A taxonomic and ecological review of *Pseudocloeon glaucum* (Agnew) (Ephemeroptera: Baetidae)

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Pseudocloeon masai (Lugo-Ortiz & McCafferty), *P. nadineae* (Lugo-Ortiz & McCafferty) and *P. quintum* (Agnew) are junior subjective synonyms of *P. glaucum* (Agnew). Larvae of *P. glaucum* manifest a wide range of variation in mouthpart morphology, particularly with respect to the development of the distomedial process of segment 2 of the labial palps, body size, general body colour and abdominal colour pattern. Such variation is observed in different cohorts and populations, and explains why several names have been applied to the same species. Larvae of *P. glaucum* also have considerable ecological tolerance, accounting for the abundance and widespread distribution of the species in the Afrotropical Region. New records from Kenya, Lesotho, Namibia and Zimbabwe are provided.

Key words: Ephemeroptera, Baetidae, *Pseudocloeon glaucum,* new synonyms, larval redescription, new records, ecology.

INTRODUCTION

Agnew (1961) described *Baetis glaucus* (Ephemeroptera: Baetidae) from larvae and male and female adults collected from the Wilge River in the Free State Province, South Africa. Lugo-Ortiz *et al.* (1999) transferred the species to *Pseudocloeon* Klapálek, and modified the specific epithet to *glaucum* to conform with the generic gender. Agnew (1961) commented that the species was widely distributed in South Africa, and indicated that the reports of '*Baetis* sp. 1' from the Tugela River system in KwaZulu-Natal by Oliff (1960a,b) and of '*Baetis* sp. A' from the Great Berg River in the Western Cape Province by Harrison (1958) and Harrison & Elsworth (1958) were *P. glaucum.* Subsequent South African reports of *P. glaucum* include: the Vaal River system in Gauteng, Mpumalanga, Northern Cape Province, and the North West Province by Chutter (1963, 1968, 1970); the Mooi and Sundays River systems in KwaZulu-Natal by Oliff & King (1964) and Oliff *et al.* (1965); the Great Fish, Mbashe and Mzimbuvu River systems in the Eastern Cape Province by O'Keeffe & de Moor (1988), Palmer & O'Keeffe (1990) and Barber-James (1995); and the Orange River along the border between the Northern Cape Province and Namibia by de Moor & Car (1986) and Palmer (1996). Harrison & Hynes (1988) reported *P. glaucum* from the middle reaches of mountain streams in Ethiopia, suggesting that the species had a widespread distribution in eastern Africa. Harrison & Hynes (1988) also indicated that *P. glaucum* occurred in Zimbabwe.

During a project to document Afrotropical Baetidae and to clarify their systematic and taxonomic status, it was discovered that *P. glaucum, P. masai* (Lugo-Ortiz & McCafferty), *P. nadineae* (Lugo-Ortiz & McCafferty) and *P. quintum* (Agnew) were the same species. *Pseudocloeon masai, P. nadineae,* and *P. quintum* are synonymized with *P. glaucum,* and reasons are provided to consider *P. glaucum,* rather than *P. quintum,* as the senior synonym. *Pseudocloeon glaucum* is redescribed to incorporate important characteristics originally overlooked by Agnew (1961) and to document the species' considerable variation, particularly with regard to the morphology of segment 2 of the labial palps, body size, general body colour and abdominal colour pattern. New records of *P. glaucum* from southern and eastern Africa are provided, and the ecological aspects of the species are discussed. Except where otherwise indicated, the specimens studied are in the Albany Museum, Grahamstown, South Africa.

TAXONOMY

Pseudocloeon glaucum (Agnew), Figs 1–16

Baetis glaucus Agnew, 1961: 14.

Baetis quintus Agnew, 1961: 12. **Syn. nov.**

Labiobaetis masai Lugo-Ortiz & McCafferty, 1997: 248. **Syn. nov.**

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Labiobaetis nadineae Lugo-Ortiz & McCafferty, 1997: 250. **Syn. nov.**

Pseudocloeon glaucum (Agnew): Lugo-Ortiz *et al.* 1999: 24.

Pseudocloeon masai (Lugo-Ortiz & McCafferty): Lugo-Ortiz *et al.* 1999: 24. **Syn. nov.**

Pseudocloeon nadinieae (Lugo-Ortiz & McCafferty): Lugo-Ortiz *et al.* 1999: 24. **Syn. nov.**

Pseudocloeon quintum (Agnew): Lugo-Ortiz *et al.* 1999: 24. **Syn. nov.**

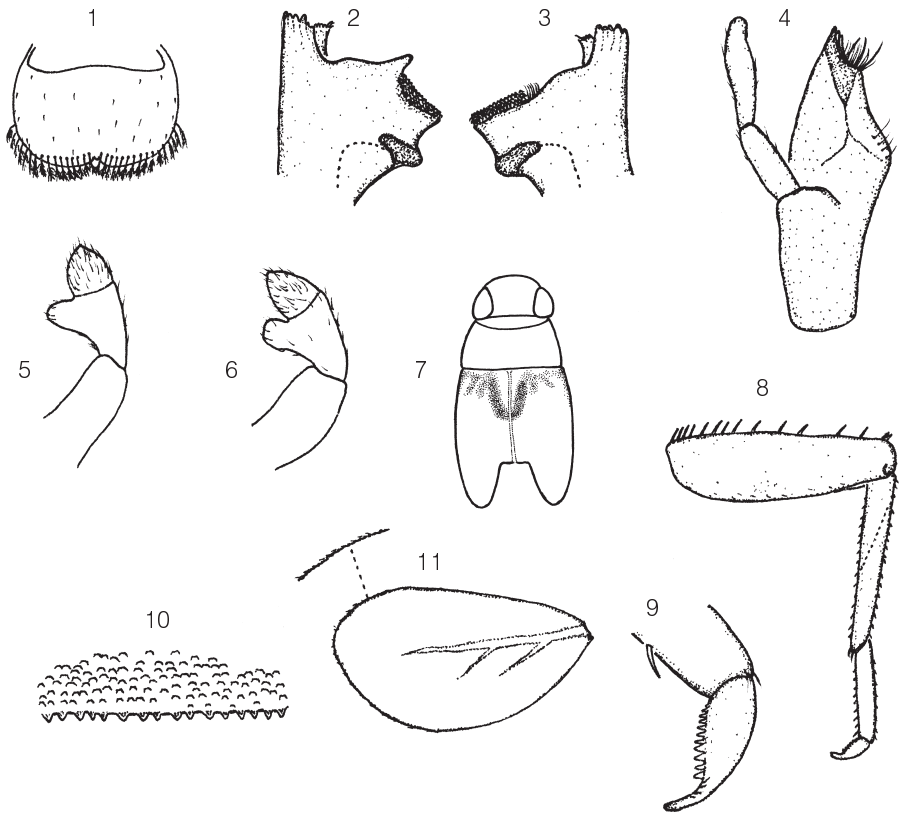
Redescription of larva (Fig. 16).

Lengths. Body: 4.5–7.5 mm; caudal filaments: 2.5–5.0 mm.

Head. Pale to medium yellow-brown, or pale to medium-brown, with cream areas on frons and around compound eyes and vermiform cream to pale yellow-brown marks on vertex. Antennae 2.0–2.5 times length of head capsule; scapes slightly chamfered distolaterally. Labrum (Fig. 1) broadly rounded anteriorly, with dorsal submarginal row of 8–10 branched setae on either side of midline and without dorsal submedial pair of setae. Hypopharynx variable, generally with broad lingua and relatively narrow superlinguae. Left mandible (Fig. 2) with 4 + 3 (outer marginal denticle often inconspicuous) or 3 + 3 denticles. Right mandible (Fig. 3) with 3 + 3 denticles. Maxillae (Fig. 4) with palp segment 1 slightly longer than segment 2; palp segment 2 with slight to moderately pronounced distomedial concavity. Labium with glossae subequal in length to paraglossae; glossae with numerous long, simple setae medially and distally; paraglossae with three rows of distally pectinate setae apically; palp segment 1 slender, subequal in length to segments 2 and 3 combined; segment 2 with pronounced distomedial process and dorsal oblique row of 3–4 minute, fine, simple setae; distomedial process narrowly rounded distally, forming obtuse medial angle with segment 3 (Fig. 5) (primarily in middle and late instar larvae), or broadly rounded and forming acute medial angle with segment 3 (Fig. 6) (primarily in early instar and pharate larvae); segment 3 slightly elongate and distally pointed, with numerous minute, fine, simple setae scattered over surface.

Thorax. Pale to medium yellow-brown, or pale to medium-brown; mesonotum (Figs 7, 16) frequently with median V-shaped marking with two oblique anterolateral dark bars on either side, apparently forming incomplete M-shaped marking. Metanotum with pale median line, occasionally with pigmented W-shaped marking (Figs 12–16). Hind-wing pads present. Legs (Fig. 8) pale yellow-brown; femora with conspicuous villopore, with 14–18 long, relatively robust, apically-pointed setae dorsally, and scattered, short, stout, simple setae ventrally, often with pale to medium-brown quadrangular mark anteriorly towards ventral margin; tibiae with scattered short, stout, simple setae and tufts of short, fine, simple setae dorsally and numerous short, stout, simple setae ventrally; tarsi with scattered short, stout, simple setae dorsally and 8–9 apically-pointed setae of increasing length ventrally; tarsal claws (Fig. 9) with 10–12 denticles, slightly increasing in length distally.

Abdomen. Pale to medium yellow-brown, or pale to medium or dark-brown; colour pattern highly variable (Figs 12–16). Tergum 1 usually with median subtriangular or broad, inverted T-shaped marking, laterally and anteriorly cream to pale yellow-brown; frequently uniformly coloured, with very faint or no subtriangular or inverted T-shaped marking. Terga 2–5 usually similar to tergum 1, but median inverted T-shaped marking more extensive, almost covering entire tergum; terga 4 and 5 frequently with side arms of inverted T-shaped marking extending anteriorly, with narrow anterior pigmented band, forming two large submedial oblong pale markings. Tergum 6 usually pale, often with large faint median M-shaped marking, anteriorly and posteriorly cream to pale yellow-brown, frequently without upper portion of M-shaped marking, forming two pigmented sublateral longitudinal markings of varying widths. Terga 7 and 8 usually uniformly coloured, either cream to pale yellow-brown anteriorly or posteriorly. Tergum 9 usually uniformly cream to pale yellow-brown, with or without cream to pale yellow-brown anterior margin. Tergum 10 usually uniformly coloured, frequently cream to pale yellow-brown anteriorly. Terga 1–10 often uniformly pale yellow-brown to medium brown, with no distinct or very faint markings. Terga (Fig. 10) with abundant scale bases and scattered minute, fine, simple setae; posteriorly with irregular triangular spination. Sterna cream to pale yellow-brown. Gills (Figs 11,16) on segments 1–7, usually well tracheated, marginally with small serrations and minute, fine, simple setae. Paraprocts with 5–10 marginal spines, increasing

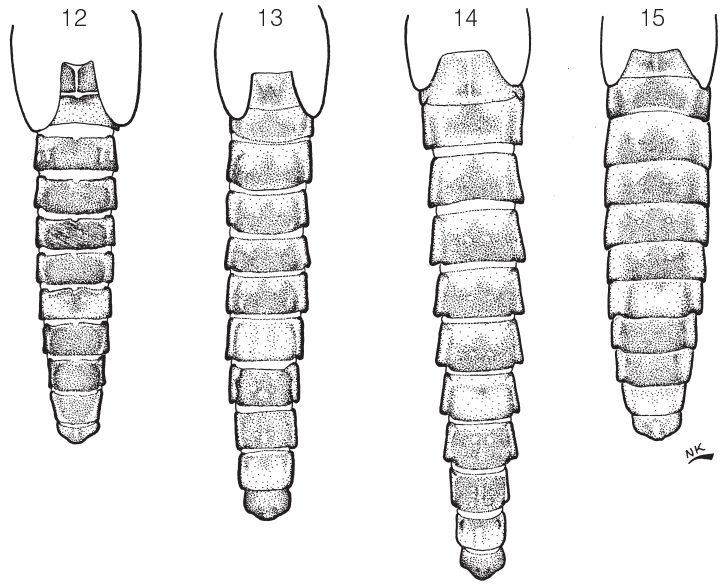


Figs 1–11. *Pseudocloeon glaucum* larva. **1**, labrum; **2**, left mandible; **3**, right mandible; **4**, right maxilla; **5**, labial palp segment 1–3; **6**, labial palp segment 1–3; **7**, mesonotal V-shape marking; **8**, left foreleg; **9**, tarsal claw; **10**, tergum 4; **11**, gill 4 and detail of margin.

slightly in length distally. Caudal filaments cream to pale yellow-brown, unbanded or with very faint median brown band; terminal filament 0.75–0.80 times length of cerci.

Type material examined. All material deposited in the Transvaal Museum, Northern Flagship Institution, Pretoria, South Africa. Codes following locality data are for cataloguing purposes in that institution. *Baetis glaucus.* Holotype: male adult, larval exuviae, SOUTH AFRICA, *Free State Province,* Wilge R, 11.viii.1960, J.D. Agnew (VAL 1325A). Paratypes: two larvae, same data as holotype (VAL 1325D). *Baetis quintus.* Holotype: male adult, larval exuviae, SOUTH AFRICA, *Northern Cape Province,* Orange R, at Prieska, 11.xii.1960, J.D. Agnew (GEN 604B). Paratypes: five larvae, same data as holotype (GEN 538 B1, 538B2).

Additional material examined. Codes following locality data are for cataloguing purposes at the Albany Museum. KENYA: larva, Awach R, Kenyadhiang, at Peggy's old house, 00.23S 34.39E, 26.vi.1996, P. Martin (CAW 180M); larvae, Awach R, 00.24S 34.40E, 26.vi.1996, P. Martin (CAW 183I). LESOTHO: larvae, Malibomatso R, at Paray, *ca* 50 km downstream of dam, bedrock in current, 29.29.52S 28.39.04E, 8.iv.1998, F. de Moor (LHD 3C); larvae, Malibomatso R, at Paray, *ca* 50 km downstream of dam, stones in current, 29.29.52S 28.39.04E, 8.iv.1998, F. de Moor (LHD 4D); larvae, Malibomatso R, at Paray, *ca* 50 km downstream of dam, drift from 16h00 to 17h00, 29.29.52S 28.39.04E, 8.iv.1998, F. de Moor (LHD 6A); larvae, Senqu R, at Sehonghong, stones in current, 29.44.20S 28.45.19E, 9.iv.1998, F. de Moor (LHD 9D); larvae, Senqu R, at Sehonghong, stones out of current, 29.44.20S 28.45.19E, 9.iv.1998, F. de Moor (LHD 10B); larvae, Senqu R, at Sehonghong, stones in current, lower end of rapids, 29.44.20S 28.45.19E, 9.iv.1998, F. de Moor (LHD 11B); larvae, Senqu R, at Sehonghong, stones in current, pick-



Figs 12–15. *Pseudocloeon glaucum* larva. Metanotum and abdominal colour patterns. **12**, Cunene River specimen (Namibia/Angola border); **13, 15**, Senqu River specimens (Lesotho); **14**, Malibomatso River specimen (Lesotho).

ing off stones, 29.44.20S 28.45.19E, 9.iv.1998, F. de Moor (LHD 12B); larvae, Senqunyane R, *ca* 1.5 km upstream of confluence with Senqu R, shallow riffle in middle, cobbles and pebbles over sand, 30.02.11S 27.34.21E, 12.iv.1998, F. de Moor (LHD 18B). NAMIBIA: larvae, Cunene R, riffle, 17.25.55S 13.59.05E, 12.xi.1997, F. de Moor (KUN 16E); larvae, Cunene R, upstream from 'The Camp', stones in slow-flowing current, side arm, 17.22.58S 13.54.49E, 13.xi.1997, S. Bethune and R. Pieterse (KUN 24B); larvae, Cunene R, rapids on bedrock and large stones, at 'The Camp', 17.22.58S 13.54.49E, 13.xi.1997, F. de Moor (KUN 27C); larvae, Cunene R, riffle, nr Ohangonga Guard Post, 17.17.57S 13.46.49E, 14.xi.1997, F. de Moor (KUN 34I); larvae, Cunene R, riffle, Etemba Guard Post, stones in current, 17.11.07S 13.35.52E, 16.xi.1997, F. de Moor (KUN 48G); larvae, Cunene R, nr Oonajana, bedrock in current with aquatic macrophytes, 17.00.18S 13.25.52E, 17.xi.1997, F. de Moor (KUN 54D); larva, Cunene R, 'Palm Grove' campsite, nr Oonjana, handpicked off stones out of current, large pool left by receding river, 17.00.18S 13.25.52E, 17.xi.1997, F. de Moor (KUN 56F); larvae, Cunene R, small isolated pool in bedrock, besides rapids, 17.00.18S 13.25.52E, 17.xi.1997, F. de Moor (KUN 59F); larvae, Cunene R, Epupa Falls, vegetation and driftwood wedged between boulders in swift current, 17.00.04S 13.14.44E, 19.xi.1997, F. de Moor (KUN 76D); larvae, Cunene R, marginal vegetation along riffle, 800 m upstream of Epupa Campsite, 17.00.03S 13.14.44E, 19.xi.1997, F. de Moor (KUN 80E); larvae, Cunene R, Baynes Mts, nr Orokawe Guard Post, wood and reeds wedged in rapids, stones in swift current, 17.01.12S 12.56.42E, 21.xi.1997, F. de Moor (KUN 96C); larvae, Cunene R, Baynes Mts, nr Orokawe Guard Post, stones in current, only slightly covered with algae and moss, 17.01.16S 12.56.42.E, 21.xi.1997, F. de Moor (KUN 97A); larvae, Cunene R, Baynes Mts, nr Orokawe Guard Post, 17.01.12S 12.56.42E, 21.xi.1997, F. de Moor (KUN 98M); larva, Cunene R, Baynes Mts, nr Orokawe Guard Post, stones out of current, 17.01.12S 12.56.42E, 21.xi.1997, F. de Moor (KUN 100E); larva, Ongongo Spring, small tributary of Hoanib R, bedrock in swift current, covered with lime and algae, 19.07.53S 13.49.12E, 22.xi.1998, F. de Moor (KUN 105A); larvae, Cunene R, Epupa Falls, solid bedrock and stones in swift-flowing rapids along lateral channels, 23.xi.1998, F. de Moor and S. Bethune (KUN 111G); larva, Cunene R, large riffle stones in current, 17.00.18S 13.25.52E, 26.xi.1998, F. de Moor (KUN 129C); larva, exuviae, Cunene R, drift net, *ca* 18h30–21h30, 13.28.53S 17.02.11E, F. de Moor (KUN 140C); larvae, Cunene R, at 'Ficus Camp,' shallow riffle, stones in current, 17.13.07S 13.38.45E, 29.xi.1998, F. de Moor and S.

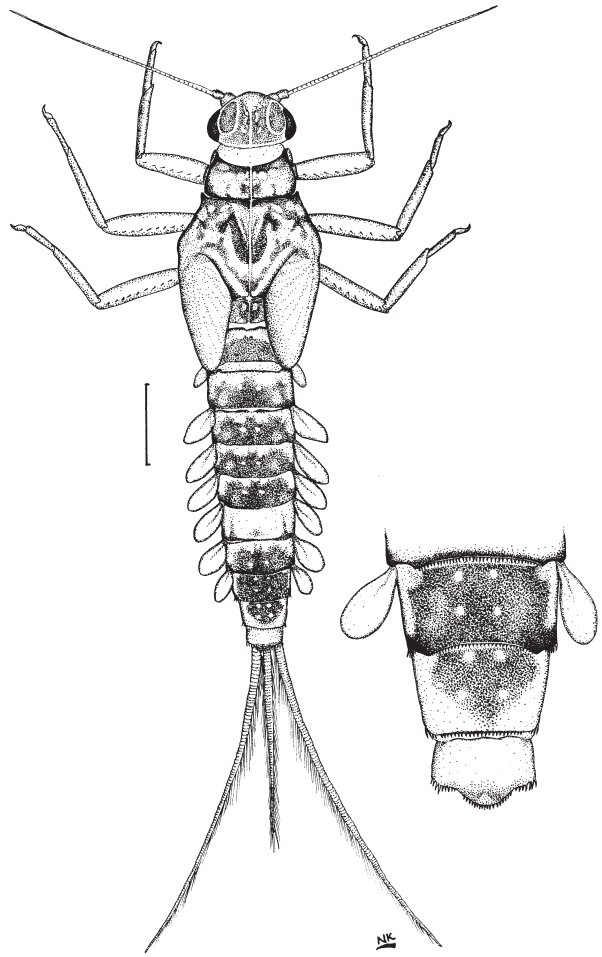


Fig. 16. *Pseudocloeon glaucum*, dorsal view of larva and details of posterior abdominal segments, Wildebees River specimen (Eastern Cape Province, South Africa) (scale bar = 1 mm).

Bethune (KUN 149E); larvae, Cunene R, 'Ficus Camp,' stones in current, large rapids with aquatic macrophytes, 17.13.07S 13.38.45E, 29.xi.1998, F. de Moor (KUN 150B); SOUTH AFRICA: larvae, Wildebees R, 31.11.04S 28. 08.14E, 26.iii.1993, F. de Moor and H.M. Barber-James (ECR 117B). ZIMBABWE: larvae, Zambezi R, rapids 15 km upstream of Chirundu Bridge, *ca* 16.10S 28.50E, 13.iv.1992, F. de Moor (ZIM 61A).

Remarks. Pseudocloeon glaucum, P. masai, P. nadineae and *P. quintum* are the same species. These names have been applied to different populations and cohorts of a species that manifests a wide range of morphological and colour variation. *Pseudocloeon glaucum* is designated as the senior subjective synonym, and *P. masai, P. nadineae* and *P. quintum* are junior subjective synonyms. The designation of *P. quintum* as a junior subjective synonym of *P. glaucum* may seem controversial because the former name has page precedence over the latter name in Agnew's (1961) study. The name *P. quintum,* however, was applied to the type material only (Agnew 1961), whereas the name *P. glaucum* has been widely cited in the literature. The designation of *P. glaucum* as the senior synonym, therefore, ensures stability and universality in the naming of the species (Article 24a of the International Code of Zoological Nomenclature).

The distomedial process of labial palp segment 2 varies between two morphological extremes in larvae of *P. glaucum.* One extreme is manifest in

middle and late instar larvae, and consists of the distomedial process being somewhat narrowly rounded apically and forming an obtuse medial angle with segment 3 (Fig. 5). This is the morphology that Agnew (1961: Fig. 5d) associated with *P. glaucum* and Lugo-Ortiz & McCafferty (1997: Figs 32, 45) associated with *P. masai* and *P. nadineae.* Significantly, the larval exuvium of the holotype of *P. quintum* also has this morphology. The other extreme occurs in early instar and pharate larvae, and consists of the distomedial process being broadly rounded apically and forming an acute medial angle with segment 3 (Fig. 6). This is the morphology that Agnew (1961: Fig. 4g) associated with *P. quintum.* The excavation of the maxillary palps, a diagnostic character of the genus, is different in other members of the genus, but shows only minor variations within the group discussed in the present paper. The morphological features of *P. quintum, P. masai* and *P. nadineae* consequently clearly place them in synonymy with *P. glaucum* as it is now defined.

Variation in body colour and abdominal colour patterns is common in many geographically widespread species belonging to the *Baetis* complex of genera (*e.g. Baetis harrisoni* Barnard in Africa and *B. tricaudatus* Dodds in North America). In larvae of *P. glaucum* body and abdominal colour patterns also vary considerably. Body colour ranges from light yellow-brown to medium brown. Most larvae have a colour pattern consisting of a broad, inverted, T-shaped marking in abdominal segments 1–5 (Figs 12–16; Agnew 1961: 4d, 5c), but a large number do not manifest any pattern, or have very faint markings. Most larvae also tend to have segment 6 paler than other segments.

There were no significant morphological differences between the holotype male adults of *P. quintum* and *P. glaucum.* The differences illustrated by Agnew (1961: Figs 4a, 4b) in the venation of the forewings and in the size and venation of the hindwings of both species are trivial and can be attributed to variation among populations. The illustration of the genitalia of *P. glaucum* by Agnew (1961: Fig. 5b) is inaccurate because it shows that segment 3 of the forceps is partially fused to segment 2 and that there is no medial plate between the forceps. The genitalia of the male holotype of *P. glaucum,* however, have a distinctly demarcated segment 3 and a medial plate between the forceps, and are essentially indistinct from the genitalia of *P. quintum* (Agnew 1961: Fig. 4c).

ECOLOGY

Agnew (1961) recorded larvae of *P. glaucum* and its synonym, *P. quintum,* from stones in flowing water. Harrison (1958) and Chutter (1968) considered *P. glaucum* an early colonizer of intermittently flowing and disturbed river systems. Harrison & Elsworth (1958) and Harrison (1958) noted that *B. harrisoni* was the dominant species in the upper foothill stony-run zone, whereas *P. glaucum* appeared to become progressively more abundant in the lower foothill stony-run zone, and was the dominant species in the foothill soft-bottom zones in the Great Berg River. In the Vaal River system, Chutter (1969, 1970) reported that *P. glaucum* replaced *B. harrisoni* as the dominant species in the unstable depositing zone and where effluent entered rivers. Harrison & Hynes (1988) showed that rivers in Ethiopia changed in community structure at 1900 m, below which *P. glaucum* replaced *B. harrisoni* as the dominant species, and suggested that this change represented the start of the epipotamon in those rivers. For a number of rivers in Lesotho, de Moor & Skoroszewski (1999) recorded differential preferences for water velocity in *B. harrisoni* (0.1–1.0 m/s) and *P. glaucum* (0.5–2.0 m/s). *Pseudocloeon glaucum* was more commonly associated with turbid water and became the dominant species in downstream reaches of the Malibomatso and Senqu Rivers in Lesotho (de Moor & Skoroszweski 1999). *Pseudocloeon glaucum* also preferred stony substrata and water flows ranging between 0.2–2.0 m/s (Palmer 1996, de Moor & Skoroszewski 1999). Palmer (1996) recorded *P. glaucum* from stones in and out of current, and from marginal vegetation out of current in the lower Orange River. The above studies showed that *P. glaucum* is most often associated with substrates ranging from pebbles to boulders in water velocities near 1 m/s in the middle to lower reaches of medium to large rivers. The species is also more tolerant of high loads of silt and sand than two other baetid species (*B. harrisoni* and *Cheleocloeon excisum* (Barnard)), commonly found in the same river systems (Chutter 1969). Its occurrence in biotopes such as marginal vegetation and stones in slow-flowing water also suggests that it is an opportunistic species able to rapidly colonize newly inundated regions and survive under a wide range of conditions of flow and substratum availability.

Information on the broad range of ecological

conditions under which *P. glaucum* has been recorded provides evidence as to why this species is commonly encountered and widespread in the Afrotropical Region. Information on flow and substratum preferences can especially be used to predict whether the species will occur in a river system. Its presence and abundance in the Cunene River was therefore predictable. The new distribution records from Kenya, Lesotho, Namibia and Zimbabwe confirm that *P. glaucum* is well established in the region.

Other Ephemeroptera species often encountered in the same biotopes as *P. glaucum* include *C. excisum, Centroptiloides bifasciata* (Esben-Petersen) and *Tricorythus discolor* (Burmeister). *Cheumatopsyche thomasseti* (Ulmer) (Trichoptera), *Simulium chutteri* Lewis and *S. bovis* de Meillon (Diptera) also often occur with *P. glaucum.*

ACKNOWLEDGEMENTS

The National Research Foundation is thanked for providing funds to C.R. Lugo-Ortiz to conduct postdoctoral studies in South Africa. The Directorate of Museums and Heritage (Eastern Cape Province, South Africa) is thanked for providing research facilities. S. Bethune and K. Roberts (Department of Water Affairs, Windhoek, Namibia) are thanked for facilitating the 1997 and 1998 surveys of the Cunene River. S. Bethune, N. Clarke, N. Köhly, R. Pieterse, K. Roberts, K. Schachtschneider, R. Simmons, E. Taylor, and R. Tharme assisted with collecting during the Cunene surveys. C. Browne, J.M. King, and H. Sabet (Metsi Consultants, South Africa) and the Lesotho Highlands Development Authority are also thanked for facilitating the surveys of the Lesotho rivers and making the data available for publication. R. Toms (Transvaal Museum, Pretoria, South Africa) is thanked for allowing us to study the type material of *B. glaucus* and *B. quintus.* W.P. McCafferty and L. Jacobus (Purdue University, West Lafayette, Indiana, USA) kindly examined the type material of *L. masai.* We are grateful to N. Köhly for the preparation of Figs 7 and 12–16.

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Accepted 3 August 2000