E,	8 mm	(Nyasaland)
FRW 169A	Nymph F,	7 mm	(Southern Cape)
	Nymph G	5.5 mm	(Southern Cape)

The whole alimentary canal was removed from the nymph with as little damage as possible and the contents teased out under a Stereo microscope. Much fine "detritus" of a light brown colour was present and interspersed with this were identifiable larval remains, which were then counted. Large nymphs about to pass into the subimaginal phase had somewhat reduced and empty digestive tracts, and these specimens were ignored. No filamentous algae were present. It will be seen from Table II that the nymphs prey on smaller baëtids, *Simulium* larvae and chironomid larvae. In the marginal vegetation habitat from which nymphs A to D inclusive were collected, the fauna of the habitat had a composition of, inter alia, 32.6% *Simulium*

larvae, 7.3% baëtid nymphs and 4.2% chironomid larvae (percentages calculated on numbers of individuals and sampling done with a hand-net with mesh opening of 0.228 mm). In the case of nymph E, the figures are 49.8% baëtids, 3.2% *Simulium* and 5.1% chironomids, while for nymphs F and G the fauna contained 23% baëtids, 3% *Simulium* and 34.4% chironomids. These results should be compared with the actual type of food found in the alimentary canal, as shown in Table II. It will be seen that it is therefore likely that the type of food ingested depends on the availability and relative abundance of the different larvae on which *C. bifasciata* feeds, just as BROWN found with *Chloëon dipterum* and *Baëis rhodani* and their algal diets.

It is not known what differences there are in the diets of small and large nymphs of *C. bifasciata*, but due to obvious physical limitations, it is probable that there is a more or less direct correlation between the size of the larva eaten and the size of the nymph which ingests it. Once again, this has been found to be the case with the two baëtids investigated by BROWN: "There is a direct relationship between the size of an alga and the frequency with which it was ingested by different sizes of larva". Larvae found in the foregut of *C. bifasciata* seemed to have been little damaged by chewing, although some of the larger larvae appeared to have been merely bitten in half, probably to aid ingestion. It would be interesting to know whether there are any special adaptations in the morphology and functioning of the mouthparts of this baëtid which are linked to its carnivorous habits. Certainly the size of the nymph seems to be a major adaptation in this direction. A secondary result of this increase in size is probably linked with the multiple folding of the posterior surfaces of the gills in larger nymphs, whereby surface area is increased without loss of rigidity, necessary in swiftly flowing water.

SUMMARY

1. The distribution of *Centroptiloides bifasciata* (E.-P.) in Southern Africa is described.

2. Some factors which appear to limit the distribution of this species are discussed.

3. Nymphs of *C. bifasciata* are carnivorous and prey on smaller baëtids, *Simulium* and chironomid larvae; the actual type of food ingested depends on its availability and relative abundance.

ZUSAMMENFASSUNG

1. Die Verbreitung der *Centroptiloides bifasciata* (E.-P.) im südlichen Afrika wird beschrieben.

2. Einige für die Verbreitung der Art beschränkend erscheinende Faktoren werden besprochen.

3. Die Nymphen der Art sind Raubtiere und leben von kleineren Baëtiden, *Simulium* und Chironomiden-Larven. Die Art der aufgenommenen Nahrung ist weitgehend von der Erreichbarkeit und Häufigkeit der als Beute dienenden Tiere abhängig.

Literature

BARNARD, K. H., - 1932 - South African Mayflies (Ephemeroptera). *Trans. Roy. Soc. S. Afr.* 20 (3), *201—259.*

——— 1940 - Additional Records, and descriptions of new species of South African Alder-flies (Megaoptera), May-flies (Ephemeroptera) etc. *Ann. S. Afr. Mus.* 32 (6), *609—661.*

BROWN, D. S., - 1960 - The ingestion and digestion of algae by *Chloëon dipterum* L. *Hydrobiologia* 16 (1), *81—96.*

——— 1961a - The morphology and functioning of the mouthparts of *Chloëon dipterum* and *Baëtis rhodani. Proc. Zool. Soc. Lond.* 136, *147—176.*

——— 1961b - The food of the larvae of *Chloëon dipterum* L. and *Baëtis rhodani* (PICTET) (Insecta, Ephemeroptera). *J. Anim. Ecol.* 30, *55—75.*

CRASS, R. S. - 1947 - The Mayflies (Ephemeroptera) of Natal and the Eastern Cape. *Ann. Natal Mus.* 11 (1), *37—110.*

DEMOULIN, G., - 1957 - Revision de quelques Ephéméroptères décrits du Congo Belge par L. NAVAS 111. *Bull. Ann. Soc. Roy. Ent. Belgique* 93 (9—10), *257—275.*

ESBEN-PETERSEN, P., - 1913 - Ephemeridae from South Africa. *Ann. S. Afr. Mus.* 10, *177—187.*

HARRISON, A. D. & J. F. ELLSWORTH, - 1958 - Hydrobiological Studies on the Great Berg River, Western Cape Province. *Trans. Roy. Soc. S. Afr.* 35 (3), *125—226.*

HARRISON, A. D. & J. D. AGNEW (in press) - The Distribution of Invertebrates Endemic to Acid Streams in the Western and Southern Cape Province.

KIMMINS, D. E., - 1948 - Ephemeroptera from Nyasaland, with descriptions of new species. *Ann. Mag. Nat. Hist.* Series 12 (i), *825—836.*

——— 1955 - Ephemeroptera from Nyasaland, with descriptions of three new species and some interesting nymphal forms. *Ann. Mag. Nat. Hist.* Series 12 (viii), *859—880.*

——— 1956 - New species of Ephemeroptera from Uganda. *Bull. Brit. Mus. (Nat. Hist). Entomol.* 4 (2), *71—87.*

——— 1960 - Notes on East African Ephemeroptera, with descriptions of new species. *Bull. Brit. Mus (Nat. Hist.) Entomol.* 9 (6), *339—355.*

LESTAGE, J. A., - 1918 - Les Ephémères d'Afrique (Notes Critiques sur les Espèces Connues). *Rev. Zool. Afr.* 6 (1), *65—114.*

——— 1924 - Les Ephémères de l'Afrique du Sud. *Rev. Zool. Afr.* 12 (3), *316—352.*

OLIFF, W. D., - 1960 - Hydrobiological Studies on the Tugela River System. Part. 1 The main Tugela River. *Hydrobiologia* 14 (3—4), *281—385.*

ULMER, G., - 1920 - Neue Ephemeropteren. *Arch. Naturg.* 81 (A), *1—80.*