To Mr. Gareth Davies, without whose constant interest, encouragement and help this work would hardly have been possible.

Very sincerely yours,

José Alberto Quartau

2nd January, 1979

A TAXONOMIC STUDY OF THE ETHIOPIAN SPECIES OF BATRACOMORPHUS LEWIS (HOMOPTERA : CICADELLIDAE) WITH AN APPLICATION OF SOME NUMERICAL METHODS

by

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TO MY MOTHER

"From the most remote period in the history of the world organic beings have been found to resemble each other in descending degrees, so that they can be classed in groups under groups".
Charles Darwin, *The Origin of Species*, (1859), Chapter XIV.

"... we need a great deal of testing of taxometric methods to determine what methods (and what kinds of characters) are most suitable under certain specified conditions".
E. Mayr, *Syst. Zool.*, *14* (1965), p. 96.

"... it is certain that electronic data processing will have an increasingly important part to play in the taxonomy of the future. Perhaps the "new taxonomy" has not yet been born, but at least it has been conceived".
P.C. Sylvester-Bradley, *Syst. Zool.*, *17* (1968), p. 180.

ABSTRACT

Quartau, J.A. de O. 1978. A taxonomic study of the Ethiopian species of Batracomorphus Lewis (Homoptera : Cicadellidae) with an application of some numerical methods.

The genus Batracomorphus is redefined by incorporating previously undescribed characters of the male abdominal apodemes. A historical account of all previous work on the genus for the Ethiopian area is presented. Eighteen new species and one new subspecies are described and keys for the recognized subgenera as well as for all the Ethiopian species and subspecies (totalling 127 forms) are included. Illustrations of the male genitalia and of the male abdominal apodemes are presented, as well as of the female seventh sternite whenever positive identification was possible.

Multivariate statistical techniques were used either to assess associations between characters or to evaluate phenetic relationships between taxa. Twenty-three measurement characters, external and of genitalia, as well as 116 qualitative, coded variables (external, abdominal apodeme and genital) were considered to determine phenetic affinities among a sample of 39 OTU's. Data were used either untransformed or standardized to zero means and unit standard deviations. The numerical methods included cluster analysis and principal component or principal coordinate analyses. Cluster analysis resulted in the production of 37 different phenograms, using taxonomic distances, product-moment correlations and Gower's coefficient as measures of similarity, following weighted-pair group method using arithmetic averages (WPGMA) or single-linkage as clustering methods. Concerning the ordinations, 16 different methods were carried out, being the phenetic relationships presented in scatter diagrams of OTU's projected onto principal components of matrices of either correlations or covariances among characters or among OTU's or principal coordinates of matrices of taxonomic or match-mismatch distances among OTU's. Both the phenograms and the ordinations were compared among themselves and clustered in the final form of dendrograms.

A phenetic classification among all known species and subspecies of the genus for the Ethiopian area was constructed using Gower's coefficient as similarity coefficient and WPGMA for clustering.

Finally some biological and ecological data were included.

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GENERAL INTRODUCTION

Batracomorphus Lewis, 1834 is the largest genus of the Iassinae with at least 212 described species currently assigned to it if full generic rank is given to the allied Nearctic and Neotropical Stragania Stål, 1862 (*). The great majority of Batracomorphus species inhabit the tropical regions of the Old World and Australia and in the African continent alone, south of the Sahara, 103 species and 5 subspecies were recently recognized (Linnavuori & Quartau, 1975). With the present study this number is raised to 121 species and 6 subspecies.

One of the difficulties in dealing with the taxonomy of this genus is that in general appearance the group is very homogeneous and frequently in each collecting site there are several sympatric species. During this study, when unidentified material was sorted and the resulting morphologically homogeneous samples from the same localities were dissected and their genitalia examined, there were instances where there proved to be as many species as specimens. This external morphological similarity, associated with a high species diversity, is a serious difficulty in the recognition of species in this genus. To overcome it, the general practice has been to use proportions or measurements from parts of the external structures and to rely mostly on characters of the male genitalia.

* Stragania has been regarded as a distinct genus by among others, Beamer & Lawson (1945a), Evans (1947a), Oman (1949a), Beirne (1956) and by Kramer (1963). Linnavuori (1957) reduced Stragania to subgeneric rank under Batracomorphus since the only distinguishing character between them is the vein separating the appendix of the elytra, which is complete in Batracomorphus and evanescent apically in Stragania. However, since there is still the lack of a critical definition of Batracomorphus on a world-wide basis, they are here considered as distinct genera.

Proportions especially between parts of the head and pronotum have been used in the description of species of Batracomorphus by several authors such as Distant (1914m), Naudé (1926a), Lindberg (1923b, 1948b, 1958), Linnavuori (1960, 1969), Anufriev (1971) and Theron (1972), among others. Blöte (1964) and Ghauri (1964), on the other hand, used a set of 10 distinct measurements when describing New Guinean species. However, no type of multiple-character analysis involving the simultaneous use of several measurements was ever attempted.

The most reliable way to discriminate between species of Batracomorphus has been to use the comparatively more significant characters of the so-called "internal male genitalia". However, no critical attempt has ever been made to construct classifications derived from the genitalia, from the external characters or from the genitalia and the external characters used altogether.

The abdominal apodemes supporting the timbal muscles associated with the sound producing organs of leafhoppers have proved to be diagnostic at the specific level in several groups (e.g., in Macrosteles : Ossiannilsson 1951d; in Kybos : Ross 1963; in Dikraneura : Knight 1968; in Idiocerus : Vilbaste 1968; in Xerophloea : Hamilton 1975; in Alebra : Le Quesne 1977). However, no taxonomic study incorporating the abdominal apodemes has been made yet in Batracomorphus.

One of the objects of this study was to increase our knowledge of the African members of Batracomorphus by incorporating observations from new material and new distinguishing characters such as the abdominal apodemes.

A second object was to find out whether the two subgenera recognized by Linnavuori & Quartau (op. cit.) correspond to phenetic clusters obtained from the use of measurements or from a large selection of attributes involving the external morphology, the abdominal apodemes, and the genitalia.

A third object was to ascertain whether phenetic classifications based on the genitalia and abdominal apodemes alone, or on the external morphology alone, give a clustering which fits the one obtained from the whole set of attributes.

A fourth aim was to discover how different numerical methods give discordant classifications. For doing this, clustering techniques were compared with ordinations, standardized data with untransformed data, distance measures with correlation, and the like, were critically evaluated.

Finally, an attempt was made to apply the best selected numerical method in order to present a satisfactory phenetic classification of all known Ethiopian species and subspecies of genus Batracomorphus.

I. TAXONOMY

(a) Historical account of the Ethiopian species

The genus Batracomorphus was erected by Lewis in 1834 to contain the Palaearctic B. irroratus, then a new species taken near London. Stål (1855a) was apparently the first author to describe an Ethiopian species (from the Cape Province) of this genus and then within the combination Bythoscopus olivacescens. Later, in 1866, he altered this name to Macropsis subolivaceus. Melichar (1908b) described another Ethiopian species from Tanganyika under the name of Pachyopsis punctatissima. Jacobi (1910b) transferred Macropsis subolivaceus to Bythoscopus Germar again. Distant (1914m) described one more species, this from Lagos, in his new genus Ossana. The first analysis of Batracomorphus Lewis involving African forms was that of Lindberg (1923b), who described Batracomorphus signata and its variety v-nigrum from Egypt (and Syria). Naudé (1926a) described three more species, two from the Cape Province (drakensteini and segregatus), and the third from Natal (cederanus), all three ascribed to Bythoscopus. Haupt (1927a) added another species (then from Palestine), Batrachomorphus glaber. Evans (1947a) described a new species from Kenya within the genus Jassus Fabricius (J. brunomaculatus). In 1948 Lindberg added a new species from Cyprus, Batracomorphus flavovirens. Evans (1954a) transferred Bythoscopus subolivaceus Stål to Jassus and in two papers published in the following year (1955a, 1955b) he, respectively, (a) transferred Jassus brunomaculatus Evans, Bythoscopus cederanus Naudé, B. segregatus Naudé and Jassus subolivaceus (Stål) to Eurinoscopus Kirkaldy; and (b) described the new species Eurinoscopus rutshurensis from the Belgian Congo and transferred Bythoscopus drakensteini Naudé to Eurinoscopus. In 1957 Linnavuori described a new species from Natal (Batracomorphus capeneri), synonymized the genus Eurinoscopus with Batracomorphus and regarded the Nearctic and Neotropical Stragania Stål as a subgenus of Batracomorphus. The following year, Linnavuori synonymized Batracomorphus flavovirens Lindberg with Batrachomorphus glaber Haupt. In the same year, Lindberg (1958) described the new species Batrachomorphus artemisiae from the Cape Verde Islands and synonymized B. glaber Haupt with B. signatus Lindberg. Bythoscopus subolivaceus (Stål) and B. cederanus Naudé were transferred to genus Batrachomorphus by Linnavuori in 1961. Dlabola (1963), independently of Lindberg (1958), again synonymized B. glaber Haupt with B. signatus Lindberg. Heller & Linnavuori (1968) described six new species from Ethiopia and Quartau (1968) another two (fernandesi and saraivae) from the Cape Verde Islands. Linnavuori added seven more new species from the Congo in 1969 (among them his new species B. parmenio) and in 1971 he still regarded as independent species the following : signatus Lindberg, glaber Haupt (= flavovirens Lindberg) and saraivae Quartau. Theron (1972) transferred Eurinoscopus segregatus (Naudé) to Batracomorphus and assigned Eurinoscopus drakensteini (Naudé) as well as Batrachomorphus cederanus (Naudé) to his new genus Iassomorphus, showing clearly that these two latter species meritted generic status of their own. Finally, a comprehensive revision of the Ethiopian species of Batracomorphus was made by Linnavuori & Quartau (1975). The genus was redefined and divided into two subgenera by taking into account the Ethiopian species : Batracomorphus sensu stricto with 88 species and Sudanoiassus Lv. & Quart. with 15 species. In all, 83 new species of Batracomorphus were described from several parts of Africa. Other important results of that study include : (a) Ossana bicolor Distant and B. capeneri Linnavuori were synonymized with Pachyopsis punctatissima Melichar which was assigned to the genus Batracomorphus; (b) Eurinoscopus rutshurensis Evans and E. brunomaculatus (Evans) were transferred to

Batracomorphus; (c) *Batracomorphus segregatus* (Naudé) was synonymized with *B. subolivaceus* (Stål); (d) *Batracomorphus saraivae* Quartau was synonymized with *B. signatus* Lindberg and *glaber* Haupt (= *flavovirens* Lindberg) was definitely considered as a synonym of *signatus* Lindberg; (e) *B. signatus* v. *v-nigrum* Lindberg was given the status of a full species, *B. v-niger*; and (f) the status of a subspecies of *B. rutshurensis* (Evans) was given to *B. parmenio* Linnavuori.

(b) Morphology

Since the morphology of leafhoppers has been dealt with in detail by several authors, e.g., Singh-Pruthi (1925b), Ribaut (1936b, 1952a), Evans (1946a, 1946b, 1947a, 1966, 1975), Oman (1949a), Kramer (1950a), Young (1952b), Ossiannilsson *et al.* (1956) and Linnavuori (1959) no attempt was made to define the descriptive and morphological terms in common use by the current leafhopper taxonomists. Only a short reference is therefore made to the most significant characters used in this study. Terminology follows most closely Linnavuori (*op. cit.*) and Linnavuori & Quartau (1975).

Similarity among females belonging to different species has made it nearly impossible to associate males and females of the same species, except when striking colouring, markings and other evidence was available. The only significant character available in females is the shape of the 7th abdominal sternite which is nevertheless variable and so was used with caution. Part of this is due to the fact that this sternite, being unattached apically, may lie at various angles in different undissected specimens and so may appear to have different shapes due to its arched form. Therefore, reference is here especially made to male morphology and all allocations of females to a given species should be regarded as tentative.

The shape of the head is very constant in *Batracomorphus*, but the ratio between the interocular width of the crown and its medial length has some diagnostic value for the separation of species. On the other hand, the ratio between the maximum width of the pronotum and its medial length is a distinguishing character at subgeneric level and is useful in separating some species. Other proportions as the ratio between the medial length of the crown and the medial length of the pronotum have also been used as a supplementary distinguishing character between species.

The crown, the pronotum, the scutellum and the elytra can bear different dark markings or be differently spotted with fuscous in different species. These colouration patterns have diagnostic value in certain species.

In the males of all the species studied, there are two pairs of sternal abdominal apodemes apparently arising respectively from the first and the second sterna (*) and extending into the abdominal cavity. The shape of these apodemes proved to be useful as supplementary distinguishing characters at the species level. Moreover, the appearance of the second sternal abdominal apodemes seemed to be diagnostic at subgeneric level. On the other hand, the second abdominal tergum has a strongly developed antecosta the thickness of which is constant in many species.

The shape of the side lobes of the pygophore and of the pygophore appendages, which may be bifurcate or bear processes of various types, are also helpful in distinguishing species. The pygophore appears incised mid-ventrally or both mid-ventrally and mid-dorsally, and this was found

* A careful examination seemed to reveal that these apodemes arise as folds respectively between the first and the second abdominal sterna and between the second and third sterna. In the descriptions they are respectively called first and second sternal abdominal apodemes for ease of identification.

to be a useful character for the separation of the two African subgenera. The 8th sternite and especially the genital plates can also have some diagnostic value in separating some species; the presence or absence of long setae along the outer margins of the genital plates seem to be diagnostic at subgeneric level.

The most significant and reliable characters for delineating and identifying species and subgenera lie in the so-called "internal male genitalia" which consist of the connective, the styli and the penis. The connective presents some intra-specific variation but characters from its shaft, base and dorsal keel can be of some taxonomic importance. Styli and penis, with their comparatively more complicated structures, are by far the most important structures for species separation. The shape of the apophysis of the stylus and of its apical hook offers characters of diagnostic value in the majority of species. The same is true of the penis: the stem differs greatly in form in different species and may bear longitudinal lamellae or processes of various sorts; the ratio between the length of the socle and the length of the stem is another distinguishing character at specific level. Notwithstanding the species specific nature of the penis and stylus, variation within species was sometimes observed and as such has been recorded in the descriptions.

(c) Materials and Techniques

1. Material Examined

Specimens examined in this study or used in the numerical analyses of Chapter II were mainly from the national collection of the British Museum (Natural History) in London. These totalled 195 specimens, being ninety four males used in the phenetic analyses. Moreover, some specimens of the Palaearctic B. irroratus Lew. collected by the author in England, were studied and included in the numerical analyses as well. For comparative purposes, other material such as a collection recently assembled in Africa by Dr. R. Linnavuori and the author's material referred to in Linnavuori & Quartau (1975) were also examined.

2. Collecting Methods

The majority of the Batracomorphus specimens studied here were collected by light trapping. It can also be seen from the literature that a great deal of material was collected at light, to which members of this genus (both sexes) are strongly attracted.

Representatives of the type-species (B. irroratus Lew.) were caught by the author on Helianthemum, near London, by sweeping.

3. Preparative Methods

The basic techniques for preparation of genitalia of leafhoppers for study have been described by several authors, e.g., Ribaut (1936b), DeLong & Davidson (1937a), Oman (1949a), Young (1952b), Beirne (1956), Gurney, Kramer & Steyskal (1964), or Knight (1965), among others.

As Young (op. cit.) remarks "Techniques are in the final analysis, individual matters, and there are probably as many techniques and modifications of techniques as there are experts". The main objective was to follow any technique which would make the so-called "internal genitalia" and other internal structures quickly available for study under very high magnification, provided they were not damaged in the process. This was achieved by following most closely the methods described by Knight (op. cit.), with two slight modifications : (a) after the abdomen was removed, it was placed in a 10% solution of caustic potash and heated slowly to a temperature just short of boiling; and (b) transference to distilled water was for 5 to 10 minutes only.

Dissection of the genitalia and abdominal apodemes was performed in glycerol on a cavity slide under a binocular stereoscopic microscope in a similar way to that described by Knight (op. cit.). Only temporary mounts were made, and these were prepared by placing a drop of glycerol near the center of a clean cavity slide.

Storage was undertaken by placing the genitalia and other dissected parts within the abdomen and the whole transferred to a small drop of glycerol previously placed in the bottom of a glass microvial. The glass was sealed with a small cork and both were positioned at an oblique angle to the pin bearing the specimen.

4. Measurements and Illustrations

Measurements were performed beneath a binocular stereoscopic microscope, to which a moving wire micrometer eyepiece was adapted. Overall length was measured from the apex of the crown to the tips of the elytra with the latter in the position of rest alongside the body. Moreover, several measurements of the head, thorax and genital parts were taken, as indicated in Table 2 (Chapter II) and in Figs. 1A - B. Of this set of measurements only the following, or ratios between these, were used in the description of species : medial length of crown (3); medial length of pronotum (4); interocular width of the crown (6); maximum width of pronotum at humeral angles (9); length of apophysis of stylus (13); total length of penis (14); length of socle of penis (15); and length of stem of penis (16).

When making the measurements of parts of the external structures, the specimens were tilted so that the various parts were brought into the horizontal plane.

All illustrations were made with the aid of camera lucidas adapted to both a compound and a stereoscopic microscope. These are shown in greater detail than is necessary for normal identification. Three main reasons lay behind this procedure : (a) emphasis in seeking a high number of characters, including additional structures not hitherto used in this genus, in order to perform the phenetic analyses described in Chapter II; (b) the need to obtain adequate information on the relationships of the species concerned; and (c) to delineate the new species accurately so as to avoid future doubts on their identity, thus always obviating comparisons with the types whenever identification of named species is made. In fact, Batracomorphus comprises a large number of species which are difficult to separate because of the lack of well-defined differentiating characters (Evans, 1966). On the other hand, much concern has been expressed about the problems associated with insect taxonomy in Africa and, as has been suggested, detailed illustrations are an effective contribution to improve its status (see, e.g., Holm, 1975).

(d) Descriptions

All species studied here, with the exception of the type-species, have been redescribed and illustrated in full (*) as in the descriptions of the new species; they follow in alphabetical order within each subgenus. Redescriptions are based on the descriptions provided by Linnavuori & Quartau (1975), with the incorporation of the new observations.

The African areas cited in "Distribution" are based on major ecological zones of Africa instead of on national boundaries. Devred's classification, based on bio-geographic correlations, was followed (see Vos, 1975).

* Exceptions are when a certain structure is exactly similar to the corresponding one illustrated in Linnavuori & Quartau (1975), or when in very bad condition, or when damaged in the process of preparation.

Whenever possible, references are made in "Ecology" to the vegetation types where the specimens were collected following the physiognomic classification provided by the "Vegetation Map of Africa South of the Tropic of Cancer" (Aubréville, Duvigneaud, Hoyle, Keay, Mendonça & Pichi-Sermolli, 1959) with Explanatory Notes by Keay (1959).

Locality records are given as they occur on the specimen labels and no attempt was made to bring the names of countries or localities up to date, in order to facilitate future reference to those specimens.

The type specimens of the new species are, as stated for each, in the collection of the British Museum (Natural History).

1. Genus BATRACOMORPHUS Lewis

Batracomorphus Lewis, 1834 : 51. Type : B. irroratus Lew.
Thalattoscopus Kirkaldy, 1905 : 334. Type : T. dryas Kk.
Eurinoscopus Kirkaldy, 1906 : 346. Type E. lentiginosus Kk.
Ossana Distant, 1914 : 518. Type : O. bicolor Dist.

Type-species, Batracomorphus irroratus Lewis 1834, by monotypy.

The genus was redescribed recently (Linnavuori & Quartau, 1975). Therefore only the additional structures studied are considered below.

Male abdominal apodemes - First sternal abdominal apodemes horizontally and both forward and backward expanded, outlining a medial notch in posterior view. Second abdominal apodemes extending posteriorly, lobe-shaped and then separated by a deep sinuation, or ridge-shaped with lobes reduced or absent.

Remarks : This genus is distinguished from the closely allied Nearctic and Neotropical Stragania Stål by the submarginal vein of the elytron, separating the appendix from the first apical cell, which is complete in Batracomorphus and evanescent apically without extending beyond the base of the second apical cell in Stragania (Oman, 1949a)(*). Batracomorphus is also closely allied to the African Iassomorphus Theron, from which it may be distinguished by the presence of appendages in the ventral margin of the side lobes of pygophore, and by the apophysis of

* This is the only distinguishing character between these two genera and, as such, genus Stragania St. could be just regarded as a subgenus of Batracomorphus. However, since there is not yet a critical definition of Batracomorphus on a world-wide basis, they are here considered as distinct genera.

the stylus which is not reduced. Batracomorphus can also be distinguished from the related Palaearctic Iassus Fabricius especially by the genital plates and styli, which are not reduced. It may be distinguished from the allied Palaearctic Straganiassus Anufriev by the longer and lower male genital segment, as well as by the presence of pygophore appendages. Batracomorphus is to a lesser extent also related to the African Acacioiassus Lv. & Quart. and Afroiassus Lv. & Quart., which separation is given by Linnavuori & Quartau (op. cit.).

Marquardtella Schmidt, from New Guinea, is probably congeneric with Batracomorphus but awaits critical examination of the type to demonstrate its true status.

The genus is separated into two subgenera for the Ethiopian area; these may be differentiated by the following key.

2. Key to Subgenera of Batracomorphus (Males)

1 Apophysis of stylus blade-shaped. Penis flattened, stem deeply and narrowly split in apical part. Second sternal abdominal apodemes lobe-shaped. Subapical part of genital plates with long setae along outer margin ...... Batracomorphus s.str.

\- Apophysis of stylus not blade-shaped. Stem of penis tubular, apex spoon-shaped. Second sternal abdominal apodemes with reduced lobes. Subapical part of genital plates without long setae along outer margin .... Sudanoiassus Lv. & Quart.

3. Key to the Ethiopian species and subspecies of *Batracomorphus* Lewis

1 Upper surface with conspicuous dark markings (neither with fuscous irroration nor unicoloured pale) in pale specimens at least basal angles of scutellum darkened .. 2

\- Upper surface either with fuscous spots, visible at least on elytra, or unicoloured green or yellowish 26

2 (1) Elytra with two transverse fuscous fasciae .... *bifasciatus* Lv. & Quart.

\- Elytra without transverse dark bands 3

3 (2) Elytra with coarse dark brown puncturing. Crown, pronotum and scutellum largely dark brown. Hind margin of female 7th sternite with a deep U-shaped medial notch .. .. *punctatissimus* (Mel.)

\- Not as above 4

4 (3) Elytra with sparse yellowish puncturing. Crown, pronotum and scutellum largely brownish. Ventral margin of appendages of pygophore large and irregularly dentate .... *classeyi* n. sp.

\- Not as above 5

5 (4) Crown with two round dark spots 6

\- Crown immaculate 8

6 (5) Penis with a minutely dentate lobe between stem and basal apodeme .... *duquensis* n. sp.

\- Penis different 7

7 (6) Stem of penis long; socle about 0.4 times as long as stem ....*thamyris* Lv. & Quart.

\- Stem of penis much shorter; socle about as long as stem .... *distinctissimus* n. sp.

8 (5) Large species, length 7 mm. Green, pronotum and scutellum tinged with brown .... leontion Lv. & Quart.

\- Smaller species, length less than 6.5 mm 9

9 (8) Elytra with dark markings 10

\- Elytra immaculate (at most appendix a little infumated) ... 16

10 (9) Pronotum and scutellum pale. Elytra with costal margin, claval suture and scutellar and commissural margins of clavus dark fuscous. Pygophore appendages strongly curved ventrad. Apophysis of stylus edentate apically. Posterior lamellae of penis serrate .... contaminatus Lv. & Quart.

\- Pronotum and scutellum more or less darkened. Pattern of elytra different 11

11 (10) Scutellar and commissural margins of clavus broadly infuscate .... brunneicollis Lv. & Quart.

\- Pattern of elytra different 12

12 (11) Commissural margin of clavus with more or less triangular fuscous spot in apical part, relatively clearly visible even in pale specimens 13

\- Clavus immaculate. Apex of elytra tinged with brown 15

13 (12) Claval spot contrasted; base of appendix with dark spot. Lateral margins of pronotum and sides of scutellum contrastedly and rather narrowly dark brown ....danae Lv. & Quart.

\- Claval spot faint. Other pattern different 14

14 (13) Appendix and first apical cell of elytra tinged with brown, apex otherwise pale. Side lobes of pygophore acutely rounded apically. Stylus broad ..dodona Lv.

\- Apex of elytra infuscate. Side lobes of pygophore truncate apically. Stylus remarkably narrow ... scitus Lv. & Quart.

15 (12) Appendages of pygophore bifurcate .. apicimacula Lv. & Quart.

– Appendages of pygophore simple ..... angularis Lv. & Quart.

16 (9) Pronotum and scutellum uniformly blackish brown .... moira Lv. & Quart.

– Not as above 17

17 (16) Appendages of pygophore with dark dentate process .... jimmaensis Hell. & Lv.

– Appendages of pygophore different 18

18 (17) Appendages of pygophore with apex triangularly expanded .... gorensis Lv. & Quart.

– Appendages of pygophore different 19

19 (18) Appendages of pygophore short, provided with a small subapical tooth. Stem of penis with a pair of triangular lobes on anterior surface .... dentifer Lv. & Quart.

– Not as above 20

20 (19) Apophysis of stylus strongly ovately expanded at middle .... theagenes Lv. & Quart.

– Apophysis of stylus at most moderately expanded at middle ... 21

21 (20) Ventral margin of apophysis of stylus with distinct arcuate sinuation .... rutshurensis (Ev.)

– Stylus different 22

22 (21) Apophysis of stylus very slender. Appendages of pygophore rather straight, minutely crenulate ventrally .... angolensis Lv. & Quart.

– Not as above 23

23 (22) Apophysis of stylus relatively thick. Appendages of pygophore strongly curvate. Stem of penis thick and more or less straight .... theognis Lv. & Quart.

– Not as above 24

24 (23) Apical hook of stylus very long, acutely angled. Appendages of pygophore longish, basal part straight, apex reflexed with ventral surface minutely dentate .... <u>dirke</u> <u>phaon</u> Lv. & Quart.

\- Apical hook of stylus much shorter, more or less normally angled 25

25 (24) Apophysis of stylus with ventral margin nearly straight, dorsal margin broadly curvate. Stem of penis rather straight .... <u>krameri</u> Lv. & Quart.

\- Apophysis of stylus with ventral margin broadly curvate, dorsal margin straight. Stem of penis distinctly curved dorsad .... <u>ikmalios</u> Lv. & Quart.

26 (1) Upper surface with fuscous spots, present at least on elytra 27

\- Upper surface unicoloured green or yellowish, at most puncturing of elytra dark (see also <u>calchas</u> Lv. & Quart.). 61

27 (26) Large species, length more than 5 mm. Pronotum appearing rather narrow with long lateral margins, less than twice as broad as medial length. Apophysis of stylus not blade-shaped, apical hook reduced, claw-like. Apex of penis in posterior aspect spoon-shaped owing to a short plate-like lamella on either side 28

\- Small or medium-sized species, length about 5 mm, rarely more. Pronotum appearing transverse, at least about twice as broad as medial length. Apophysis of stylus blade-shaped, apical hook strong. Stem of penis deeply and narrowly cleft in apical part (see also <u>hystaspes</u> Lv. & Quart.)................................ 41

28 (27) Apophysis of stylus narrow, without distinct subapical expansion on ventral surface 29

\- Apophysis of stylus broadening apicad, ventral surface with roundish or angulate subapical expansion 30

29 (28) Apex of appendages of pygophore roughly T-shaped, smooth .... brunomaculatus (Ev.)

\- Apex of appendages of pygophore dentate .... cecrops Lv. & Quart.

30 (28) Appendages of pygophore not expanded apically, more or less sharp-tipped 31

\- Appendages of pygophore more or less expanded apically ... 36

31 (30) Crown and pronotum unicoloured pale (sometimes very indistinct and minute dark dotting on pronotum)....... 32

\- Crown with two round more or less fuscous spots. Pronotum with distinct dark irroration 34

32 (31) Stem of penis in lateral aspect appearing very broad and short, spoon in posterior aspect narrow, sharp-tipped .... cassandra Lv. & Quart.

\- Stem of penis in lateral aspect narrower and longer, spoon much broader 33

33 (32) Length 6.5 mm. Appendages of pygophore strongly falcate .... callimachus Lv. & Quart.

\- Length 6.75-8 mm. Appendages of pygophore rather straight with only apex bent mesad ...... pollux Lv. & Quart.

34 (31) Spoon of penis very long, parallel-sided .... minerva Lv. & Quart.

\- Spoon of penis shorter 35

35 (34) Spoon of penis triangular .... cato Lv. & Quart.

\- Spoon of penis parallel-sided ... lituratus Lv. & Quart.

36 (30) Apex of appendages of pygophore truncately expanded, dentate .... castor Lv. & Quart.

\- Appendages of pygophore different 37

37 (36) Appendages of pygophore truncately expanded apically....... 38

\- Appendages of pygophore dissimilar 39

38 (37) Spoon of penis triangular. Appendages of pygophore incrassate .... triangularis Lv. & Quart.

\- Spoon of penis more or less parallel-sided. Appendages of pygophore rather straight, not incrassate .... kivuensis Lv. & Quart.

39 (37) Apex of appendages of pygophore fork-shaped. Dark pattern reduced .... narkissos Lv. & Quart.

\- Appendages of pygophore different. Elytra with faint fuscous spots 40

40 (39) Apex of appendages of pygophore roughly T-shaped .... lusingaensis Lv. & Quart.

\- Apex of appendages of pygophore hook-shaped .... magniceps Lv. & Quart.

41 (27) Crown, ocellocular area and upper margin of frontoclypeus uniformly dark coffee-brown ...... sordidus Hell. & Lv.

\- Colouring different 42

42 (41) Penis with a pair of spine-like or ligulate processes...... 43

\- Penis different 44

43 (42) Posterior surface of stem of penis with a pair of ligulate dentate lobes .... bilobatus Lv. & Quart.

\- Anterior surface of penis with a pair of spiniform apical processes .... calchas Lv. & Quart.

44 (42) Penis with a pair of large longitudinal lobes on anterior surface of stem ....beninensis n. sp.

\- Penis different 45

45 (44) Appendages of pygophore bifurcate 46

\- Appendages of pygophore simple 48

46 (45) Bifurcation of appendages of pygophore apical, primary and secondary branches very small ..sapobensis n. sp.

\- Bifurcation of appendages of pygophore subapical, primary and secondary branches longer 47

47 (46) Branches of appendages of pygophore parallel, close to each other. Apophysis of stylus broad .... theokritos Lv. & Quart.

\- Appendages of pygophore fork-shaped. Apophysis of stylus slender .... lamto Lv. & Quart.

48 (45) Apical hook of stylus strongly acutely angled .... polydoros Lv. & Quart.

\- Apical hook of stylus normally or obtusely angled 49

49 (48) Apical hook of stylus more or less obtusely angled 50

\- Apical hook of stylus normally angled 51

50 (49) Stem of penis straight, with a pair of roundedly triangular apical lobes on anterior surface .... welwitschi n. sp.

\- Stem of penis slightly curved dorsad, anterior lamellae finely serrate .... mosselensis n. sp.

51 (49) Posterior margin of penis in lateral aspect strongly sinuate in basal half 52

\- Posterior margin of penis in lateral aspect at most shallowly sinuate basally 53

52 (51) Stem of penis stout, provided with a pair of coarsely dentate lamellae on anterior surface .. hipponax Lv.

\- Stem of penis narrower and longer, anterior lamellae only finely serrate .... quirimboensis n. sp.

53 (51) Crown with two round brown or dark spots. Pronotum with abundant dark pattern 54

\- At most pronotum with dark pattern 55

54 (53) Anterior lamellae of stem of penis minutely dentate.
Ventral margin of apophysis of stylus smooth ....
.... abundans Lv. & Quart.

\- Anterior lamellae of stem of penis practically smooth.
Ventral margin of apophysis of stylus finely
dentate .... lewisi n. sp.

55 (53) Pronotum spotted with brown 56

\- Pronotum unicoloured pale 57

56 (55) Apophysis of stylus with small apical tooth on ventral
margin; apical hook acute ...... kisala Lv. & Quart.

\- Apophysis of stylus edentate apically; apical hook blunt .
.... gobiswaterensis n. sp.

57 (55) Posterior surface of stem of penis with a pair of coarsely
dentate longitudinal lamellae in apical half 58

\- Posterior surface of stem of penis smooth, anterior
surface with a pair of longitudinal dentate lamellae... 59

58 (57) Stem of penis gracile in lateral aspect, anterior surface
smooth. Apophysis of stylus moderately constricted
apically .... chianguensis Lv. & Quart.

\- Stem of penis thicker in lateral aspect, anterior surface
with a pair of teeth. Apophysis of stylus strongly
constricted apically .... iocasta Lv.

59 (57) Appendages of pygophore very long and gracile, smooth .....
.... adspersus Hell. & Lv.

\- Appendages of pygophore relatively short and stout,
more or less serrate apically 60

60 (59) Yellowish, shiny. Crown 0.20 - 0.23 times as long as pronotum, 5 - 6 times as broad as long. Puncturing of elytra nearly concolorous. Apophysis of stylus gracile .... <u>cynthia</u> Lv. & Quart.

\- Green, rather opaque. Crown very short, 0.14 times as long as pronotum, 8 times as broad as long. Puncturing of elytra dark. Apophysis of stylus broad .... <u>conspersus</u> Lv. & Quart.

61 (26) Apophysis of stylus not blade-shaped, apical hook reduced, claw-like. Apex of penis spoon-shaped (see also <u>narkissos</u> Lv. & Quart.) 62

\- Apophysis of stylus blade-shaped, apical hook in general well-developed. Apex of penis narrowly and deeply split, not spoon-shaped 63

62 (61) Socle of penis short; stem relatively short and stout...... .... <u>nimule</u> Lv. & Quart.

\- Socle of penis longer, stout; stem relatively long and gracile .... <u>wardi</u> n. sp.

63 (61) Appendages of pygophore bifurcate 64

\- Appendages of pygophore simple 86

64 (63) Secondary (thinner) branch of appendages of pygophore long and gracile 65

\- Secondary branch of appendages of pygophore short 70

65 (64) Secondary branch of appendages of pygophore distinctly longer than the primary one 66

\- Secondary branch of appendages of pygophore at most as long as the primary one 68

66 (65) Socle of penis in lateral aspect short, about 0.3 times as long as stem, stem rather straight .... <u>incognitus</u> Lv. & Quart.

\- Socle of penis in lateral aspect longer, at least 0.5 times as long as stem, stem distinctly curved dorsad 67

67 (66) Secondary branch of appendages of pygophore much less than double the length of the primary one. Apical hook of stylus narrowing to apex, but not sharp .... liberiensis Lv. & Quart. and l. carvalhoi n.ssp.

\- Secondary branch of appendages of pygophore very long, about double the length of the primary one. Apical hook of stylus sharp .... dalatandoensis n. sp.

68 (65) Branches of appendages of pygophore parallel, close to each other .... ariadne Lv. & Quart.

\- Branches of appendages of pygophore curvate 69

69 (68) Stem of penis rather straight, very elongate, apex distinctly recurved anteriorly. Apical hook of stylus acutely angled .... centralensis Lv. & Quart.

\- Stem of penis curved dorsad, much shorter, stout, apex only slightly recurved anteriorly. Apical hook of stylus distinctly acutely angled .... atossa Lv. & Quart.

70 (64) Secondary branch of appendages of pygophore far from apex, lying about at middle of appendage 71

\- Secondary branch of appendages of pygophore apical or subapical 74

71 (70) Apical hook of stylus sharp-tipped, claw-like .... kabwekanonus Lv. & Quart.

\- Apical hook of stylus with blunt apex 72

72 (71) Socle of penis short, in lateral aspect about 0.3 times as long as stem; stem long, rather straight .... phaidra Lv. & Quart.

\- Socle of penis much longer, in lateral aspect more than 0.6 times as long as stem; stem incrassate, distinctly curved dorsad 73

73 (72) Apophysis of stylus remarkably gracile; apical hook straight, apex obliquely truncate .. aigeios Lv. & Quart.

\- Apophysis of stylus much broader; apical hook curved, apex pointed .... pasiphae Lv. & Quart.

74 (70) Penis with a pair of longish spines on anterior surface of stem 75

\- Penis without spines on anterior surface 76

75 (74) Stem of penis gracile, spines subapical ... minos Lv. & Quart.

\- Stem of penis robust, spines far from apex .... viator Lv. and v. minorquis Lv. & Quart.

76 (74) Secondary branch of appendages of pygophore a dentate lobe 77

\- Secondary branch of appendages of pygophore tooth or spine-like 79

77 (76) Apical hook of stylus sharp-tipped ..... daidalos Lv. & Quart.

\- Apical hook of stylus different 78

78 (77) Apical hook of stylus very long. Subapical lobe of appendages of pygophore on mesial surface .... mimus Lv. & Quart.

\- Apical hook of stylus shorter. Subapical lobe of appendages of pygophore on ventral surface .. natalensis n. sp.

79 (76) Apical hook of stylus slender, more or less tapering apicad 80

\- Apical hook of stylus stout, not tapering apicad 84

80 (79) Socle of penis short, in lateral aspect less than 0.3 times as long as stem .... teispes Lv. & Quart.

\- Socle of penis long 81

81 (80) Appendages of pygophore short, straight and thick........... .... ariarammes Lv. & Quart.

\- Appendages of pygophore different 82

82 (81) Puncturing of elytra brown, setae dark brown or blackish, longish .... bispinosus Hell. & Lv.

\- Puncturing of elytra concolorous, setae indistinct and pale.. 83

83 (82) Appendages of pygophore long and slender, strongly curved; secondary branch short, weakly divergent................ .... akhmenes Lv. & Quart.

\- Appendages of pygophore straighter, secondary branch longish, strongly divergent ... arsames Lv. & Quart.

84 (79) Apical hook of stylus long, apex blunt ... hollisi n. sp.

\- Apical hook of stylus shorter, apex more or less truncate.... 85

85 (84) Stem of penis very long, strongly curved dorsad, socle short ... mongbwalu Lv. & Quart. and m. distinguendus.... Lv. & Quart.

\- Stem of penis relatively short, only a little curved dorsad, socle long .... kapouensis Lv. & Quart.

86 (63) Stem of penis curved ventrad, provided with distinct triangular apical lobes directed laterad 87

\- Stem of penis curved dorsad 88

87 (86) Apophysis of stylus nearly straight, of equal width throughout .... guierae Lv. & Quart.

\- Apophysis of stylus strongly reflexed, basal half much narrower than apical .... creusa Lv. & Quart.

88 (86) Socle of penis in lateral aspect very short, at most 0.3 times as long as stem; stem long and gracile, longitudinal lamellae on anterior surface narrow or absent 89

\- Socle of penis in lateral aspect at least 0.35 times as long as stem, often much longer; stem usually relatively stout, provided with more or less distinct wing-like lamellae on anterior surface 95

89 (88) Apex of appendages of pygophore roughly T-shaped .... _humilis_ Lv. & Quart.

\- Not as above 90

90 (89) Stem of penis with coarsely dentate broadish longitudinal lamellae on posterior surface in apical half 91

\- Stem of penis without broadish coarsely dentate lamellae on posterior surface 92

91 (90) Appendages of pygophore falcate ..... _astyages_ Lv. & Quart.

\- Appendages of pygophore rather straight, apex suddenly bent ventrad .... _hystaspes_ Lv. & Quart.

92 (90) Stem of penis with a pair of small triangular apical lobes on anterior margin .... _clarensis_ n. sp.

\- Stem of penis different 93

93 (92) Ventral margin of apophysis of stylus shallowly sinuate, apical tooth small .... _boulardi_ Lv. & Quart.

\- Ventral margin of apophysis of stylus expanded, apical tooth larger 94

94 (93) Apical hook of stylus edentate; apophysis of stylus with very strong apical tooth. Stem of penis long and slender .... _harpaganus_ Lv. & Quart.

\- Apical hook of stylus with small subapical tooth; apical tooth of apophysis of stylus smaller. Stem of penis longer and narrower .... _samaruensis_ n. sp.

95 (88) Anterior lamellae of penis broad and coarsely dentate. .... _mandane_ Lv. & Quart.

\- Anterior lamellae of penis at most finely dentate 96

96 (95) Apical hook of stylus very acute 97

\- Apical hook of stylus thicker 101

97 (96) Socle of penis in lateral aspect less than 0.5 times as long as stem 98

\- Socle of penis much longer 99

98 (97) Ventral margin of apical part of pygophore appendages dentate. Apical tooth on ventral margin of apophysis of stylus sharp .... _echo_ Lv.

\- Ventral margin of apical part of pygophore appendages smooth. Apical tooth on ventral margin of apophysis of stylus very small .... _ceresensis_ n. sp.

99 (97) Appendages of pygophore straight ..... _artemisiae_ Ldb.

\- Appendages of pygophore moderately to strongly curved...... 100

100(99) Stem of penis digitate, tapering apicad; socle in lateral aspect about 0.9 times as long as stem .... _signatus_ Ldb.

\- Stem of penis long and gracile, of equal breadth throughout; socle in lateral aspect about 0.7 times as long as stem .... _akhmenes hargeisanus_ Lv. & Quart.

101(96) Apical hook of stylus with a distinct subapical tooth...... 102

\- Apical hook of stylus edentate 105

102(101) Apophysis of stylus distinctly constricted apically 103

\- Apophysis of stylus different 104

103(102) Socle of penis in lateral aspect about 0.4 times as long as stem .... _fernandesi_ Quart.

\- Socle of penis in lateral aspect as long as stem .... _foroforo_ Lv. & Quart.

104(102) Appendages of pygophore nearly straight .... _v.niger_ Ldb.

\- Appendages of pygophore semicircularly curved .... _perplexus_ Lv. & Quart.

105(101) Socle of penis in lateral aspect at most 0.4 times as long as stem 106

\- Socle of penis in lateral aspect at least 0.5 times as long as stem 107

106(105) Apophysis of stylus of subequal breadth, apical hook slightly obtusely angled or upcurved .... subolivaceus (St.)

– Apophysis of stylus strongly expanded in apical two-thirds, apical hook acutely angled .... arcuatus Lv. & Quart.

107(105) Apophysis of stylus very long and gracile 108

– Apophysis of stylus different 109

108(107) Apophysis of stylus and stem of penis very narrow .... richteri Hell. & Lv.

– Apophysis of stylus and stem of penis broader .... lucalensis n. sp.

109(107) Ventral margin of apophysis of stylus strongly curved at middle. Anterior lamellae of penis distinctly serrate. Appendages of pygophore bearing a sclerotized spiral... .... inara Lv. & Quart.

– Not as above 110

110(109) Ventral corner of socle of penis acutely prominent, horn-shaped .... acuminatus Lv. & Quart.

– Ventral corner of socle of penis rounded 111

111(110) Apical corner of ventral margin of apophysis of stylus strongly rounded, apical tooth absent or obtuse (see also sinuatus Lv. & Quart.) 112

– Apical corner of ventral margin of apophysis of stylus not strongly rounded, provided with a distinct tooth .. 121

112(111) Apical hook of stylus sharp-tipped, a little upcurved apically .... telepinus Lv. & Quart.

– Apical hook of stylus thicker, not as above 113

113 (112) Appendages of pygophore very long, in ventral aspect distinctly spiral ... <u>longispinus</u> Lv. & Quart.

\- Appendages of pygophore shorter, in ventral aspect not distinctly spiral 114

114 (113) Posterior margin of socle of penis distinctly sinuate. Apophysis of stylus in apical two-thirds strongly expanded, elongately ovate ... <u>pamba</u> Lv. & Quart.

\- Posterior margin of socle of penis rather straight. Apophysis of stylus much narrower 115

115 (114) Apophysis of stylus of equal breadth in apical half 116

\- Apophysis of stylus more or less constricted apically ... 118

116 (115) Apical hook of stylus rather slender. Appendages of pygophore very slender, acute .... <u>santosjuniori</u> Lv. & Quart.

\- Apical hook of stylus stouter. Appendages of pygophore thicker 117

117 (116) Stem of penis gracile. Appendages of pygophore rather short, apex expanded, obliquely truncate and finely dentate .... <u>thersites</u> Lv. & Quart.

\- Stem of penis thick. Appendages of pygophore long, not as above .... <u>sudanicus</u> Lv. & Quart.

118 (115) Apical hook of stylus very long, relatively thin; apical corner of ventral margin completely rounded, edentate 119

\- Apical hook of stylus shorter, thicker; apical corner of ventral margin less rounded, provided with a very small tooth 120

119 (118) Appendages of pygophore rather straight, apically deflected. Apical hook of stylus very long, distinctly acutely angled ...... dirke Lv. & Quart.

\- Appendages of pygophore arcuate. Apical hook of stylus shorter, only slightly acutely angled ... timaea Lv.

120 (118) Appendages of pygophore with apex expanded, obliquely truncate.............. dirkoides Lv. & Quart.

\- Appendages of pygophore not expanded apically .... chlorophanoides Lv. & Quart.

121 (111) Stem of penis slender owing to very narrow anterior lamellae .... filigranus Lv. & Quart.

\- Stem of penis thicker, anterior lamellae broadish 122

122 (121) Apophysis of stylus gracile. Stem of penis in lateral aspect unusually thick ..... boukokoensis Lv. & Quart.

\- Apophysis of stylus broader. Stem of penis in lateral aspect thinner, digitate 123

123 (122) Ventral margin of apophysis of stylus distinctly sinuate in apical third ..... rutshurensis parmenio Lv.

\- Ventral margin of apophysis of stylus not sinuate in apical part (see also thersites Lv. & Quart., chlorophanoides Lv. & Quart., and dirkoides Lv. & Quart.) .... sinuatus Lv. & Quart.

4. Subgenus BATRACOMORPHUS Lewis

Usually small and robust species, uniformly green or yellowish, with dark pattern or with fuscous irroration. Pronotum appearing transverse, about twice as broad as medial length, lateral margins usually rather short and diverging caudad.

Second sternal abdominal apodemes of male lobe-shaped, with a deep mesal sinuation.

Male pygophore usually with a mid-ventral incision only (with both a mid-ventral and mid-dorsal incision in the Palaearctic B. irroratus Lew.). Apophysis of stylus blade-shaped, with a well-developed apical hook; ventral margin of apophysis usually provided with a distinct apical tooth. Penis flattended, stem deeply and narrowly split in apical part. Subapical part of genital plates with long setae along outer margin.

Distribution: Widespread in all the major zoogeographical regions with exception of the New World.

B. (s.str.) irroratus Lew.

(Figs. 1A : a-f; 1B : g-k)

Batracomorphus irroratus Lewis, 1834 : 52.

Bythoscopus microcephalus Herrich-Schäffer, 1838 : 8.

Jassus punctulatus Forel, 1858 : 253.

Macropsis punctuosus Kirschbaum, 1868 : 168.

Macropsis verrucosa Haupt, 1917 : 239.

A Palaearctic species, not of African distribution, and here studied for comparative purposes. After its description by Lewis (1834a), it has been described by several authors such as Edwards

(1886a, 1894d), Buckton (1890c), Melichar (1896a), Kusnezov (1929d), Haupt (1935a), Ribaut (1952a) or, more recently, by Le Quesne (1965). Therefore, only a short description of the structures not hitherto described is given.

Male abdominal apodemes - Notch of first sternal abdominal apodemes oval to angularly oval, lobes expanded medially, usually closely apposed. Second sternal abdominal apodemes lobe-shaped, distinctly longer and set farther apart than half their individual width at middle, outer margins steep, inner margins nearly vertical. Antecosta of second abdominal tergum forming a narrow ridge, with a small mesal sinuation.

Distribution : Palaearctic - Afghanistan, Albania, Austria, Belgium, Bulgaria, China, Czechoslovakia, Denmark, France, German D.R. and F.R., Great Britain, Greece, Hungary, Italy, Mongolia, Switzerland, Turkey, U.S.S.R., Yugoslavia (Nast, 1972).

Ecology : Records from Europe (e.g.,Edwards, 1894d, Ribaut, 1952a, Dlabola, 1954a or Le Quesne, 1965) suggest that this species feeds and probably oviposits mainly on Helianthemum. According to Emeljanov (1967), B. irroratus from Russia is associated with other plants such as Artemisia, Astragalus arbuscula, Kochia prostrata, Camphorosma monspeliacum, etc.

Material studied : 5 males, Great Britain : Longdown Hill, Bucks., 24.7.76, Quartau. In coll. Quartau. On Helianthemum sp.

Remarks : A peculiar species due to the fact that it is the only representative within Batracomorphus in which the apophysis of the pygophore appendages is extremely reduced.

Fig. 1A - B. (s.str.) irroratus Lewis

a, male pygophore, left lateral view

b, left appendage of pygophore, left lateral view

c, connective, left lateral view

d, connective, dorsal view

e, penis, left lateral view

f, left stylus, left lateral view

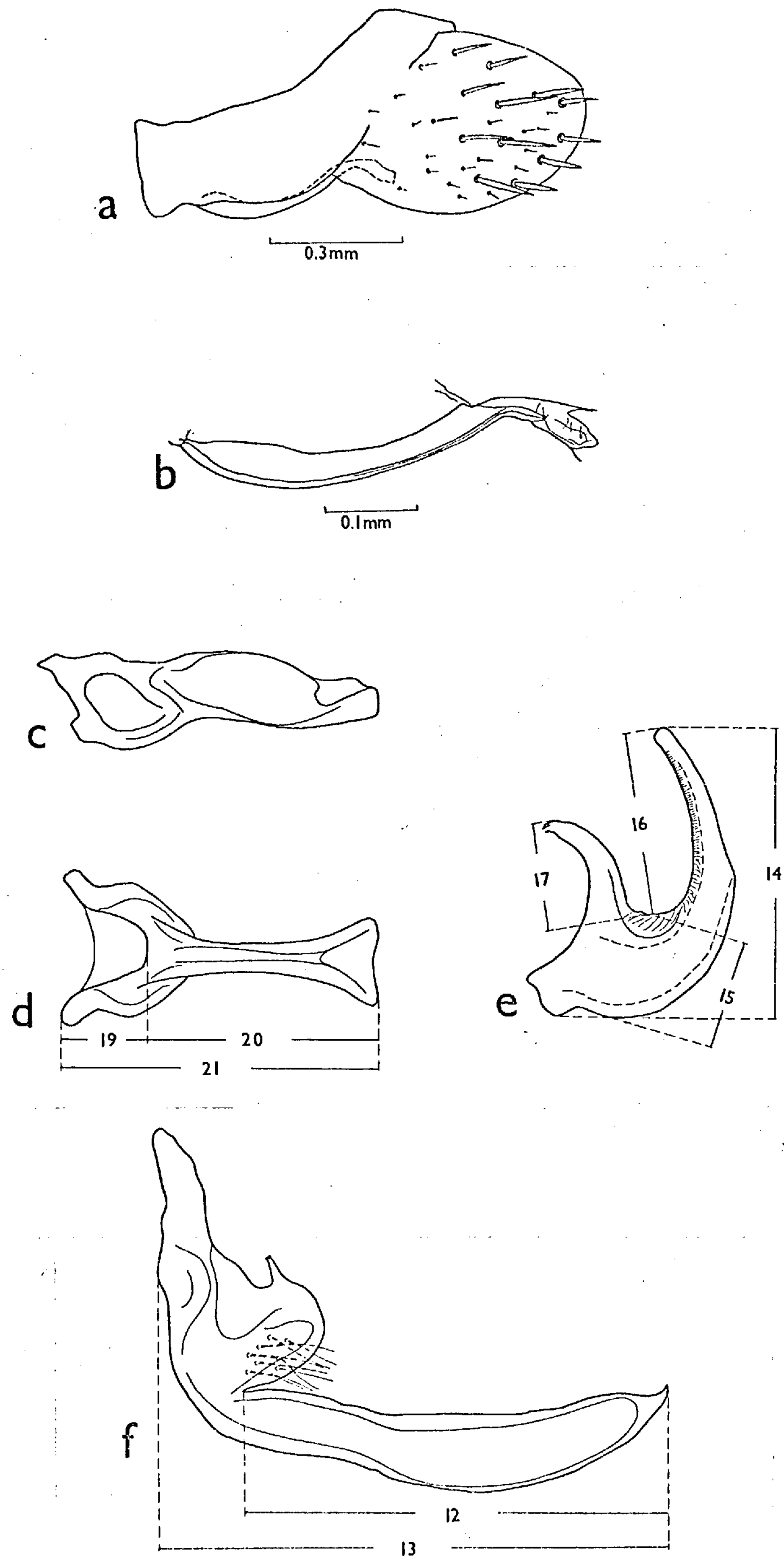
a
0.3mm
b
0.1mm
c
d
19
20
21
e
16
17
14
15
f
12
13

Fig. 1B - B. (s.str.) irroratus Lewis

g, 8th sternite, ventral view

h, left genital plate, dorsal view

i, antecosta of second abdominal tergum, posterior view

j, first sternal abdominal apodemes, posterior view

k, second sternal abdominal apodemes, postero-dorsal view

Scale as shown with pygophore, 8th sternite, genital plates and abdominal apodemes to same scale and appendages of pygophore, connective, penis and styli also to same scale.

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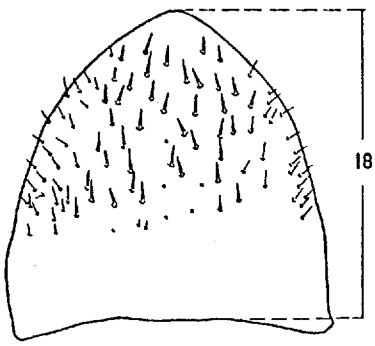

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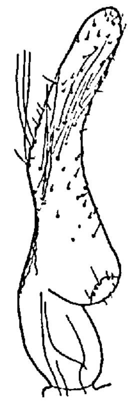

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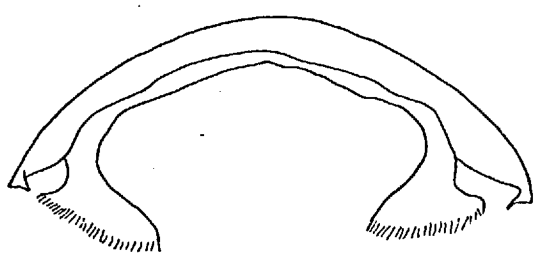

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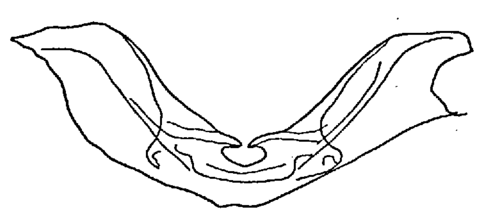

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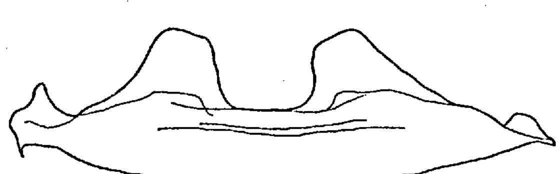

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B. (s.str.) akhmenes Lv. & Quart.

Batracomorphus (s.str.) akhmenes Linnavuori & Quartau, 1975 : 103.

B. (s.str.) akhmenes hargeisanus Lv. & Quart.

(Figs. 2A : a-f; 2B : g-k; 2C : l-n)

Batracomorphus (s.str.) akhmenes hargeisanus Linnavuori & Quartau, 1975 : 103.

Shiny. Yellowish or yellowish green. Eyes brownish grey or reddish. Pronotum yellowish green, immaculate. Scutellum yellowish green, sometimes with two faint brownish longitudinal stripes; basal triangular spots faint. Elytra greenish yellow to yellowish, immaculate; appendix infumated, base with a brown spot; veins of elytra concolorous; commissural margin of clavus with a subapical brownish spot. Legs greenish yellow, tarsi and apical part of tibiae green.

Medium-sized, robust. Length 4.75 - 5.55 mm. Crown 5.7 - 6.9 times (male, mean 6.3) or 6.4 - 7.8 times (female, mean 7.1) as broad as long, 0.16 - 0.20 times (male, mean 0.18) or 0.14 - 0.18 times (female, mean 0.16) as long as pronotum. Pronotum 1.90 - 2.03 times (male, mean 1.97) or 1.89 - 2.15 times (female, mean 1.99) as broad as long, more or less finely and transversely furrowed. Elytra distinctly punctate; puncturing dense, concolorous; setae longish, pale.

Male with notch of first sternal abdominal apodemes broadly triangular; lobes expanded medially, very closely apposed. Second sternal abdominal apodemes lobe-shaped, distinctly longer than half their individual width at middle, moderately separated, outer margins approximately steep, inner margins nearly vertical, mesal margin approximately straight. Antecosta of second abdominal tergum strongly developed, with a small mesal sinuation.

Male genitalia with 8th sternite broad; apical part broadly rounded, setae dense. Side lobes of pygophore roundedly truncate apically, each with 8 - 12 macrosetae; appendages moderately curved, simple, ventral margin large and irregularly serrate. Length of stylus 0.72 mm; dorsal margin of apophysis approximately straight, ventral margin moderately curved; apical tooth on ventral margin of apophysis small; apical hook moderately developed, stout, sharp, slightly acutely angled. Length of penis 0.47 - 0.48 mm (mean 0.48 mm); stem more or less slender, distinctly curved dorsad, anterior lamellae smooth to minutely serrate; socle in lateral aspect 0.69 - 0.84 times as long as stem; angle between socle and base of stem on posterior margin less than 180°. Base of connective in dorsal view broad; shaft shorter than base, dorsal keel in lateral view lower than base. Genital plates turned slightly laterad at mid-length, subapical part with long setae along outer margin.

Female genitalia with 7th sternite as illustrated.

Distribution : Eastern. Kalaharian.

Ecology : Arid sandy localities. Wooded steppe with abundant Acacia and Commiphora. On Acacia.

Material studied : 1 male, 1 female, Botswana : Lake Ngami, 12 mls., N.E. Sehithwa, 16 - 17. IV. 1972, at light, Southern African Expedition, B.M. 1972 - I; 1 female, Toteng, 42 mls., S.W. Maun, 17. IV. 1972, at light, Southern African Expedition, B.M. 1972 - I. 1 male, 5 females, S.W. Africa : Rietfontein, 23 mls., S.W. Grootfontein, 3. IV. 1972, at light, Southern African Expedition, B.M. 1972 - I. In coll. B.M. (N.H.).

Remarks : This subspecies is apparently a form of more arid areas in comparison with the nominate form which seems to inhabit savanna forests. The Kalaharian material seems to differ very little from the Eastern forms, except in the curvature of the pygophore appendages which is moderate in the former and nearly semicircular in the latter.

Closely related to signatus Ldb. but easily distinguished from it by the shorter socle of penis, and by the stem of penis longer and of equal breadth throughout. Distinguished from ceresensis n. sp. by the irregularly dentate ventral margin of the pygophore appendages, the longer socle of penis, and by the narrower stem of penis.

Fig. 2A - B. (s.str.) akhmenes hargeisanus Lv. & Quart. (a - k, L. Ngami; l, Rietfontein; m, L. Ngami; n, Rietfontein)

a, male pygophore, left lateral view

b, left appendage of pygophore, left lateral view

c, connective, left lateral view

d, connective, dorsal view

e, penis, left lateral view

f, left stylus, left lateral view

2A

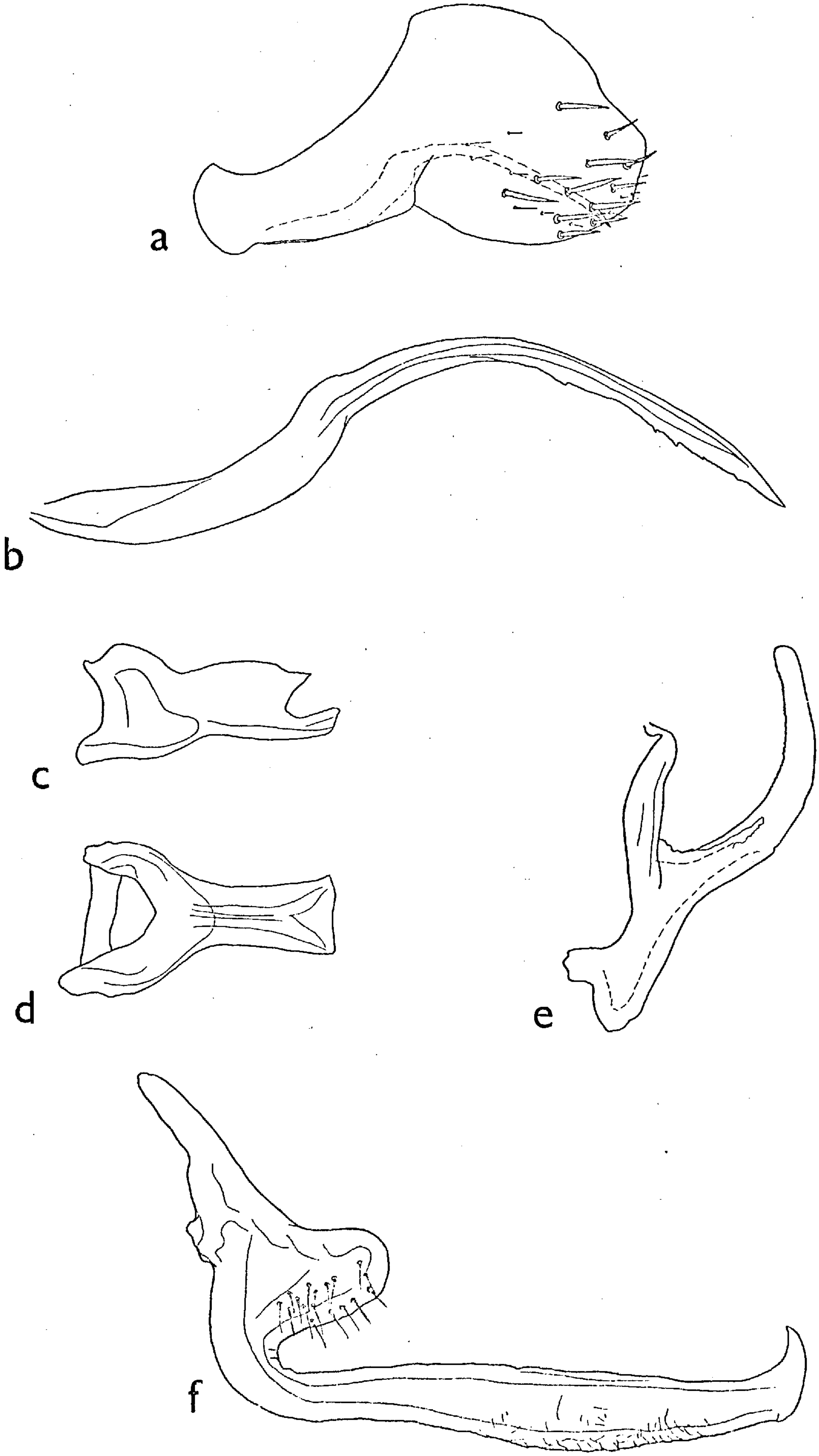


Fig. 2B - B. (s.str.) akhmenes hargeisanus Lv. & Quart.

g, 8th sternite, ventral view

h, left genital plate, dorsal view

i, antecosta of second abdominal tergum, posterior view

j, first sternal abdominal apodemes, posterior view

k, second sternal abdominal apodemes, postero-dorsal view

2B

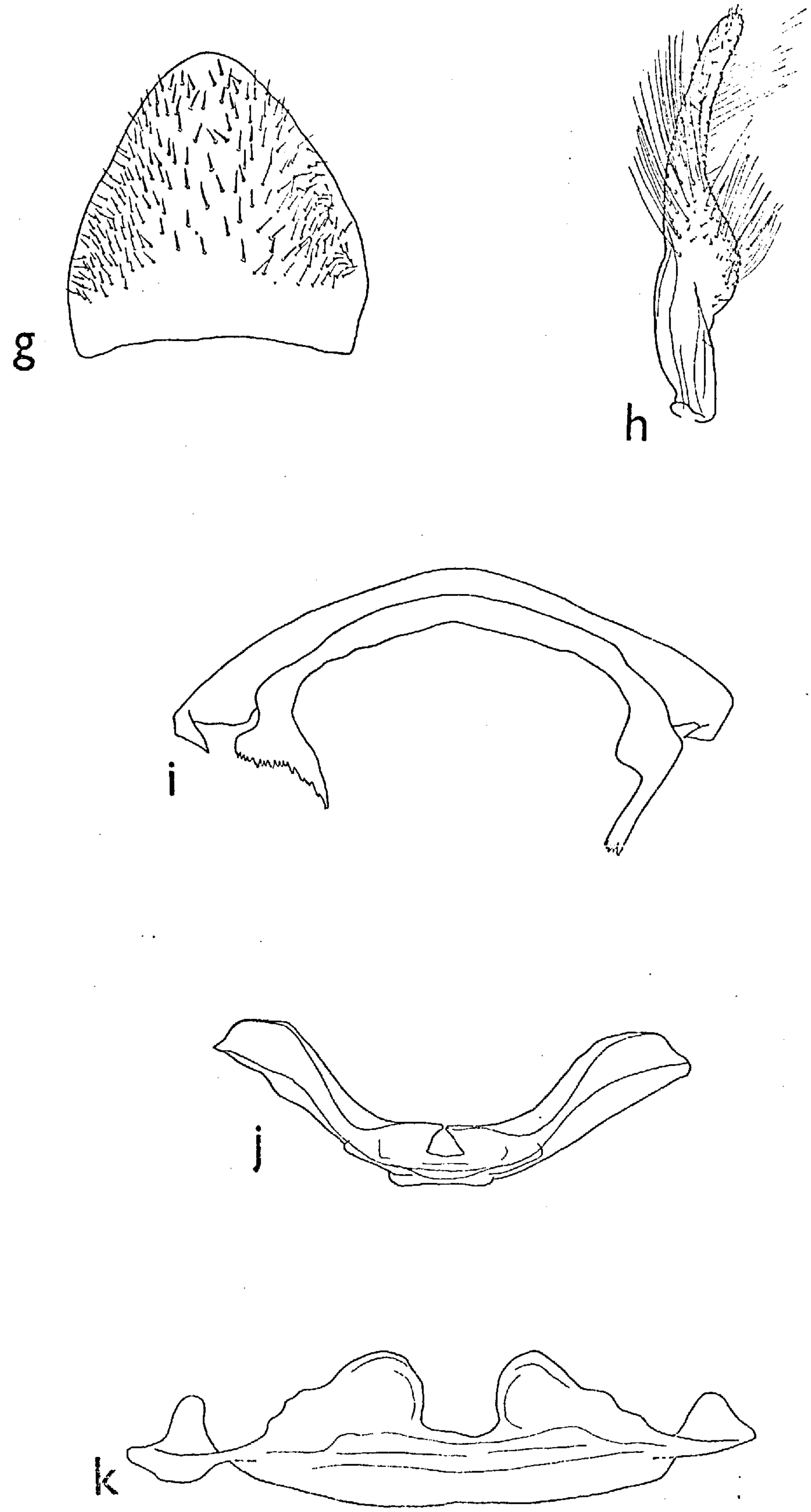


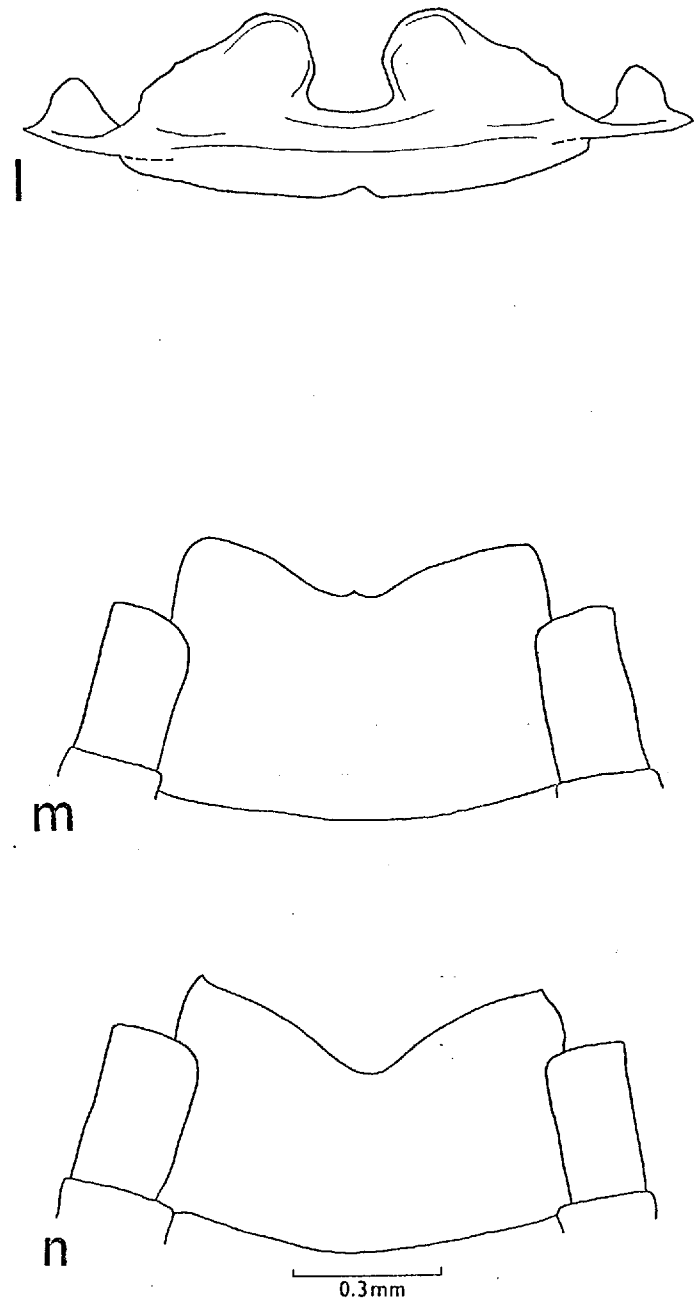
Fig. 2C - B. (s.str.) akhmenes hargeisanus Lv. & Quart.

l, second sternal abdominal apodemes, postero-dorsal view

m - n, female 7th abdominal sternite, ventral view

Scale as in Figs. 1A and 1B or, otherwise, as indicated.

2C



B. (s.str.) arcuatus Lv. & Quart.

(Figs. 3A : a–g; 3B : h–j)

Batracomorphus (s.str.) arcuatus Linnavuori & Quartau, 1975 : 121 - 122.

Shiny. Golden yellow. Eyes reddish grey. Pronotum and scutellum golden yellow, immaculate. Elytra light yellow; base of appendix infumated, first apical cell and tips of second and third apical cells slightly infumated; veins of elytra yellowish, some parts greenish; commissural margin of clavus greenish in posterior half. Legs greenish, some parts yellowish.

Medium-sized, relatively elongate. Length of male, 4.42 - 4.62 mm; female unknown. Crown 9.4 times as broad as long, 0.23 times as long as pronotum. Pronotum 2.47 times as broad as long, coarsely and transversely furrowed. Elytra more or less distinctly punctate; puncturing dense, concolorous; setae short or longish, brownish.

Second sternal abdominal apodemes of male lobe-shaped, moderately separated, outer margins not steep, inner margins vertical, apices with a small tooth, mesal margin rounded.

Male genitalia with 8th sternite broad; apical part acutely rounded, setae relatively dense. Side lobes of pygophore rounded apically, each with 11 - 19 macrosetae; appendages more or less strongly curved, simple, subapical part slightly expanded and minutely serrate on ventral margin. Length of stylus, 0.65 mm; apophysis very broad in lateral aspect, dorsal margin strongly expanded, ventral margin slightly sinuate near base; apical tooth on ventral margin of apophysis obsolete; apical hook long, relatively slender, blunt, acutely angled. Length of penis 0.47 - 0.48 mm; stem broad, distinctly curved dorsad, with small tubercles on lateral surfaces; socle in lateral aspect 0.35 - 0.43 times as long as stem; angle between socle and base of stem on posterior margin about 180°. Base of connective in dorsal view wider than long; shaft approximately as long as base, dorsal keel in lateral view approximately as high as base. Genital plates turned strongly laterad at mid-length, subapical part with some long setae along outer margin.

Distribution : Guinean. Zambesian.

Ecology : Moist Forest at low and medium altitudes. Gallery forest.

Material studied : 1 male - Angola; Duque de Bragança Falls, 11 - 12. III. 1972, at light, Southern African Expedition, B.M. 1972 - I. In coll. B.M. (N.H.).

Remarks : Distinguished from timaea Lv. by the much more expanded apophysis of stylus, the shorter socle of penis, and by the minutely serrate appendages of pygophore. Distinguished from pamba Lv. & Quart. by the shorter socle of penis, and by the subapically expanded and minutely serrate pygophore appendages.

Fig. 3A - _B_. (s.str.) _arcuatus_ Lv. & Quart.

a, male pygophore, left lateral view

b, apex of left appendage of pygophore, broadest aspect

c, right appendage of pygophore, left lateral view

d, connective, left lateral view

e, connective, dorsal view

f, penis, left lateral view

g, right stylus, right lateral view

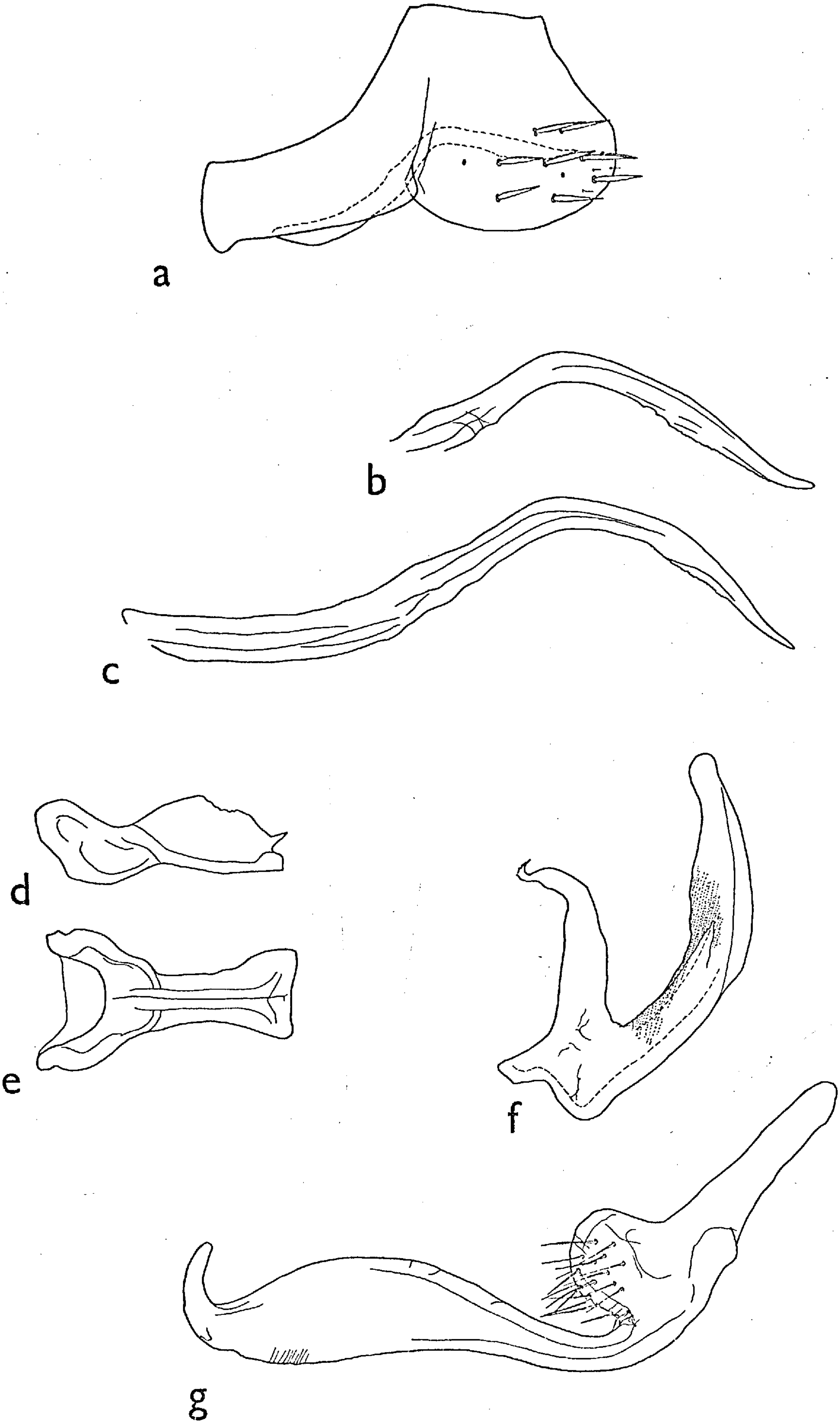

a
b
c
d
e
f
g

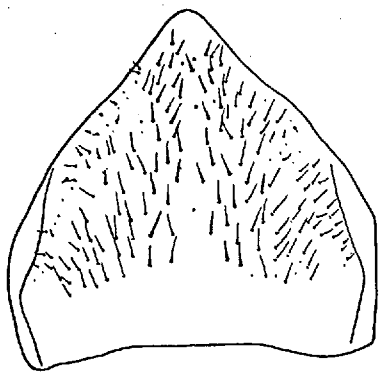
Fig. 3B - B. (s.str.) arcuatus Lv. & Quart.

h, 8th sternite, ventral view

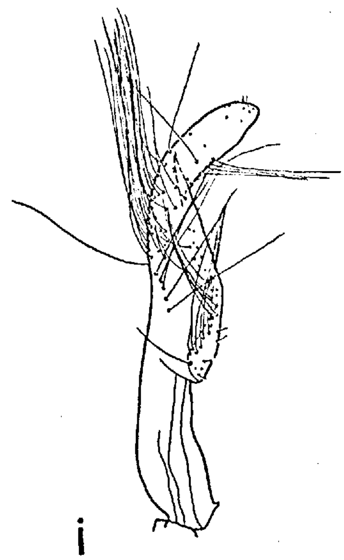
i, left genital plate, dorsal view

j, second sternal abdominal apodemes, postero-
dorsal view

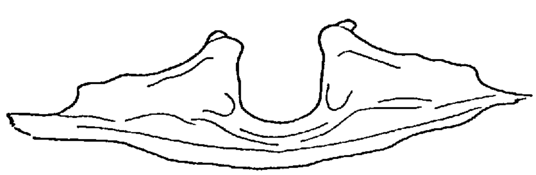
Scale as in Figs. 1A and 1B.



h



i



j

B. (s.str.) beninensis n. sp.

(Figs. 4A : a-f; 4B : g-l; 4C : m)

Fairly shiny. Yellowish. Eyes reddish. Pronotum yellowish, disk densely and minutely spotted with brown. Scutellum yellowish, densely spotted with brown. Elytra pale yellow, densely spotted with brownish; appendix and first apical cell faintly infumated; veins concolorous, commissural margin of clavus greenish in apical half. Legs pale yellow, tibiae light brownish yellow, tarsi greenish.

Medium-sized, robust. Length of male, 4.77 mm; female, 5.23 mm. Crown 6.1 times (male) or 6.0 times (female) as broad as long, 0.18 times (male) or 0.20 times (female) as long as pronotum. Pronotum 1.93 times (male) or 2.01 times (female) as broad as long, coarsely and finely furrowed. Elytra distinctly punctate; puncturing dense, in brown spots dark, in other parts concolorous; setae short (male) or longish (female), dark brown.

Male with notch of first sternal abdominal apodemes approximately circular; lobes expanded medially, very closely apposed. Second sternal abdominal apodemes lobe-shaped, long, moderately separated, outer margins steep, inner margins oblique, mesal margin rounded. Antecosta of second abdominal tergum strongly developed, with a small mesal sinuation.

Male genitalia with 8th sternite moderately broad; apical part acutely rounded, setae relatively sparse. Side lobes of pygophore roundedly truncate apically, each with 10 - 11 macrosetae arising from dark pits; appendages moderately curved, simple, very minutely serrate apically. Length of stylus 0.91 mm; apophysis broad, dorsal margin moderately expanded, ventral margin approximately straight; apical tooth on ventral margin small; apical hook long, stout, relatively sharp, acutely angled. Length of penis 0.63 mm; stem stout, rather straight, with a pair of large longitudinal lobes on anterior surface; socle in lateral aspect 0.28 times as long as stem; angle between socle and base of stem on posterior margin greater than 180°. Base of connective in dorsal view broad; shaft approximately as long as base, dorsal keel in lateral view as high as base. Genital plates turned moderately laterad at mid-length, subapical part with several long setae along outer margin.

Female genitalia with 7th sternite as illustrated.

Distribution : Guinean.

Ecology : Moist Forest at low and medium altitudes.

Material studied : Holotype male - Nigeria : Nigerian Institute for Oilpalm Research, near Benin. 13. III. 1972, E.W. Classey, B.M. 1972 - 190. Allotype - same data as holotype. Holotype and allotype in coll. B.M. (N.H.).

Remarks : A rather distinctive species because of the longitudinal lobes on anterior surface of stem of penis. On the basis of stylus resembling kisala Lv. & Quart., but very different in penis and side lobes of pygophore.

Fig. 4A - B. (s.str.) beninensis n. sp.

(a - l, holotype; m, allotype)

a, male pygophore, left lateral view

b, left appendage of pygophore, left lateral view

c, connective, left lateral view

d, connective, dorsal view

e, penis, left lateral view

f, penis, posterior view

4A

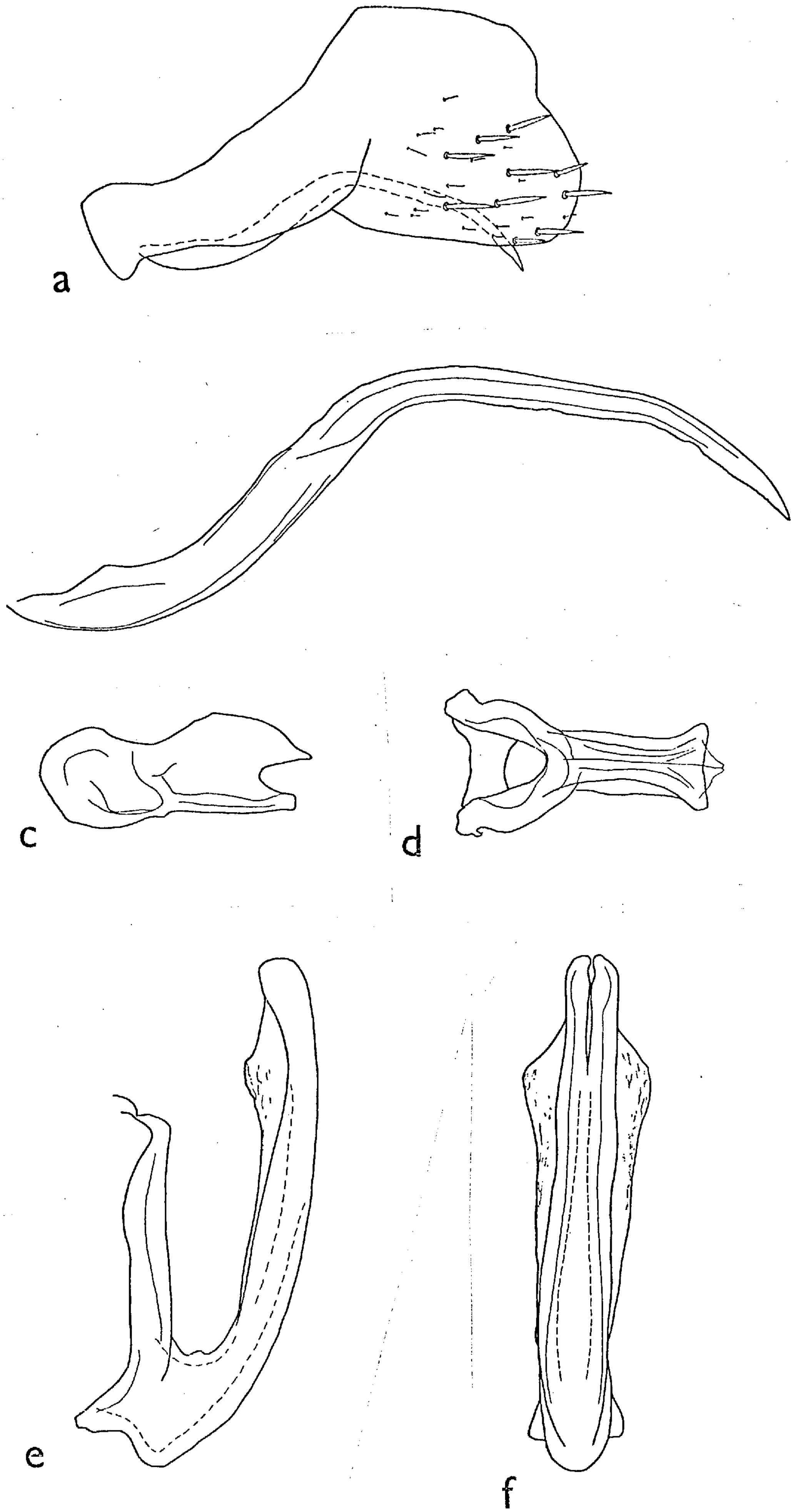


Fig. 4B - B. (s.str.) beninensis n. sp.

g, right stylus, left lateral view

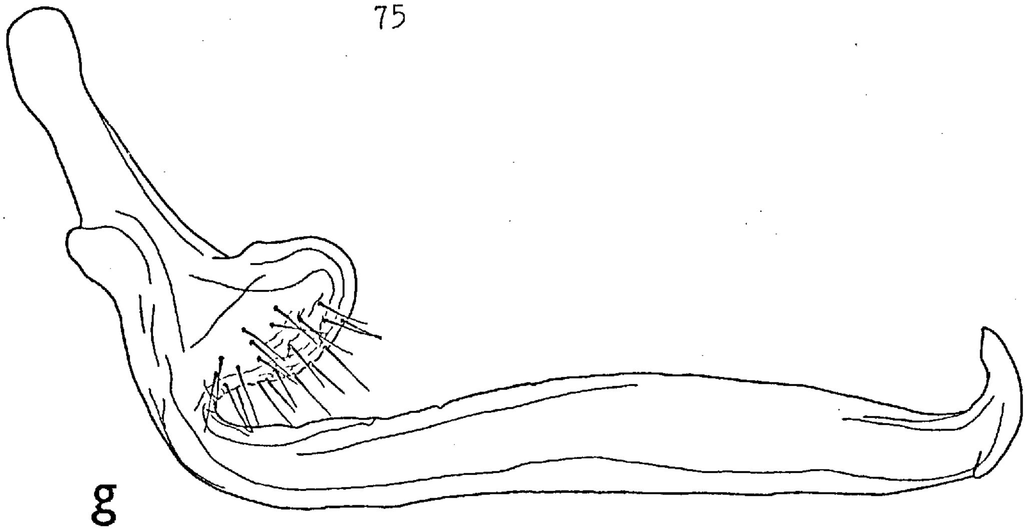
h, 8th sternite, ventral view

i, left genital plate, dorsal view

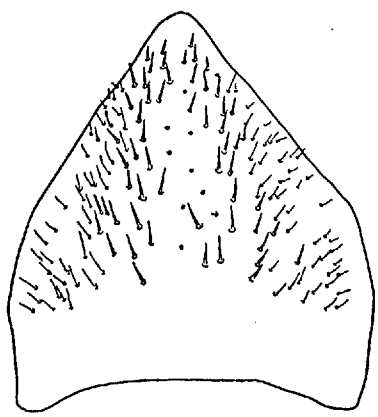
j, antecosta of second abdominal tergum, posterior view

k, first sternal abdominal apodemes, posterior view

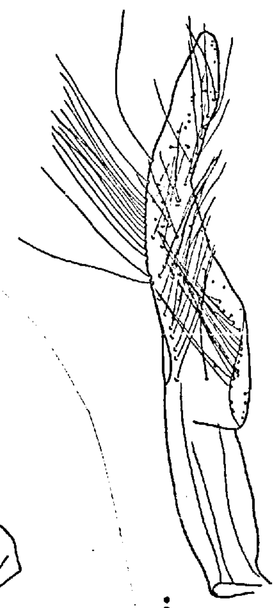
l, second sternal abdominal apodemes, postero-dorsal view



g

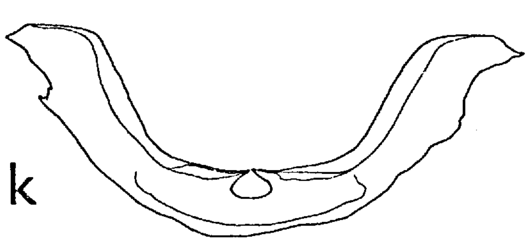


h



i

j



k

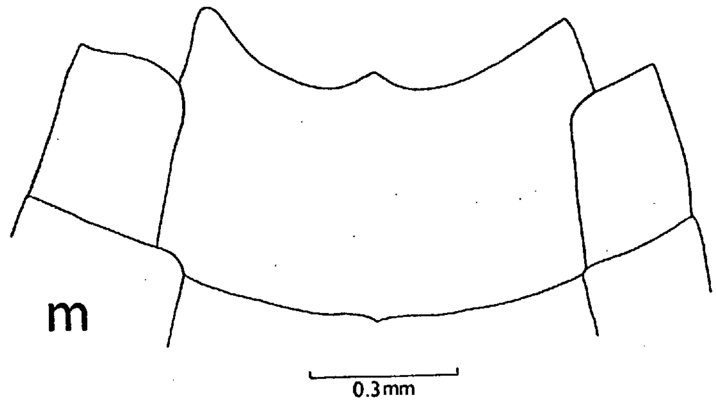
l

Fig. 4C - *B.* (s.str.) *beninensis* n. sp.

m, female 7th abdominal sternite, ventral view

Scale as in Figs. 1A and 1B or, otherwise, as indicated.

4C



m

B. (s.str.) bifasciatus Lv. & Quart.

(Figs. 5A : a-f; 5B : g-k)

Batracomorphus (s.str.) bifasciatus Linnavuori & Quartau, 1975 : 43.

Fairly shiny. Olive yellowish or yellowish green. Anteclypeus, lora and genae tinged with light greenish. Eyes dark brown. Pronotum and scutellum olive yellowish, immaculate. Elytra whitish or pale yellowish, with two transverse fuscous fasciae (faint in new material), one at middle of clavus, the other at level of base of appendix; base of appendix infumated; veins of elytra concolorous, some parts greenish. Legs yellow, tarsi and apical part of tibiae green.

Small, robust. Length 3.72 - 5.25 mm. Crown 5.20 - 5.75 times as broad as long, about 0.2 times as long as pronotum. Pronotum 1.95 - 2.00 times as broad as long, finely and transversely furrowed. Elytra obsoletely punctate; puncturing sparse, in fuscous bands dark brown, in other parts concolorous; setae short, dark brown.

Male with notch of first sternal abdominal apodemes oval, compressed; lobes expanded medially, very closely apposed. Second sternal abdominal apodemes lobe-shaped, moderately separated, outer margins more or less steep, inner margins slightly oblique, mesal margin rounded. Antecosta of second abdominal tergum strongly developed, mesal sinuation absent.

Male genitalia with 8th sternite moderately elongate, apical part broadly rounded, setae relatively dense. Side lobes of pygophore roundedly truncate apically, each with 8 - 12 macrosetae; appendages very slightly curved, simple, ventral margin practically smooth. Length of stylus 0.58 - 0.68 mm; apophysis gracile, dorsal margin slightly expanded, ventral margin approximately straight; apical tooth on ventral margin of apophysis small; apical hook moderately developed, stout, normally angled. Length of penis 0.42 - 0.50 mm; stem relatively slender, rather straight, lateral surfaces with small tubercles, anterior lamellae dentate; socle of penis in lateral aspect 0.80 - 0.86 times as long as stem; angle between socle and base of stem on posterior margin less than 180°. Base of connective in dorsal view wider than long; shaft shorter than base, dorsal keel in lateral view approximately as high as base. Genital plates turned moderately laterad at mid-length, subapical part with some long setae along outer margin.

Female genitalia with hind margin of 7th sternite subtruncate.

Distribution : Mostly Guinean.

Ecology : Moist Forest at low and medium altitudes.

Material studied : 1 male - Nigeria : Sapoba Forest Reserve, near Benin, 10 - 12. II. 1972, E.W. Classey, B.M. 1972 - 190. In coll. B.M. (N.H.).

Remarks : Previously known from Liberia, Sudan and Zaire from moist tropical forest and therefore expected to be found in Nigeria in a similar vegetation type. The holotype, illustrated in Linnavuori & Quartau (1975 : Figs. 25a - d), has an obviously damaged penis, of which the basal apodeme is missing.

This species is peculiar because of the bifasciate elytra, which can be more or less fuscous. On the basis of some genital structures (e.g.,penis) resembling <u>telepinus</u> Lv. & Quart. but very different in appendages of pygophore and elytral fasciae. Distinguished from <u>boukokoensis</u> Lv. & Quart. by the elytral fasciae, and by the longer socle and slender stem of penis.

Fig. 5A - _B._ (s.str.) _bifasciatus_ Lv. & Quart.

a, male pygophore, left lateral view

b, left appendage of pygophore, left lateral view

c, connective, left lateral view

d, connective, dorsal view

e, penis, left lateral view

f, left stylus, left lateral view

5A

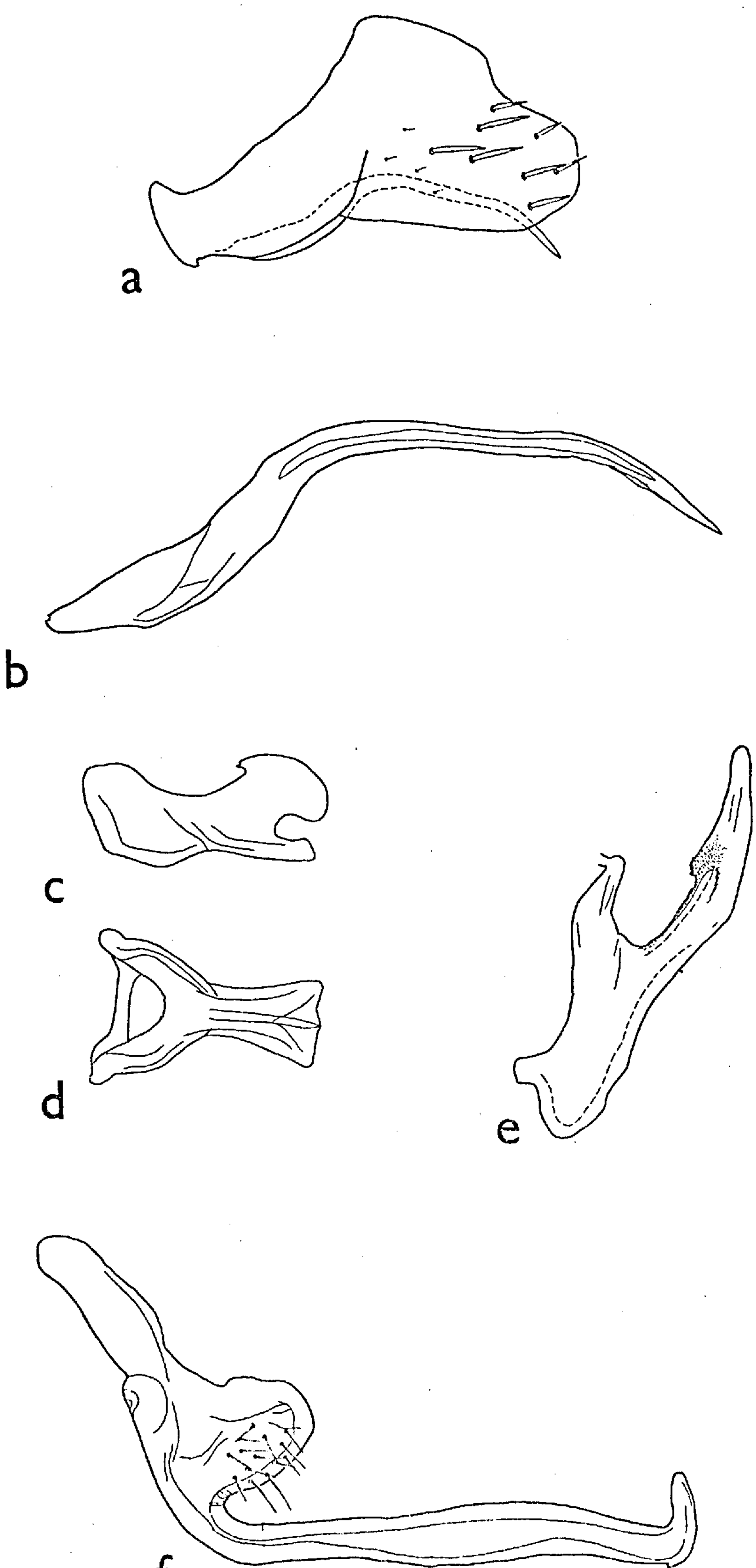


Fig. 5B - B. (s.str.) bifasciatus Lv. & Quart.

g, 8th sternite, ventral view

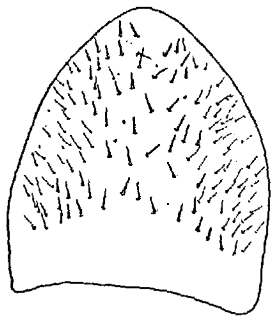
h, left genital plate, dorsal view

i, antecosta of second abdominal tergum, posterior view

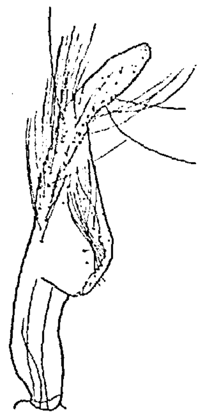
j, first sternal abdominal apodemes, posterior view

k, second sternal abdominal apodemes, postero-dorsal view

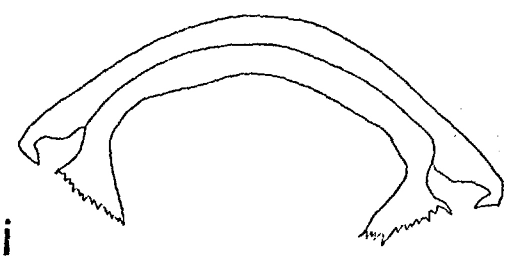
Scale as in Figs. 1A and 1B.



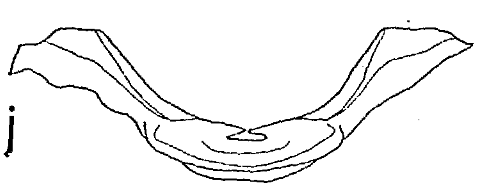
g



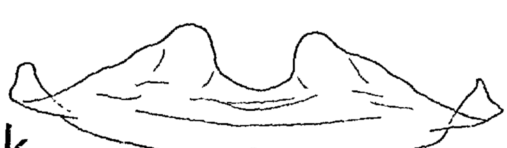
h



i



j



k

B. (s.str.) ceresensis n. sp.

(Figs. 6A : a-f; 6B : g-l)

Shiny. Yellowish. Eyes reddish grey to brownish grey. Pronotum yellowish, often immaculate, sometimes minutely dotted with faint brownish. Scutellum yellowish, immaculate. Elytra pale yellowish, densely dotted with brown; base of appendix tinged with faint brownish; veins of elytra concolorous; commissural margin of clavus greenish. Legs yellowish, tarsi and apical part of tibiae green.

Medium-sized, robust. Length of male, 4.64 - 4.70 mm (mean 4.66 mm); female, 5.29 - 5.36 mm (mean 5.34 mm). Crown 5.1 - 5.4 times (male, mean 5.2) or 5.3 - 6.1 times (female, mean 5.6) as broad as long, 0.22 - 0.24 times (male, mean 0.23) or 0.21 - 0.25 times (female, mean 0.23) as long as pronotum. Pronotum 2.07 - 2.11 times (male, mean 2.09) or 2.11 - 2.25 times (female, mean 2.18) as broad as long, finely and transversely furrowed. Elytra distinctly punctate; puncturing dense, of a conspicuous brown; setae often short, dark.

Male with notch of first sternal abdominal apodemes approximately oval; lobes expanded medially, closely apposed. Second sternal abdominal apodemes lobe-shaped, longer than half their individual width at middle, moderately separated, outer margins steep, inner margins oblique, mesal margin rounded. Antecosta of second abdominal tergum very narrow, mesal sinuation obsolete.

Male genitalia with 9th sternite very broad; apical part broadly rounded, setae relatively dense. Side lobes of pygophore broadly truncate, each with 11 - 14 macrosetae; appendages moderately curved, simple, ventral margin approximately smooth, apex acute, not expanded. Length of stylus 0.71 - 0.73 mm (mean 0.72 mm); dorsal margin of apophysis approximately straight; ventral margin with a small arcuate sinuation near base, slightly expanded at middle; apical tooth on ventral margin of apophysis very small; apical hook long, stout, sharp, normally angled. Length of penis 0.50 - 0.53 mm (mean 0.52 mm); stem moderately stout, rather straight, anterior lamellae very minutely serrate; socle in lateral aspect 0.45 - 0.47 times (mean 0.46) as long as stem; angle between socle and base of stem on posterior margin about 180°. Base of connective in dorsal view short and broad; shaft approximately as long as base, dorsal keel in lateral view as high as base. Genital plates turned strongly laterad at mid-length, subapical part with several long setae along outer margin.

Female genitalia with 7th sternite as illustrated.

Distribution : Cape.

Ecology : Cape macchia.

Material studied : Holotype male - S. Africa : Ceres, Cape Province, March 1925, R.E. Turner, Brit. Mus., 1925 - 161; Allotype - 1 female, same data as holotype. Paratypes - 1 male, 2 females, same data as holotype; 1 male, Milnerton, Cape Town, 14 - 28. XII. 1925, R.E. Turner, Brit. Mus., 1926 - 28. Holotype and paratypes in B.M. (N.H.).

Remarks : Distinguished from echo Lv. by the smooth ventral margin of apical part of pygophore appendages, and by the smaller apical tooth on ventral margin of apophysis of stylus which in echo is sharp. Distinguished from akhmenes hargeisanus Lv. & Quart. by the smaller socle of penis, the more robust stem of same, and by the smooth ventral margin of pygophore appendages.

Fig. 6A - B. (s.str.) ceresensis n. sp.

(a-i, k, holotype; j, paratype, Ceres; l, allotype)

a, male pygophore, left lateral view

b, left appendage of pygophore, left lateral view

c, connective, left lateral view

d, connective, dorsal view

e, penis, left lateral view

f, left stylus, left lateral view

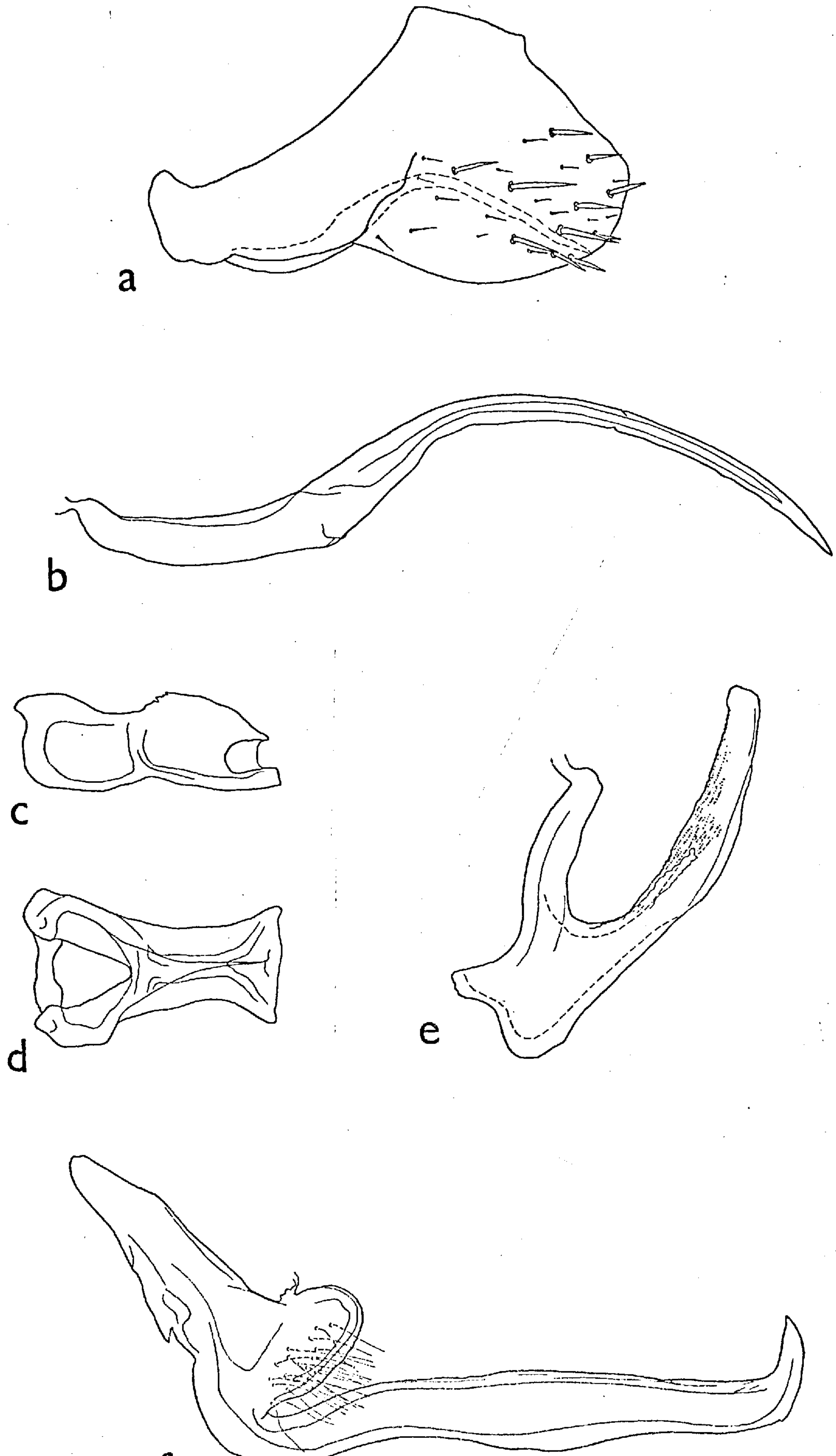

a
b
c
d
e
f

Fig. 6B - B. (s.str.) ceresensis n. sp.

g, 8th sternite, ventral view

h, left genital plate, dorsal view

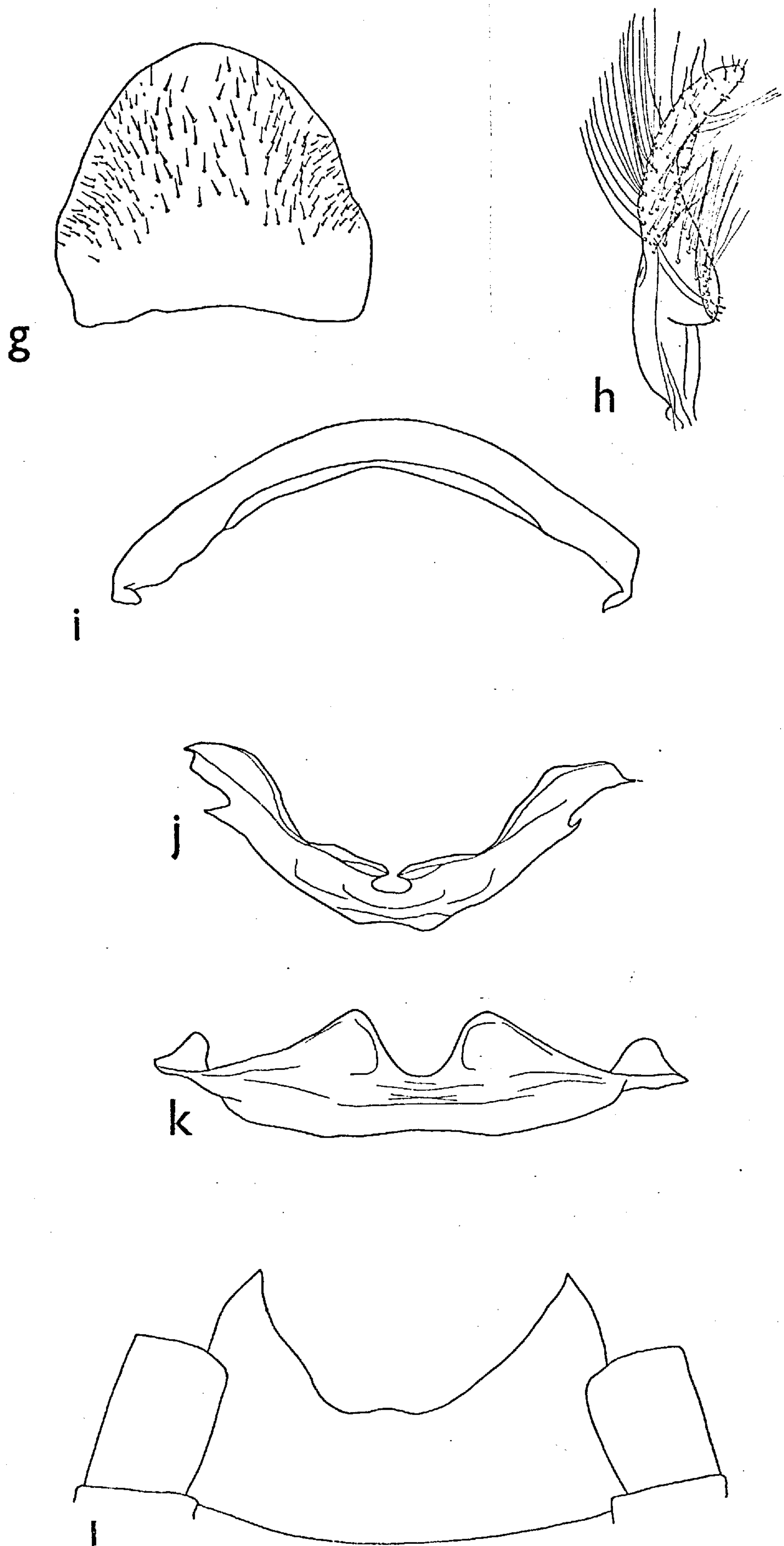
i, antecosta of second abdominal tergum, posterior view

j, first sternal abdominal apodemes, posterior view

k, second sternal abdominal apodemes, postero-dorsal view

l, female 7th abdominal sternite, ventral view

Scale as in Figs. 1A and 1B or, otherwise, as indicated.


g
h
i
j
k
l
0.3mm

B. (s.str.) clarensis n. sp.

(Figs. 7A : a-g; 7B : h-p)

Fairly shiny. Pale yellow or pale olive. Eyes reddish or reddish grey. Pronotum and scutellum pale yellow or pale olive, immaculate. Elytra pale yellowish; base of appendix with a small brownish spot; veins of elytra concolorous; commissural margin of clavus tinged with green in apical part. Legs pale yellow, tarsi greenish.

Medium-sized, robust. Length of male, 4.38 - 4.64 mm (mean 4.51 mm); female unknown. Crown 5.7 - 6.0 times (mean 5.8) as broad as long, 0.18 - 0.20 times (mean 0.19) as long as pronotum. Pronotum 1.94 - 2.02 times (mean 1.99) as broad as long, finely and tranversely furrowed. Elytra distinctly punctate; puncturing dense, concolorous; setae short, yellowish or brownish.

Male with notch of first sternal abdominal apodemes angularly oval to oval, compressed; lobes expanded medially, closely apposed. Second sternal abdominal apodemes lobe-shaped, moderately separated, outer margins not steep, inner margins oblique, mesal margin more or less rounded. Antecosta of second abdominal tergum strongly developed, with a small mesal sinuation.

Male genitalia with 8th sternite relatively elongate; apical part more or less broadly rounded, setae dense. Side lobes of pygophore more or less broadly rounded apically, each with 6 - 14 macrosetae; appendages curved at apex, simple, ventral surface smooth, apex very minutely serrate. Length of stylus 0.74 - 0.76 mm (mean 0.75 mm); apophysis stout, dorsal margin approximately straight, ventral margin broadly expanded at middle; apical tooth on ventral margin of apophysis small; apical hook short, stout, more or less acute, obtusely angled, with a small subapical tooth. Length of penis 0.57 - 0.59 mm (mean 0.58 mm); stem very slender, long, moderately curved dorsad, with a pair of small triangular apical lobes on anterior margin; anterior lamellae and apical lobes of stem very minutely serrate; socle in lateral aspect 0.19 - 0.21 times (mean 0.20) as long as stem; angle between socle and base of stem on posterior margin greater than 180°. Base of connective in dorsal view longer than wide; shaft short, dorsal keel in lateral view approximately as high as base. Genital plates turned moderately laterad at mid-length, subapical part with several long setae along outer margin.

Distribution : Transvalian. Kalaharian.

Ecology : Dry savanna with Colophospermum mopane. Wooded steppe with abundant Acacia and Commiphora.

Material studied : Holotype male - Angola : 3 mls. N. Santa Clara, 30. III - 1. IV. 1972, at light, Southern African Expedition, B.M. 1972 - I. Paratypes - 1 male, same data as holotype; 1 male, S.W. Africa : Gobiswater Farm, 12 mls. N. Grootfontein, 5. IV. 1972, at light, Southern African Expedition, B.M. 1972 - I. Holotype and paratypes in coll. B.M. (N.H.)..

Remarks : The species is slightly variable in the shape of the notch of the first sternal abdominal apodemes.

Related to hystaspes Lv. & Quart. on the basis of the pygophore appendages and the general shape of the penis, yet easily distinguished from it by the serrate lamellae of penis, which are posterior in hystaspes and anterior in clarensis n. sp. Related also to welwitschi n. sp. but easily distinguished from it by the thinner and somewhat curved stem of penis.

Seven females, same data as holotype, all with hind margin of the 7th abdominal sternite moderately sinuate and with a somewhat obsolete medial lobe, possibly belong to this species. In coll. B.M. (N.H.).

Fig. 7A - B. (s.str.) clarensis n. sp.

(a-e, g-k, m, o, holotype; f, n, p, paratype, Gobiswater Fm.; l, paratype, 3 mls. N. Santa Clara)

a, male pygophore, left lateral view

b, left appendage of pygophore, left lateral view

c, connective, left lateral view

d, connective, dorsal view

e-f, penis, left lateral view

g, penis, posterior view

7A

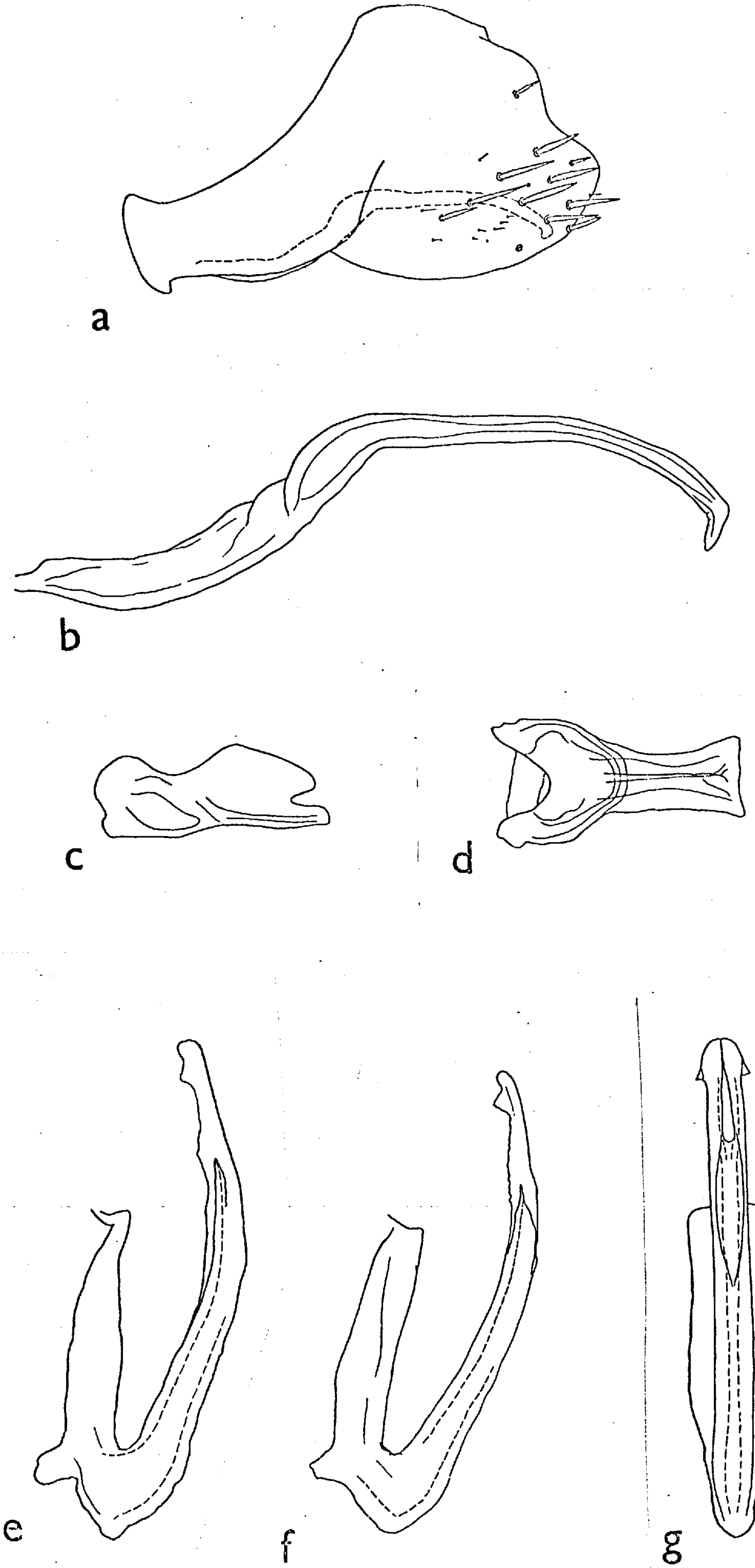


Fig. 7B - B. (s.str.) clarensis n. sp.

h, left stylus, left lateral view

i, 8th sternite, ventral view

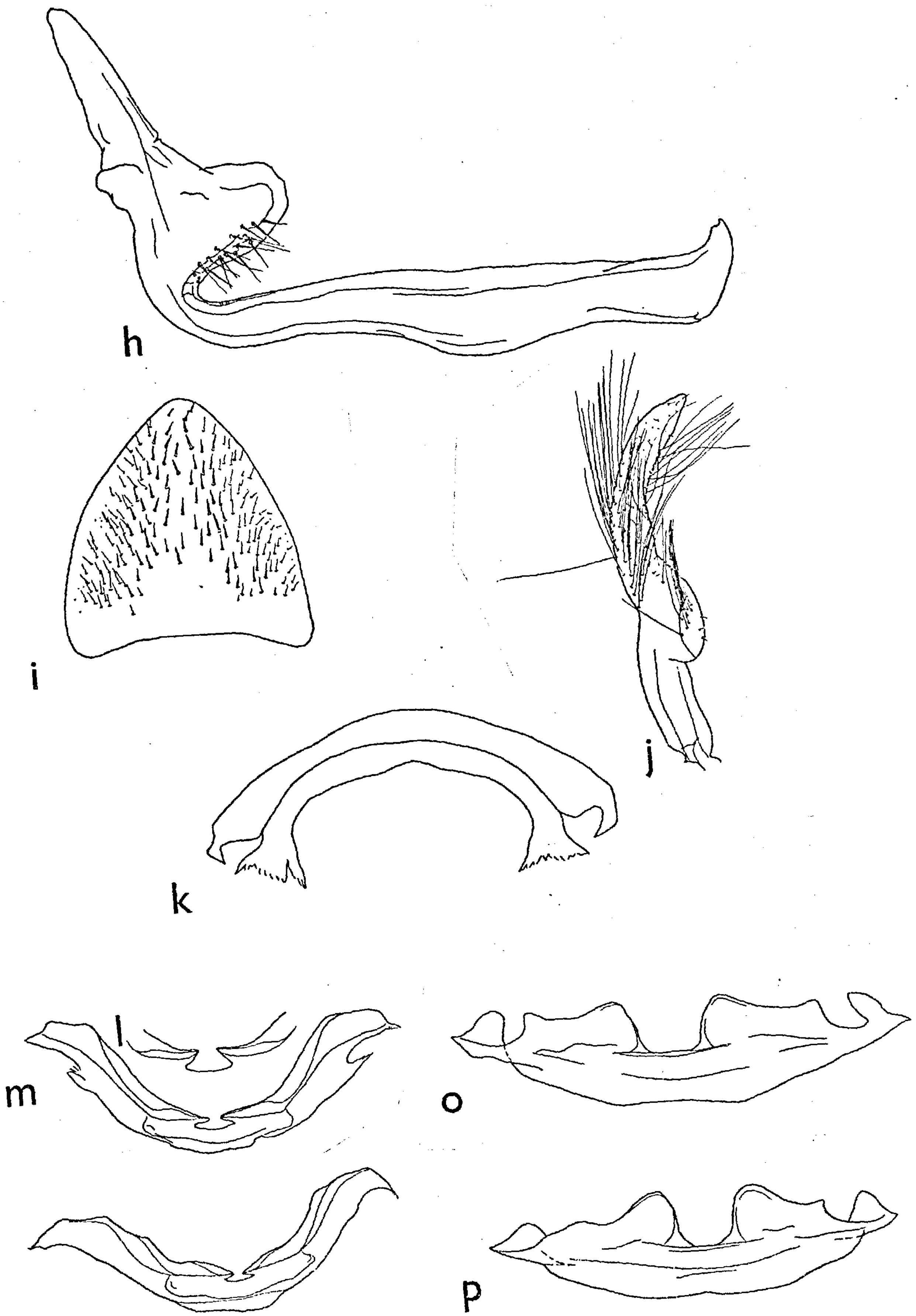
j, left genital plate, dorsal view

k, antecosta of second abdominal tergum, posterior view

l-n, first sternal abdominal apodemes, posterior view

o-p, second sternal abdominal apodemes, postero-dorsal view

Scale as in Figs. 1A and 1B.


h
i
j
k
l
m
o
n
p

B. (s.str.) classeyi n. sp.

(Figs. 8A : a-g; 8B : h-m)

Fairly shiny. Crown brownish; upper part of face golden yellow, lower part pale yellow. Eyes reddish brown. Pronotum brownish, lateral margins and humeral angles pale yellow. Scutellum brownish, apex pale yellow. Elytra pale yellowish, immaculate; base of appendix very slightly infumated; veins of elytra concolorous. Legs yellowish.

Small, robust. Length of male, 3.92 mm; female unknown. Crown 5.6 times as broad as long, 0.16 times as long as pronotum. Pronotum 1.52 times as broad as long, finely and transversely furrowed. Elytra distinctly punctate; puncturing sparse, concolorous; setae short, yellowish.

Male with notch of first sternal abdominal apodemes rectangular; lobes slightly expanded medially, widely separated from each other. Second sternal abdominal apodemes lobe-shaped, distinctly set farther apart than their individual width at middle, outer margins not steep, inner margins oblique, mesal margin straight. Antecosta of second abdominal tergum narrowish, mesal sinuation obsolete.

Male genitalia with 8th sternite moderately broad; apical part more or less broadly rounded, setae relatively dense. Side lobes of pygophore rounded apically, each with 12 - 13 macrosetae; appendages rather straight, ventral margin largely and irregularly dentate. Length of stylus 0.60 mm; dorsal margin of apophysis moderately expanded, ventral margin with a small subapical arcuate sinuation; apical tooth on ventral margin of apophysis small; apical hook moderately developed, more or less stout, blunt, acutely angled.

Length of penis 0.43 mm; stem slightly curved dorsad, lateral surfaces with small tubercles, anterior lamellae very minutely serrate; socle in lateral aspect 0.86 times as long as stem; angle between socle and base of stem on posterior margin about 180°. Base of connective in dorsal view wider than long; shaft approximately as long as base, dorsal keel in lateral view higher than base. Genital plates turned strongly laterad at mid-length, subapical part with several long setae along outer margin.

Distribution : Guinean.

Ecology : Moist Forest at low and medium altitudes.

Material studied : Holotype male - Nigeria : Nigerian Institute for Oilpalm Research near Benin, 13. III. 1972, E.W. Classey, B.M. 1972 - 190. In coll. B.M. (N.H.).

Named after the collector of the type, Mr. E.W. Classey.

Remarks : On the basis of the pygophore appendages and penis resembling foroforo Lv. & Quart. but easily distinguished from it, mainly by the external colouration, overall size and by the stylus. Distinguished from santosjuniori Lv. & Quart. by the external colouration, the shorter socle of penis and by the largely and irregularly dentate ventral margin of the apophysis of stylus.

Fig. 8A - B. (s.str.) classeyi n. sp.

a, male pygophore, left lateral view

b, left appendage of pygophore, left lateral view

c, left appendage of pygophore, dorsal view

d, right appendage of pygophore, left lateral view

e, connective, left lateral view

f, connective, dorsal view

g, penis, left lateral view

8A

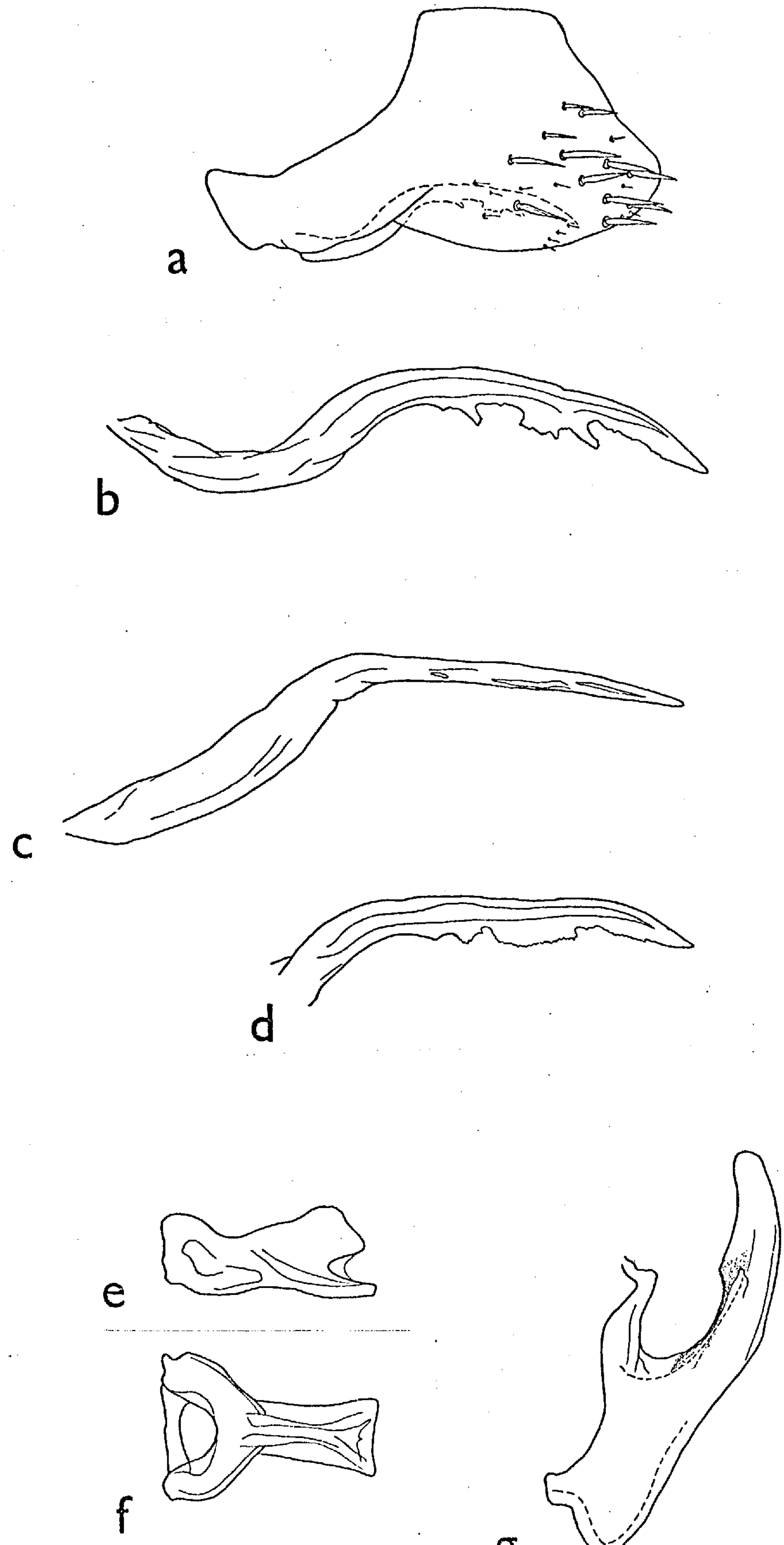


Fig. 8B - B. (s.str.) classeyi n. sp.

h, left stylus, left lateral view

i, 8th sternite, ventral view

j, left genital plate, dorsal view

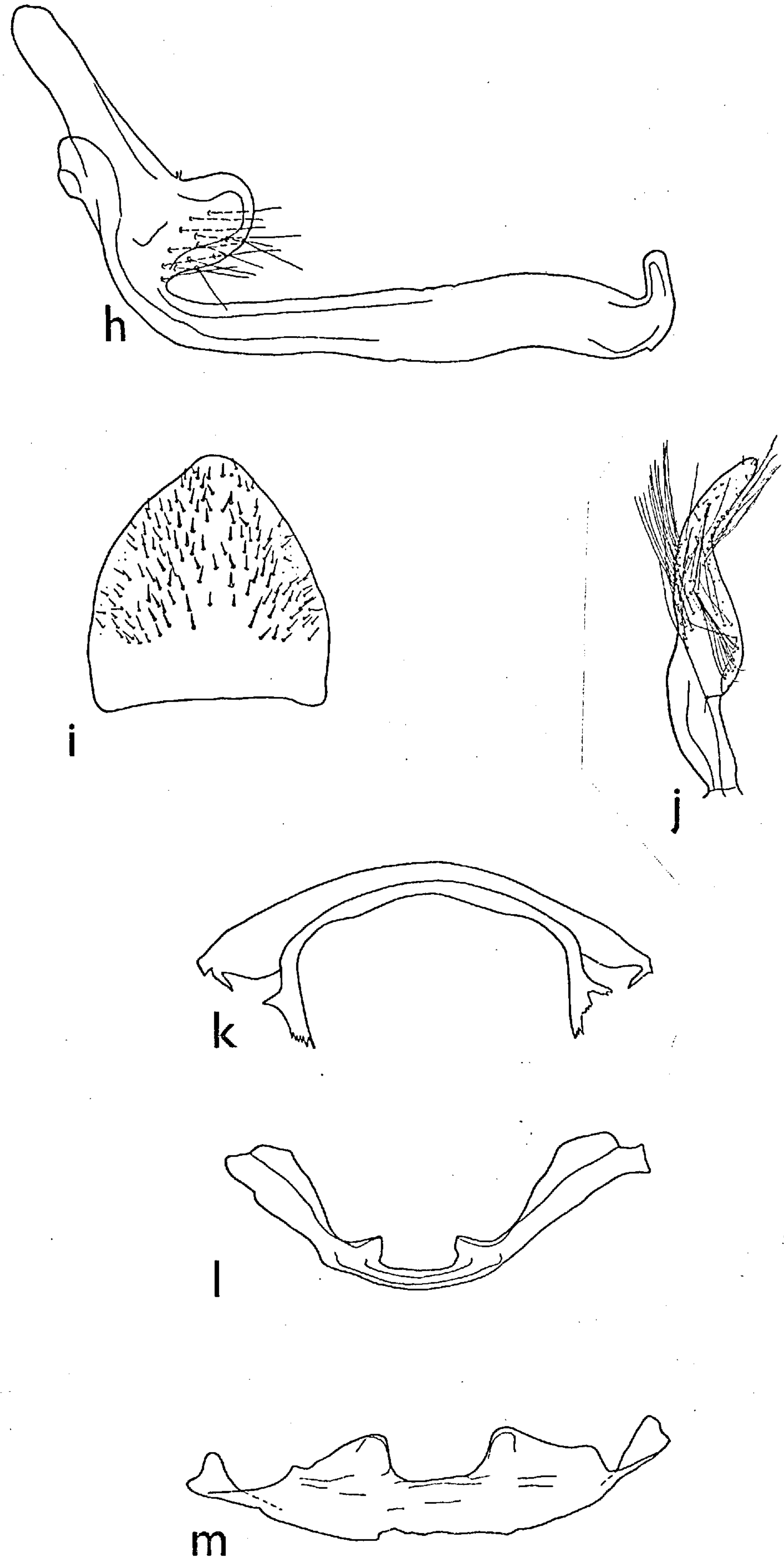
k, antecosta of second abdominal tergum, posterior view

l, first sternal abdominal apodemes, posterior view

m, second sternal abdominal apodemes, postero-dorsal view

Scale as in Figs. 1A and 1B.

8B



B. (s.str.) dalatandoensis n. sp.

(Figs. 9A : a-e; 9B : f-m; 9C : n-v)

Shiny to fairly shiny. Yellowish to greenish yellow. Eyes reddish to reddish brown. Pronotum yellowish, humeral angles sometimes tinged with green. Scutellum yellowish, basal triangles sometimes light golden. Elytra yellowish, immaculate; base of appendix tinged with brownish; first apical cell very slightly infumated; veins of elytra concolorous, sometimes tinged with green, especially claval suture, scutellar and commissural margins of clavus. Legs yellowish, tarsi and apical part of tibiae tinged with greenish.

Medium-sized, relatively elongate. Length of male, 4.57 - 4.90 mm (mean 4.70 mm); female unknown. Crown 5.40 - 6.50 times (mean 5.98) as broad as long, 0.18 - 0.22 times (mean 0.19) as long as pronotum. Pronotum 1.93 - 2.23 times (mean 2.00) as broad as long, finely and transversely furrowed. Elytra distinctly punctate; puncturing dense, yellowish or light brownish; setae short, brownish.

Male with notch of first sternal abdominal apodemes oval, compressed; lobes expanded medially, closely apposed. Second sternal abdominal apodemes lobe-shaped, moderately separated, outer margins not steep, inner margins nearly vertical, mesal margin approximately straight. Antecosta of second abdominal tergum moderately developed, mesal sinuation obsolete.

Male genitalia with 8th sternite often wider than long; apical part broadly rounded, setae dense. Side lobes of pygophore acutely rounded apically, each with 5 - 12 macrosetae; appendages moderately curved in lateral view, bifurcate with secondary (thinner) branch longer than primary one; apical part of primary branch minutely serrate; secondary branch with a small mesal spine-like process. Length of stylus 0.74 - 0.77 mm (mean 0.75 mm); dorsal and ventral margins of apophysis approximately straight to moderately expanded; apical tooth on ventral margin of apophysis very small; apical hook moderately developed,stout, sharp, normally to acutely angled. Length of penis 0.55 - 0.61 mm (mean 0.58 mm); stem relatively stout, moderately curved dorsad, tubercles on lateral surfaces obsolete, anterior lamellae coarsely serrate; socle in lateral aspect 0.65 - 0.82 times (mean 0.72 mm) as long as stem; angle between socle and base of stem on posterior margin less than 180°. Base of connective in dorsal view broad; shaft often as long as base, dorsal keel in lateral view approximately as high as base. Genital plates turned slightly laterad at mid-length, with some long setae along outer margin.

Distribution : Guinean.

Ecology : Moist Forest at low and medium altitudes.

Material studied : Holotype male - Angola : Salazar, I.I.A.A., 9 - 15. II. 1972, at light, Southern African Expedition, B.M. 1972 - I. Paratypes - 14 males(*), same data as holotype; 1 male, 3 mls, S.W. Salazar, 15. III. 1972, other data as holotype. Holotype and paratypes in coll. B.M. (N.H.).

Remarks : The species is slightly variable especially in the shape of the appendages of the pygophore and connective.

Distinguished from liberiensis Lv. & Quart. by the much longer secondary branch of the pygophore appendages, the sharp apical hook of the stylus, and by the coarsely serrate lamellae of penis.

Eleven females, plus one specimen without abdomen, same data as holotype, and one female, 3 mls. S.W. of Salazar, 15. III. 1972, all females with the hind margin of the 7th abdominal sternite more or less slightly sinuate and with an obsolete medial lobe, possibly belong to this species. In coll. B.M. (N.H.).

(*) Only 9 males were measured.

Fig. 9A - B. (s.str.) dalatandoensis n. sp.
(a-c, f, k, m, o, q-s, u, holotype; d-e, i, l, n, p, paratype, 3 mls S.W. Salazar; g-h, j, t, v, three different paratypes, Salazar)

a, male pygophore, left lateral view

b, d, right appendage of pygophore, ventral view

c, left appendage of pygophore, ventral view

e, apex of right appendage of pygophore, dorsal view

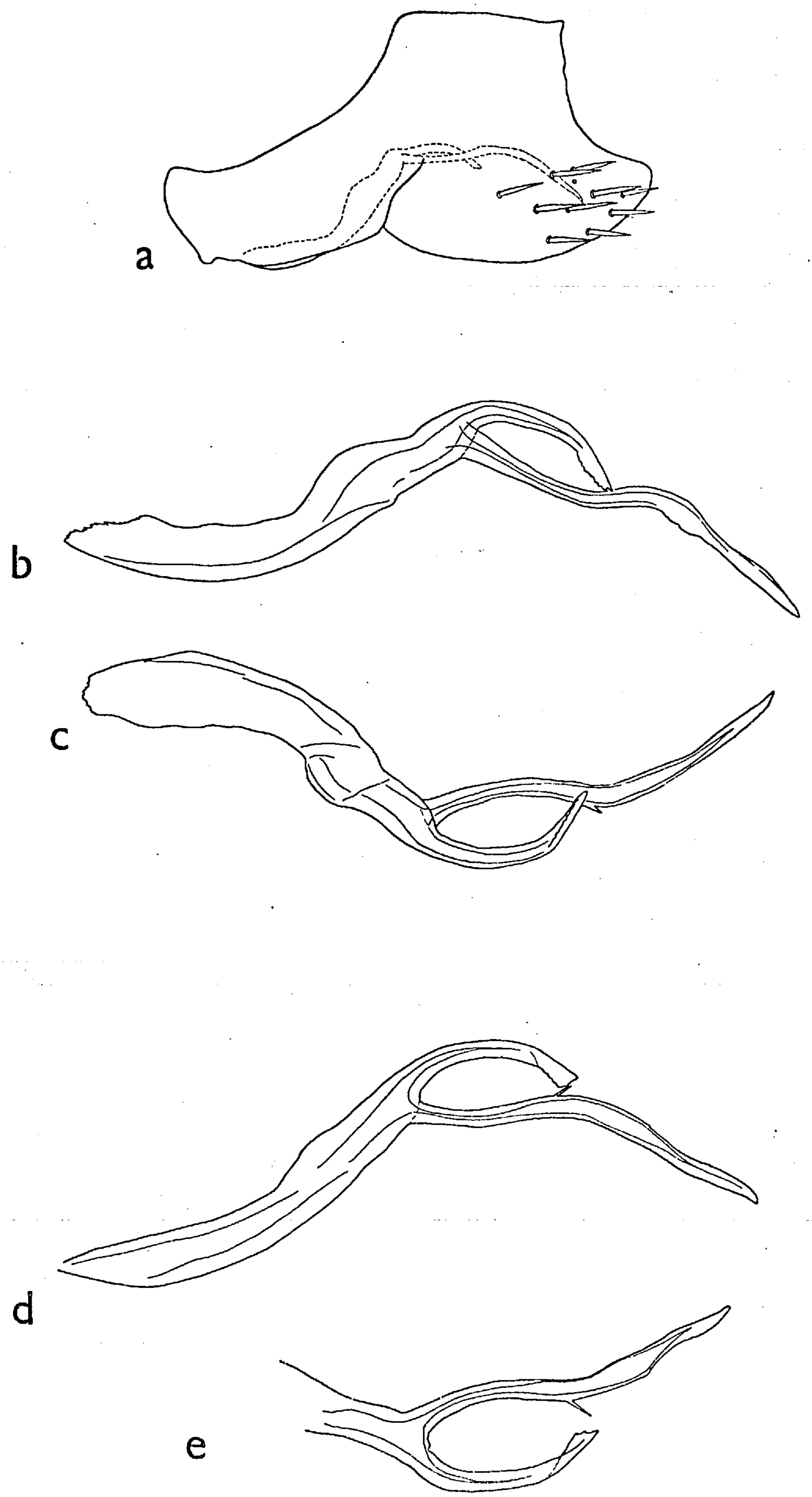

a
b
c
d
e

Fig. 9B - *B*. (s.str.) *dalatandoensis* n. sp.

f-h, connective, dorsal view

i-j, connective, left lateral view

k-l, penis, left lateral view

m, left stylus, left lateral view

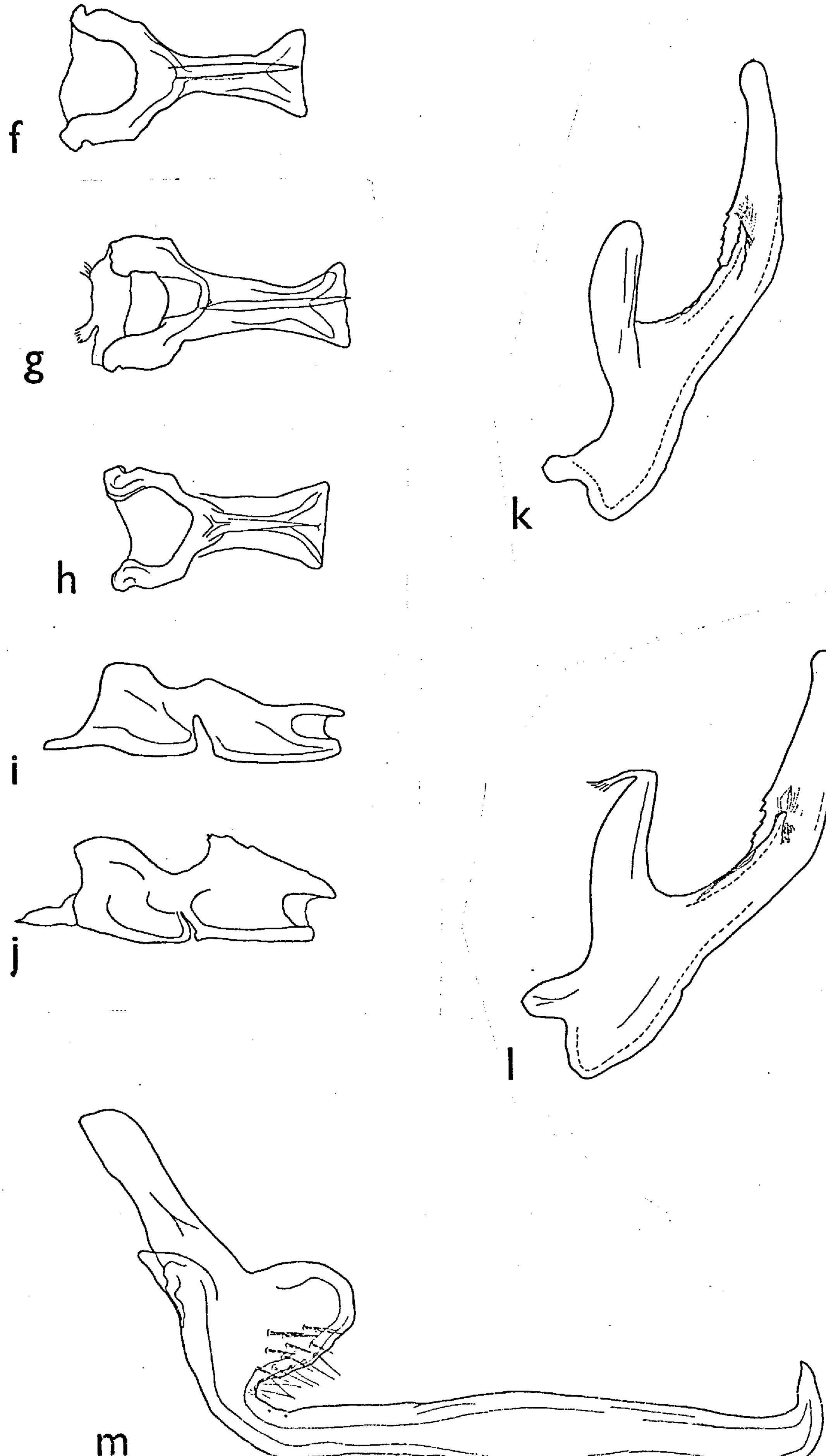

f
g
h
i
j
k
l
m

Fig. 9C - *B.* (s.str.) *dalatandoensis* n. sp.

n, left stylus, left lateral view

o-p, 8th sternite, ventral view

q, left genital plate, dorsal view

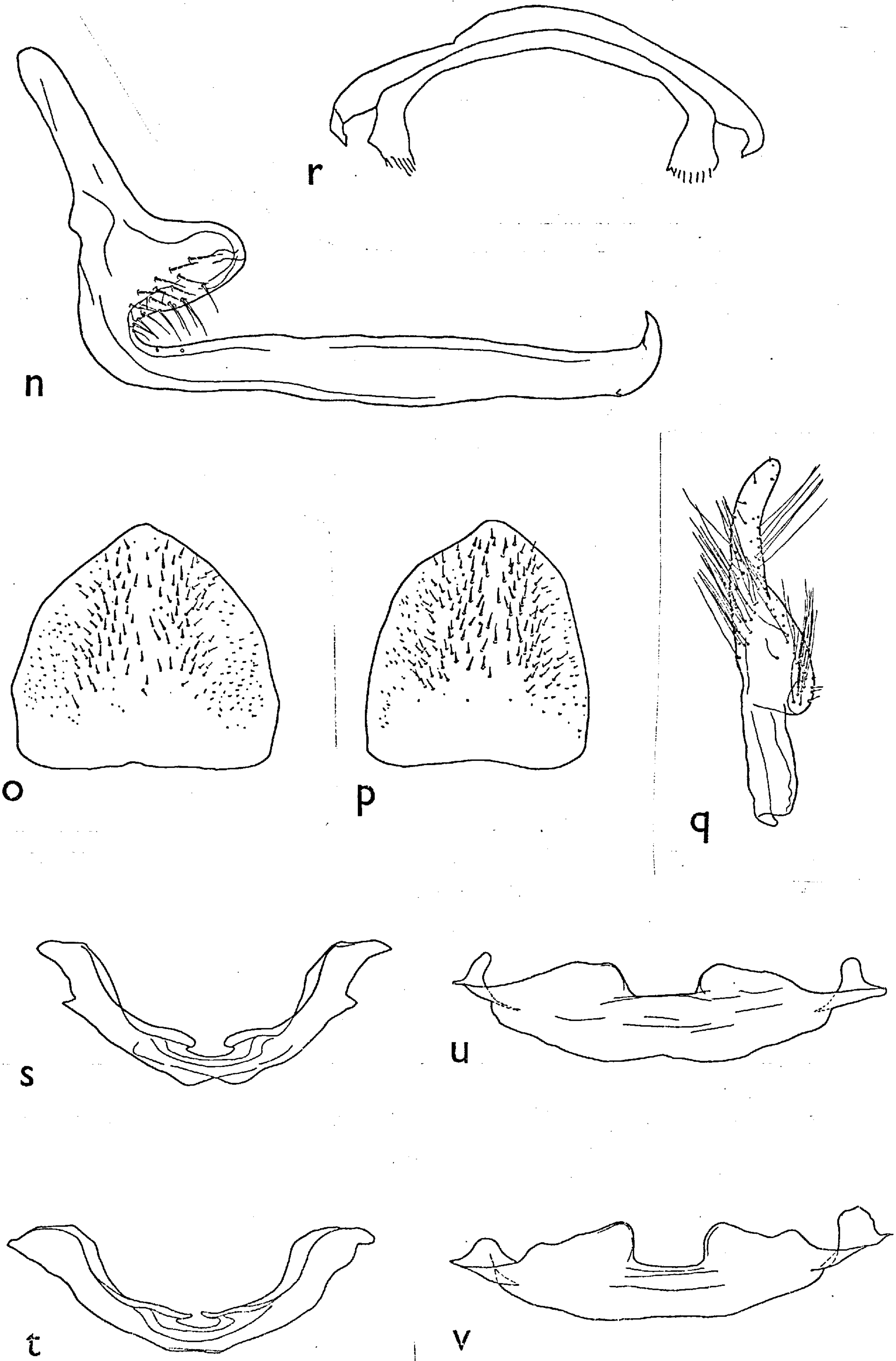
r, antecosta of second abdominal tergum, posterior view

s-t, first sternal abdominal apodemes, posterior view

u-v, second sternal abdominal apodemes, postero-dorsal view

Scale as in Figs. 1A and 1B.

9C



B. (s.str.) danae Lv. & Quart.

(Figs. 10A : a-i; 10B : j-m)

Batracomorphus (s.str.) danae Linnavuori & Quartau, 1975 : 46.

Shiny. Yellowish or whitish yellow. Eyes reddish brown. Pronotum yellowish, lateral margins and humeral angles dark brown. Scutellum golden brown, lateral margins narrowly dark brown. Elytra yellowish to golden brown; appendix infumated, with a basal dark spot; first apical cell and tips of second and third apical cells tinged with brownish; veins of elytra concolorous, commissural margin of clavus with a subapical triangular brown spot. Legs yellowish, tibiae slightly tinged with reddish.

Medium-sized, robust. Length of male, 4.50 - 5.03 mm; female, 4.77 - 5.25 mm. Crown 5.9 - 7.1 times as broad as long, 0.15 - 0.20 times as long as pronotum. Pronotum 1.87 - 2.00 times as broad as long, coarsely and transversely furrowed. Elytra rather distinctly punctate; puncturing dense, concolorous; setae short, pale or dark.

Male genitalia with 8th sternite distinctly broad; apical part broadly rounded, setae sparse. Side lobes of pygophore acute apically, each with 8-12 macrosetae; appendages rather straight, simple, subapical part expanded and serrate. Length of stylus 0.60 - 0.61 mm; dorsal margin of apophysis broadly expanded, ventral margin with a subapical arcuate sinuation; apical tooth on ventral margin of apophysis strongly developed; apical hook long, stout, with a small subapical tooth. Length of penis 0.30 - 0.42 mm; stem more or less gracile, distinctly curved dorsad, lateral surfaces with small tubercles, anterior lamellae very finely serrate; socle in lateral aspect 0.66 - 0.94 times as long as stem; angle between socle and base of stem on posterior margin about 180°. Base of connective in dorsal view broad; shaft long, dorsal keel in lateral view approximately as high as base. Genital plates rather straight, subapical part with numerous long setae along outer margin.

Female genitalia with 7th sternite as illustrated.

Distribution : Soudanian. Zambesian.

Ecology : Undergrowth in rain forest. Savanna forests. Forest savanna mosaic.

Material studied : 1 male, Tanganyika : Masoko Crater Lake, 3,200 ft., 33° 06' E, 8° 25' S, 26. VIII. 1959, Cambridge E. African Expedition, B.M. 1960 - 50. 1 female, Nigeria : Jos plateau, Bechyne, 1. I. 1956, Exped. Mus. G. Frey, Nigeria-Kamerun. In coll. B.M. (N.H.).

Remarks : The new male from Tanganyika differs slightly from the type series by the narrower apophysis of stylus, the apical tooth on ventral margin of same which is not acutely angled, and by the stem of penis which is not so strongly curved.

Distinguished from dodona Lv. by the colouration of pronotum and scutellum, the acute apical hook of stylus, and by the strong apical tooth on ventral margin of apophysis of stylus.

Fig. 10A - B. (s.str.) danae Lv. & Quart.

a, pattern of colouration of elytra

b, male pygophore, left lateral view

c, left appendage of pygophore, left lateral view

d-e, apex of left and right appendages of pygophore in broadest aspect

f, connective, left lateral view

g, connective, dorsal view

h, penis, postero-dorsal view

i, penis, left lateral view

10A

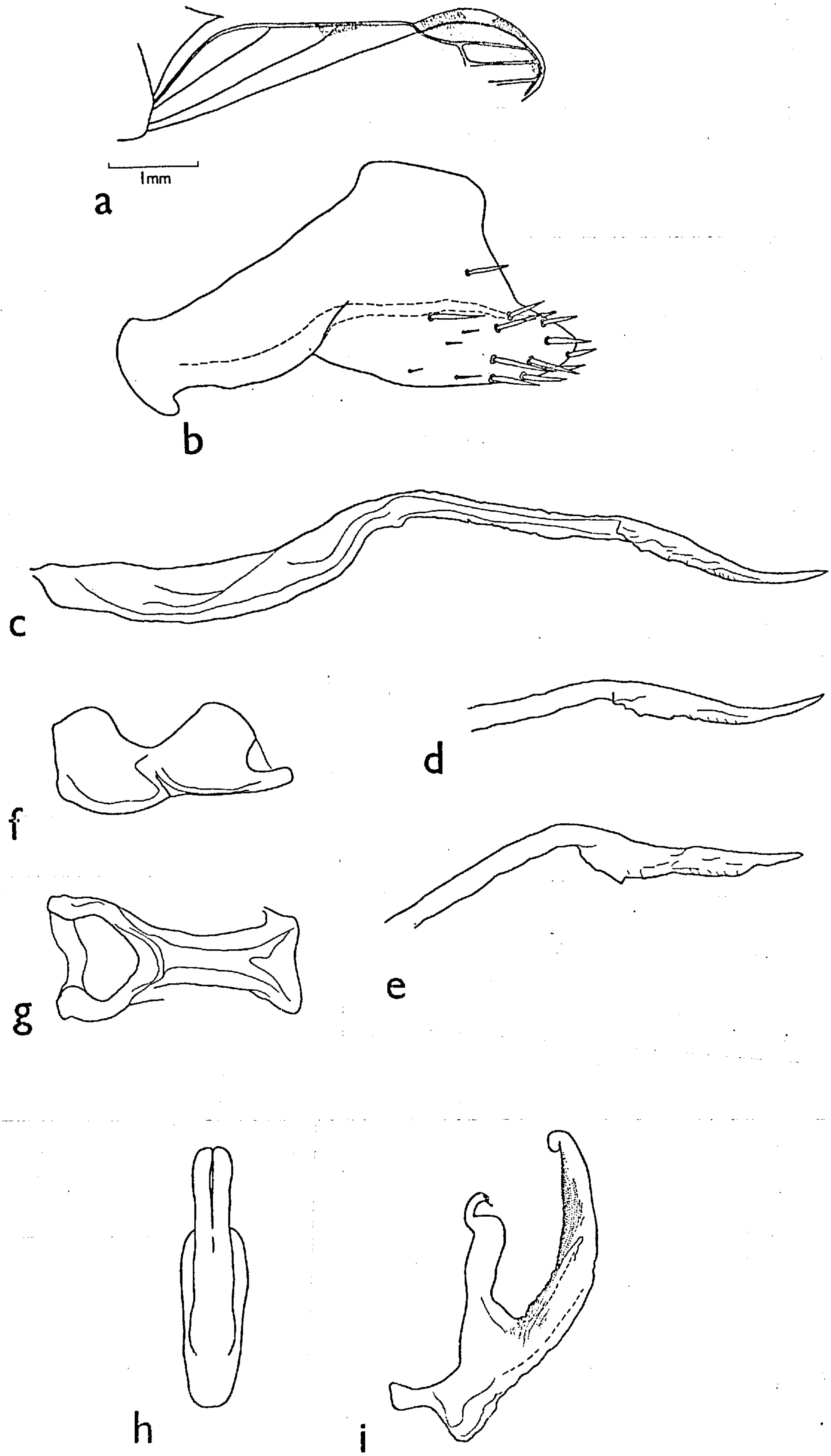


Fig. 10B - B. (s.str.) danae Lv. & Quart.

j, left stylus, left lateral view

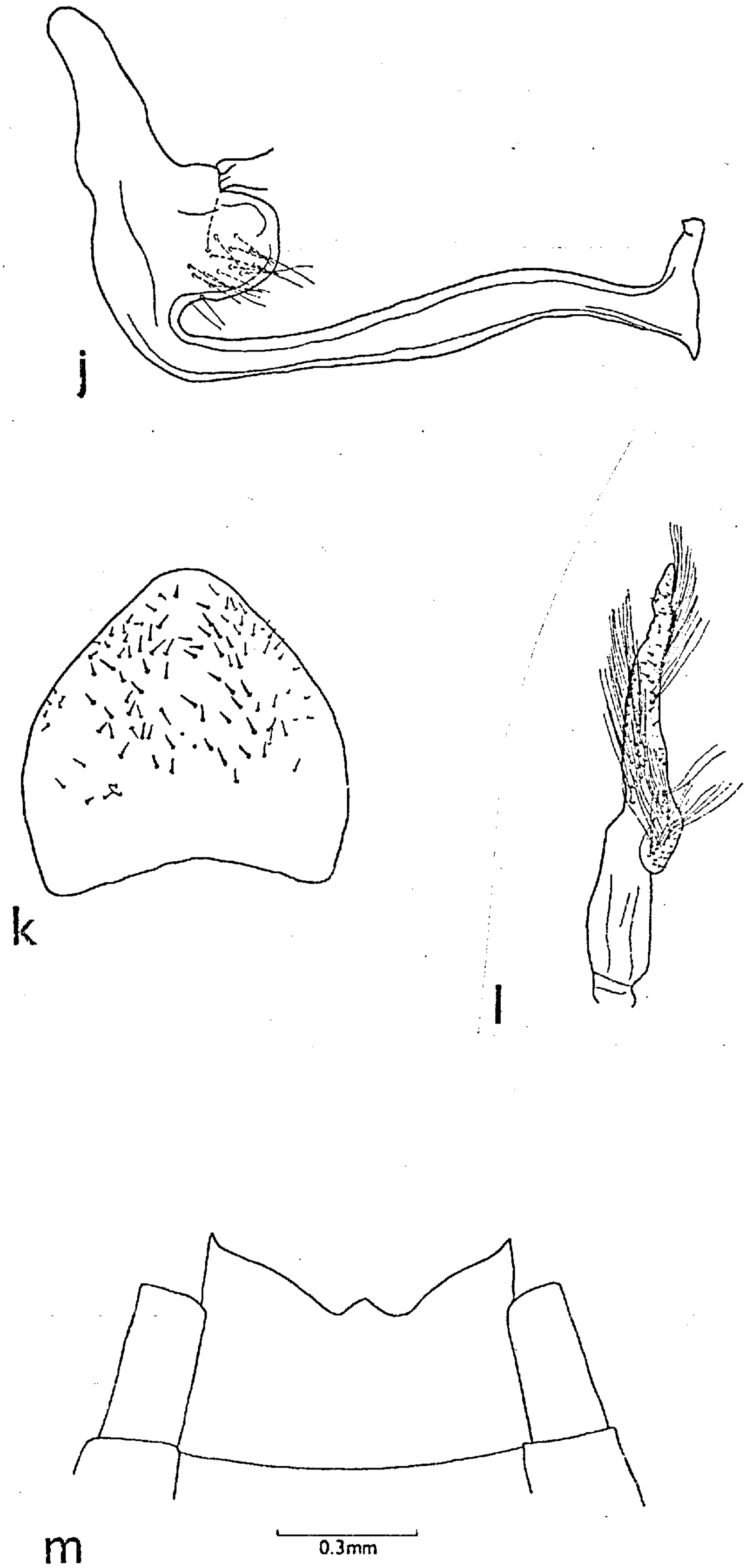
k, 8th sternite, ventral view

l, left genital plate, dorsal view

m, female 7th abdominal sternite, ventral view

Scale as in Figs. 1A and 1B or, otherwise, as indicated.

10B



B. (s.str.) dirkoides Lv. & Quart.

(Figs. 11A : a-f; 11B : g-k)

Batracomorphus (s.str.) dirkoides Linnavuori & Quartau, 1975 : 120 - 121.

Fairly shiny. Yellowish. Eyes reddish brown. Pronotum yellow to yellowish golden, a slight tinge of green near humeral angles. Scutellum yellowish golden, immaculate. Elytra yellowish; base of appendix infumated; first apical cell very light infumated; veins of elytra concolorous, some parts tinged with greenish; apex of commissural margin of clavus greenish. Legs yellowish, tarsi tinged with green.

Medium-sized, relatively elongate. Length of male, 4.21 - 4.83 mm; female unknown. Crown 5.4 - 8.4 times as broad as long, 0.19 - 0.21 times as long as pronotum. Pronotum 1.91 - 2.00 times as broad as long, finely and transversely furrowed. Elytra more or less obsoletely punctate; puncturing dense, yellowish; setae short, brownish.

Male with notch of first sternal abdominal apodemes rectangular; lobes not expanded medially, widely separated from each other. Second sternal abdominal apodemes lobe-shaped, relatively short, moderately separated, outer margins not steep, inner margins approximately vertical, mesal margin slightly curved. Antecosta of second abdominal tergum strongly developed, mesal sinuation obsolete.

Male genitalia with 8th sternite wider than long; apical part broadly rounded, setae relatively sparse. Side lobes of pygophore rounded apically, each with 9 - 12 macrosetae; appendages moderately curved in lateral view, simple, apical part serrate and more or less truncately expanded. Length of stylus 0.70 - 0.71 mm (mean 0.71 mm); dorsal and ventral margins of apophysis nearly straight to moderately curvate; apical tooth on ventral margin of apophysis very small to obsolete; apical hook long, more or less stout, slightly acutely angled. Length of penis 0.48 - 0.54 mm; stem relatively stout, moderately curved dorsad, apex slightly recurved anteriorly, lateral surfaces with small tubercles; socle in lateral aspect 0.85 - 1.06 times as long as stem; angle between socle and base of stem on posterior margin about 180°. Base of connective in dorsal view broad; shaft approximately as long as base, dorsal keel in lateral view distinctly higher than base. Genital plates turned slightly laterad at mid-length, subapical part with numerous long setae along outer margin.

Distribution : Guinean. Zambesian.

Ecology : Moist Forest at low and medium altitudes. Gallery forest.

Material studied : 1 male, Angola : Salazar, I.I.A.A., 9 - 15. III. 1972, at light, Southern African Expedition, B.M. 1972 - I; 1 male, Duque de Bragança Falls, 11 - 12. III. 1972, other data as before. In coll. B.M. (N.H.).

Remarks : Easily distinguished from dirke Lv. & Quart. by the much shorter and thicker apical hook of stylus. Distinguished from chlorophanoides Lv. & Quart. by the apically expanded pygophore appendages.

Fig. 11A - B. (s.str.) dirkoides Lv. & Quart.

(a-k, Salazar)

a, male pygophore, left lateral view

b, left appendage of pygophore, left lateral view

c, connective, left lateral view

d, connective, dorsal view

e, penis, left lateral view

f, left stylus, left lateral view

11A

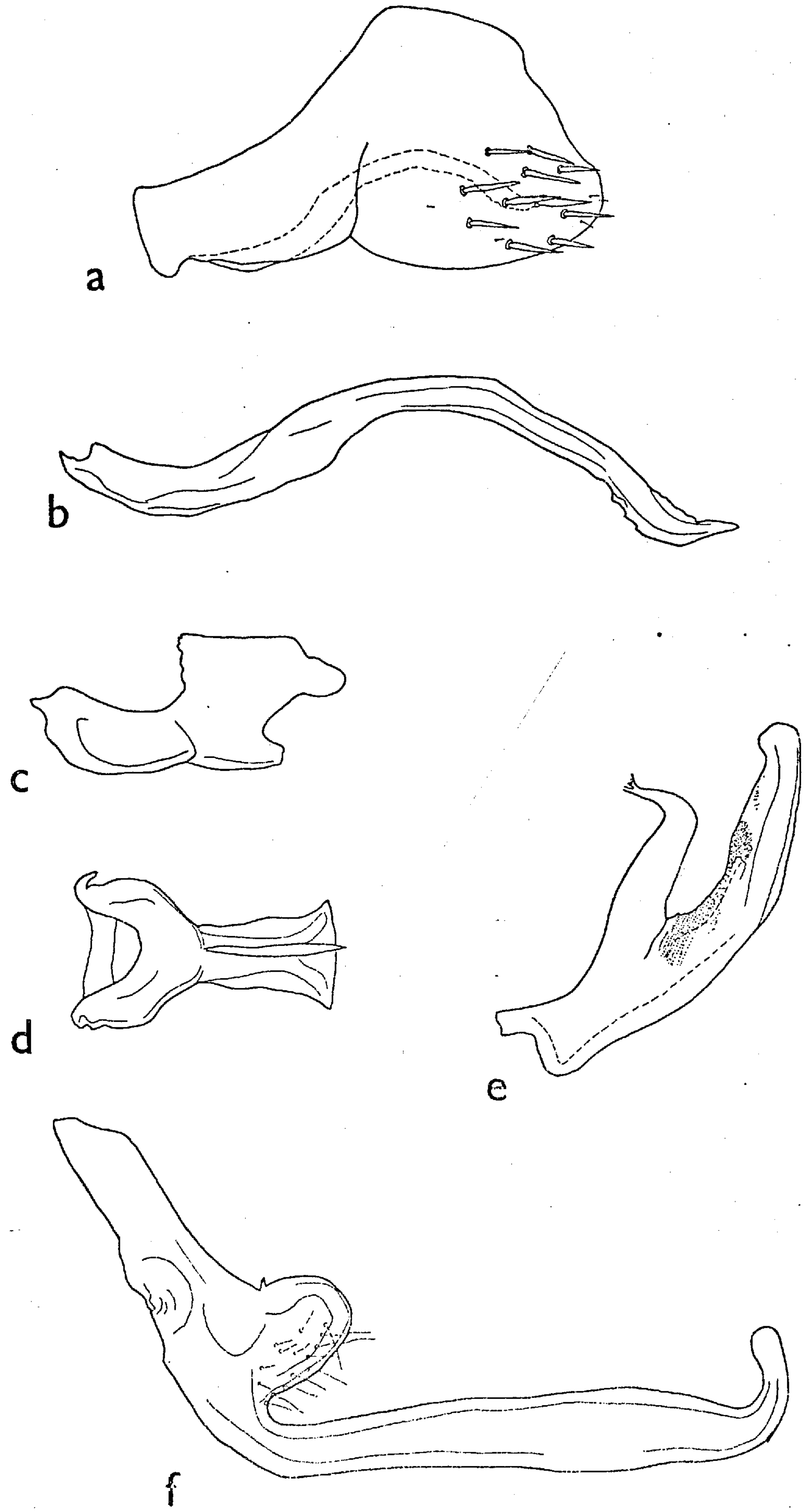


Fig. 11B - B. (s.str.) dirkoides Lv. & Quart.

g, 8th sternite, ventral view

h, left genital plate, dorsal view

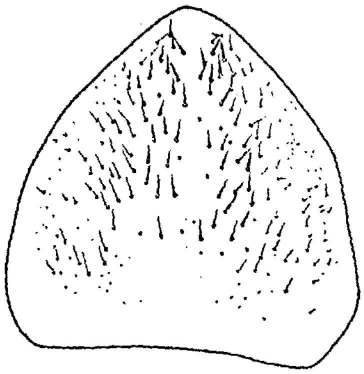
i, antecosta of second abdominal tergum, posterior view

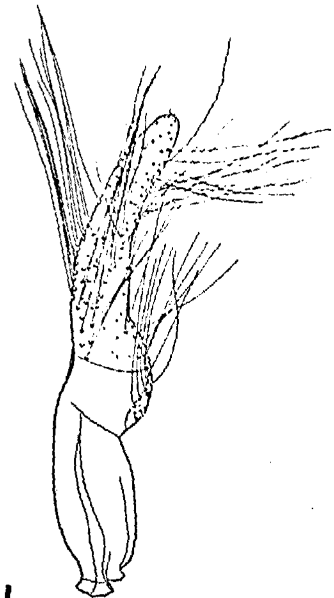
j, first sternal abdominal apodemes, posterior view

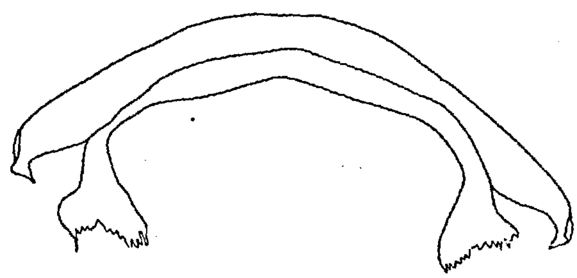
k, second sternal abdominal apodemes, postero-dorsal view

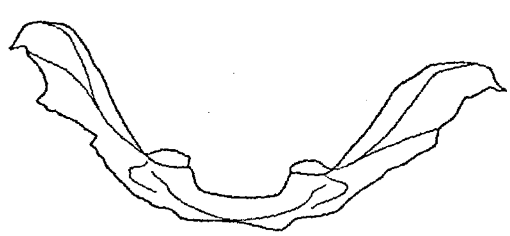
Scale as in Figs. 1A and 1B.

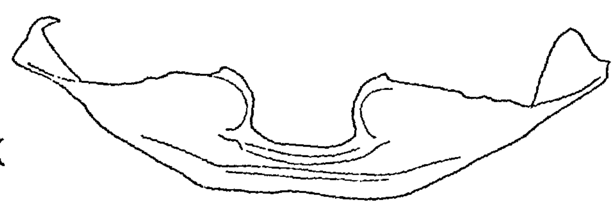
11B


g


h


i


j


k

B. (s.str.) distinctissimus n. sp.

(Figs. 12A : a-f; 12B : g-k)

Shiny. Brownish. Crown dark coffee-brown, with two black roundish spots. Upper part of face, frontoclypeus, anteclypeus, lora and genae dark brown. Eyes brownish grey. Pronotum brown, disk with small dark spots, anterior margin with some largish black spots, lateral margins with one largish black spot on each side between eye and humeral angle. Scuttelum brown, with two dark brown spots medially, basal angles blackish, lateral margins dark. Elytra brownish, very densely spotted with brown; appendix, first apical cell and distal part of second, third and fourth apical cells infumated; veins of elytra brownish. Legs brown, tarsi dark brown.

Medium-sized, robust. Length of male, 4.57 mm; female unknown. Crown 5.5 times as broad as long, 0.21 times as long as pronotum. Pronotum 2.03 times as broad as long, coarsely and transversely furrowed. Elytra distinctly punctate; puncturing dense, in dark spots dark, in other parts concolorous; setae longish, pale.

Male with notch of first sternal abdominal apodemes oval; lobes expanded medially, relatively separated from each other. Second sternal abdominal apodemes lobe-shaped, long, moderately separated, outer margins steep, inner margins nearly vertical, mesal margin rounded. Antecosta of second abdominal tergum strongly developed, mesal sinuation obsolete.

Male genitalia with 8th sternite broad; apical part broadly rounded, setae relatively dense. Side lobes of pygophore broadly rounded apically, each with 17 - 18 macrosetae plus several small setae; appendages more or less strongly curved, simple, ventral margin very minutely crenulate. Length of stylus 0.70 mm; dorsal and ventral margins of apophysis of stylus approximately straight; apical tooth on ventral margin absent; apical hook moderately developed, acute and normally angled.

Length of penis 0.46 mm; stem stout, distinctly curved dorsad, lateral surfaces without small tubercles, anterior lamellae minutely serrate; socle in lateral aspect 1.07 times as long as stem; angle between socle and base of stem on posterior margin greater than 180°. Base of connective in dorsal view broad; shaft distinctly longer than base, dorsal keel in lateral view lower than base. Genital plates rather straight, subapical part with several long setae along outer margin.

Distribution : Guinean.

Ecology : Moist Forest at low and medium altitudes.

Material studied : Holotype male - Angola : Salazar, I.I.A.A., 9 - 15. III. 1972, at light, Southern African Expedition, B.M. 1972 - I. In coll. B.M. (N.H.).

Remarks : A somewhat distinctive species within those with conspicuous dark markings on upper surface. On the basis of penis and stylus resembling <u>ariadne</u> Lv. & Quart., but easily distinguished from it by the external colouring as well as by the simple appendages of pygophore.

Fig. 12A - B. (s.str.) distinctissimus n. sp.

a, male pygophore, left lateral view

b, right appendage of pygophore, left lateral view

c, connective, left lateral view

d, connective, dorsal view

e, penis, left lateral view

f, left stylus, left lateral view

12A

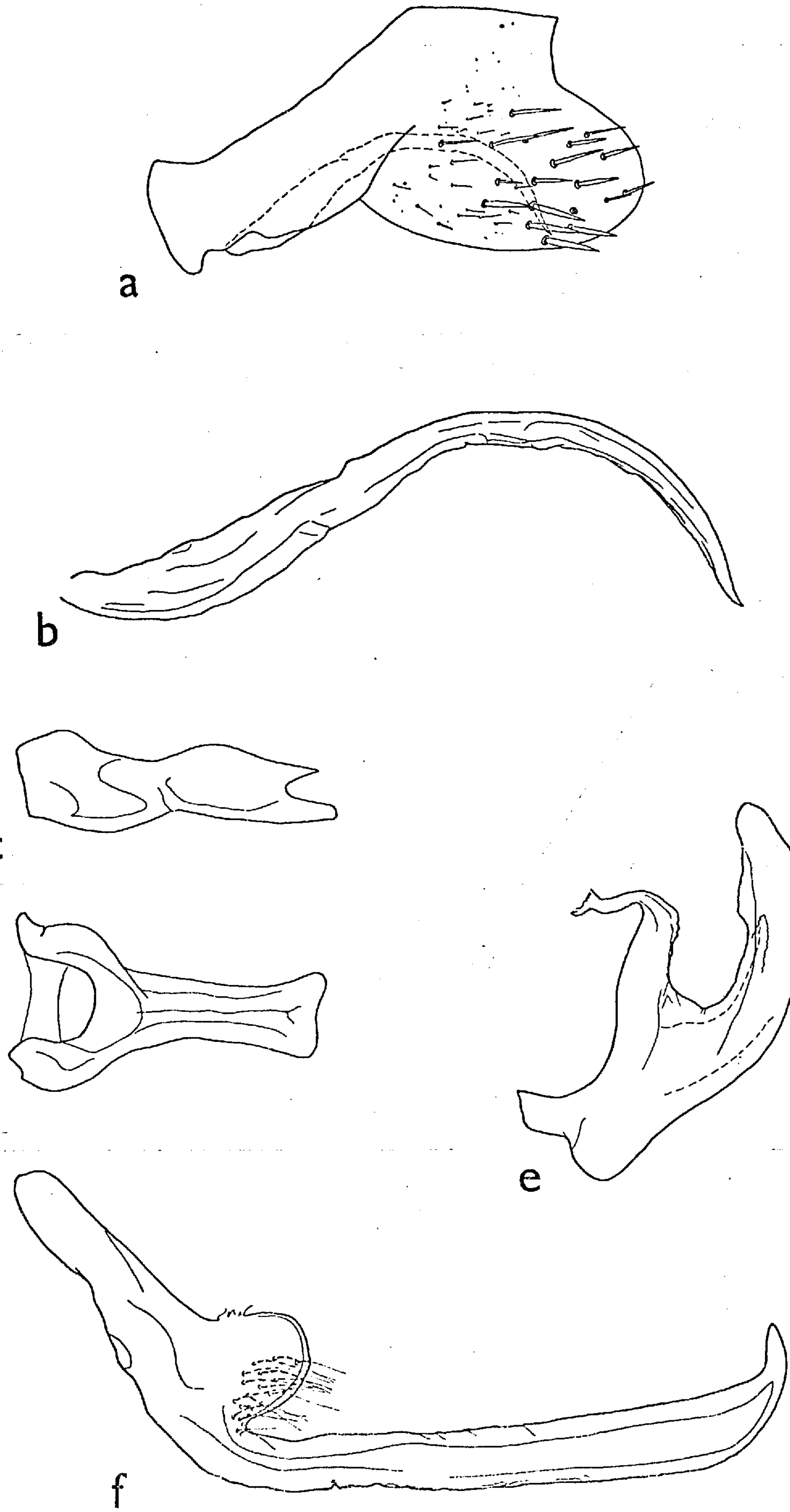


Fig. 12B - <u>B</u>. (s.str.) <u>distinctissimus</u> n. sp.

g, 8th sternite, ventral view

h, left genital plate, dorsal view

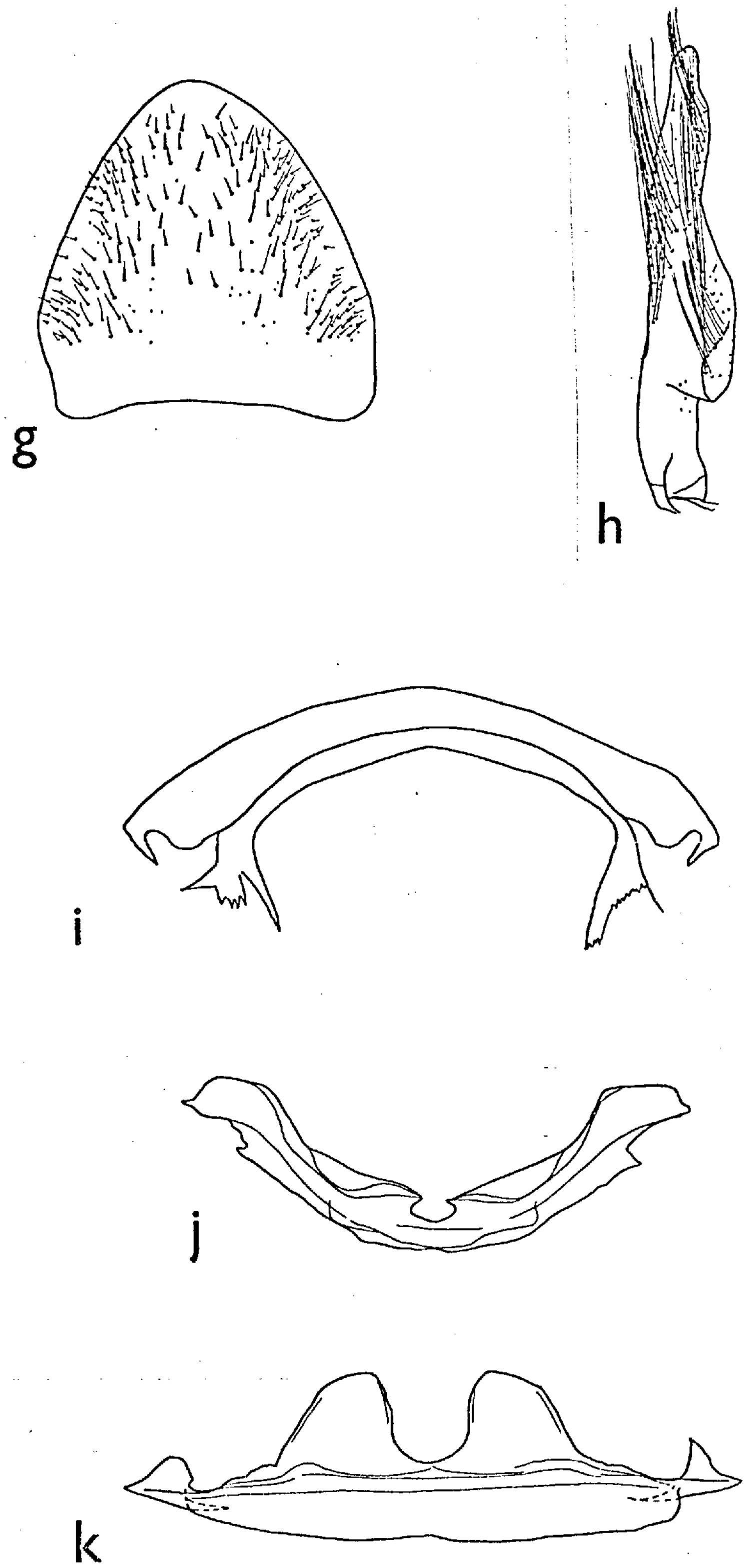
i, antecosta of second abdominal tergum, posterior view

j, first sternal abdominal apodemes, posterior view

k, second sternal abdominal apodemes, postero-dorsal view

Scale as in Figs. 1A and 1B.

12B



B. (s.str.) duquensis n. sp.

(Figs. 13A : a-f; 13B : g-m)

Fairly shiny. Brownish yellow. Crown yellowish, with two roundish dark spots. Eyes reddish brown. Pronotum yellow, base slightly tinged with light brown and with several dark brown dots; anterior part with four pairs of brown spots behind eyes. Scutellum brownish yellow, with two brownish spots; lateral margins fuscous subapically; apex yellowish. Elytra yellowish; base of appendix infumated; veins of elytra concolorous, commissural margin of clavus and veins in costal area greenish; commissural margin of clavus with a brownish spot at mid-length. Legs yellow, tarsi tinged with greenish.

Medium-sized, relatively elongate. Length of male, 4.90 mm; female unknown. Crown 5.5 times as broad as long, 0.20 times as long as pronotum. Pronotum 1.96 times as broad as long, coarsely and transversely furrowed. Elytra obsoletely punctate; puncturing sparse and concolorous (dark in the claval spot); setae short, yellowish.

Male with notch of first sternal abdominal apodemes rectangular; lobes not expanded medially, widely separated from each other. Second sternal abdominal apodemes lobe-shaped, relatively short, moderately separated, outer margins not steep, inner margins nearly vertical, mesal margin rounded. Antecosta of second abdominal tergum moderately developed, mesal sinuation obsolete.

Male genitalia with 8th sternite relatively narrow; apical part acutely rounded, setae sparse. Side lobes of pygophore roundedly truncate apically, each with 18 - 19 macrosetae; appendages strongly curved, simple, subapical and apical part minutely serrate. Length of stylus 0.77 mm; apophysis gradually narrowing to apex, slightly expanded, ventral margin broadly curved; apical tooth on ventral margin extremely developed, near size of apical hook; apical hook short, stout, more or less normally angled. Length of penis 0.53 mm; a minutely dentate lobe between stem and apodeme; stem relatively thick, moderately curved dorsad, anterior margin minutely serrate, apex slightly recurved anteriorly; socle in lateral aspect 1.18 times as long as stem; angle between socle and base of stem on posterior margin near 180°. Base of connective in dorsal view broad; shaft long, dorsal keel in lateral view approximately as high as base. Genital plates turned slightly laterad at mid-length, subapical part with long setae along outer margin.

Distribution : Zambesian.

Ecology : Gallery forest.

Material studied : Holotype male - Angola; Duque de Bragança Falls, 11 - 12. III. 1972, at light, Southern African Expedition, B.M., 1972 - I. In coll. B.M. (N.H.).

Remarks : Closely related to <u>scitus</u> Lv. & Quart. but easily distinguished from it by the two round dark spots on crown, and by the extremely developed apical tooth on the ventral margin of the apophysis of stylus.

Fig. 13A - B. (s.str.) duquensis n. sp.

a, head, pronotum and scutellum, dorsal view

b, male pygophore, left lateral view

c, left appendage of pygophore, left lateral view

d, connective, left lateral view

e, connective, dorsal view

f, penis, left lateral view

13A

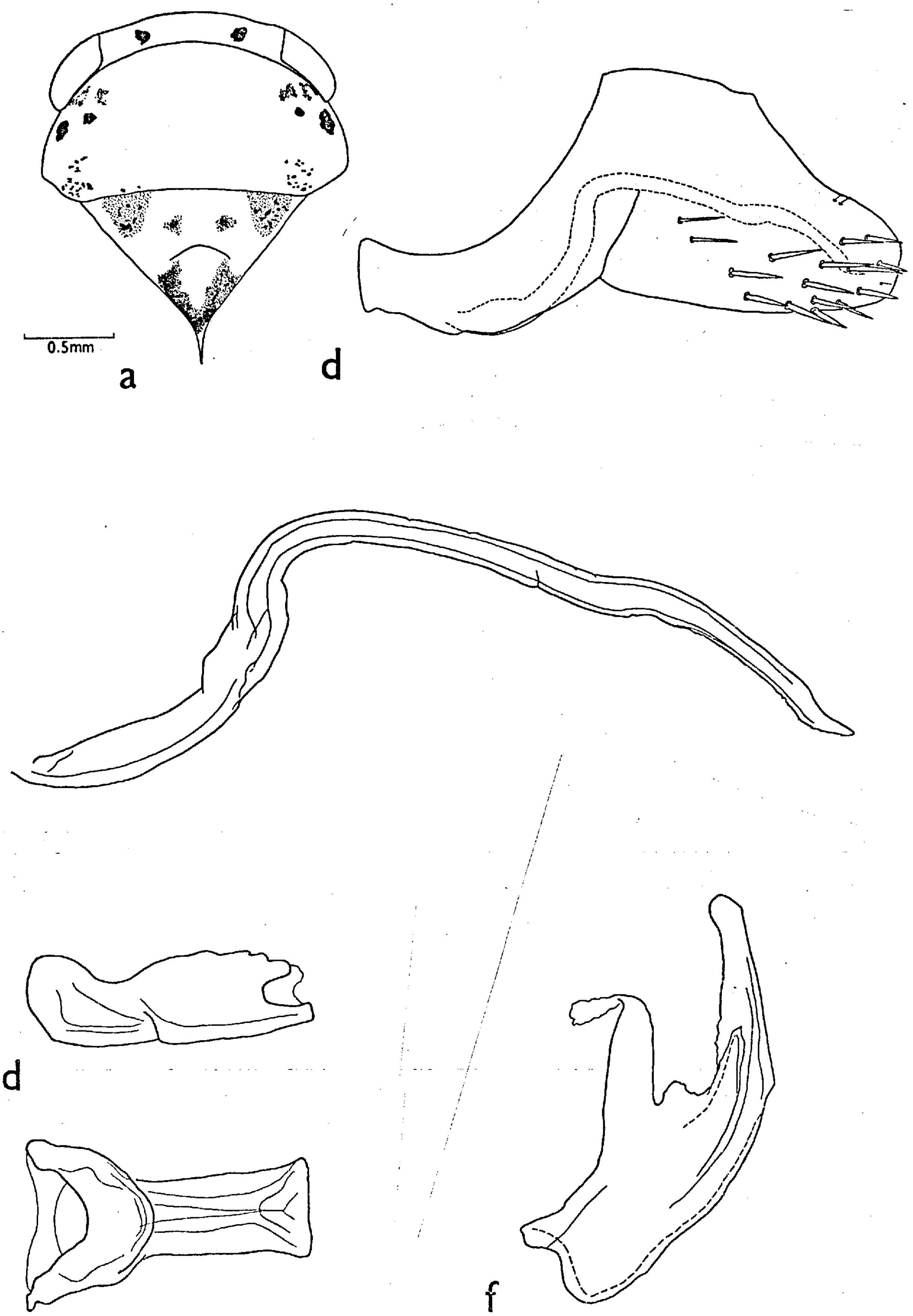


Fig. 13B - B. (s.str.) duquensis n. sp.

g, left stylus, left lateral view

h, apex of left stylus, apical tooth in broadest aspect

i, 8th sternite, ventral view

j, left genital plate, dorsal view

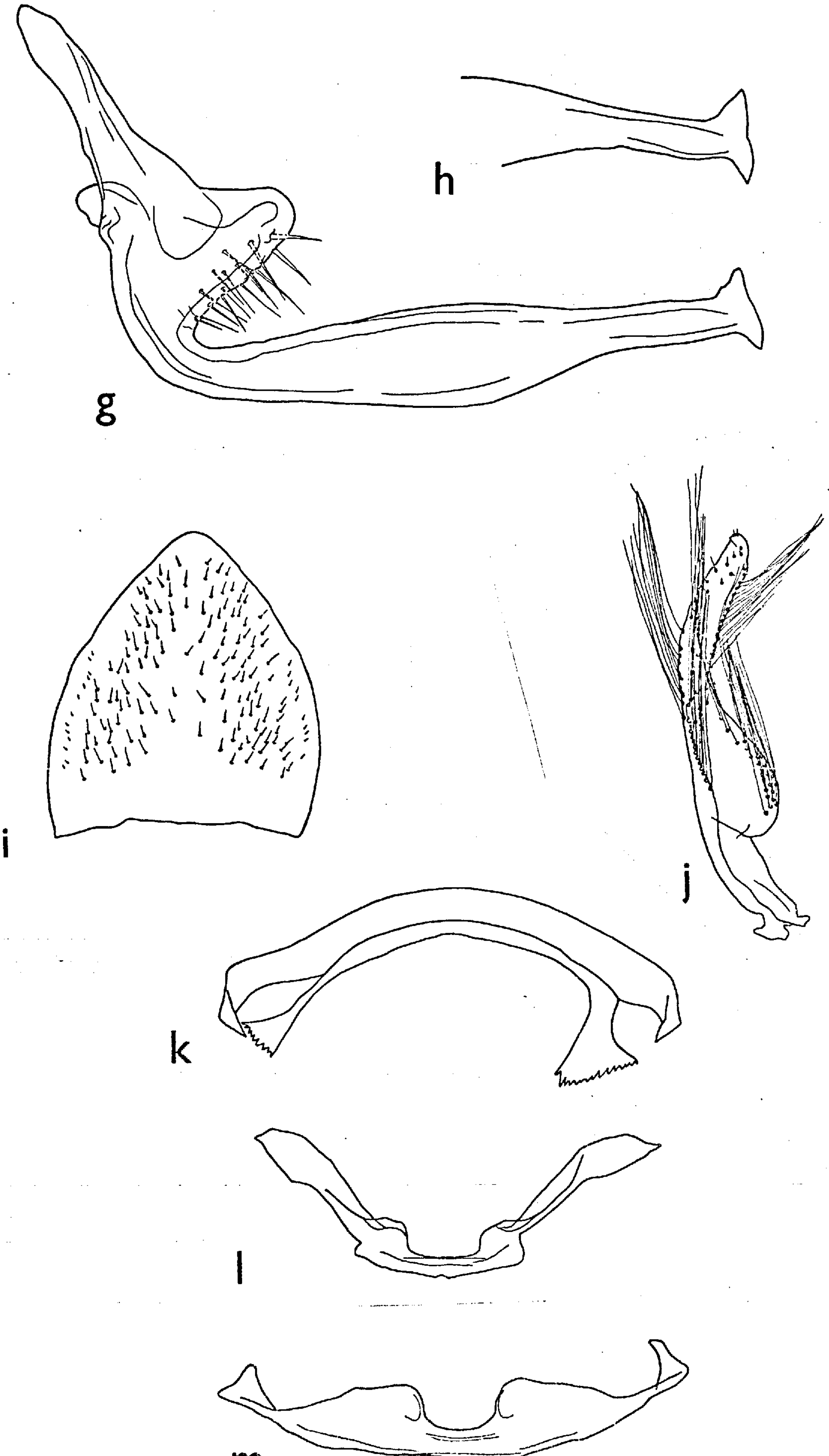
k, antecosta of second abdominal tergum, posterior view

l, first sternal abdominal apodemes, posterior view

m, second sternal abdominal apodemes, postero-dorsal view

Scale as in Figs. 1A and 1B or, otherwise, as indicated.

13B



B. (s.str.) gobiswaterensis n. sp.

(Figs. 14A : a-f; 14B : g-k)

Fairly shiny. Yellowish. Eyes reddish. Pronotum yellowish, base and disk with some light brownish spots. Scutellum yellowish, immaculate. Elytra light yellowish, more or less densely spotted with light brownish; base of appendix infumated; veins of elytra concolorous; commissural margin of clavus greenish on apical two-thirds. Legs yellowish, tarsi greenish.

Medium-sized, elongate. Length of male, 4.96 mm; female unknown. Crown 5.8 times as broad as long, 0.18 times as long as pronotum. Pronotum 1.93 times as broad as long, finely and transversely furrowed. Elytra distinctly punctate; puncturing dense, brownish in brownish spots, concolorous in other parts; setae short, light brown.

Male with notch of first sternal abdominal apodemes rectangular; lobes not expanded medially, widely separated. Second sternal abdominal apodemes lobe-shaped, small, distinctly set farther apart than their individual width at middle, outer margins steep, inner margins more or less vertical, mesal margin rather straight. Antecosta of second abdominal tergum narrow, without mesal sinuation.

Male genitalia with 8th sternite moderately broad; apical part broadly rounded, setae relatively dense. Side lobes of pygophore roundedly truncate apically, each with 8 - 10 macrosetae; appendages moderately curved, simple, ventral margin minutely crenulate. Length of stylus 0.73 mm; apophysis gracile, dorsal and ventral margins rather straight; apical tooth on ventral margin of apophysis absent; apical hook moderately developed, stout, blunt, normally angled. Length of penis 0.49 mm; stem moderately stout, slightly curved dorsad, apex recurved anteriorly, lateral surfaces with small tubercles, anterior lamellae minutely serrate; socle in lateral aspect 0.96 times as long as stem; angle between socle and base of stem on posterior margin about 180°. Base of connective in dorsal view broad; shaft long, dorsal keel in lateral view lower than base. Genital plates turned slightly laterad at mid-length, subapical part with several long setae along outer margin.

Distribution : Kalaharian.

Ecology : Wooded steppe with abundant Acacia and Commiphora.

Material studied : Holotype male - S.W. Africa : Gobiswater Fm., 12 mls. N. Grootfontein, 5. IV. 1972, at light, Southern African Expedition, B.M. 1972 - I. In coll. B.M. (N.H.).

Remarks : Closely related to chlorophanoides Lv. & Quart. but easily distinguished from it by the longer stem of penis, and by the brownish spots of pronotum and elytra. Related also to dirkoides Lv. and Quart. but easily distinguished from it by the appendages of pygophore as well as by the spots of pronotum and elytra. On external grounds near kisala Lv. & Quart. but distinguished from it by the subapically edentate apophysis of stylus, and by the blunt apical hook of same.

Fig. 14A - B. (s.str.) gobiswaterensis n. sp.

a, male pygophore, left lateral view

b, left appendage of pygophore, left lateral view

c, connective, left lateral view

d, connective, dorsal view

e, penis, left lateral view

f, left stylus, left lateral view

14A

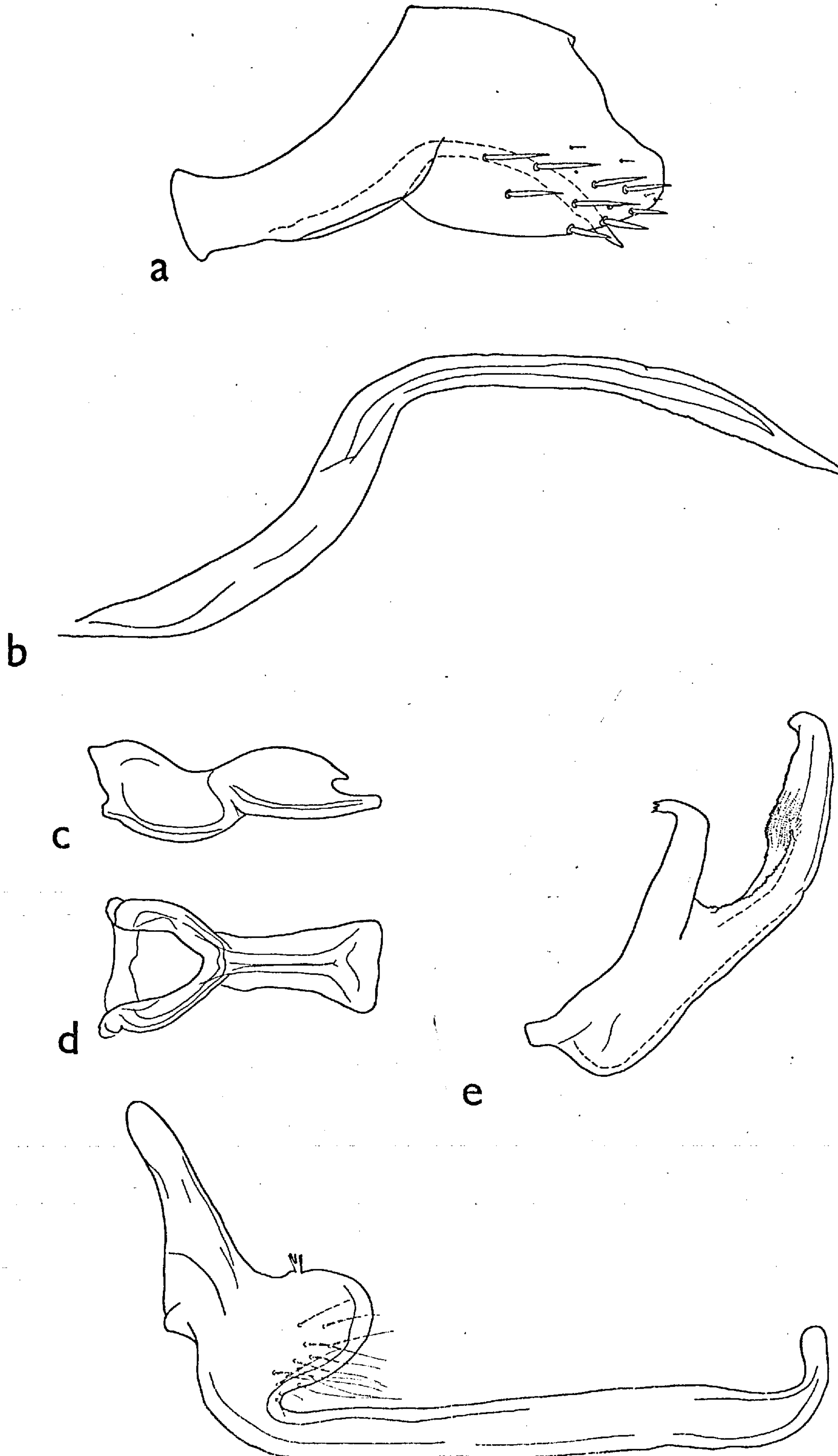


Fig. 14B - B. (s.str.) gobiswaterensis n. sp.

g, 8th sternite, ventral view

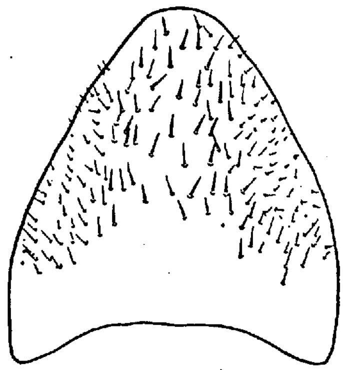
h, left genital plate, dorsal view

i, antecosta of second abdominal tergum, posterior view

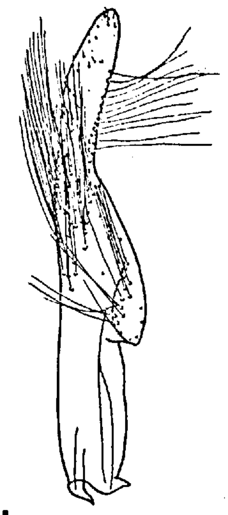
j, first sternal abdominal apodemes, posterior view

k, second sternal abdominal apodemes, postero-dorsal view

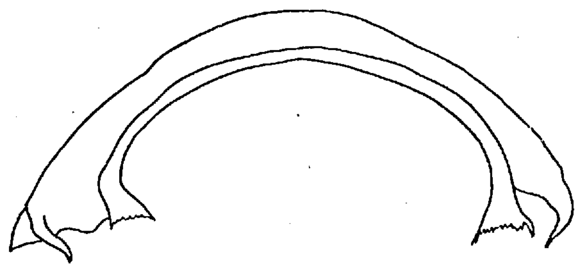
Scale as in Figs. 1A and 1B.



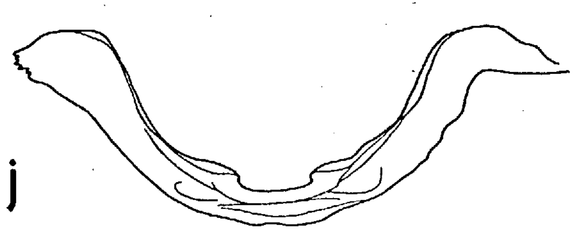
g



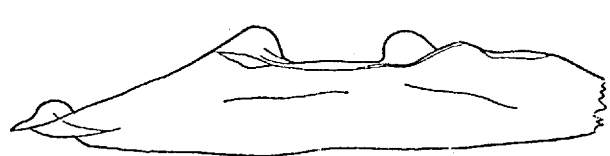
h



i



j



k

_B_. (s.str.) _hollisi_ n. sp.

(Figs. 15A : a-g; 15B : h-l)

Fairly shiny. Greenish yellow. Eyes reddish brown. Pronotum yellowish green, scutellum golden yellow, immaculate. Elytra light yellowish; base of appendix slightly infumated; veins of elytra yellowish, some parts greenish. Legs yellowish, tarsi and apical part of tibiae tinged with green.

Medium-sized, relatively elongate. Length of male, 4.90 mm; female unknown. Crown 5.9 times as broad as long, 0.18 times as long as pronotum. Pronotum 1.87 times as broad as long, finely and transversely furrowed. Elytra more or less distinctly punctate; puncturing dense, concolorous; setae longish, pale.

Male with notch of first sternal abdominal apodemes broadly triangular; lobes expanded medially, closely apposed. Second sternal abdominal apodemes lobe-shaped, relatively long, moderately separated, outer margins more or less steep, inner margins oblique, mesal margin rounded. Antecosta of second abdominal tergum strongly developed, with an obsolete mesal sinuation.

Male genitalia with 8th sternite broad; apical part more or less broadly rounded, setae relatively dense. Side lobes of pygophore truncate apically, each with 8 - 9 macrosetae; appendages more or less strongly curved, apically bifurcate. Length of stylus 0.72 mm; apophysis strongly narrowing to apex; dorsal margin moderately expanded; ventral margin with a distinct arcuate sinuation near base, strongly expanded at middle; apical tooth on ventral margin of apophysis obsolete; apical hook long, stout, blunt, more or less normally angled. Length of penis 0.49 mm; stem moderately slender, relatively curved dorsad, tubercles on lateral surfaces obsolete, anterior lamellae minutely serrate; socle of penis in lateral aspect 0.60 times as long as stem; angle between socle and base of stem on posterior margin about 180°. Base of connective in dorsal view as wide as long; shaft shorter than base, dorsal keel in lateral view approximately as high as base. Genital plates rather straight, subapical part with numerous setae along outer margin.

Distribution : Guinean.

Ecology : Moist Forest at low and medium altitudes.

Material studied : Holotype male - Angola : Salazar, I.I.A.A., 9 - 15. III. 1972, at light, Southern African Expedition, B.M. 1972 - I. In coll. B.M. (N.H.).

Named after Mr. D. Hollis, the collector of the type and the member of the Southern African Expedition (British Museum, 1972) in charge of the Hemiptera.

Remarks : Distinguished from ariaramnes Lv. & Quart. by the larger size, the truncate side lobes of pygophore, the much more expanded apophysis of stylus, and by the stouter apical hook of stylus.

Fig. 15A - B. (s.str.) hollisi n. sp.

a, male pygophore, left lateral view

b, left appendage of pygophore, left lateral view

c, apex of left appendage of pygophore, broadest aspect

d, connective, left lateral view

e, connective, dorsal view

f, penis, left lateral view

g, left stylus, left lateral view

15A

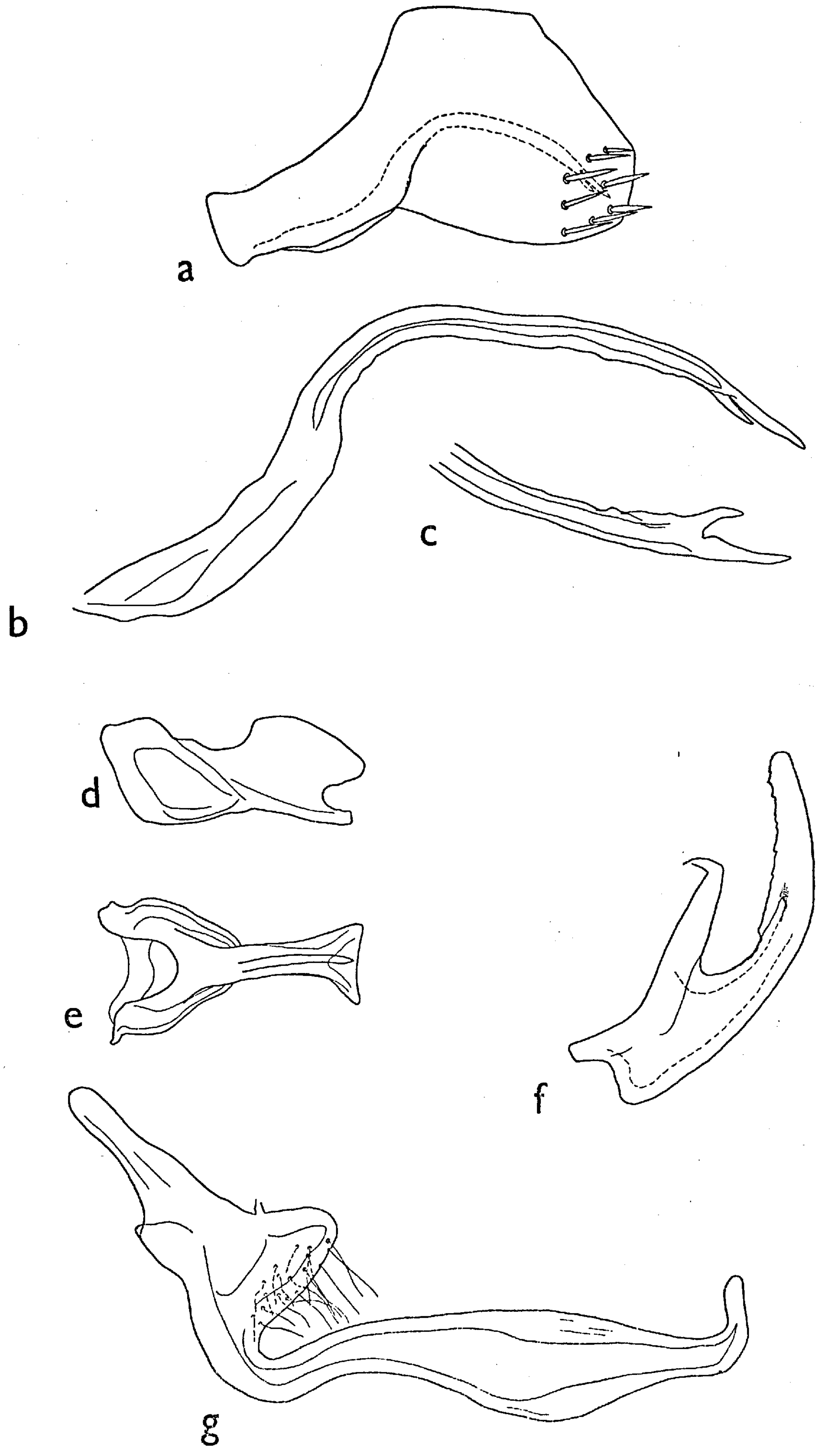


Fig. 15B - B. (s.str.) hollisi n. sp.

h, 8th sternite, ventral view

i, left genital plate, dorsal view

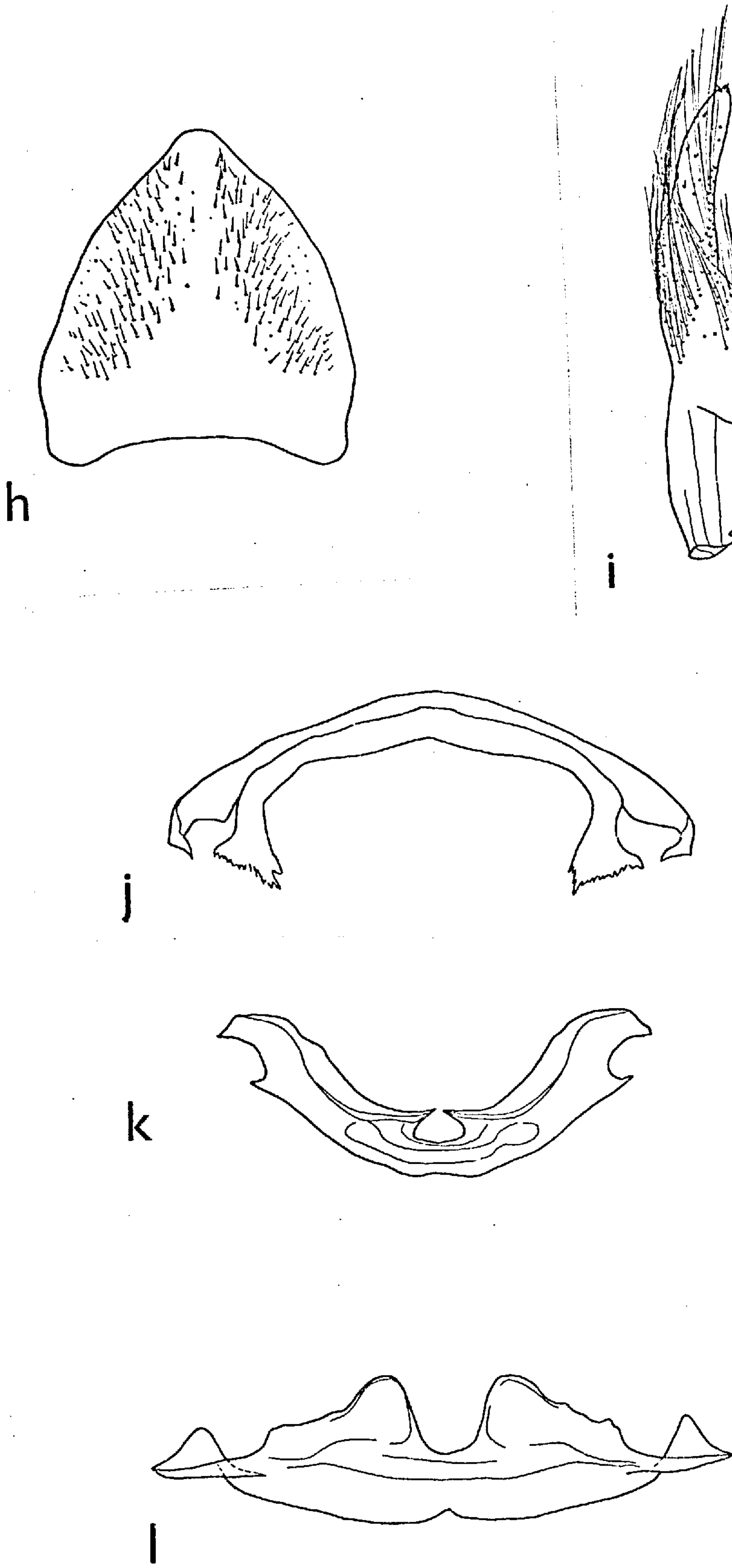
j, antecosta of second abdominal tergum, posterior view

k, first sternal abdominal apodemes, posterior view

l, second sternal abdominal apodemes, postero-dorsal view

Scale as in Figs. 1A and 1B.

15B



B. (s.str.) incognitus Lv. & Quart.

(Figs. 16A : a-f; 16B : g-k)

Batracomorphus (s.str.) incognitus Linnavuori & Quartau, 1975 : 77 - 78.

Fairly shiny. Yellowish to pale green. Eyes greyish brown or reddish brown. Pronotum and scutellum yellowish to greenish, immaculate. Elytra yellowish to greenish; appendix and first apical cell slightly tinged with brown; base of appendix with a small fuscous dot; veins of elytra concolorous.

Medium-sized, robust. Length 4.5 - 5.5 mm . Crown 6.2 - 6.7 times as broad as long, 0.16 - 0.18 times as long as pronotum. Pronotum 2.0 times as broad as long, finely and transversely furrowed. Elytra obsoletely punctate; puncturing dense, concolorous; setae short, dark, rarely pale.

Male with notch of first sternal abdominal apodemes oval, compressed; lobes expanded medially, moderately separated from each other. Second sternal abdominal apodemes lobe-shaped, longer than half their individual width at middle, moderately separated, outer margins steep, inner margins nearly vertical, mesal margin rounded. Antecosta of second abdominal tergum strongly developed, mesal sinuation obsolete.

Male genitalia with 8th sternite moderately broad; apical part more or less broadly rounded, setae dense. Side lobes of pygophore more or less broadly rounded apically, each with 11 - 16 macrosetae; appendages bifurcate with primary branch moderately curved, secondary branch thin, longer than the primary one. Length of stylus 0.65 - 0.76 mm; apophysis relatively broad, dorsal margin broadly expanded, ventral margin with an arcuate sinuation subapically; apical tooth on ventral margin of apophysis small; apical hook stout, blunt, normally angled. Length of penis 0.46 - 0.53 mm; stem relatively stout, rather straight, apex recurved anteriorly, posterior lamellae serrate, anterior surface with a pair of minutely serrate teeth, lateral surfaces with small tubercles; socle in lateral aspect 0.25 times as long as stem; angle between socle and base of stem on postero-ventral margin greater than 180°. Base of connective in dorsal view broad, short; shaft approximately as long as base, dorsal keel in lateral view higher than base. Genital plates turned moderately laterad at mid-length, subapical part with several long setae along outer margin.

Female genitalia with hind margin of 7th sternite moderately sinuate and with a small triangular medial lobe.

Distribution : Guinean.

Ecology : Moist Forest at low and medium altitudes.

Material studied : 1 male, Angola : Quirimbo, V. 1934, K. Jordan, B.M. 1934 - 435. In coll. B.M. (N.H.).

Remarks : Distinguished from humilis Lv. & Quart. by the bifurcate appendages of pygophore. Distinguished from centralensis Lv. & Quart. by the shorter stylus and penis, and by the appendages of pygophore, of which the secondary branch is distinctly longer than the primary one.

Fig. 16A - B. (s.str.) incognitus Lv. & Quart.

a, male pygophore, left lateral view

b, left appendage of pygophore, left lateral view

c, connective, left lateral view

d, connective, dorsal view

e, penis, left lateral view

f, left stylus, left lateral view

16A

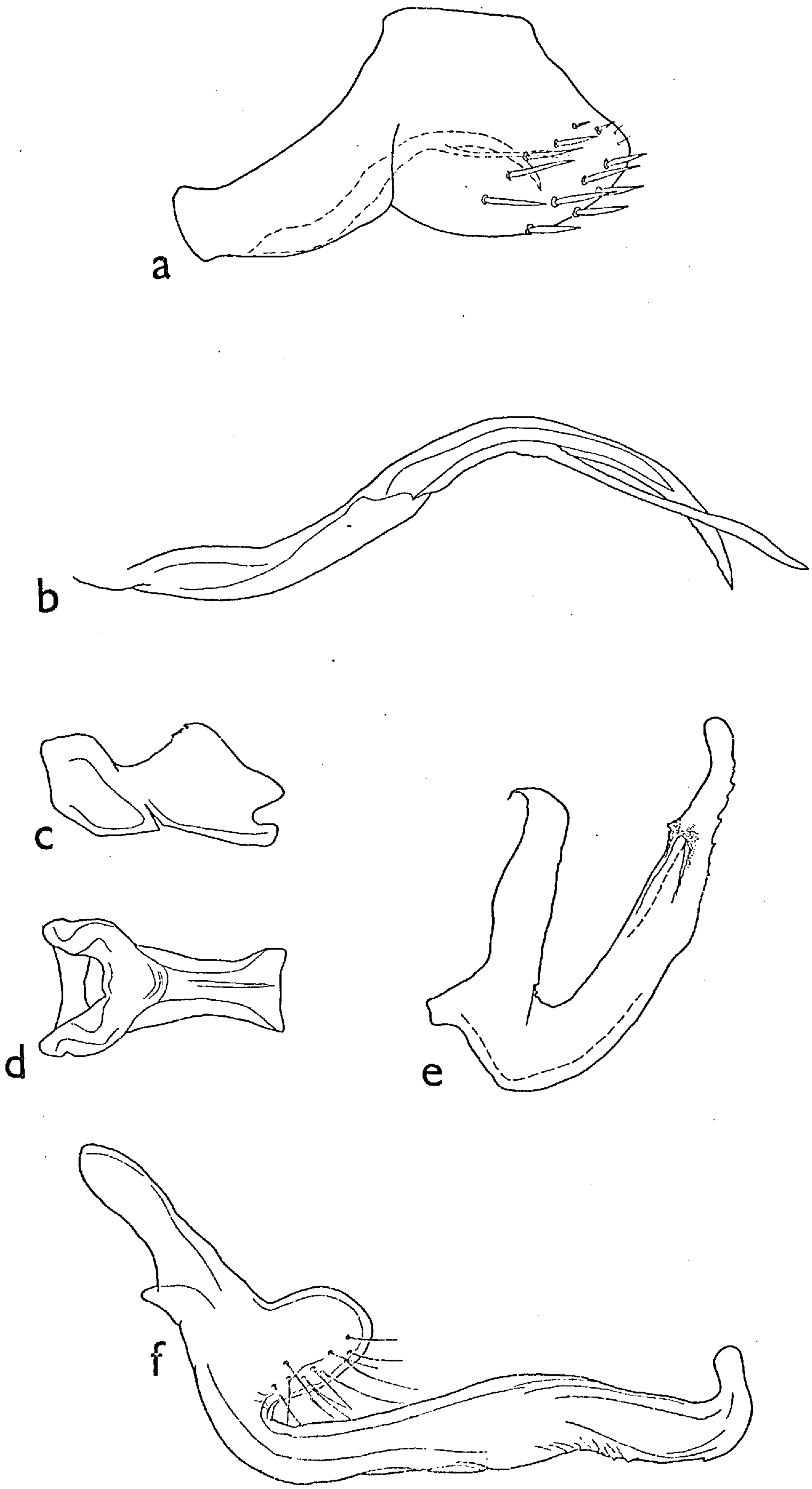


Fig. 16B - B. (s.str.) incognitus Lv. & Quart.

g, 8th sternite, ventral view

h, left genital plate, dorsal view

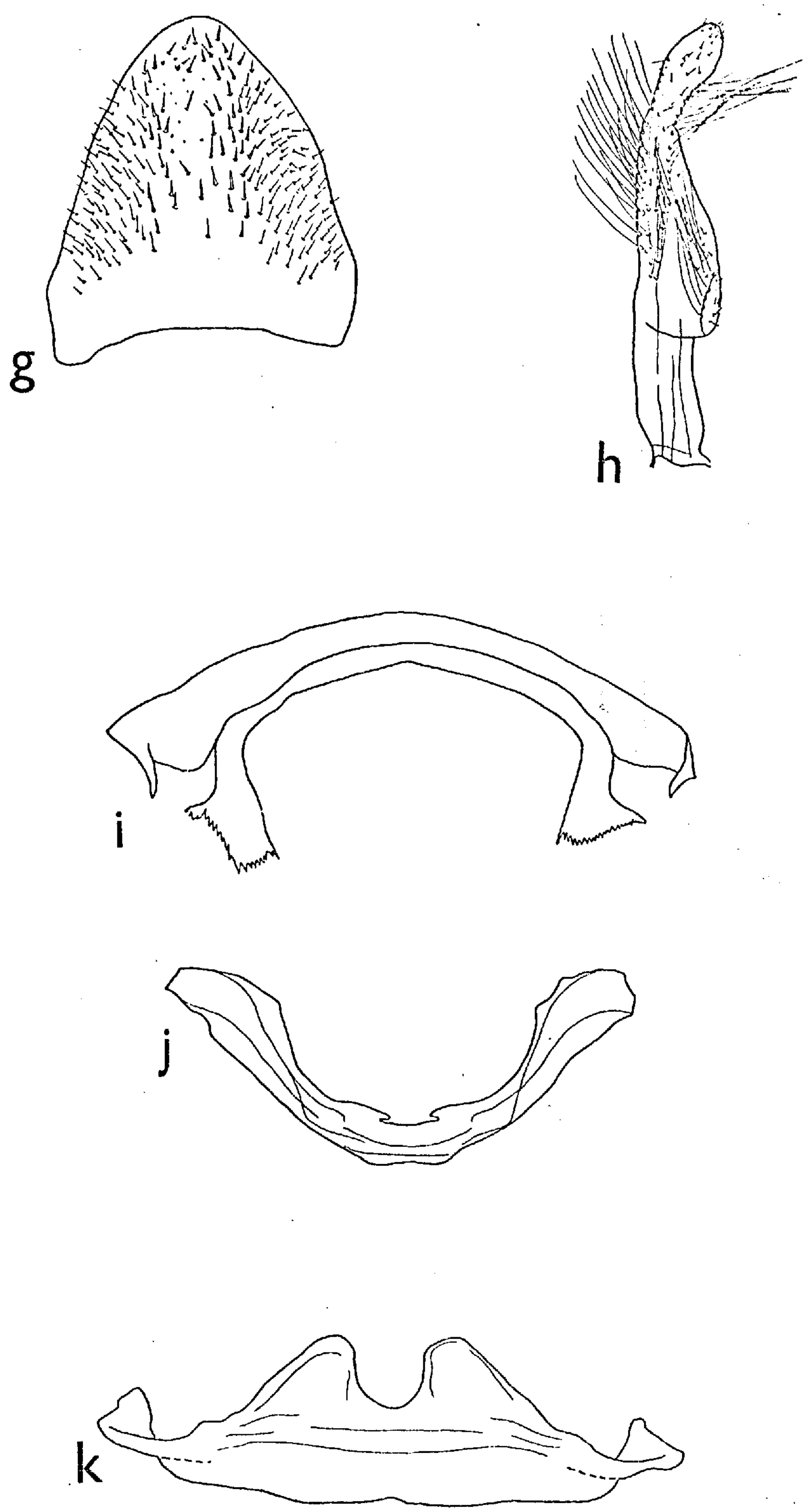
i, antecosta of second abdominal tergum, posterior view

j, first sternal abdominal apodemes, posterior view

k, second sternal abdominal apodemes, postero-dorsal view

Scale as in Figs. 1A and 1B.

16B



B. (s.str.) lewisi n. sp.

(Figs. 17A : a-g; 17B : h-l)

Shiny. Golden yellow. Eyes reddish grey. Crown with two roundish brown spots. Pronotum golden brown, lateral margins and humeral angles greenish; base and disk densely and minutely spotted with brown. Scutellum brownish yellow, with two brown spots medially and several brown dots. Elytra whitish yellow, more or less densely spotted with light brown; base of appendix tinged with brown; first apical cell and tips of all other apical cells slightly infumated; veins of elytra concolorous; commissural margin of clavus greenish in apical half. Legs pale yellow, tarsi and apical part of tibiae greenish.

Medium-sized, relatively elongate. Length of male, 4.90 mm; female unknown. Crown 5.0 times as broad as long, 0.20 times as long as pronotum. Pronotum 1.89 times as broad as long, coarsely and transversely furrowed. Elytra obsoletely punctate; puncturing more or less sparse, dark brown in brown spots, concolorous in other parts; setae short, dark.

Male with notch of first sternal abdominal apodemes oval, compressed; lobes expanded medially, relatively separated. Second sternal abdominal apodemes lobe-shaped, moderately separated, outer margins not steep, inner margins approximately vertical, mesal margin rounded. Antecosta of second abdominal tergum strongly developed, mesal sinuation absent.

Male genitalia with 8th sternite longer than wide, apical part acutely rounded, setae dense. Side lobes of pygophore truncate apically, each with 13 - 18 macrosetae; appendages moderately curved in lateral view, simple, subapical part expanded and very minutely serrate. Length of stylus 0.71 mm; apophysis broad, dorsal margin more or less straight, ventral margin broadly curved and finely dentate; apical tooth on ventral margin of apophysis small; apical hook moderately developed, stout, blunt, normally angled. Length of penis 0.47 mm; stem more or less gracile, moderately curved dorsad, apex recurved anteriorly, tubercles on lateral surfaces obsolete, anterior lamellae practically smooth; socle in lateral aspect 1.10 times as long as stem; angle between socle and base of stem on posterior margin about 180°. Base of connective in dorsal view longer than wide; shaft distinctly longer than base, dorsal keel in lateral view higher than base. Genital plates turned slightly laterad at mid-length, subapical part with numerous long setae along outer margin.

Distribution : Guinean.

Ecology : Moist Forest at low and medium altitudes.

Material studied : Holotype male - Angola : Salazar, I.I.A.A., 9 - 15. III. 1972, at light, Southern African Expedition, B.M. 1972 - I. In coll. B.M. (N.H.).

Named after the author of the genus, R.H. Lewis.

Remarks : A distinctive species because of the presence of minute teeth on the ventral margin of the apophysis of stylus. External colouration similar to abundans Lv. & Quart., yet distinguished by the denser spotting on base of pronotum and by the paler spotting of elytra.

Fig. 17A - _B_. (s.str.) _lewisi_ n. sp.

a, male pygophore, left lateral view

b, right appendage of pygophore, left lateral view

c, connective, left lateral view

d, connective, dorsal view

e, penis, left lateral view

f, apex of right stylus, left lateral view (slightly latero-dorsally)

g, left stylus, left lateral view

17A

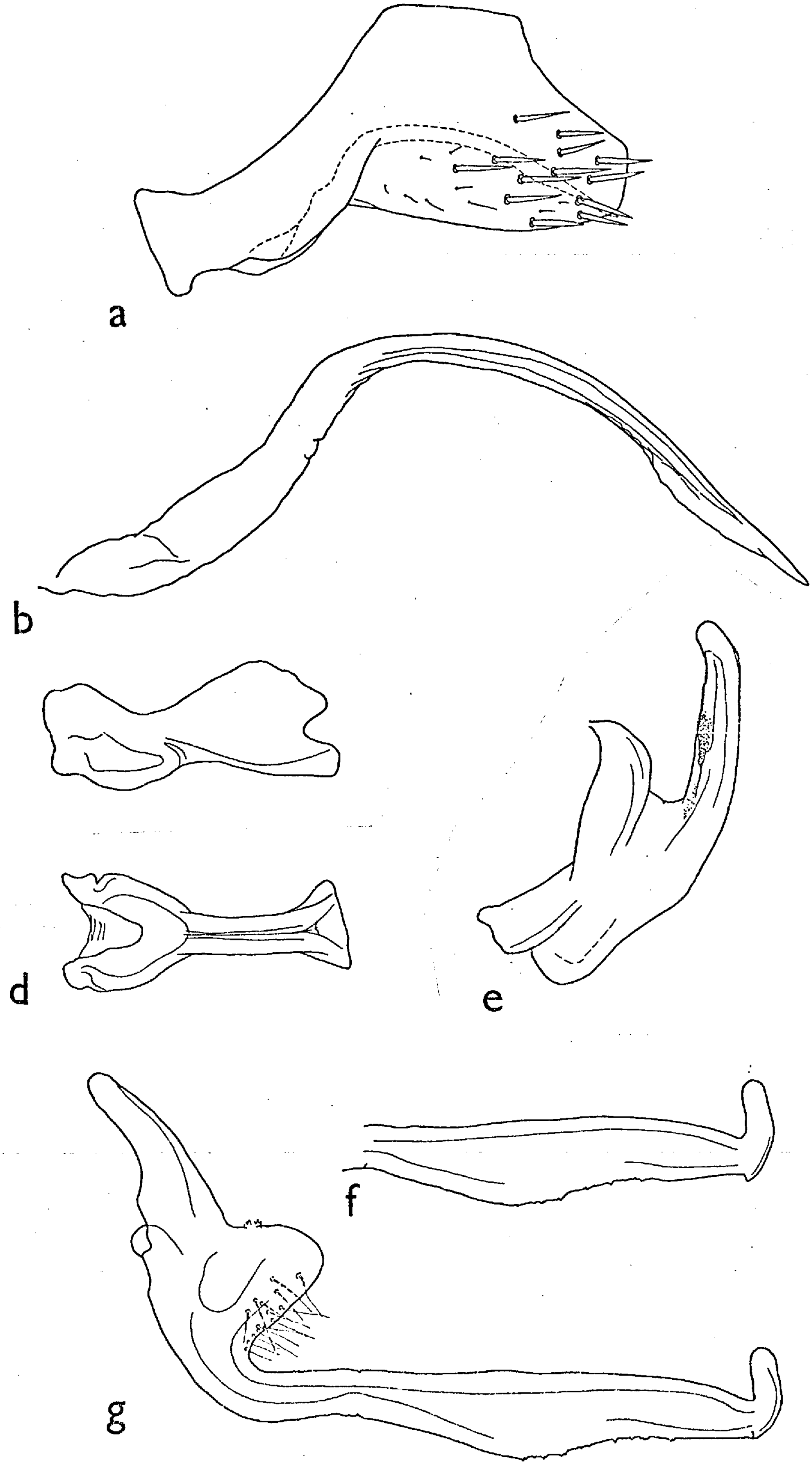


Fig. 17B - B. (s.str.) lewisi n. sp.

h, 8th sternite, ventral view

i, left genital plate, dorsal view

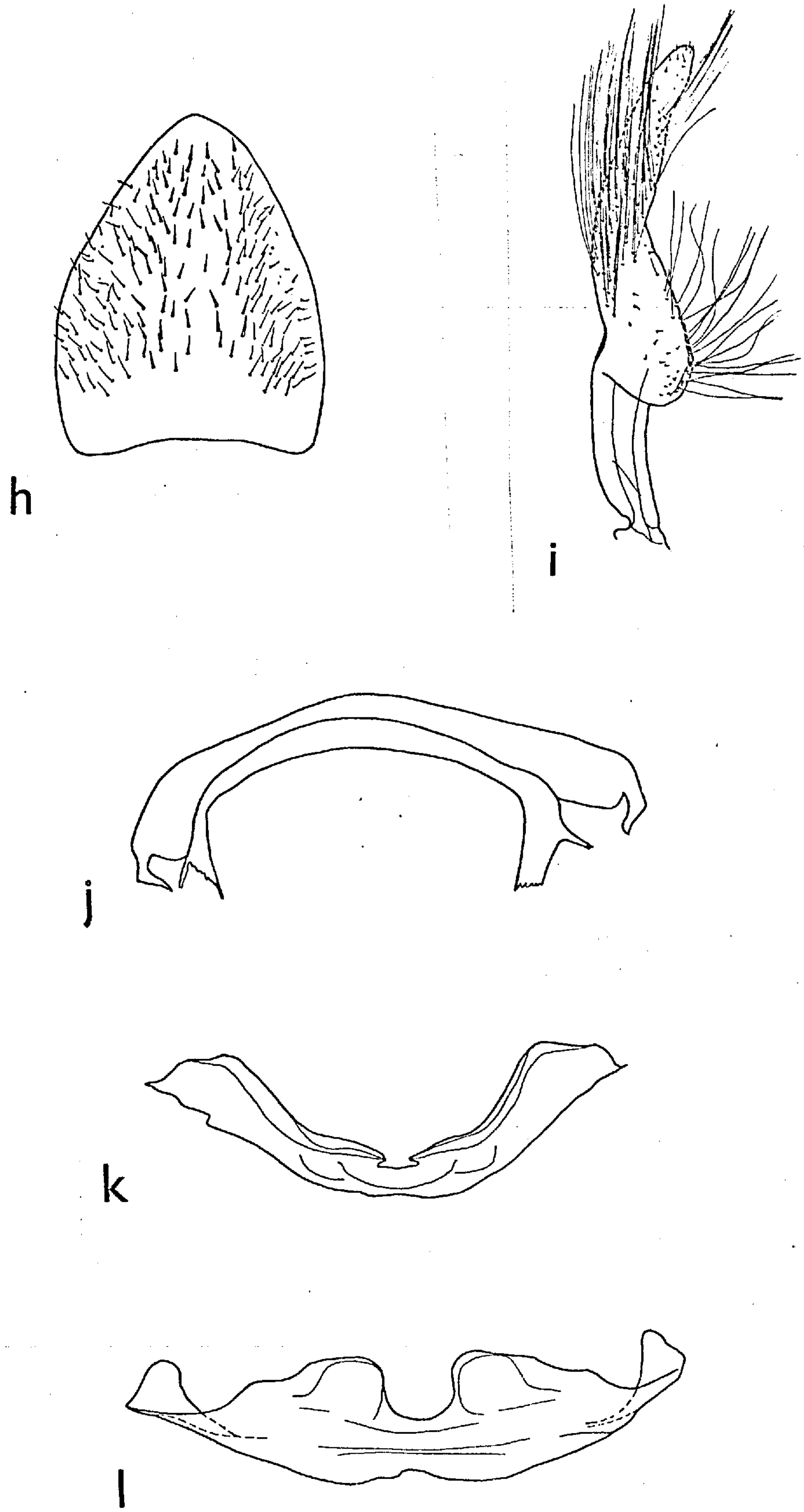
j, antecosta of second abdominal tergum, posterior view

k, first sternal abdominal apodemes, posterior view

l, second sternal abdominal apodemes, postero-dorsal view

Scale as in Figs. 1A and 1B.

17B



B. (s.str.) *liberiensis* Lv. & Quart.

Batracomorphus (s.str.) *liberiensis* Linnavuori & Quartau, 1975 : 89.

B. (s.str.) *liberiensis carvalhoi* n. ssp.

(Figs. 18A : a-h; 18B : i-m)

Fairly shiny. Yellowish. Anteclypeus, lora and lower part of genae tinged with green. Eyes dark brown. Pronotum and scutellum yellowish, immaculate. Elytra whitish yellow; base of appendix slightly tinged with brown; first apical cell and tips of second and third apical cells slightly infumated; veins of elytra yellowish, some parts greenish; commissural margin of clavus greenish in apical part. Legs yellowish, tarsi and parts of tibiae tinged with green.

Small, robust. Length of male, 4.11 mm; female unknown. Crown 4.7 times as broad as long, 0.24 times as long as pronotum. Pronotum 1.94 times as broad as long, finely and transversely furrowed. Elytra obsoletely punctate; puncturing very sparse, concolorous; setae short, pale.

Male with notch of first sternal abdominal apodemes oval, compressed; lobes expanded medially, closely apposed. Second sternal abdominal apodemes lobe-shaped, relatively long, moderately separated, outer margins oblique, inner margins vertical, mesal margin rounded. Antecosta of second abdominal tergum strongly developed, with a small mesal sinuation.

Male genitalia with 8th sternite broad (convex in the preparation); apical part more or less broadly rounded, setae sparse. Side lobes of pygophore broadly rounded apically, each with 7 - 9 macrosetae; appendages moderately curved, bifurcate with secondary branch thin, longer than primary one, apical part of primary branch minutely serrate. Length of stylus 0.61 mm; dorsal and ventral margins of apophysis slightly expanded;

apical tooth on ventral margin of apophysis small; apical hook moderately developed, blunt, normally angled. Length of penis 0.46 mm; stem slender, slightly curved dorsad, tubercles on lateral surfaces obsolete, anterior lamellae minutely serrate; socle in lateral aspect 0.51 times as long as stem; angle between socle and base of stem on posterior margin about 180^{o}. Base of connective in dorsal view as wide as long; shaft short, dorsal keel developed, distinctly higher than base in lateral view. Genital plates turned slightly laterad at mid-length, subapical part with some long setae along outer margin.

Distribution : Guinean.

Ecology : Moist Forest at low and medium altitudes.

Material studied : Holotype male - Angola : Salazar, I.I.A.A., 9 - 15. III. 1972, at light, Southern African Expedition, B.M. 1972 - I. In coll. B.M. (N.H.).

Named after Eng. P. de Carvalho, who added considerably to our knowledge of the Angolan entomofauna.

Remarks : Very near the nominate form but slightly larger, stem of penis longer, and branches of pygophore appendages shorter and closer to each other. Distinguished from dalatandoensis n. sp. by the much shorter secondary branch of the pygophore appendages, the more or less blunt apical hook of the stylus, and by the minutely serrate anterior lamellae of the stem of the penis.

Two females, same data as holotype, with hind margin of 7th abdominal sternite shallowly sinuate and with a small medial lobe, possibly belong to this subspecies.

Fig. 18A - _B_. (s.str.) _liberiensis_ _carvalhoi_ n. ssp.

a, male pygophore, left lateral view

b, apex of left appendage of pygophore, ventral view

c, left appendage of pygophore, left lateral view

d, right appendage of pygophore, left lateral view

e, penis, left lateral view

f, connective, left lateral view

g, connective, dorsal view

h, left stylus, left lateral view

18A

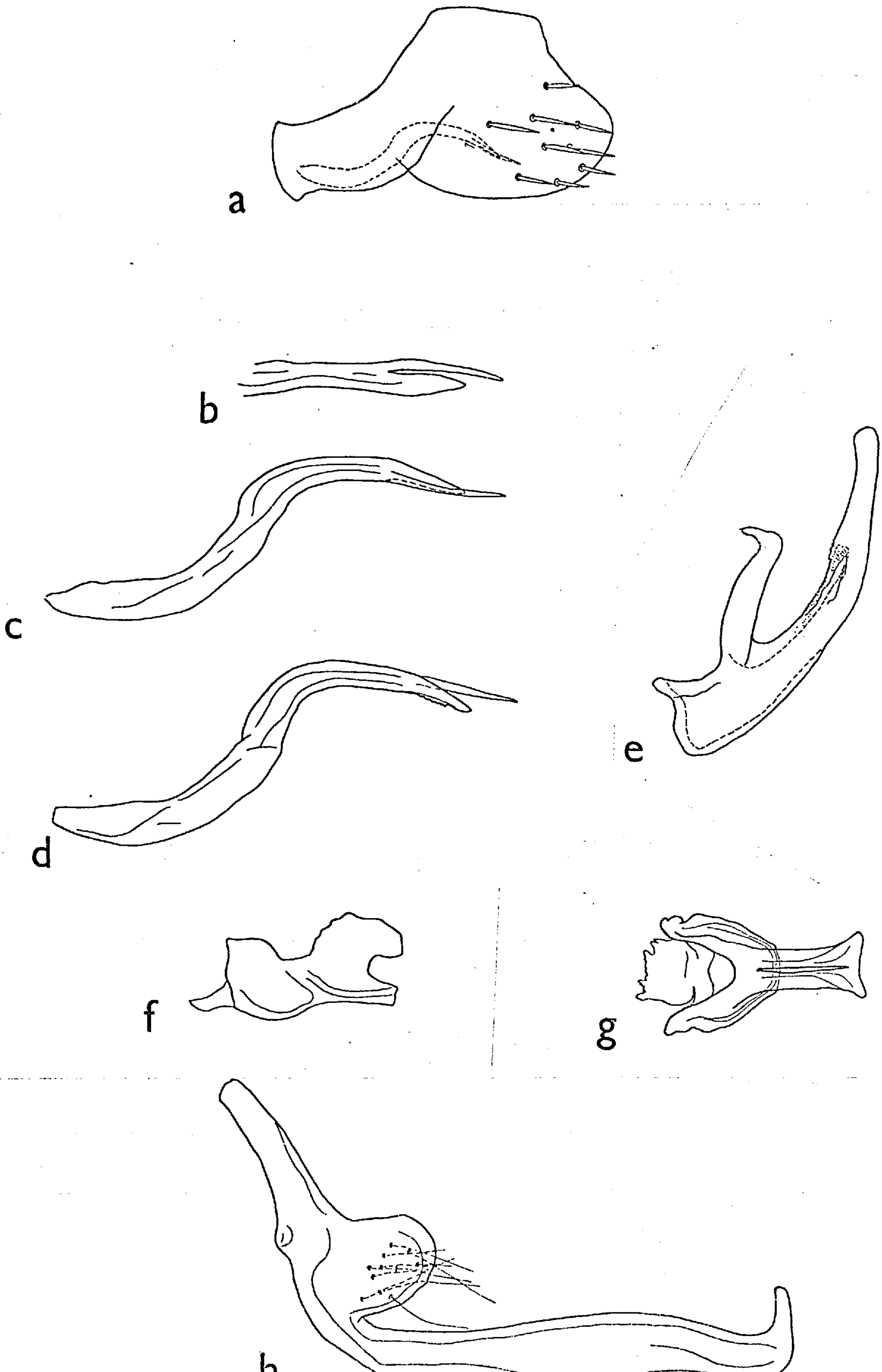


Fig. 18B - _B_. (s.str.) _liberiensis_ _carvalhoi_ n. ssp.

i, 8th sternite, ventral view

j, right genital plate, dorsal view

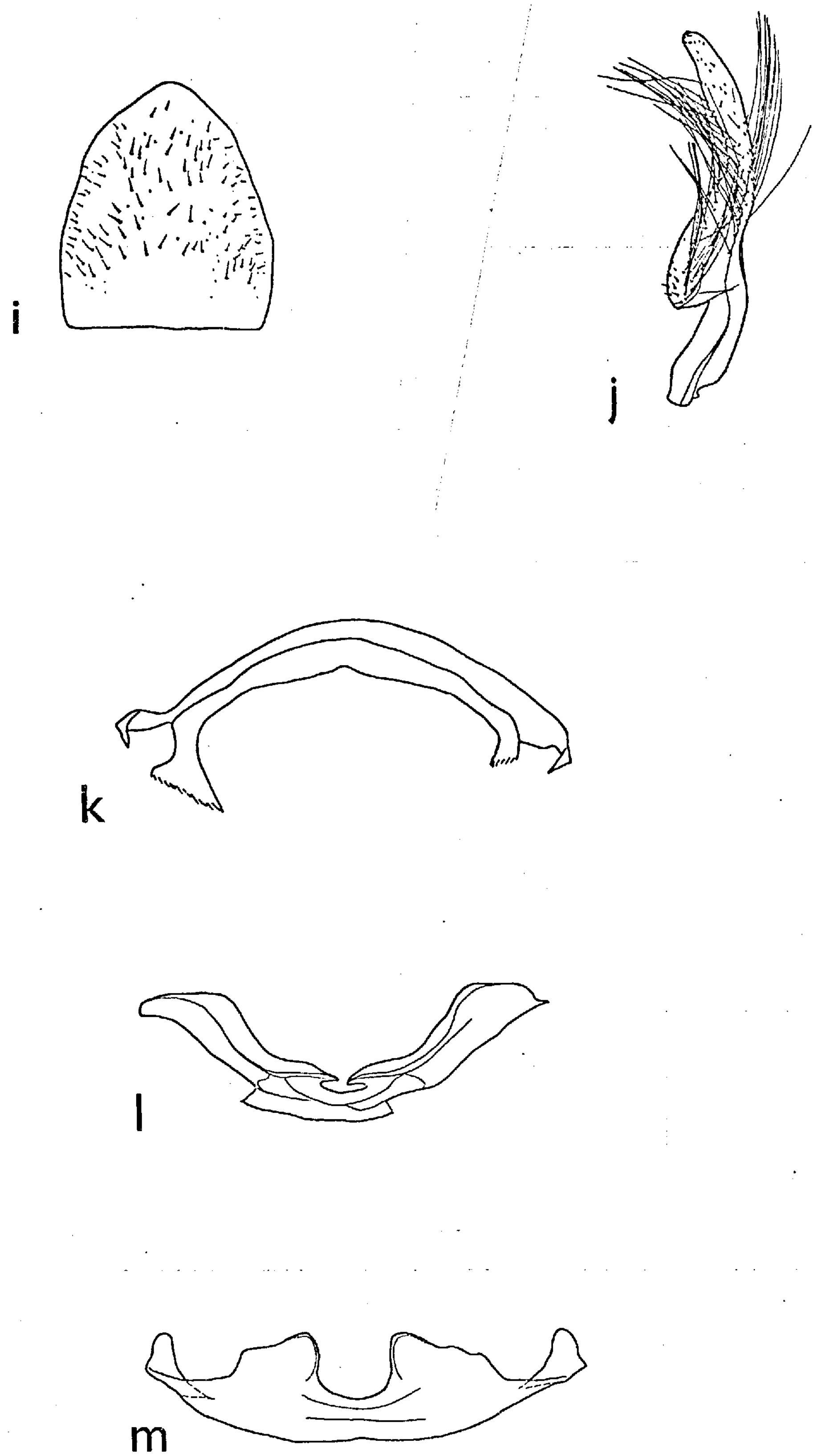
k, antecosta of second abdominal tergum, posterior view

l, first sternal abdominal apodemes, posterior view

m, second sternal abdominal apodemes, postero-dorsal view

Scale as in Figs. 1A and 1B.

18B



B. (s.str.) lucalensis n. sp.

(Figs. 19A : a-g; 19B : h-k)

Shiny to fairly shiny. Yellowish. Eyes reddish grey. Pronotum and scutellum yellowish, immaculate. Elytra whitish yellow or pale yellow; base of appendix tinged with brown; first apical cell infumated; veins of elytra yellowish. Legs yellow, apical part of femora and basal part of tibiae tinged with brown.

Medium-sized, elongate. Length of male, 5.49 mm (mean 5.49 mm); female unknown. Crown 7.0 - 7.1 times (mean 7.1) as broad as long, 0.15 times as long as pronotum. Pronotum 1.96 times as broad as long, transversely and finely (holotype) or coarsely (paratype) furrowed. Elytra distinctly punctate; puncturing dense, concolorous; setae short and yellowish (holotype) or longish and brownish (paratype).

Antecosta of second abdominal tergum of male strongly developed, mesal sinuation obsolete.

Male genitalia with 8th sternite wider than long; apical part broadly rounded, setae dense. Side lobes of pygophore broadly rounded apically, each with 10 - 13 macrosetae; appendages slightly curved, simple, apical part very minutely serrate. Length of stylus 0.92 - 0.93 mm (mean 0.93 mm); dorsal margin of apophysis approximately straight, ventral margin slightly expanded; apical tooth on ventral margin of apophysis small; apical hook very long, stout, slightly obtusely angled. Length of penis 0.65 - 0.66 mm (mean 0.66 mm); stem stout, moderately curved dorsad, lateral surfaces with small tubercles, anterior lamellae serrate; socle in lateral aspect 0.71 - 0.77 times (mean 0.74) as long as stem; angle between socle and base of stem on posterior margin about 180°. Base of connective in dorsal view wider than long; shaft distinctly longer than base, dorsal keel in lateral view higher than base. Genital plates turned slightly laterad at mid-length, subapical part with several long setae along outer margin.

Distribution : Zambesian.

Ecology : Gallery Forest.

Material studied : Holotype male - Angola : Duque de Bragança Falls, 11 - 12. III. 1972, at light, Southern African Expedition, B.M. 1972 - I. Paratype - 1 male, same data as holotype. Holotype and paratype in coll. B.M. (N.H.).

Remarks : Related to richteri Hell. & Lv. but easily distinguished from it by the broader apophysis of stylus as well as the broader stem of penis.

Fig. 19A - B. (s.str.) lucalensis n. sp.

(a-e, g-k, holotype; f, paratype)

a, male pygophore, left lateral view

b, right appendage of pygophore, left lateral view

c, apex of right appendage of pygophore, latero-ventral view

d, connective, left lateral view

e-f, connective, dorsal view

g, penis, left lateral view

19A

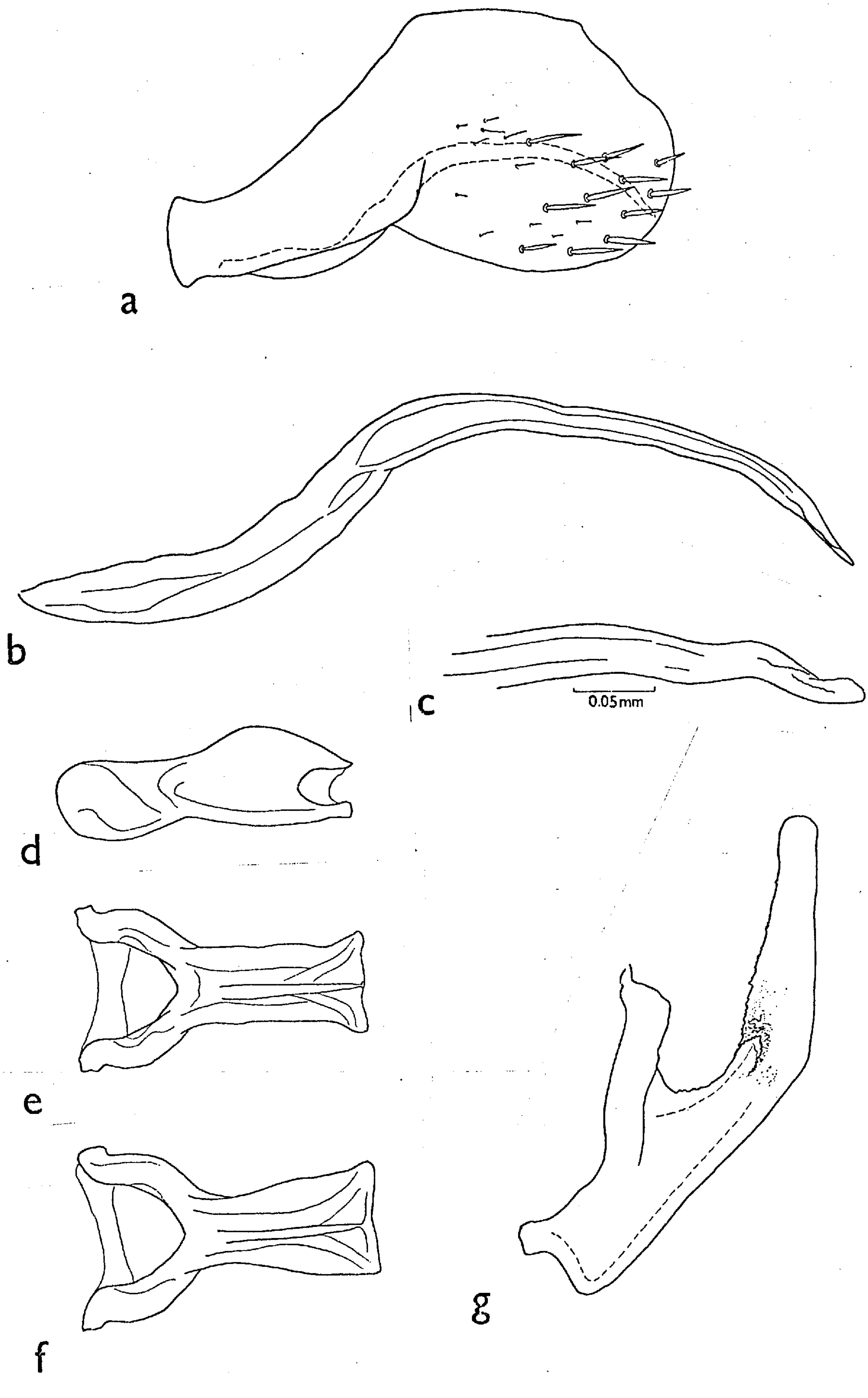


Fig. 19B - B. (s.str.) lucalensis n. sp.

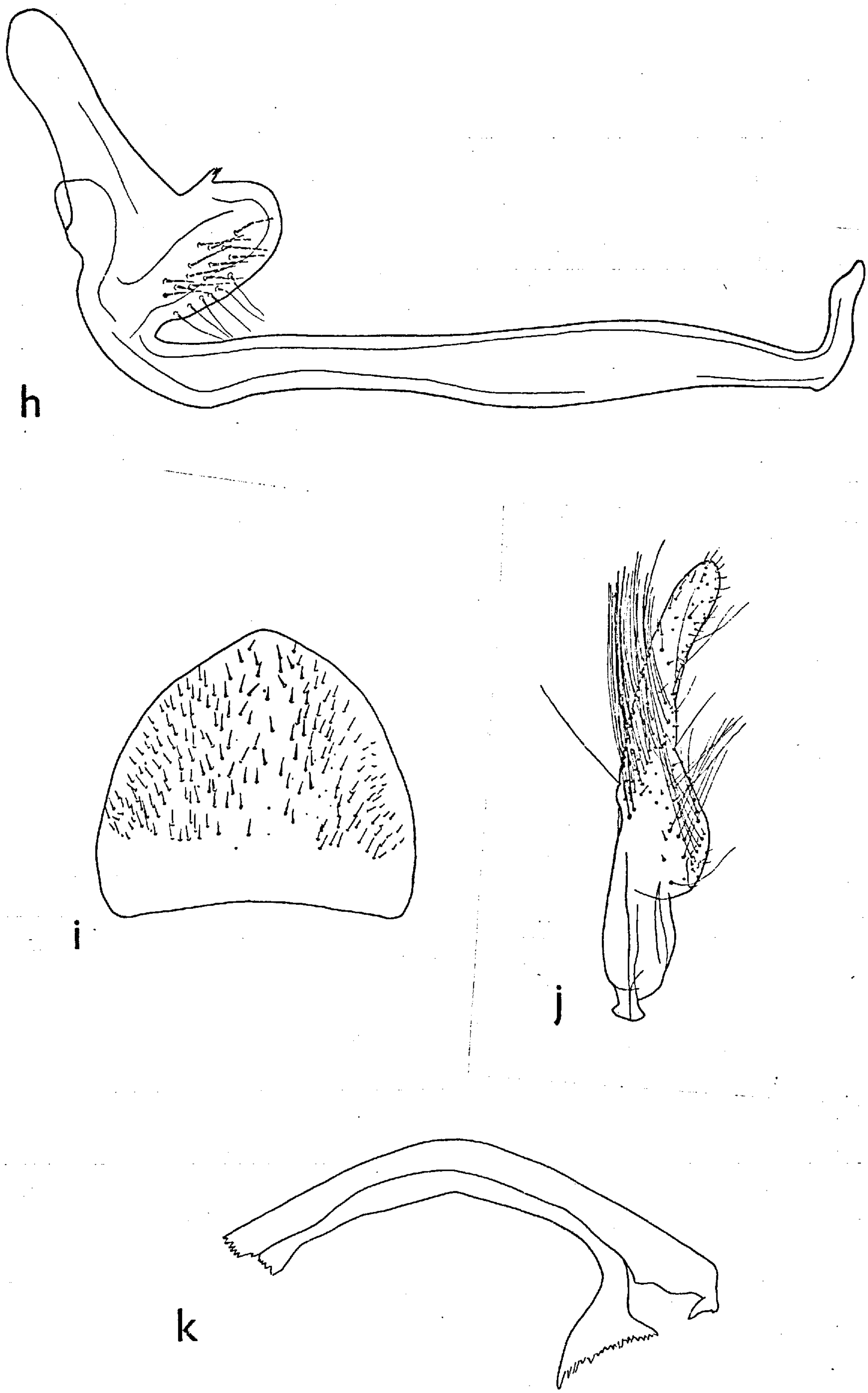
h, left stylus, left lateral view

i, 8th sternite, ventral view

j, left genital plate, dorsal view

k, antecosta of second abdominal tergum, posterior view

Scale as in Figs. 1A and 1B or, otherwise, as indicated.


h
i
j
k

B. (s.str.) mandane Lv. & Quart.

(Figs. 20A : a-g; 20B : h-k)

Batracomorphus (s.str.) mandane Linnavuori & Quartau, 1975 : 66 - 67.

Fairly shiny. Greenish yellow to yellowish. Eyes reddish grey. Pronotum yellowish, disk golden yellowish, humeral angles slightly tinged with greenish. Scutellum yellowish, lateral margins golden yellowish. Elytra light yellow; base of appendix tinged with brown; first apical cell slightly infumated; veins of elytra yellowish, some parts tinged with green; apical part of commissural margin of clavus greenish. Legs greenish yellow, tarsi and distal part of tibiae greenish.

Medium-sized, moderately robust to robust. Length, 5.0 - 5.25 mm. Crown 6.30 - 6.75 times as broad as long, 0.16 - 0.18 times as long as pronotum. Pronotum about twice as broad as long, finely and transversely furrowed. Elytra absoletely to more or less distinctly punctate; puncturing dense, concolorous; setae short, brownish.

Second sternal abdominal apodemes of male lobe-shaped, moderately separated, outer margins not steep, inner margins nearly vertical, mesal margin rounded. Antecosta of second abdominal tergum strongly developed, with a small mesal sinuation.

Male genitalia with 8th sternite broad; apical part broadly rounded, setae relatively sparse. Side lobes of pygophore acutely rounded apically, each with 8 - 11 macrosetae; appendages moderately curved in lateral view, simple, subapical part very minutely crenulate on ventral margin. Length of stylus 0.86 mm; apophysis gradually and strongly narrowing to apex, dorsal margin approximately straight, ventral margin moderately expanded; apical tooth on ventral margin of apophysis moderately developed; apical hook long, stout, blunt, more or less obtusely angled.

Length of penis 0.63 - 0.66 mm; stem more or less stout, slightly curved dorsad, tubercles on lateral surfaces obsolete, anterior lamellae coarsely dentate; socle in lateral aspect 0.68 - 0.75 times as long as stem; angle between socle and base of stem on posterior margin less than 180°. Base of connective in dorsal view wider than long; shaft short, dorsal keel in lateral view approximately as high as base. Genital plates turned slightly laterad at mid-length, subapical part with some long setae along outer margin.

Female genitalia with hind margin of 7th sternite subtruncate, lateral angles acute.

Distribution : Guinean. Zambesian.

Ecology : Moist savanna forests. Gallery forest.

Material studied : 1 male - Angola : Duque de Bragança Falls, 11 - 12. III. 1972, at light, Southern African Expedition, B.M. 1972 - I. In coll. B.M. (N.H.).

Remarks : Previously known from moist savanna forests in Sudan, this new finding enlarges considerably its distribution. The species is distinguished from hipponax Lv. by the immaculate pronotum, scuttelum and elytra, and by the penis which on posterior margin is only shallowly sinuate basally.

Fig. 20A - B. (s.str.) mandane Lv. & Quart.

a, male pygophore, left lateral view

b, left appendage of pygophore, left lateral view

c, apex of right appendage of pygophore broadest aspect

d, connective, left lateral view

e, connective, dorsal view

f, penis lateral view

g, left stylus, left lateral view

20A

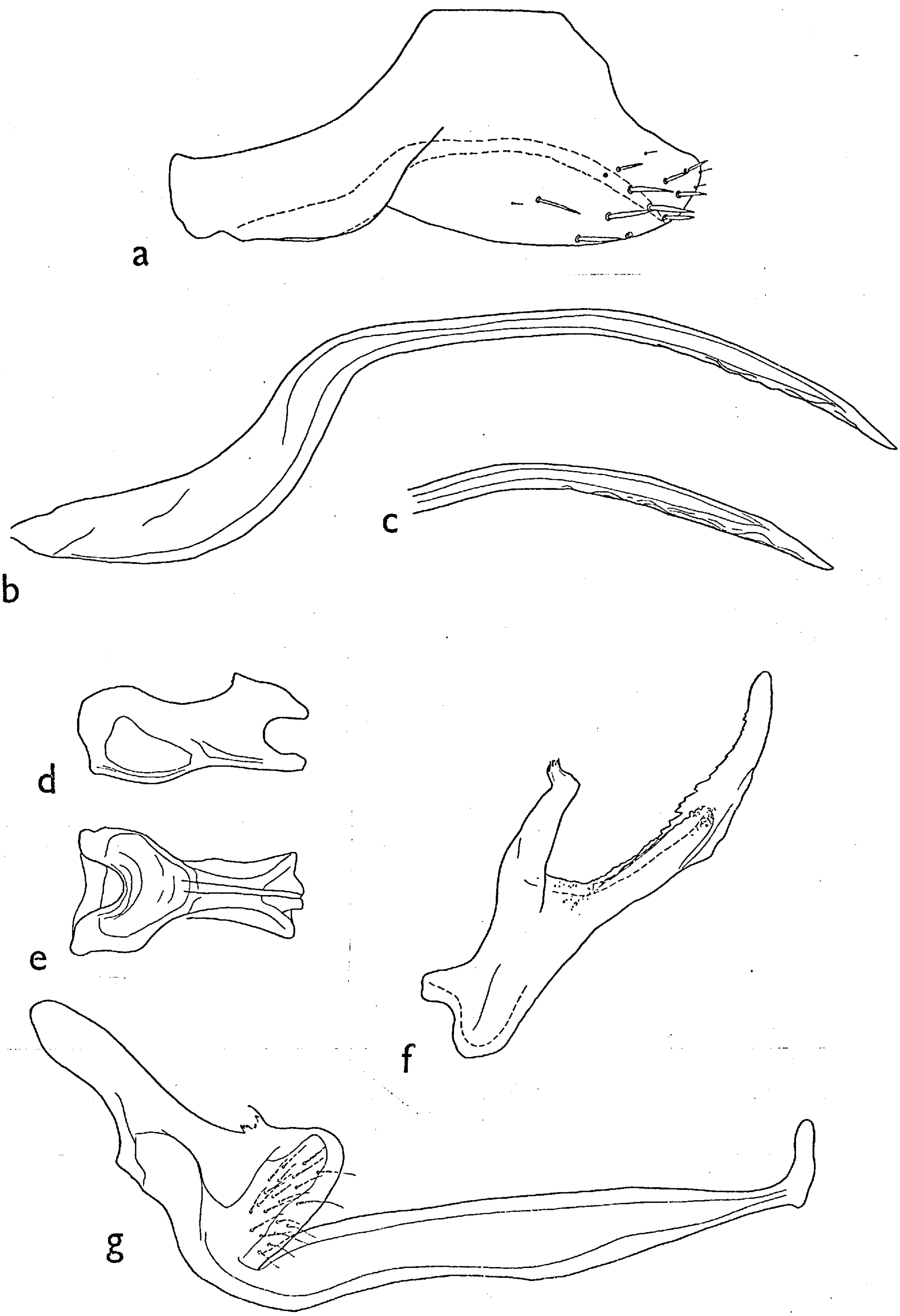


Fig. 20B - *B.* (s.str.) *mandane* Lv. & Quart.

h, 8th sternite, ventral view

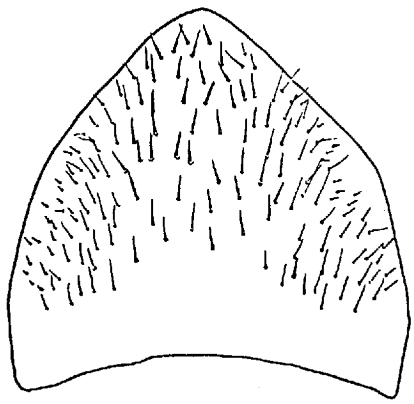
i, left genital plate, dorsal view

j, antecosta of second abdominal tergum, posterior view

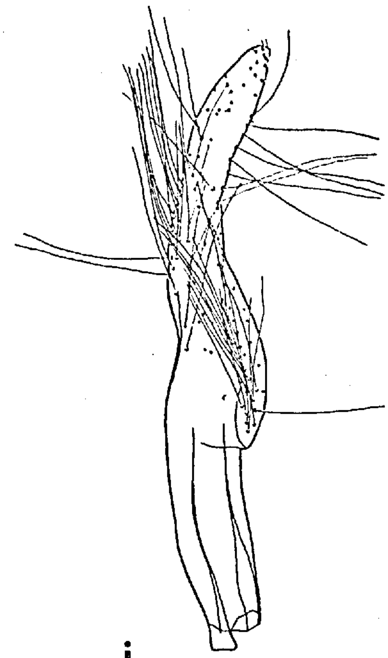
k, second sternal abdominal apodemes, postero-dorsal view

Scale as in Figs. 1A and 1B.

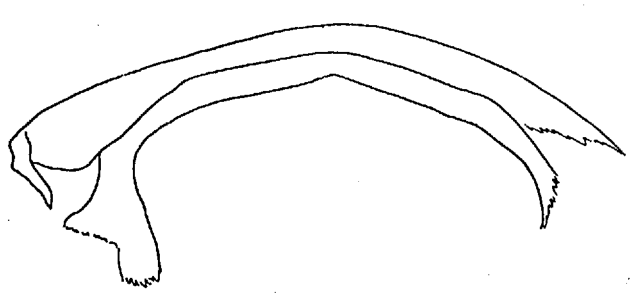
20B



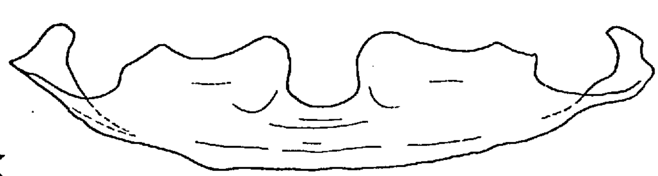
h



i



j



k

B. (s.str.) minos Lv. & Quart.

(Fig. 21A : a–e; 21B : f–k)

Batracomorphus (s.str.) minos Linnavuori & Quartau, 1975 : 84 – 85.

Shiny. Yellowish. Eyes brown to brownish grey. Pronotum and scutellum yellowish, immaculate. Elytra yellowish; base of appendix with a brown spot; tips of apical cells slightly infumated; veins of elytra yellowish; commissural margin of clavus tinged with green in apical half. Legs yellowish, tarsi greenish.

Small to medium-sized, relatively elongate. Length 4.08 – 5.36 mm. Crown 6.2 – 6.8 times as broad as long, 0.16 – 0.22 times as long as pronotum. Pronotum 1.94 – 2.28 times as broad as long, transversely and finely (male) or coarsely (female) furrowed. Elytra obsoletely punctate; puncturing dense, concolorous; setae short or longish, pale.

Male with notch of first sternal abdominal apodemes oval; lobes expanded medially, closely apposed. Second sternal abdominal apodemes lobe-shaped, moderately separated, outer margins not steep, inner margins oblique, mesal margin rounded. Antecosta of second abdominal tergum moderately developed, mesal sinuation obsolete.

Male genitalia with 8th sternite wider than long; apical part rounded, setae dense. Side lobes of pygophore roundedly truncate apically, each with 6 – 13 macrosetae; appendages moderately curved, apically bifurcate. Length of stylus 0.61 – 0.75 mm; dorsal margin of apophysis broadly expanded, ventral margin with a subapical arcuate sinuation; apical tooth on ventral margin of apophysis absent : apical hook stout, truncate, normally to acutely angled. Length of penis 0.51 – 0.75 mm; penis as illustrated in Linnavuori & Quartau (1975); stem gracile, distinctly curved dorsad, latero-posterior surfaces with a series of small teeth, anterior margin with a distinct pair of subapical spines; socle 0.20 – 0.26 times as long as stem. Base of connective in dorsal view approximately as wide as broad; shaft moderately developed, dorsal keel in lateral view lower than base. Genital plates turned slightly laterad at mid-length, subapical part with some long setae along outer margin.

Female genitalia with 7th sternite as illustrated.

Distribution : Guinean. Eastern.

Ecology : Undergrowth in rain and gallery forests. Moist Forest at low and medium altitudes.

Material studied : 1 male, 1 female, Kenya : Kakamega Forest, 0° 15' N, 34° 52' E, 5,100 ft, 18 - 22. I. 1972, C.F. Huggins, B.M. 1972 - 468. In coll. B.M. (N.H.).

Remarks : Previously known from Sudan and Central African Republic. The Kenyan material seems to be larger, with the branches of the bifurcate pygophore appendages stouter.

Distinguished from viator Lv. by the gracile penis, and by the subapical paired spines on anterior margin of stem of same.

Fig. 21A - B. (s.str.) minos Lv. & Quart.

a, male pygophore, left lateral view

b, left appendage of pygophore, left lateral view

c, connective, left lateral view

d, connective, dorsal view

e, left stylus, left lateral view

21A

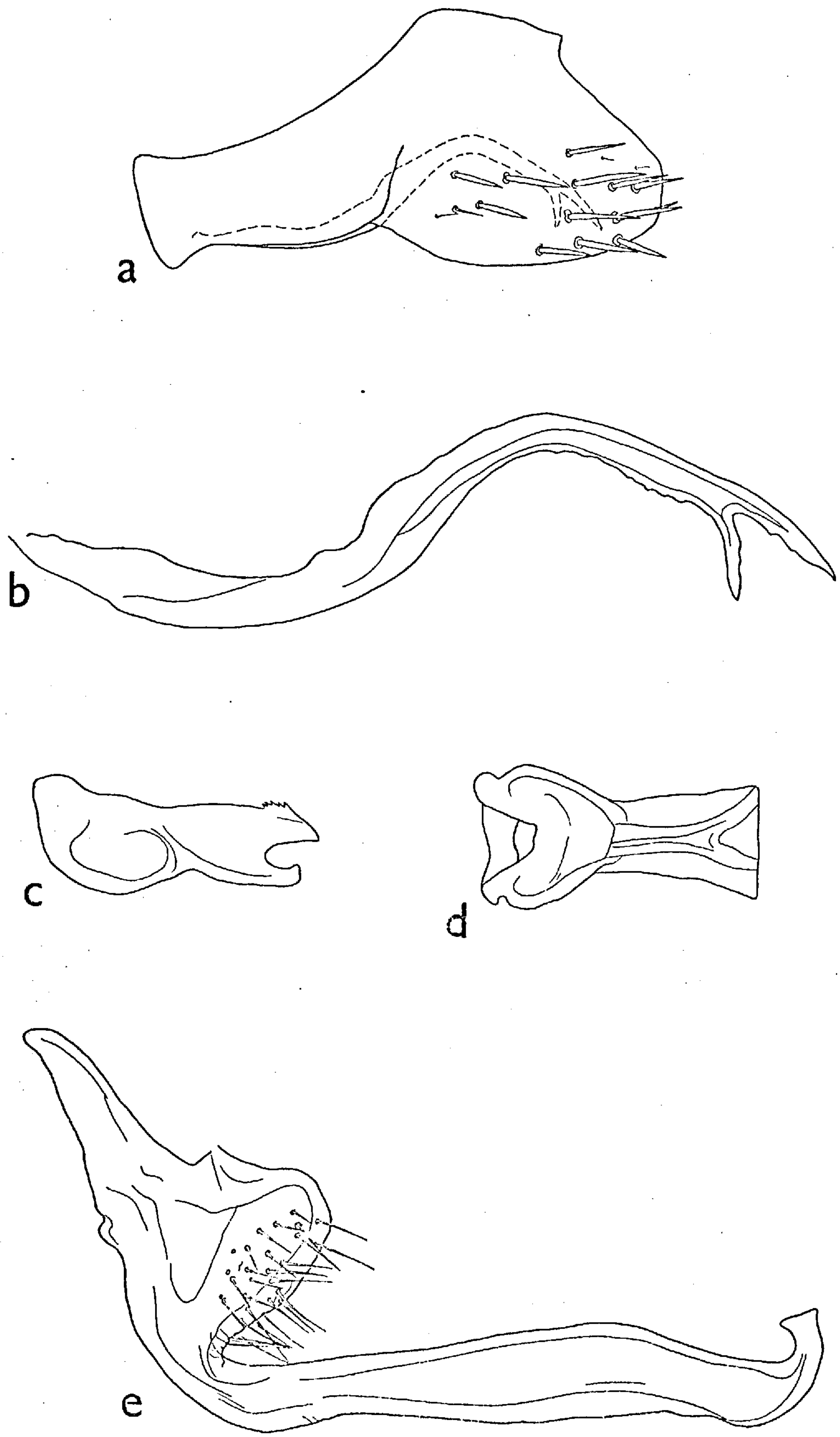


Fig. 21B - B. (s.str.) minos Lv. & Quart.

f, 8th sternite, ventral view

g, left genital plate, dorsal view

h, antecosta of second abdominal tergum, posterior view

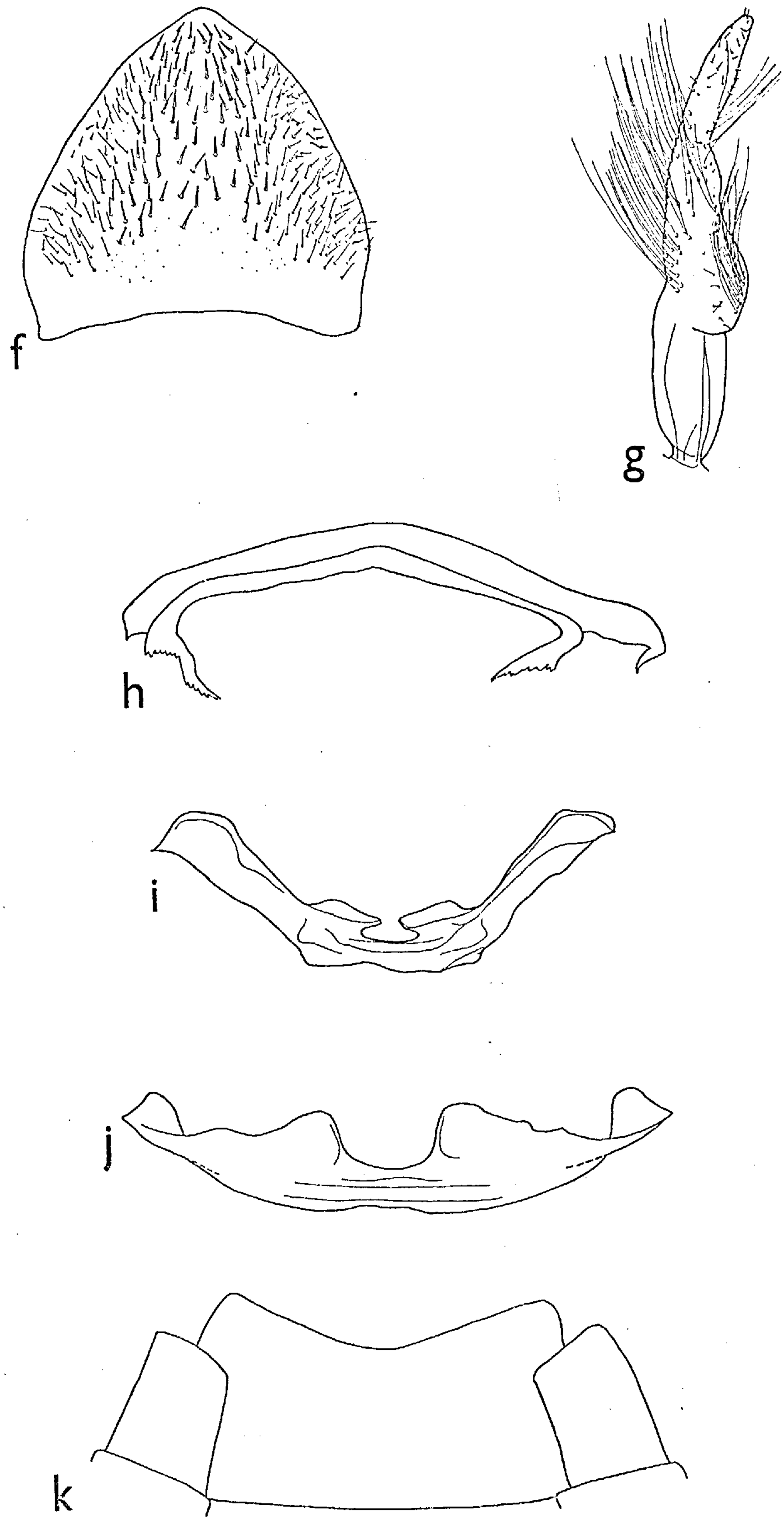
i, first sternal abdominal apodemes, posterior view

j, second sternal abdominal apodemes, postero-dorsal view

k, female 7th abdominal sternite, ventral view

Scale as in Figs.1A and 1B or, otherwise, as indicated.

21B



<u>B</u>. (s.str.) <u>mosselensis</u> n. sp.

(Figs. 22A : a-h; 22B : i-p)

Fairly shiny to shiny. Yellowish to brownish yellow. Eyes reddish, reddish brown or brownish grey. Pronotum and scutellum yellowish to brownish yellow, immaculate. Elytra yellowish to brownish yellow, densely spotted with faint brownish; appendix brownish, infumated or with a small brownish spot at base; sometimes tips of second and third apical cells slightly infumated; veins of elytra concolorous. Legs yellowish to brownish yellow, tarsi often greenish.

Medium-sized and moderately elongate (male) or large and elongate (female). Length of male, 4.90 - 5.16 mm (mean 5.07 mm); female, 5.81 - 6.14 mm (mean 5.94 mm). Crown 4.9 - 5.3 times (male, mean 5.18) or 5.1 - 6.0 times (female, mean 5.4) as broad as long, 0.22 - 0.25 times (male, mean 0.23) or 0.20 - 0.24 times (female, mean 0.23) as long as pronotum. Pronotum 2.03 - 2.14 times (male, mean 2.09) or 1.98 - 2.17 times (female, mean 2.04) as broad as long, coarsely and finely furrowed. Elytra obsoletely punctate, puncturing dense, in spots brownish and in other parts concolorous; setae of elytra short (male) or longish (female), pale or brownish.

Male with notch of first sternal abdominal apodemes oval, compressed; lobes expanded medially, relatively separated. Second sternal abdominal apodemes lobe-shaped, set farther apart than their individual width at middle, outer margins steep, inner margins oblique, mesal margin straight or rounded. Antecosta of second abdominal tergum moderately developed, mesal sinuation obsolete.

Male genitalia with 8th sternite wider than long; apical part more or less broadly rounded, setae dense. Side lobes of pygophore normally rounded, each with 11 - 17 macrosetae; appendages nearly straight, apical part slightly truncately expanded, very minutely serrate, sometimes with an obsolete subapical tooth on dorsal surface. Length of stylus 0.72 -

0.80 mm (mean 0.77 mm); apophysis broad, dorsal margin broadly expanded, ventral margin approximately straight or sinuate subapically; apical tooth on ventral margin of apophysis moderately developed; apical hook stout, blunt, obtusely angled to slightly upcurved. Length of penis 0.48 - 0.54 mm (mean 0.53 mm); stem stout, slightly curved dorsad, lateral surfaces with small tubercles, anterior lamellae finely serrate; socle in lateral aspect 0.28 - 0.40 times (mean 0.34) as long as stem; angle between socle and base of stem on posterior margin approximately 180°. Base of connective in dorsal view broad; shaft about as long as base, dorsal keel in lateral view slightly lower than base. Genital plates turned moderately to strongly laterad at mid-length, subapical part with several long setae along outer margin.

Female genitalia with 7th sternite as illustrated.

Distribution : Cape. Transvalian.

Ecology : Cape macchia. Costal Forest-Savanna Mosaic.

Material studied : Holotype male - S. Africa : Cape Province, Mossel Bay, VIII. 1930, R.E. Turner, Brit. Mus., 1930 - 416. Allotype - 1 female, same data as holotype. Paratypes - 2 males, 3 females, same data as holotype; 1 female, 16 - 28. IV. 1928, other data as holotype; 1 female, May. 1930, other data as holotype; 3 males, 4 females, VI - VII. 1930, other data as holotype; 1 male, Pondoland, Port St. John, 1 - 5. April, 1923, R.E. Turner, Brit. Mus., 1923 - 241. Holotype and paratypes in coll. B.M. (N.H.).

Remarks : The species is slightly variable in the apex of the pygophore appendages and in the shape of the stylus even among individuals from the same locality.

Near subolivaceus (St.) but distinguished from it by the elytral spotting, the stouter stem of penis and apical hook of stylus, and by the subapical tooth of the pygophore appendages, which when present, is dorsal. Distinguished from welwitschi n. sp. by the densely spotted elytra, the nearly straight pygophore appendages, and by the slightly curved stem of penis which has no apical lobes on dorsal surface.

Fig. 22A - B. (s.str.) mosselensis n. sp.

(a-b, d-g, i-m, holotype; c, h, p, two paratypes, Mossel Bay; n, paratype, Port St. John; o, allotype)

a, male pygophore, left lateral view

b-c, left appendage of pygophore, dorsal and left lateral views respectively

d, connective, left lateral view

e, connective, dorsal view

f, penis, left lateral view

g-h, left stylus, left lateral view

22A

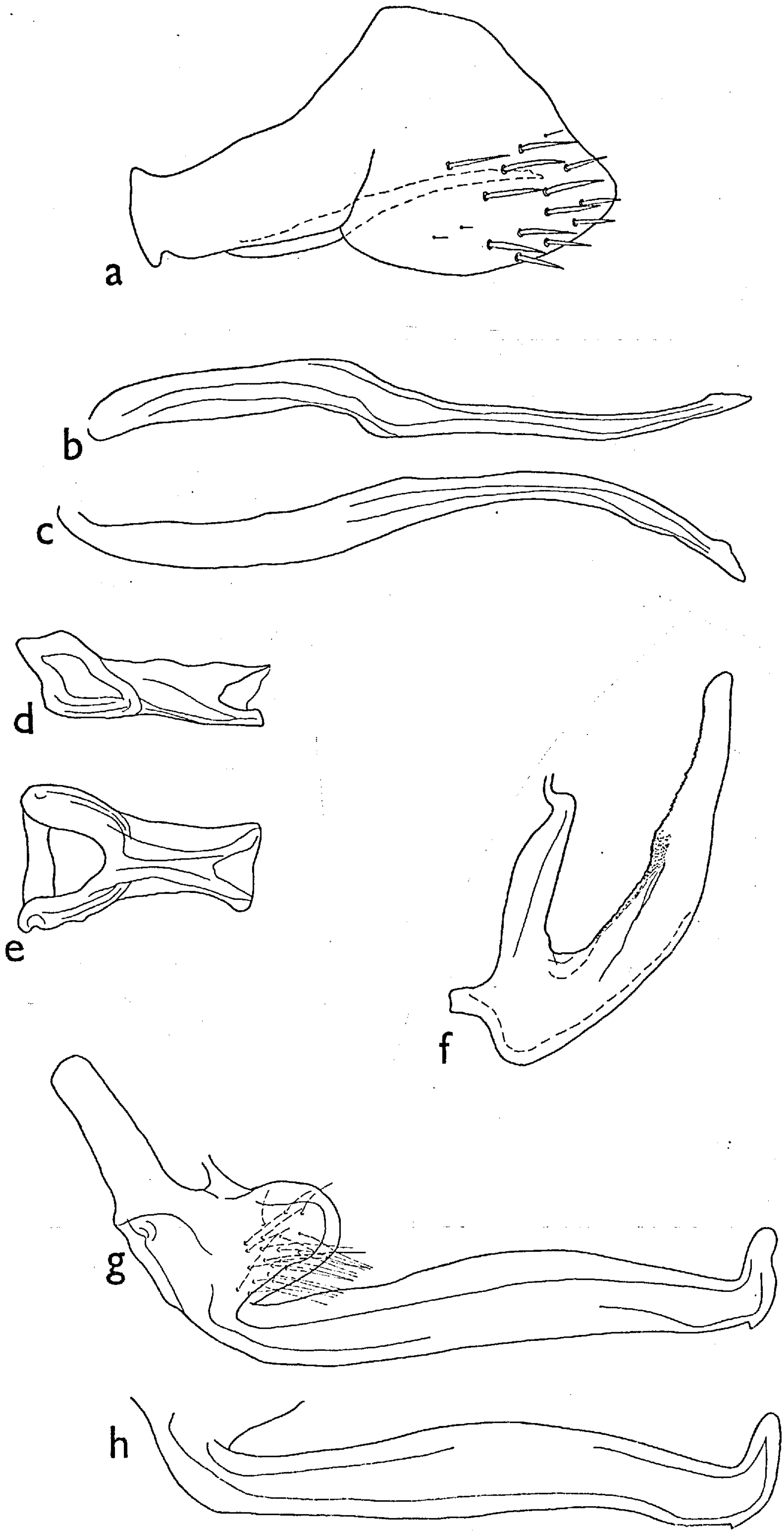


Fig. 22B - B. (s.str.) mosselensis n. sp.

i, 8th sternite, ventral view

j, left genital plate, dorsal view

k, antecosta of second abdominal tergum, posterior view

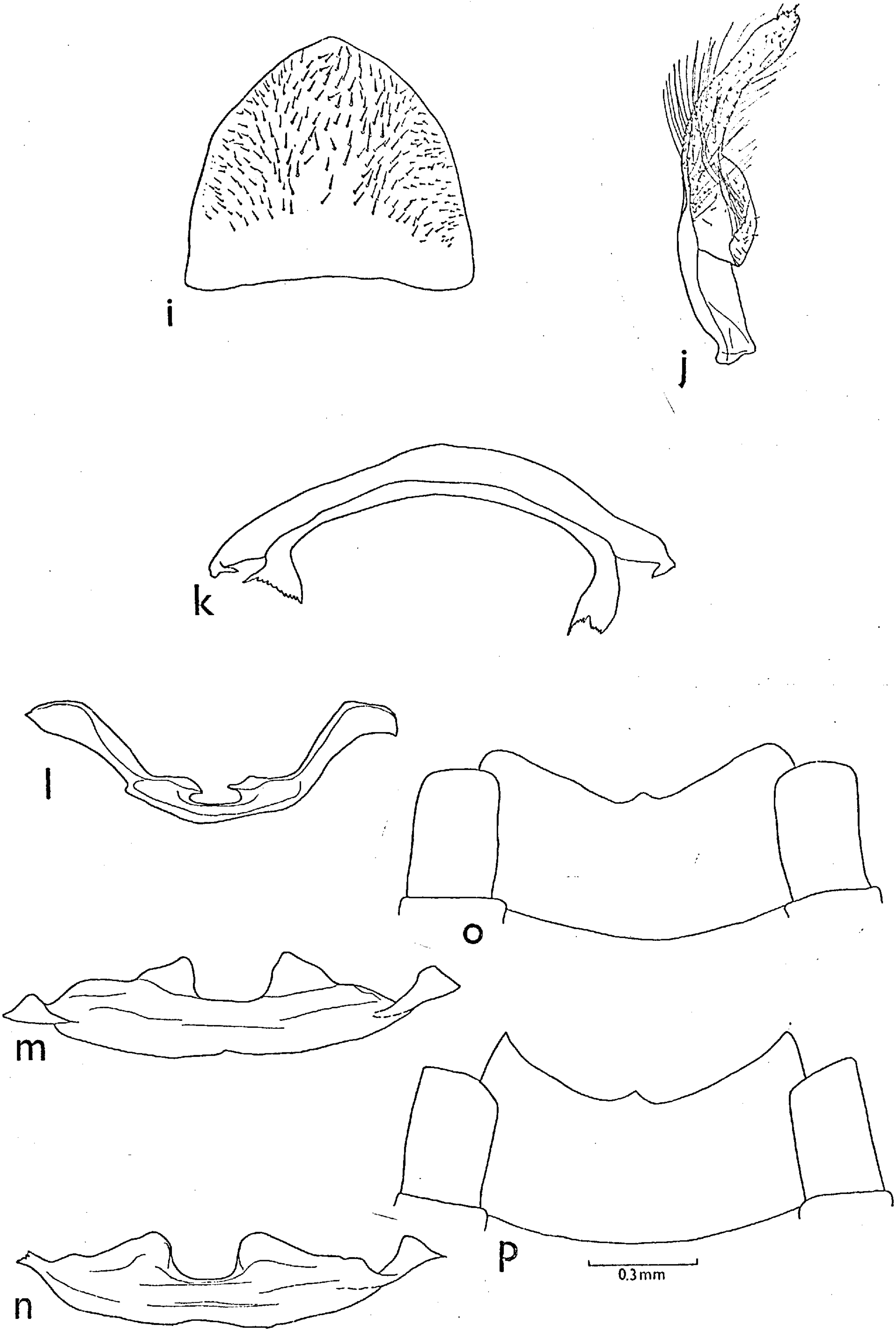
l, first sternal abdominal apodemes, posterior view

m-n, second sternal abdominal apodemes, postero-dorsal view

o-p, female 7th abdominal sternite, ventral view

Scale as in Figs. 1A and 1B or, otherwise, as indicated.

22B



B. (s.str.) natalensis n. sp.

(Figs. 23A : a-g; 23B : h-l; 23C : m-p)

Shiny. Yellowish. Eyes greyish brown. Pronotum yellowish, immaculate. Scutellum yellowish, sometimes with two brownish spots medially. Elytra light golden yellow; appendix infumated; veins of elytra concolorous. Legs yellowish, tarsi and apex of tibiae greenish.

Medium-sized (male) to large (female), robust. Length of male, 5.49 mm (mean 5.49 mm); female, 6.08 - 6.47 mm (mean 6.29 mm). Crown 5.7 (male) or 5.6 - 6.0 times (female, mean 5.7) as broad as long, 0.20 (male) or 0.20 - 0.22 times (female, mean 0.21) as long as pronotum. Pronotum 2.08 (male) or 1.97 - 2.14 times (female, mean 2.08) as broad as long, coarsely and transversely furrowed. Elytra distinctly punctate; puncturing dense, concolorous; setae longish, brownish.

Male with notch of first sternal abdominal apodemes broadly triangular; lobes expanded medially, closely apposed. Second sternal abdominal apodemes lobe-shaped, relative position of lobes variable from very near to relatively near, outer margins steep, inner margins nearly vertical, mesal margin rounded. Antecosta of second abdominal tergum strongly developed, mesal sinuation obsolete.

Male genitalia with 8th sternite very broad; apical part slightly and broadly concave on each side of medial line, setae relatively dense. Side lobes of pygophore roundedly truncate apically, each with 15 - 23 macrosetae; appendages moderately curved, bifurcate apically, secondary branch a minutely serrate subapical lobe. Length of stylus 0.89 - 0.92 mm (mean 0.91 mm); apophysis broad, dorsal margin approximately straight, ventral margin broadly expanded at middle; apical tooth on ventral margin of apophysis small; apical hook moderately developed, stout, blunt, normally angled. Length of penis 0.66 - 0.67 mm (mean 0.67 mm); stem more or less stout, moderately curved dorsad, lateral surfaces with small tubercles, anterior lamellae minutely serrate; socle in lateral aspect 0.68 - 0.74

times (mean 0.71) as long as stem; angle between socle and base of stem on posterior margin slightly less than 180°. Base of connective in dorsal view short, broad; shaft long, dorsal keel in lateral view approximately as high as base. Genital plates turned strongly laterad at mid-length, subapical part with a few long setae along outer margin.

Female genitalia with 7th sternite as illustrated.

Distribution : Basutolian.

Ecology : Temperate and Subtropical Grassland (?)

Material studied : Holotype male - South Africa : Natal, Van Reenen, Drakensberg, Dec. 1926, R.E. Turner, Brit. Mus., 1927 - 25. Allotype - same data as holotype. Paratypes - 1 male, 1 female, same data as holotype; 1 male, 3 females, 1 - 22. I. 1927, other data as holotype; 1 female, 23 - 26. I. 1927, other data as holotype. Holotype and paratypes in coll. B.M. (N.H.).

Remarks : The species is slightly variable in the shape of the second sternal abdominal apodemes. The apex of the left appendage of pygophore of the holotype is apparently damaged.

Related to mimus Lv. & Quart. but easily distinguished from it by both the smaller apical hook of stylus, and by the subapical lobe of the pygophore appendages which is ventral.

Fig. 23A - B. (s.str.) natalensis n. sp.
(a-b, g-h, m, p, two paratypes; c-f, i-k, n,
holotype; o, allotype)

a, male pygophore, left lateral view

b-c, left appendage of pygophore, left lateral view

d, connective, left lateral view

e, connective, dorsal view

f-g, penis, left lateral view

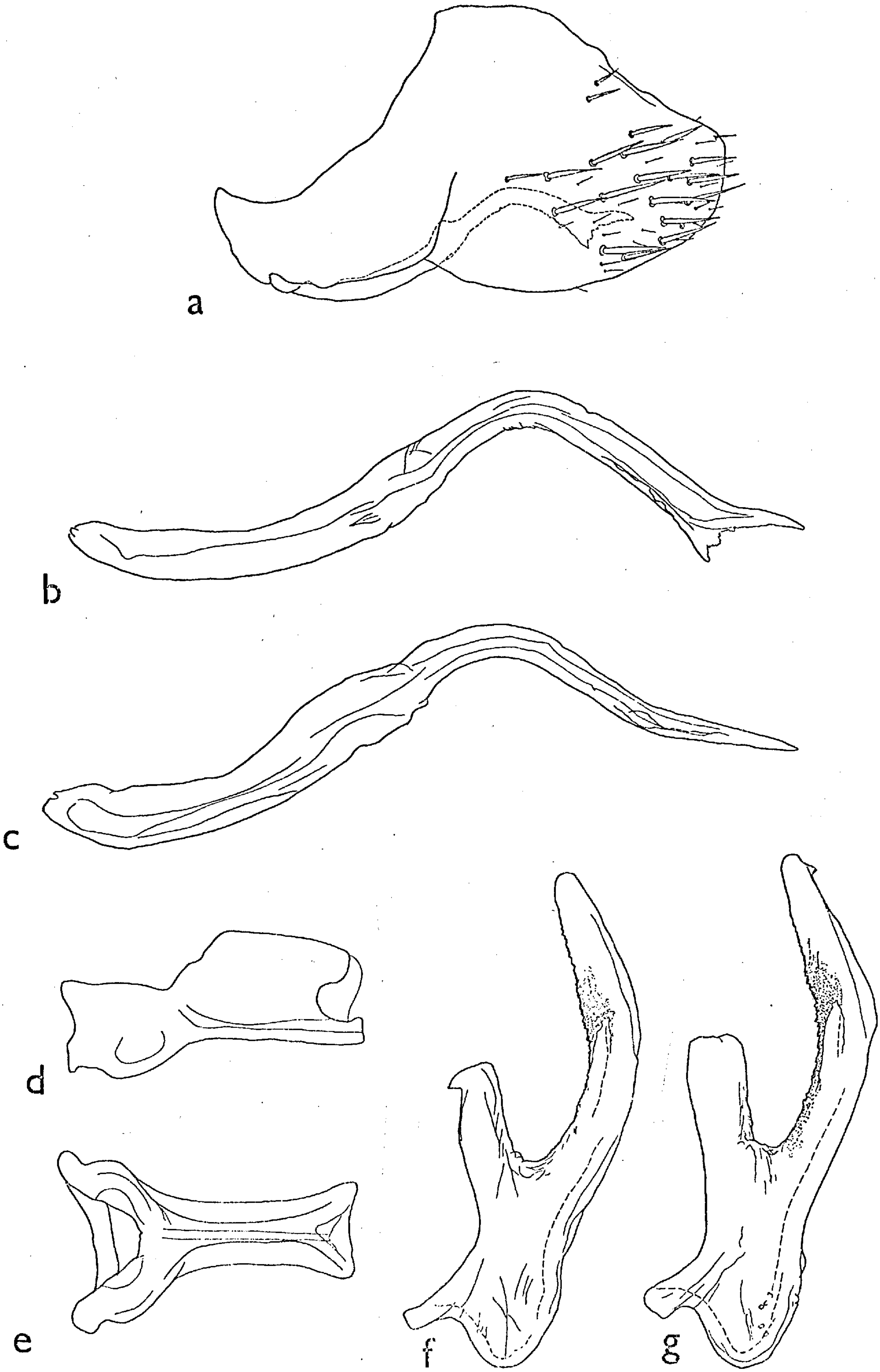

a
b
c
d
e
f
g

Fig. 23B - B. (s.str.) natalensis n. sp.

h, left stylus, left lateral view

i, 8th sternite, ventral view

j, left genital plate, dorsal view

k, antecosta of second abdominal tergum, posterior view

l, first sternal abdominal apodemes, posterior view

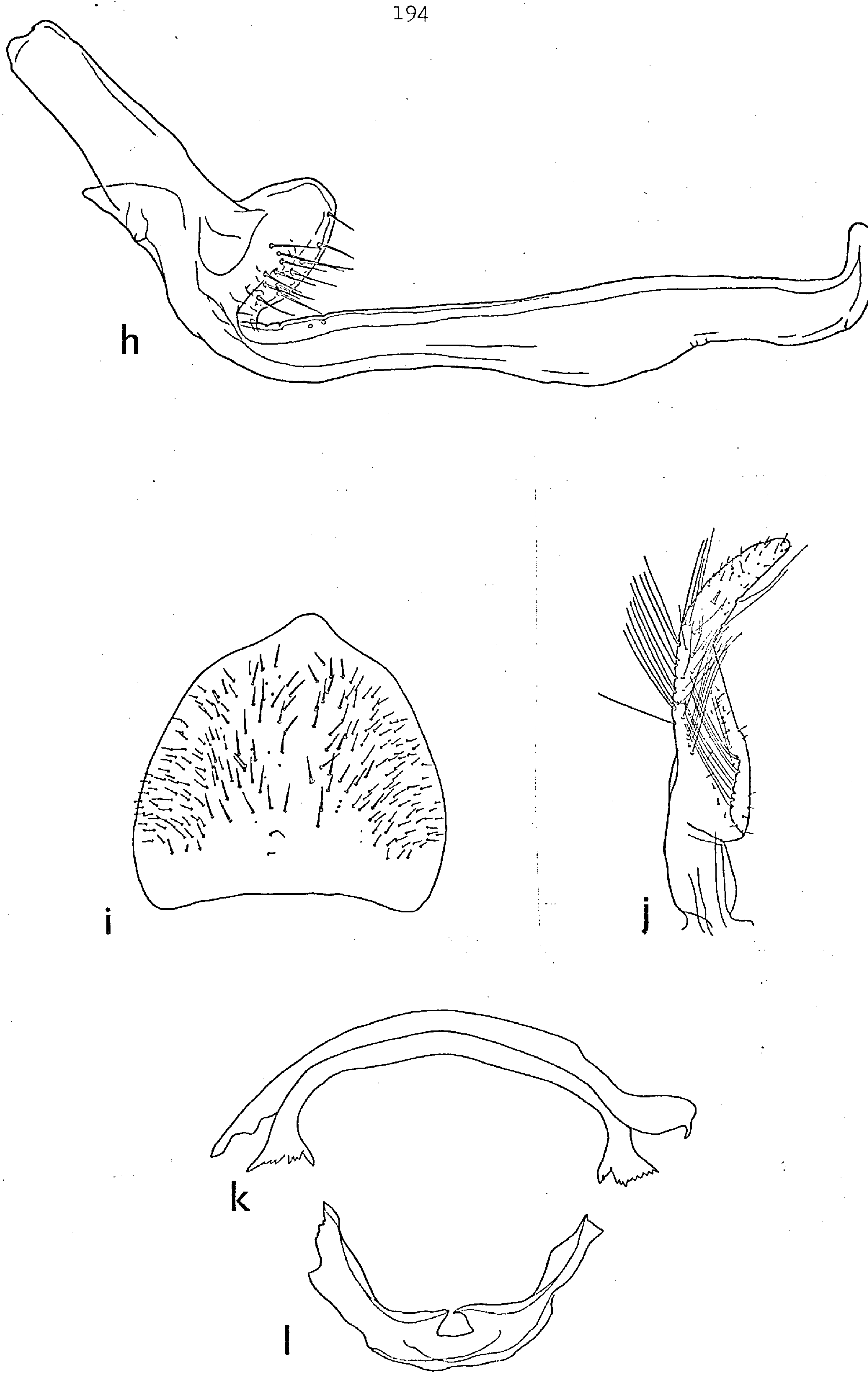
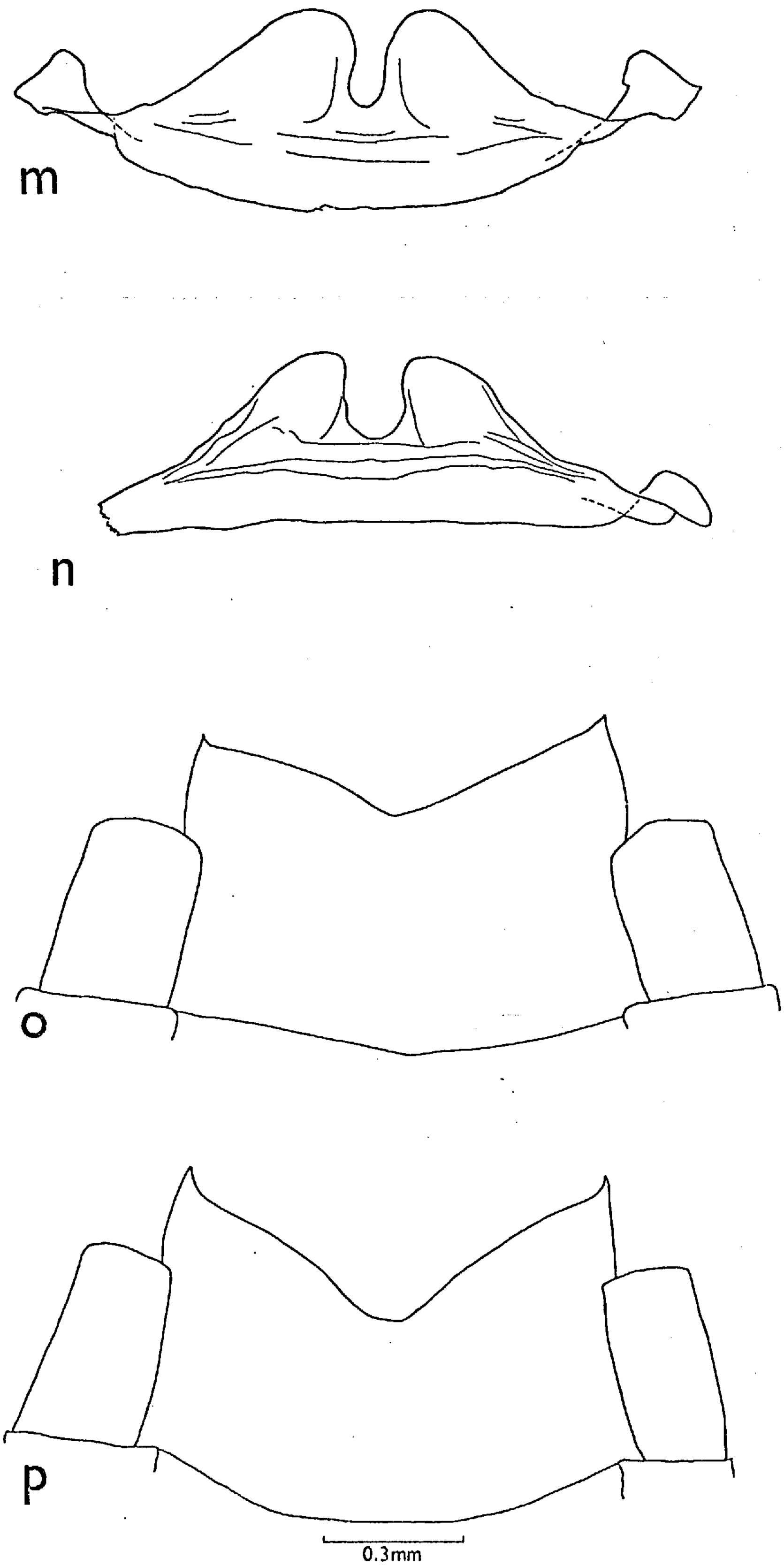

h
i
j
k
l

Fig. 23C - B. (s.str.) natalensis n. sp.

m-n, second sternal abdominal apodemes,
postero-dorsal view

o-p, female 7th abdominal sternite,
ventral view

Scale as in Figs. 1A and 1B or, otherwise, as indicated.


m
n
o
p
0.3mm

B. (s.str.) quirimboensis n. sp.

(Figs. 24A : a-f; 24B : g-l)

Fairly shiny. Yellowish, densely spotted with brown. Eyes dark brown or reddish brown. Base and disk of pronotum densely spotted with brown. Scutellum with some brownish spots. Elytra yellowish, densely spotted with roundish, partly coalescent brownish spots; base of appendix tinged with brown; appendix and first apical cell infumated; veins of elytra light brownish. Legs yellowish, tarsi tinged with green.

Large, relatively elongate. Length of male, 5.58 - 5.88 mm (mean 5.78 mm); female unknown. Crown 5.7 - 6.3 times (mean 6.0) as broad as long, 0.18 times as long as pronotum. Pronotum 1.85 - 2.00 (mean 1.93) as broad as long, coarsely and transversely furrowed. Elytra absoletely punctate; puncturing rather sparse, dark in brown spots, in other parts concolorous; setae short, dark brown to brownish.

Male with notch of first sternal abdominal apodemes oval, compressed; lobes expanded medially, closely apposed. Second sternal abdominal apodemes lobe-shaped, short, moderately separated, outer margins not steep, inner margins near vertical, mesal margin rounded. Antecosta of second abdominal tergum strongly developed, with a small mesal sinuation.

Male genitalia with 8th sternite broad; apical part more or less broadly rounded, setae dense. Side lobes of pygophore acutely rounded apically, each with 11 - 17 macrosetae; appendages moderately curved, simple, acute and not expanded apically. Length of stylus 0.94 - 0.96 mm (mean 0.95 mm); apophysis of stylus gracile, dorsal margin broadly expanded, ventral margin approximately straight; apical tooth on ventral margin small; apical hook very long, blunt, normally angled. Length of penis 0.74 - 0.75 mm (mean 0.75 mm); posterior margin strongly sinuate; stem distinctly curved dorsad, with small tubercles on lateral surfaces, anterior lamellae finely serrate; socle in lateral aspect 0.87 - 0.92 times (mean 0.90) as long as stem; angle between socle and base of stem on posterior margin much less than 180°. Base of connective in dorsal view wider than long; shaft short, dorsal keel in lateral view higher than base or approximately as high as base. Genital plates turned slightly laterad at mid-length, subapical part with long setae along outer margin.

Distribution : Guinean.

Ecology : Moist Forest at low and medium altitudes.

Material studied : Holotype male - Angola : Quirimbo, V. 1934, K. Jordan, B.M. 1934 - 435. Paratype - 1 male, Angola : 7 mls. W. Gabela, 16 - 18. III. 1972, Southern African Expedition, B.M. 1972 - I. Holotype and paratype in coll. B.M. (N.H.).

Remarks : Distinguished from hipponax Lv. by the thinner and longer stem of penis, and by the finely serrate lamellae of same.

Fig. 24A - B. (s.str.) quirimboensis n. sp.

(a-b, d-j, holotype; c, k, paratype)

a, male pygophore, left lateral view

b, left appendage of pygophore, left lateral view

c-d, connective, left lateral view

e, connective, dorsal view

f, penis, left lateral view

24A

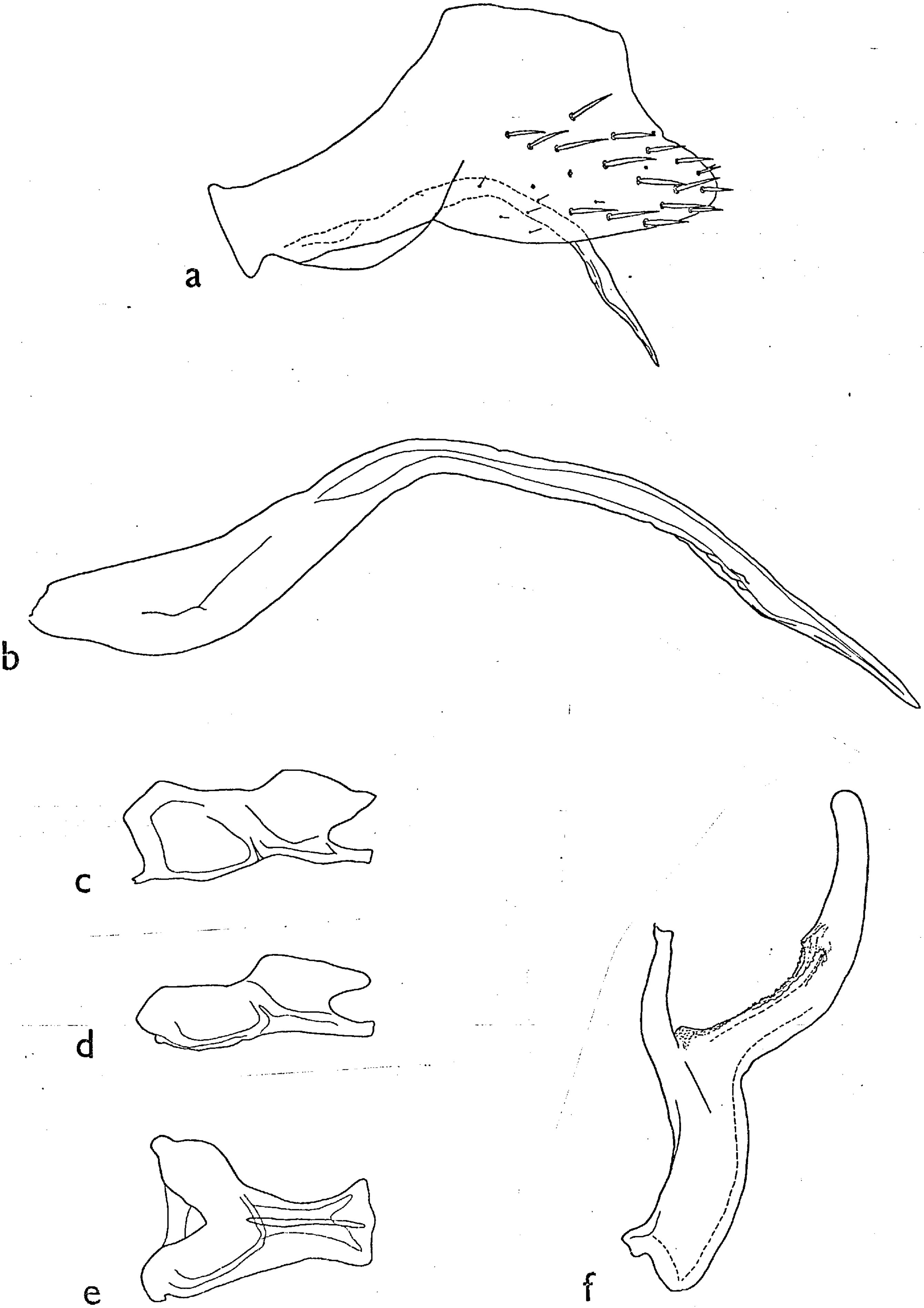


Fig. 24B - B. (s.str.) quirimboensis n. sp.

g, left stylus, left lateral view

h, 8th sternite, ventral view

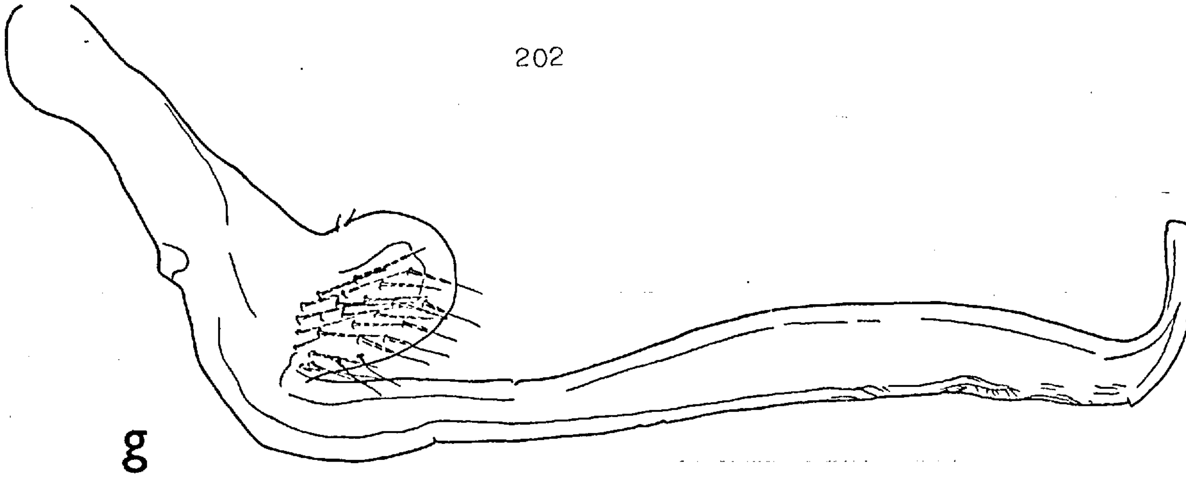
i, left genital plate, dorsal view

j, antecosta of second abdominal tergum, posterior view

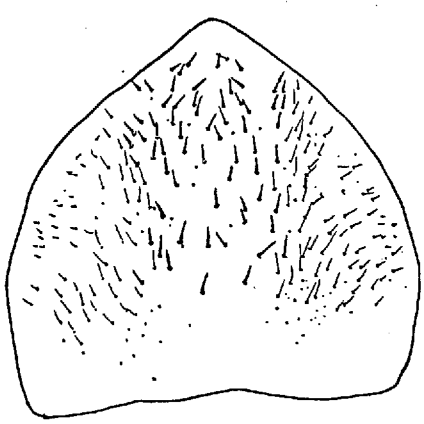
k, first sternal abdominal apodemes, posterior view

l, second sternal abdominal apodemes, postero-dorsal view

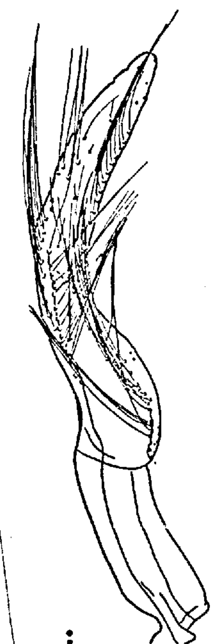
Scale as in Figs. 1A and 1B.



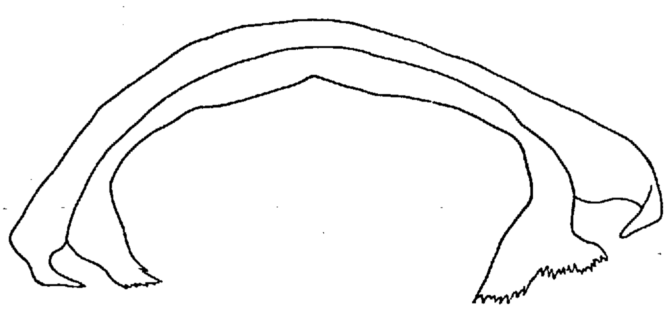
g



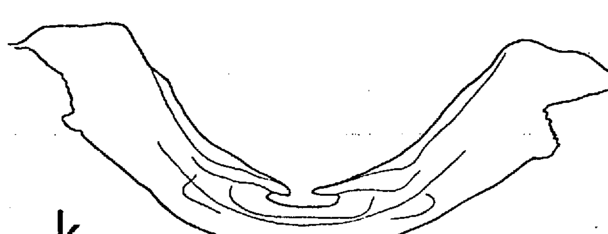
h



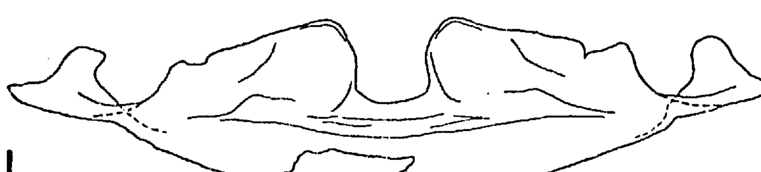
i



j



k



l

B. (s.str.) samaruensis n. sp.

(Figs. 25A : a-h; 25B : i-s)

Fairly shiny. Yellowish or greenish yellow. Eyes reddish brown to brown. Pronotum and scutellum yellowish or greenish yellow, immaculate. Elytra pale yellowish; base of appendix with a small faint brownish spot; veins of elytra concolorous, some parts tinged with greenish; apical part of commissural margin of clavus tinged with green. Legs yellowish, tarsi and apical part of tibiae green.

Small, relatively elongate. Length of male, 4.18 - 4.44 mm (mean 4.23 mm); female, 4.70 mm. Crown 4.5 - 5.8 times (male, mean 5.0) or 5.4 times (female) as broad as long, 0.20 - 0.24 times (male, mean 0.23) or 0.21 times (female) as long as pronotum. Pronotum 1.88 - 2.04 times (male, mean 1.97) or 2.07 times (female) as broad as long, finely and transversely furrowed. Elytra obsoletely punctate; puncturing concolorous; setae short, pale (male) or brownish (female).

Male with notch of first sternal abdominal apodemes oval to broadly triangular; lobes expanded medially, often very closely apposed. Second sternal abdominal apodemes lobe-shaped, distinctly longer than half their individual width at middle, moderately separated, outer margins steep, inner margins oblique to vertical, mesal margin often rounded. Antecosta of second abdominal tergum strongly developed, mesal sinuation obsolete or well defined.

Male genitalia with 8th sternite moderately broad; apical part more or less acutely rounded, setae dense. Side lobes of pygophore roundedly truncate apically, each with 8 - 13 macrosetae; appendages rather straight, simple, apex smooth to minutely serrate, sometimes slightly expanded. Length of stylus 0.65 - 0.67 mm (mean 0.66 mm); apophysis gradually narrowing to apex; dorsal margin of apophysis approximately straight to moderately expanded, ventral margin broadly expanded; apical tooth on ventral margin of apophysis small; apical hook stout, slightly acutely angled, with a small subapical tooth. Length of penis 0.44 - 0.49 mm (mean 0.46 mm); stem slender and long, distinctly curved dorsad, anterior lamellae coarsely serrate; socle in lateral aspect 0.28 - 0.34 times (mean 0.31) as long as stem; angle between socle and base of stem on posterior margin about 180°. Base of connective in dorsal view broad; shaft approximately as long as base, dorsal keel in lateral view as high as base. Genital plates turned moderately to strongly laterad at mid-length, subapical part with several long setae along outer margin.

Female genitalia with 7th sternite as illustrated.

Distribution : Soudanian.

Ecology : Grassland savanna.

Material studied : Holotype male - Nigeria : Samaru, 3 - 10. VI. 1970, Mercury Vapour, light trap, P.H. Ward, B.M. 1970 - 604. Allotype - 1 female, 18 - 25. V. 1970, other data as holotype. Paratypes - 2 males, 18 - 25. V. 1970, 1 male, 15 - 25. V. 1970, 1 male, 21 - 29. VII. 1970, 1 male, 26 - 31. V. 1970, other data as holotype. Holotype and paratypes in coll. B.M. (N.H.).

Remarks : The species is slightly variable especially in the sternal abdominal apodemes.

Closely related to <u>harpaganus</u> Lv. & Quart. but distinguished from it by the presence of a small subapical tooth in the apical hook of stylus, the smaller apical tooth on ventral margin of apophysis of stylus, and by the narrower stem of penis.

Fig. 25A - B. (s.str.) samaruensis n. sp.
(a–c, e–f, h–i, l, o, r, holotype; d, g, j–k, m–n, p–q, four paratypes; s, allotype)

a, male pygophore, left lateral view

b, left appendage of pygophore, left lateral view

c, apex of left appendage of pygophore, left lateral view in broadest aspect

d, apex of left appendage of pygophore, right latero-dorsal view

e, connective, left lateral view

f, connective, dorsal view

g–h, left stylus, left lateral view

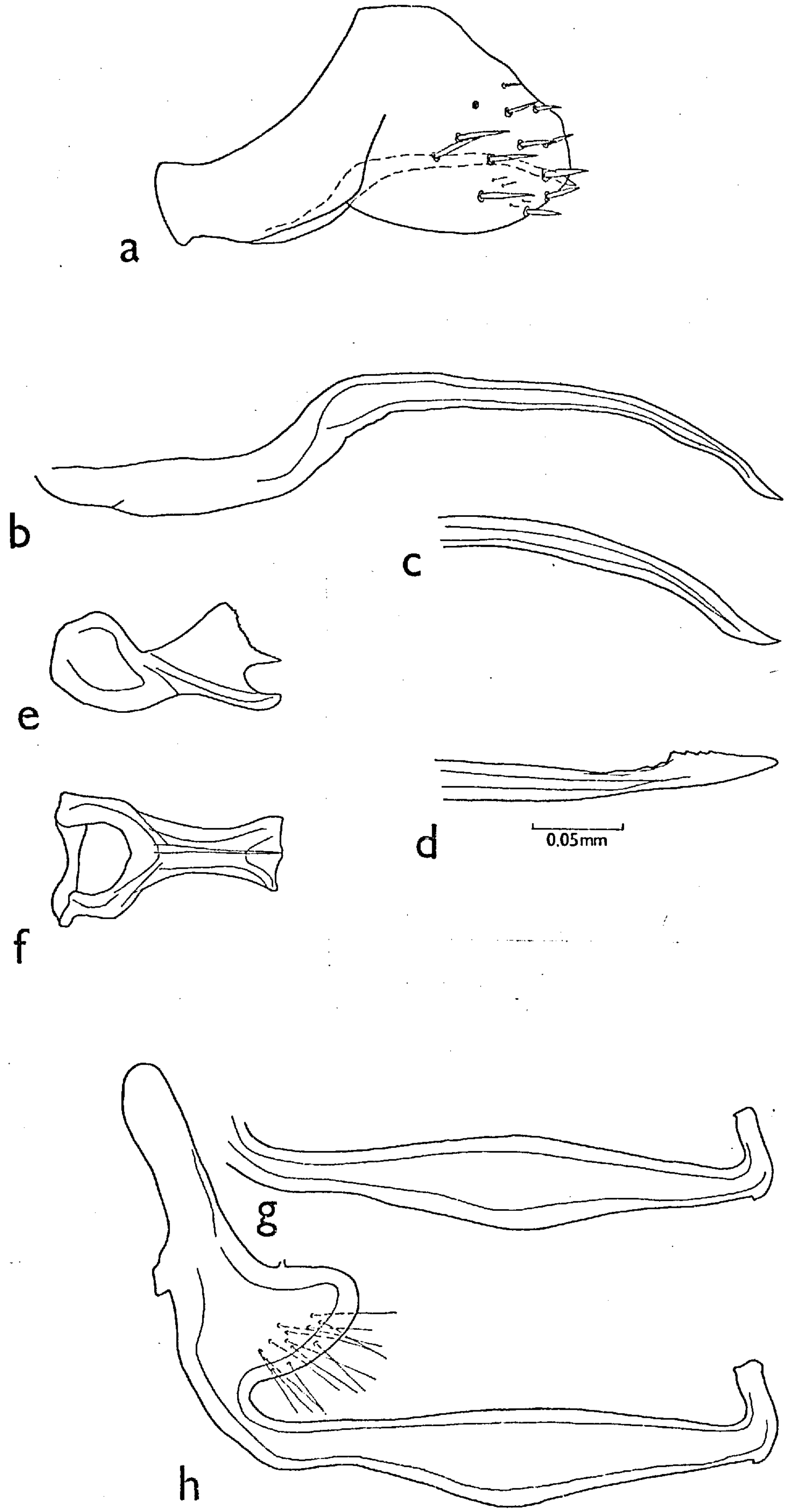

a
b
c
e
d
0.05mm
f
g
h

Fig. 25B - B. (s.str.) samaruensis n. sp.

i-j, penis, left lateral view

k, 8th sternite, ventral view

l, left genital plate, dorsal view

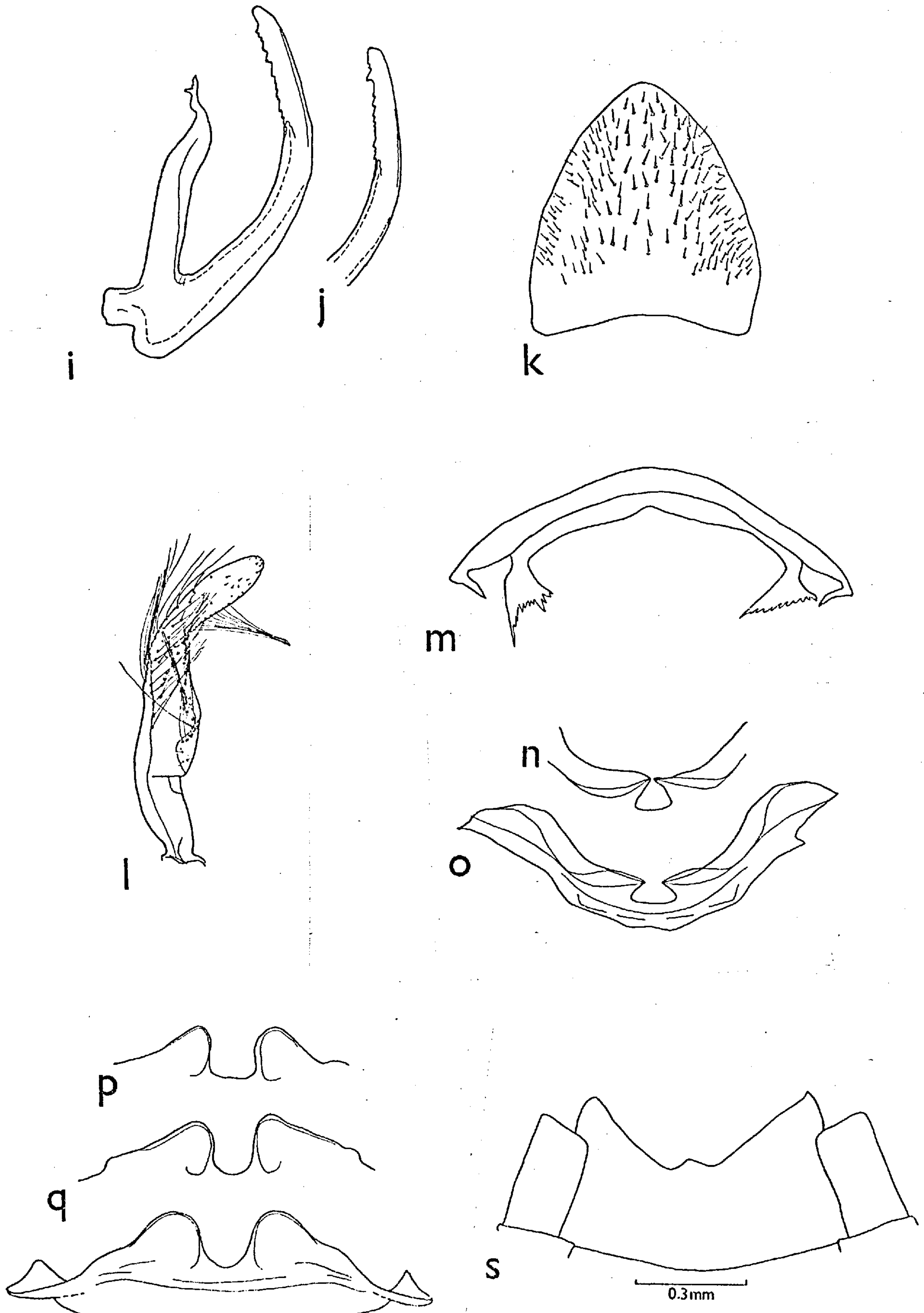
m, antecosta of second abdominal tergum, posterior view

n-o, first sternal abdominal apodemes, posterior view

p-r, second sternal abdominal apodemes, postero-dorsal view

s, female 7th abdominal sternite, ventral view

Scale as in Figs. 1A and 1B or, otherwise, as indicated.


i
j
k
l
m
n
o
p
q
r
s
0.3mm

B. (s.str.) santosjuniori Lv. & Quart.

(Figs. 26A : a-f; 26B : g-k)

Batracomorphus (s.str.) santosjuniori Linnavuori & Quartau, 1975 : 116 - 117.

Dull to fairly shiny. Yellowish (greenish when alive). Eyes reddish brown. Pronotum and scutellum yellowish, immaculate. Elytra pale greenish yellow; base of appendix with a small brownish spot; veins of elytra concolorous, commissural margin of clavus greenish, especially at apex. Legs yellowish, tarsi greenish.

Small, relatively robust. Length of male, 3.89 - 4.18 mm (mean 4.04 mm); female, 4.21 - 4.22 mm (mean 4.22 mm). Crown 5.4 times as broad as long, 0.19 - 0.22 times (mean 0.21) as long as pronotum. Pronotum 1.92 - 2.10 times (mean 2.01) as broad as long, finely and transversely furrowed. Elytra obsoletely punctate; puncturing relatively sparse, concolorous; setae short, brownish.

Male with notch of first sternal abdominal apodemes oval, compressed; lobes expanded medially, closely apposed. Second sternal abdominal apodemes lobe-shaped, distinctly longer than half their individual width at middle, outer margins steep, inner margins near vertical, mesal margin approximately straight. Antecosta of second abdominal tergum narrowly developed, mesal sinuation obsolete.

Male genitalia with 8th sternite broad; apical part more or less broadly rounded, setae relatively dense. Side lobes of pygophore rounded apically, each with 9 - 12 macrosetae; appendages moderately curved, slender, simple, ventral margin smooth. Length of stylus 0.56 mm; dorsal margin of apophysis approximately straight, ventral margin very slightly expanded; apical tooth on ventral margin of apophysis absent; apical hook short, gracile, blunt, normally angled. Length of penis 0.39 - 0.41 mm (mean 0.40 mm); stem slender, moderately curved dorsad, lateral surfaces with small tubercles, anterior lamellae minutely serrate; socle in lateral aspect 1.13 - 1.16 times (mean 1.14) as long as stem; angle between socle and base of stem on posterior margin about 180°. Base of connective in dorsal view approximately as wide as long; shaft short, dorsal keel in lateral view about as high as base. Genital plates rather straight, subapical part with several long setae along outer margin.

Female genitalia with hind margin of 7th sternite shallowly sinuate and with a small medial tooth.

Distribution : Transvalian. Zambesian. Guinean.

Ecology : Steppe of Luanda. Moist Forest at low and medium altitudes. On Terminalia catappa.

Material studied : 1 male - Nigeria : Ibadan, V. 1967, B.M. Gerard, B.M. 1967 - 594. In coll. B.M. (N.H.).

Remarks : Distinguished from thersites Lv. & Quart. by the pygophore appendages which are not obliquely truncate apically, by the apophysis of stylus which is edentate on ventral margin, and by the longer socle of penis.

Fig. 26A - _B_. (s.str.) _santosjuniori_ Lv. & Quart.

a, male pygophore, left lateral view

b, left appendage of pygophore, left lateral view

c, connective, left lateral view

d, connective, dorsal view

e, penis, left lateral view

f, left stylus, left lateral view

26A

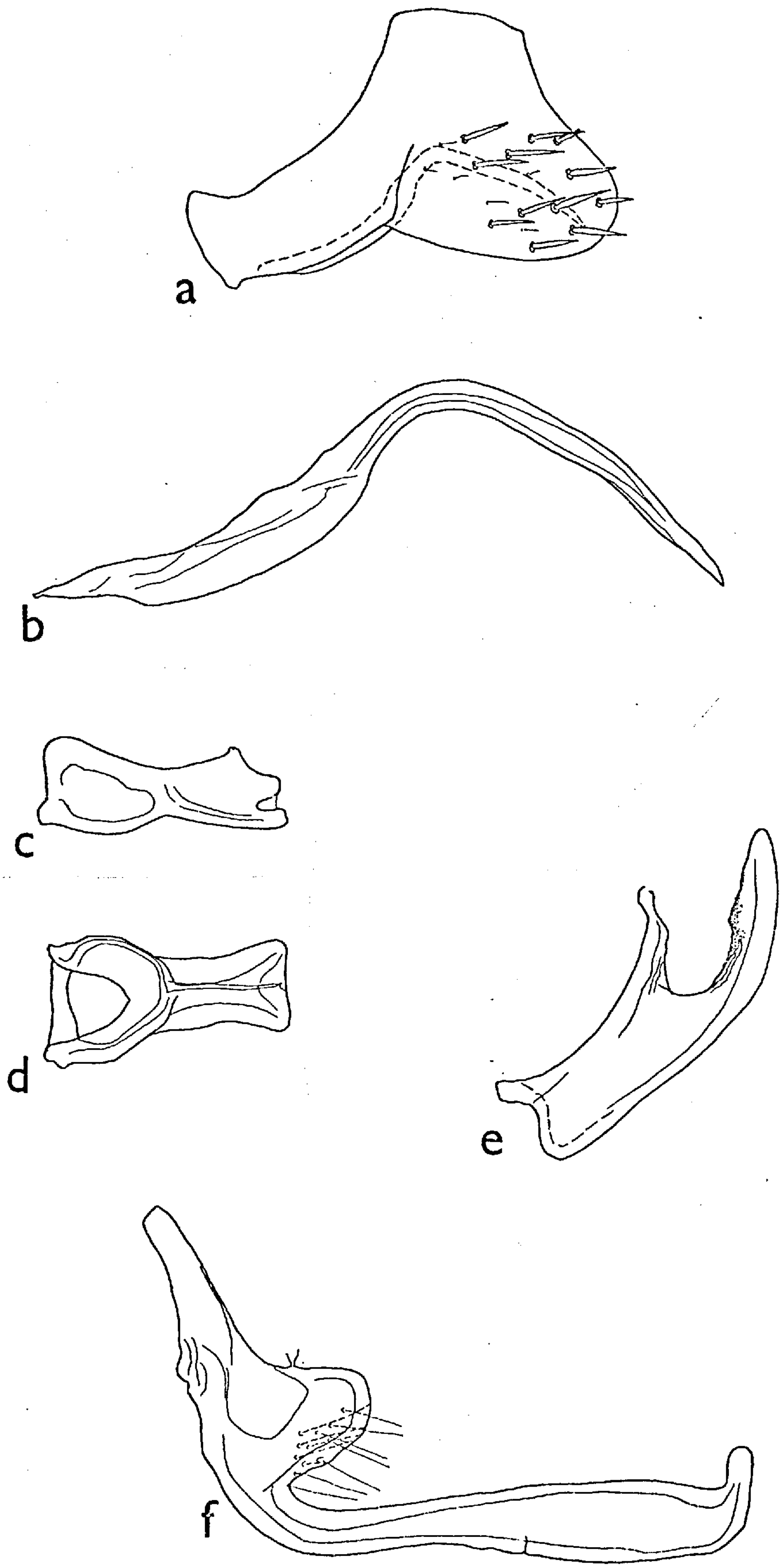


Fig. 26B - B. (s.str.) santosjuniori Lv. & Quart.

g, 8th sternite, ventral view

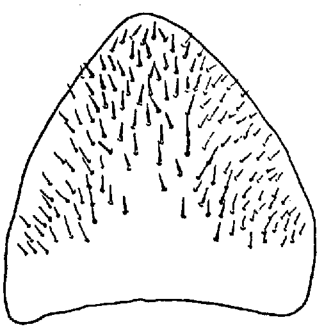
h, left genital plate, dorsal view

i, antecosta of second abdominal tergum, posterior view

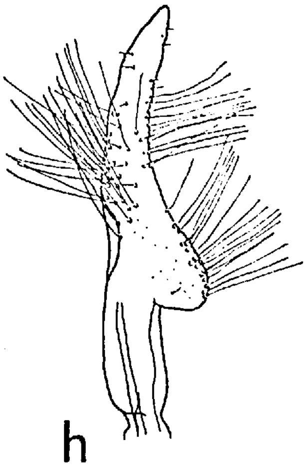
j, first sternal abdominal apodemes, posterior view

k, second sternal abdominal apodemes, postero-dorsal view

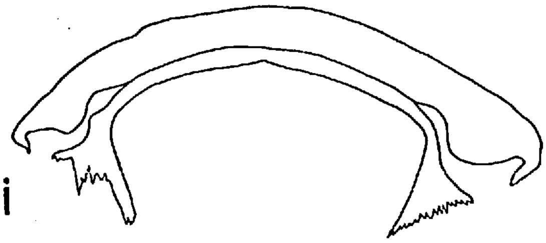
Scale as in Figs. 1A and 1B.



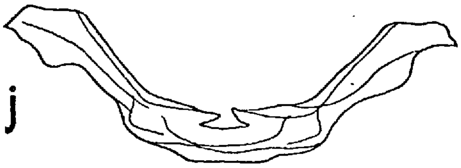
g



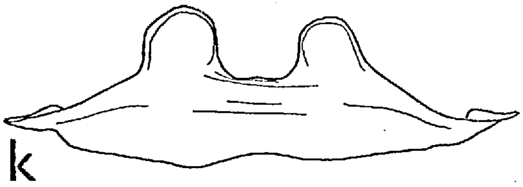
h



i



j



k

B. (s.str.) sapobensis n. sp.

(Figs. 27A : a-g; 27B : h-k)

Fairly shiny. Yellowish. Eyes reddish. Pronotum yellowish, disk, base and lateral margins dotted with brown. Scutellum golden yellow, spotted with light brownish. Elytra light yellowish, densely spotted with brown; base of appendix with a small brownish spot; appendix, first apical cell and tips of second and third apical cells infumated; veins of elytra concolorous; apical part of commissural margin of clavus greenish. Legs light yellow-brown, tarsi tinged with green.

Medium sized, robust. Length of male, 4.90 mm; female unknown. Crown 5.6 times as broad as long, 0.19 times as long as pronotum. Pronotum 1.96 times as broad as long, coarsely and transversely furrowed. Elytra distinctly punctate; puncturing dense, dark in brownish spots, in other parts concolorous; setae short, dark.

Male with notch of first sternal abdominal apodemes expanded medially (not illustrated because partly damaged). Second sternal abdominal apodemes lobe-shaped, relatively short, moderately separated, outer margins not steep, inner margins oblique, mesal margin rounded. Antecosta of second abdominal tergum strongly developed, with a small mesal sinuation.

Male genitalia with 8th sternite broad; apical part broadly rounded, setae dense. Side lobes of pygophore broadly rounded apically, each with 13-15 macrosetae and some small setae; appendages moderately curved, bifurcate apically, secondary branch spine-like, primary one minutely crenulate. Length of stylus 0.77 mm; dorsal margin of apophysis slightly expanded, ventral margin with a small arcuate sinuation; apical tooth on ventral margin of apophysis small; apical hook long, stout, more or less normally angled. Length of penis 0.53 mm; stem moderately stout, slightly curved dorsad, with small tubercles on lateral surfaces, anterior lamellae very minutely serrate; socle in lateral aspect 0.56 times as long as stem;

angle between socle and base of stem on posterior margin about 180°. Base of connective in dorsal view longer than wide; shaft shorter than base, dorsal keel in lateral view lower than base. Genital plates turned strongly laterad at mid-length, subapical part with long setae along outer margin.

Distribution : Guinean.

Ecology : Moist Forest at low and medium altitudes.

Material studied : Holotype male - Nigeria : Sapoba Forest Reserve near Benin, 12. III. 1972, E.W. Classey, B.M. 1972 - 190. In coll. B.M. (N.H.).

Remarks : A somewhat related to lamto Lv. & Quart. but smaller and easily distinguished from it by the much shorter branches of the pygophore appendages.

Fig. 27A - B. (s.str.) sapobensis n. sp.

a, male pygophore, left lateral view

b, apex of right appendage of pygophore, ventral view

c, right appendage of pygophore, left lateral view

d, connective, left lateral view

e, connective, dorsal view

f, penis, left lateral view

g, left stylus, left lateral view

27A

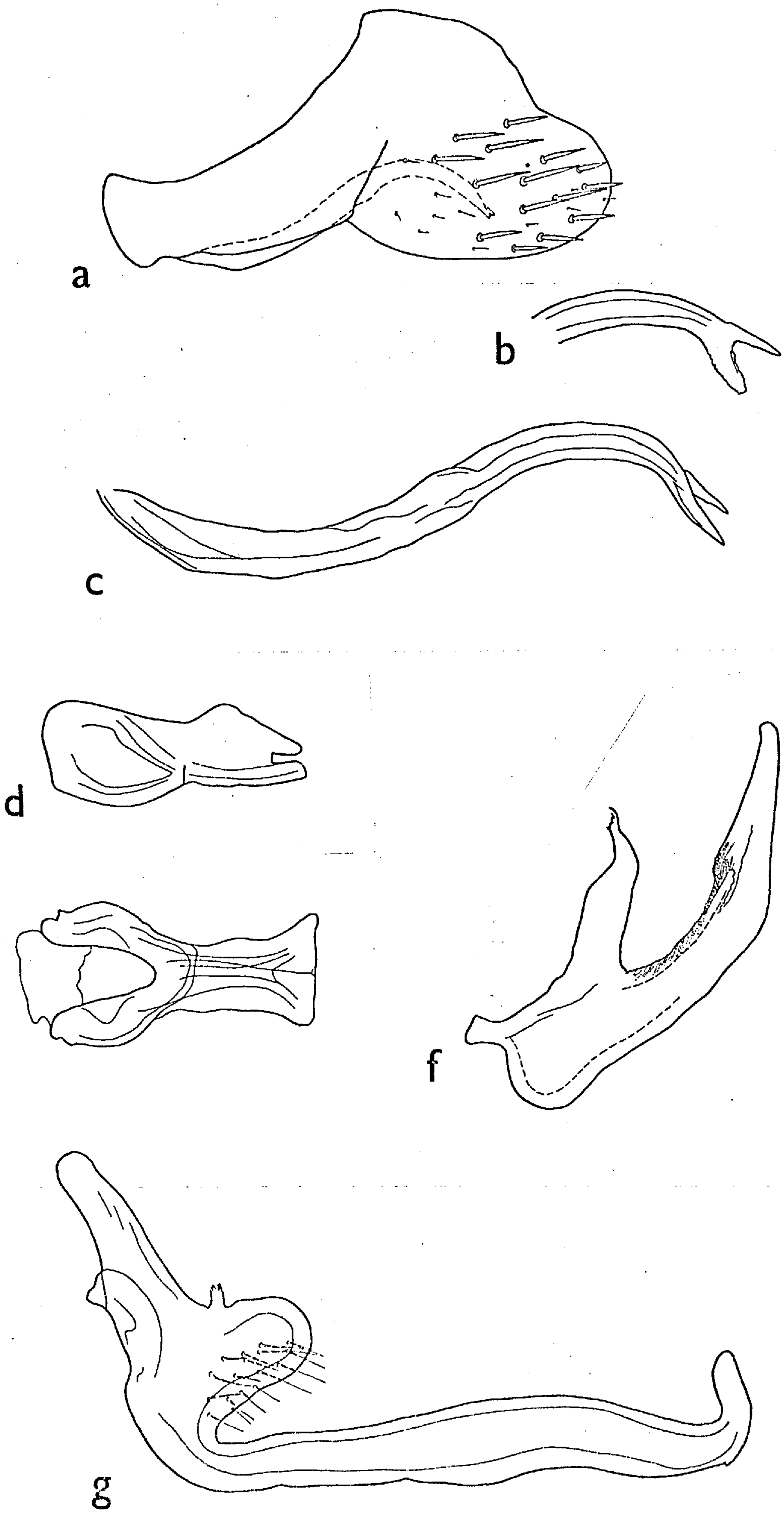


Fig. 27B - B. (s.str.) sapobensis n. sp.

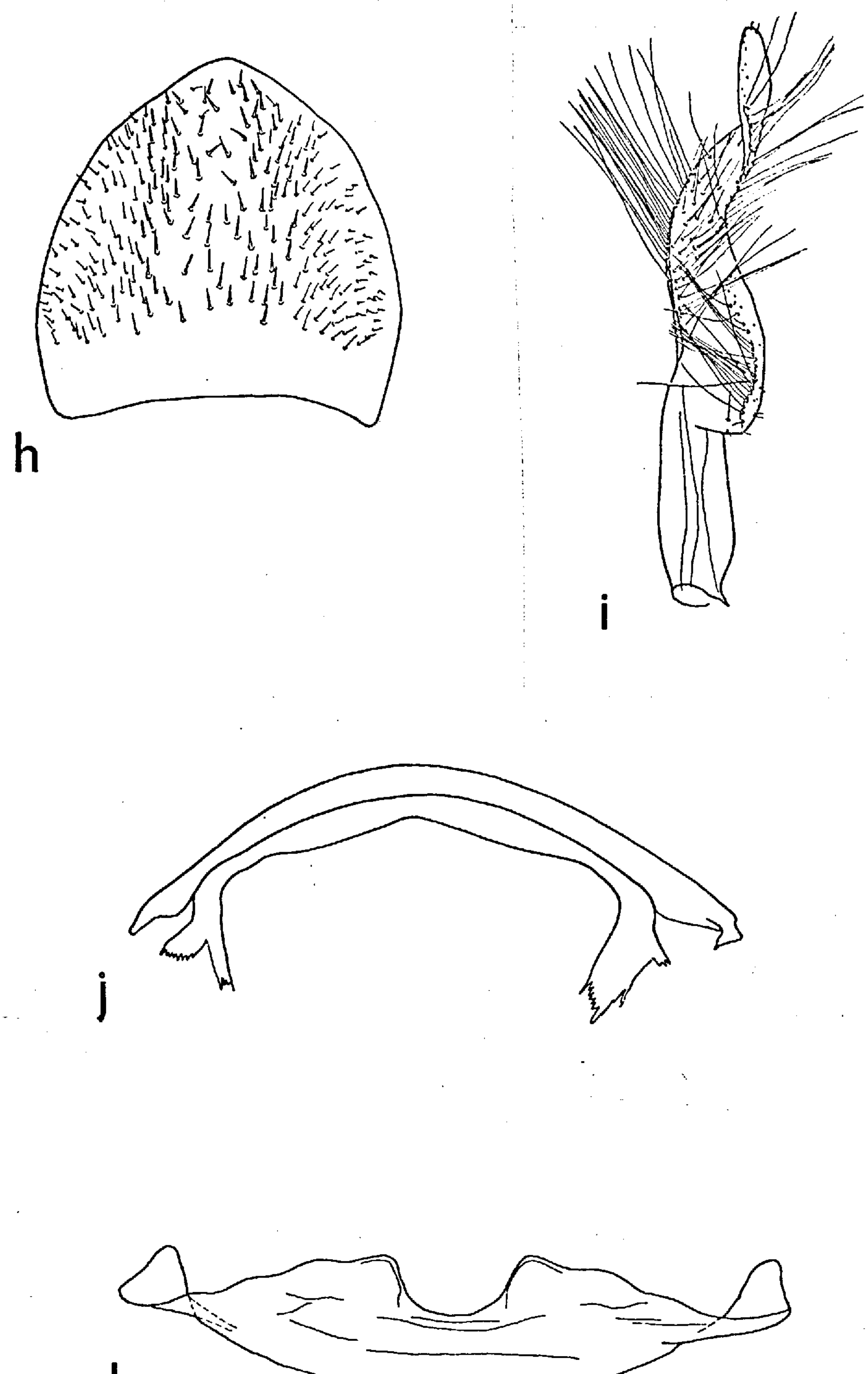
h, 8th sternite, ventral view

i, left genital plate, dorsal view

j, antecosta of second abdominal tergum, posterior view

k, second sternal abdominal apodemes, postero-dorsal view

Scale as in Figs. 1A and 1B.


h
i
j
k

B. (s.str.) signatus Ldb.

(Figs. 28A : a-g)(*)

Batrachomorphus signatus Lindberg, 1923 : 69 - 70.

Batrachomorphus glaber Haupt, 1927 : 15.

Batrachomorphus flavovirens Lindberg, 1948 : 134.

Batracomorphus saraivae Quartau, 1968 : 5 - 7.

Fairly shiny. Pale greenish yellow to pale green. Eyes reddish grey to brownish. Pronotum and scutellum greenish yellow, immaculate. Elytra greenish yellow or pale greenish; base of appendix with a small brownish or fuscous spot; veins of elytra concolorous, some parts tinged with green; claval suture and commissural margin of clavus greenish. Legs yellowish, tarsi and parts of tibiae greenish.

Medium-sized, relatively robust. Length 4.50 - 5.50 mm. Crown 4.70 - 6.75 times as broad as long, 0.16 - 0.23 times as long as pronotum. Pronotum 1.94 - 2.00 times as broad as long, finely and transversely furrowed. Elytra distinctly punctate; puncturing dense, concolorous; setae short, pale or brownish.

Male with notch of first sternal abdominal apodemes oval, compressed; lobes expanded medially, closely apposed. Second sternal abdominal apodemes lobe-shaped, moderately separated, outer margins not steep, inner margins curved, mesal margin rounded. Antecosta of second abdominal tergum strongly developed, with a small mesal sinuation.

Male genitalia with 8th sternite elongate; apical part broadly rounded, setae sparse. Side lobes of pygophore somewhat variable, broadly

* Illustrated in great detail in Linnavuori & Quartau (1975). Only the new structures are here presented.

rounded, truncate or bluntly angulate apically, each with 7 - 14 macrosetae; appendages semicircularly curved, simple, ventral margin smooth. Length of stylus 0.67 - 0.68 mm; apophysis of stylus broad, not constricted apically, dorsal margin approximately straight, ventral margin moderately expanded and with a small sinuation basally; apical tooth on ventral margin of apophysis small; apical hook very short, claw-like, more or less acutely angled. Length of penis 0.45 - 0.47 mm; stem tapering apicad, distinctly curved dorsad, tubercles on lateral surfaces obsolete; socle in lateral aspect 0.90 - 0.96 times as long as stem; angle between socle and base of stem on posterior margin less than 180°. Base of connective in dorsal view longer than wide; shaft short, dorsal keel in lateral view approximately as high as base. Genital plates turned slightly laterad at mid-length, subapical part with several long setae along outer margin.

Female genitalia with 7th sternite as illustrated in Linnavuori & Quartau (1975 : Fig. 61a).

Distribution : Soudanian. Sahelian. Mediterranean.

Ecology : Desert. Subdesert. Grassland savanna. On Acacia.

Material studied : 1 male - Nigeria : Samaru, Fadama, 9. VI. 1970, P.H. Ward, B.M. 1970 - 604. In coll. B.M. (N.H.).

Remarks : The species is especially variable in the shape of the side lobes of pygophore.

Closely related to akhmenes hargeisanus Lv. & Quart. but easily distinguished from it by the stouter stem and longer socle of penis. Closely related to artemisiae Ldb. and v-niger Ldb. as well, but easily distinguished from these species by the semicircularly curved appendages of pygophore.

Fig. 28A - B. (s.str.) signatus Ldb.

a, connective, left lateral view

b, connective, dorsal view

c, 8th sternite, ventral view

d, left genital plate, dorsal view

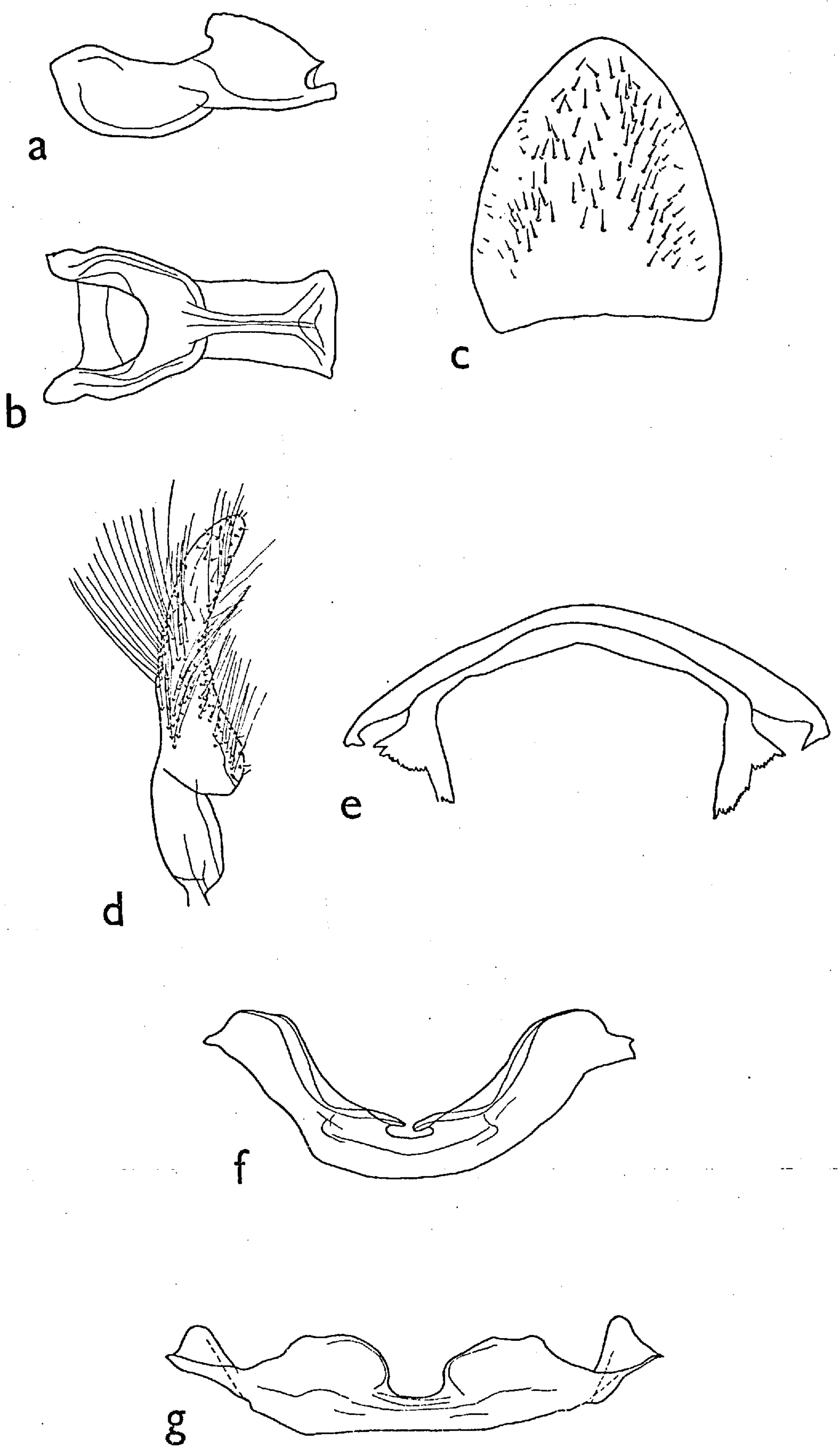
e, antecosta of second abdominal tergum, posterior view

f, first sternal abdominal apodemes, posterior view

g, second sternal abdominal apodemes, postero-dorsal view

Scale as in Figs. 1A and 1B.

28A



B. (s.str.) subolivaceus (St.)

(Figs. 29A : a-g; 29B : h-q; 29C : r-w;
29D : x-zd; 29E : ze-zg)

Bythoscopus subolivaceus Stål, 1855 : 99.
Bythoscopus segregatus Naudé, 1926 : 20.

Shiny. Orangish yellow, yellowish brown or greenish. Eyes greyish brown, greyish or reddish grey. Pronotum and scutellum yellowish, yellowish brown or greenish, immaculate. Elytra greenish or yellowish, corium sometimes with a faint brownish stripe parallel to claval suture; appendix slightly infumated, base of same with a fuscous or brownish spot; sometimes first apical cell slightly smoky; veins of elytra yellowish, some parts greenish; commissural margin of clavus greenish, especially on apical part, sometimes apical half brownish. Legs yellowish, tarsi and apical part of tibiae greenish.

Small to medium-sized, moderately robust. Length of male, 3.85 - 4.77 mm; female, 4.38 - 5.75 mm. Crown 4.5 - 6.8 times as broad as long, 0.18 - 0.29 times as long as pronotum. Pronotum 1.94 - 2.26 times as broad as long, finely and transversely furrowed. Elytra distinctly punctate; puncturing dense, concolorous or slightly brownish in the brownish stripe; setae short, pale.

Male with notch of first sternal abdominal apodemes oval, compressed; lobes expanded medially, closely apposed. Second sternal abdominal apodemes lobe-shaped, often moderately separated, rarely set closer together than half their individual width at middle, outer margins steep, inner margins oblique to vertical, mesal margin approximately straight to rounded. Antecosta of second abdominal tergum strongly developed, with an obsolete to a small mesal sinuation.

Male genitalia with 8th sternite broad, apical part more or less broadly rounded, setae relatively dense. Side lobes of pygophore short, broadly rounded apically, each with 5 - 15 macrosetae; appendages approximately straight to moderately curved, short, somewhat variable in shape; apical part of appendages smooth or minutely serrate, sometimes provided with a bluntly triangular subapical expansion or a strong subapical tooth on ventral margin. Length of stylus 0.58 - 0.71 mm; apophysis broadish, somewhat variable in shape, sometimes constricted apically, dorsal margin moderately to broadly expanded, rarely straight, ventral margin approximately straight; apical tooth on ventral margin distinct, sometimes strong; apical hook moderately developed, more or less stout, blunt, slightly obtusely angled. Length of penis 0.42 - 0.56 mm; stem long, moderately stout, approximately straight to moderately curved dorsad; lateral surfaces with small tubercles, anterior lamellae very minutely serrate, nearly smooth; socle in lateral aspect 0.21 - 0.38 times as long as stem; angle between socle and base of penis on postero-ventral margin greater than 180°. Base of connective in dorsal view broad; shaft in general as long as base, rarely shorter or longer, dorsal keel in lateral view often as high as base, sometimes lower. Genital plates rather straight to turned slightly laterad at mid-length, subapical part with some long setae along outer margin.

Female genitalia with 7th sternite as illustrated.

Distribution : Cape. Karroo-Namaqualian. Kalaharian. Basutolian.

Ecology : Cape macchia. Semi-desert. Wooded Steppe with abundant <u>Acacia</u> and <u>Commiphora</u>. Temperate and Subtropical Grassland.

Material studied : 1 male, Botswana; Lake Ngami, 12 mls, N.E. Sehithwa, 16 - 17. IV. 1972, at light, Southern African Expedition, B.M. 1972 - I. 1 male, 1 female, South Africa : Winburg, O.F.S.,

8. XI. 1966, A.L. Capener, Ac. No. 113, Brit. Mus. 1968 - 511; 7 males, 4 females, Cape Province, Ceres, Feb. 1925, R.E. Turner, Brit. Mus., 1925 - 116; 9 males, 14 females, Ceres, March 1925, R.E. Turner, Brit. Mus., 1925 - 161; 1 female, Ceres, April 1925, R.E. Turner, Brit. Mus., 1925 - 210; 2 males, 7 females, Cape Town, Milnerton, 14 - 28. XII. 1925, R.E. Turner, Brit. Mus., 1926 - 28; 5 males, 5 females, Cape Province, Matjesfontein, 1 - 18. XII. 1928, R.E. Turner, Brit. Mus., 1929 - 15; 1 male, Cape Province, Swellendam, 17. XII. 31 - 18. I. 32, R.E. Turner, Brit. Mus., 1932 - 56; 1 female, Cape Province, Queenstown, 3,500 ft, 16. I - 10. II. 1923, R.E. Turner, Brit. Mus., 1923 - 140; 3 females, Cape Province, Mossel Bay, VI - VII. 1930, R.E. Turner, Brit. Mus., 1930 - 402. In coll. B.M. (N.H.).

Remarks : The species is variable mainly in the appendages of pygophore, apophysis of stylus and second sternal abdominal apodemes. Part of this variability seems to be geographical but even among individuals from the same locality there is considerable variation such as in the appendages of pygophore and stylus.

Easily distinguished from astyages Lv. & Quart. by the absence of coarsely dentate longitudinal lamellae on posterior surface of stem of penis. Distinguished from arcuatus Lv. & Quart. by the apophysis of stylus which is not strongly expanded, and by the apical hook of same which is obtusely angled.

Three specimens without abdomen, Ceres, March 1925, R.E. Turner, Brit. Mus., 1925 - 161, probably belong to this species.

A large male from Mossel Bay (S. Africa, Cape Province, VI - VII. 1930, R.E. Turner, Brit. Mus., 1930 - 402, in coll. B.M. (N.H.), possibly representing a separate species is here described and provisionally assigned to subolivaceus (Figs. 29E : ze-zg).

Description - as subolivaceus, with the following differences : Length, 5.42 mm. Corium of elytra without faint brownish stripe parallel to claval suture. Elongate. Appendages of pygophore more acute apically. Apophysis of stylus with a stouter and shorter apical hook. Second sternal abdominal apodemes with inner margins curved.

Fig. 29A - _B_. (s.str.) _subolivaceus_ (St.)
(a, e-f, h-i, n-p, r-t, w, y, L. Ngami;
b, Milnerton; c, g, j-k, l-m, o, q, u, z,
za, six males from Ceres; d, zb, Swellendam;
v, x, Winburg ; zc, female from Ceres; zd,
female from Winburg; ze-zg, another male
from Ceres (_subolivaceus_ ?)

a, male pygophore, left lateral view
b-e, left appendage of pygophore, left
lateral view
f-g, apical part of left appendage of
pygophore, left lateral view

29A

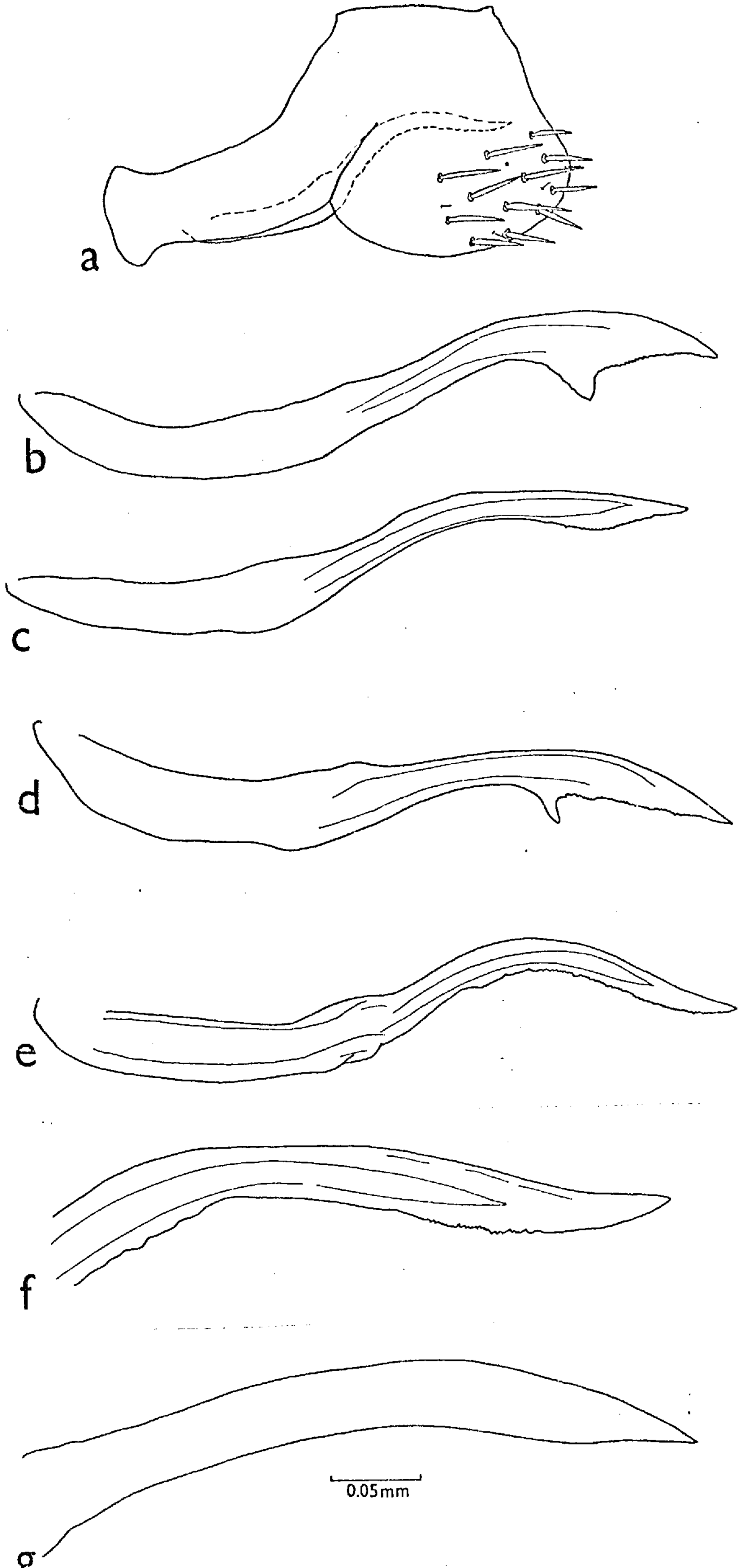


Fig. 29B - B. (s.str.) subolivaceus (St.)

h, j, l, connective, left lateral view

i, k, m, connective, dorsal view

n, penis, left lateral view

o-q, left stylus, left lateral view

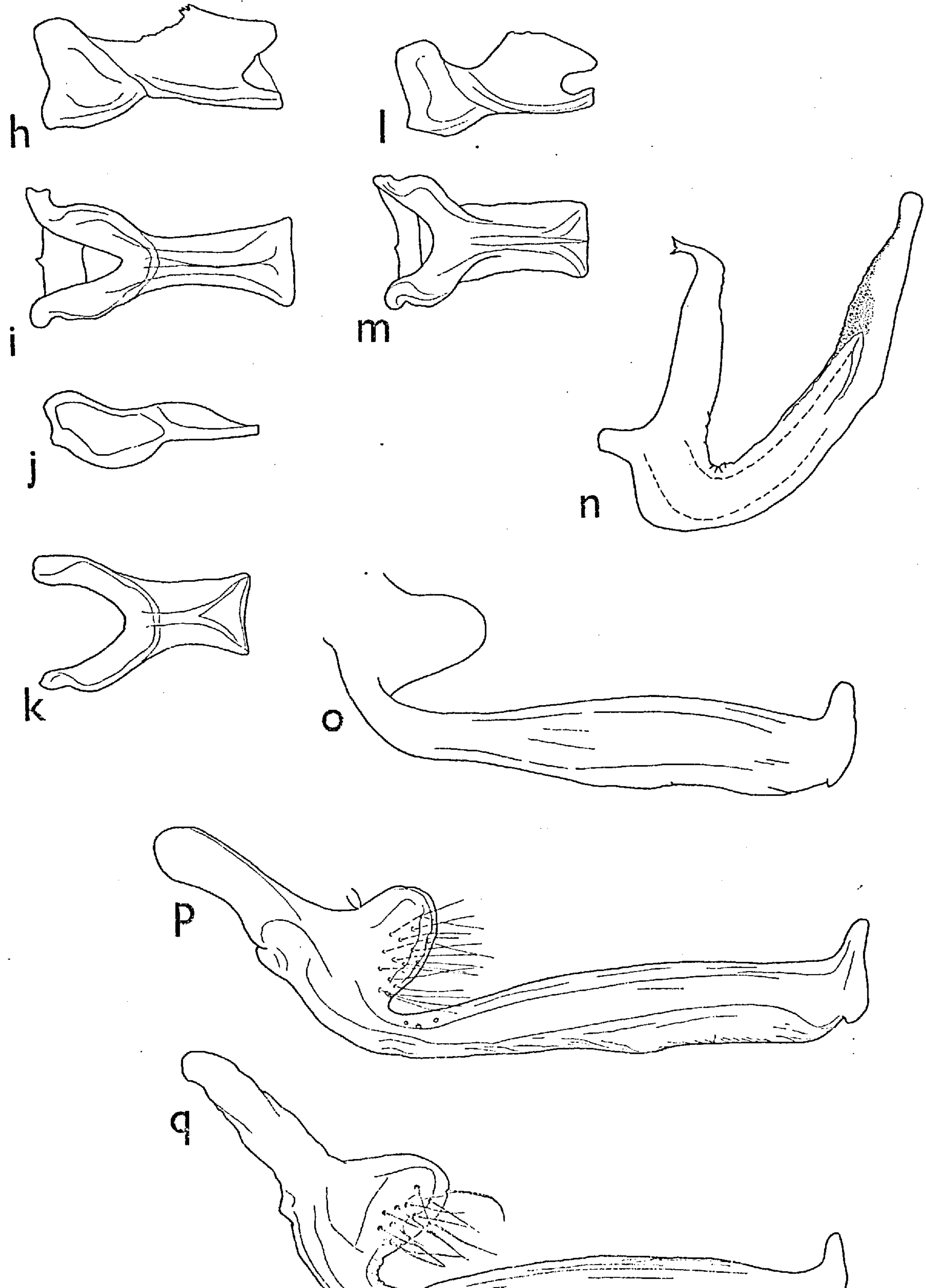

h
l
i
m
j
n
k
o
p
q

Fig. 29C - B. (s.str.) subolivaceus (St.)

r, 8th sternite, ventral view

s, left genital plate, dorsal view

t-u, antecosta of second abdominal tergum, posterior view

v-w, first sternal abdominal apodemes, posterior view

29C

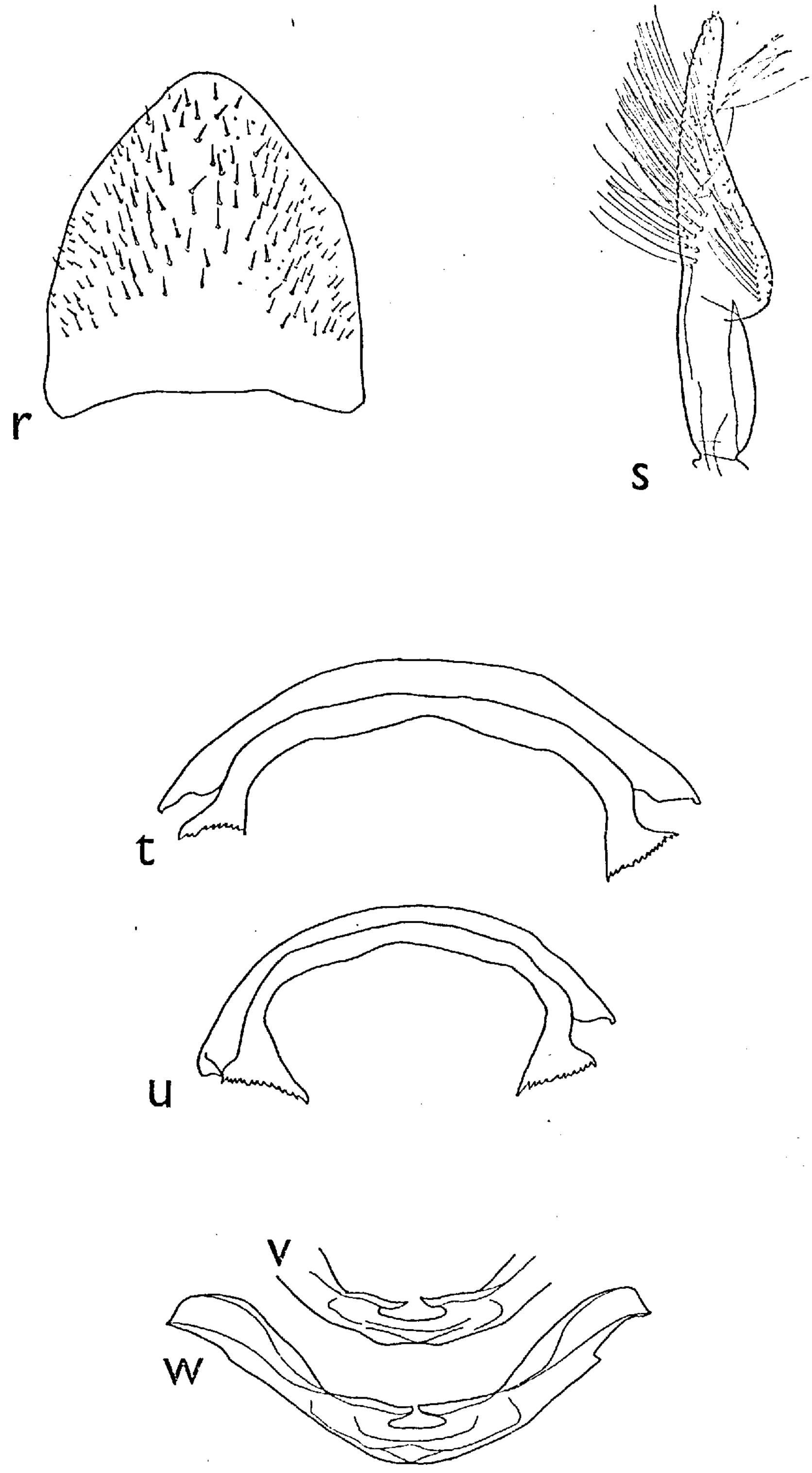


Fig. 29D - B. (s.str.) subolivaceus (St.)

x-zb, second sternal abdominal apodemes,
postero-dorsal view

zc-zd, female 7th abdominal sternite,
ventral view

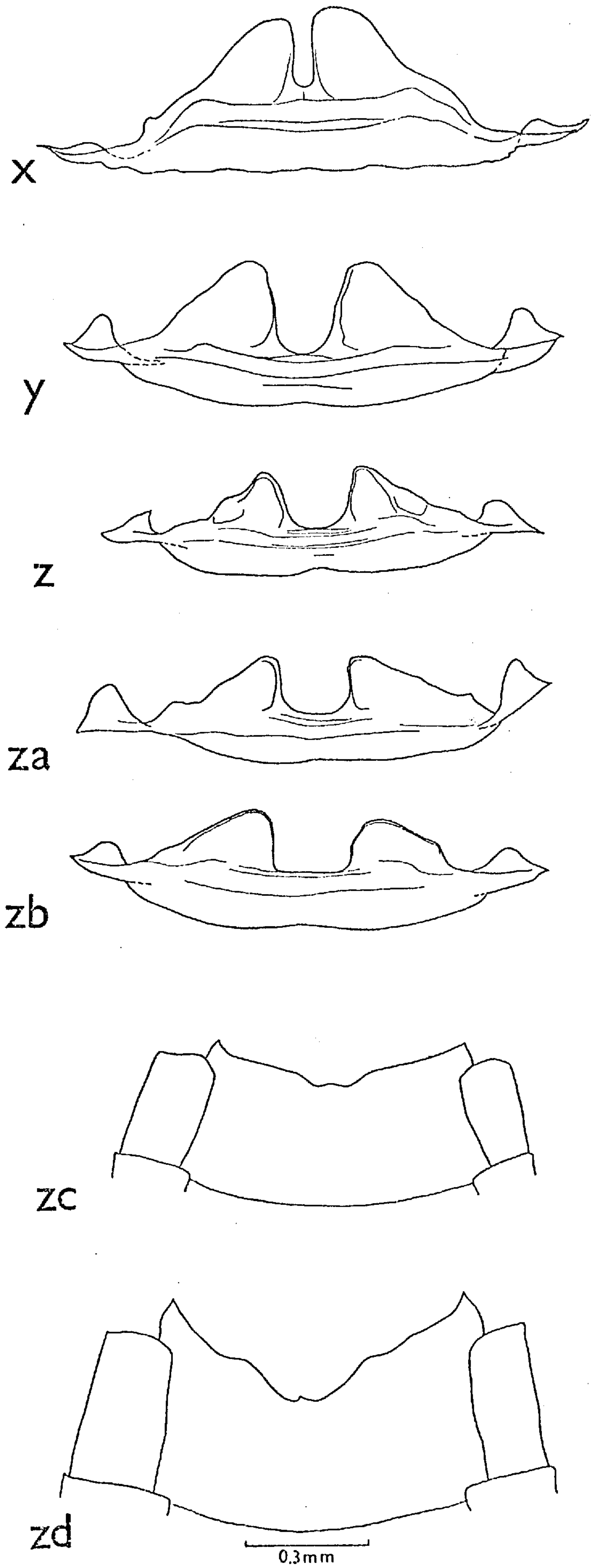

x
y
z
za
zb
zc
zd
0.3mm

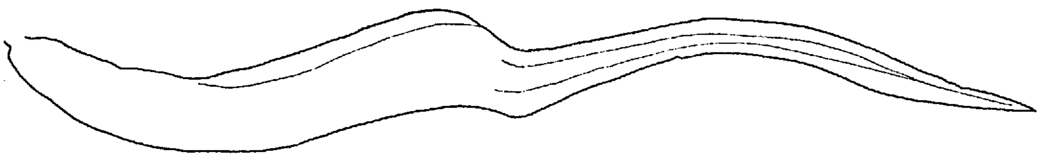
Fig. 29E - B. (s.str.) subolivaceus (St.)(?)

ze, left appendage of pygophore,
left lateral view

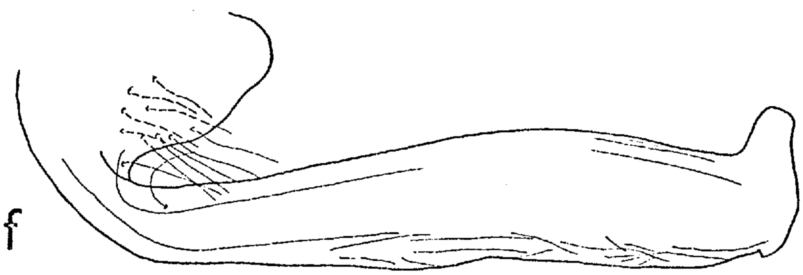
zf, left stylus, left lateral view

zg, second sternal abdominal apodemes,
postero-dorsal view

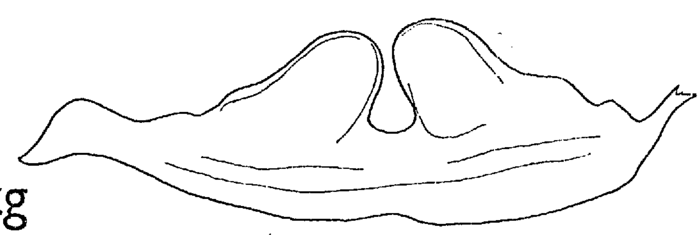
Scale as in Figs. 1A and 1B or, otherwise, as indicated.



ze



zf



zg

B. (s.str.) teispes Lv. & Quart

(Figs. 30A : a-f; 30B : g-k)

Batracomorphus (s.str.) teispes Linnavuori & Quartau, 1975 : 83.

Fairly shiny to shiny. Yellowish. Eyes reddish brown. Pronotum yellowish, with golden tinge. Scutellum greenish yellow, immaculate. Elytra light yellowish; base of appendix with a faint fuscous spot; veins of elytra concolorous, commissural margin of clavus tinged with green at apex. Legs pale yellowish, tarsi tinged with green.

Medium-sized, moderately robust. Length of male, 4.75 - 5.09 mm (mean 4.92 mm); female unknown. Crown 5.3 - 5.4 times (mean 5.4) as broad as long, 0.21 times as long as pronotum. Pronotum twice as broad as long, finely and transversely furrowed. Elytra obsoletely punctate; puncturing concolorous; setae short, pale or brownish.

Male with notch of first sternal abdominal apodemes approximately oval; lobes expanded medially, relatively separated from each other. Second sternal abdominal apodemes lobe-shaped, moderately separated, outer margins not steep, inner margins approximately vertical, mesal margin straight. Antecosta of second abdominal tergum strongly developed, mesal sinuation absent.

Male genitalia with 8th sternite broad; apical part broadly rounded, setae dense. Side lobes of pygophore broadly rounded to roundedly truncate apically, each with 7 - 15 macrosetae; appendages strongly curved, bifurcate just at apex, secondary branch small, tooth-like. Length of stylus 0.78 - 0.90 mm (mean 0.84 mm); apophysis long, dorsal margin approximately straight, ventral margin slightly expanded; apical tooth on ventral margin of apophysis small; apical hook very long, more or less normally angled. Length of penis 0.57 - 0.69 mm (mean 0.63 mm); stem very long, moderately curved dorsad, anterior surface with a pair of apical teeth, posterior surface with finely serrate lamellae, lateral surfaces with small tubercles; socle in lateral aspect 0.16 - 0.27 times (mean 0.22) as long as stem; angle between socle and base of stem on postero-ventral margin greater than 180°. Base of connective in dorsal view broad; shaft moderately developed, dorsal keel in lateral view approximately as high as base. Genital plates turned slightly laterad at mid-length, sub-apical part with long setae along outer margin.

Distribution : Soudanian.

Ecology : Gallery forest. Grassland savanna.

Material studied : 1 male, Nigeria : Samaru, 18 - 25. V. 1970, M/V light trap, white sheet, P.H. Ward. B.M. 1970 - 604. In coll. B.M. (N.H.).

Remarks : Distinguished from mongbwalu distinguendus Lv. & Quart. by the much less curved stem of penis, the apical teeth of same, and by the longer apical hook of stylus which apically is not truncate.

Fig. 30A - B. (s.str.) teispes Lv. & Quart.

a, male pygophore, left lateral view

b, left appendage of pygophore, left lateral view

c, connective, left lateral view

d, connective, dorsal view

e, penis, left lateral view

f, left stylus, left lateral view

30A

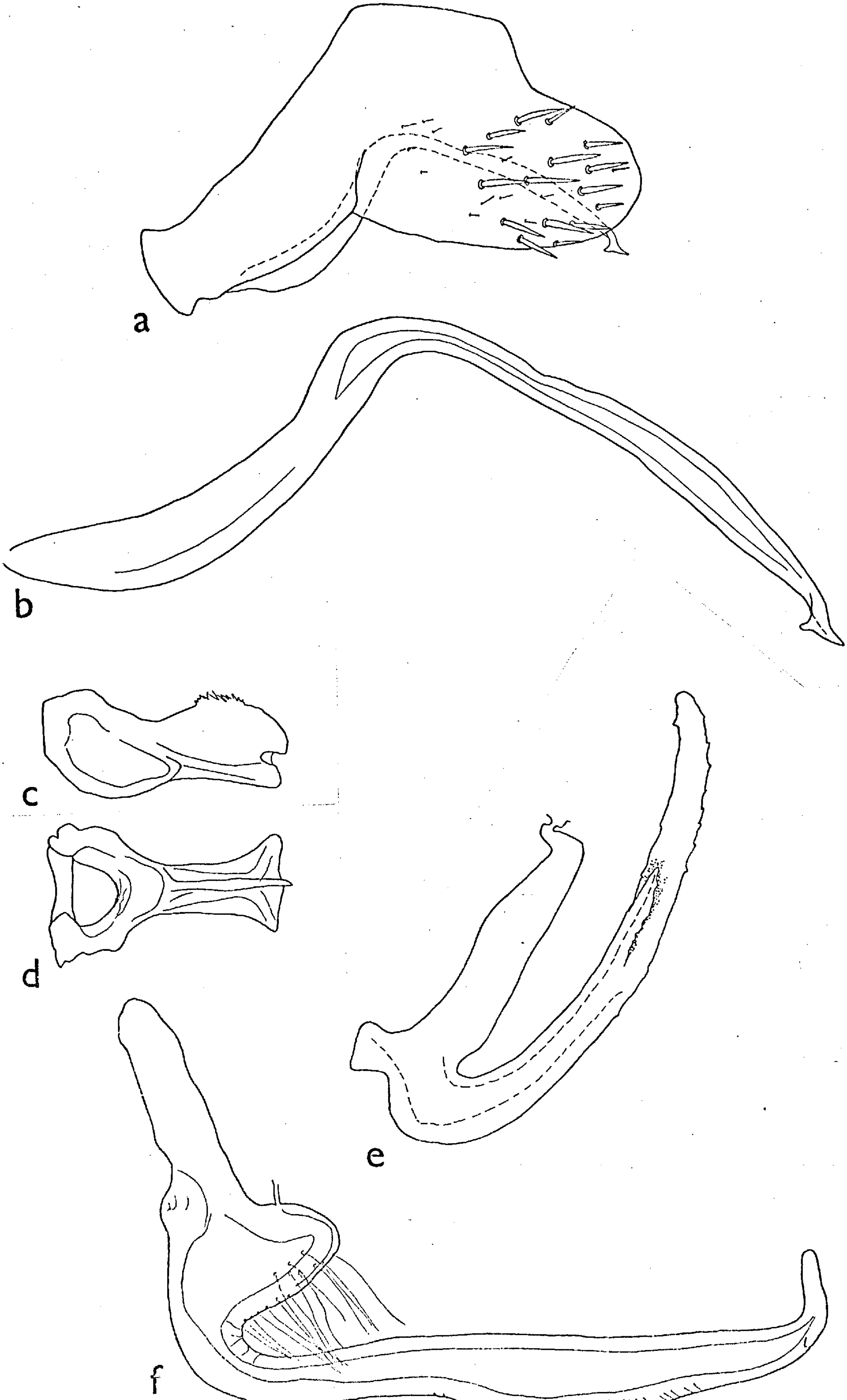


Fig. 30B - B. (s.str.) teispes Lv. & Quart.

g, 8th sternite, ventral view

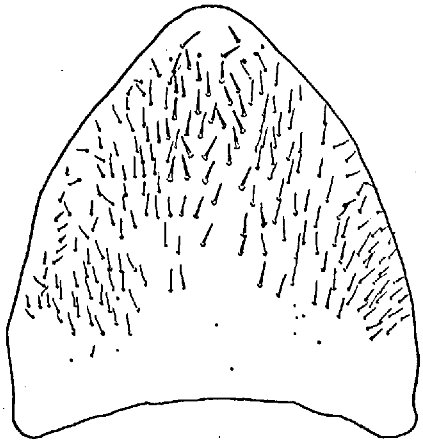
h, left genital plate, dorsal view

i, antecosta of second abdominal tergum, posterior view

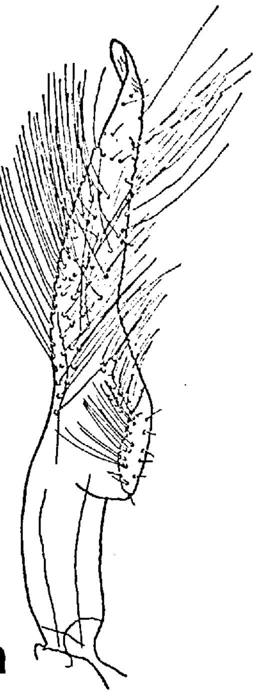
j, first sternal abdominal apodemes, posterior view

k, second sternal abdominal apodemes, postero-dorsal view

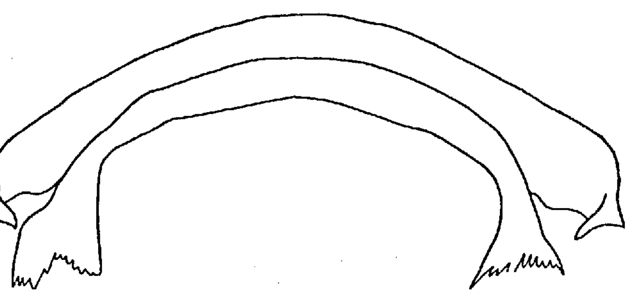
Scale as in Figs. 1A and 1B.



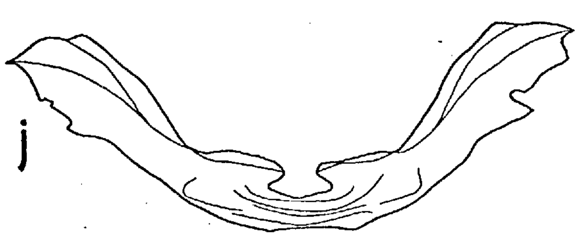
g



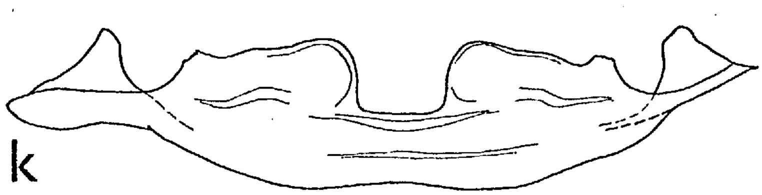
h



i



j



k

B. (s.str.) thamyris Lv. & Quart.

(Figs. 31A : a-g; 31B : h-k)

Batracomorphus (s.str.) thamyris Linnavuori & Quartau, 1975 : 41 - 42.

Fairly shiny. Pale ochraceous or pale greenish yellow. Eyes reddish brown or brownish grey. Crown with two round dark spots. Pronotum pale yellowish, anterior margin often with a row of fuscous spots, lateral margins with two blackish spots behind eyes. Scutellum yellowish, with black or brown basal triangles, often with two brown spots medially, apex pale. Elytra pale ochraceous; base of appendix tinged with brown, veins more or less fuscous. Legs yellowish, tarsi and apex of tibiae green.

Medium-sized, rather elongate. Length 5.0 - 5.5 mm . Crown 4.7 - 5.6 times as broad as long, 0.15 - 0.21 times as long as pronotum. Pronotum about twice as broad as long, finely and transversely furrowed. Elytra obsoletely punctate; puncturing dense, concolorous; setae short, pale.

Male with second sternal abdominal apodemes lobe-shaped; lobes moderately separated, outer margins more or less steep, inner margins vertical, mesal margin straight.

Male genitalia with 8th sternite broad; apical part more or less broadly rounded, setae dense. Side lobes of pygophore broadly angulate apically, each with 11 - 17 macrosetae; appendages rather straight, simple, apical part slightly expanded and minutely serrate. Length of stylus 0.78 - 0.90 mm; apophysis gracile, dorsal margin slightly expanded, ventral margin nearly straight; apical tooth on ventral margin of apophysis absent; apical hook long, stout, blunt, normally angled. Length of penis 0.64 - 0.65 mm; stem long, rather straight, finely serrate apically, tubercles on lateral surfaces absent; socle 0.38 - 0.40 times as long as stem; angle between socle and base of stem on posterior margin greater than 180°. Base of connective in dorsal view broad; shaft longer than base, dorsal keel slightly lower than base. Genital plates rather straight, subapical part with a few long setae along outer margin.

Female genitalia with 7th sternite as illustrated.

Distribution : Soudanian.

Ecology : Savanna forests. Grassland savanna.

Material studied : 1 female, paratype, Sudan : Bahr el Ghazal, R. Pongo, 18. II. 63, Linnavuori, in author's collection. 1 male, Nigeria : Samaru, Fadama, 9. VI. 1970, P.H. Ward, B.M. 1970 - 604; 1 female, Samaru, 26 - 31. V. 1970, mercury vapour light trap, other data as before; in B.M. (N.H.).

Remarks : Previously known from Sudan. The new material is much paler in pronotum and has the scutellum immaculate.

A distinctive species, though resembling polydoros Lv. & Quart. on the basis of the penis. Easily distinguished from the latter, however, by the normally angled apical hook of stylus, and by the minutely serrate pygophore appendages.

Fig. 31A - B. (s.str.) thamyris Lv. & Quart.

a, head, pronotum and scutellum, dorsal view

b, male pygophore, left lateral view

c, left appendage of pygophore, left lateral view

d, connective, left lateral view

e, connective, dorsal view

f, penis, left lateral view

g, right stylus, right lateral view

31A

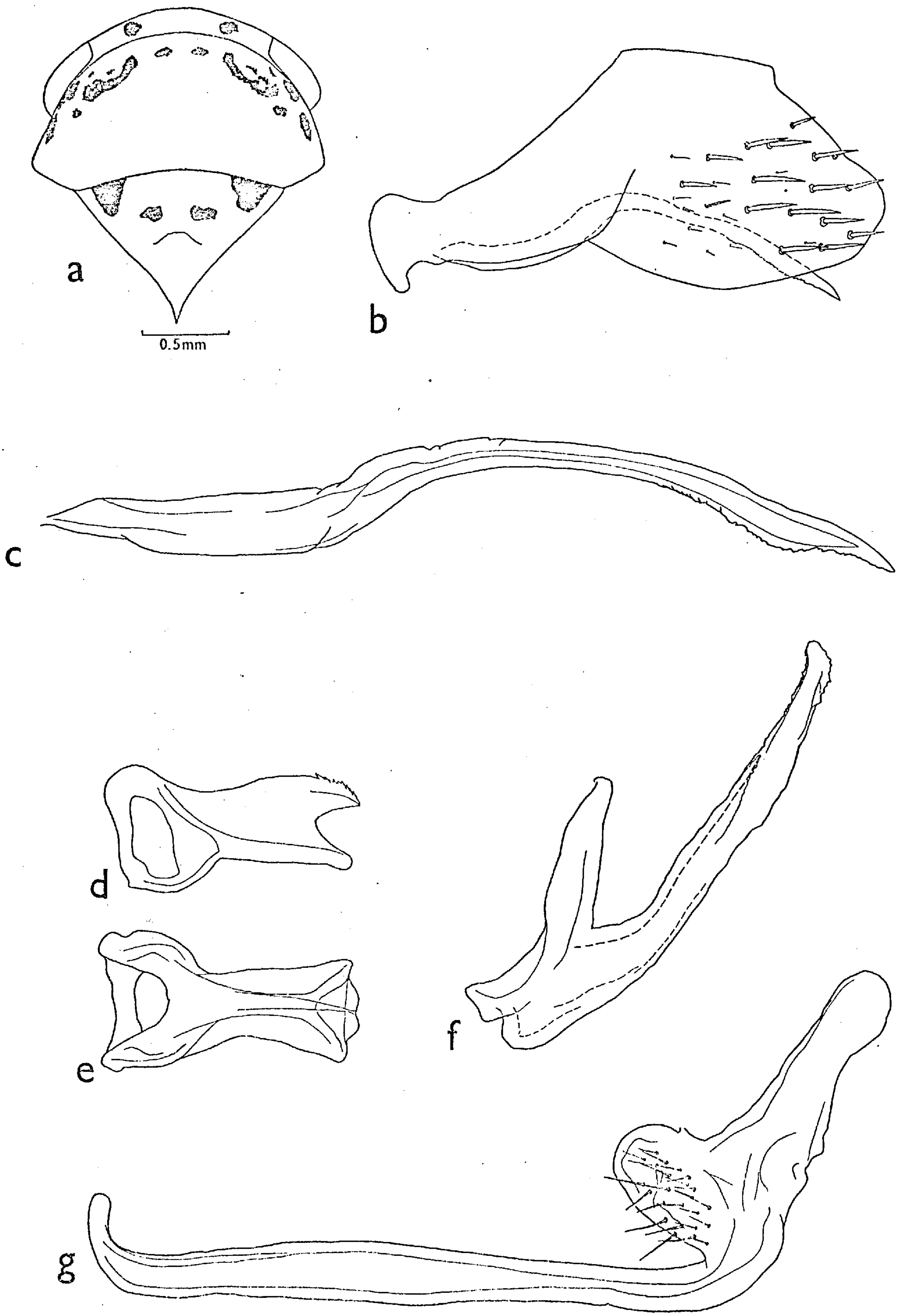


Fig. 31B - B. (s.str.) thamyris Lv. & Quart.

h, 8th sternite, ventral view

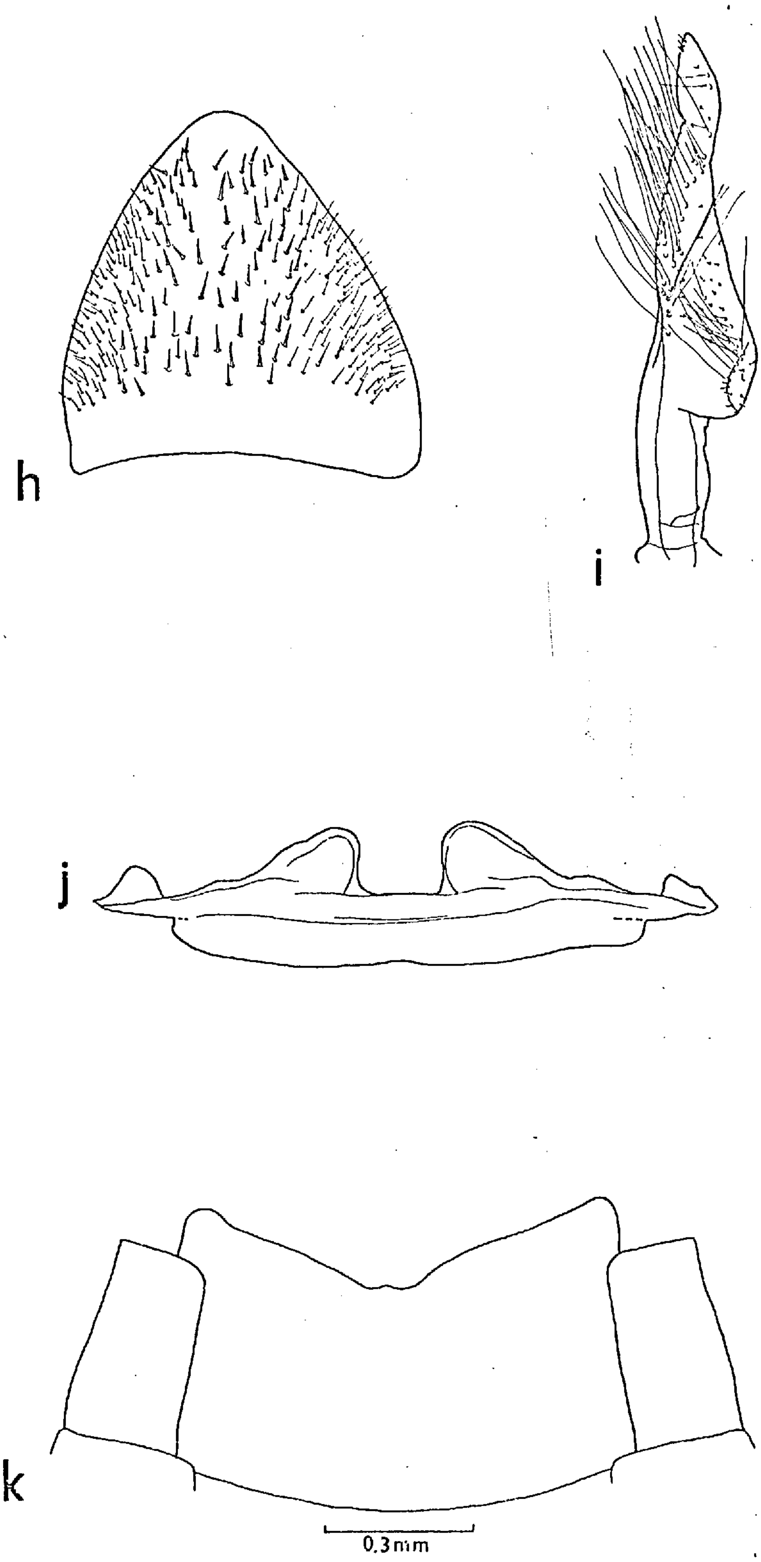
i, left genital plate, dorsal view

j, second sternal abdominal apodemes, postero-dorsal view

k, female 7th abdominal sternite, ventral view

Scale as in Figs. 1A and 1B or, otherwise, as indicated.

31B



B. (s.str.) timaea Lv.

(Figs. 32A : a-f; 32B : g-k)

Batracomorphus (s.str.) timaea Linnavuori, 1969 : 1134.

Fairly shiny. Whitish green or greenish yellow. Eyes reddish grey. Pronotum and scutellum yellowish to greenish, immaculate. Elytra yellowish or whitish green; base of appendix tinged with brown; veins of elytra concolorous; commissural margin of clavus green. Legs yellowish or whitish green, tarsi and apical part of tibiae green.

Small to medium-sized, moderately elongate. Length 4.20 - 4.96 mm. Crown 5.3 - 6.6 times as broad as long, 0.18 - 0.21 times as long as pronotum. Pronotum 2.10 - 2.16 times as broad as long, finely and transversely furrowed. Elytra obsoletely punctate; puncturing sparse, concolorous; setae short, dark.

Male with notch of first sternal abdominal apodemes oval; lobes expanded medially, relatively separated from each other. Second sternal abdominal apodemes lobe-shaped, distinctly longer and set farther apart than half their individual width at middle, inner margins rounded, mesal margin angularly curved. Antecosta of second abdominal tergum strongly developed, with a small mesal sinuation.

Male genitalia with 8th sternite elongate; apical part acutely rounded, setae dense. Side lobes of pygophore rounded to broadly truncate apically, each with 10 - 11 macrosetae; appendages strongly curved, simple, expanded apically. Length of stylus 0.66 - 0.71 mm; apophysis broad, dorsal margin nearly straight, ventral margin strongly expanded at middle; apical tooth on ventral margin of apophysis obsolete; apical hook long, slightly acutely angled. Length of penis 0.48 - 0.53 mm; stem stout, slightly curved dorsad, lateral surfaces with small tubercles, anterior lamellae practically smooth; socle in lateral aspect 0.70 - 0.76 times as long as stem; angle between socle and base of stem on ventral margin about 180°. Base of connective in dorsal view broad; shaft longer than base, dorsal keel in lateral view distinctly higher than base. Genital plates rather straight, subapical part with several long setae along outer margin.

Female genitalia with hind margin of 7th sternite strongly sinuate and with an obsolete medial tooth.

Distribution : Guinean.

Ecology : Moist Forest at low and medium altitudes.

Material studied : 1 male, Angola : Salazar, I.I.A.A., 9 - 15. III. 1972, at light, Southern African Expedition, B.M. 1972 - I. In coll. B.M. (N.H.).

Remarks : Distinguished from arcuatus Lv. & Quart. by the much less expanded apophysis of stylus, the longer socle of penis, and by the smooth apical expansion of the pygophore appendages. Distinguished from dirke Lv. & Quart. mainly by the apical hook of stylus which is shorter and slightly acutely angled.

Fig. 32A - B. (s.str.) timaea Lv.

a, male pygophore, left lateral view

b, right appendage of pygophore, left lateral view

c, connective, left lateral view

d, connective, dorsal view

e, penis, left lateral view

f, left stylus, left lateral view

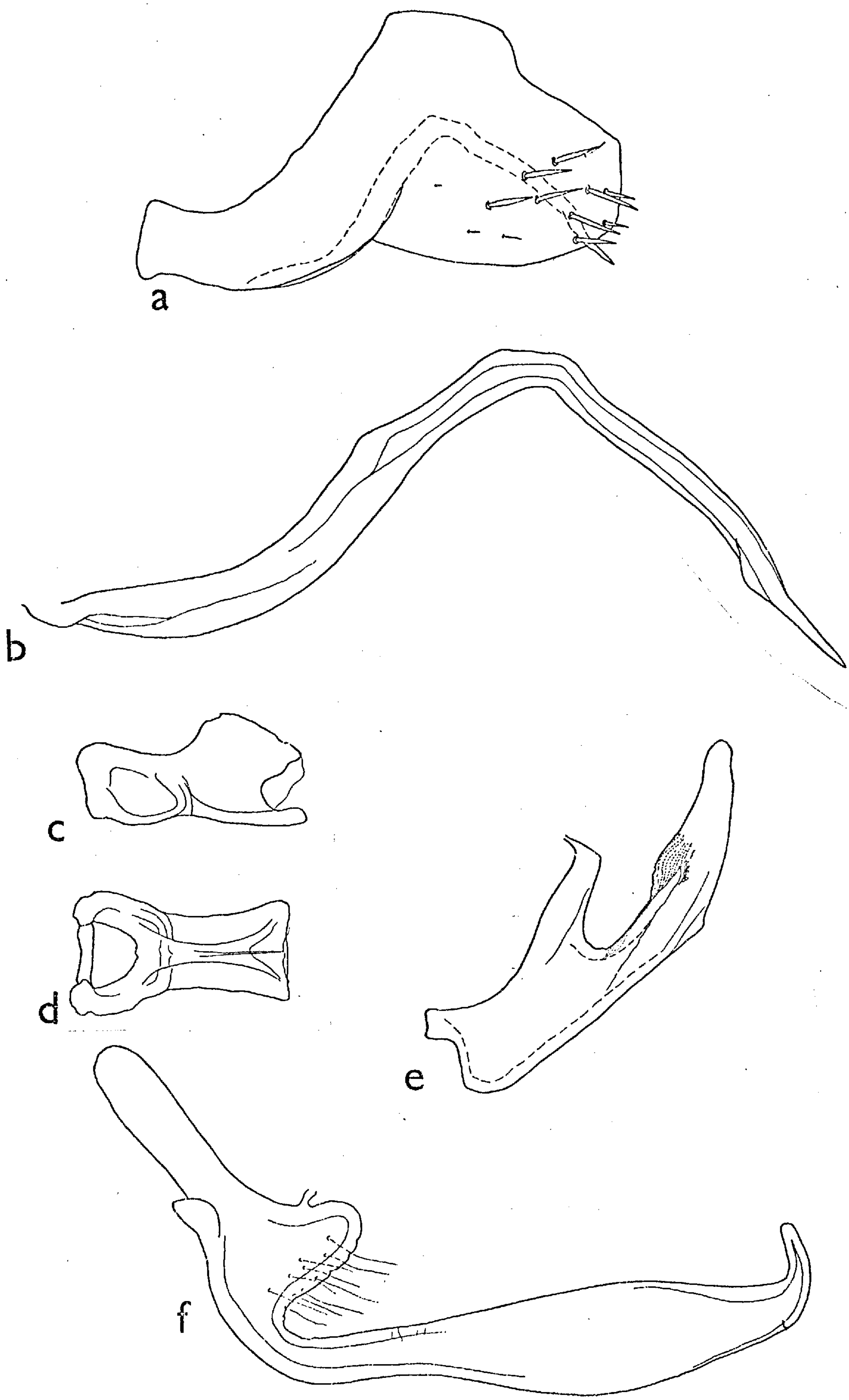

a
b
c
d
e
f

Fig. 32B - B. (s.str.) timaea Lv.

g, 8th sternite, ventral view

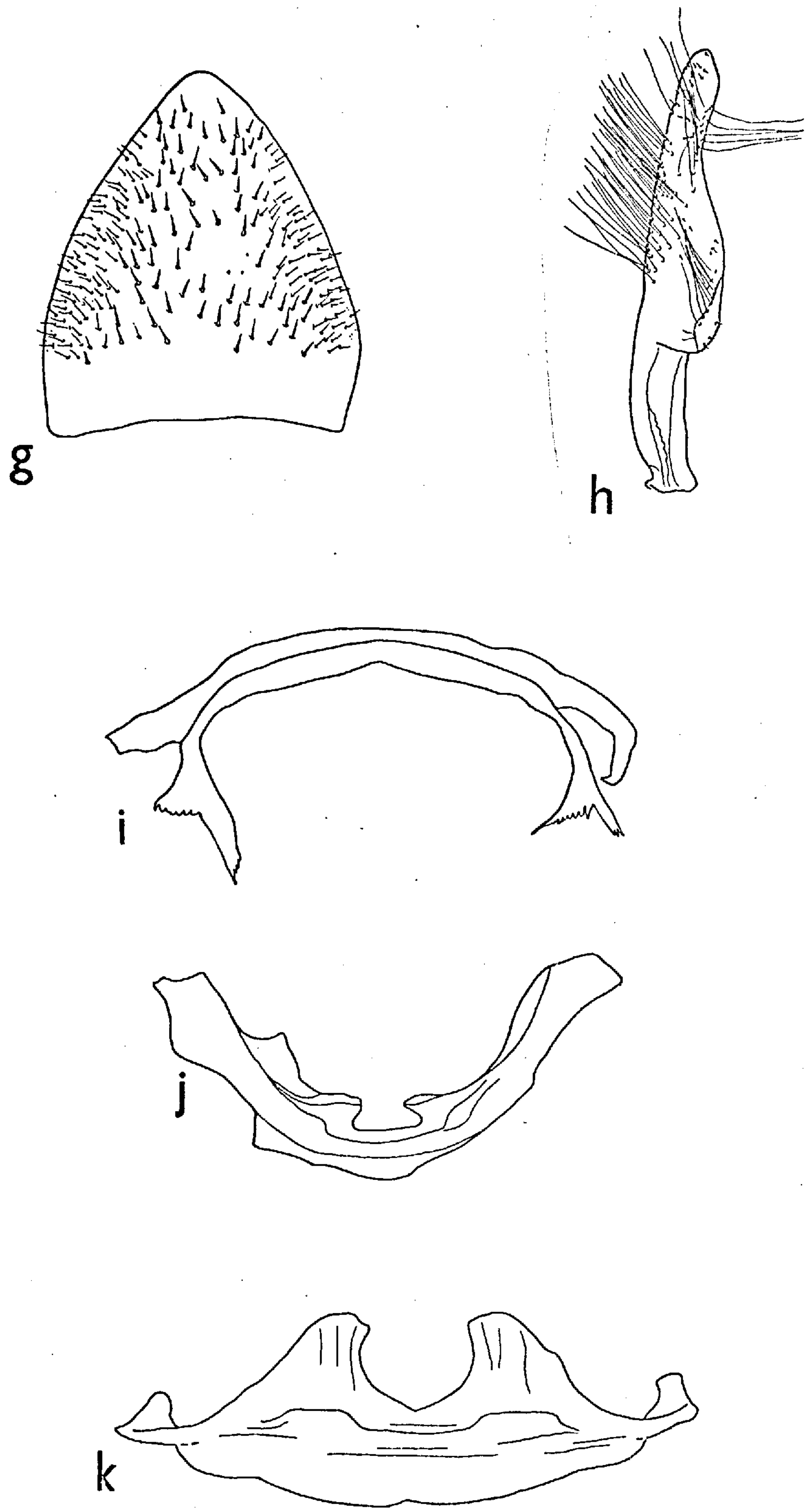
h, left genital plate, dorsal view

i, antecosta of second abdominal tergum, posterior view

j, first sternal abdominal apodemes, posterior view

k, second sternal abdominal apodemes, postero-dorsal view

Scale as in Figs. 1A and 1B.


g
h
i
j
k

B. (s.str.) welwitschi n. sp.

(Figs. 33A : a-h; 33B : i-m; 33C : n-r)

Shiny. Greenish yellow. Eyes reddish brown or brownish grey. Pronotum yellowish green, part of disk and lateral margins tinged with intense green. Scutellum yellowish, some parts tinged with green. Elytra whitish or whitish yellow, with some faint brownish spots especially on clavus; base of appendix with a small brown spot; veins of elytra yellowish, sometimes tinged with green, especially claval suture, scutellar and commissural margins of clavus. Legs yellowish, tarsi and apical part of tibiae tinged with green.

Medium-sized, relatively elongate. Length of male 4.57 - 4.77 mm (mean 4.70 mm); female unknown. Crown 5.0 - 5.8 times (mean 5.4) as broad as long, 0.18 - 0.22 times (mean 0.20) as long as pronotum. Pronotum 1.96 - 2.07 times (mean 2.00) as broad as long, coarsely and transversely furrowed. Elytra distinctly punctate; puncturing dense, brownish.

Male with notch of first sternal abdominal apodemes oval to oval, compressed; lobes expanded medially, closely apposed. Second sternal abdominal apodemes lobe-shaped, moderately separated, outer margins not steep, inner margins oblique, mesal margin rounded. Antecosta of second abdominal tergum strongly developed, mesal sinuation absent.

Male genitalia with 8th sternite broad; apical part acutely to more or less broadly rounded, setae dense. Side lobes of pygophore rounded apically, each with 6 - 13 macrosetae; appendages moderately curved in lateral view, simple, minutely serrate on ventral surface. Length of stylus 0.73 - 0.79 mm (mean 0.76 mm); apophysis broad in lateral view, dorsal margin broadly expanded, ventral margin more or less straight; apical tooth on ventral margin of apophysis small; apical hook moderately developed, stout, more or less obtusely angled. Length of penis 0.54 - 0.58 mm (mean 0.57 mm); stem straight, with a pair of roundedly triangular apical lobes on anterior surface, lateral surfaces without tubercles; socle in lateral aspect 0.25 - 0.29 times (mean 0.27) as long as stem; angle between socle and base of stem on postero-ventral margin greater than 180°. Base of connective in dorsal view broad; shaft approximately as long as base, dorsal keel in lateral view as high as base or higher than base. Genital plates turned slightly laterad at mid-length, subapical part with numerous long setae along outer margin.

Distribution : Guinean.

Ecology : Moist Forest at low and medium altitudes.

Material studied : Holotype male - Angola : Salazar, I.I.A.A., 9 - 15. III. 1972, at light, Southern African Expedition, B.M. 1972 - I. Paratypes - 3 males, same data as holotype. Holotype and paratypes in B.M. (N.H.).

Named after the great naturalist and pioneer in Angola, F.Welwitsch.

Remarks : The species is slightly variable in the appendages of pygophore, connective and stylus even among individuals from the same locality.

Related to hystaspes Lv. & Quart., mainly on the basis of the side lobes of pygophore and its appendages. Distinguished from it by the rather straight penis, and by the roundedly triangular apical lobes on anterior margin of stem of penis. Related also to clarensis n. sp. but easily distinguished from it by the stouter and rather straight stem of penis. A female with hind margin of 7th abdominal sternite moderately sinuate, and a specimen without abdomen, both same data as holotype, possibly belong to this species.

Fig. 33A - _B._ (s.str.) _welwitschi_ n. sp.

(a,b,d,f,h,j-l,n-q,holotype; c,e,g,i,m,r, two paratypes)

a, male pygophore, left lateral view

b-c, left appendage of pygophore,
left lateral view

d-e, connective, left lateral view

f-g, connective, dorsal view

h, left stylus, left lateral view

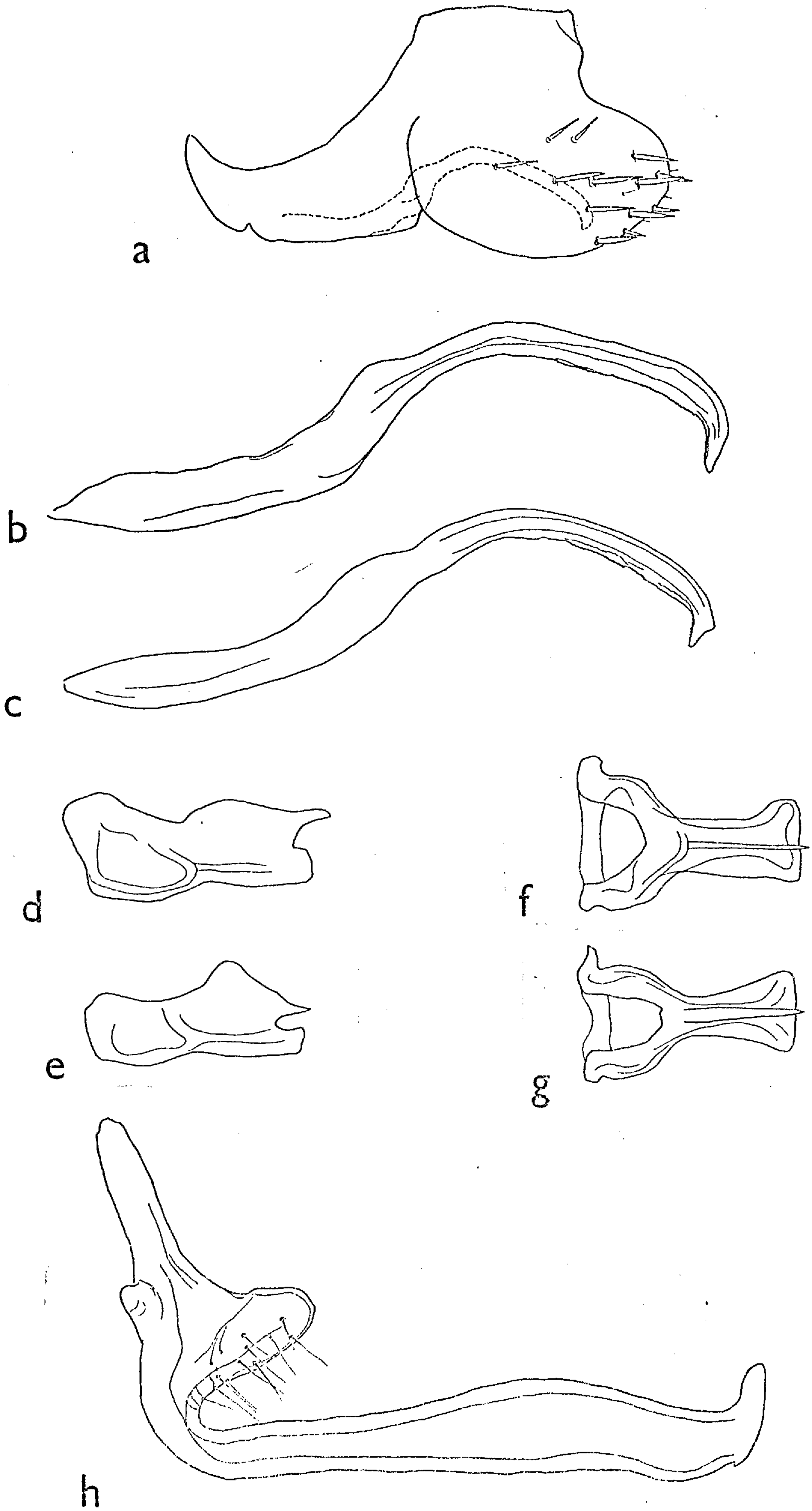

a
b
c
d
e
f
g
h

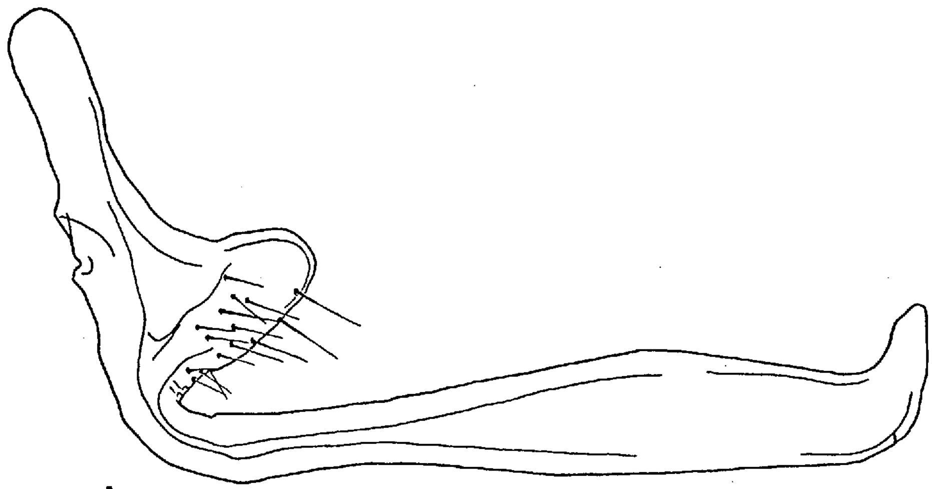
Fig. 33B - B. (s.str.) welwitschi n. sp.

i, left stylus, left lateral view

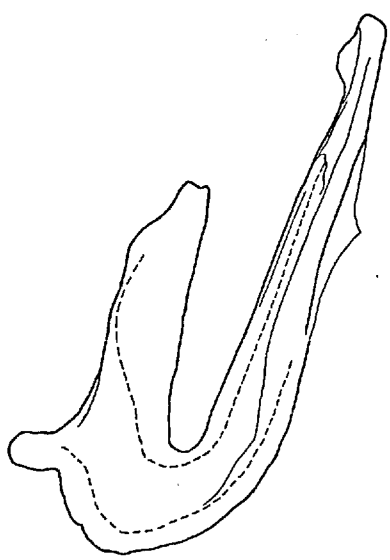
j, penis, left lateral view

k, apex of penis, left lateral view

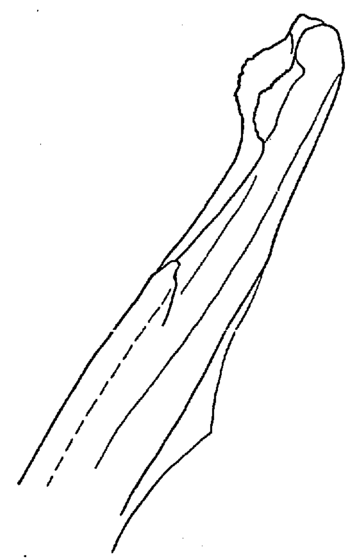
l-m, 8th sternite, ventral view



i

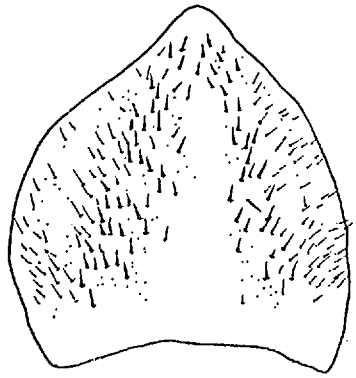


j

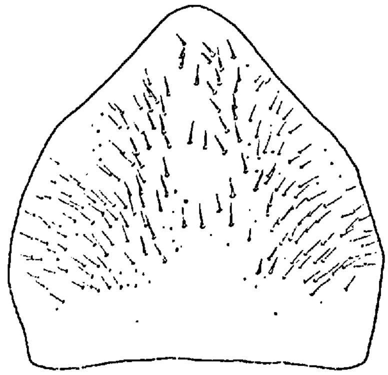


k

0.05mm



l



m

Fig. 33C - B. (s.str.) welwitschi n. sp.

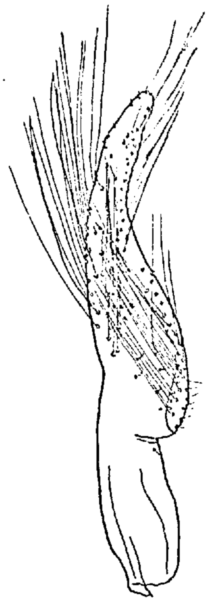
n, left genital plate, dorsal view

o, antecosta of second abdominal tergum, posterior view

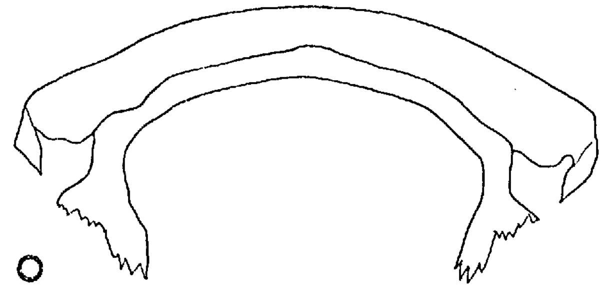
p, first sternal abdominal apodemes, posterior view

q-r, second sternal abdominal apodemes, postero-dorsal view

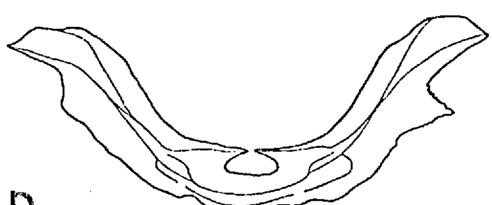
Scale as in Figs. 1A and 1B or, otherwise, as indicated.



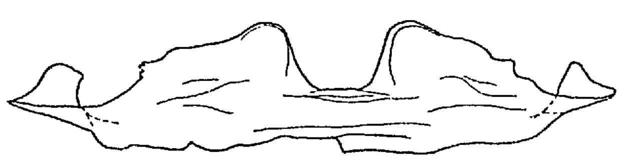
n



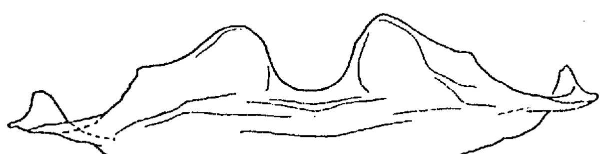
o



p



q



r

5. Subgenus SUDANOIASSUS Lv. & Quart.

Sudanoiassus Linnavuori & Quartau, 1975 : 130. Type-species : B. (S.) kivuensis Linnavuori & Quartau, 1975, by original designation.

Usually large, elongate species with fuscous spots on upper surface. Pronotum often appearing relatively narrow, usually less than twice as broad as medial length; lateral margins longish, rather weakly diverging caudad.

Second sternal abdominal apodemes of male ridge-shaped, with lobes reduced or absent.

Male pygophore usually very elongate, low, with both a mid-ventral and a mid-dorsal incision. Apophysis of stylus not blade-shaped, ventral margin often with roundish or angulate subapical expansion, apical hook very reduced, claw-like. Stem of penis tubular, apex in posterior view spoon-shaped. Subapical part of genital plates without long setae along outer margin.

Distribution : Tropical Africa.

B. (S.) cecrops Lv. & Quart.

(Figs. 34A : a-f; 34B : g-l)

Batracomorphus (Sudanoiassus) cecrops Linnavuori & Quartau, 1975 : 131 - 132.

Fairly shiny. Pale ochraceous or yellowish green. Eyes reddish brown. Pronotum more or less densely spotted with brown medially and basally. Scutellum pale ochraceous or yellowish green, immaculate. Elytra pale yellowish, densely spotted with brown; base of appendix slightly infumated, brown spotted; veins of elytra greenish. Legs pale ochraceous to yellowish green, tarsi tinged with intense green.

Large,moderately robust. Length of male, 5.81 - 6.50 mm; female unknown. Crown 4.85 - 6.80 times as broad as long, 0.15 - 0.21 times as long as pronotum. Pronotum 1.77 times as broad as long, rather coarsely and transversely furrowed. Elytra distinctly punctate; puncturing dense, concolorous; setae short, brownish.

Male with lobes of second sternal abdominal apodemes reduced, short, relatively separated, outer and inner margins oblique, mesal margin rounded; base of inner margins with a small tooth. Antecosta of second abdominal tergum strongly developed, mesal sinuation obsolete.

Male genitalia with 8th sternite broad; apical part broadly rounded, setae relatively dense. Side lobes of pygophore more or less acutely rounded apically, each with 9 - 13 macrosetae; appendages rather straight, apex truncately expanded, apical margin dentate. Length of stylus 0.75 - 0.80 mm; apophysis relatively slender, dorsal margin sinuate, ventral margin broadly curvate; apical hook reduced, claw-like, obtusely angled. Length of penis 0.53 - 0.54 mm; stem relatively stout, distinctly curved dorsad, tubular; apex of stem spoon-shaped, ovate in outline; socle in lateral view 0.47 times as long as stem; angle between socle and base of stem on postero-ventral margin greater than 180°. Base of connective in dorsal view elongate; shaft distinctly longer than base, dorsal keel in lateral view higher than base. Genital plates turned strongly laterad at mid-length, sub-apical setae along outer margin absent.

Distribution : Guinean. Transvalian.

Ecology : Moist Forest at low and medium altitudes (?). Dry woodland with Colophospermum mopane.

Material studied : 1 male, Angola : 3 mls. N. Santa Clara, 30. III - 1. IV. 1972, Southern African Expedition, B.M. 1972 - I. In coll. B.M. (N.H.).

Remarks : Previously known from Zaire, apparently from a completely different vegetation type.

Easily distinguished from brunomaculatus (Ev.) by the dentate apex of pygophore appendages.

Fig. 34A - B. (S.) cecrops Lv. & Quart.

a, male pygophore, left lateral view

b, left appendage of pygophore, left lateral view

c, connective, left lateral view

d, connective, dorsal view

e, penis, postero-dorsal view

f, penis, left lateral view

34A

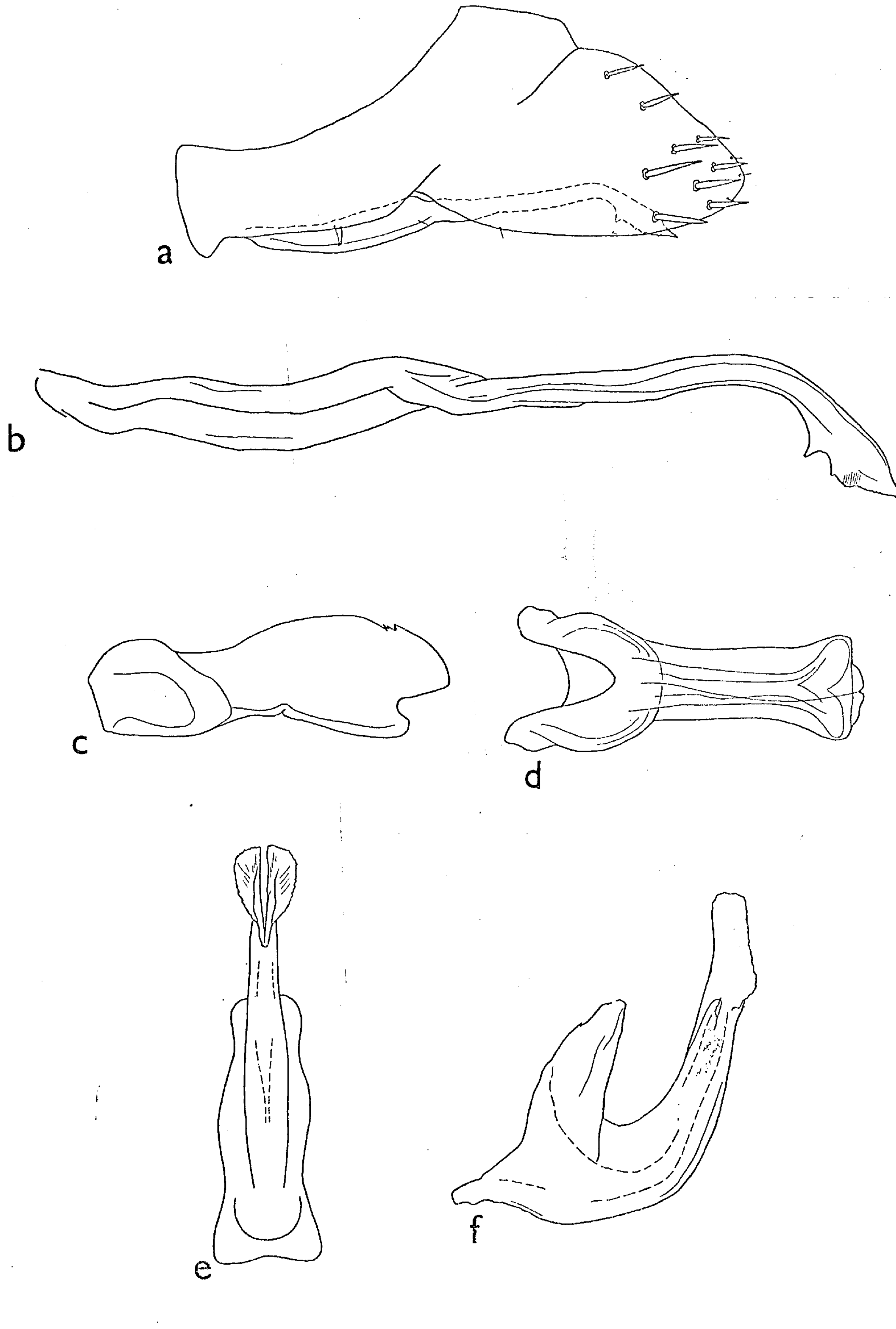


Fig. 34B - B. (S.) cecrops Lv. & Quart.

g, left stylus, left latero-dorsal view

h, left stylus, left lateral view

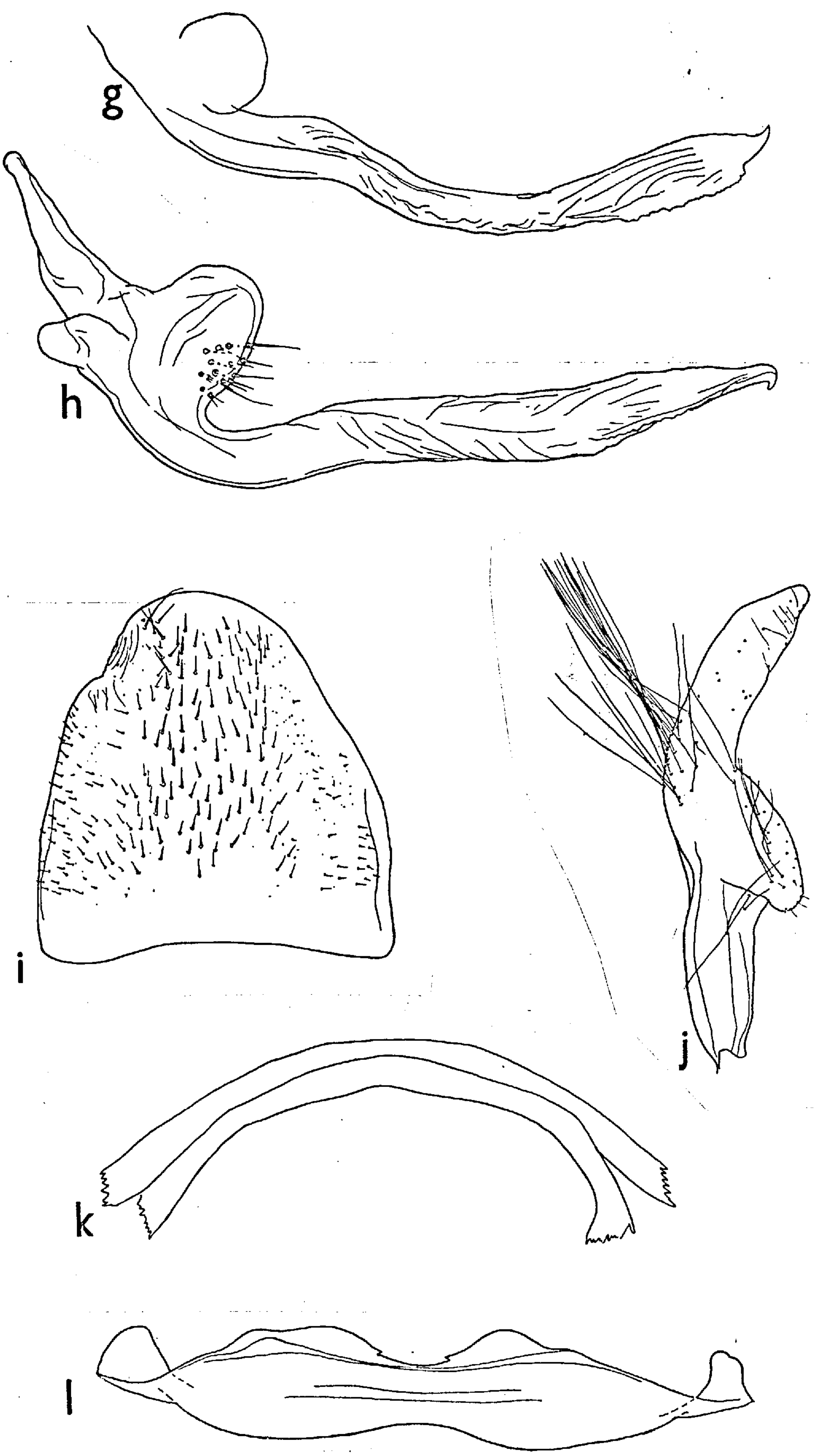
i, 8th sternite, ventral view

j, left genital plate, dorsal view

k, antecosta of second abdominal tergum, posterior view

l, second sternal abdominal apodemes, postero-dorsal view

Scale as in Figs. 1A and 1B.


g
h
i
j
k
l

B. (S.) kivuensis Lv. & Quart.

(Figs. 35A : a-h; 35B : i-n; 35C : o-x)

Batracomorphus (Sudanoiassus) kivuensis Linnavuori & Quartau, 1975 : 137 - 138.

Fairly shiny. Yellowish to yellowish green. Eyes reddish brown or reddish. Pronotum and scutellum yellowish, immaculate. Elytra yellowish, with faint fuscous spots; base of appendix tinged with brown; veins concolorous. Legs yellowish, tarsi and apical part of tibiae tinged with green.

Large, relatively elongate. Length 5.74 - 6.50 mm. Crown 5.3 - 7.1 times (male, mean 6.4) or 5.7 times (female) as broad as long, 0.14 - 0.20 times (male, mean 0.16) or 0.17 times (female) as long as pronotum. Pronotum 1.84 - 1.95 times (male, mean 1.88) or 1.81 times (female) as broad as long, coarsely and transversely furrowed. Elytra distinctly punctate; puncturing dense, dark; setae short, dark.

Male with notch of first sternal abdominal apodemes variable, from angularly oval to rectangular; lobes often expanded medially, closely apposed, rarely widely separated from each other. Second sternal abdominal apodemes with reduced lobes, as illustrated. Antecosta of second abdominal tergum narrow, mesal sinuation small or obsolete.

Male genitalia with 8th sternite moderately broad; apical part broadly rounded, setae dense. Side lobes of pygophore acutely rounded apically, each with 8 - 12 macrosetae; appendages rather straight, more or less truncately or roundedly expanded apically, shape of apex variable. Length of stylus 0.66 - 0.69 mm (mean 0.68 mm); apophysis broadening apicad, dorsal margin more or less sinuate, ventral margin with a roundish subapical expansion; apical hook reduced, claw-like, more or less acutely angled. Length of penis 0.42 - 0.53 mm; stem variable in thickness, distinctly curved dorsad, tubular; apex of stem spoon-shaped, triangular to more or less parallel-sided in outline, apical margin variable from bluntly to sharply tipped; socle in lateral aspect 0.35 - 0.55 times as long as stem; angle between socle and base of stem on postero-ventral margin greater than 180°. Base of connective in dorsal view elongate; shaft longer than base, dorsal keel in lateral view approximately as high as base. Genital plates turned strongly laterad at mid-length, sub-apical setae along outer margin absent.

Female genitalia with 7th abdominal sternite as illustrated in Linnavuori & Quartau (1975 : Fig. 91 l).

Distribution : Guinean.

Ecology : Moist Forest at low and medium altitudes. Forest-Savanna Mosaic.

Material studied : 5 males, 1 female, Uganda : Kawanda, Kampala, 11. V. 76, light trap, O.H. Makumbi coll. (C.I.E., A8793). In coll. B.M. (N.H.).

Remarks : Variable, especially in apical part of pygophore appendages, stem of penis, and sternal abdominal apodemes, even among specimens from the same locality. The connective and the apical hook of stylus also show some variation.

Easily distinguished from lusingaensis Lv. & Quart. by the appendages of pygophore which are more or less truncately or roundedly expanded apically. Distinguished from magniceps Lv. & Quart. by the rather straight appendages of pygophore, and by the more or less parallel-sided spoon of penis.

Fig. 35A - B. (S.) kivuensis Lv. & Quart.

(a-x, four males)

a, male pygophore, left lateral view

b,d, left appendage of pygophore, left lateral view

c, apex of right appendage of pygophore, left lateral view

e, connective, left lateral view

f-h, connective, dorsal view

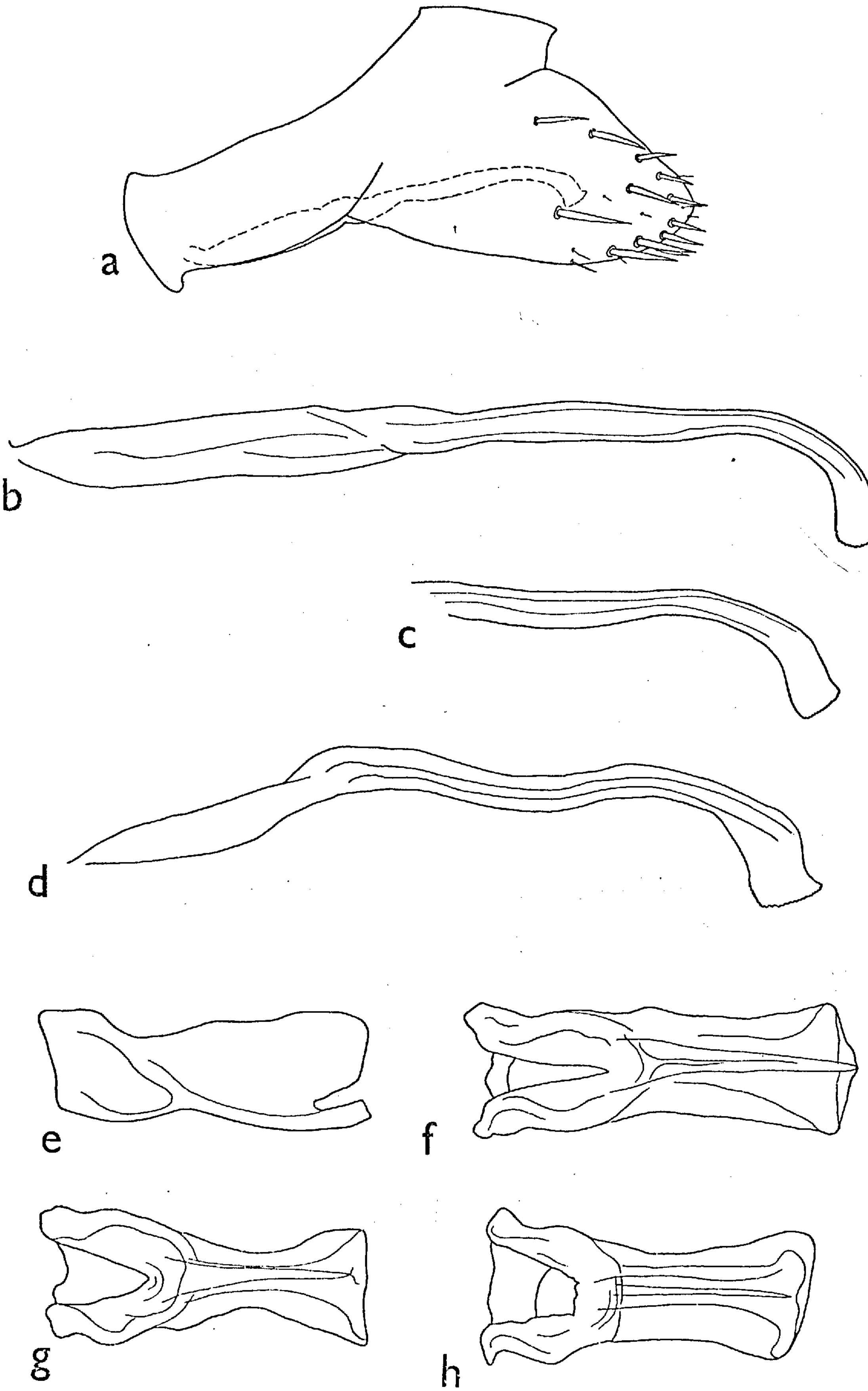

a
b
c
d
e
f
g
h

Fig. 35B - B. (S.) kivuensis Lv. & Quart.

i,k, penis, left lateral view

j,l, penis, posterior view

m-n, left stylus, right dorsal and
left lateral views

35B

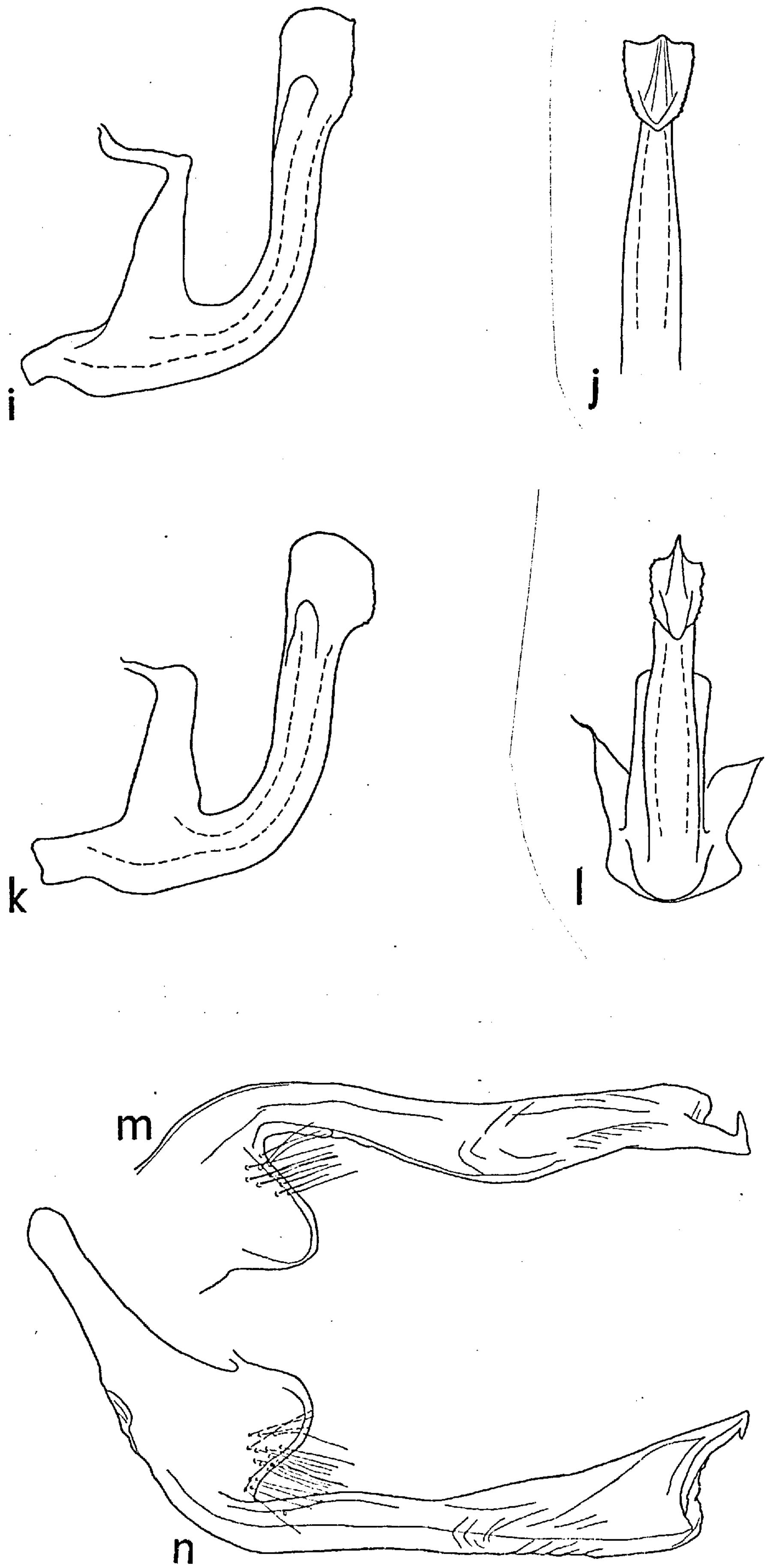


Fig. 35C - B. (S.) kivuensis Lv. & Quart.

o, left stylus, left lateral view

p-q, left stylus, apical hook in broadest view

r, 8th sternite, ventral view

s, left genital plate, dorsal view

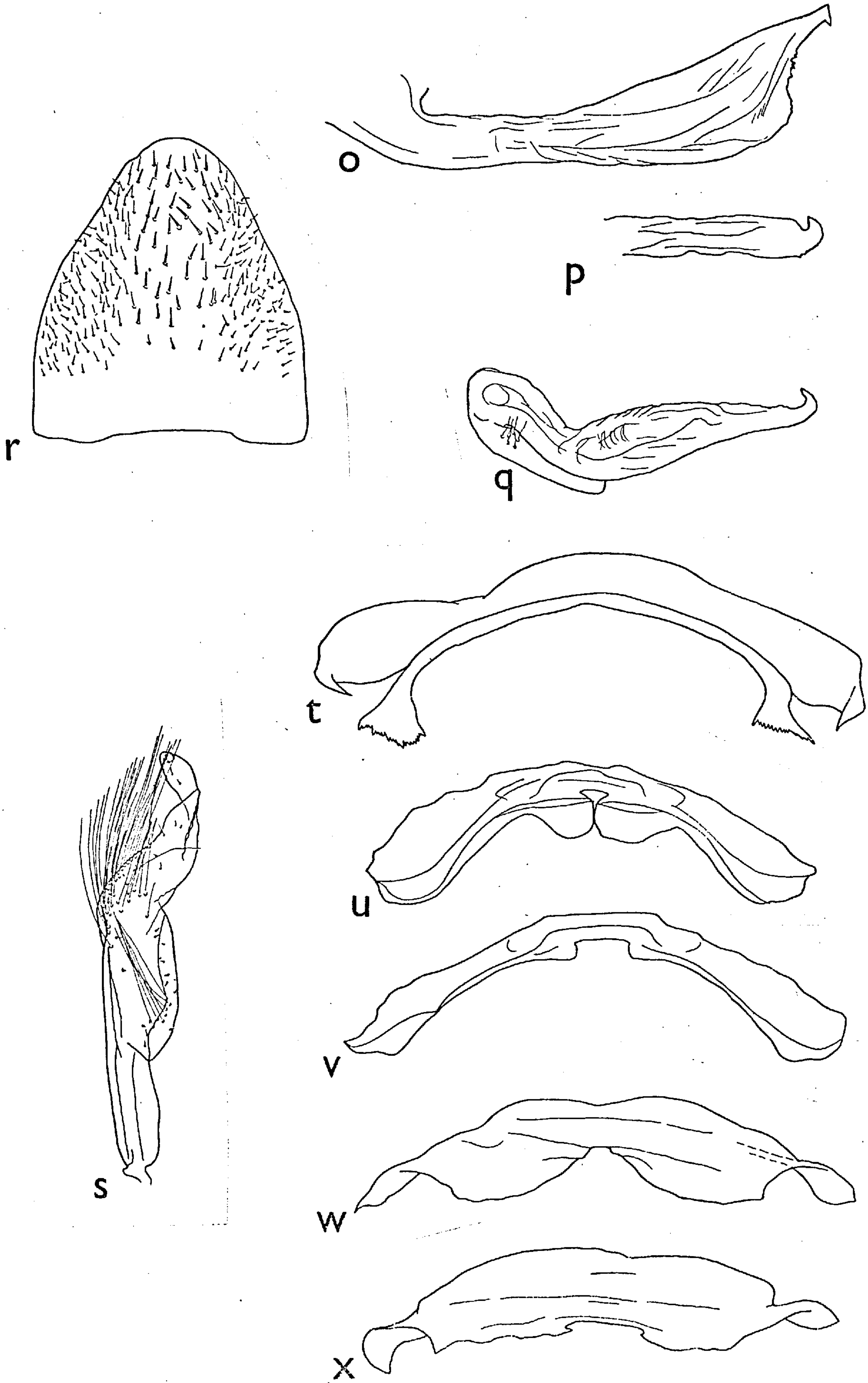
t, antecosta of second abdominal tergum, posterior view

u-v, first sternal abdominal apodemes, posterior view

w-x, second sternal abdominal apodemes, postero-dorsal view

Scale as in Figs. 1A and 1B.

35C



B. (S.) lituratus Lv. & Quart.

(Figs. 36A : a-g; 36B : h-l; 36C : m-o)

Batracomorphus (Sudanoiassus) lituratus Linnavuori & Quartau, 1975 : 139 - 140.

Shiny. Yellowish or yellowish green. Eyes reddish brown. Crown with two round fuscous spots, often with minute brown irroration. Pronotum yellowish or yellowish green, often densely spotted with brown. Scutellum yellowish or yellowish green, basal triangles more or less tinged with brown, disk sometimes with fuscous spotting. Elytra light yellowish or yellowish green, spotted with brown or faint fuscous; base of appendix brownish, first apical cell slightly infumated; veins of elytra concolorous. Legs yellowish, tarsi greenish.

Large, relatively robust. Length, 5.88 - 6.50 mm. Crown 5.0 - 5.4 times as broad as long, 0.18 - 0.21 times as long as pronotum. Pronotum 1.82 - 1.90 times as broad as long, more or less finely and transversely furrowed. Elytra distinctly punctate; puncturing dense, brown; setae short, brownish.

Male with notch of first sternal abdominal apodemes broadly triangular; lobes expanded medially, closely apposed. Second sternal abdominal apodemes with reduced lobes, mesal margin rounded. Antecosta of second abdominal tergum strongly developed, mesal sinuation obsolete.

Male genitalia with 8th sternite broad; apical part more or less broadly angled, setae sparse. Side lobes of pygophore obtusely rounded apically, each with 12 - 13 macrosetae; appendages long, gracile, moderately curved, simple, apex sharp. Length of stylus 0.67 mm; apophysis broadening apicad, dorsal margin more or less sinuate, ventral margin with an angulate subapical expansion; apical hook reduced, claw-like, acutely angled. Length of penis 0.45 - 0.54 mm; stem relatively stout, moderately curved dorsad, tubular; apex of stem spoon-shaped, more or less parallel-sided in outline, apical margin deeply angularly excavated; socle in lateral aspect 0.28 times as long as stem; angle between socle and base of stem on postero-ventral margin greater than 180°. Base of connective in dorsal view broad; shaft distinctly longer than base, dorsal keel in lateral view higher than base. Genital plates broad, turned strongly laterad at mid-length, subapical setae along outer margin absent.

Female genitalia with hind margin of 7th sternite shallowly sinuate, lateral angles rounded.

Distribution : Guinean. Zambesian.

Ecology : Moist Forest at low and medium altitudes. Gallery forest.

Material studied : 1 male - Angola : Duque de Bragança Falls, 11 - 12. III. 1972, at light, Southern African Expedition, B.M., 1972 - I. In coll. B.M. (N.H.).

Remarks : Previously known from Zaire. The specimen from Angola differs from the type series in being paler : the fuscous spots on crown are faint, the pronotum is spotted in mesal and basal parts only and the basal triangular spots of scutellum are concolorous.

Distinguished from lusingaensis Lv. & Quart. by the appendages of pygophore which are not T-shaped apically, and by the spoon of penis which is more or less parallel-sided and deeply angularly excavated on apical margin.

Fig. 36A - B. (S.) lituratus Lv. & Quart.

a, male pygophore, left lateral view

b, right appendage of pygophore, left lateral view

c, apex of right appendage of pygophore, broadest aspect

d, connective, left lateral view

e, connective, dorsal view

f, penis, left lateral view

g, penis, posterior view

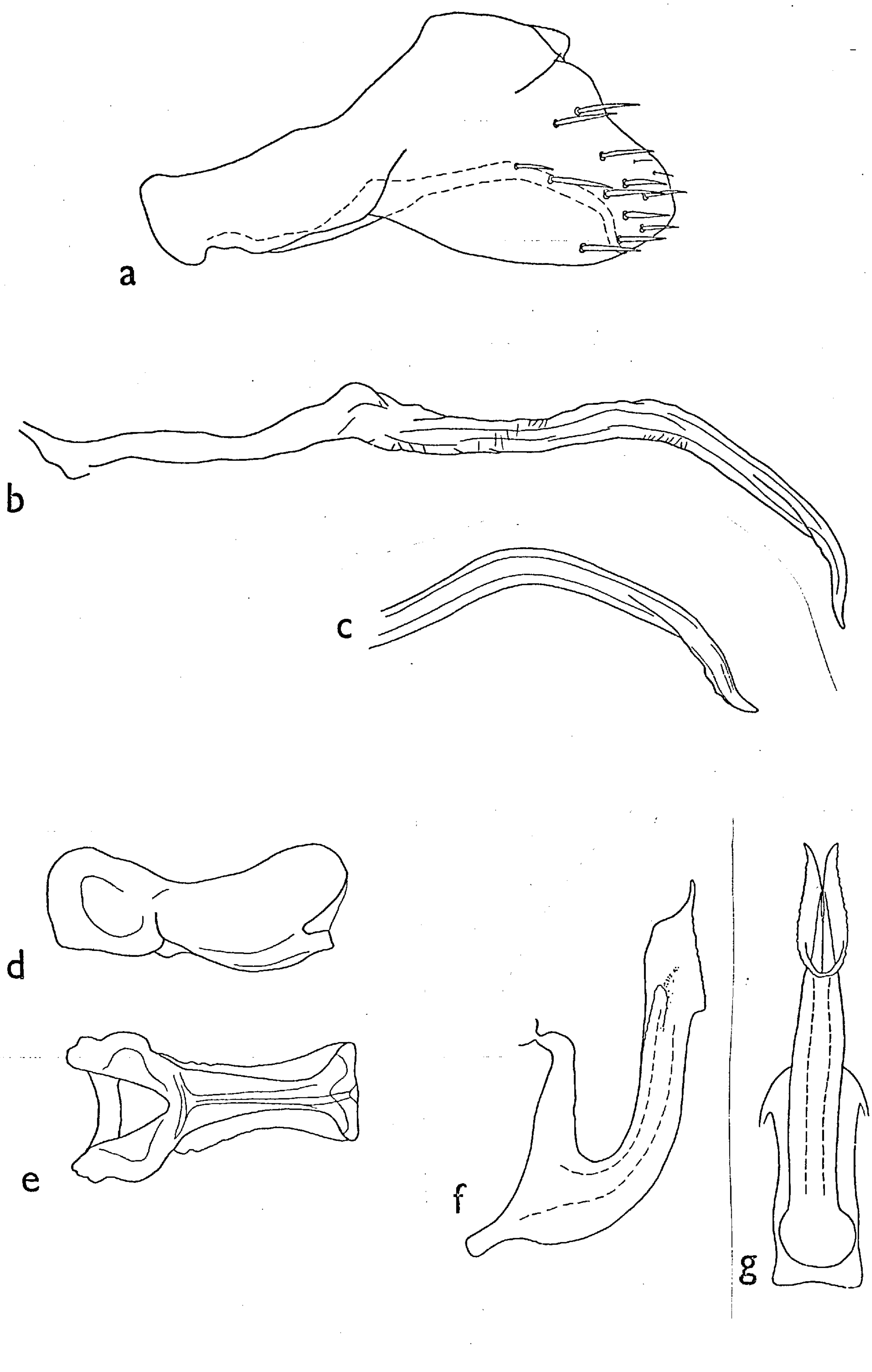

a
b
c
d
e
f
g

Fig. 36B - B. (S.) lituratus Lv. & Quart.

h, left stylus, left lateral view

i, right stylus, left lateral view with apical hook in broadest aspect

j, right stylus, left lateral view

k, 8th sternite, ventral view

l, left genital plate, dorsal view

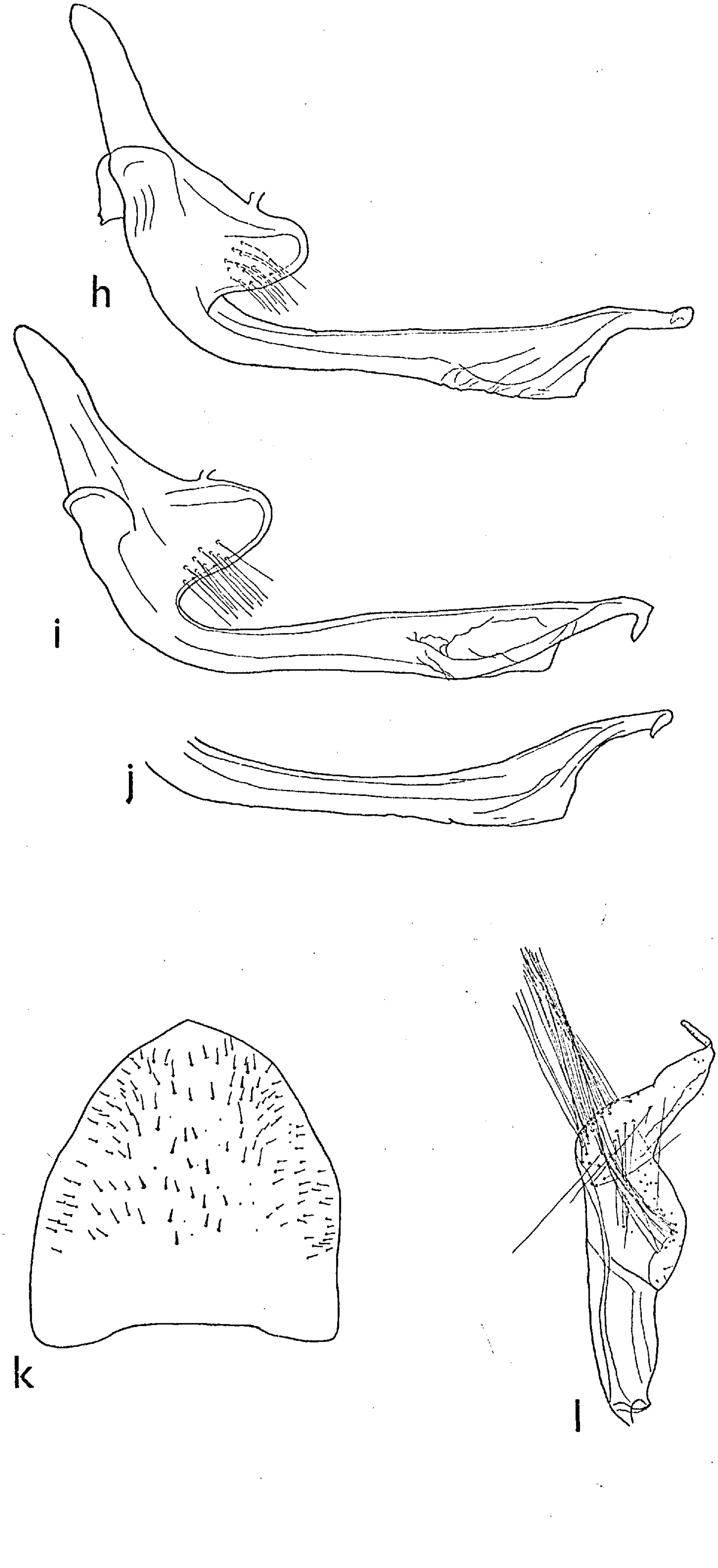

h
i
j
k
l

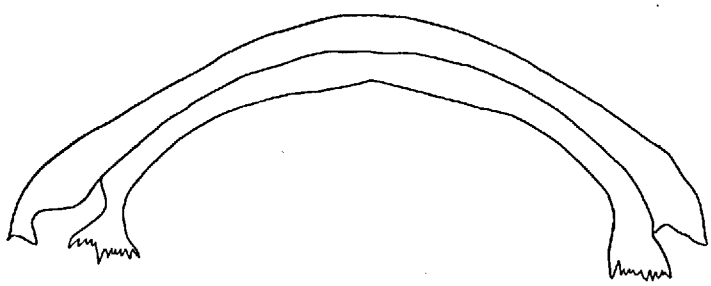
Fig. 36C - B. (S.) lituratus Lv. & Quart.

m, antecosta of second abdominal tergum, posterior view

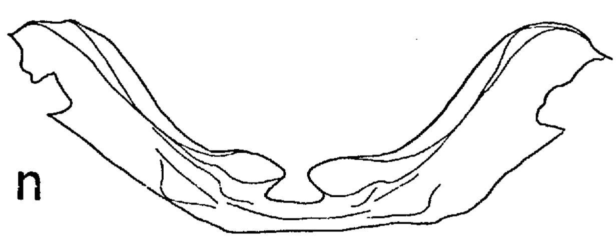
n, first sternal abdominal apodemes, posterior view

o, second sternal abdominal apodemes, postero-dorsal view

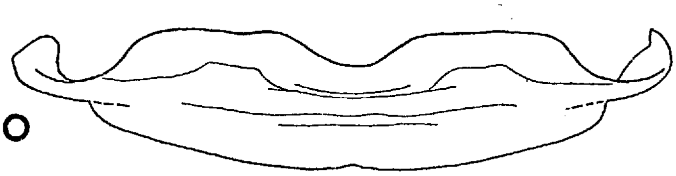
Scale as in Figs. 1A and 1B.



m



n



o

B. (S.) magniceps Lv. & Quart.

(Figs. 37A : a-j; 37B : k-o)

Batracomorphus (Sudanoiassus) magniceps Linnavuori & Quartau, 1975 : 136 - 137.

Fairly shiny. Pale green or ochraceous. Eyes reddish or reddish brown. Pronotum and scutellum pale green or yellowish, immaculate. Elytra yellowish, with faint brownish or distinct fuscous spots; base of appendix with a fuscous spot; veins concolorous, with some parts tinged with green. Legs yellowish, tarsi and apical part of tibiae green.

Large, elongate. Length of male, 5 - 6 mm; female, 6.5 mm . Crown 4.0 - 6.8 times as broad as long, 0.15 - 0.28 times as long as pronotum. Pronotum 1.7 - 1.9 times as broad as long, coarsely and transversely furrowed. Elytra obsoletely or distinctly punctate; puncturing concolorous or brownish; setae short, dark.

Male with notch of first sternal abdominal apodemes circular; lobes expanded medially, closely apposed. Second sternal abdominal apodemes with reduced lobes, mesal margin small, rounded. Antecosta of second abdominal tergum strongly developed, mesal sinuation obsolete.

Male genitalia with 8th sternite broad, apical part more or less broadly rounded, setae dense. Side lobes of pygophore acutely rounded apically, each with 9 - 13 macrosetae; appendages more or less semicircularly curved dorsad, dorsal margin dentate subapically, apex sharp, hook-shaped. Length of stylus 0.57 - 0.66 mm; apophysis broadening apicad, dorsal margin more or less sinuate, ventral margin with a roundish subapical expansion; apical hook reduced, claw-like, acutely angled. Length of penis 0.32 - 0.44 mm; stem moderately stout, distinctly curved dorsad, tubular; apex of same spoon-shaped, triangular in outline, apical margin more or less shallowly sinuate; socle 0.64 - 0.66 times as long as stem; angle between socle and base of stem on postero-ventral margin about 180°. Base of connective in dorsal view relatively elongate; shaft distinctly longer than base, dorsal keel in lateral view distinctly higher than base. Genital plates turned strongly laterad at mid-length, subapical setae along outer margin absent.

Female genitalia with hind margin of 7th sternite shallowly sinuate, lateral angles rounded.

Distribution : Guinean. Eastern.

Ecology : Moist Forest at low and medium altitudes. Forest-Savanna Mosaic.

Material studied : 2 males, Uganda : Kawanda, Kampala, 11. V. 76, light trap, O.H. Makumbi coll., C.I.E. A8793. In coll. B.M. (N.H.).

Remarks : Easily distinguished from lusingaensis Lv. & Quart. by the apex of pygophore appendages which is hook-shaped, not T-shaped. Distinguished from kivuensis Lv. & Quart. by its curved dorsad pygophore appendages, and by the more or less shallowly sinuate apical margin of spoon of penis.

Fig. 37A - _B_. (_S_.) _magniceps_ Lv. & Quart.

a, male pygophore, left lateral view

b, left appendage of pygophore, left lateral view

c, apex of left appendage of pygophore, broadest aspect

d, connective, left lateral view

e, connective, dorsal view

f, penis, posterior view

g, penis, left lateral view

h, left stylus, left lateral view

i-j, apex of right and left stylus, broadest aspects

37A

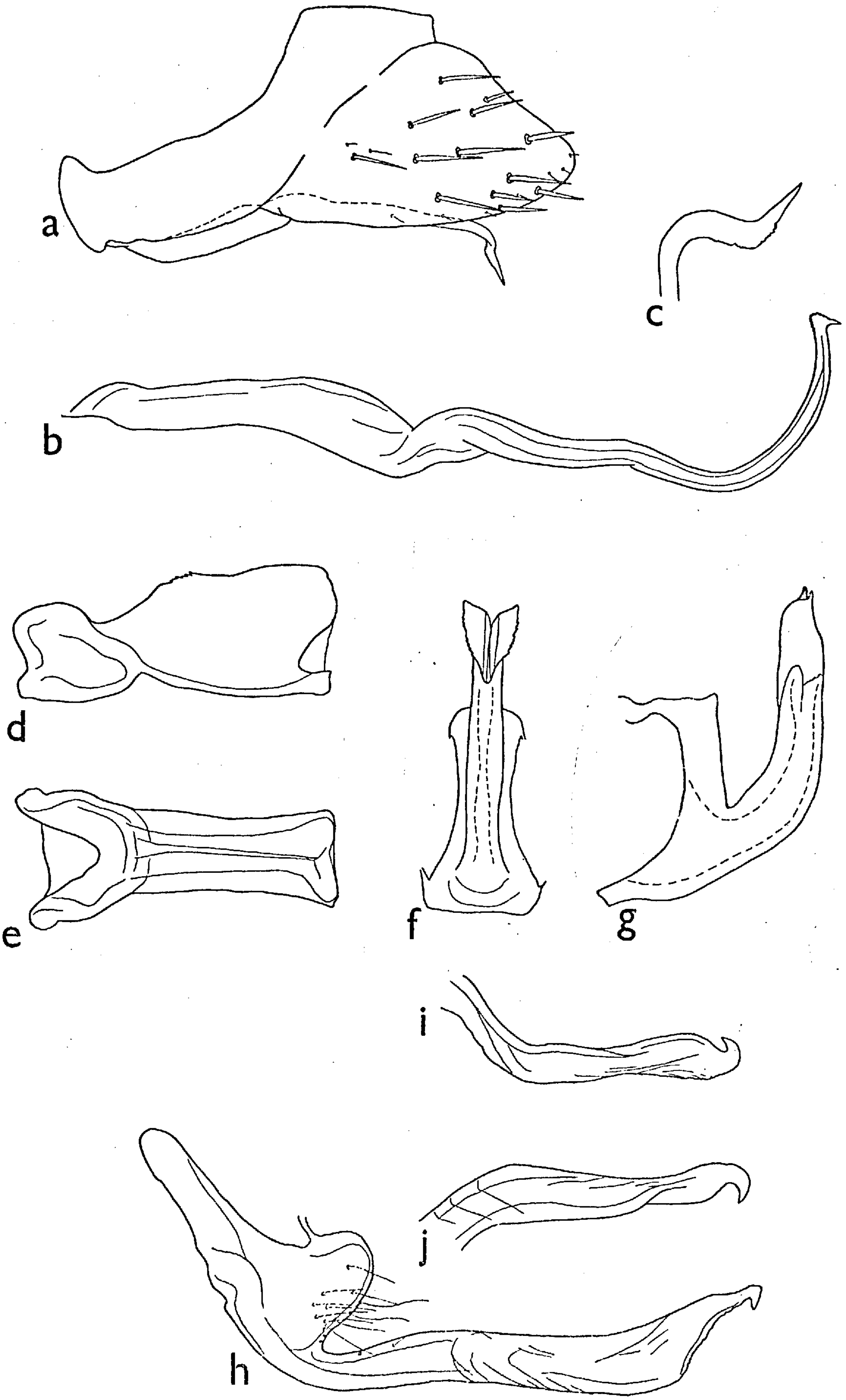


Fig. 37B - B. (S.) magniceps Lv. & Quart.

k, 8th sternite, ventral view

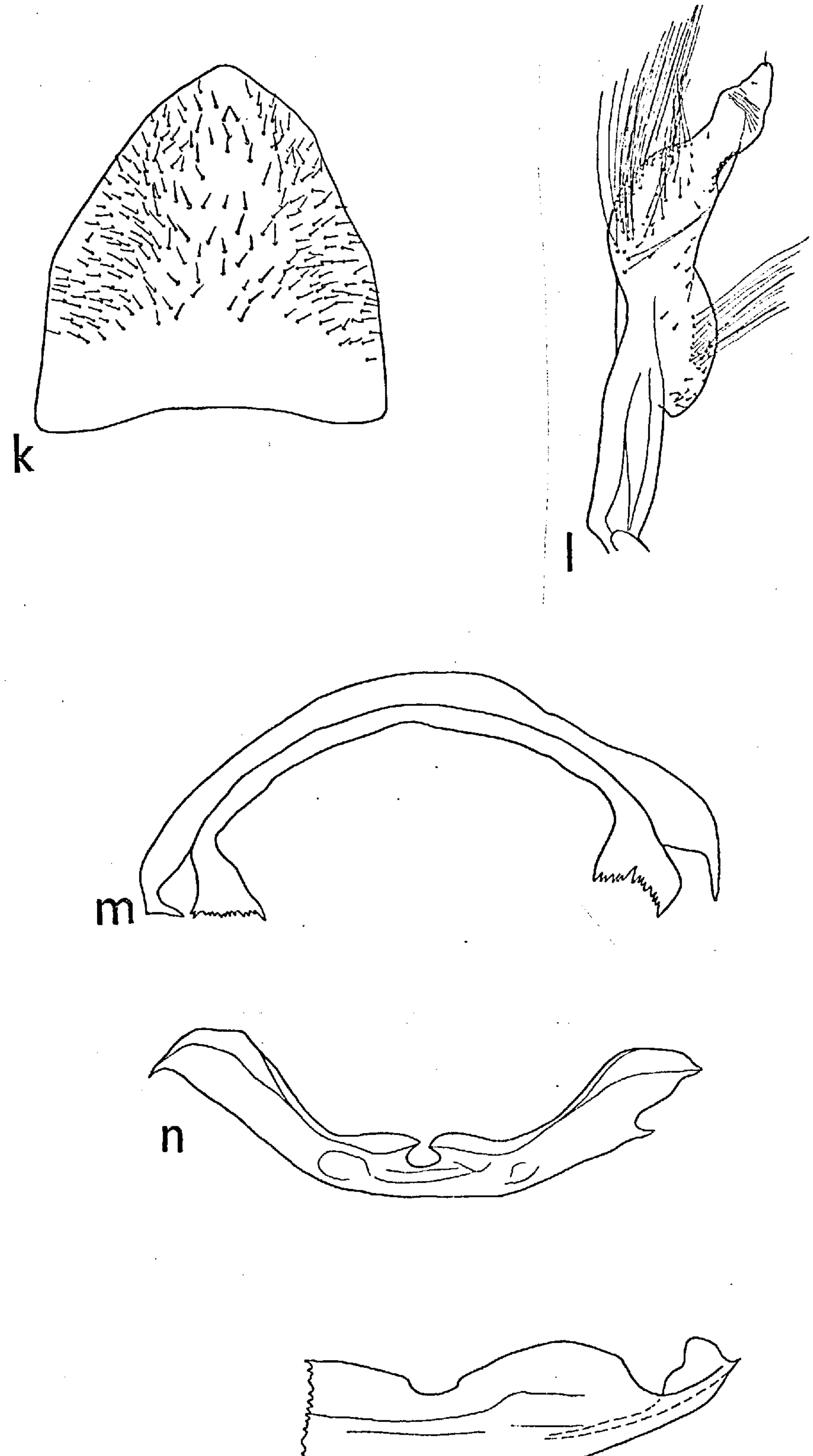
l, left genital plate, dorsal view

m, antecosta of second abdominal tergum, posterior view

n, first sternal abdominal apodemes, posterior view

o, second sternal abdominal apodemes, postero-dorsal view

Scale as in Figs. 1A and 1B.


k
l
m
n
o

B. (S.) wardi n. sp.

(Figs. 38A : a-g; 38B : h-k; 38C : l-n)

Fairly shiny. Yellowish. Eyes reddish brown or reddish grey. Pronotum yellowish, sometimes base minutely spotted with faint brownish. Scutellum yellowish, immaculate. Elytra yellowish, immaculate; base of appendix very faintly infumated, near concolorous; veins of elytra yellowish, some parts tinged with green; commissural margin of clavus greenish in apical part. Legs yellowish, tarsi and apical part of tibiae tinged with green, fore and middle tibiae tinged with red.

Large, moderately robust. Length of male, 5.81 mm; female, 6.47 - 6.66 mm (mean 6.57 mm). Crown 5.7 times (male) or 6.3 - 7.1 times (female, mean 6.7) as broad as long, 0.19 times (male) or 0.16 - 0.18 times (female, mean 0.17) as long as pronotum. Pronotum 1.90 times (male) or 1.83 - 1.90 times (female, mean 1.87) as broad as long, coarsely and transversely furrowed. Elytra distinctly punctate; puncturing dense, concolorous; setae short, light brownish.

Second sternal abdominal apodemes of male with reduced lobes; mesal margin rounded. Antecosta of second abdominal tergum strongly developed, with a small mesal sinuation.

Male genitalia with 8th sternite moderately broad; apical part more or less broadly rounded, setae dense. Side lobes of pygophore acute apically, each with 13 - 15 macrosetae; appendages nearly straight, simple, truncately expanded apically. Length of stylus 0.78 mm; apophysis broadening apicad, dorsal margin sinuate, ventral margin with an angulate subapical expansion; apical hook reduced, claw-like, acutely angled. Length of penis 0.63 mm; stem slender, rather straight; apex of stem spoon-shaped, approximately triangular in outline, apical lamellae minutely serrate; socle very stout, 0.50 times as long as stem; angle between socle and base of stem on posterior margin 180°. Base of connective in dorsal view as wide as long; shaft relatively short, dorsal keel in lateral view distinctly higher than base. Genital plates turned strongly laterad at mid-length, subapical setae along outer margin absent.

Female genitalia with 7th sternite as illustrated.

Distribution : Soudanian.

Ecology : Grassland savanna.

Material studied : Holotype male - Nigeria : Samaru, 18 - 25. V. 1970, M/V light trap, white sheet, P.H. Ward, B.M. 1970 - 604. Allotype - 1 female, same data as holotype. Paratype - 1 female, same data as holotype. Holotype and paratypes in coll. B.M. (N.H.).

Named after the collector, Mr. P.H. Ward.

Remarks : A peculiar species within Sudanoiassus on account of the unusually stout socle of penis. Stylus of the lusingaensis type, appendages of pygophore near some cases of kivuensis. In colouring resembling nimule Lv. & Quart. but very different in penis and pygophore appendages.

Fig. 38A - B. (S.) wardi n. sp.

(a-m, holotype; n, allotype)

a, male pygophore, left lateral view

b, left appendage of pygophore, left lateral view

c, left appendage of pygophore, apex in broadest aspect

d, connective, dorsal view

e, connective, left lateral view

f, penis, left lateral view

g, penis, posterior view

38A

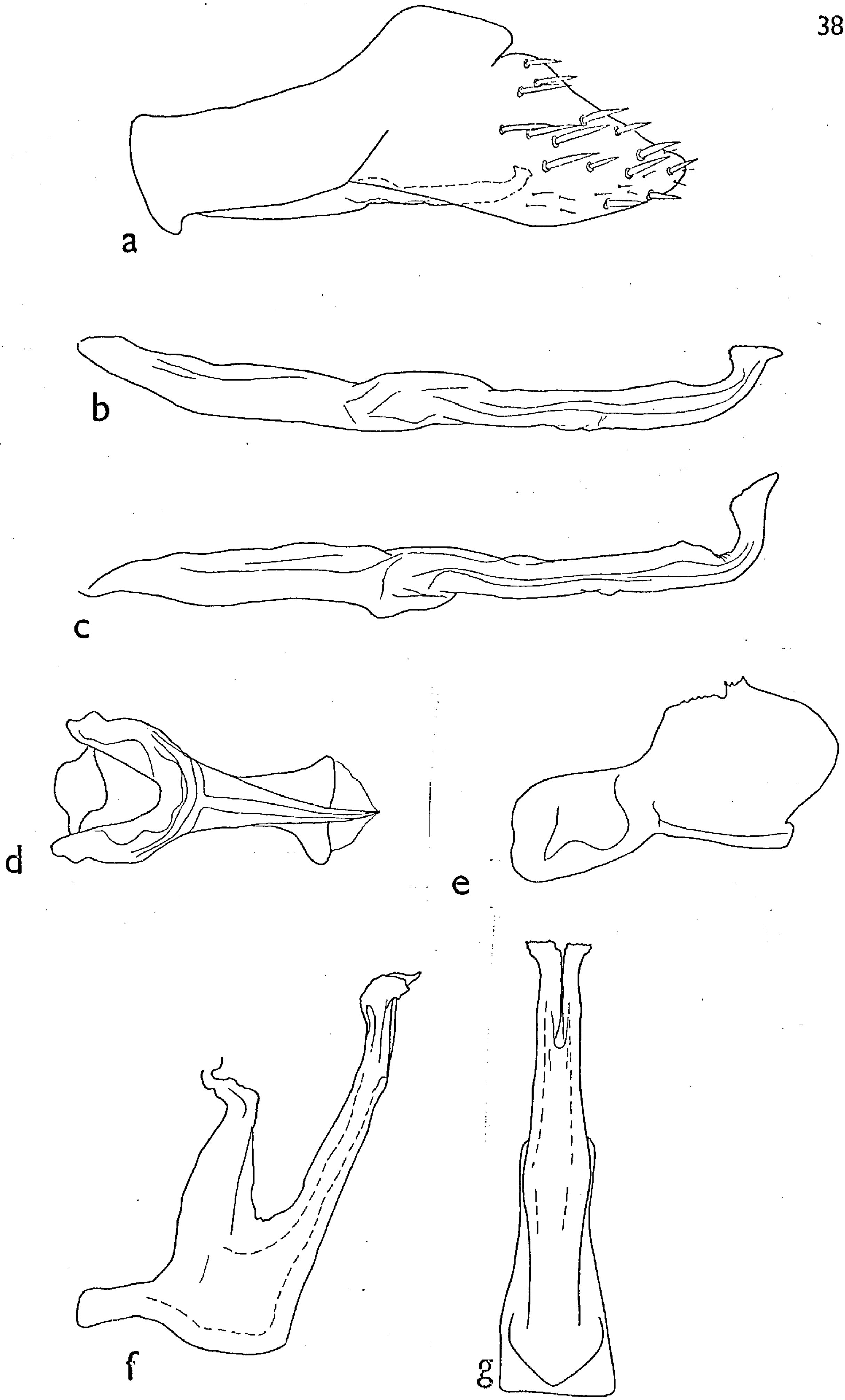


Fig. 38B - B. (S.) wardi n. sp.

h, left stylus, left lateral view

i, left stylus, right lateral view

j, 8th sternite, ventral view

k, left genital plate, dorsal view

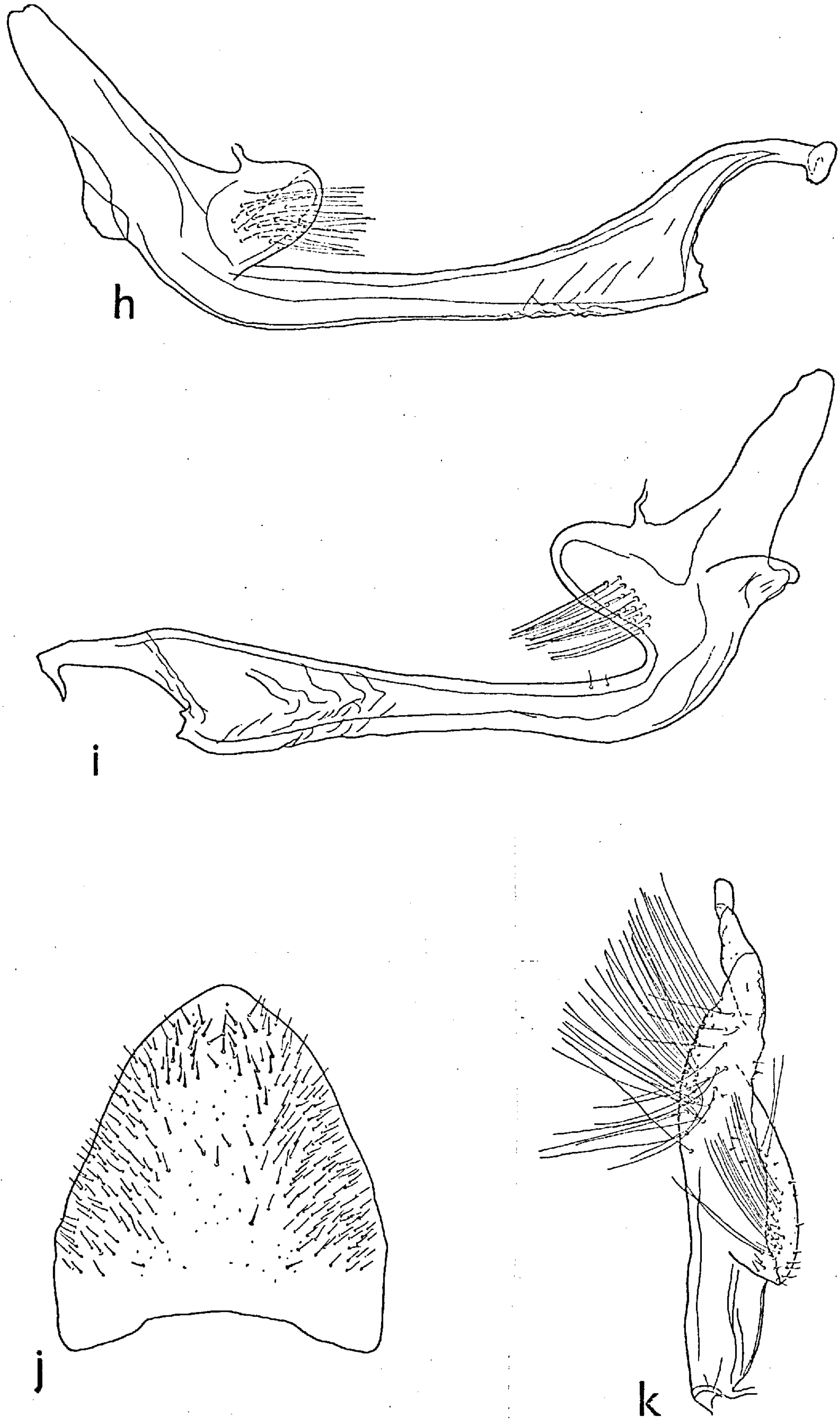

h
i
j
k

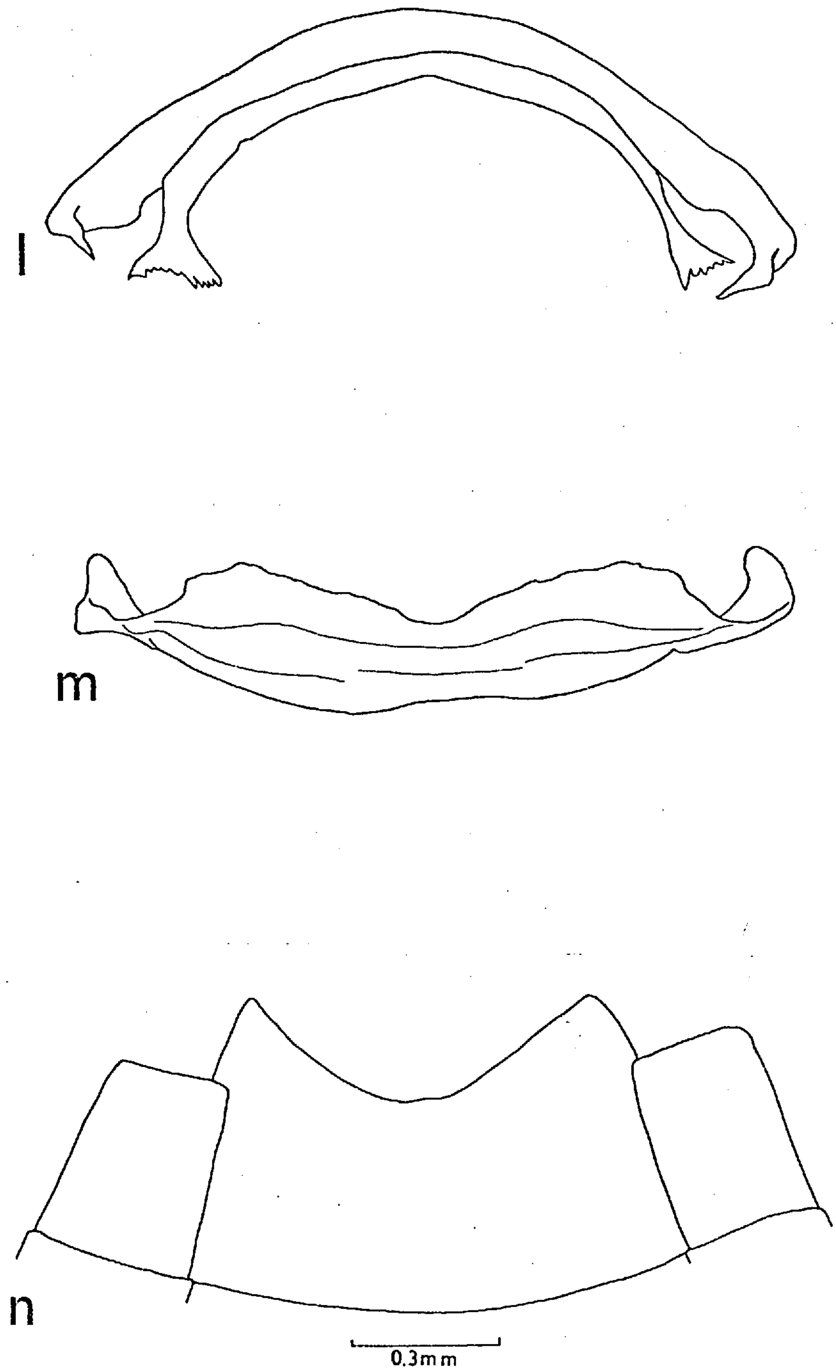
Fig. 38C - B. (S.) wardi n. sp.

l, antecosta of second abdominal tergum, posterior view

m, second sternal abdominal apodemes, postero-dorsal view

n, female 7th abdominal sternite, ventral view

Scale as in Figs.1A and 1B or, otherwise, as indicated.


l
m
n
0,3mm

II. MULTIVARIATE ANALYSIS

(a) Introduction

The genus Batracomorphus Lewis is a homogeneous group of leafhoppers which are difficult to separate as indicated in the previous chapter. As stated above (p. 22), the Ethiopian species were treated recently in a revision of the subfamilies Iassinae and Acroponinae by Linnavuori & Quartau (1975). The new material studied in Chapter I and the results given in the revision served as the bases of the present, quantitative analysis.

Two main character sets were analysed, one made up of measured continuous and meristic variables and the other of qualitative variables (two-state and multistate ordered and unordered), which were collected from the male genitalia, the abdominal apodemes and some external structures. The latter character set included also some ecological and zoogeographical data.

An attempt was made to assess character associations in order to isolate possible structural and/or functional character groups. Product-moment correlation coefficients among measurements from external structures and genitalia were analysed by principal component analysis and cluster analysis in the hope of gaining some insight into the relationships between some of these structural characters.

Moreover, a sample comprising the species described in Chapter I was used to test if the placement of species in subgenera by numerical methods was in close agreement with traditional views. Another aim was to determine the effect on a numerical classification of using different suites of characters, e.g., male genitalia and abdominal apodemes vs. external characters. The assessment of several other modifications was also attempted, such as: (a) measured continuous variables vs. qualitative variables; (b) standardized vs. unstandardized characters; (c) correlations vs. distance measures or correlations vs. Gower's similarity coefficient; and (d) cluster analysis vs. ordination.

(b) Materials and Methods

1. OTU's

Two different sets of OTU's were used in the numerical analysis: (a) a total of 99 male specimens of Batracomorphus, comprising 24 species (*) represented by one male each and 15 species represented by more than one specimen (Table 1); and (b) a total of 127 forms comprising the 103 species and the 5 subspecies recognized in Linnavuori & Quartau (1975) together with the new material described in Chapter I.

2. Characters

For each of the 99 specimens a total of 139 characters were chosen and their states determined. Characters were mainly selected from the external structures, the abdominal apodemes, and genitalia (+) and embodied in two main primary matrices: matrix A, with 23 measured continuous or meristic variables (Table 2); and matrix B, with 116 mixed variables, i.e., two-state and multistate, ordered and unordered (Table 3). From these matrices two other were obtained, that is matrices I and II (Table 2 and 3, respectively), where each character state is respectively the mean and the most frequent value for each species, unless the alternative "variable" is given. The clustering of species was made according to the author's concept of conventional taxonomists' species in Batracomorphus. This study is a treatment of the derived matrices only, and is therefore, centered at the supra-specific level. Measurements of matrix I were not converted into millimetres, the actual units of the ocular micrometer being used in the analyses.

* Specimen 79, of doubtful status (subolivaceus St?) was run as an independent OTU in matrices I and II.

\+ There is some ecological and zoogeographical data as well.

For each of the 127 species and subspecies, which is the current number of known forms of Batracomorphus from the Ethiopian area, the first 90 characters of Table 3 were used to form a third set of characters (matrix III).

Certain states were coded as "non-applicable", as this term is used in numerical taxonomy (Sneath & Sokal, 1973, p. 115). As referred to in each analysis, a few combinations of characters were not considered, either to avoid redundancy caused by partial logical correlations or because some characters were invariant in some matrices.

Copies of matrices I-III are given in the Appendix.

3. Comments on the lists of characters

As referred to in Chapter I the terminology of leafhopper morphology used follows most closely Linnavuori (1959) and Linnavuori & Quartau (1975). Under zoogeography Devred's classification of African ecological zones was followed (Vos, 1975). In ecology a rather simplified and generalized classification was followed in order to have only a few states and to be able to accommodate the few ecological data available for each species. The African vegetation types range from moist tropical forest through types with both tree and grasses in varying proportions to pure grasslands, shrubby vegetation associated with low rainfall, and ultimately to desert. Detailed vegetation maps for Africa are those by Phillips (1959) or by Keay (1959). The following are the correspondences between each of the states used and Keay's types (given by numbers):

1. Desert and sub-desert: types 28-32;
2. Grasslands: types 5 and 6;
3. Woodlands, savannas and steppes: types 16-27;
4. Moist tropical forest: types 7-11;
5. Montane: types 1, 3 and 4;

6. Undergrowth in moist, montane and temperate forests: includes the lower layers of plants of rather different vegetation types both floristically and physiognomically; these layers are made up of shrubs and herbaceous plants including grasses and ferns; the canopy refers to the types referred to in states 4, 5 and 7;
7. Temperate forest and Mediterranean types: types 2 and 15;
8. Variable: combinations of any of the previous states.

Table 1 OTU's USED IN THIS STUDY

Code numbers: Matrices A and B	Matrices I and II	No. of specimens	Species or subspecies name	Distribution
			Batracomorphus s.str.	
1-11	1	11	dalatandoensis n.sp.	Guinean.
12-13	2	2	quirimboensis n.sp.	Guinean.
14	3	1	l. carvalhoi n.ssp.	Guinean.
15	4	1	hollisi n.sp.	Guinean.
16	5	1	danae Lv.& Quart.	Soudanian; Zambesian.
17	6	1	duquensis n.sp.	Zambesian.
18-21	7	4	welwitschi n.sp.	Guinean.
22-23	8	2	lucalensis n.sp.	Zambesian.
24-25	9	2	dirkoides Lv.& Quart.	Guinean; Zambesian.
26	10	1	arcuatus Lv.& Quart.	Guinean; Zambesian.
27	11	1	mandane Lv.& Quart.	Guinean; Zambesian.
28	12	1	lewisi n.sp.	Guinean.
29	13	1	signatus Ldb.	Soudanian; Sahelian; Mediterranean.
30	14	1	distinctissimus n.sp.	Guinean.
31-33	15	3	clarensis n.sp.	Transvalian; Kalaharian.
34	16	1	gobiswaterensis n.sp.	Kalaharian.
35	17	1	sapobensis n.sp.	Guinean.
36	18	1	beninensis n.sp.	Guinean.
37	19	1	classeyi n.sp.	Guinean.
38	20	1	bifasciatus Lv.& Quart.	Guinean.

Table 1 (continued)

Code numbers				
Matrices A and B	Matrices I and II	No. of specimens	Species or subspecies name	Distribution
39-41	21	3	natalensis n.sp.	Basutolian.
42-47	22	6	samaruensis n.sp.	Soudanian.
48-50	23	3	ceresensis n.sp.	Cape.
			Sudanoiassus Lv.& Quart.	
51	24	1	wardi n.sp.	Soudanian.
			Batracomorphus s.str.	
52	25	1	teispes Lv.& Quart.	Soudanian.
53-58	26	6	mosselensis n.sp.	Cape; Transvalian.
59	27	1	santosjuniori Lv.& Quart.	Transvalian; Zambesian; Guinean.
60-78	28	19	subolivaceus (St.)	Cape; Karroo-Namaqualian; Kalaharian; Basutolian.
79	29	1	subolivaceus (St.)?	Cape.
			Sudanoiassus Lv.& Quart.	
80	30	1	lituratus Lv.& Quart.	Guinean; Zambesian.
			Batracomorphus s.str.	
81-82	31	2	a. hargeisanus Lv.& Quart.	Eastern; Kalaharian.
83	32	1	incognitus Lv.& Quart.	Guinean.
84	33	1	minos Lv.& Quart.	Guinean; Eastern.
85	34	1	thamyris Lv.& Quart.	Soudanian.
86	35	1	timaea Lv.	Guinean

Table 1 (continued)

Code numbers				
Matrices A and B	Matrices I and II	No. of specimens	Species or subspecies name	Distribution
			Sudanoiassus Lv.& Quart.	
87-91	36	5	kivuensis Lv.& Quart.	Guinean.
92	37	1	cecrops Lv.& Quart.	Guinean; Transvalian.
93-94	38	2	magniceps Lv.& Quart.	Guinean; Eastern.
			Batracomorphus s.str.	
95-99	39	5	irroratus Lew.	Palaearctic.

Table 2 LIST OF CHARACTERS: MEASUREMENT VARIABLES

(Matrices A and I) (*)

Character no.	Description
1	Overall length (from apex of the crown to the tips of elytra) (15 x)
2	Head-width across eyes (62.5 x)
3	Medial length of crown (62.5 x)
4	Medial length of pronotum (62.5 x)
5	Medial length of scutellum (62.5 x)
6	Interocular width of crown (62.5 x)
7	Distance between ocelli (62.5 x)
8	Distance between ocelli and eyes (62.5 x)
9	Maximum width of pronotum at humeral angles (15 x; 62.5 x)
10	Width of scutellum at base (62.5 x)
11	Length of elytra (15 x)
12	Length of apophysis of stylus (125 x)
13	Length of apophysis of stylus as in Linnavuori & Quartau (1975) (125 x)
14	Total length of penis (125 x)
15	Length of socle of penis (125 x)
16	Length of stem of penis (125 x)
17	Length of basal apodeme of penis (125 x)
18	Medial length of 8th sternite (125 x)
19	Length of anterior incision between the arms of connective in dorsal view (125 x)
20	Length from hindmost point of anterior incision between arms to apex of shaft of connective in dorsal view (125 x)
21	Total length of connective (125 x)
22	Length of elytral setae (125 x)
23	Density of pronotal furrowing (no. of pronotal furrows/ 60 ocular divisions measured medially and from the posterior margin of pronotum) (125 x)

* All measurements involving paired structures were taken twice and recorded as the mean. The length of the elytral setae was taken as the mean of any 4 setae in the discal area of the left elytron. Measurements of the genitalia were taken as indicated in Figs. 1A-B. In brackets are given the total magnifications at which these measurements were recorded. Calibration coefficients for conversion into millimetres for the magnifications of 15 x, 62.5 x, and 125 x were respectively 0.06538, 0.01563 and 0.00781.

Table 3 LIST OF CHARACTERS: TWO-STATE AND MULTISTATE ORDERED OR UNORDERED VARIABLES (Matrices B, II and III)

Character no.	Description
General	
1	Size: small (≤4.50 mm) (1), medium-sized (4.50-5.50mm) (2), large (≥5.50mm) (3).
2	General appearance (*): robust (≤2.75) (1), intermediate (2.75-2.90) (2), elongate (≥2.90) (3).
3	General brilliance: shiny (1), fairly shiny (2), dull (3).
4	General colour: greenish or olivaceous (1), green-yellow (2), yellowish or ochraceous (3), yellow-brown (4), brown (5), variable (6).
Head	
5	Colour of crown: greenish (1), yellowish (2), brownish (3), greyish or dark (4), variable (5).
6	Upper part of face infumated (1), not so (2).
7	Lower part of face infumated (1), not so (2).
8	Colour of eyes: reddish or purplish (1), reddish brown or reddish grey (2), greyish, brownish grey or brown (3).
9	Crown with two round reddish, brown or dark spots: present (1), absent (2).
Pronotum	
10	General colour: greenish (1), yellowish (2), brownish (3), greyish or dark (4), variable (5).
11	Base: tinged with brown or fuscous (1), with dark spots or dots (2), immaculate (+) (3).
12	Anterior margin: tinged with brown or fuscous (1), with reddish, brown or with dark spots or dots (2), immaculate (+) (3).

* Given by the ratio between variables 1 and 9 of Table 2 and at the same magnification.

\+ Includes yellowish, greenish or golden tinges.

Table 3 (continued)

Character no.	Description
13	Lateral margins or humeral angles: tinged with brown or fuscous (1), with dark spots or dots (2), immaculate (*) (3).
14	Disk with four faint longitudinal brownish spots: present (1), absent (2).
15	Disk more or less densely spotted with brown: present (1), absent (2).
16	Disk minutely dotted with brown or dark: present (1), absent (2).
<u>Scutellum</u>	
17	General colour: greenish (1), yellowish (2), brownish (3), greyish or dark (4), variable (5).
18	Basal triangular spots: absent or concolorous (1), tinged with light brown (2), tinged or spotted with brown (3).
19	Lateral margins infuscate or tinged with brown (+): present (1), absent (2).
20	Middle spots: absent or concolorous (1), two medial brown present (2), several brown or dark present (3).
21	Apex fuscous or tinged with dark (+): present (1), absent (2).
22	Minutely dotted with brown or dark: present (1), absent (2).
<u>Elytra</u>	
23	General colour: whitish (1), yellow or ochraceous (2), greenish (3), greyish or brownish (4), variable (5).
24	Two transverse fuscous fasciae: present (1), absent (2).
25	More or less densely spotted with brown or with fuscous (excluding appendix): present (1), absent (2).
26	Corium with a brownish or fuscous stripe parallel to claval suture or along Cu: present (1), absent (2).
27	Base of appendix infumated, or tinged with brown: present (1), absent (2).

* Includes yellowish, greenish or golden tinges.

\+ When all scutellum dark, (1) was computed as well.

Table 3 (continued)

Character no.	Description
28	First apical cell infumated, or tinged with brown: present (1), absent (2).
29	Tips of second and third apical cells infumated, or tinged with brown: present (1), absent (2).
30	Appendix, first apical cell and posterior part of other apical cells infumated, or tinged with brown: present (1), absent (2).
31	General colour of veins: fuscous or dark (1), greenish or yellowish (2), light brownish (3), reddish (4).
32	Claval suture fuscous or tinged with brown: present (1), absent (2).
33	Scutellar margin of clavus fuscous or tinged with brown: present (1), absent (2).
34	Commissural margin of clavus: fuscous or tinged with brown (1), with a dark apical spot (2), with a middle or subapical dark spot (3), yellowish or greenish (4).
35	Puncturing: distinctly punctate (1), in pale areas obsoletely and in dark areas distinctly punctate (2), obsoletely punctate (3).
36	Puncturing: dense (1), sparse (2).
37	Colour of puncturing: concolorous (1), in dark areas dark and in other parts concolorous (2), brownish or dark (3).
38	Setae: short ($\leqslant$0.03mm) (1), longish (>0.03mm) (2), absent (3).
39	Colour of setae: pale or yellowish (1), brownish or brown (2), dark (3).
Under surface	
40	General colour: greenish (1), yellowish (2), yellow-brown (3), brown (4), variable (5).
41	Under surface of thorax largely blackish brown (1), not so (2).

Table 3 (continued)

Character no.	Description
Legs	
42	General colour: green or olivaceus (1), yellowish (2), yellow-brown (3), brown or dark (4), variable (5).
43	Fore and middle femora tinged with brown: present (1), absent (2).
44	Hind femora tinged with dark brown: present (1), absent (2).
45	Tarsi tinged with green: present (1), absent (2).
Varia	
46	Pronotum distinctly convex (1), not so (2).
47	Ratio between width and length of crown: crown long ($\leqslant$5) (1), intermediate (5-6.5) (2), short ($\geqslant$6.5) (3).
48	Ratio between width and length of pronotum measured medially: Pronotum narrow ($<$2) (1), intermediate (=2) (2), wide ($>$2) (3).
49	Ratio between length of crown and length of pronotum measured medially: ($\geqslant$0.18) (1), ($<$0.18) (2).
50	Sulcation of pronotum: finely furrowed (1), deeply or coarsely furrowed (2).
Male pygophore	
51	Macrosetae of side lobes arising from dark pits (1), not so (2).
52	Number of macrosetae: ($\leqslant$8) (1), (8-14) (2), ($\geqslant$14) (3).
53	Side lobes apically: acute (1), truncate (2), rounded (3), variable (4).
54	Side lobes with a short weakly sclerotized lobe on dorsal margin: present (1), absent (2).
Appendages of pygophore	
55	In lateral view (apex excluded): nearly straight (1), moderately curved (2), strongly curved (3).

Table 3 (continued)

Character no.	Description
56	Bifurcate with secondary branch thin, longer than the primary one (1), bifurcate with secondary branch long but shorter or with the same length as the primary one (2), bifurcate with the secondary branch short (3), bifurcate with the bifurcation just as apex, sub-apex or with a small subapical tooth (4), simple (5), variable (6).
57	A sclerotized spiral on apical part: present (1) absent (2).
58	Inner surface with a sclerotized spinose process: present (1), absent (2).
59	Middle part on ventral surface: approximately smooth (1), minutely serrate or crenulate (2), large and irregularly serrate or dentate (3).
60	Apical or subapical part serrate, crenulate or dentate (1), not so (2).
61	Apical part expanded (not considered when expansion due to apical bifurcation)(1), not so (2).
Stylus	
62	Length (variable 13 of Table 2): short (⩽0.60mm) (1), intermediate (0.60-0.85mm) (2), long (⩾0.85mm) (3).
63	Apophysis gracile in lateral aspect (1), not so (2).
64	Apophysis with a few tubercles: present (1), absent (2).
65	Dorsal margin of apophysis in lateral view: approximately straight (1), moderately expanded (2), broadly or strongly expanded (3), more or less sinuate (4).
66	Ventral margin of apophysis in lateral view: broadly or strongly expanded and not sinuate (1), moderately expanded or approximately straight (2), with a distinct subapical sinuation (3), with a distinct sinuation near base or at middle (4), sinuate both apically and basally (5), with a roundish or angulate subapical expansion (6).
67	Apical tooth on ventral margin of apophysis: strongly developed (1), moderate (2), absent (3).
68	Apophysis strongly constricted near apex or gradually and strongly narrowing to apex (1), not so (2).

Table 3 (continued)

Character no.	Description
69	Apical hook of apophysis claw-like (1), not so (2).
70	Apical hook of apophysis: short (1), intermediate (2), long (3).
71	Apical hook of apophysis stout (1), not so (2).
72	Apical hook of apophysis sharp (1), not so (2).
73	Direction of apical hook of apophysis: obtusely angled (1), normally angled (2), acutely angled (3), variable (4).
74	Apical hook of apophysis with a subapical tooth: present (1), absent (2).
Penis	
75	Length: short (≤0.45mm) (1), intermediate (0.45-0.55mm) (2), long (≥0.55mm) (3).
76	Ventral corner of socle: acutely prominent (1), moderately prominent (2), rounded and not prominent (3).
77	Stem slender (1), not so (2).
78	Stem: distinctly curved dorsad (1), fairly straight or moderately curved dorsad (2), distinctly curved ventrad (3).
79	Stem tubular (1), not so (2).
80	Apex of stem recurved anteriorly (1), not so (2).
81	Apex of stem in posterior view: spoon-shaped and approximately ovate (1), spoon-shaped, pear-shaped (2), spoon-shaped, very narrow and tapering apicad (3), spoon-shaped, triangular, apical margin at most shallowly sinuate or sharp-tipped (4), spoon-shaped, parallel-sided, apical margin deeply, angularly excavated (5), spoon-shaped, narrowish, long, parallel-sided (6), not spoon-shaped (7).
82	Dorsal triangular apical lobes of stem: present (1), absent (2).
83	Posterior surface of stem with a pair of ligulate dentate lobes: present (1), absent (2).
84	Posterior surface of stem with longitudinal serrate or dentate lamellae: present (1), absent (2).

Table 3 (continued)

Character no.	Description
85	Posterior or postero-lateral surface of stem provided with a series of small teeth: present (1), absent (2).
86	Stem with small tubercles on lateral or anterior surfaces: present (1), absent (2).
87	Anterior surface of stem: smooth (1), minutely serrate or crenulate (2), coarsely serrate (3).
88	Anterior surface of stem: with a pair of teeth or triangular lobes (1), with a distinct pair of subapical spines (2), without teeth, triangular lobes or subapical spines (3).
89	Ratio between length of socle and length of stem: socle short ($\leqslant$0.40) (1), intermediate (0.40-0.65) (2), long ($\geqslant$0.65) (3).
90	Angle between socle and base of stem measured on ventral margin: $<180^{\circ}$ (1), $\simeq 180^{\circ}$ (2), $>180^{\circ}$ (3).
Ecology	
91	Desert and subdesert (1), grasslands (2), woodlands, savannas and steppes (3), moist tropical forest (4), montane (5), undergrowth in moist, montane and temperate forests (6), temperate forest and Mediterranean types (7), variable (8).
Zoogeography	
92	Mediterranean (1), Saharian (2), Sahelian (3), Soudanian (4), Eastern (5), Guinean (6), Zambesian (7), Transvalian (8), Kalaharian (9), Basutolian (10), Karroo-Namaqualian (11), Cape (12), variable (13).
First sternal abdominal apodemes (*)	
93	Outline of notch: rectangular (1), oval, compressed (2), oval or angularly oval (3), circular or broadly triangular (4).
94	Lobes expanded medially (1), not so (2).
95	Lobes: closely apposed (1), relatively separated (2), widely separated (3).

* In caudal view with notch in maximum outline.

Table 3 (continued)

Character no.	Description
Second sternal abdominal apodemes (+)	
96	Lobe-shaped (1), not so (2).
97	Distinctly longer than half their individual width at middle (1), not so (2).
98	Mesal margin: approximately straight (1), rounded (2), angular (3).
99	Lobes: distinctly set closer together than their individual width at middle (1), condition between states 1 and 3 (2), distinctly set farther apart than their individual width at middle (3).
100	Outer margins steep (1), not so (2).
101	Inner margins approximately vertical (1), not so (2).
102	Base of inner margins with a small tooth: present (1), absent (2).
103	Apex or subapical part with a small tooth: present (1), absent (2).
Antecosta of second abdominal tergum (+)	
104	Strongly developed (1), not so (2).
105	Mesal sinuation: well defined (1), obsolete or absent (2).
8th sternite	
106	As wide as long or wider than long (1), not so (2).
107	Apical part acutely rounded (1), not so (2).
108	Setae: dense (1), sparse (2).
Male pygophore (continued)	
109	Very elongate and low (length/maximum height>2.3) (1), not so (2).
110	With a mid-ventral incision only (1), with both a mid-ventral and mid-dorsal incision (2).

\+ In caudal view and in widest aspect.

Table 3 (continued)

Character no.	Description
Connective	
111	Base in dorsal view: longer than maximum width (1), as wide as long or wider than maximum length (2).
112	Shaft in dorsal view: distinctly longer than base (1), approximately as long as base (2), distinctly shorter than base (3).
113	Dorsal keel in lateral view: distinctly higher than base (1), approximately as high as base (2), distinctly lower than base (3).
Genital plates	
114	Turned strongly laterad at mid-length (1), not so (2).
115	Subapical part with long setae along outer margin: present (1), absent (2).
Head (continued)	
116	Crown: shorter in middle than next to eye (1), of equal length in middle as next to eye (2), longer in middle than next to eye (3).

4. Methods

Data processing was carried out through the use of several multivariate statistical programs both on the CDC 6000 series of the University of London Computer Centre and on the CDC Cyber/6400 of the Imperial College Computer Centre.

Cluster analysis was performed through two different programs: (a) the computer program 7.6 from Davis (1973) amended and extended by R.G. Davies (Dept. of Zoology and Applied Entomology, Imperial College) through which a set of different analyses were undertaken using either Pearson's product-moment correlation coefficient, the taxonomic distance coefficient, or Gower's similarity coefficient (Gower, 1971a), as measures of similarity or dissimilarity; data were in several instances standardized to zero mean and unit variance (Sneath & Sokal, 1973) and the clustering method known as weighted pair-group method analysis (WPGMA) was used; this program can accept missing or non-comparable data and as a result of each analysis a hierarchical classification is produced in the form of a dendrogram of phenetic resemblance (phenogram: Mayr, 1965; Sokal & Camin, 1965); (b) a second program written by R.G. Davies and similar to the previous one but extended from the program 46 described in Davies (1971), through which single-linkage cluster analysis was carried out.

In order to aid in the interpretation and discussion of the dendrograms obtained, a phenon line was sometimes chosen. In the Q-type analyses these lines are purely group-defining with no special taxonomic or statistical significance attached to them.

Principal component analysis (PCA) and its variation known as principal coordinate analysis (PCRDA) as developed by Gower (1966) were carried out through a recently developed program written by R.G. Davies. This program admits missing or non-comparable data, can standardize or transform data according to several options and can compute several types of association matrices. Computation of eigenvectors and eigenvalues of a real symmetric matrix is performed by the diagonalization method originated by Jacobi and adapted by Von Neumann (Ralston & Wilf, 1967). Matrices of covariances and correlations were analysed by PCA and matrices of taxonomic distance as well as of match-mismatch distance by PCRDA. Match-mismatch distance is defined as $(1 - S_{SM})^{\frac{1}{2}}$ in which S_{SM} is defined as 1 for negative matches (Boratynski & Davies, 1971). A decision to use data with missing or non-comparable values in principal component analysis is not to be undertaken lightly. The statistical problems involved are considerable and have not been fully solved (Beale, pers. comm.). It is sometimes recommended to replace missing values by column means (Webster, 1977). Sneath & Sokal (1973), however, recommend the omission of the two data points from the calculation of similarity or distance when one of them is missing or non-comparable. This was done in the program used though it is pointed out by Sneath & Sokal that this may cause an otherwise Euclidean metric to become non-Euclidean. What is more relevant to principal component and coordinate analysis, however (and what is not mentioned by Sneath & Sokal) is that the similarity/dissimilarity matrices resulting from this computational device are not positive semi-definite: their trace is not equal to the sum of their latent roots and the latter include some negative values. Fortunately, the amount of missing or non-comparable data in the present study is small and it is not expected to invalidate appreciably the conclusions reached.

Cophenetic correlation coefficients to test the fidelity with which each phenogram expressed the original similarity matrix were not calculated emphasis having been placed on comparisons among phenograms. The different phenograms obtained were compared by extracting topological distances (Phipps, 1971) and finding the correlations between the resulting matrices. Cluster analysis was applied to the resulting correlation matrix which leads ultimately to the arrangement of the different analyses in the form of a dendrogram.

The results of PCA and PCRDA were compared through the Rotational Fit Method of Gower (1971b). This was done using a recently developed program by R.G. Davies which calculates a residual fit matrix as a result of comparing two or more different sets of orthogonal coordinates of a given set of OTU's. The resulting residual fit matrix for all possible pairwise comparisons was ultimately treated by cluster analysis which leads again to the arrangement of the different analyses in the form of a dendrogram.

Where necessary, additional programs for the treatment of the data were written by R.G. Davies.

(c) Assessment of Character Associations

Principal component analysis and average linkage cluster analysis by the weighted pair-group method (WPGMA) were carried out in order to assess character associations between the measurement variables of matrix I (Table 2) (*). The product-moment correlation coefficient was used for this assessment (Tyron & Bailey, 1970; Solomon, 1971) both in cluster analysis and in component analysis.

1. Untransformed data

1.1 Principal component analysis

A Q-mode principal component analysis was carried out by transposing the data matrix so that the OTU's were treated as variables and the characters as OTU's. Ten components were extracted from the 21 times 21 matrix of between-character correlations based on unstandardized data. They accounted for 97.34% of the total variation, the first three components extracting 74.11% of the variation in the association matrix. Figs 39a-b are plots of the 21 characters respectively on the 1st and 2nd, and on the 1st and 3rd component axes. These plots give a pictorial view of the relationships among the characters, showing the following associations: (a) a major separate group of size-dependent variables (characters number 1-2, 4-11, 18 and 20); (b) an association of stylus and penis lengths (characters number 13-14) and of lengths of the stem and of the basal apodeme of penis (characters number 16-17); (c) a negative association between character number 23 and the group of variables positively related with general size; and (d) a negative association especially between characters number 15 and 17.

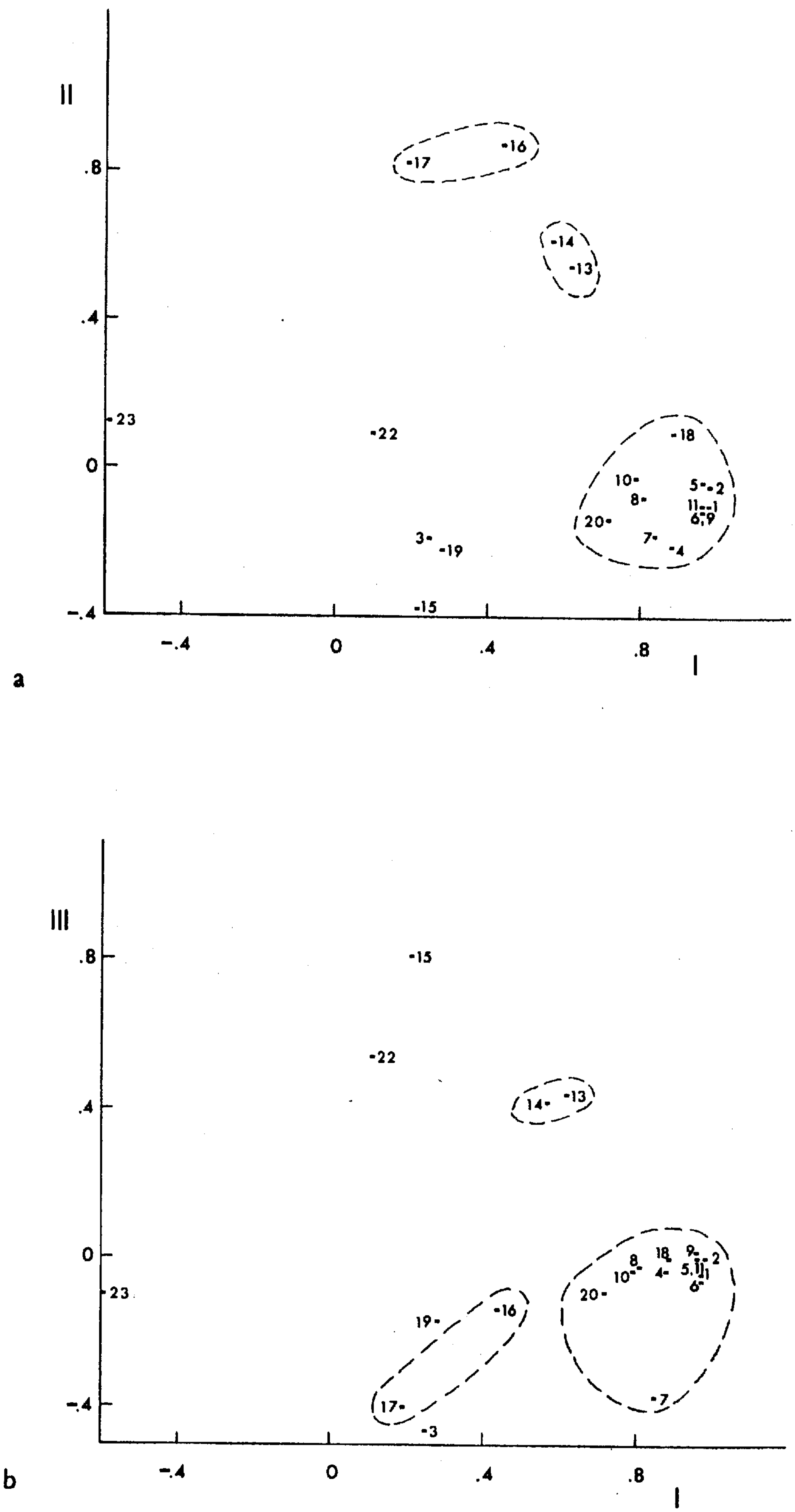
1.2 Cluster analysis

R-type analysis was applied to the correlation matrix of the 21 unstandardized variables (Fig. 40a). Considering a cut-off line

* Variables 12 and 21 were not considered because of redundancy.

Fig. 39 - a. A two dimensional view of the relationships among the 21 characters of matrix I in a space determined by component I (53.17%) and component II (11.92%) of the first ten axes of a Q-mode principal component analysis of the matrix of correlations between the characters. Data unstandardized. Components I and II, taken together, account for 65.09% of the total variation.

- b. A two dimensional view of the relationships among the 21 characters of matrix I in a space determined by component I (53.17%) and component III (9.02%) of the first ten axes of a Q-mode principal component analysis of the matrix of correlations between the characters. Data unstandardized. Components I and III, taken together, account for 62.19% of the total variation.


II
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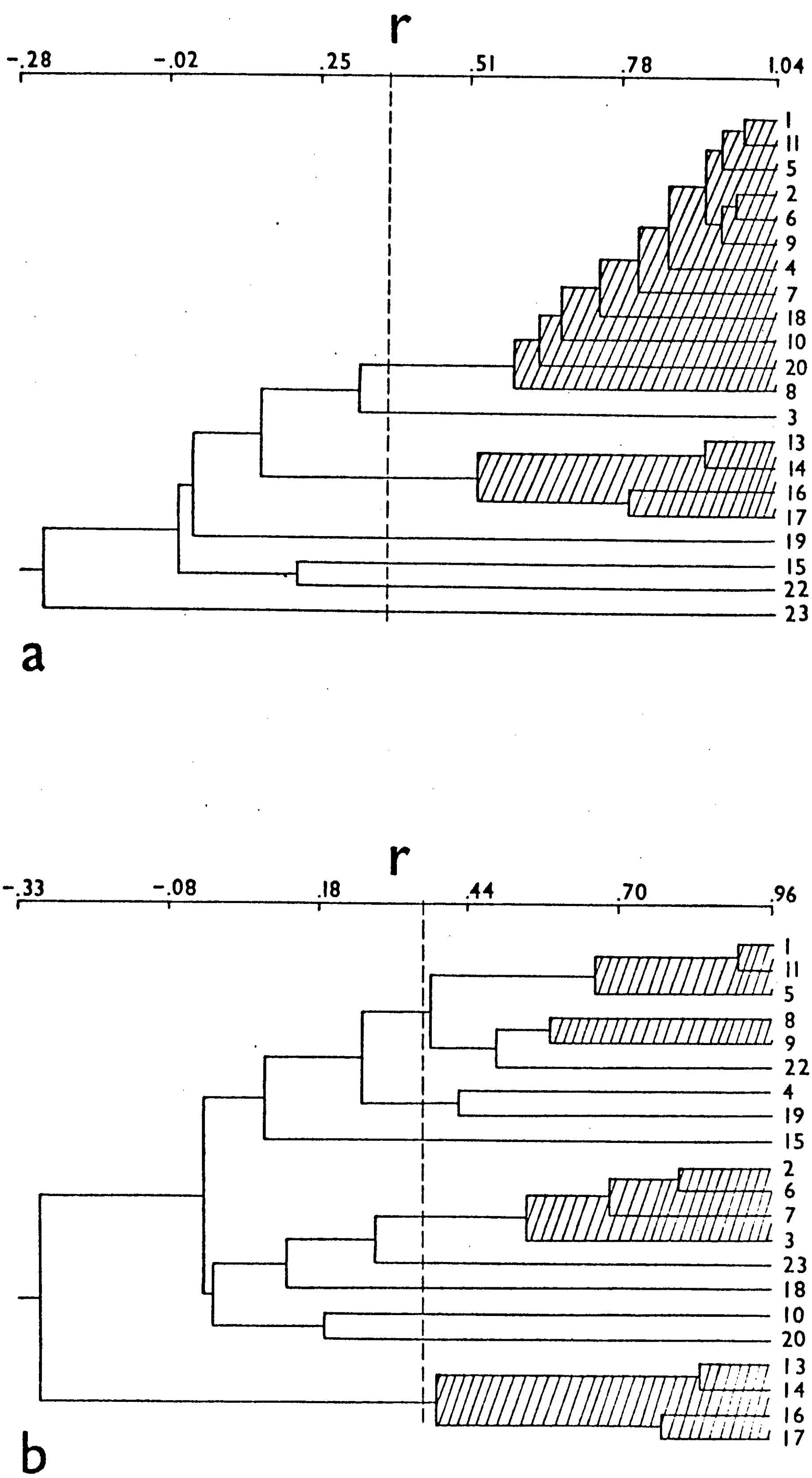
Figs 40a-b - WPGMA cluster analysis of character correlations with data respectively untransformed and standardized across OTU's. Cross-hatched are the associations in concordance with the respective ordinations. Note that in the standardized analysis the cluster of size-dependent variables was broken apart. Characters as follows (*):

1. Overall length
2. Head-width across eyes
3. Medial length of crown
4. Medial length of pronotum
5. Medial length of scutellum
6. Interocular width of crown
7. Distance between ocelli
8. Distance between ocelli and eyes
9. Maximum width of pronotum at humeral angles
10. Width of scutellum at base
11. Length of elytra
13. Length of apophysis of stylus
14. Total length of penis
15. Length of socle of penis
16. Length of stem of penis
17. Length of basal apodeme of penis
18. Medial length of 8th sternite
19. Length of anterior incision of connective
20. Length of shaft of connective
22. Length of elytral setae
23. Density of pronotal furrowing

* For details see Table 2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at $\underline{r}$ = 0.36 (middle point for a significant $\underline{r}$ at the 0.05 and 0.01 probability levels for the sample size of this matrix) (*) practically the same picture emerged again. In fact, this dendrogram (a) depicts the two groups of intercorrelated variables detected by the previous ordination (cross-hatched in Fig. 40a), (b) isolates variable 23 at a negative clustering level, and (c) gives a nearly independent status for the remaining variables.

1.3 Discussion

Results from these two multivariate techniques are in close agreement. Simultaneous application of cluster analysis and of principal component analysis therefore appears to be particularly useful in the assessment of covariant character sets. These techniques also seem to supplement each other. PCA detected covariant character suites in axes of variation having no statistical correlation with each other, depicting negative associations at the same time. Cluster analysis did not depict negative associations but showed the relationships of the variables within clusters. The use of the two techniques consequently permitted a fuller and unbiassed understanding of the underlying structure of these data.

2. Standardized data

In order to compare the results given by untransformed data and by standardized values, matrix I was standardized by OTU's prior to the calculation of the correlation matrix, so that the values for each OTU had a mean of zero and a standard deviation of one. Principal component analysis and average linkage cluster analysis (WPGMA) were again carried out.

2.1 Principal component analysis

A Q-mode principal component analysis was again carried out by

* This value neglects the fact that the correlations are not independent of one another; it is, therefore, used as a rough guide only.

transposing the data matrix, so that the OTU's were treated as variables and the characters as OTU's. Again ten components were extracted from the 21 times 21 matrix of between-character correlations based now on data standardized across OTU's. These components accounted for 93.75% of the total variation, the first three components extracting 59.19% of the variation in the similarity matrix. Figs 41a-b are plots of the 21 characters respectively on the 1st and 2nd, and on the 1st and 3rd component axes. These scatter diagrams show the following main associations: (a) two clusters comprising, respectively, characters number 2-3, 6-7 and 1,4-5, 8-9,11; (b) the same association of stylus and penis lengths displayed by the unstandardized analyses and forming again two sub-groups (characters number 13-14 and 16-17); and (c) the negative association especially between characters number 15 and 17.

2.2 Cluster analysis

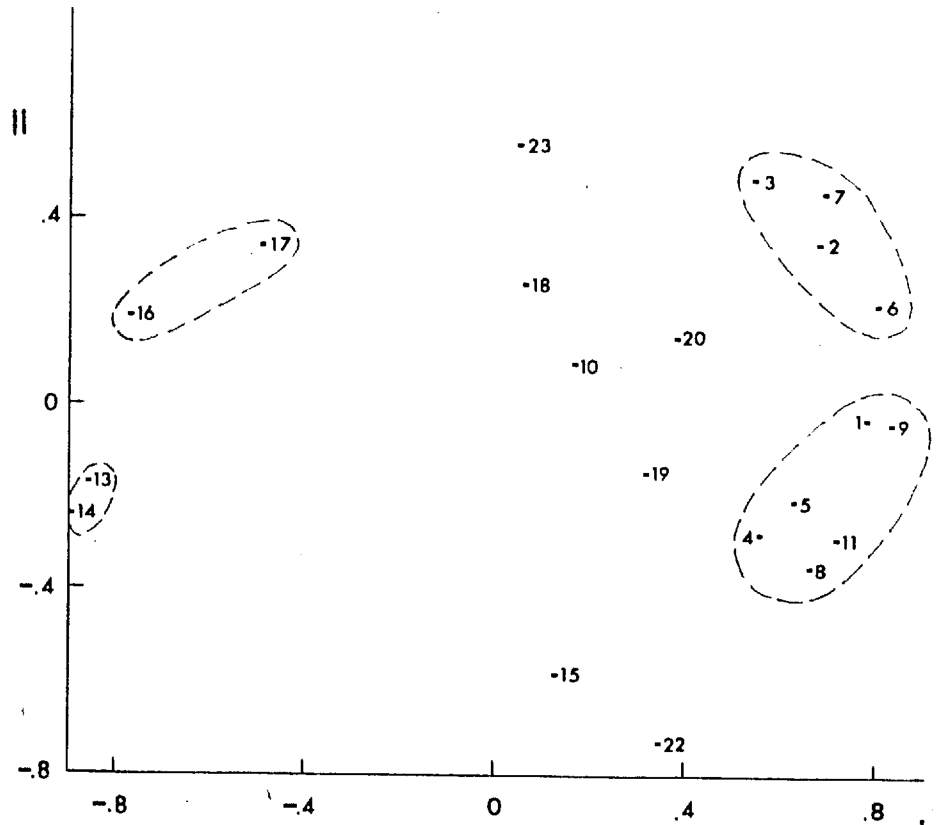
R-type cluster analysis was applied to the correlation matrix of the 21 standardized variables across OTU's (Fig. 40b). Considering again the similarity level at $\underline{r}$ = 0.36 as a rough guide, a similar pattern to that achieved by the corresponding ordination was yielded. In fact, (a) characters number 13-14 and 16-17 are again associated, and (b) characters number 1,5,8-9, 11 and characters number 2-3, 6-7 form again two small clusters. However, there are differences in detail, e.g., the relative position of variables number 4 and 22, which appeared as if they had shifted between each other.

2.3 Discussion

Here again, with standardized data, there is good agreement between the results produced by the cluster analysis and those given by the ordination. However, the dendrogram seemed to have over-emphasized the delimitation of clusters and grouped variables which the ordination showed to be rather weakly associated (e.g., variable number 15 which clustered with the group including variable number 1; or variable

Fig. 41 - a. A two dimensional view of the relationships among the 21 characters of matrix I in a space determined by component I (36.35%) and component II (11.90%) of the first ten axes of a Q-mode principal component analysis of the matrix of correlations between the characters. Data standardized. Components I and II, taken together, account for 48.25% of the total variation.

- b. A two dimensional view of the relationships among the 21 characters of matrix I in a space determined by component I (36.35%) and component III (10.94%) of the first ten axes of a Q-mode principal component analysis of the matrix of correlations between the characters. Data standardized. Components I and III, taken together, account for 47.29% of the total variation.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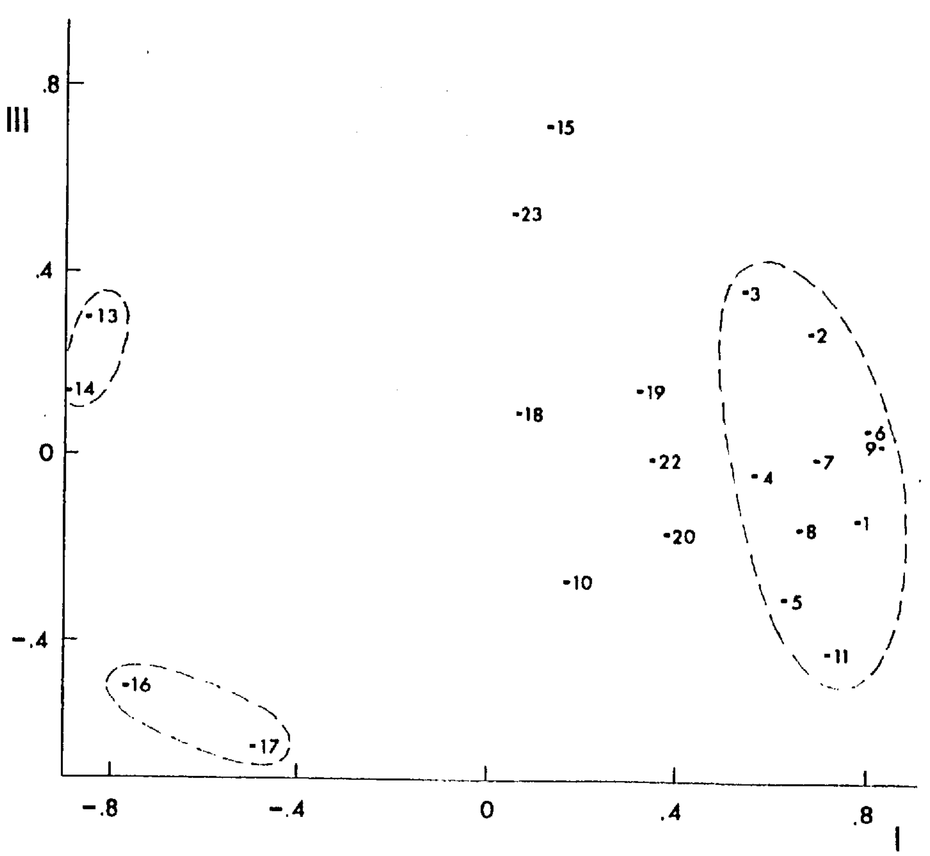
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number 23 in relation to the group including variable number 2). These differences are (a) a result of the method of cluster analysis, which tends to impose a hierarchical structure even when this structure is only weakly defined by the data, and (b) the fact that the dendrogram is somewhat inaccurate at low levels of similarity.

Principal component analysis seemed, therefore, to have given a more realistic representation of the relationships between these variables, although the dendrogram had the advantage of simplicity and clarity.

3. General Discussion

3.1 Influence of data standardization

As expected, with the product-moment correlation coefficient in the clustering of OTU's, for which most of these comparisons have been made (e.g.,Sokal & Michener, 1967; Moss, 1968), results differ according to whether or not the original variables are standardized.

Cluster analysis of the original data and of the standardized data yielded the dendrograms shown in Figs 40a and 40b respectively. As is clearly seen, the dendrograms based on standardized data produced quite a different picture, which is reflected in the low correlation of 0.22 obtained when the two matrices representing these dendrograms were compared by the method of Phipps (1971). Notwithstanding this fact, it is interesting to note that of the two sets of covariant characters revealed by the unstandardized analysis, only the group of size-dependent variables was divided when standardization was carried out. As standardization tends to equalize the influence of OTU's, thus preventing larger OTU's from exerting more effect than smaller ones, it is natural to suppose that (a) the clustering in the unstandardized data was greatly influenced by general size and (b) the clusters displayed by the dendrogram based on standardized data were grouped on other factors such as proportions or shape rather than on general size. Another argument favouring this interpretation is the fact that the association independent of general size (comprising variables number 13-14 and 16-17) was practically unaffected by standardization. A minor difference concerns the position of variable number 3, which in the unstandardized analysis appeared as an independent source of variation but was clustered when standardization had been carried out. As mentioned before, this may well suggest that the length of the crown, a variable independent of size, is probably related to shape or some other factor.

Principal component analysis was also affected by standardization as a comparison of the plots of Figs. 39a-b and 41a-b immediately reveals. First, when standardization of data was carried out, there was a large reduction in the variation extracted by the first component from 53.17% to 36.35%. In fact, standardization removed the effect of size originally present in the first component and by doing so caused a fall in the proportion of variation extracted. Concerning the character associations themselves, part of what was explained above for the dendrograms also applies here. Examination of the plots shows a well defined and compact cluster of size-dependent variables in the unstandardized analysis. When emphasis was not given to size, however, as in the analysis of standardized data, the cluster split into two rather loose sub-clusters. As principal component analysis does not impose such rigid structural assumptions as hierarchical cluster analysis, it is natural that the delimitation of clusters was much less sharp, as was especially evident when standardization had been carried out.

3.2 Character associations

Clustering of variables, as opposed to OTU's, has not attracted very much attention in animal taxonomy, but a few recent studies have been undertaken. For instance, Power (1971) in Brewer's blackbirds

(Euphagos cyanocephalus) or Johnston & Selander (1971) in sparrows (Passer domesticus) have applied hierarchical cluster analysis and principal component analysis simultaneously in the assessment of covariant character sets. These authors were, however, more concerned in analysing character loadings than character coordinates, so that they did not visualise the position of the variables by projecting them into planes defined by axes of variation. Their analyses of character associations would therefore seem to be less satisfactory than those carried out here.

As a result of all four analyses of the quantitative characters of Batracomorphus the following associations were revealed:

(1) Characters number 1-2, 4-11, 18 and 20 appeared to be mostly size dependent variables. Thus, larger specimens have relatively wider crowns, larger pronota and scutella, longer elytra, longer 8th sternites, and longer connective shafts. On the other hand, the density of pronotal furrowing seemed to be correlated negatively with general size: the larger the specimens the smaller the density of furrowing. It is interesting to note, however, that the length of crown (character number 3) is not associated with general size, which suggests the possibility of it being a reflection in Batracomorphus of the great plasticity that characterizes the head of the Iassinae (Evans, 1975; Linnavuori & Quartau, 1975).

(2) The following correlations seemed to suggest both functional importance during copulation and natural selection for (a) a positive association between the sizes of penis and stylus, (b) a positive association between the sizes of stem and basal apodeme of the penis, and (c) a negative association between the sizes of the socle and the basal apodeme of the penis. These may be interpreted as follows: the first association seems to indicate a co-adaptation between the clasping function of the styli and the insertion of the

penis during copulation; the second would permit a greater maneuverability of the penis; and the third association indicates a compensatory development between the basal apodeme and the socle of penis.

A functional understanding of taxonomic differentiation in the male genitalia is still rudimentary in the majority of insect groups. It has been suggested that the strongly associated genital structures of the male evolved in relation to the correct manner in which the female must be clasped as well as to a certain maneuverability that must be permitted during copulation (Scudder, 1971). In most of the studied Hemiptera, genital structures such as the styli have been reported to grasp the ovipositor valves but in some groups of Homoptera the styli are mainly protective devices rather than clasping structures (Singh-Pruthi, 1925b). In some leafhoppers (Oman, 1972) styli and penis are simultaneously extruded in order to stroke or probe the area at the base of the female's pygophore. Concerning the Iassinae and particularly the genus Batracomorphus we have only just begun to examine the problem of how the genital structures are related to each other and only very detailed behavioural studies can confirm the interpretations here suggested on multivariate statistical grounds.

(d) Clustering of OTU's: Continuous Data

1. Analyses undertaken

The list summarizing the analyses carried out with matrix I is shown in Table 4. The abbreviations listed were used throughout this study. ST or UN indicates whether characters were standardized or not. COR, DIS or GOW refer to the use of correlation, distance or Gower's similarity coefficient to analyse the similarity between the OTU's. GEN and EXS denotes the use of genital characters only (with omission of variables number 12 and 21) or characters from external structures only. ALL denotes inclusion of all characters in the analysis, including variables number 12 and 21. SL or WPGMA refer to the clustering method followed, that is, single-linkage or weighted pair-group method using arithmetic averages. In the table is also given the correlation coefficient between nodes traversed for each phenogram and those for phenogram no. 18, the phenetic classification which fitted best the relationships based on conventional methods.

In all, twenty-one different analyses were undertaken, forming the five arbitrary groups shown in Table 4. As referred to before the analysis which was in best general accord with the orthodox view was phenogram GOW-GEN-EXS-SL (18), that is a phenogram computed from a Gower's matrix based on 8 genital characters plus on 13 external structural characters and clustered by the single-linkage method. When using the Gower's similarity coefficient it is immaterial whether one standardizes the original data since the Gower matrix is unaffected by standardization. This is due to the fact that in computing Gower's coefficient, division by the range for each character effects a form of standardization. Therefore, to save computer time whenever the Gower's matrix was computed the data were never standardized.

Table 4 <u>LIST OF ANALYSES OF MATRIX I WITH CORRELATIONS</u> (*)

<u>WPGMA</u>

<u>Genitalia and external structures</u> (+)

1. UN-COR-GEN-EXS (0.13)
2. UN-DIS-GEN-EXS (0.19)
3. ST-COR-GEN-EXS (0.15)
4. ST-DIS-GEN-EXS (0.33)
5. GOW-GEN-EXS (0.52)

<u>Genitalia</u> (+)

6. UN-COR-GEN (0.15)
7. ST-COR-GEN (0.11)
8. UN-DIS-GEN (0.23)
9. ST-DIS-GEN (0.22)
10. GOW-GEN (0.35)

<u>External structures</u>

11. UN-COR-EXS (0.16)
12. ST-COR-EXS (0.19)
13. UN-DIS-EXS (0.35)
14. ST-DIS-EXS (0.32)
15. GOW-EXS (0.31)

<u>All characters</u>

19. GOW-ALL (0.51)
20. ST-COR-ALL (0.21)
21. ST-DIS-ALL (0.45)

<u>SL</u>

<u>Genitalia and external structures</u> (+)

16. ST-COR-GEN-EXS (0.22)
17. ST-DIS-GEN-EXS (0.55)
18. GOW-GEN-EXS (1.00)

* In parentheses are given the correlations between each phenogram and the phenogram which fitted best the relationships based on conventional views (analysis no. 18).

\+ Characters 12 and 21 not included.

As an alternative to presenting each phenogram, only one phenogram from each group was depicted, i.e., the phenogram within each group having the highest correlation with the reference phenogram (GOW-GEN-EXS-SL, no. 18). In decreasing order, the most highly correlated phenograms of each of the five groups with the standard for comparison were: GOW-GEN-EXS-WPGMA ($\underline{r}$ = 0.52), GOW-ALL-WPGMA ($\underline{r}$ = 0.51) and GOW-GEN-WPGMA ($\underline{r}$ = 0.35) or UN-DIS-EXS-WPGMA ($\underline{r}$ = 0.35). The results achieved by each of these analyses are discussed as follows.

1.1 Genitalia plus external structure analyses (WPGMA)

The phenogram representing this group of analyses is GOW-GEN-EXS-WPGMA (no. 5, Fig. 42a). It showed a correlation of 0.52 with phenogram number 18.

This analysis resulted in two main clusters: one with the smaller species [liberiensis carvalhoi (3), samaruensis (22), subolivaceus (28), classeyi (19), bifasciatus (20), santosjuniori (27) and irroratus (39)]; the other group with the larger species incorporating both elements of Sudanoiassus and of Batracormorphus s. str. The former subgenus [wardi (24), lituratus (30), cecrops (37), kivuensis (36) and magniceps (38)] is not subdivided but is clustered with a large group of medium-sized or large elements of Batracomorphus s.str. There is not, therefore, a clear distinction between the two subgenera and there was emphasis on size in the resulting clusters. Moreover, some species did not cluster with what are presumed conventionally to be the nearest relatives, such as signatus (13) in relation to akhmenes hargeisanus (31) or arcuatus (10) to timaea (35).

1.2 Genitalia analyses (WPGMA)

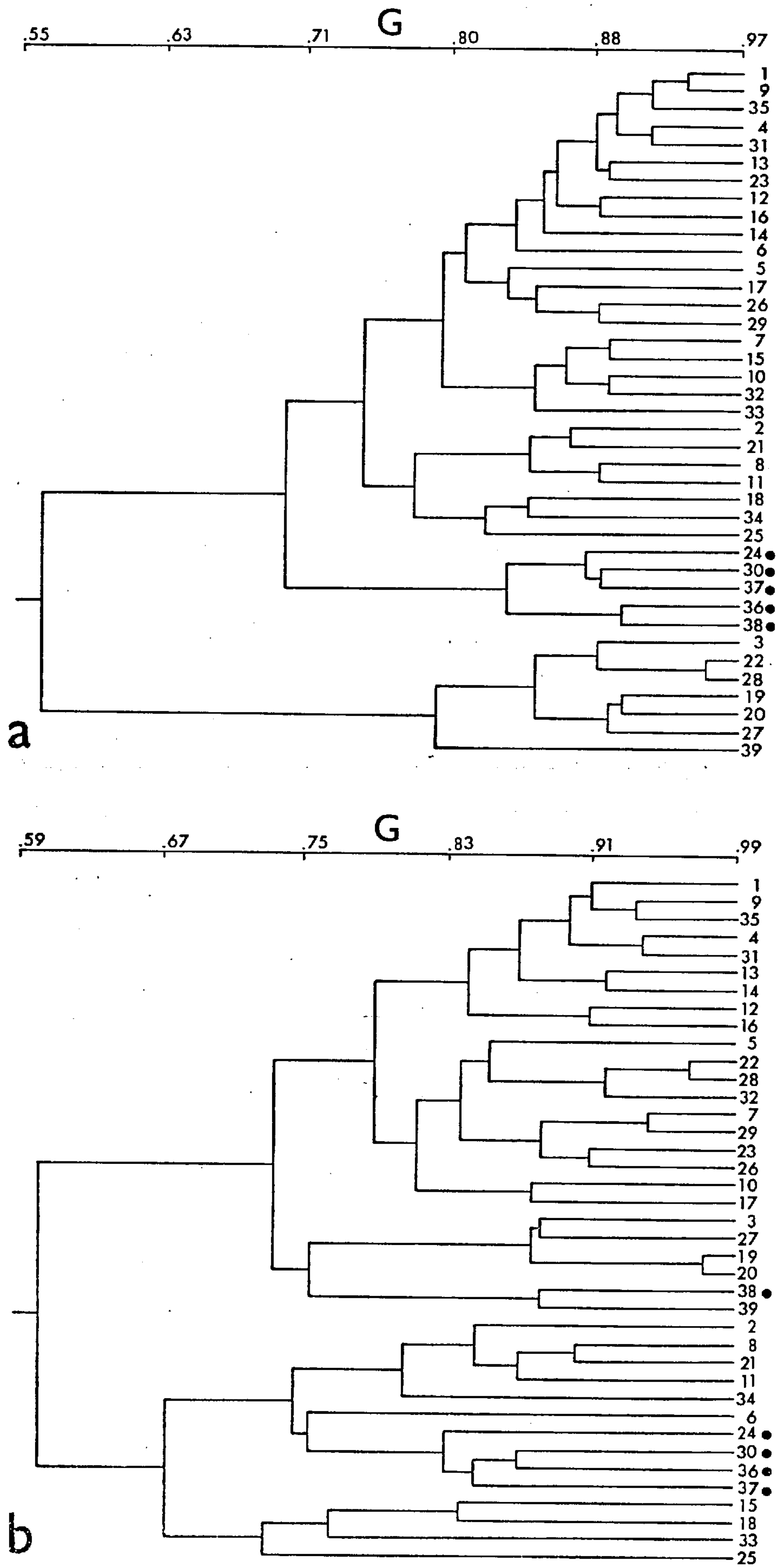
The phenogram which was chosen to represent this group is GOW-GEN-WPGMA (no. 10, Fig. 42b) which is a less satisfactory representation of the taxonomic relationships among this sample of Batracomorphus than the previous analysis. It showed a correlation of 0.35 with phenogram number 18.

The two major clusters found in this phenogram each incorporate elements of Sudanoiassus, which is therefore subdivided. This was caused by the fact that magniceps (38) clustered with irroratus (39). Moreover, a great many species did not cluster with their presumed closest relatives on an orthodox view, such as mandane (11) with quirimboensis (2), welwithschi (7) with clarensis (15), dirkoides (9) with gobiswaterensis (16), or signatus (13) with akhmenes hargeisanus

Fig. 42 - a. Gower's coefficient phenogram (GOW-GEN-EXS-WPGMA) of 39 OTU's based on the weighted pair group method of cluster analysis using arithmetic averages for the 21 characters of matrix I (genitalia plus external structures, excluding characters number 12 and 21).

- b. Gower's coefficient phenogram (GOW-GEN-WPGMA) of 39 OTU's based on the weighted pair group method of cluster analysis using arithmetic averages for the 8 genital characters of matrix I (characters number 12 and 21 not included).

Names of OTU's as in Table 1. The species belonging to Sudanoiassus Lv. & Quart. are marked with a solid circle.


G
.55 .63 .71 .80 .88 .97
1 9 35 4 31 13 23 12 16 14 6 5 17 26 29 7 15 10 32 33 2 21 8 11 18 34 25 24● 30● 37● 36● 38● 3 22 28 19 20 27 39
a
G
.59 .67 .75 .83 .91 .99
1 9 35 4 31 13 14 12 16 5 22 28 32 7 29 23 26 10 17 3 27 19 20 38● 39 2 8 21 11 34 6 24● 30● 36● 37● 15 18 33 25
b

(31), among other pairs. This analysis therefore produced rather poor results, showing a partial confusion of the recognized subgenera.

1.3 External structure analyses (WPGMA)

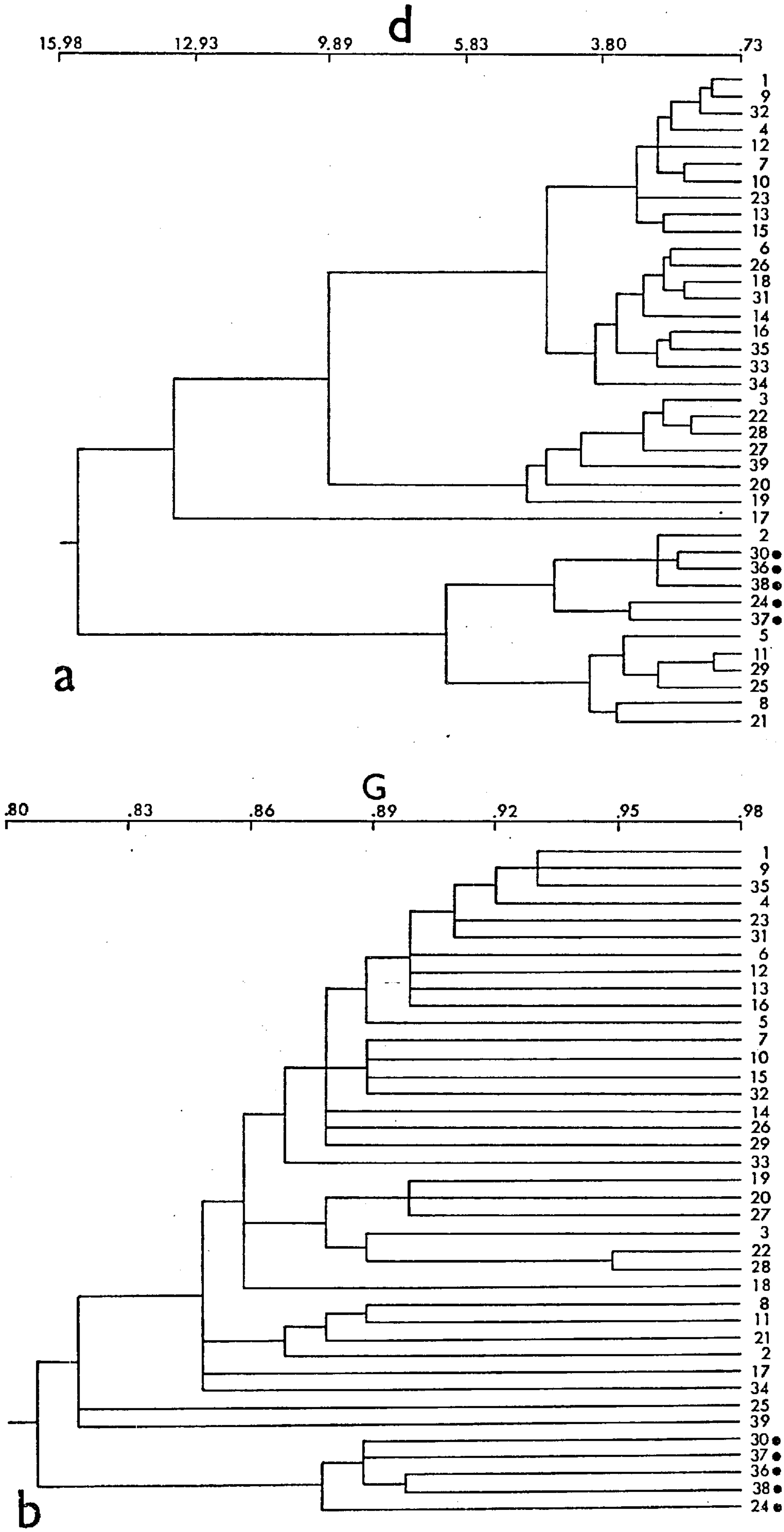
The phenogram of this group with the highest correlation with phenogram number 18 (*r* = 0.35) was UN-DIS-EXS-WPGMA (no. 13, Fig. 43a), which is again a poor representation of the taxonomic relationships of this group of leafhoppers. Notwithstanding this fact, the *Sudanoiassus* species came out in one cluster, though it also incorporated *quirimboensis* (2), a species belonging to *Batracomorphus* s.str. The reason for this was that the species were clearly clustered by size, so that the analysis produced two main groups: one involving the large and moderately large species i.e., *Sudanoiassus* plus *quirimboensis* (2), and a group formed by *danae* (5), *mandane* (11), *subolivaceus* (?) (29), *teispes* (25), *lucalensis* (8) and *natalensis* (21), while the other group contained medium-sized and small species and was the main, largest cluster. The group of smaller species is quite obvious and comprised *liberiensis carvalhoi* (3), *samaruensis* (22), *subolivaceus* (28), *santosjuniori* (27), *irroratus* (39), *bifasciatus* (20) and *classeyi* (19).

1.4 Genitalia plus external structure analyses (SL)

The analysis representing this group is GOW-GEN-EXS-SL (no. 18, Fig. 43b) and among all the analyses undertaken with matrix I this is the one which presents a phenetic classification in best accord with the orthodox taxonomic view. This phenogram shows two main clusters: one made up of the *Sudanoiassus* species; the other clustering all the *Batracomorphus* s.str. species, including *irroratus* (39), a Palaearctic species in an outstandingly isolated position. The placement of many individual species also seems satisfactory. Examples are the following: *welwitschi* (7) in relation to *clarensis* (15); *akhmenes hargeisanus* (31) in relation to *ceresensis* (23); *classeyi* (19) in relation to *santosjuniori* (27); and to a lesser extent, *mandane* (11) in relation to *quirimboensis* (2).

Fig. 43 - a. Distance phenogram (UN-DIS-EXS-WPGMA) of 39 OTU's based on the weighted pair group method of cluster analysis using arithmetic averages for the 13 non-genital charaters of matrix I (external structures). Data unstandardized.

- b. Gower's coefficient phenogram (GOW-GEN-EXS-SL) of 39 OTU's based on the single-linkage method of cluster analysis for the 21 characters of matrix I (genitalia plus external structures, excluding characters number 12 and 21). Names of OTU's as in Table 1. The species belonging to Sudanoiassus Lv. & Quart. are marked with a solid circle.


d
15.98
12.93
9.89
5.83
3.80
.73
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9
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4
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7
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23
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24
b

Since the only difference between this analysis and analysis no. 5 was the clustering method followed, it seems that single-linkage is better than WPGMA for the phenetic representation of this group when defined by measurement variables.

1.5 Genitalia plus external structure analyses (23 variables; WPGMA)

The phenogram representing this group of analyses is GOW-ALL-WPGMA (no. 19, Fig. 44a) and is very much the same as GOW-GEN-EXS (no. 5, Fig. 42a), since the only difference are some switches of species such as *gobiswaterensis* (16), *signatus* (13) or *beninensis* (18). It showed a correlation of 0.51 with phenogram number 18 and 0.89 with phenogram number 5. The similarity with this latter was to be expected since the only difference between these two analyses is that GOW-ALL-WPGMA incorporated two more variables, that is, numbers 12 and 21. Since variable 12 is highly correlated with variable 13 (r = 0.99) and variable 21 is made up of variables 19 and 20, showing a correlation of 0.78 with the latter, very little new variation was incorporated in this analysis.

1.6 Discussion

Results of the Q-type analyses of the continuous variables of *Batracomorphus* suggest the following:

(1) The different methods used are based on different suites of characters so that their estimates of phenetic affinity gave different pictures of the relationships between members of this sample of *Batracomorphus*. However, there is a certain amount of agreement between the resulting phenograms since, on the whole, the subgenus *Sudanoiassus* was recognized as a uniform group. Only rarely (as in Fig. 42b) were the species belonging to this subgenus separated.

(2) The similarity coefficient that seemed best to describe the relationships among this group of insects was Gower's similarity

coefficient, the next most like it in results was the taxonomic distance coefficient, while the correlation coefficient seemed to be the least effective. It is noteworthy in this regard that this is in disagreement with several authors (e.g.,Boyce, 1964; Cheetam, 1968) but, on the other hand, agrees with many others (e.g.,Jago, 1969; Boratynski & Davies, 1971; Smith, 1972).

(3) When measurements of the genitalia and of external structures were analysed together, standardization "improved" the analyses based on distances and, to a lesser extent, those achieved by correlations. This closely resembles the results of Moss (1968), who, working on mites (Dermanyssidae) found that the majority of individuals in his study tended to be displaced farther from their nearest phenetic relatives in the unstandardized phenograms. Contrary to the results of the present study, however, he found that standardization was particularly valuable with respect to correlations. Thornton & Kai (1967) also found that standardization was an indispensible process at least when correlations were used. Gower's coefficient does not require standardization since it already allows for a form of standardization.

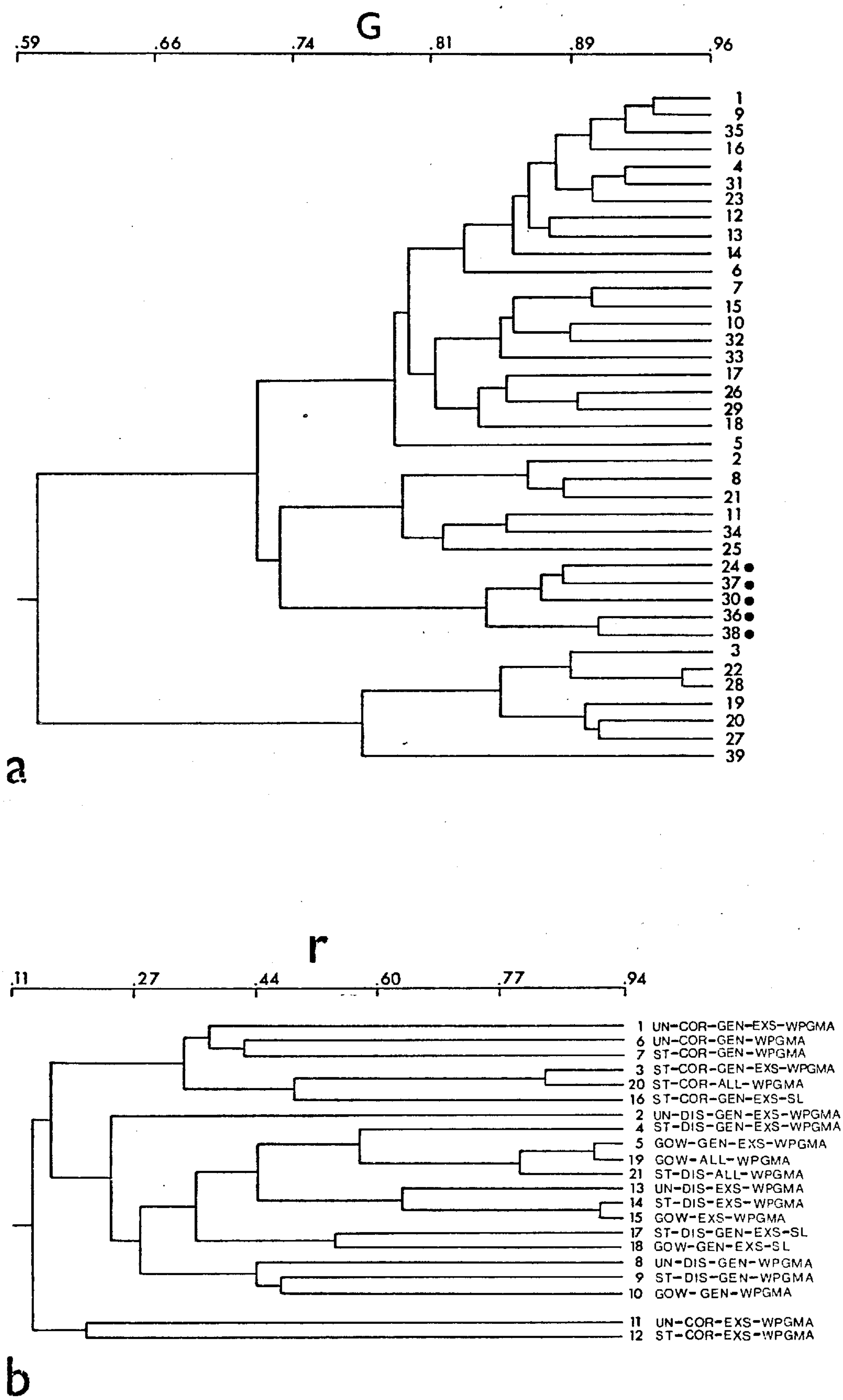
(4) Classifications based on genital measurements alone or on external measurements alone yielded poorer results than those based simultaneously on both groups of variables, which is in agreement with the results of several authors, e.g.,Boyce (1964), who emphasized the need for sampling of characters from the different functional units of which an organism is composed. Whether the effect is due to this or merely to the fact that more characters (of whatever kind) are being used is not clear.

(5) Single linkage seemed to describe the relationships of Batracomorphus better than WPGMA. The reason for this may be in part due to one or both of the two following factors: (a) this sample of

Fig. 44 - a. Gower's coefficient phenogram (GOW-ALL-WPGMA) of 39 OTU's based on the weighted pair group method of cluster analysis using arithmetic averages for the 23 characters of matrix I (genitalia plus external structures, including characters number 12 and 21). Names of OTU's as in Table 1. The species belonging to Sudanoiassus Lv. & Quart. are marked with a solid circle.

- b. Dendrogram showing relationships of phenograms from each analysis of matrix I. The number associated with labels correspond to the sequence of Table 4. This dendrogram is implied by the coefficients of correlation of topological distances for each phenogram, using the WPGMA clustering method.

44


G
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a
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.11
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.60
.77
.94
1 UN-COR-GEN-EXS-WPGMA
6 UN-COR-GEN-WPGMA
7 ST-COR-GEN-WPGMA
3 ST-COR-GEN-EXS-WPGMA
20 ST-COR-ALL-WPGMA
16 ST-COR-GEN-EXS-SL
2 UN-DIS-GEN-EXS-WPGMA
4 ST-DIS-GEN-EXS-WPGMA
5 GOW-GEN-EXS-WPGMA
19 GOW-ALL-WPGMA
21 ST-DIS-ALL-WPGMA
13 UN-DIS-EXS-WPGMA
14 ST-DIS-EXS-WPGMA
15 GOW-EXS-WPGMA
17 ST-DIS-GEN-EXS-SL
18 GOW-GEN-EXS-SL
8 UN-DIS-GEN-WPGMA
9 ST-DIS-GEN-WPGMA
10 GOW-GEN-WPGMA
11 UN-COR-EXS-WPGMA
12 ST-COR-EXS-WPGMA
b

species may form an elongate cluster and as such may be better represented by single-linkage than by average linkage (Sneath, 1969); (b) single-linkage is closely related to the shortest spanning tree, a graph method claimed to link close neighbours with fidelity (Gower & Ross, 1969; Rohlf, 1973), and therefore ensuring "success" to lower taxonomic levels. The general problem of assessing the merits or demerits of single-linkage as against WPGMA or other average linkage techniques is, however, a complicated matter. Jardine & Sibson (1968, 1971) claim that single-linkage best fulfils the mathematical criteria of a desirable clustering method, though their views have been criticised (Williams, Lance, Dale & Clifford, 1971). Fisher & Ness (1971) have brought forward empirical support for single-linkage classification.

2. Classification of classifications

The dendrogram summary of the similarities between the 21 phenograms is shown in Fig. 44b. As referred to in "Materials and Methods" this dendrogram depicts the coefficients of correlation of topological distances for each phenogram, using the WPGMA clustering procedure. It is only an approximate guide to the relationships between the different analyses carried out and the present attempt at evaluation of these relationships should not be over-emphasized. For some undesirable qualities of the method see, for instance, Farris (1973) or Rohlf (1974).

This dendrogram shows the phenograms divided into the three following basic groups: (1) methods based on correlation coefficients, using GEN, GEN-EXS, and ALL; (2) methods based on distances and Gower's coefficient; and (3) methods based on correlations using EXS. The correlation analyses tended to group according to character sets employed, as did the distances and Gower analyses, but the former appeared as isolated clusters, whereas the methods based on distances and Gower coefficients clustered together. It is also clear that distances based on standardized data yielded results which were more like the Gower coefficient analyses than they resembled the analyses of distances based on untransformed data.

2.1 Conclusions and discussion

The following are the conclusions drawn from combinations of analyses which clustered so as to illustrate the effects caused by different methods of numerical classification.

2.1.1. Influence of the clustering method

When correlation coefficients were used as measures of similarity, they overwhelmed the effects of the clustering method, i.e., analyses employing correlations grouped together irrespective of whether they were clustered by WPGMA or SL (Fig. 45a). On the other hand, when distances or Gower coefficients were used, the clustering method overwhelmed the action of the similarity coefficient, and the analyses were grouped according to the clustering procedure.

Correlations of respectively 0.52, 0.45 and 0.37 were found between the following analyses: GOW-WPGMA (5) vs. GOW-SL (18); COR-WPGMA (3) vs. COR-SL (16); and DIS-WPGMA (4) vs. DIS-SL (17). Phenograms grouped by different clustering techniques were therefore more similar when they were based on Gower or correlation coefficients than when they depended on distance coefficients. This is a result in keeping with those of Sokal & Michener (1967) for distances and correlations.

2.1.2. Influence of the total number of characters

Phenograms based on 21 and on 23 characters clustered on the whole according to the similarity coefficient (Fig. 45b). This was to be expected since the difference was due to only two variables, which were in any case redundant. The only apparent exception was the clustering of ST-DIS-GEN-EXS-WPGMA (4) which showed the highest

Figs 45a-b - Dendrograms showing relationships of phenograms for the following groups of analyses:

(a) 3. ST-COR-GEN-EXS-WPGMA

4. ST-DIS-GEN-EXS-WPGMA

5. GOW-GEN-EXS-WPGMA

16. ST-COR-GEN-EXS-SL

17. ST-DIS-GEN-EXS-SL

18. GOW-GEN-EXS-SL

(b) 3. ST-COR-GEN-EXS-WPGMA

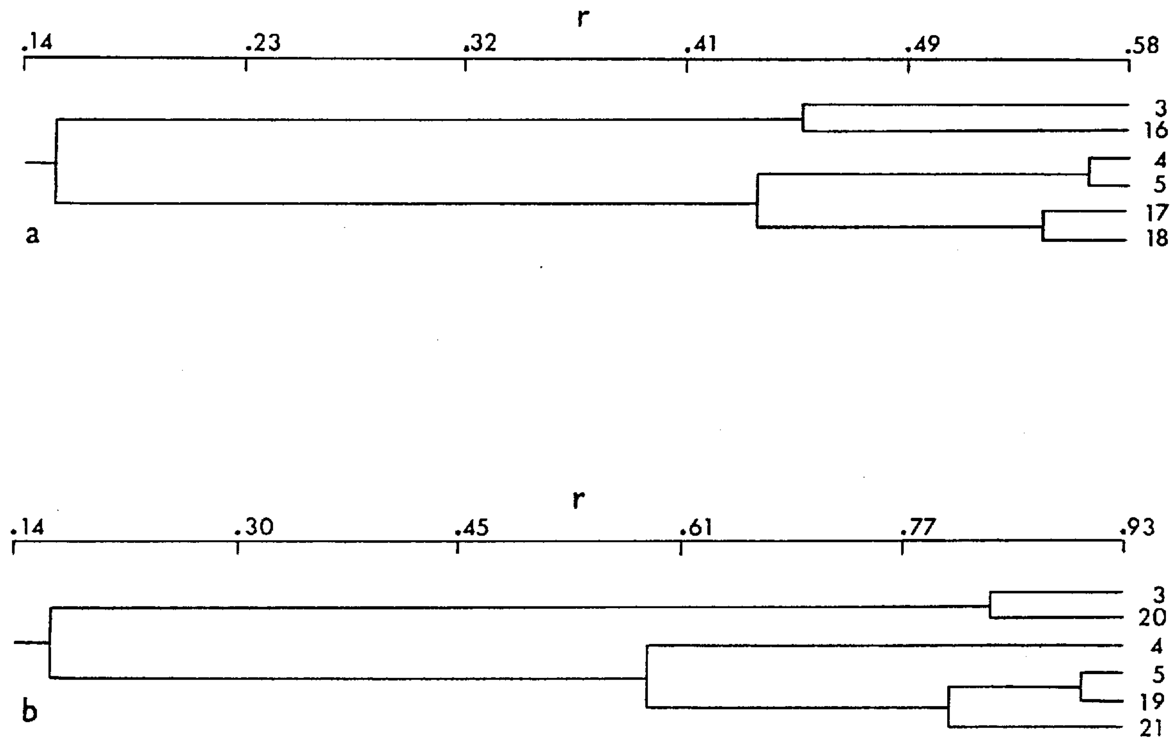
4. ST-DIS-GEN-EXS-WPGMA

5. GOW-GEN-EXS-WPGMA

19. GOW-ALL-WPGMA

20. ST-COR-ALL-WPGMA

21. ST-DIS-ALL-WPGMA


r
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16
4
5
17
18
a
r
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.30
.45
.61
.77
.93
3
20
4
5
19
21
b

correlation with ST-DIS-ALL-WPGMA (21) ($\underline{r}$ = 0.62). Its misleading position in the dendrogram seems to have been due to the characteristics of the average clustering procedure implied by WPGMA, which isolated such an analysis from its "closest neighbour".

Correlations of respectively 0.83, 0.62 and 0.89 were found between the following analyses: COR-GEN-EXS (3) vs. COR-ALL (20); DIS-GEN-EXS (4) vs. DIS-ALL (21); GOW-GEN-EXS (5) vs. GOW-ALL (19). The use of Gower's coefficient and correlations therefore tended to give more uniform results than did distances when the number of characters was changed. This is in general agreement with results obtained by Sokal & Michener (1967), Schnell (1970), and Chui & Thornton (1971) for distances and correlations.

2.1.3. Influence of different suites of characters

(1) Gower's coefficient analyses (Fig. 46a)

Correlations of respectively 0.51, 0.49, 0.19 and 0.89 were found between the following analyses: GEN-EXS (5) vs. EXS (15); GEN-EXS (5) vs. GEN (10); EXS (15) vs. GEN (10); and GEN-EXS (5) vs. ALL (19). The analysis based on external characters was therefore slightly more highly correlated with the analysis involving simultaneously genital and external characters as compared with the analysis based on the latter and on the genitalia alone. On the other hand, analyses based on genitalia alone and on external structures alone were very weakly correlated. As expected, GEN-EXS (5) and ALL (19) analyses were strongly correlated.

(2) Correlations based on unstandardized data (Fig. 46b)

Correlations of respectively 0.08, 0.41 and 0.04 were found between the following analyses: GEN-EXS (1) vs. EXS (11); GEN-EXS (1) vs. GEN (6); and EXS (11) vs. GEN (6). Therefore, the analysis based on genitalia alone was much more highly correlated with the analysis involving genital and external characters than was the analysis based on the external measurements.

(3) Correlations based on standardized data (Fig. 46c)

Correlations of respectively 0.28, 0.51 and 0.01 were found between the following analyses: GEN-EXS (3) vs. EXS (12); GEN-EXS (3) vs. GEN (7); and EXS (12) vs. GEN (7). The analysis based on genitalia alone was therefore much more highly correlated with the analysis based on genital and external measurements than was the analysis based on external characters only.

(4) Distances based on unstandardized data (Fig. 46d)

Correlations of respectively 0.22, 0.31 and 0.20 were found between the following analyses: GEN-EXS (2) vs. EXS (13); GEN-EXS (2) vs. GEN (8); and EXS (13) vs. GEN (8). The analysis based on genitalia alone is therefore slightly more highly correlated with the analysis based on genital and external characters than was the analysis based on external characters only.

(5) Distances based on standardized data (Fig. 46e)

Correlations of respectively 0.42, 0.33 and 0.17 were found between the following analyses: GEN-EXS (4) vs. EXS (14); GEN-EXS (4) vs. GEN (9); and EXS (14) vs. GEN (9). These results were therefore in keeping with those provided by Gower's coefficient, where the analysis most highly correlated with GEN-EXS was EXS.

As a result of these five analyses it appears that the following conclusions may be drawn. On the whole, Gower's coefficient studies tended to give more uniform results than did the use of distances or correlations when different suites of characters were used. As between distances and correlations, the distances tended to give more uniform results when different sets of characters were used, a result in agreement with the findings of Rohlf (1963) though curiously the opposite was found by Sokal & Michener (1967) and Schnell (1970).

Figs. 46a-e - Dendrograms showing relationships of phenograms for the following groups of analyses:

(a) 5. GOW-GEN-EXS-WPGMA

10. GOW-GEN-WPGMA

15. GOW-EXS-WPGMA

19. GOW-ALL-WPGMA

(b) 1. UN-COR-GEN-EXS-WPGMA

6. UN-COR-GEN-WPGMA

11. UN-COR-EXS-WPGMA

(c) 3. ST-COR-GEN-EXS-WPGMA

7. ST-COR-GEN-WPGMA

12. ST-COR-EXS-WPGMA

20. ST-COR-ALL-WPGMA

(d) 2. UN-DIS-GEN-EXS-WPGMA

8. UN-DIS-GEN-WPGMA

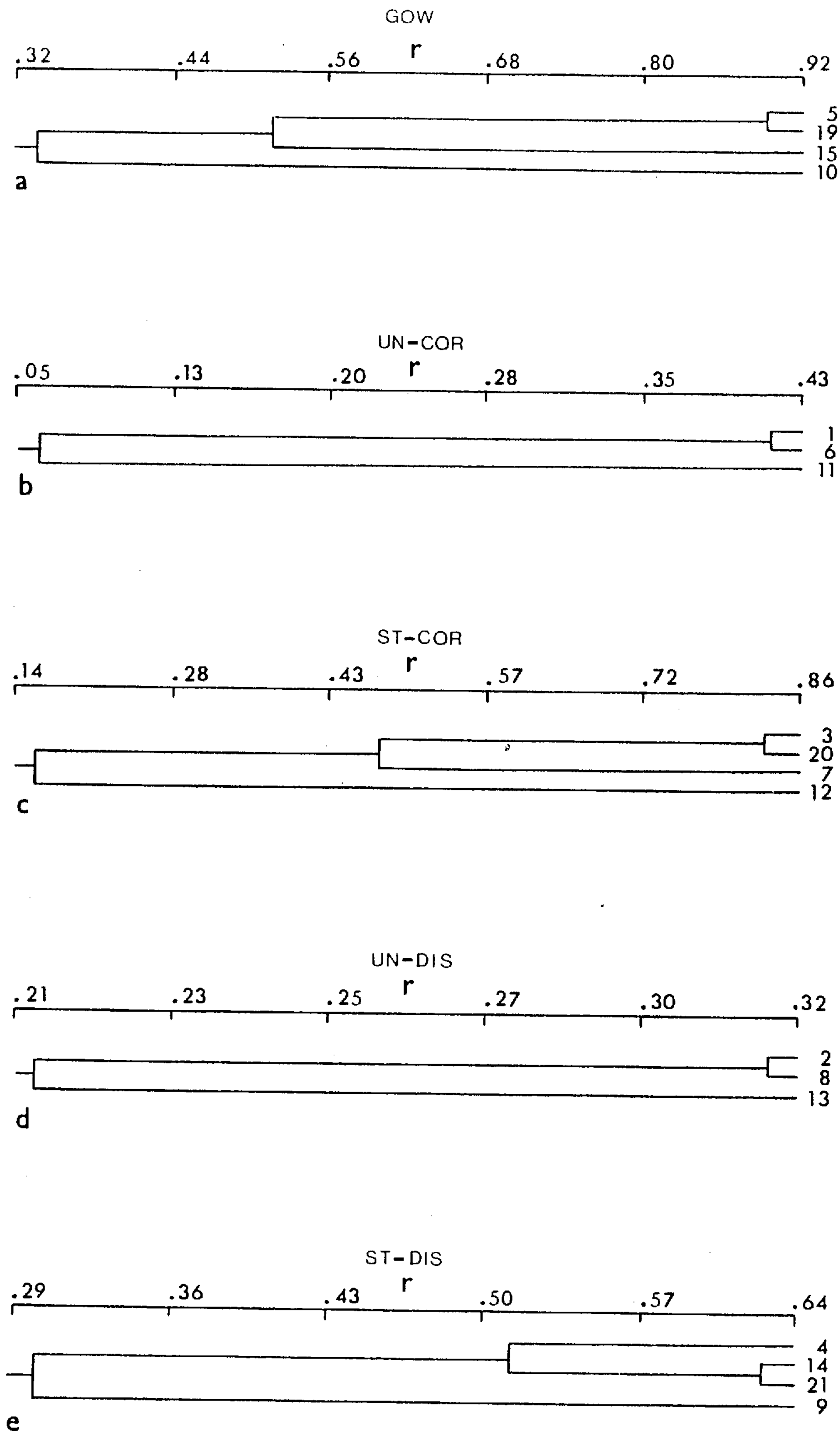
13. UN-DIS-EXS-WPGMA

(e) 4. ST-DIS-GEN-EXS-WPGMA

9. ST-DIS-GEN-WPGMA

14. ST-DIS-EXS-WPGMA

21. ST-DIS-ALL-WPGMA


GOW
r
.32 .44 .56 .68 .80 .92
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19
15
10
a
UN-COR
r
.05 .13 .20 .28 .35 .43
1
6
11
b
ST-COR
r
.14 .28 .43 .57 .72 .86
3
20
7
12
c
UN-DIS
r
.21 .23 .25 .27 .30 .32
2
8
13
d
ST-DIS
r
.29 .36 .43 .50 .57 .64
4
14
21
9
e

In particular, the EXS and GEN analyses differed in their resemblance to GEN-EXS according to the similarity coefficient employed. Thus, EXS produced a phenogram which was more highly correlated with that from GEN-EXS when Gower's coefficient or distances based on standardized data were used; on the other hand, when correlation coefficients were calculated, it was GEN which produced results more highly correlated with GEN-EXS. The reason for this seems to be two-fold: (a) EXS analyses incorporate variables mainly dependent on general size, as shown in Section (c), whereas GEN does not; (b) distances (and Gower's coefficient) are especially sensitive to differences in size rather than in shape, whereas the opposite holds for correlations (Boyce, 1964; Rohlf & Sokal, 1965; Moss, 1968). Hence it appears that GEN-EXS or ALL analyses produce classifications especially dependent on size when distances or Gower coefficients are used; in such a circumstance, it is natural to expect that any analysis based mainly on size-dependent variables like EXS will tend to resemble, and therefore to cluster with the previous classifications. The only instance, where the results did not seem to fit this rationale was provided by the analyses of distances based on unstandardized data. But it is not unlikely that such an exception might have been due to a distortion provided by the method used for comparing phenograms.

2.1.4. Influence of the similarity coefficient

(1) Genital characters only (Fig. 47a)

Analyses based on distances and on Gower's coefficient clustered together, the same thing happening among the correlation analyses. The distance analysis based on standardized data was more highly correlated with the Gower analysis than with the distances analysis based on untransformed data.

(2) External characters only (Fig. 47b)

This yields the same results as before concerning distance and Gower's coefficient analyses. Both correlation analyses are somewhat isolated and did not cluster together.

(3) Genital and external characters (Fig. 47c)

This gives very much the same results as in (1).

As a result, distance and Gower's coefficient analyses tended to group together, and the same happened among correlation analyses, irrespective of the suite of characters on which they were based. This can again be explained by the differences in the relative emphasis that these coefficients give to the size and shape components of phenetic affinity. While Gower's coefficient seemed to approach the distances in giving greater emphasis to size, the same did not apply to correlations which are known to be especially sensitive to differences in shape (Boyce, 1964; Rohlf & Sokal, 1965). These differences are not simply empirical observations but are directly related to the computational basis of the coefficient. The correlation coefficient utilizes moments about the means and is therefore not greatly affected by the size of the latter, whereas both the taxonomic distance coefficient and Gower's coefficient depend on absolute differences between measurements and are strongly influenced by their relative sizes.

2.1.5. Influence of standardization (Figs 47a-c)

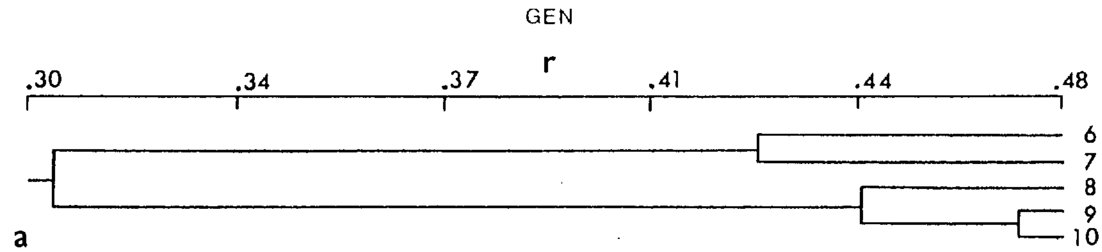
The correlations between standardized and unstandardized distances for analyses based respectively on genital characters, external characters and on both sets of characters were 0.42, 0.64 and 0.22; for correlations, the corresponding values were 0.43, 0.21 and 0.45. It appeared, therefore, that the effect of standardization when applied to correlations or to distances was a function of the suites of characters analysed. In fact, (a) correlations are especially sensitive to standardization when characters are predominantly size-dependent ($\underline{r}$ = 0.21 for standardized vs. unstandardized data based

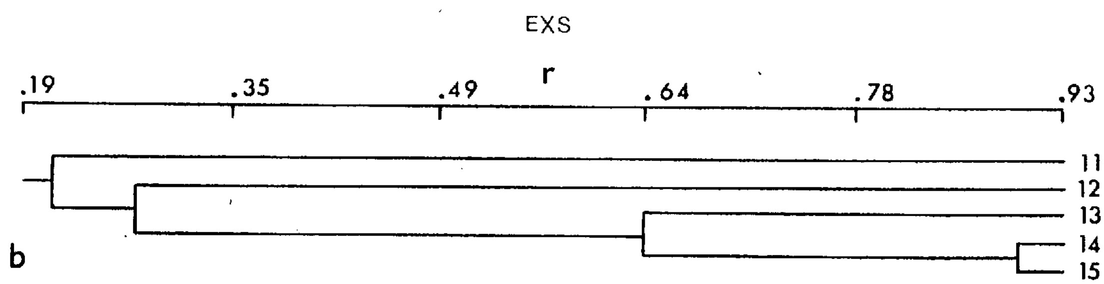
Figs. 47a-c - Dendrograms showing relationships of phenograms for the following groups of analyses:

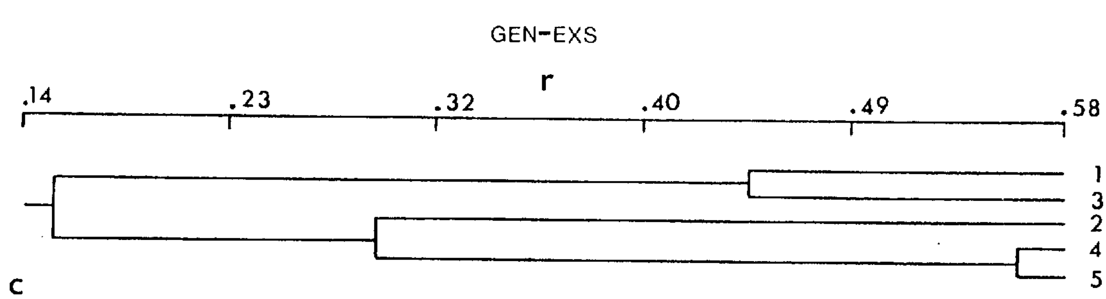
(a)
6. UN-COR-GEN-WPGMA
7. ST-COR-GEN-WPGMA
8. UN-DIS-GEN-WPGMA
9. ST-DIS-GEN-WPGMA
10. GOW-GEN-WPGMA

(b)
11. UN-COR-EXS-WPGMA
12. ST-COR-EXS-WPGMA
13. UN-DIS-EXS-WPGMA
14. ST-DIS-EXS-WPGMA
15. GOW-EXS-WPGMA

(c)
1. UN-COR-GEN-EXS-WPGMA
2. UN-DIS-GEN-EXS-WPGMA
3. ST-COR-GEN-EXS-WPGMA
4. ST-DIS-GEN-EXS-WPGMA
5. GOW-GEN-EXS-WPGMA


GEN
r
.30
.34
.37
.41
.44
.48
6
7
8
9
10
a


EXS
r
.19
.35
.49
.64
.78
.93
11
12
13
14
15
b


GEN-EXS
r
.14
.23
.32
.40
.49
.58
1
3
2
4
5
c

on external characters), (b) when characters were predominantly shape-dependent, correlations and distances seemed to be equally sensitive to standardization ($\underline{r}$ of 0.42 and 0.43 for standardized vs. unstandardized data based on genital characters and respectively analysed by distances and by correlations), and (c) when the characters comprised both size-dependent and shape-dependent variables (genital plus external characters) it was the distances that proved to be more sensitive to standardization ($\underline{r}$ = 0.22 for standardized vs. unstandardized data based on genital plus external characters and analysed by distances).

(e) Clustering of OTU's: Qualitative Data

1. Analyses undertaken

The list summarizing the analyses carried out with matrix II is shown in Table 5. The abbreviations ST, UN, COR, DIS and GOW are as indicated in Section (d). GEN-ABD (*) denotes the use of genital characters and characters from the abdominal apodemes analysed together. EXS (**) indicates the use of characters from external structures only. ALL (***) denotes inclusion of all characters in the analysis, that is characters from the genitalia, from the abdominal apodemes and from external structures. WEI (****) indicates that the invariant characters within each species were weighted and that of the remaining characters only those variable in just one or two species were considered. All analyses were clustered by WPGMA. In the table is also given the correlation coefficient between nodes traversed for each phenogram and those for phenogram no. 9, the phenetic classification based on this data matrix which fitted best the relationships based on conventional methods.

In all, sixteen different analyses were undertaken, forming the four arbitrary groups shown in Table 5. As stated before, the analysis which was in best general agreement with the orthodox view was phenogram ST-DIS-GEN-ABD (9), that is a phenogram computed from a distance matrix based on 58 standardized variables involving the genitalia and the abdominal apodemes and clustered by WPGMA.

* 58 characters present: 51-53, 55-56, 59-63, 65-82, 84-90 and 93-115.

** 45 characters present: 1-3, 5-13, 15-20, 22-25, 28-40, 42-50 and 116.

*** 104 out of the 116 characters listed in Table 3, i.e., with omission of the following characters which are redundant or invariant among all species: 4, 14, 21, 26-27, 41, 54, 57-58, 64, 83 and 92.

**** 58 characters present: 27 invariant and weighted with factor 2 plus 31 variable in just one or two species and not weighted.

Table 5 LIST OF ANALYSES OF MATRIX II WITH CORRELATIONS (*)

Characters equally weighted

All characters

1. UN-COR-ALL (0.34)
2. UN-DIS-ALL (0.35)
3. ST-COR-ALL (0.32)
4. ST-DIS-ALL (0.47)
5. GOW-ALL (0.41)

Genitalia and abdominal apodemes

6. UN-COR-GEN-ABD (0.43)
7. UN-DIS-GEN-ABD (0.41)
8. ST-COR-GEN-ABD (0.56)
9. ST-DIS-GEN-ABD (1.00)
10. GOW-GEN-ABD (0.77)

External structures

11. UN-COR-EXS (-0.04)
12. UN-DIS-EXS (-0.01)
13. ST-COR-EXS (0.18)
14. ST-DIS-EXS (0.08)
15. GOW-EXS (0.06)

Invariant characters weighted

16. GOW-WEI (0.43)

* In parentheses are given the correlations between each phenogram and the phenogram which fitted best the relationships based on conventional views (analysis no. 9).

Again as in Section (d) only one phenogram from each group was illustrated, i.e., the phenogram within each of the four groups having the highest correlation with the reference phenogram (ST-DIS-GEN-ABD, no. 9). In decreasing order the most highly correlated phenograms of each of the groups with the standard for comparison were: ST-DIS-ALL (r = 0.47), GOW-WEI (r = 0.43) and ST-COR-EXS (r = 0.18). The results achieved by each of these analyses are discussed as follows.

1.1 All character analyses (104 variables)

The phenogram representing this group of analyses is ST-DIS-ALL (no. 4, Fig. 48a). It showed a correlation of 0.47 with phenogram number 9.

Besides distinctissimus (14), which appeared quite isolated from all other species, this analysis resulted in two main clusters: one made up of the Sudanoiassus species; the other clustering all the Batracomorphus s.str. species, including irroratus (39), a Palaearctic species. There was therefore quite a good distinction between these two subgenera. Excluding the misplacement of distinctissimus (14), which reveals that its dark colouring was over-emphasized, the clustering of many individual species also seems satisfactory. Examples are the following: welwitschi (7) in relation to clarensis (15); signatus (13) in relation to akhmenes hargeisanus (31); arcuatus (10) in relation to timaea (35); or, within Sudanoiassus, kivuensis (36) in relation to magniceps (38).

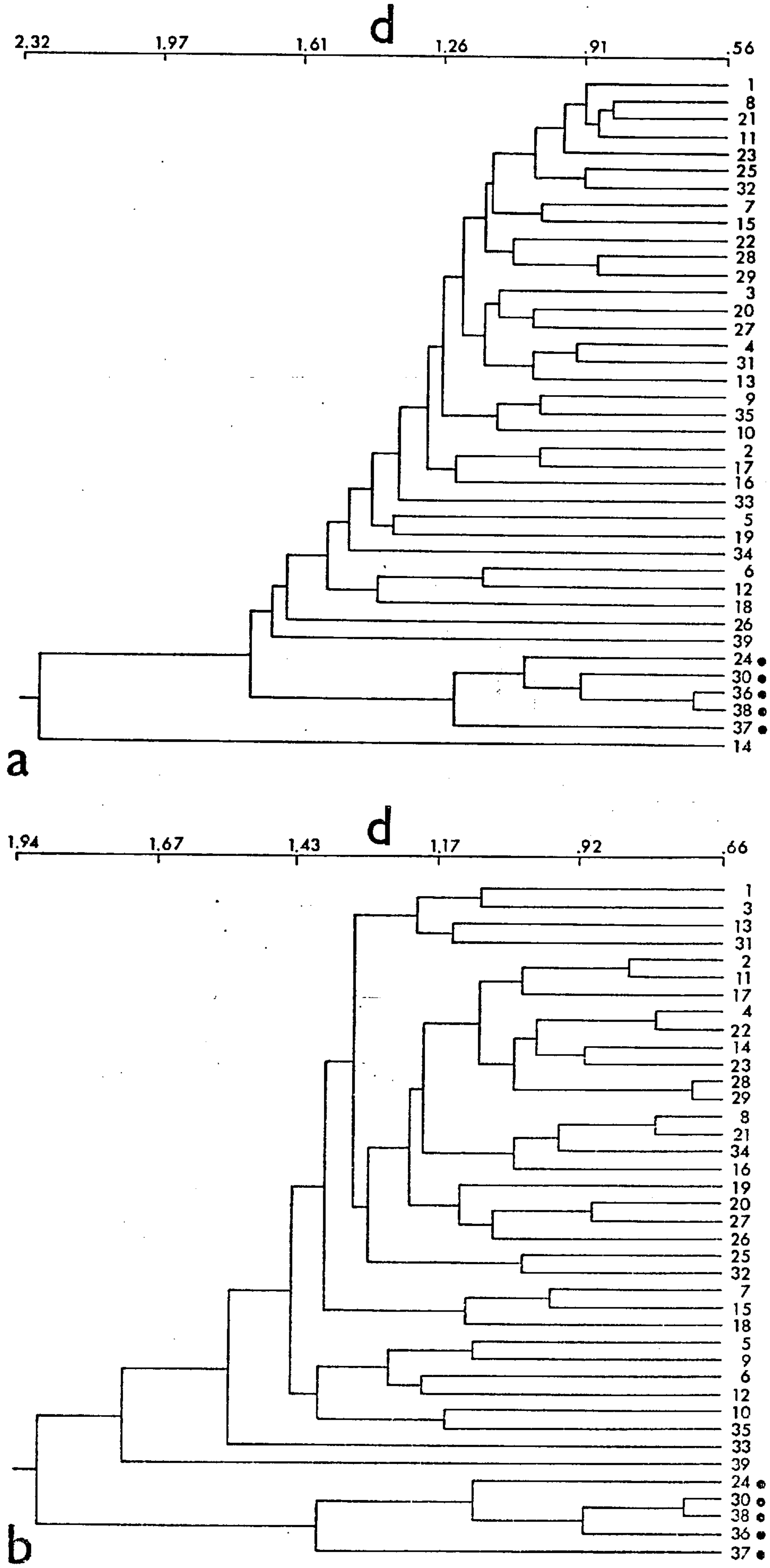
1.2 Genitalia plus abdominal apodeme analyses (58 variables)

The analysis representing this group is ST-DIS-GEN-ABD (no. 9, Fig. 48b) and among all the analyses undertaken with this matrix this was the phenogram which presented a phenetic classification in best accord with the orthodox taxonomic view. This phenogram shows two main clusters: one made up of the Sudanoiassus species; the other clustering all the Batracomorphus s.str. species, including irroratus (39),

Fig. 48 - a. Distance phenograms (ST-DIS-ALL) of 39 OTU's based on the weighted pair group method of cluster analysis using arithmetic averages for the 104 standardized variables of matrix II (all available characters).

- b. Distance phenogram (ST-DIS-GEN-ABD) of 39 OTU's based on the weighted pair group method of cluster analysis using arithmetic averages for 58 standardized variables of matrix II (genitalia plus abdominal apodemes).

Names of OTU's as in Table 1. The species belonging to Sudanoiassus Lv. & Quart. are marked with a solid circle.


d
2,32
1,97
1,61
1,26
,91
,56
1
8
21
11
23
25
32
7
15
22
28
29
3
20
27
4
31
13
9
35
10
2
17
16
33
5
19
34
6
12
18
26
39
24
30
36
38
37
14
a
d
1,94
1,67
1,43
1,17
,92
,66
1
3
13
31
2
11
17
4
22
14
23
28
29
8
21
34
16
19
20
27
26
25
32
7
15
18
5
9
6
12
10
35
33
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24
30
38
36
37
b

a Palaearctic species in an outstandingly isolated position. Moreover, a great many species clustered with their presumed closest relatives on an orthodox view. Examples are the following: dalatandoensis (1) with liberiensis carvalhoi (3); quirimboensis (2) with mandane (11); welwitschi (7) with clarensis (15); signatus (13) with akhmenes hargeisanus (31); classeyi (19) with santosjuniori (27); arcuatus (10) with timaea (35); or, within Sudanoiassus, the cluster of lituratus (30) with both kivuensis (36) and magniceps (38).

1.3 External structure analyses (45 variables)

The phenogram of this group with the highest correlation with phenogram number 9 (r = 0.18) was ST-COR-EXS (no. 13, Fig. 49a), which is rather different from other phenograms presented thus far. It is a poor representation of the taxonomic relationships of this group of leafhoppers but, curiously, did not over-emphasize the dark colouring of distinctissimus (14) as ST-DIS-ALL (no. 4, Fig. 48a) did.

The two major clusters found in this phenogram each incorporate elements of Batracomorphus s.str., which is therefore subdivided. In fact the smaller cluster is made up of Sudanoiassus plus seven species of Batracomorphus s.str., i.e., quirimboensis (2), sapobensis (17), beninensis (18), duquensis (6), lewisi (12), classeyi (19), and gobiswaterensis (16). Moreover, many pairs of presumed closely related species did not cluster together, such as dalatandoensis (1) with liberiensis carvalhoi (3), quirimboensis (2) with mandane (11), welwitschi (7) with clarensis (15), dirkoides (9) with gobiswaterensis (16), classeyi (19) with santosjuniori (27), or arcuatus (10) with timaea (35). Notwithstanding a not very satisfactory analysis on conventional grounds, the Sudanoiassus species came out in one cluster only, though it also incorporated gobiswaterensis (16), a species belonging to Batracomorphus s.str.

1.4 Analysis involving weighting of characters (58 variables)

This analysis (GOW-WEI, no. 16, Fig. 49b) involved a total of 58 variables comprising characters from external structures, genitalia and from the abdominal apodemes; of these variables 27 proved to be invariant within the species concerned and were given the weight of 2; the remaining 31 proved to vary in just one or two species and were not weighted. The resulting phenogram showed a correlation of 0.43 with phenogram number 9.

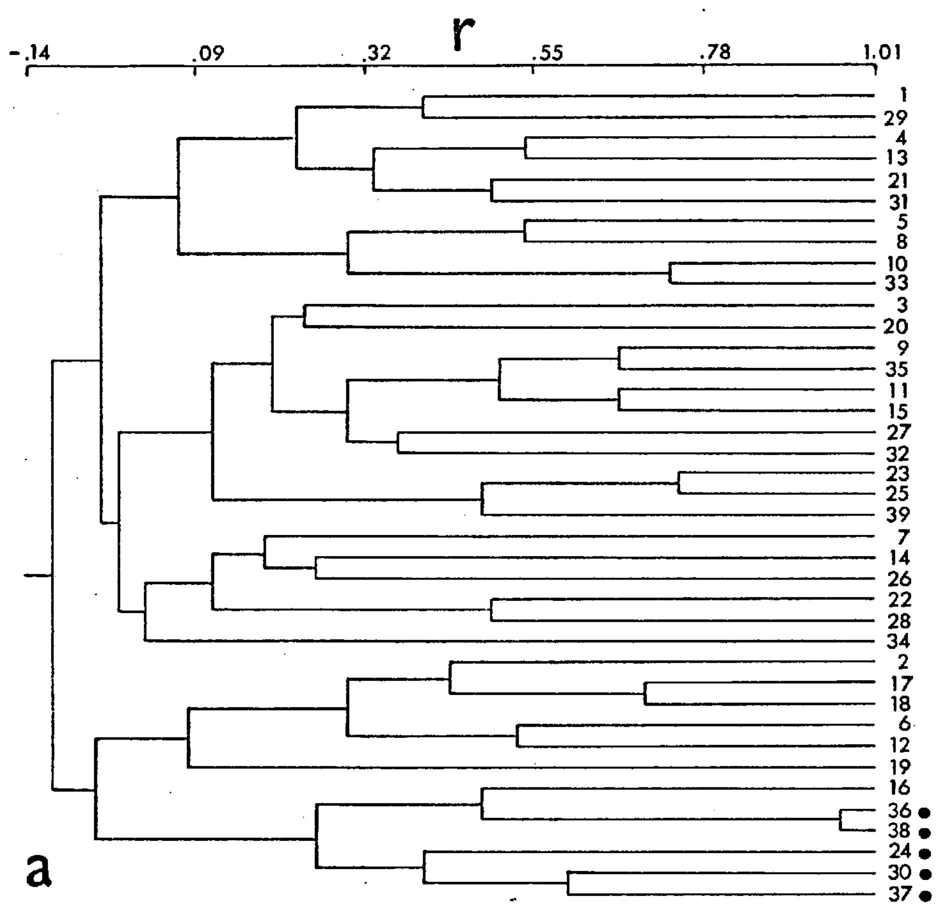
This analysis produced results similar to those of ST-DIS-ALL (*r* = 0.67) in spite of being based on only about half of its variables. In fact, *distinctissimus* (14) again appeared isolated from all other species, which is an indication that its conspicuous dark colouring was once more over-emphasized; furthermore, this analysis resulted also in two main clusters: one made up of the *Sudanoiassus* species, the other clustering all the *Batracomorphus* s.str. However, there are some differences. For instance, *irroratus* (39) was not placed in such an isolated position since it clustered with *signatus* (13). It is interesting to note in this regard that of all the Ethiopian species considered in the study *signatus* (13) is the nearest species on distribution grounds to *irroratus* (39), a Palaearctic species, since it inhabits the Mediterranean area besides the Soudanian and Sahelian zones.

This analysis again gave a quite good distinction between the two subgenera *Batracomorphus* s.str. and *Sudanoiassus*. The placement of many individual species also seems satisfactory on an orthodox view, e.g., *welwitschi* (7) in relation to *clarensis* (15), *classeyi* (19) in relation to *santosjuniori* (27), *mosselensis* (26) in relation to *subolivaceus* (28) and *arcuatus* (10) in relation to *timaea* (35).

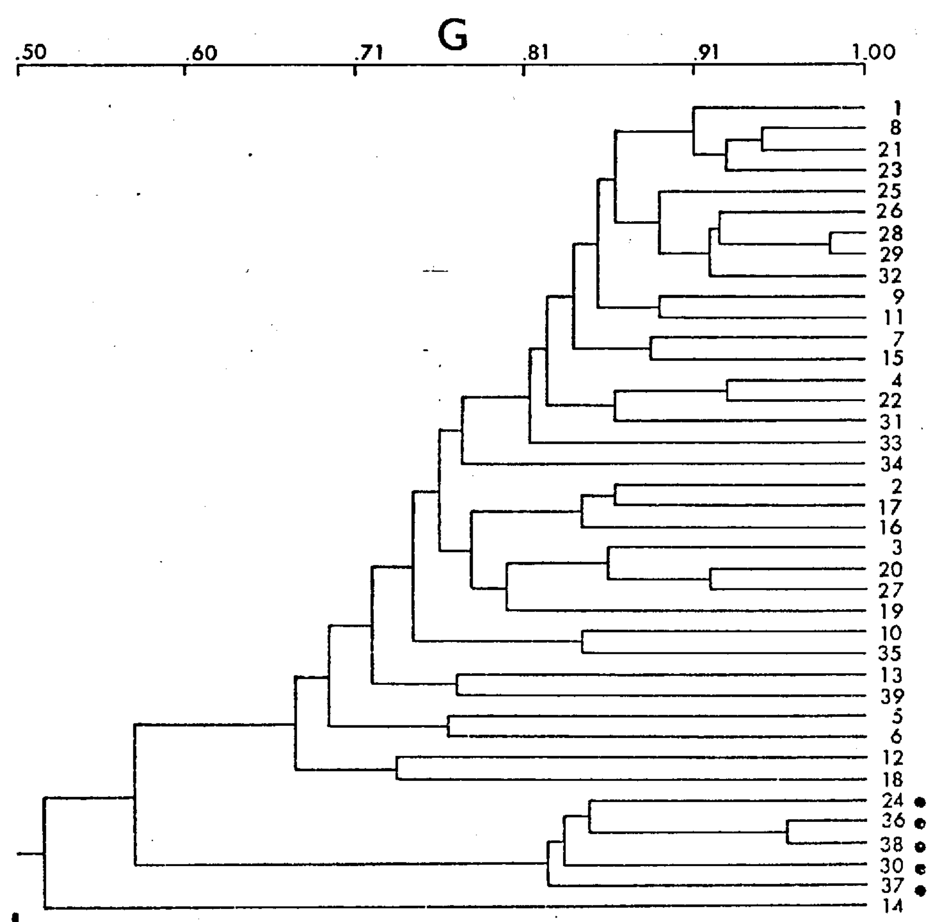
Fig. 49 - a. Correlation phenogram (ST-COR-EXS) of 39 OTU's based on the weighted pair-group method of cluster analysis using arithmetic averages for 45 standardized variables of matrix II (external structures).

- b. Gower's coefficient phenogram (GOW-WEI) of 39 OTU's based on the weighted pair-group method of cluster analysis using arithmetic averages for 58 variables of matrix II (invariant characters within species weighted).

Names of OTU's as in Table 1. The species belonging to Sudanoiassus Lv. & Quart. are marked with a solid circle.


r
-.14
.09
.32
.55
.78
1.01
1
29
4
13
21
31
5
8
10
33
3
20
9
35
11
15
27
32
23
25
39
7
14
26
22
28
34
2
17
18
6
12
19
16
36
38
24
30
37

a


G
.50
.60
.71
.81
.91
1.00
1
8
21
23
25
26
28
29
32
9
11
7
15
4
22
31
33
34
2
17
16
3
20
27
19
10
35
13
39
5
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12
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37
14

b

1.5 Discussion

The results of these Q-type analyses of the qualitative characters of Batracomorphus suggest the following:

(1) The different analyses are based on different sets of characters or gave weight to some characters so that different pictures of the relationships between members of this sample of Batracomorphus were produced. However, as happened with the analyses involving measurement variables, there is considerable concordance between the resulting phenograms. As a matter of fact, the subgenus Sudanoiassus was, on the whole, recognized as a uniform group since only rarely were the species belonging to this subgenus separated (e.g., in analyses involving external structures alone such as in numbers 11, 12 and 15, which are not illustrated).

(2) The similarity coefficient that seemed best to describe the relationships among this group of insects was the taxonomic distance coefficient, with Gower's similarity coefficient the next most like it. The correlation coefficient seemed to be the least effective except for the analyses involving external structures alone. As stated in Section (d) this is a result in keeping with those of several authors such as Jago (1969), Boratynski & Davies (1971) and Smith (1972).

(3) On the whole, standardization improved the analyses based either on distances or on correlations. When all available characters were present, or when genital and abdominal apodeme characters were used, standardization "improved" the analyses based on distances and, to a lesser extent, those achieved by correlations. Standardization had very little effect on both correlation and distance analyses when external structures were used. This is in general accord with the analyses based on measurement variables and, as stated there, these results agreed only partly with those of Moss (1968) or Thornton & Kai (1967).

(4) Classifications based on external structures alone yielded much poorer results than those based either on genitalia and abdominal apodemes or on all available characters. Of these two last groups of analyses the most satisfactory results, taking conventional views as a standard, are those given by genital and abdominal apodeme characters. This was to be expected since the orthodox view gives weight to highly complex structures such as the genitalia or to structures assumed to be associated with isolating mechanisms such as the abdominal apodemes of the sound-producing organ of leafhoppers. In a numerical approach this attitude can be exemplified by any of the analyses of GEN-ABD, that is analyses which consider only the genitalia and the abdominal apodemes. By doing so, the characters from these structures are actually weighted in relation to the external structural characters, since the latter are excluded from the analyses by automatically receiving a zero weight. On the other hand, the analyses based on all available characters, which correspond to a typical phenetic approach, are slightly less satisfactory than the group of GEN-ABD analyses. It appears, therefore, that the external characters have mostly behaved as "noise" rather than adding useful information. This is in conflict with the results provided by the measurement variables, where the most acceptable classifications were derived from analyses based simultaneously on genital and external characters. One possible explanation for this is that on such measurement analyses the number of genital characters was too small for an accurate description of the highly complicated structure of the male genitalia. In fact, only 8 genital variables were used there as against 58 (35 genital, and 23 from the abdominal apodemes) in the qualitative data analyses.

(5) The analysis in which weight was given to the invariant characters within species and in which variable characters were given

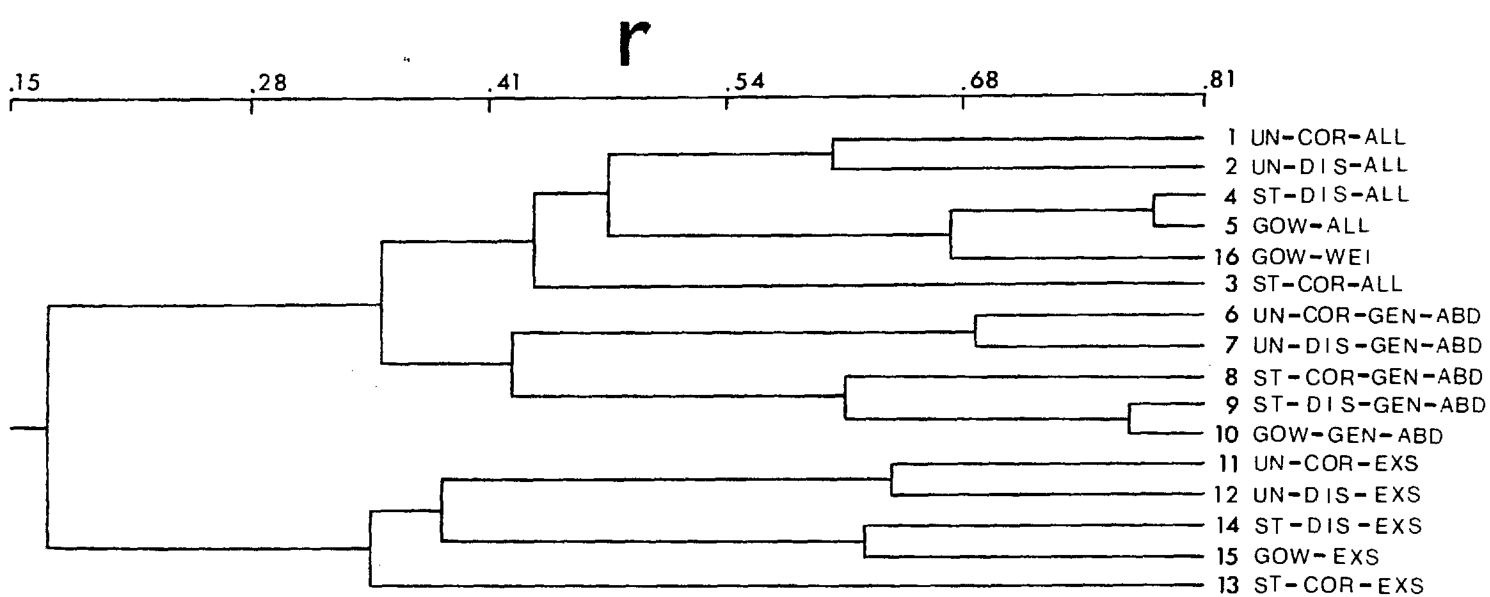
less emphasis (GOW-WEI, no. 16) produced a classification similar to the analysis based on all available characters (GOW-ALL, no. 5) and showing a correlation with it of 0.67. It is claimed that such an analysis would be either an expression of cladistic relationships or a better expression of genotypic manifestations of this group of leafhoppers since (a) invariant characters within species are reliable indicators of cladistic relationships (Farris, 1966; Eades, 1970) and (b) variable characters may be largely due to environmental effects (Goodman, 1969). There is, however, no evidence at hand to confirm any of these interpretations in Batracomorphus. But what is noteworthy is the fact that such an analysis, when compared for instance with GOW-ALL, has enabled a considerable reduction to be made in the number of characters without any appreciable loss of effectiveness.

2. Classification of classifications

The dendrogram summary of the similarities between the 16 phenograms is shown in Fig. 50. The same comments made in Subsection 2 of Section (d) also apply here.

This dendrogram shows the phenograms clustered clearly according to suites of characters. There are two basic groups: (1) methods using the three kinds of similarity coefficients and based on all available characters as well as those based simultaneously on characters of the genitalia and of the abdominal apodemes; and (2) methods using also all three similarity coefficients and based on external characters alone. The major former group (1) is again structured according to suites of characters. It includes two sub-clusters: (a) methods using the three similarity coefficients and based on all available characters; and (b) methods also using these coefficients and based simultaneously on the genitalia as well as the abdominal apodemes.

Fig. 50 - Dendrogram showing relationships of phenograms from each analysis of matrix II. The number associated with labels correspond to the sequence of Table 5. This dendrogram is implied by the coefficients of correlation of topological distances for each phenogram, using the WPGMA clustering method.


r
.15
.28
.41
.54
.68
.81
1 UN-COR-ALL
2 UN-DIS-ALL
4 ST-DIS-ALL
5 GOW-ALL
16 GOW-WEI
3 ST-COR-ALL
6 UN-COR-GEN-ABD
7 UN-DIS-GEN-ABD
8 ST-COR-GEN-ABD
9 ST-DIS-GEN-ABD
10 GOW-GEN-ABD
11 UN-COR-EXS
12 UN-DIS-EXS
14 ST-DIS-EXS
15 GOW-EXS
13 ST-COR-EXS

As happened with the measurement variables, it is again obvious that distances based on standardized data yielded results resembling the Gower coefficient analyses much more than those of distances based on untransformed data.

2.1 Conclusions and discussion

The following are the conclusions drawn from combinations of analyses which clustered so as to illustrate the effects caused by different methods of numerical classification.

2.1.1. Influence of different suites of characters

(1) Gower's coefficient analyses (Fig. 51a)

Correlations of respectively 0.67, 0.53, 0.45 and 0.07 were found between the following analyses: ALL (5) vs. WEI (16); ALL (5) vs. GEN-ABD (10); ALL (5) vs. EXS (15); and GEN-ABD (10) vs. EXS (15). The analysis weighting the invariant characters was therefore more highly correlated with the analysis involving all available characters than with any of the other analyses. On the other hand, the analysis based on genital and abdominal apodeme characters was more highly correlated with the analysis involving all characters as compared with the analysis based on the latter and on the external characters alone. Moreover, the analysis involving simultaneously the genitalia and the abdominal apodemes and the analysis based on external structures alone were practically uncorrelated.

(2) Correlations based on unstandardized data (Fig. 51b)

Correlations of respectively 0.49, 0.14, and -0.05 were found between the following analyses: ALL (1) vs. GEN-ABD (6); ALL (1) vs. EXS (11); and GEN-ABD (6) vs. EXS (11). Therefore, the analysis based simultaneously on genital and abdominal apodeme characters was much more highly correlated with the analysis involving all available characters than was the analysis based on external structures alone.

Figs. 51a-e - Dendrograms showing relationships of phenograms for the following groups of analyses:

(a) 5. GOW-ALL

10. GOW-GEN-ABD

15. GOW-EXS

16. GOW-WEI

(b) 1. UN-COR-ALL

6. UN-COR-GEN-ABD

11. UN-COR-EXS

(c) 2. UN-DIS-ALL

7. UN-DIS-GEN-ABD

12. UN-DIS-EXS

(d) 3. ST-COR-ALL

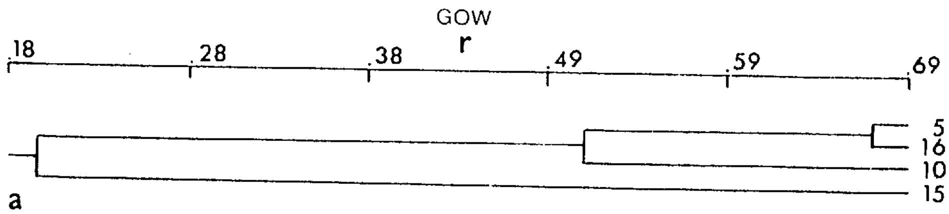
8. ST-COR-GEN-ABD

13. ST-COR-EXS

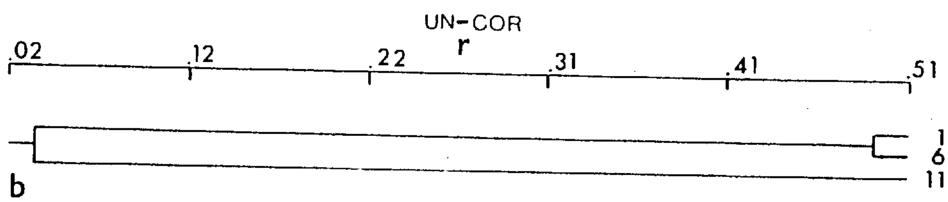
(e) 4. ST-DIS-ALL

9. ST-DIS-GEN-ABD

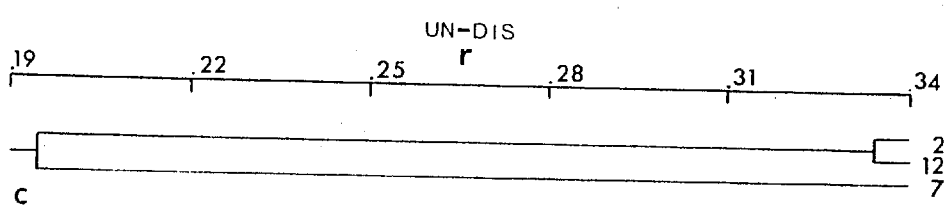
14. ST-DIS-EXS


GOW
r
.18 .28 .38 .49 .59 .69
5
16
10
15

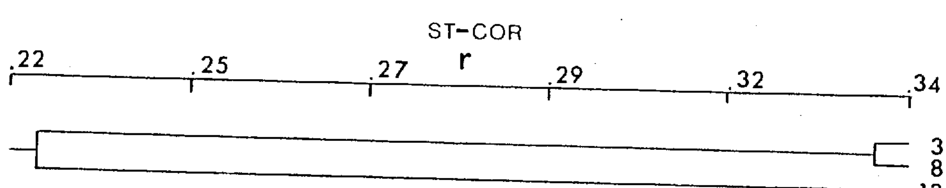
a


UN-COR
r
.02 .12 .22 .31 .41 .51
1
6
11

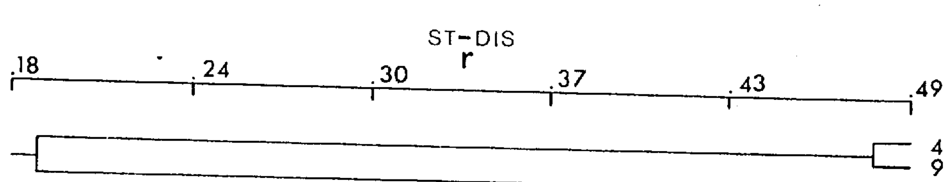
b


UN-DIS
r
.19 .22 .25 .28 .31 .34
2
12
7

c


ST-COR
r
.22 .25 .27 .29 .32 .34
3
8
13

d


ST-DIS
r
.18 .24 .30 .37 .43 .49
4
9
14

e

On the other hand, the analysis involving conjointly genital and abdominal apodeme characters was practically uncorrelated with the analysis based on external structures alone.

(3) Distances based on unstandardized data (Fig. 51c)

Correlations of respectively 0.34, 0.32, and 0.07 were found between the following analyses: ALL (2) vs. EXS (12); ALL (2) vs. GEN-ABD (7); and GEN-ABD (7) vs. EXS (12). The analysis based on external characters was therefore slightly more correlated with the analysis involving all available characters as compared with the analysis based on the latter and the analysis based simultaneously on genital and abdominal apodeme characters. On the other hand, the analyses based simultaneously on genital and abdominal apodeme characters and on external structures were practically uncorrelated.

(4) Correlations based on standardized data (Fig. 51d)

Correlations of respectively 0.34, 0.34, and 0.12 were found between the following analyses: ALL (3) vs. GEN-ABD (8); ALL (3) vs. EXS (13); and GEN-ABD (8) vs. EXS (13). Therefore, the analysis based simultaneously on the genitalia and abdominal apodemes or the analysis based on external structures are equally correlated with the analysis involving all available characters. On the other hand, the analyses based on gènital and abdominal apodeme characters and on external characters are very weakly correlated.

(5) Distances based on standardized data (Fig. 51e)

Correlations of respectively 0.47, 0.31, and 0.07 were found between the following analyses: ALL (4) vs. GEN-ABD (9); ALL (4) vs. EXS (3); and GEN-ABD (9) vs. EXS (14). These results were therefore in keeping with those provided by Gower's coefficient, where the analysis most highly correlated with ALL was GEN-ABD. Again GEN-ABD and EXS were practically uncorrelated.

As a result of these five groups of analyses the same conclusions follow as those drawn from the measurement data analyses. On the whole, when different suites of characters were used, Gower's coefficient studies tended to give more uniform results than did the use of distances or correlations. As between distances and correlations, the distances tended to give slightly more uniform results when different sets of characters were used, a result in keeping with the findings of Rohlf (1963) and of Moss (1968).

On balance, the suite of characters that produced classifications most closely resembling those derived from all available characters was GEN-ABD, i.e., genitalia and abdominal apodemes taken together. Only in two instances (SC and UD) were the EXS analyses as similar to ALL as was GEN-ABD. The reasons why GEN-ABD approached ALL more than EXS did, appear to be mainly due to the facts that (a) GEN-ABD incorporated more variables than EXS, and hence included a greater fraction of the genome sampled, and (b) genital and abdominal apodeme characters, as opposed to external structures, are much richer in inter-specific variation, thus contributing much more useful information. Furthermore, this latter view (b) must also explain the lack of congruence between the classifications based on GEN-ABD and those on EXS, irrespective of the similarity coefficient used. In fact, it is assumed that the genitalia are the pleiotropic result of large number of genes and in some instances are also associated with isolating mechanisms by providing a mechanical barrier between species (Mayr, 1970; Scudder, 1971). As a result, the genital apparatus shows little intraspecific variation but exhibits high inter-specific variation. Similarly, as the abdominal apodemes are related to sound-production in leafhoppers (Ossiannilsson, 1946a; 1949a; 1951d), they are associated with pair-forming behaviour, and therefore have special properties at the species level (Littlejohn, 1969). On the contrary, external characters are much less variable among the genus Batracomorphus, since different species have apparently evolved similar general appearances such as cryptic colouring patterns. It is thus reasonable to expect that classifications based on such different fractions of the phenome would have produced completely different classifications. This must also explain why the non-specificity hypothesis (as outlined by Sokal & Sneath, 1963) does not apply in this instance.

2.1.2. Influence of the similarity coefficient

(1) Genital and abdominal apodemes (Fig. 52a)

Analyses based on distances and on Gower's coefficient clustered together, the same happening between both unstandardized analyses either for correlations or for distances. The correlation analysis based on standardized data was more highly correlated with the distance analysis based on standardized data than with the correlation analysis based on untransformed data.

(2) External characters (Fig. 52b)

Very much the same results hold as before. In spite of the correlation analysis computed from standardized data being much more isolated, it was again more highly correlated with the distance analysis based on standardized data than with the correlation analysis based on untransformed data.

(3) All available characters (Fig. 52c)

Practically the same picture holds as in (2). The correlation analysis based on standardized data was, however, slightly more highly correlated with the correlation analysis based on untransformed data than with the distance analysis based on standardized data.

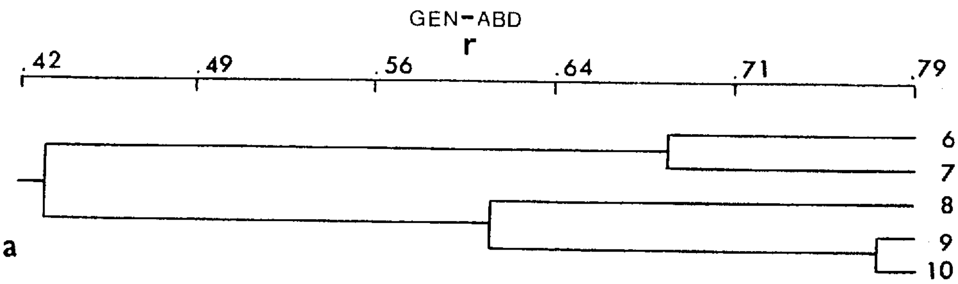
Figs 52a-c - Dendrograms showing relationships of phenograms for the following groups of analyses:

(a)
6. UN-COR-GEN-ABD
7. UN-DIS-GEN-ABD
8. ST-COR-GEN-ABD
9. ST-DIS-GEN-ABD
10. GOW-GEN-ABD

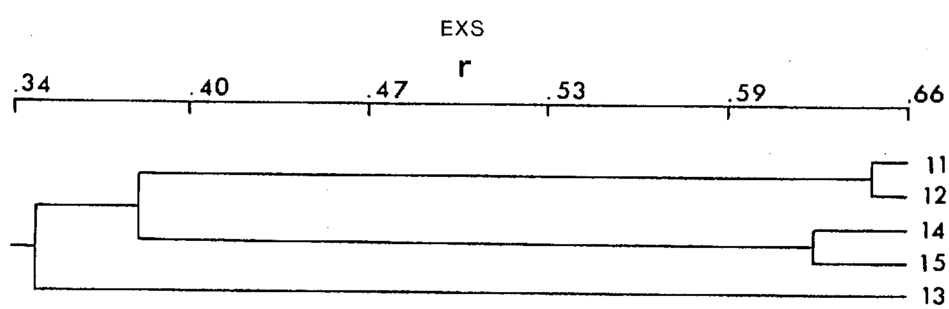
(b)
11. UN-COR-EXS
12. UN-DIS-EXS
13. ST-COR-EXS
14. ST-DIS-EXS
15. GOW-EXS

(c)
1. UN-COR-ALL
2. UN-DIS-ALL
3. ST-COR-ALL
4. ST-DIS-ALL
5. GOW-ALL

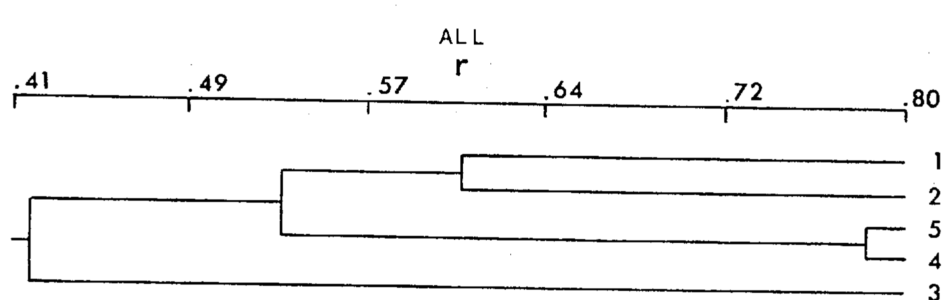
383


GEN-ABD
r
.42
.49
.56
.64
.71
.79
6
7
8
9
10

a


EXS
r
.34
.40
.47
.53
.59
.66
11
12
14
15
13

b


ALL
r
.41
.49
.57
.64
.72
.80
1
2
5
4
3

c

As a result, distances based on standardized data always clustered with Gower analyses, as also happened with the measurement data. What was different, however, was the tendency of the unstandardized analyses, based on correlations or on distances, to cluster together, irrespective of the suite of characters on which they were based. This means that unlike what happened with the measurement data, where the tendency was for the phenograms to cluster according to the similarity coefficient, the presence or absence of standardization overwhelmed the effects of the different similarity coefficient.

2.1.3. Influence of standardization (Figs 52a-c)

The correlations between standardized and unstandardized distances for analyses based respectively on genital and abdominal apodeme characters, external characters, and on all available characters were respectively 0.41, 0.29 and 0.48; for correlations, the corresponding values were 0.47, 0.31 and 0.54. The effect of standardization when applied to correlations or to distances seemed therefore to be mainly dependent on the number of characters included in the analyses. In fact, both the distances and the correlations were (a) especially sensitive to standardization when the analyses were based on external characters (45 variables); (b) moderately affected for the analyses based on genital and abdominal apodeme characters (58 variables); and (c) less sensitive for the analyses based on all available characters (104 variables). Moreover, as between distances and correlations, the latter appeared to be less sensitive to standardization irrespective of the suites or number of characters used. This is a result in keeping with those of the measurement data for the analyses including both size-dependent and shape-dependent variables.

(f) Cluster Analysis of OTU's: General Conclusions

The following is a summary of the main conclusions drawn from a total of thirty seven different analyses carried out with either measurement variables (23 continuous measurements, matrix I) or qualitative, coded variables (64 two-state, 32 ordered and 20 unordered multistate characters; matrix II).

(1) Different numerical procedures, based on different types of data and on different suites of characters, yielded different pictures of the phenetic affinity between members of this sample of species of the genus Batracomorphus. On the whole, however, the subgenus Sudanoiassus was recognized as a uniform group.

(2) In general, qualitative data seemed to have described the relationships of Batracomorphus better than continuous data. This is probably a direct effect of the much higher number of characters present in the former data matrix.

(3) The most effective similarity coefficients for measured and for qualitative coded data appeared to be respectively Gower's coefficient and the taxonomic distance coefficient. For both types of data the correlation coefficient seemed to be the least effective, which is in agreement with the unsound theoretical basis that it has for these applications (Eades, 1965; Minkoff, 1965).

(4) For both continuous and qualitative data, Gower's coefficient studies tended on the whole to give more uniform results than did distances or correlations when different suites of characters were used. As between distances and correlations, the distances tended to give more uniform results when different sets of characters were used. However, when the total number of characters was slightly altered (21 vs. 23 measurement variables) Gower's coefficient and correlations tended to give more uniform results than did distances.

(5) On the whole, standardization of characters to zero means and unit variances improved the analyses based on distances and on correlations. Gower's similarity coefficient is unaffected by standardization since its computation already incorporates a form of standardization.

(6) In the measurement data the sensitivity of the similarity coefficient to standardization seemed to be mostly dependent on the types of characters being analysed. In fact, (a) correlations were especially sensitive to data standardization when characters were predominantly size-dependent, (b) correlations and distances were equally sensitive to standardization when characters were predominantly independent of size, and (c) distances were more sensitive to standardization when characters comprised both types of variables.

(7) In the analyses of qualitative data, the effect of standardization upon the similarity coefficient appeared to be primarily dependent on the number of characters present. Hence (a) when the smallest number of characters was present (external structures) both distances and correlations were especially sensitive; (b) when an intermediate number of variables was present (genitalia and abdominal apodemes) both distances and correlations were moderately sensitive; and (c) when the largest number of characters was present (all available characters) both distances and correlations were less sensitive to standardization. As between distances and correlations, it was the distances that proved to be more sensitive to the effect of standardization.

(8) While in the measured variable analyses there appeared a tendency for clustering of phenograms according to the similarity coefficient and irrespective of whether the data were standardized, the contrary held for the qualitative data, in which the presence of absence of standardization tended to predominate over the action

of the similarity coefficient. Whether this difference was due to different types of variables or merely to the fact that more characters were used in the latter group of analyses is not clear.

(9) When small numbers of characters were used (measured variables) the most acceptable classifications were derived from analyses incorporating both genital and non-genital (external) characters. On the other hand, the analyses based on external characters (mostly with size-dependent variables) or those based on genital characters (mostly with size-independent variables) differed from the analyses based on both types of characters according to the similarity coefficient used. When these last analyses were made so as to give emphasis to the size dependent variables (by the use of distances or Gower's coefficient) they approached the external structural analyses; conversely, when the analyses tended to emphasize shape (through the use of correlations) then they approached the genital analyses.

(10) When larger numbers of characters were present in the analyses (qualitative data), the most effective classifications were derived from analyses involving the genitalia and the abdominal apodemes. The analyses based solely on external structures yielded rather poor results and those based on all available characters (external structures, genitalia and abdominal apodemes) produced slightly less satisfactory results than those involving the genitalia and the abdominal apodemes only. Moreover, the analyses based both on the genitalia and abdominal apodemes resembled those based on all available characters more closely than those based on external structural characters alone and irrespective of the similarity coefficient used. It was suggested that the external structures, on account of their mainly adaptive character, such as the similar cryptic patterns adquired by different species, behaved more like

"noise" as opposed to the genital and abdominal apodeme characters. These latter two groups of characters appeared to have contributed useful information on account of their much richer inter-specific variation and intra-specific constancy. This closely resembles the results arrived at by Thornton & Kai (1967) for psocids (Insecta: Psocoptera) when treating asexual character analyses vs. all character analyses or this latter in comparison with sexual character analyses.

(11) Where it was tested (as in the analysis of measured variables) single-linkage cluster analysis seemed to describe the relationships of this sample of *Batracomorphus* better than weighted pair-group arithmetic average linkage clustering analysis (WPGMA).

(12) Numerical weighting of characters which are invariant within species and the exclusion of highly variable characters produced results comparable to the analyses involving all available characters. It appears therefore that the highly variable characters tended to behave as "noise" rather than adding useful information. Consequently this method of analysis may provide a simple technique for *a posteriori* character selection and reduction.

(g) Ordination of OTU's: Continuous Data

1. Analyses undertaken

The ordinations carried out with matrix I are summarized in Table 6. The abbreviations ST, UN, COR and DIS are as indicated in Section (d). COV or MMD refers respectively to the use of covariance or match-mismatch distance coefficients (as defined in Boratynski & Davies, 1971) to analyse the data. COL and ROW, when combined with ST indicate the way the standardization was performed, that is, the data were standardized by columns or by rows to zero means and unit standard deviations. On the other hand, when combined with either DIS, MMD, COV or COR, they refer to the way the analysis was carried out, i.e., on a between-columns or a between-rows association matrix, using either taxonomic distance, match-mismatch distance, covariances or correlations as similarity/dissimilarity coefficients. PCA and PCRDA indicate which type of ordination was performed, whether principal component analysis or principal coordinate analysis.

In all, twelve (*) different analyses were undertaken, that is, eight principal component and four principal coordinate analyses. The eigenvectors associated with the 10 largest latent roots were always extracted and the percentage of variance accounted for by the first five components or coordinates are recorded in Table 7. In all instances with just the two exceptions provided by the match-mismatch distance analyses, the first three eigenvalues accounted for more than 58% of the total variation. Standardization was always carried out orthogonal to the mode of the ordination.

* As standardization by characters does not affect the results provided by the match-mismatch distance, only eleven different analyses were obtained. On the other hand, this similarity coefficient is inappropriate for continuous data, since it makes use of only a small fraction of the information available. Accordingly, its use in this study was for comparative purposes only.

Table 6 LIST OF ORDINATIONS OF MATRIX I WITH ROTATIONAL FIT STATISTICS (°)

Genitalia and external structures (+)

1.* ST-COL-DIS-ROW-PCRDA (0.60)

2. ST-COL-MMD-ROW-PCRDA (1.17)

3. UN-DIS-ROW-PCRDA (0.62)

4.* UN-MMD-ROW-PCRDA (1.17)

5. UN-COV-COL-PCA (0.01)

6. ST-ROW-COV-COL-PCA (0.46)

7.* UN-COR-COL-PCA (0.00)

8.* ST-ROW-COR-COL-PCA (0.45)

9.* UN-COV-ROW-PCA (0.60)

10. ST-COL-COV-ROW-PCA (0.68)

11. UN-COR-ROW-PCA (0.61)

12. ST-COL-COR-ROW-PCA (0.71)

° In parentheses are given the rotational fit statistics (R^2) based on the first 10 axes between each ordination and the ordination which fitted best the relationships based on conventional views (no. 7). Analyses selected as the best representatives within groups of closely related ordinations (as implied by cluster analysis) are marked with an asterisk.

+ All variables except number 12 and 21.

Table 7 PERCENTAGES OF VARIATION ACCOUNTED FOR BY THE FIRST FIVE LATENT ROOTS (EIGENVALUES)

Method (*)	Latent root (eigenvalue)					Cumulative %	
	I	II	III	IV	V	3 axes	5 axes
1	53.15	11.93	9.05	7.72	4.75	74.13	86.60
2	4.41	4.06	3.89	3.62	3.56	12.36	19.54
3	60.15	18.80	10.17	4.21	1.79	89.12	95.12
4	4.41	4.06	3.89	3.62	3.56	12.36	19.54
5	60.18	18.77	10.13	3.60	1.79	89.08	94.47
6	44.73	23.38	9.06	5.42	4.49	77.17	87.08
7	53.17	11.92	9.02	7.74	4.77	74.11	86.62
8	36.35	11.90	10.94	9.28	6.96	59.19	75.43
9	97.50	1.17	0.62	0.29	0.12	99.29	99.70
10	31.12	17.49	14.52	11.45	7.70	63.13	82.28
11	97.54	1.11	0.58	0.25	0.13	99.23	99.61
12	25.67	19.89	13.13	10.73	8.17	58.69	77.59

* For meaning see Table 6.

The ordinations were compared through the Rotational Fit Method of Gower (1971b), and the resulting matrix of R^2-values based on the first 10 axes for each ordination was treated by cluster analysis as referred to in Section (b). The dendrogram showing similarities among the 12 ordinations is given in Fig. 53. It is implied by R^2-values between configurations of OTU's, each represented by different orthogonal coordinates, and using the WPGMA clustering method.

The ordination which was in best general agreement with the traditional view was analysis UN-COR-COL-PCA (7), that is a principal component analysis of a matrix of correlations between columns of unstandardized data.

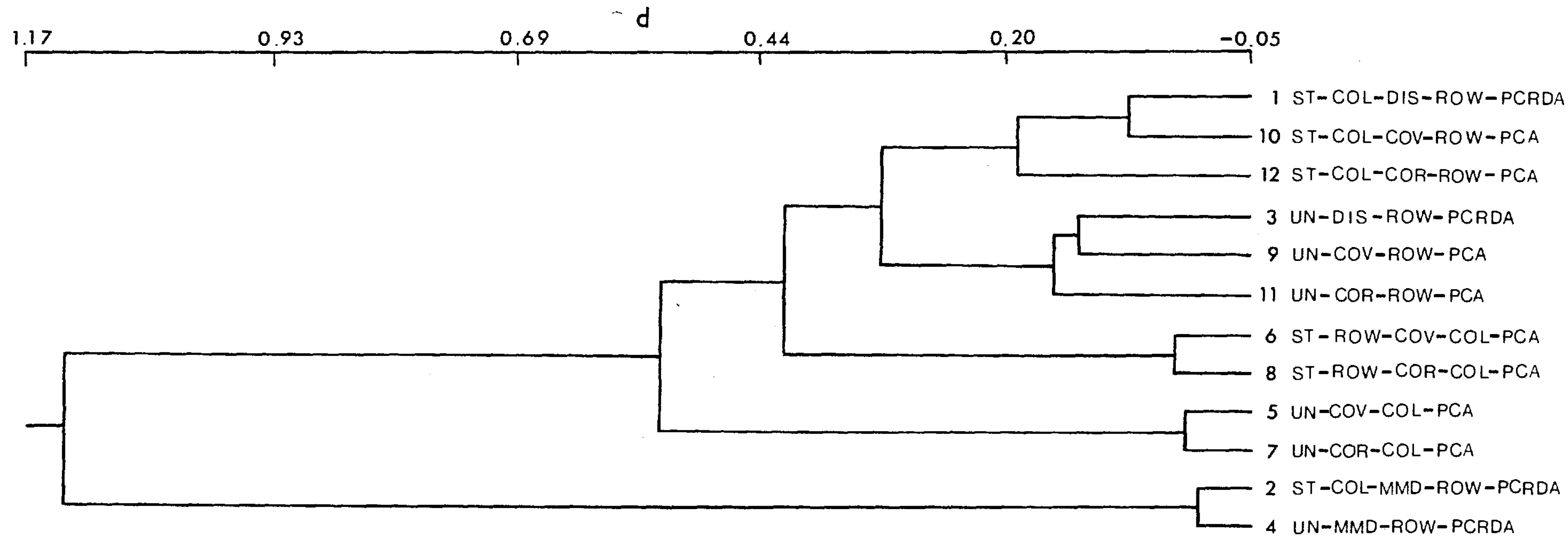
As an alternative to presenting the results of each ordination, groups of related ordinations were considered and within each group only the ordination having the lowest distance from the reference ordination (UN-COR-COL-PCA) was depicted. The clusters of related ordinations were considered as those defined in the dendrogram by an arbitrary cut-off line at a similarity level of about 0.25.

In decreasing order of similarity to the standard, the most related ordinations of each group were: ST-ROW-COR-COL-PCA (R^2 = 0.45), ST-COL-DIS-ROW-PCRDA (R^2 = 0.60) or UN-COV-ROW-PCA (R^2 = 0.60), and MMD-ROW-PCRDA (R^2 = 1.17) either unstandardized or standardized by columns. The results were plotted for pairs of components or coordinates as a series of scatter diagrams, thus expressing the relationships between OTU's in terms of a reduced number of derived variables. The selected ordinations are treated as follows.

1.1. ST-COL-DIS-ROW-PCRDA (Ordination 1)

A between-species taxonomic distance matrix based on data standardized by characters was subjected to a principal coordinate analysis.

Fig. 53 - Dendrogram showing relationships of ordinations of matrix I. The number associated with labels corresponds to the sequence of Table 6. This dendrogram is implied by the R^2-values between configurations of OTU's each representing one ordination, using the WPGMA clustering method.


d
1.17
0.93
0.69
0.44
0.20
-0.05
1 ST-COL-DIS-ROW-PCRDA
10 ST-COL-COV-ROW-PCA
12 ST-COL-COR-ROW-PCA
3 UN-DIS-ROW-PCRDA
9 UN-COV-ROW-PCA
11 UN-COR-ROW-PCA
6 ST-ROW-COV-COL-PCA
8 ST-ROW-COR-COL-PCA
5 UN-COV-COL-PCA
7 UN-COR-COL-PCA
2 ST-COL-MMD-ROW-PCRDA
4 UN-MMD-ROW-PCRDA

About three-quarters (74.12%) of the variation in the study was explained by the first three axes. The first axis accounted for 53.15% of the variation in the data and depicts a size factor. It showed a correlation of 0.97 with the overall length of the insect in the original data, so that species sorted along it with the smaller on the left and the larger on the right of the diagrams (Figs 54a-b). A separation of Batracomorphus s.str. and Sudanoiassus is reasonably apparent along this axis, as was to be expected since these groups differ significantly in size. The second and third axes accounted respectively for 11.92 and 9.05% of the total variation and were both size-independent (having correlations of respectively -0.09 and 0.16 with overall length in the original data). Since this is a principal coordinate analysis computed by orthodox methods, character loadings were not available.

Figures 54a-b and 55a are plots of two coordinate axes on which the position of the 39 OTU's are marked. The best separation between Batracomorphus s.str. and Sudanoiassus was afforded by coordinates I and II as well as by coordinates II and III. When the I and III axes of variation were used, a good separation of the type-species (39) occurred but the two subgenera tended to fuse.

This ordination represents quite a satisfactory analysis at the subgeneric level, and the same is true for lower taxonomic levels. The placement of several individual species also seems satisfactory. Examples are the following: classeyi (19) in relation to santosjuniori (27); welwitschi (7) in relation to clarensis (15); dirkoides (9) in relation to gobiswaterensis (16); and, to a lesser extent, arcuatus (10) in relation to timaea (35).

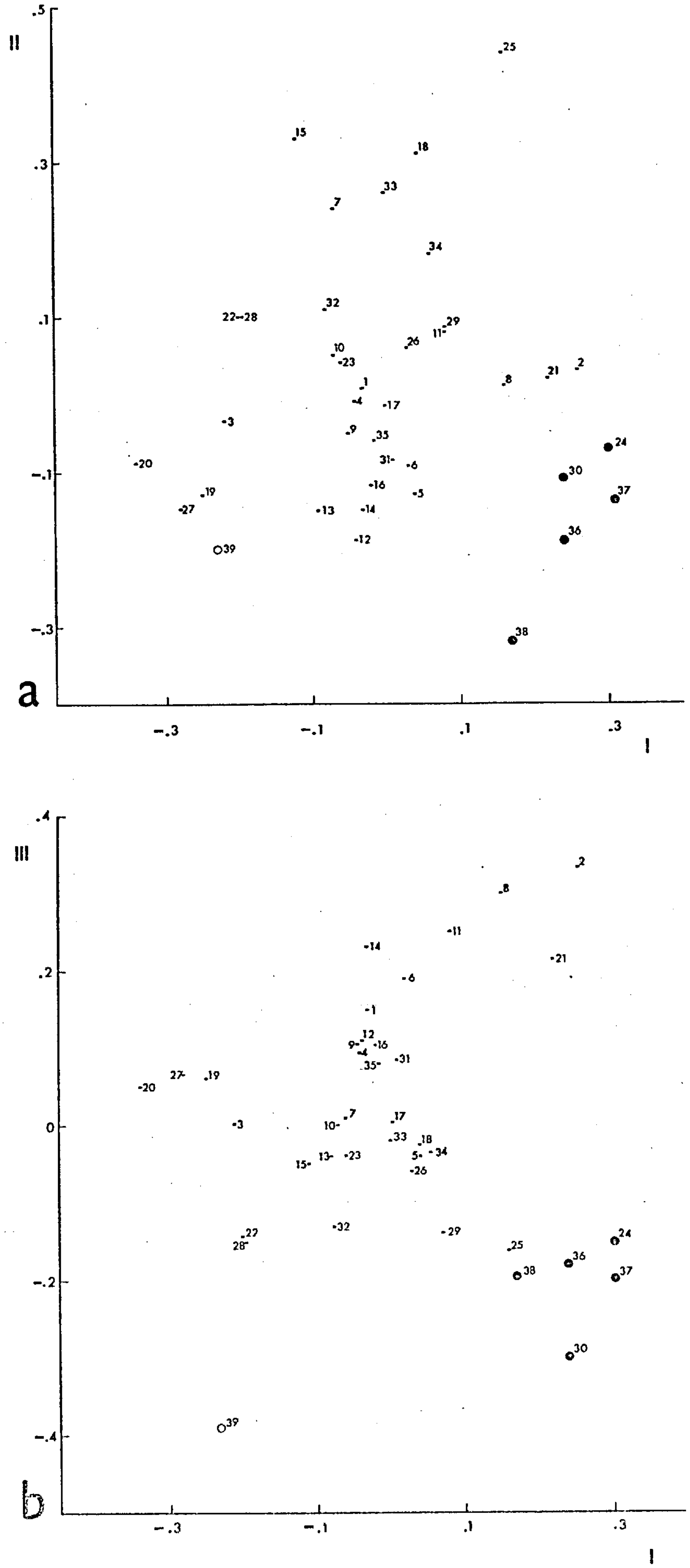
1.2 UN-MMD-ROW-PCRDA (Ordination 4)

A between-species match-mismatch distance matrix based on unstandardized data was subjected to a principal coordinate analysis.

Fig. 54 - a. A two dimensional view of the relationships among the OTU's of matrix I in a space determined by coordinate I (53.15%) and coordinate II (11.92%) of the first ten axes of a principal coordinate analysis of the matrix of taxonomic distances. Data standardized by characters. Coordinates I and II, taken together, account for 65.07% of the total variation.

- b. As above but referred to coordinates I and III (9.05%). These coordinates, taken together, account for 62.20% of the total variation.

Names of OTU's as in Table 1. Solid circles are species of Sudanoiassus Lv. & Quart.; small solid rectangles are species of Batracomorphus s.str.; the type-species is marked with a hollow circle.


II
.5
.3
.1
−.1
−.3
a
−.3
−.1
.1
.3
I
III
.4
.2
0
−.2
−.4
b
−.3
−.1
.1
.3
I

This was the poorest of all ordinations carried out here, no doubt because of the quite inappropriate nature of the match-mismatch coefficient for continuous data.

The first, second and third axes accounted for 4.41, 4.06 and 3.89% (12.36% combined) of the total variation, showing that there was very considerable loss of information when reducing the 21-dimensional space to three dimensions. All three axes proved to be independent of general size (having correlations of respectively 0.00, -0.33 and 0.03 with overall length in the original data).

This analysis did not succeed in separating Batracomorphus s.str. from Sudanoiassus and, moreover, the placement of a great many individual species appeared unsatisfactory. Rather surprising, however, the species belonging to Sudanoiassus still formed a recognizable cluster, especially in terms of axes II and III (Fig. 55b).

1.3. UN-COR-COL-PCA (Ordination 7)

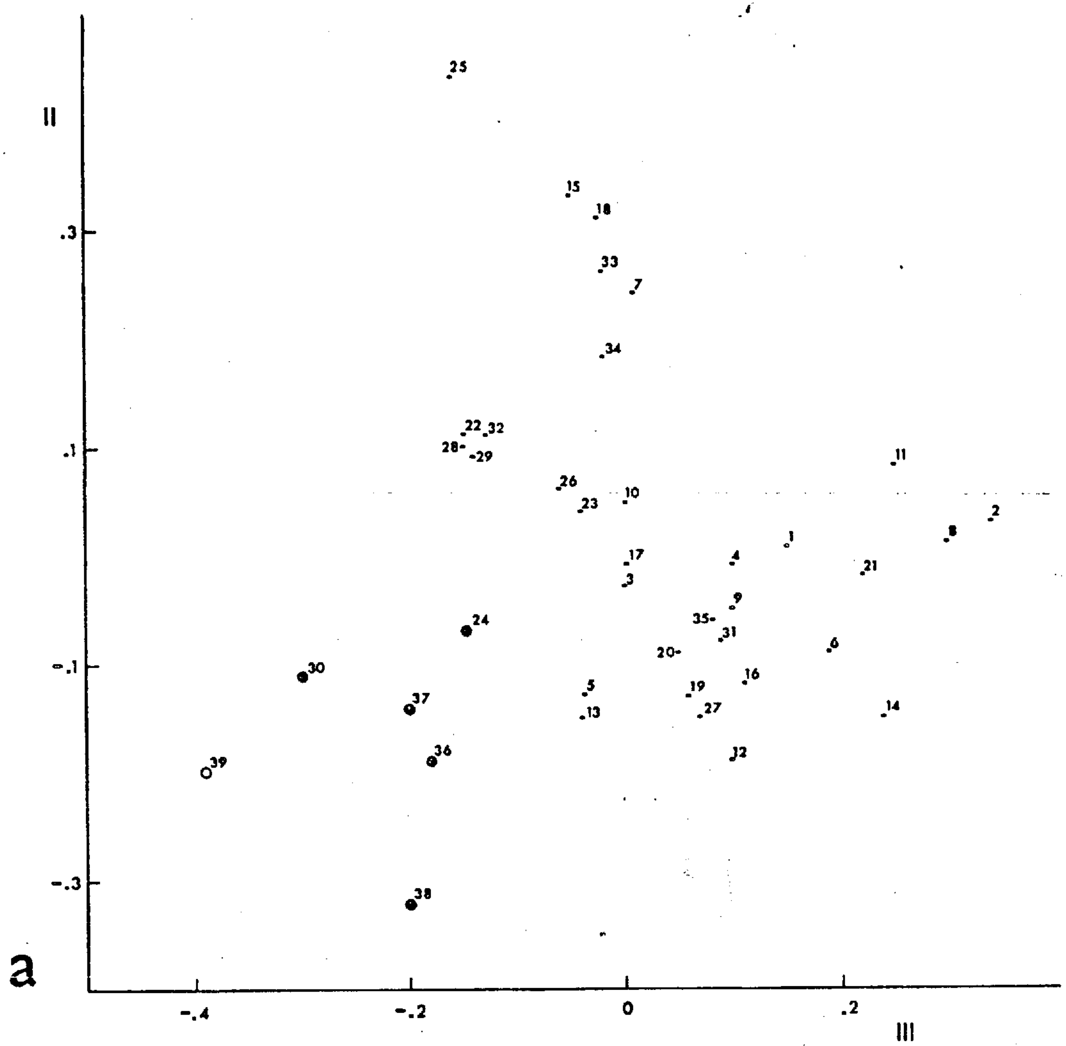
A between-character correlation matrix based on unstandardized data was subjected to a principal component analysis. This analysis seemed by far the most satisfactory ordination of all those carried out with continuous data.

About three-quarters of the variation in the study (74.11%) was explained by the first three components. The first principal component accounted for 53.17% of the variation, and represented a size factor. Most length and width measurements of external structures loaded heavily on this component, which showed a correlation of 0.94 with overall length in the original data. Characters loading most heavily on this component were, in decreasing order, numbers 2, 1, 6, 9, 5 and 11 (Table 8). The diagrams illustrating the first component (Figs 56a-b) show the species ordered by size along this axis.
Fig. 57a is a scatter diagram showing the regression line of the first principal component (normalized vector) on the overall length. The two

Fig. 55 - a. As in Fig. 54a but referred to coordinates II and III. These coordinates, taken together, account for 20.97% of the total variation.

- b. A two dimensional view of the relationships among the OTU's of matrix I in a space determined by coordinate II (4.06%) and coordinate III (3.89%) of the first ten axes of a principal coordinate analysis of the matrix of match-mismatch distances. Data unstandardized. Coordinates II and III, taken together, account for 7.95% of the total variation.

Names of OTU's as in Table 1. Solid circles are species of Sudanoiassus Lv. & Quart.; small solid rectangles are species of Batracomorphus s.str.; the type-species is marked with a hollow circle.


II
.3
.1
-.1
-.3
a
-.4
-.2
0
.2
III

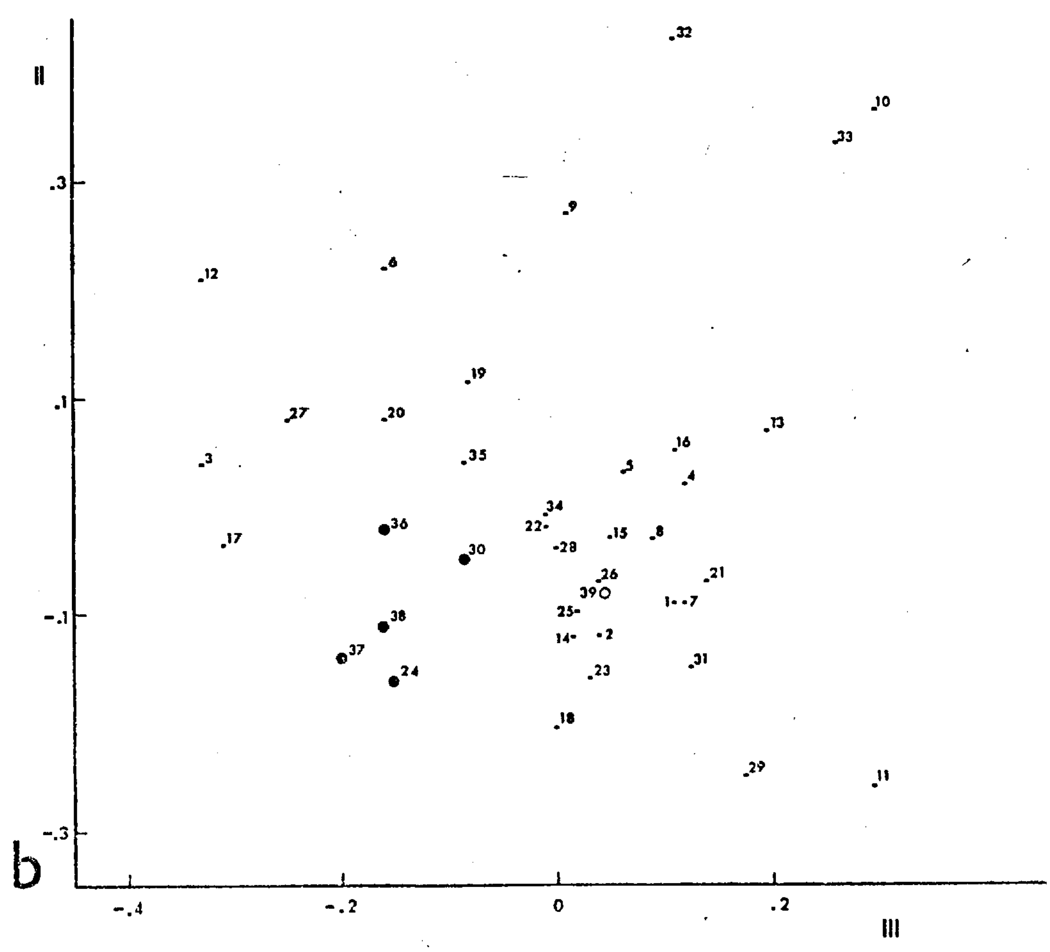

II
.3
.1
-.1
-.3
b
-.4
-.2
0
.2
III

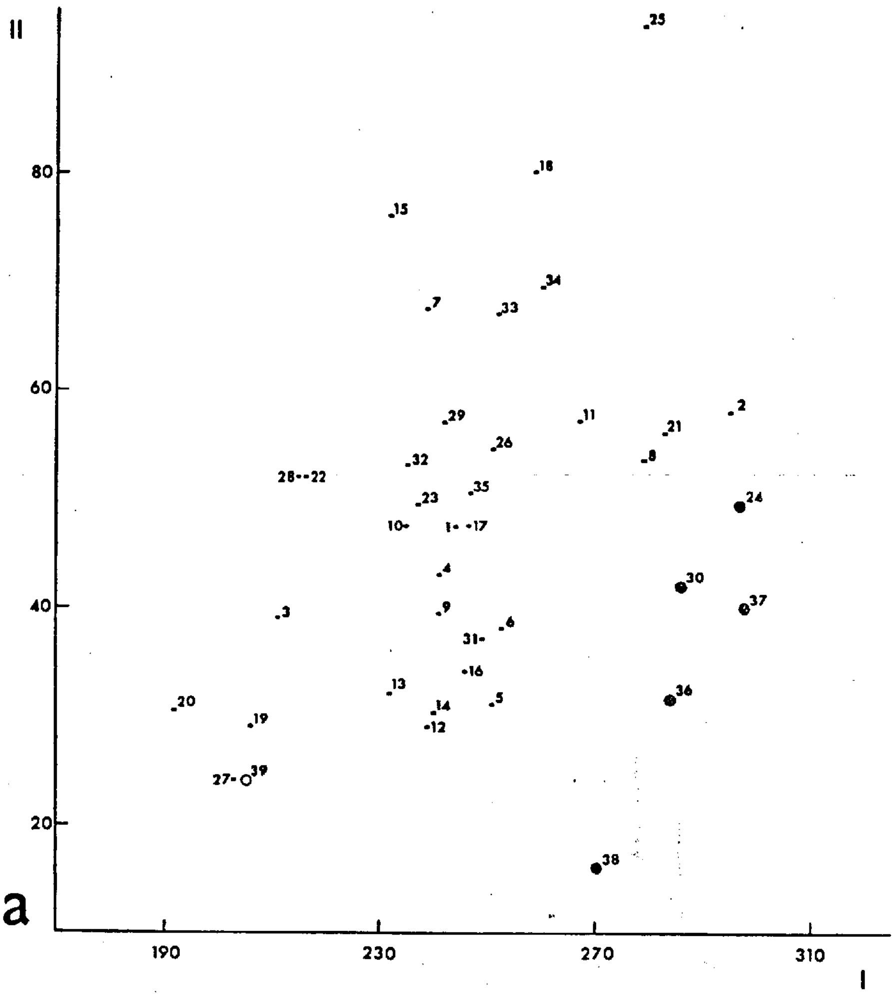
Table 8 EIGENVECTOR MATRIX IN A PRINCIPAL COMPONENT ANALYSIS OF THE MATRIX OF CORRELATIONS AMONG THE MEASUREMENT VARIABLES (DATA NOT STANDARDIZED)

Variables		Scaled Eigenvectors				
	I	II	III	IV	V	VI
1	.966	-.096	-.039	.036	-.060	-.086
2	.980	-.045	.003	-.010	-.014	.010
3	.250	-.193	-.457	.571	.190	.525
4	.879	-.212	-.026	-.208	.078	-.207
5	.959	-.041	.000	.009	.017	-.082
6	.964	-.119	-.066	-.022	-.030	.056
7	.845	-.179	-.365	-.000	.102	.061
8	.812	-.086	-.018	.005	-.223	.295
9	.962	-.123	.018	-.104	-.050	-.013
10	.787	-.026	-.026	.077	-.198	-.259
11	.958	-.104	-.000	.033	-.103	-.120
13	.622	.537	.440	.165	.218	.151
14	.570	.611	.418	.156	.283	-.008
15	.224	-.375	.810	.275	.225	-.002
16	.438	.867	-.138	.001	.101	-.008
17	.189	.822	-.397	-.166	-.207	.025
18	.894	.086	-.008	.022	.155	-.024
19	.284	-.221	-.170	-.654	.475	.298
20	.719	-.141	-.086	.479	-.269	-.001
22	.106	.092	.543	-.326	-.535	.473
23	-.597	.117	-.105	.562	.016	.025
Latent roots	11.165	2.503	1.894	1.625	1.000	.846
% of variation: component	53.168	11.921	9.020	7.737	4.764	4.030
% of variation: cumulative	53.168	65.089	74.109	81.846	86.610	90.640

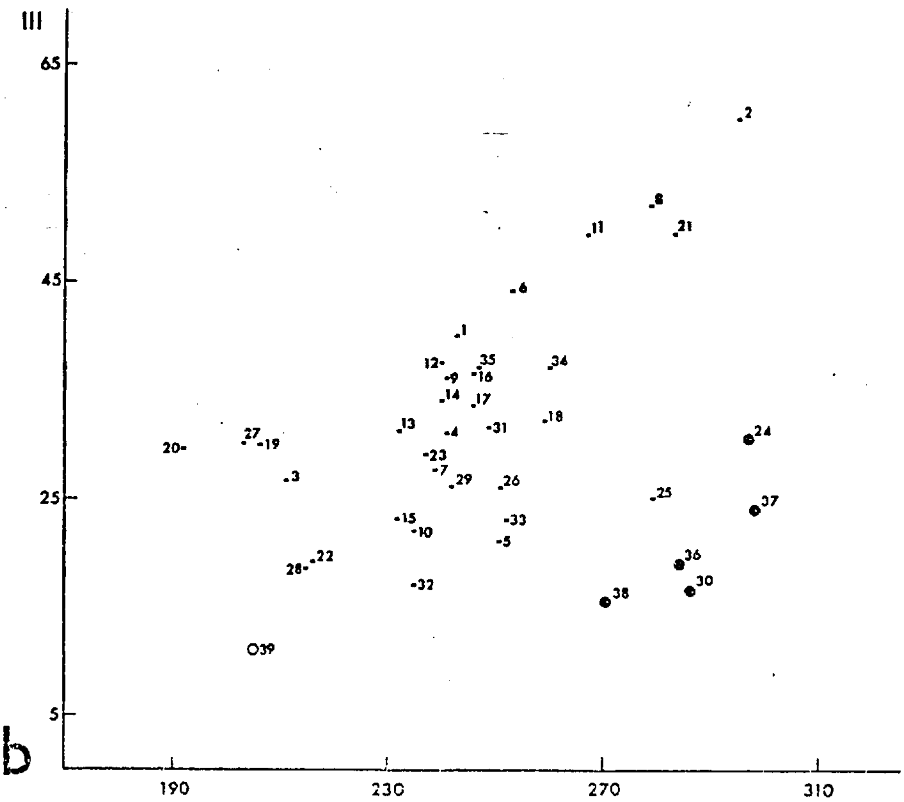
Fig. 56 - a. A two dimensional view of the relationships among the OTU's of matrix I in a space determined by component I (53.17%) and component II (11.92%) of the first ten axes of a principal component analysis of the matrix of correlations among characters. Data unstandardized. Components I and II, taken together, account for 65.09% of the total variation.

- b. As above but referred to components I and III (9.02%). These components, taken together, account for 62.19% of the total variation.

Names of OTU's as in Table 1. Solid circles are species of Sudanoiassus Lv. & Quart.; small solid rectangles are species of Batracomorphus s.str.; the type-species is marked with a hollow circle.



a



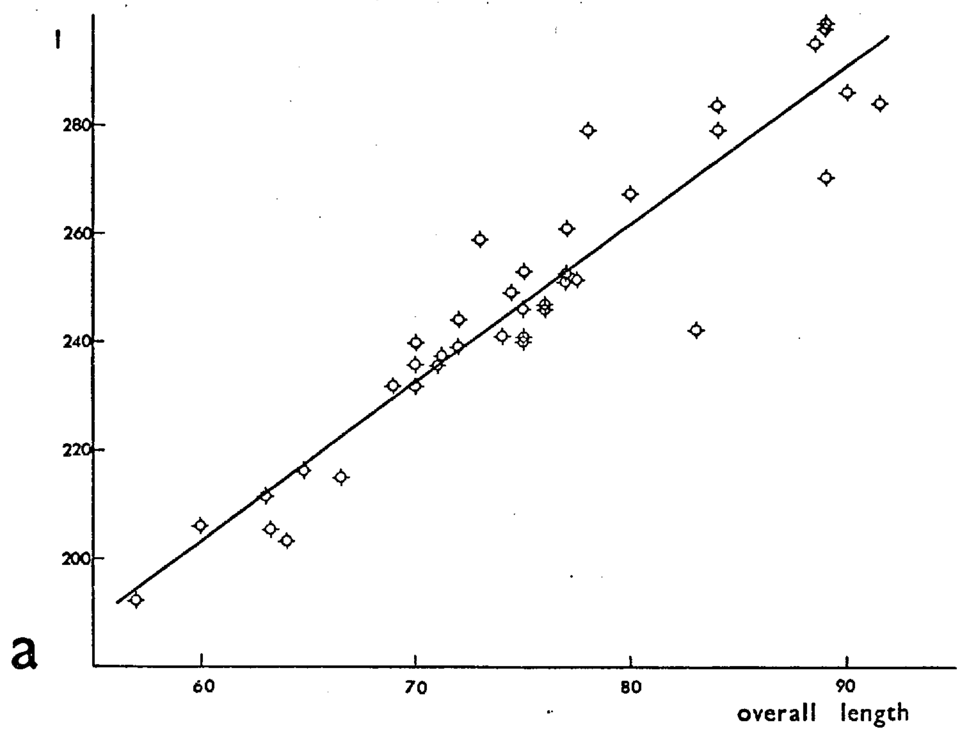
b

variables are linearly related and, as stated before, with a correlation of 0.94. Fig. 57b is a histogram showing the frequency distribution of OTU's on the first principal component. It reveals three apparent modes: two, on the left and middle correspond to the small and medium-sized species of Batracomorphus s.str., while the mode on the right refers to Sudanoiassus. The second principal component, accounting for 11.92% of the total variation, was interpreted as a factor related to penis and stylus dimensions. It showed a correlation of only 0.13 with overall length and was most heavily loaded on characters 16, 17, 14 and 13 (Table 8). The third principal component accounted for 9.02% of the variation in the study, and was interpreted as a factor related to the socle of the penis. It showed a correlation of only 0.20 with overall length in the original data but weighted heavily the contribution of character number 15. Of the remaining seven components, the sixth (accounting for only 4.03% of the total variation) appeared as a good discriminant between Batracomorphus s.str. and Sudanoiassus. Fig. 58b depicts the separation of these subgenera afforded by this component, which is probably close to the orientation of an optimum discriminant function. It appeared especially highly loaded on variables 3 (weight of 0.53) and 22 (weight of 0.47) and was therefore interpreted as a factor related to crown and elytral setae lengths. The histogram showing the frequency distribution of OTU's on the sixth component has two modes which correspond to the subgenera of Batracomorphus (Fig. 59).

Figs 56a-b and 58a-b are plots of two component axes on which the position of the OTU's are marked. The best separation between Batracomorphus s.str. and Sudanoiassus was afforded, in decreasing order, by axes I and II, I and III, and I and VI. Only axes II and III show the subgenera fused. The position of the type-species (39) is in the majority of the diagrams nearer Batracomorphus s.str. than

Fig. 57 - a. Scatter diagram and regression line of the first principal component (normalized vector) on the overall length (units of the ocular micrometer) of analysis no. 7.

- b. Histogram of the frequency distribution of OTU's on the first principal component of analysis no. 7.


I
280
260
240
220
200
a
60
70
80
90
overall length

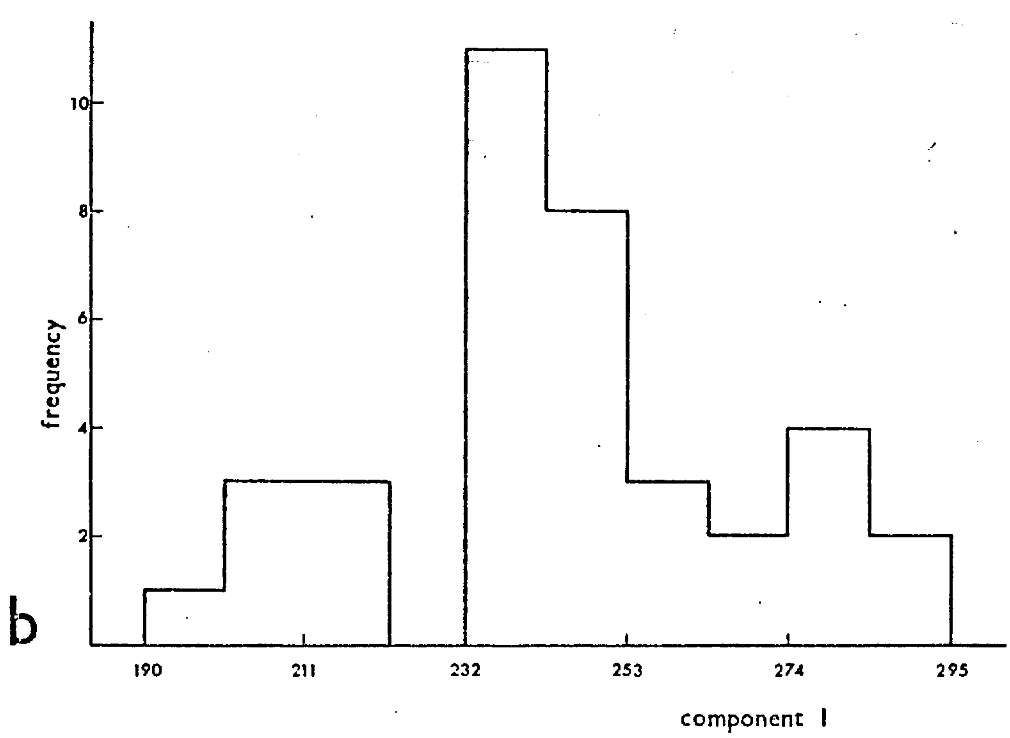

10
8
6
4
2
frequency
b
190
211
232
253
274
295
component I

Fig. 58 - a. As in Fig. 56a but referred to components II and III. These components, taken together, account for 20.94% of the total variation.

- b. As above but referred to components I and VI (4.03%). These components, taken together, account for 57.20% of the total variation.

Names of OTU's as in Table 1. Solid circles are species of Sudanoiassus Lv. & Quart.; small solid rectangles are species of Batracomorphus s.str.; the type-species is marked with a hollow circle.

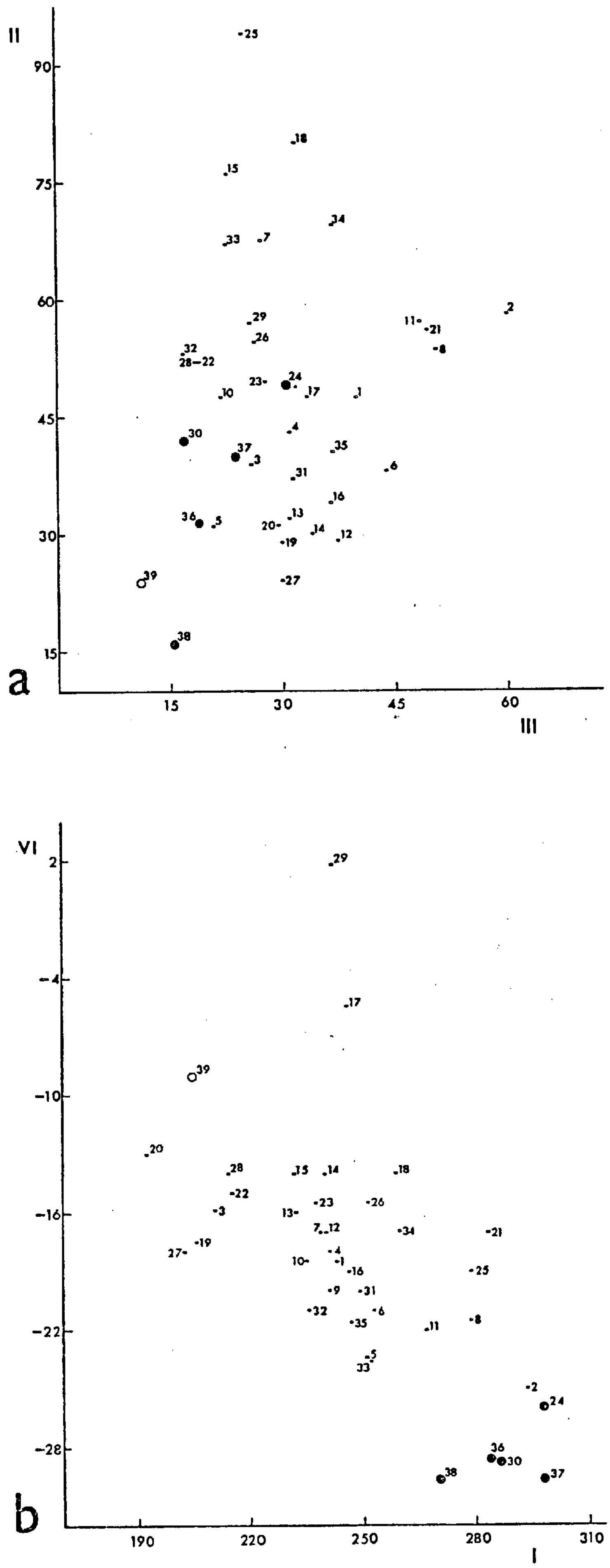
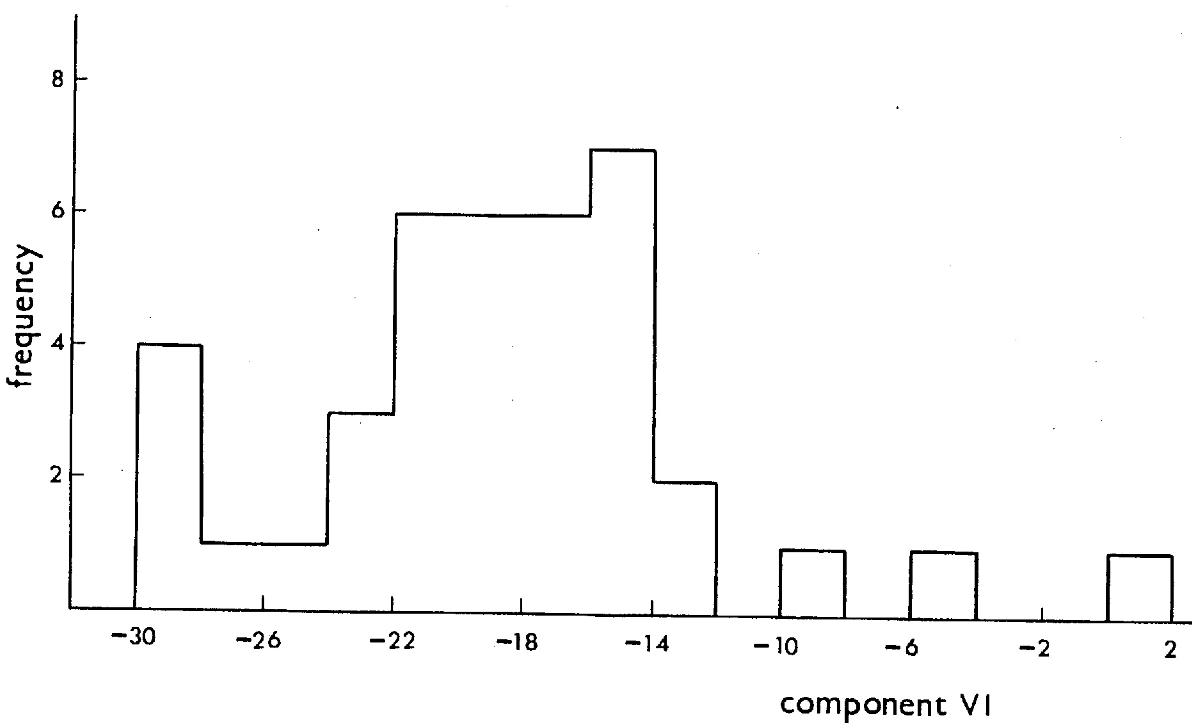

a
II
90
75
60
45
30
15
15
30
45
60
III
b
VI
2
-4
-10
-16
-22
-28
190
220
250
280
310
I

Fig. 59 - Histogram of the frequency distribution of OTU's on the sixth principal component of analysis no. 7.



frequency
8
6
4
2
−30
−26
−22
−18
−14
−10
−6
−2
2
component VI

Sudanoiassus, which is a satisfactory result. Also satisfactory is the placement of many individual species, such as: welwitschi (7) and clarensis (15); classeyi (19) and santosjuniori (27); dirkoides (9) and gobiswaterensis (16); signatus (13) and distinctissimus (14); and, to a lesser extent, arcuatus (10) and subolivaceus (28) or quirimboensis (2) and mandane (11).

1.4. ST-ROW-COR-COL-PCA (Ordination 8)

A between-character correlation matrix of data standardized by species was subjected to a principal component analysis.

The first three components explained 36.35, 11.90 and 10.94% (59.19% combined) of the total variation in the similarity matrix. The correlations between these components and overall length were, respectively, 0.19, -0.26, and -0.33, indicating that none was especially associated with general size. This is the result of standardization, which in certain circumstances may be used to eliminate a general size-factor should this be considered desirable (cf. Ordination 7). The first principal component defines a contrast between the size of some genital structures (penis and stylus) and a number of external structural characters (overall length, interocular width of crown, width of pronotum, and length of elytra) (for list of loadings see Table 9). The second component is an elytral setae factor (highest loading for character number 22). The third component has the highest positive loading for character number 15 and the highest negative loading for character number 17. It therefore defines a contrast between the dimensions of the socle of the penis and the basal apodeme of the penis. Neither of these components provided a good discrimination between Batracomorphus s.str. and Sudanoiassus.

The charts constructed from combinations of pairs of the first three components are shown in Figs 60a-b and 61. The separation of Batracomorphus into subgenera is particularly poor and the type-species

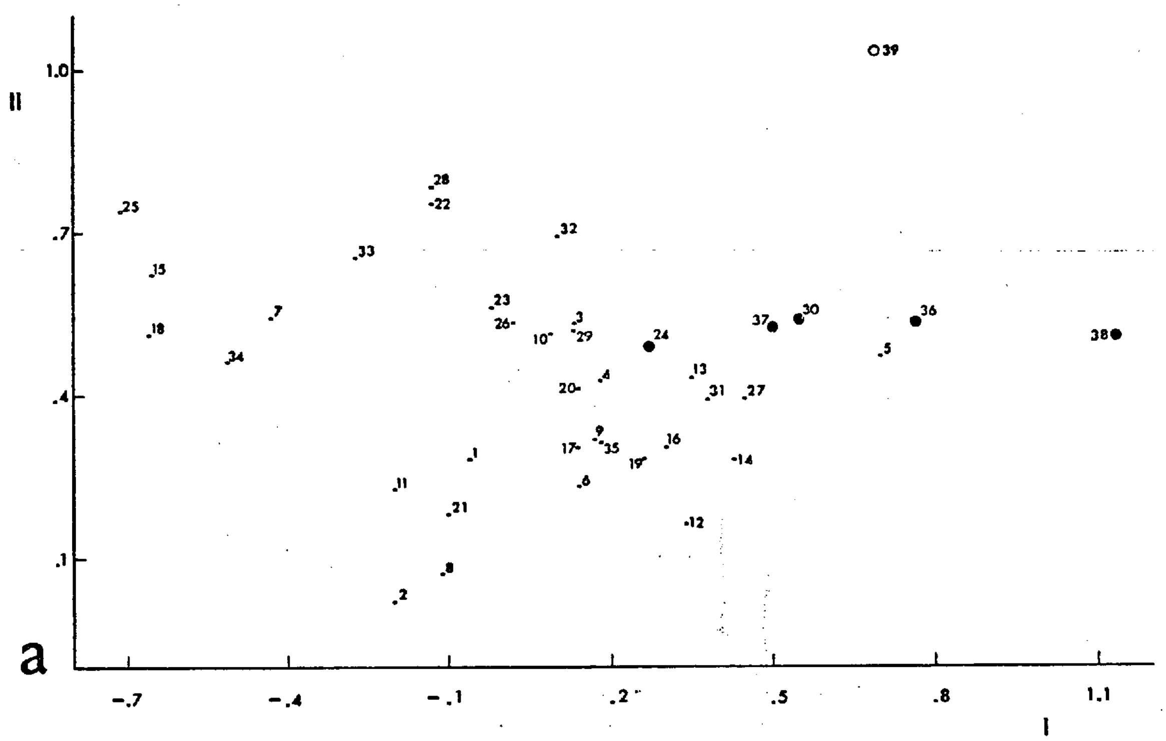
Table 9 EIGENVECTOR MATRIX IN A PRINCIPAL COMPONENT ANALYSIS OF THE MATRIX OF CORRELATIONS AMONG THE MEASUREMENT VARIABLES (DATA STANDARDIZED)

Variables		Scaled Eigenvectors					
		I	II	III	IV	V	VI
1		.783	-.032	-.311	-.274	-.070	.165
2		.684	.350	.288	.235	.373	-.003
3		.536	.493	.371	-.137	.089	.320
4		.563	-.284	-.030	.317	-.235	-.405
5		.628	-.210	-.295	-.121	-.327	.138
6		.797	.223	.072	.236	.303	-.070
7		.692	.463	-.004	.256	-.015	-.213
8		.658	-.350	-.149	.073	.328	.391
9		.828	-.037	.026	.247	.092	.125
10		.167	.091	-.259	-.362	-.029	-.725
11		.719	-.291	-.424	-.342	-.077	.114
13		-.855	-.170	.385	-.029	.137	.191
14		-.905	-.239	.137	-.007	.087	.017
15		.132	-.575	.720	-.299	-.011	-.074
16		-.768	.189	-.499	.206	.119	.112
17		-.491	.345	-.634	.273	.105	.188
18		.058	.261	.109	-.180	-.757	.387
19		.324	-.152	.148	.695	-.457	.017
20		.382	.150	-.161	-.686	.196	.047
22		.348	-.726	-.008	.198	.245	.130
23		.050	.561	.527	-.132	-.033	.026
Latent roots		7.633	2.499	2.297	1.950	1.460	1.331
% of variation	component	36.350	11.898	10.938	9.284	6.955	6.338
	cumulative	36.350	48.248	59.186	68.470	75.425	81.763

Fig. 60 - a. A two dimensional view of the relationships among OTU's of matrix I in a space determined by component I (36.36%) and component II (11.90%) of the first ten axes of a principal component analysis of the matrix of correlations between characters. Data standardized by species. Components I and II, taken together, account for 48.26% of the total variation.

- b. As above but referred to components I and III (10.94%). These components, taken together, account for 47.30% of the total variation.

Names of OTU's as in Table 1. Solid circles are species of Sudanoiassus Lv. & Quart.; small solid rectangles are species of Batracomorphus s.str.; the type-species is marked with a hollow circle.


a
II
1.0
.7
.4
.1
I
-.7
-.4
-.1
.2
.5
.8
1.1
39
28
22
25
15
18
33
7
34
32
23
26
3
10
29
24
37
30
36
38
5
20
4
13
31
27
9
17
35
16
19
14
1
11
6
21
12
8
2

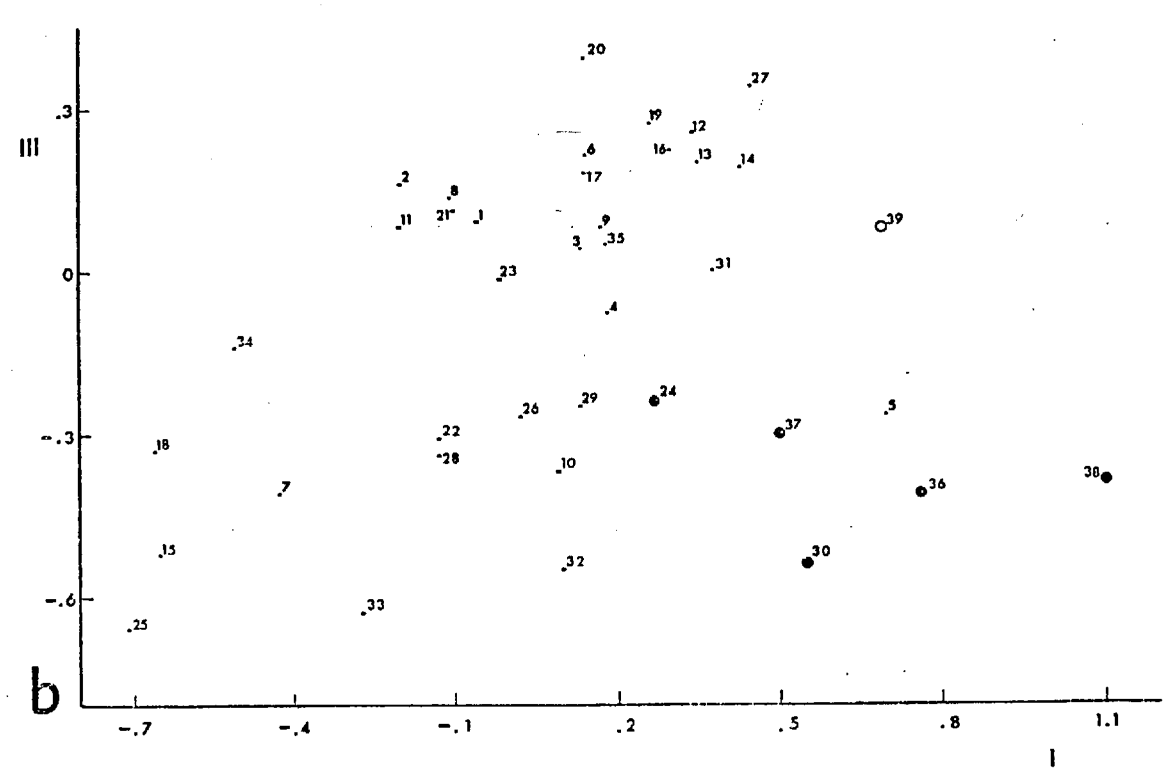
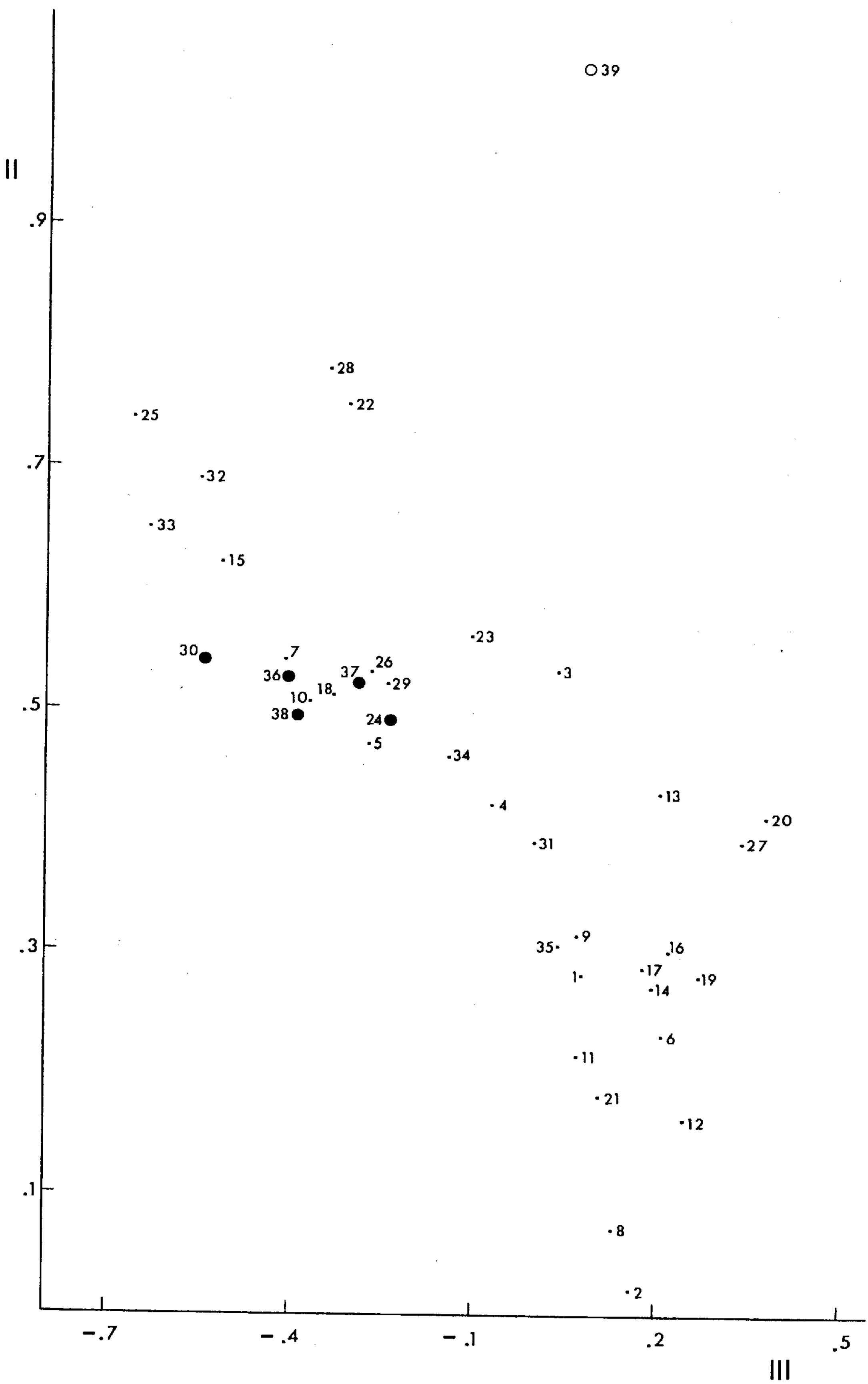

b
III
.3
0
-.3
-.6
I
-.7
-.4
-.1
.2
.5
.8
1.1
20
27
19
12
6
16
13
14
17
2
8
11
21
1
9
39
3
35
23
31
4
34
24
29
26
5
37
22
28
18
10
7
36
38
30
15
32
33
25

Fig. 61 - As in Fig. 60a but referred to components II and III. These components, taken together, account for 22.84% of the total variation.

Names of OTU's as in Table 1. Solid circles are species of Sudanoiassus Lv. & Quart.; small solid rectangles are species of Batracomorphus s.str.; the type-species is marked with a hollow circle.


II
.9
.7
.5
.3
.1
−.7
−.4
−.1
.2
.5
III
39
28
22
25
32
33
15
23
30
7
36
26
37
29
3
18
10
38
24
5
34
4
13
20
31
27
9
35
16
17
1
19
14
6
11
21
12
8
2

(39) appears in too isolated a position. Nevertheless, the placement of a great many species seemed quite satisfactory. Examples are the following: welwitschi (7) and clarensis (15); classeyi (19) and santosjuniori (27); dirkoides (9) and gobiswaterensis (16); signatus (13) and distinctissimus (14); quirimboensis (2) and mandane (11); or signatus (13) and akhmenes hargeisanus (31).

1.5 UN-COV-ROW-PCA (Ordination 9)

A between-species covariance matrix of unstandardized data was subjected to a principal component analysis.

Nearly all the variation present in the study was extracted by the first three components (99.27%), so that there was virtually no distortion in distances when reducing the 21-dimensional space to three dimensions only. The first principal component accounted for 97.49% of the variation in the similarity matrix and showed a correlation of 0.95 with overall length in the original data. The ordination diagrams illustrating this component (Figs 62a-b) reflect the range of dimensions in different species and it was interpreted as a general size factor. The second and third components accounted respectively for 1.16 and 0.62% of the variation in the study and were both size-independent (correlations of -0.16 and 0.12 with overall length). Since this is a Q-mode analysis, character loadings were not available.

The unusually high values for the largest latent root in this ordination and in ordination 11 needs a further comment. They are the consequence of unusually high correlations between the OTU's. This in turn is an expression of the considerable differences in size between some of the OTU's, a difference related to differences between the subgenera. It raises, however, from a numerical taxonomic standpoint, the question of whether covariances and correlations are, in general, suitable indices of similarity in such Q-type analyses.

Fig. 62 - a. A two dimensional view of the relationships among the OTU's of matrix I in a space determined by component I (97.49%) and component II (1.16%) of the first ten axes of a principal component analysis of the matrix of variance-covariances between species. Data unstandardized. Components I and II, taken together, account for 98.65% of the total variation.

- b. As above but referred to components I and III (0.62%). These components, taken together, account for 98.11% of the total variation.

Names of OTU's as in Table 1. Solid circles are species of Sudanoiassus Lv. & Quart.; small solid rectangles are species of Batracomorphus s.str.; the type-species is marked with a hollow circle.

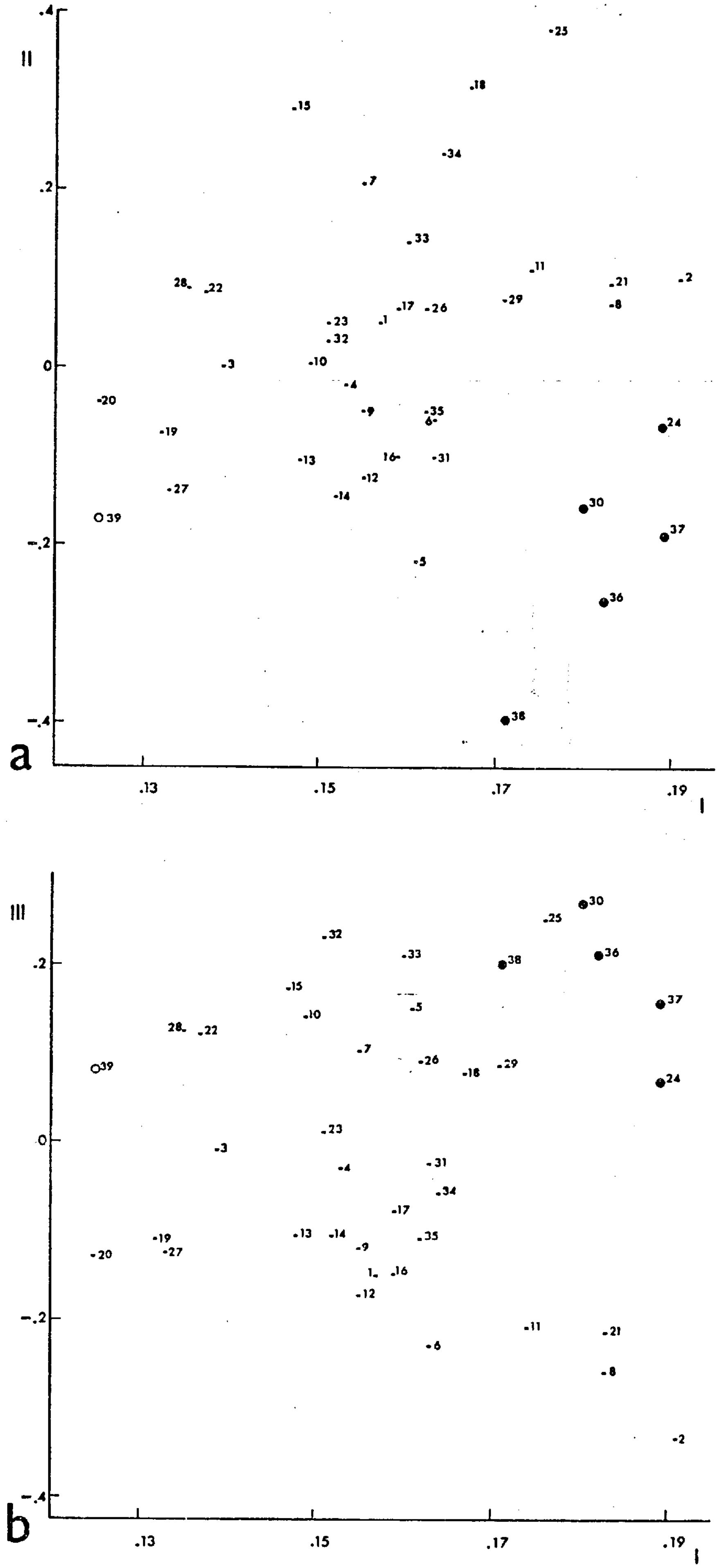
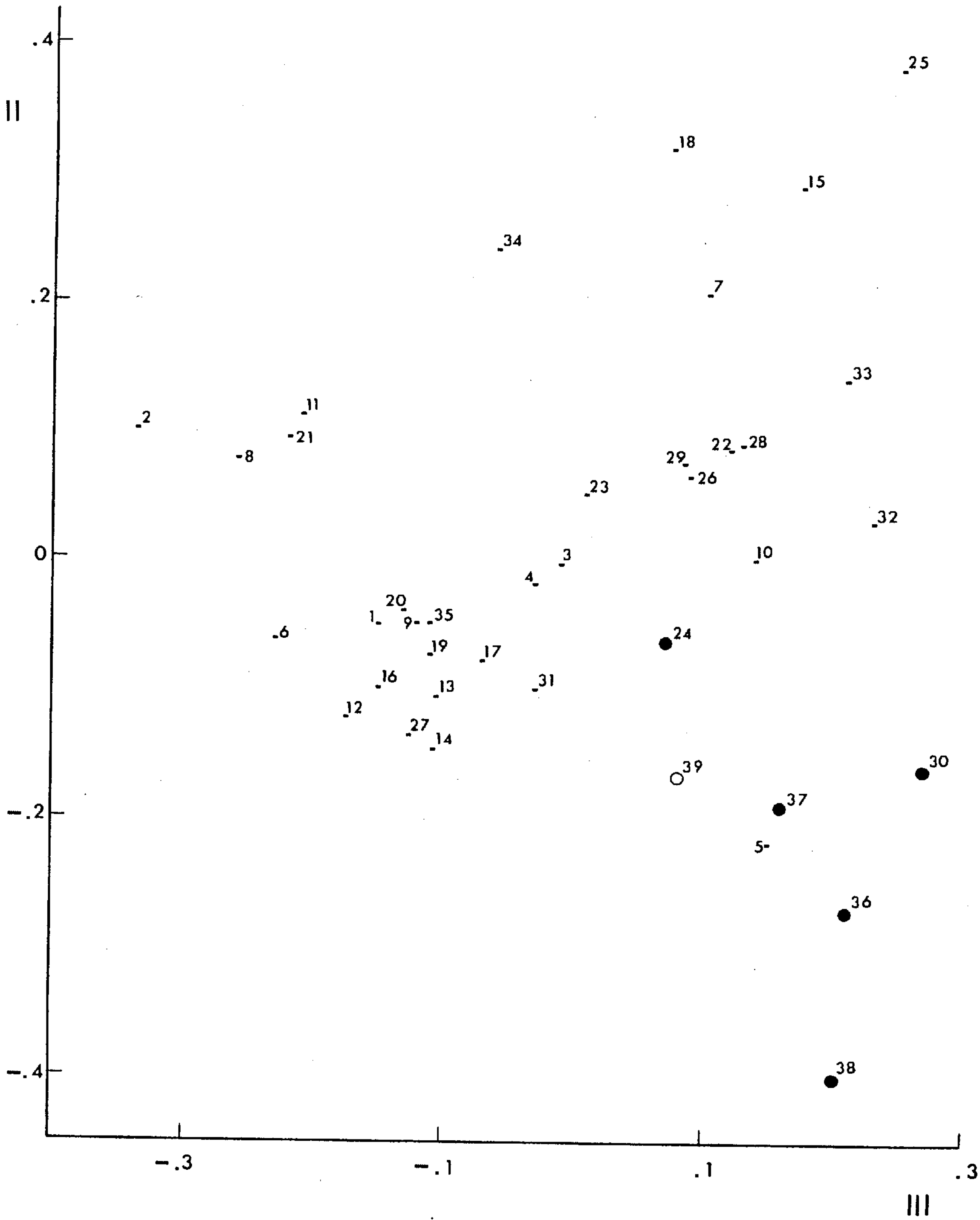

a
II
.4
.2
0
-.2
-.4
.13
.15
.17
.19
I
25
18
15
34
7
33
11
21
2
28
22
17
26
29
8
23
1
32
3
10
4
20
9
35
6
24
19
13
16
31
12
27
14
39
30
37
5
36
38
b
III
.2
0
-.2
-.4
.13
.15
.17
.19
I
30
25
32
33
38
36
15
5
37
10
28
22
7
39
26
18
29
24
23
3
4
31
34
17
19
13
14
35
20
27
9
1
16
12
11
21
6
8
2

Fig. 63 - As in Fig. 62a but referred to components II and III. These components, taken together, account for 1.78% of the total variation.

Names of OTU's as in Table 1. Solid circles are species of Sudanoiassus Lv. & Quart.; small solid rectangles are species of Batracomorphus s.str.; the type-species is marked with a hollow circle.


.4
.2
0
-.2
-.4
II
-.3
-.1
.1
.3
III
25
18
15
34
7
33
2
11
21
8
22
28
29
26
23
32
3
10
4
20
1
9
35
6
24
19
17
16
13
31
12
27
14
39
30
37
5
36
38

In general, the results provided by this ordination were quite satisfactory. The best separation between Batracomorphus s.str. and Sudanoiassus was afforded, in decreasing order, by axes I and II, II and III, and I and III (Figs 62a-b and 63). The placement of the type-species was also satisfactory in the two first plots and the clustering of several pairs of species was also satisfactory, such as: welwitschi (7) and clarensis (15); classeyi (19) and santosjuniori (27); dirkoides (9) and gobiswaterensis (16); signatus (13) and distinctissimus (14); quirimboensis (2) and mandane (11); or arcuatus (10) and subolivaceus (28).

1.6 Discussion

The results of the ordinations of the Batracomorphus species based on continuous characters suggest the following:

(1) This set of ordinations correspond to a set of different methods of principal component and coordinate analysis so that different estimates of phenetic affinity were produced. Nevertheless, the estimates agreed in their broader aspects and only in detail is there appreciable divergence. The first general impression, therefore, is that in all eleven different methods the subgenus Sudanoiassus was recognized as one cluster. Furthermore, most of the different methods revealed two major groups in Batracomorphus corresponding to the two subgenera recognized by traditional taxonomic views. These findings closely resemble the conclusions of Boratynski & Davies (1971) when several forms of principal axis ordination were applied to males of the Diaspididae (Homoptera, Coccoidea).

(2) The highest values of cumulative percentage of variation were afforded by principal components based on covariance and correlation matrices between OTU's (9, 11), followed by principal coordinates based on taxonomic distances (3) and by principal components based on a covariance matrix between variables (5) (see Table 7).

The lowest cumulative percentage of variation was afforded by principal coordinates based on a match-mismatch distance matrix. These percentages indicate the extent to which a scatter-diagram based on the first three axes will have distorted the original distances and on these grounds alone, the results of the two Q-mode principal component analyses might have been expected to provide the best results. This was not in fact the case for, as pointed out by Boratynski & Davies (1971), some of the total variation may be of little taxonomic interest. For example, some depends merely on the fact that each OTU is distinct. This may explain the present results and others such as those of Rohlf (1967). In his study of Culicid pupae, where the percentages of variance accounted for only 58% for the first three axes, the principal component analysis yielded distances which were very highly correlated ($\underline{r}$ = 0.95) with those derived from the original data.

(3) The assessment of the "best" similarity coefficient calls for the following comments: (a) there was clear evidence that match-mismatch distance provided the poorest picture of the relationships between members of this sample of leafhoppers. This was certainly due to the fact that with continuous data such a measure makes use of only a very small fraction of the information available in the similarity matrix; (b) the choice between covariance, correlation and taxonomic distance poses some difficulties since the effectiveness of the analysis seemed also to depend on other factors such as mode of the ordination (Q- versus R-mode); and (c) the analyses which gave a clearer separation of Batracomorphus into subgenera were not necessarily better for the clustering of individual species. Taking all these points into consideration, the following impressions emerged. In Q-mode analyses and for data standardized by columns, taxonomic distance coefficients were undoubtedly the best measures. Conversely, for unstandardized data

either the distances or the covariances seemed to be equally effective. For R-mode analyses a possible choice can only be made between covariances and correlations; for either unstandardized data or data standardized by species, both measures gave equally effective results, with the balance slightly in favour of correlations.

(4) Some of the considerations referred to in (3) apply as well to the assessment of the relative merit of Q- and R-type techniques. In fact, Q-mode analysis provided quite satisfactory results when either a distance matrix or a covariance matrix of unstandardized data was analysed. On the other hand, R-mode analysis also provided quite good results for both correlations or covariances applied to unstandardized data. On the whole, however, R-type analysis seemed to have provided slighly better results than Q-type analysis.

(5) The results of R-type analysis of covariance and correlation matrices were worsened by standardization when considering either at subgeneric or at specific levels. Concerning Q-type analyses, covariances and correlations techniques, standardization improved the results at subgeneric level (clearer separation of the two subgenera) but worsened them considerably at the species level (poorer clustering of individual species); taxonomic distance analyses, on the other hand, did not show any appreciable improvement either at specific or at subgeneric levels; and as stated elsewhere, the principal coordinate analysis of the match-mismatch distance matrix was not affected by standardization. The results here achieved are somewhat in conflict with the results provided by cluster analysis [Section (d)] where for the same data and mode of analysis standardization improved the results based on distances, and to a lesser extent, those achieved by correlations.

2. Classification of classifications

The dendrogram summarising the similarities between the 12 ordinations is shown in Fig. 53. As mentioned before in Section (c) this diagram is only an approximate guide because of possible distortions inherent in the dendrogram.

Excluding the match-mismatch distance analyses, which are strikingly isolated, this dendrogram shows the ordinations divided into three major groups: (1) methods based on covariances and correlations between characters, with unstandardized data; (2) methods based on covariances and correlations between characters, with data standardized by species; and (3) Q-mode methods of either covariances, correlations or taxonomic distances based on unstandardized data and on data standardized by characters. Within the last group it is interesting to note that the covariance, correlation and taxonomic distance analyses clustered according to whether or not they involved standardization. It is also clear from this dendrogram that the following pairs of methods were near identical: (a) a principal coordinate analysis of taxonomic distances with data standardized by characters (1) in relation to a Q-mode principal component analysis of covariances with data standardized by characters (10); (b) a R-mode principal component analysis of covariances with data standardized by species (6) in relation to a R-mode principal component analysis of correlations with data standardized by species (8); and (c) a R-mode principal component analysis of covariances with unstandardized data (5) in relation to a R-mode principal component analysis of correlations with unstandardized data (7).

2.1 Conclusions and discussion

The following conclusions may be drawn from combinations of analyses so as to illustrate the effects caused by different methods of numerical classification.

2.1.1. Influence of a Q- or R-mode ordination

R^2-values of respectively 0.146, 0.161, 0.017 and 0.010 were found between the following analyses: ST-COL-COV-ROW-PCA (10) vs.

ST-COL-COR-ROW-PCA (12); UN-COV-ROW-PCA (9) vs. UN-COR-ROW-PCA (11); ST-ROW-COV-COL-PCA (6) vs. ST-ROW-COR-COL-PCA (8); and UN-COV-COL-PCA (5) vs. UN-COR-COL-PCA (7). Ordinations based on covariances and correlations are therefore more similar when they are analysed in a R-mode fashion than when analyzed by a Q-mode technique.

2.1.2. <u>Influence of the similarity coefficient</u>

(1) <u>Q-mode analysis</u>

Ordinations based on match-mismatch distances are markedly isolated. On the other hand, ordinations based on taxonomic distances, on covariances and on correlations tended to cluster together. R^2-values of 0.069, 0.209 and 0.146 were found between the following analyses: ST-COL-DIS-ROW-PCRDA (1) vs. ST-COL-COV-ROW-PCA (10); ST-COL-DIS-ROW-PCRDA (1) vs. ST-COL-COR-ROW-PCA (12); and ST-COL-COV-ROW-PCA (10) vs. ST-COL-COR-ROW-PCA (12). On the other hand, R^2-values of 0.124, 0.308 and 0.161 were found between the following analyses: UN-DIS-ROW-PCRDA (3) vs. UN-COV-ROW-PCA (9); UN-DIS-ROW-PCRDA (3) vs. UN-COR-ROW-PCA (11); and UN-COV-ROW-PCA (9) vs. UN-COR-ROW-PCA (11). Thus for both standardized and unstandardized data, the results provided by taxonomic distances were more similar to those obtained by covariances than the former were like correlations, or covariances were like correlations.

(2) <u>R-mode analysis</u>

R^2-values of 0.017 and 0.011 were found between the following analyses: ST-ROW-COV-COL-PCA (6) vs. ST-ROW-COR-COL-PCA (8); and UN-COV-COL-PCA (5) vs. UN-COR-COL-PCA (7). Results provided by covariances and correlations were therefore almost identical whether data were standardized or not. A similar result has been found by Davies & Boratynski (unpublished) in an analysis of male Coccoidea.

2.1.3. <u>Influence of standardization</u>

The R^2 statistic between standardized and unstandardized ordinations for Q-mode analyses based on taxonomic distance was

0.274. On the other hand, the R^2-values between standardized and unstandardized covariance techniques for Q- and R-mode analyses were 0.335 and 0.441; for correlation techniques, the corresponding values were 0.339 and 0.453. It appeared, therefore, that distances were the coefficients most robust to standardization, followed by covariances. On the other hand, the effect of standardization when applied to covariances or to correlations depended on the mode in which the ordination was performed. In fact, both covariances and correlations were more sensitive to standardization in R-type than in Q-type analysis.

Table 10 gives the correlations in the original data between the first three components or coordinates and the overall length for all ordinations. From this table it can be seen that the first axis proved to be associated with size in seven out of the 12 analyses. When a principal coordinate analysis was performed on a taxonomic distance matrix (Ordination 3 vs. 1), standardization of data hardly altered the first coordinate in respect of its high correlation with size. The same applies to a Q-mode principal component analysis performed on a covariance matrix (Ordination 9 vs. 10). On the other hand, a Q-mode principal component analysis performed on a correlation matrix based on unstandardized data yielded a first component not associated with size (11); however, when standardization was performed, the first component showed a large correlation of -0.84 with overall length (12). In R-mode principal component analyses performed either on a covariance or a correlation matrix, standardization had the effect of removing the influence of size, thus resulting in the first principal component of the standardized analyses having a low correlation with overall length (e.g., Ordinations 5 vs. 6 and 7 vs. 8).

Table 10 CORRELATIONS BETWEEN THE FIRST THREE NORMALIZED COMPONENTS/COORDINATES AND OVERALL LENGTH

Method (*)	Principal components/coordinates		
	I	II	III
1	0.97	-0.10	0.16
2	-0.00	-0.33	0.03
3	0.92	-0.14	-0.08
4	-0.00	-0.33	0.03
5	0.90	-0.29	-0.06
6	-0.10	-0.15	0.06
7	0.94	0.13	0.20
8	0.19	-0.26	-0.33
9	0.95	-0.16	0.12
10	0.89	-0.18	-0.02
11	-0.14	-0.11	0.16
12	-0.84	-0.26	-0.29

* For meaning see Table 6.

(h) Ordination of OTU's: Qualitative Data

1. Analyses undertaken

The list summarizing the ordinations carried out with matrix II are shown in Table 11. The abbreviations are as indicated in Section (g).

Four different ordinations were undertaken, that is, two principal component and two principal coordinate analyses. Ten eigenvectors were also extracted and the percentage of variation accounted for by the first five components or coordinates is recorded in Table 12.

In comparison with the results obtained with continuous data, the percentage of variation associated with the latent roots extracted was considerably lower. In all cases the first five eigenvalues taken together accounted for less than 50% of the total variation.

The ordinations were again compared and clustered through the method used with continuous data. The resulting dendrogram showing similarities among these analyses is given in Fig. 64. In comparison with the ordinations involving continuous data, it is interesting to note that all four analyses are here much more similar (i.e., closer to each other). Only UN-DIS-ROW-PCRDA (no. 2) appeared slightly isolated.

The ordination which was in best general accord with the traditional view was analysis ST-ROW-COR-COL-PCA (no. 3), that is a principal component analysis of a matrix of correlations between columns of data standardized by rows. As with the continuous data, an arbitrary cut-off line at about 0.25 of the similarity level was considered for delimitation of groups of close ordinations. Therefore, only two representative ordinations were selected to be discussed in detail, that is, ST-ROW-COR-COL-PCA (no. 3) and UN-DIS-ROW-PCRDA (no. 2).

Table 11 LIST OF ORDINATIONS OF MATRIX II WITH ROTATIONAL FIT STATISTICS (o)

Genitalia, abdominal apodemes and external structures (+)

1. ST-COL-DIS-ROW-PCRDA (0.13)
2.* UN-DIS-ROW-PCRDA (0.28)
3.* ST-ROW-COR-COL-PCA (0.00)
4. UN-COR-COL-PCA (0.09)

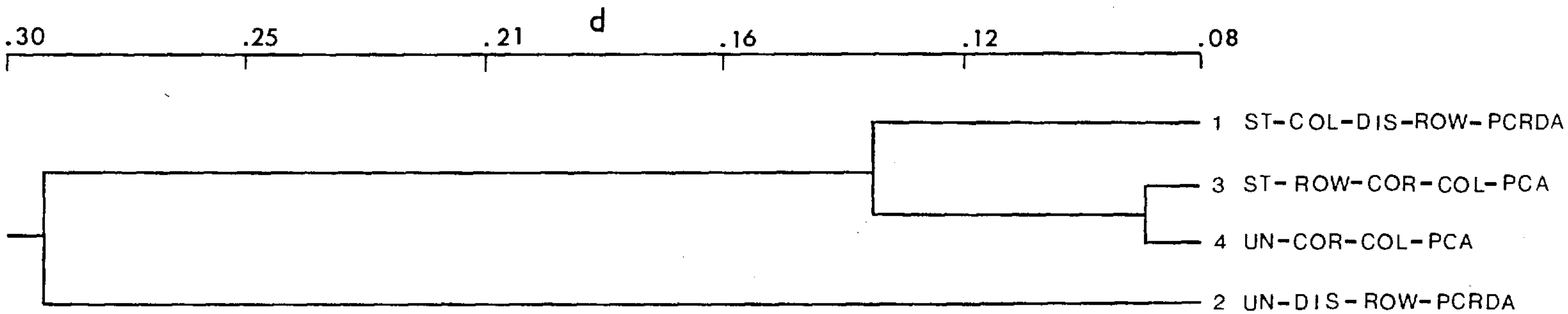
Table 12 PERCENTAGES OF VARIATION ACCOUNTED FOR BY THE FIRST FIVE LATENT ROOTS (EIGENVALUES)

Method	Latent root (eigenvalue)					Cumulative %	
	I	II	III	IV	V	3 axes	5 axes
1	14.81	10.22	7.41	5.84	5.50	32.44	43.78
2	17.04	13.18	7.22	6.34	5.67	37.44	49.45
3	14.57	10.44	7.35	5.84	5.47	32.36	43.67
4	14.91	10.32	7.05	5.89	5.42	32.28	43.59

o In parentheses are given the rotational fit statistics (R^2) based on the first 10 principal components or coordinates between each ordination and the ordination which fitted best the relationships based on traditional views (no. 3). Analyses selected as the best representatives within groups of closely related ordinations (as implied by cluster analysis) are marked with an asterisk.

\+ All variables except the following: 4, 14, 21, 26, 27, 41, 54, 57, 58, 64, 83, 85, 92 and 102.

Fig. 64 - Dendrogram showing relationships of ordinations of matrix II. The number associated with labels corresponds to the sequence of Table 11. This dendrogram is implied by the R^2-values between configurations of OTU's, each representing one ordination and uses the WPGMA clustering method.


d
.30
.25
.21
.16
.12
.08
1 ST-COL-DIS-ROW-PCRDA
3 ST-ROW-COR-COL-PCA
4 UN-COR-COL-PCA
2 UN-DIS-ROW-PCRDA

1.1 UN-DIS-ROW-PCRDA (Ordination 2)

A between-species taxonomic distance matrix based on unstandardized data was subjected to a principal coordinate analysis. This was the poorest of the four ordinations carried out, in spite of it being generally satisfactory.

Only about one third (37.44%) of the variation in the study was explained by the first three axes. The first axis accounted for 17.04% of the variation in the data and was somewhat related with a general size factor. It showed a correlation of -0.63 with the overall length of the insect in the original data. A complete separation of Batracomorphus s.str. and Sudanoiassus was given by the discrimination afforded on the first principal coordinate, which is probably near the orientation of an optimum discriminant function. The second and third axes accounted respectively for 13.18 and 7.22% of the total variation and were both independent of size (having correlations of respectively -0.10 and -0.27 with overall length in the original data). Since this is a principal coordinate analysis computed by orthodox methods, character loadings were not available.

Figs 65-67 are plots of two coordinate axes on which the position of the OTU's were marked. The best separation between Batracomorphus s.str. and Sudanoiassus was afforded either by coordinates I and II or by I and III. When the II and III axes of variation were used, the two subgenera appeared mixed up.

Excluding the plot combining coordinates II and III, this ordination represents a completely satisfactory analysis at the subgeneric level. The placement of several individual species also seemed quite satisfactory. Examples are the following: dalatandoensis (1) and liberiensis carvalhoi (3); dirkoides (9) and gobiswaterensis (16); or mosselensis (26) and subolivaceus (28).

Fig. 65 - A two dimensional view of the relationships among the OTU's of matrix II in a space determined by coordinate I (17.04%) and coordinate II (13.18%) of the first ten axes of a principal coordinate analysis of the matrix of taxonomic distances. Data unstandardized. Coordinates I and II, taken together, account for 30.22% of the total variation.

Names of OTU's as in Table 1. Solid circles are species of Sudanoiassus Lv. & Quart.; small solid rectangles are species of Batracomorphus s.str.; the type-species is marked with a hollow circle.

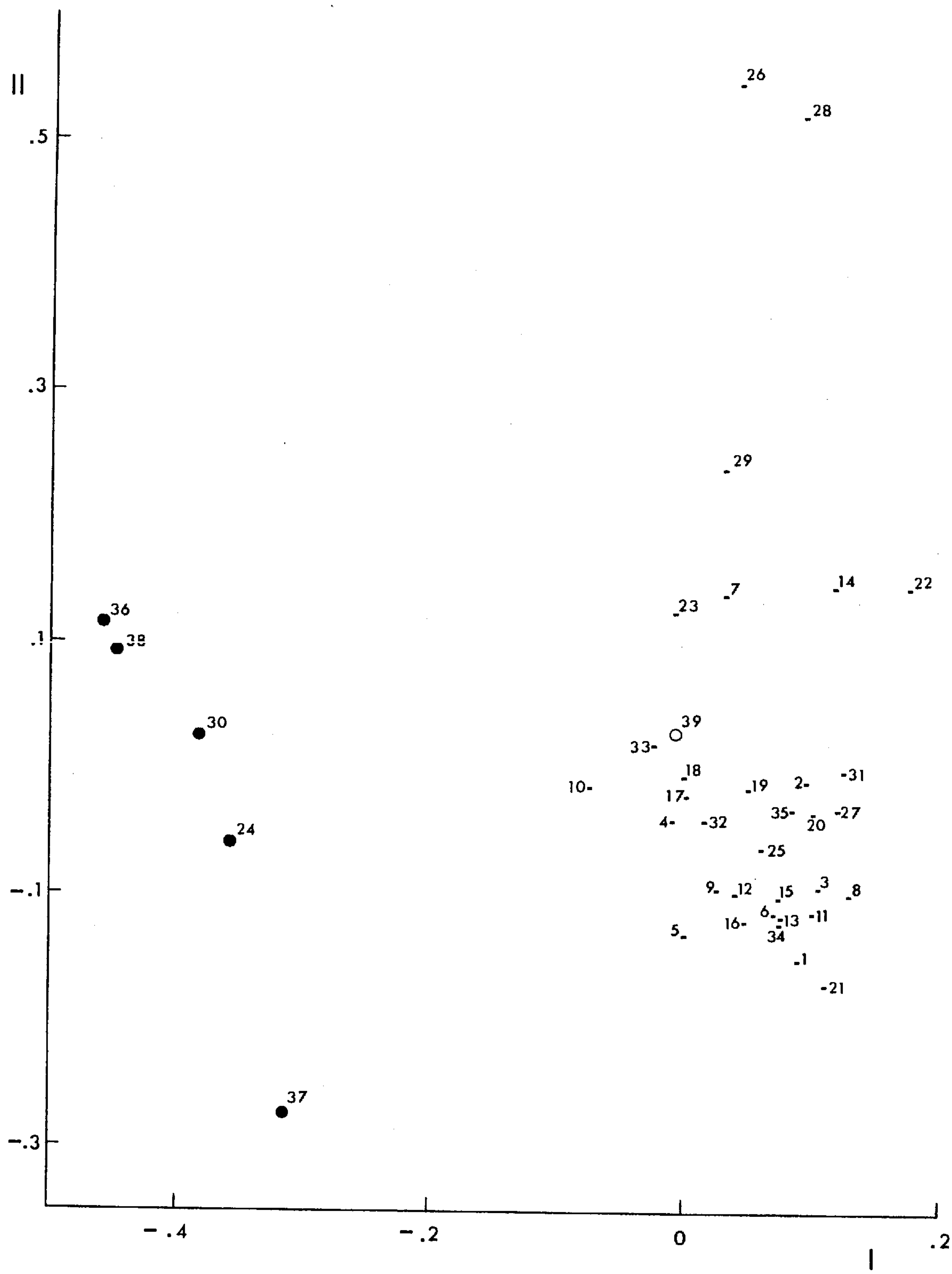

II
.5
.3
.1
-.1
-.3
-.4
-.2
0
.2
I
26
28
29
7
14
22
23
36
38
30
24
37
39
33
18
31
10
19
2
17
4
32
35
20
27
25
9
12
15
3
8
6
13
11
16
34
5
1
21

Fig. 66 - As in Fig. 65 but referred to coordinates I and III (7.22%). These coordinates, taken together, account for 24.26% of the total variation.

Names of OTU's as in Table 1. Solid circles are species of Sudanoiassus Lv. & Quart.; small solid rectangles are species of Batracomorphus s.str.; the type-species is marked with a hollow circle.

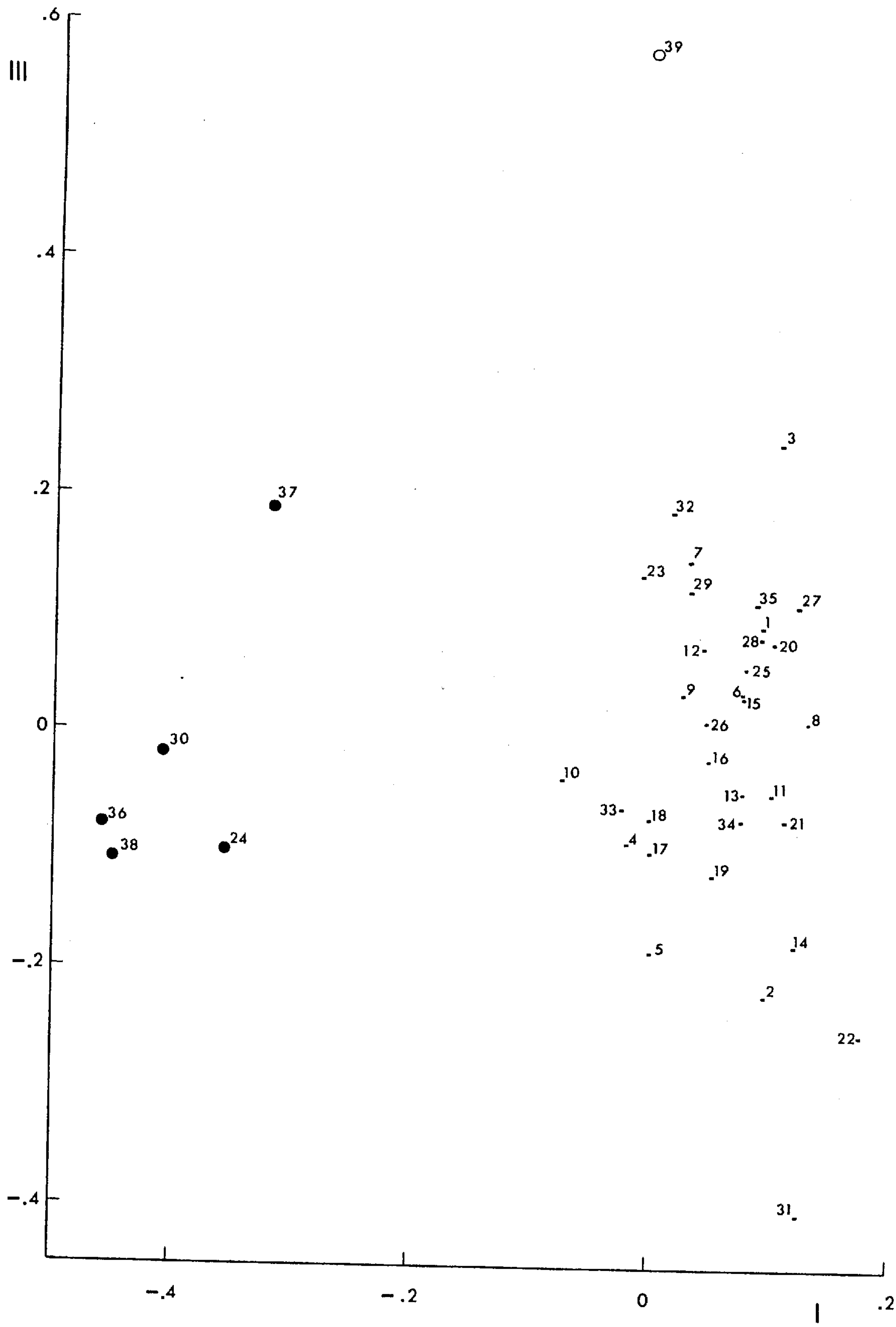
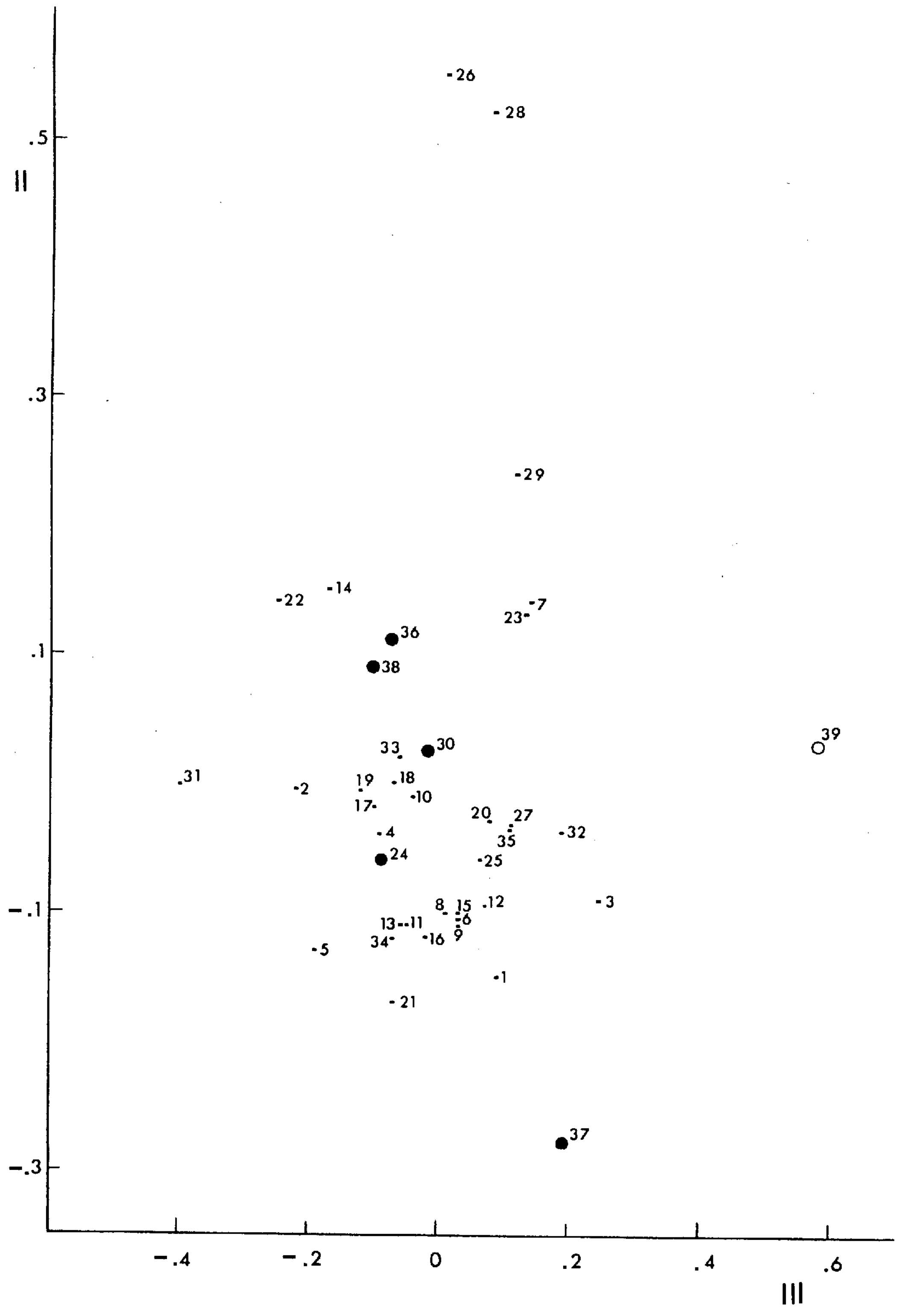

III
.6
.4
.2
0
−.2
−.4
−.4
−.2
0
.2
I
39
3
37
32
7
23
29
35
27
1
28
20
12
25
9
6
15
8
30
26
16
10
11
13
36
33
18
34
21
38
24
4
17
19
14
5
2
22
31

Fig. 67 - As in Fig. 65 but referred to coordinates II and III. These coordinates, taken together, account for 20.40% of the total variation.

Names of OTU's as in Table 1. Solid circles are species of Sudanoiassus Lv. & Quart.; small solid rectangles are species of Batracomorphus s.str.; the type-species is marked with a hollow circle.


.5
.3
.1
-.1
-.3
II
-.4
-.2
0
.2
.4
.6
III
26
28
29
14
22
7
23
36
38
39
33
30
31
2
19
18
10
17
20
27
4
32
35
24
25
8
15
12
3
13
11
6
34
16
9
5
1
21
37

1.2 ST-ROW-COR-COL-PCA (Ordination 3)

A between-character correlation matrix based on data standardized by rows was subjected to a principal component analysis. This was the best ordination out of the four carried out with qualitative data.

As in the previous ordination, only about one third (32.36%) of the variation in the study was explained by the first three axes. The first component accounted for 14.57% of the variation in the correlation matrix and was again partly correlated with size. It showed a correlation of 0.66 with overall length in the original data. A complete separation of Batracomorphus s.str. and Sudanoiassus was also given by the discrimination afforded on this axis. The characters loading most heavily on the first component (*) correspond to those characters that by traditional methods were found to separate Batracomorphus s.str. from Sudanoiassus. In fact, in decreasing order, the highest positive scores were for characters number: 96 (Second sternal abdominal apodemes lobe-shaped or not), 115 (Subapical part of genital plates with long setae along outer margin or not), 110 (Male pygophore with a mid-ventral incision only or with both a mid-ventral and a mid-dorsal incision), 76 (Ventral corner of socle of penis acutely, moderately prominent or not prominent) and 1 (Small, medium-sized or large); the highest negative scores were for characters number: 81 (Apex of stem of penis spoon-shaped or not), 79 (Stem of penis tubular or not), 69 (Apical hook of apophysis of stylus claw-like or not) and 109 (Male pygophore very elongate and low or not). As mentioned in the key and in the descriptions of these two subgenera (Chapter I), the main differentiating characters for Batracomorphus s.str. vs. Sudanoiassus were numbers 96, 115, 81, 79, and to a lesser extent, 1, 110 and 109.

* Complete list of loadings for the various components were not reproduced here to conserve space.

The second principal component accounted for 10.44% of the total variation, and was interpreted as a factor making for dark coloration of face, femora and claval venation. It showed a correlation of only -0.22 with overall length in the original data and was most heavily loaded, in decreasing order, on characters number 6 (Upper part of face infumated or not), 7 (Lower part of face infumated or not), 33 (Scutellar margin of clavus tinged with brown or not), 43 (Fore and middle femora tinged or not with brown), 44 (Hind femora tinged with brown or not), 34 (Commissural margin of clavus tinged with brown apically or subapically, yellowish or greenish) and 32 (Claval suture of elytra tinged with brown or not). The ordination diagrams (Figs. 68b, 69) reflect, in axis II, the position of species with dark or pale face, pale femora and pale claval venation. For instance, either dalatandoensis (1) and liberiensis carvalhoi (3), two unicoloured yellowish forms are at the top of such diagrams as against, e.g., distinctissimus (14), a dark species, which is isolated on the bottom edge of the diagrams.

The third principal component accounted for 7.35% of the total variation and was interpreted as a contrast between scutellar spotting and expansion of the lobes of the first sternal abdominal apodemes, taken together, and the dotting of scutellum as well as dotting and spotting of pronotum, also taken together. It proved to be size-independent (a correlation of 0.10 with overall length in the original data) and was most heavily loaded, in decreasing order, and for positive scores, on characters number: 20 (Scutellar spots absent, two or several); 95 (Lobes of first sternal abdominal apodemes closely apposed, relatively separated or widely separated), and 94 (Lobes of first sternal abdominal apodemes expanded mesad or not); for negative scores, it was mostly heavily loaded on characters number 22 (Scutellum dotted with dark or not), 11 (Base of pronotum

Fig. 68 - a. A two dimensional view of the relationships among the OUT's of matrix II in a space determined by component I (15.57%) and component III (7.35%) of the first ten axes of a principal component analysis of the matrix of correlations among characters. Data standardized. Components I and III, taken together, account for 22.92% of the total variation.

- b. As above but referred to components I and II (10.44%). These components, taken together, account for 26.01% of the total variation.

Names of OTU's as in Table 1. Solid circles are species of Sudanoiassus Lv. & Quart.; small solid rectangles are species of Batracomorphus s.str.; the type-species is marked with a hollow circle.

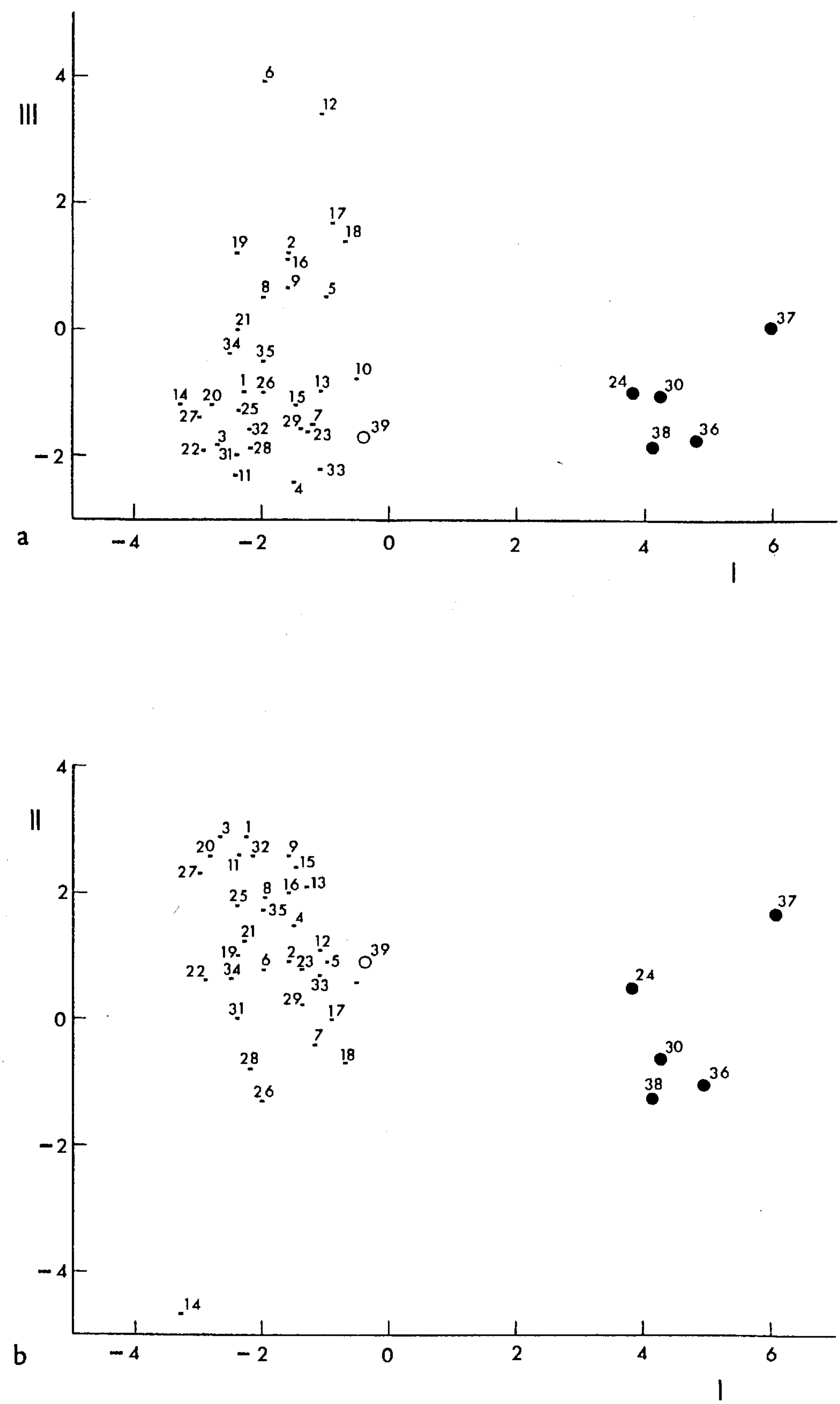
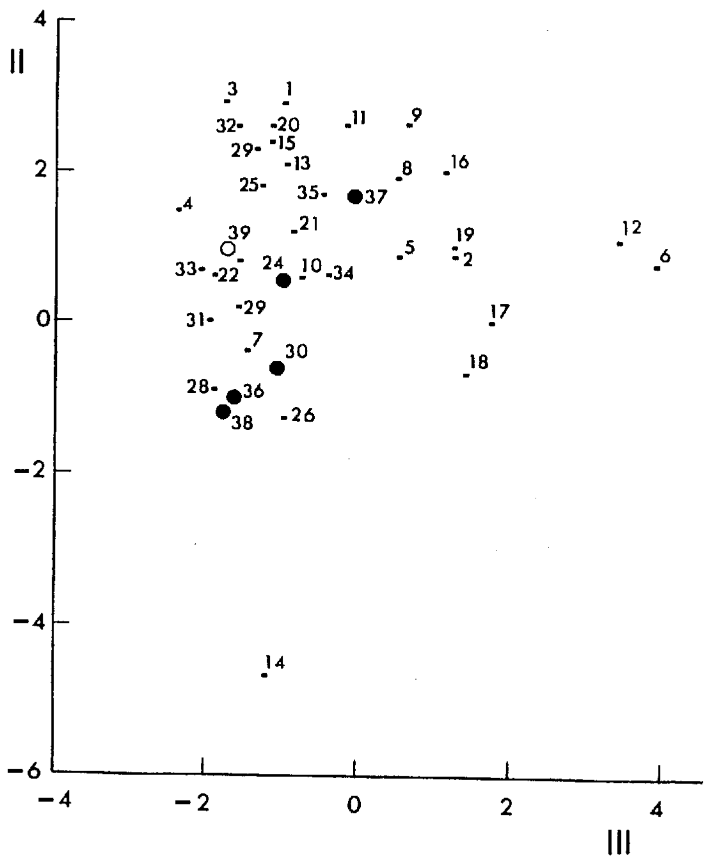

III
I
a
II
I
b

Fig. 69 - As in Fig. 68a but referred to components II and III. These components, taken together, account for 17.79% of the total variation.

Names of OTU's as in Table 1. Solid circles are species of Sudanoiassus Lv. & Quart.; small solid rectangles are species of Batracomorphus s.str.; the type-species is marked with a hollow circle.


II
4
2
0
−2
−4
−6
−4
−2
0
2
4
III
3
1
32
20
11
9
29
15
13
8
16
25
35
37
4
21
39
19
12
24
10
34
5
2
6
33
22
29
17
31
7
30
18
28
36
38
26
14

tinged with brown, dark spotted or immaculate) and 16 (Disk of pronotum dotted with dark or not).

Figs 68-69 are plots of two component axes on which the position of the OTU's were marked. The best separation between Batracomorphus s.str. and Sudanoiassus was afforded either by axes I and II or by axes I and III. The combination of axes II and III gave the species of the subgenera mixed up. In the two first diagrams also satisfactory is the position of the type-species (39), which was clustered with species in the subgenus Batracomorphus s.str. Also satisfactory was the position of several individual species, such as: dalatandoensis (1) and liberiensis carvalhoi (3); dirkoides (9) and gobiswaterensis (16); mosselensis (26) and subolivaceus (28); or kivuensis (36) and magniceps (38).

1.3 Discussion

The results of the ordinations of the Batracomorphus species based on qualitative (two-state and multistate ordered or unordered) characters suggest the following:

(1) This set of four ordinations produced rather similar estimates of phenetic affinity among this group of leafhoppers. There is, indeed, a considerable degree of concordance between these estimates. In general all are in close accord with conventional views of relationships within this genus.

(2) All methods yielded similar and relatively low cumulative percentages of variation (see Table 12). Only a principal coordinate analysis of a taxonomic distance matrix of unstandardized data (no. 2) produced slightly higher values than the other methods. The comments on amount of variation extracted vs. taxonomic importance, produced for continuous data also apply here. These comparatively lower percentages therefore do not imply by any means that the results with qualitative data are less satisfactory than those achieved with

continuous data.

(3) The effectiveness of either distances or correlations seems to depend largely on the data being standardized. In fact, the results of both principal component and principal coordinate analyses were improved by standardization. Nevertheless, correlations appeared to have described slightly better the relationships among these leafhoppers than distances. This is in disagreement with the results provided by cluster analysis with the same data, where distances were considered better than correlations.

(4) Considering the assessment of the relative merit of R-type principal component analysis and principal coordinate analysis, the choice is slightly in favour of the former on grounds of performance alone. Another real advantage is that the normal method of computing R-type PCA provides the weighting coefficients from which the principal components are later computed. These coefficients may have a special interest since the characters that afford a better discrimination between any two OTU's or groups of OTU's along a certain component are those with high loadings on such a component. A point of great interest was the finding that in the R-type principal component analysis based on standardized data, the coefficients most heavily loading on the first component generally corresponded to the characters that had previously been shown by traditional methods to be best in separating Batracomorphus s.str. from Sudanoiassus. As pointed out by Moss et al. (1977) this may seem to imply "that traditional taxonomists think in terms of principal component analyses".

(5) As stated before, the standardization improved both principal component and coordinate analyses, and especially the latter. This is in complete accord with the cluster analyses involving the same data and the same similarity coefficients.

2. Classification of classifications

The dendrogram summarising the similarities between the four ordinations is shown in Fig. 64. This dendrogram shows the different methods divided into two groups: (a) a single ordination, a principal coordinate analysis based on a taxonomic distance matrix with data unstandardized; (b) two R-type principal component analyses based on correlations with data unstandardized and with data standardized by rows and a principal coordinate analysis based on a taxonomic distance matrix with data standardized by columns. Within the latter group, it is clear that the two analyses based on correlations are nearly identical, showing that the R-type principal component analysis is very little affected by standardization.

2.1 Influence of standardization

The R^2 statistic between standardized and unstandardized ordinations of principal coordinate analyses was 0.29; for R-type principal components based on correlations, the corresponding value was 0.09. It appeared, therefore, that distances were more sensitive to the effects of standardization than correlations.

The R^2-values between the principal coordinate analysis based on unstandardized data (no. 2) and either R-type principal component analysis based on unstandardized (no. 4) or on standardized data (no. 3) were, respectively, 0.27 and 0.28. The corresponding values for the principal coordinate analysis based on standardized data (no. 1) were 0.14 and 0.13. Therefore, standardization resulted in principal coordinate analysis resembling more closely an R-type principal component analysis.

Table 13 gives the correlations in the original data between the first three principal components or coordinates and the overall length for all set of ordinations. From this table it can be seen that the first axis proved to be moderately associated with size

Table 13 CORRELATIONS BETWEEN THE FIRST THREE NORMALIZED COMPONENTS/COORDINATES AND OVERALL LENGTH

Method (*)	Principal components/coordinates		
	I	II	III
1	-0.65	0.04	0.11
2	-0.63	-0.10	-0.27
3	0.66	-0.22	0.10
4	0.64	0.18	-0.01

* For meaning see Table 11.

in all analyses irrespective of whether the data were standardized or not. Contrary to what happened with continuous data, standardization had no appreciable effect in respect of size when applied to R-mode principal component analysis based on correlations (Ordination 3 vs. 4).

(i) Ordination of OTU's: General Conclusions

The following is a summary of the main conclusions drawn from a total of sixteen ordinations carried out either with a group of 23 measurement continuous variables or a set of 116 qualitative, coded characters.

(1) Different ordinations based on different sets of characters produced different estimates of phenetic structure. Nevertheless, practically all estimates agreed in their broader aspects, e.g., a separation of *Batracomorphus* into two subgenera. A major difference between the continuous and the qualitative data analyses was, however, that in the latter the resulting ordinations were relatively closer to each other. This is probably a direct effect of the higher number of characters present in this latter group of analyses, a result which therefore offers some support for the matches asymptote hypothesis (Sokal & Sneath, 1963).

(2) Qualitative data produced, in general, a better separation between *Batracomorphus* s.str. and *Sudanoiassus* than continuous data. Concerning lower taxonomic levels, such as the associations of closely related species, both types of data yielded equally satisfactory results. Examples are the R-mode principal component analyses of correlation matrices based on unstandardized data and on data standardized by rows, respectively, for continuous and qualitative data.

(3) Ordinations based on continuous data yielded, in general, much higher percentages of the total variance explained by the first component than those based on qualitative data, where the latent roots decreased very slowly (cf. Table 7 and 12). This must simply be a reflection of the high correlations between the continuous variables as opposed to the qualitative data where some near-random variation was probably present.

(4) For continuous data, taxonomic distances were the best measures in Q-mode analysis with data standardized by columns; with unstandardized data, either distances or covariances seemed equally effective; in R-mode analysis, with either unstandardized data or data standardized by rows, both covariances and correlations gave equally effective results, the balance being slightly in favour of correlations. On the other hand, for qualitative data, either taxonomic distances or correlations in either a principal coordinate analysis or in a R-mode principal component analysis, both based on standardized data, produced equally effective results; the balance was again slightly in favour of correlations.

(5) On grounds of performance alone, and for either continuous data or qualitative data, R-mode analyses appeared to have provided slightly better results than Q-mode analysis. Another real advantage of R-type analysis was that it enabled one to select the characters that discriminate better between *Batracomorphus* s.str. and *Sudanoiassus*. On the whole, and for both types of data, R-mode principal component analysis based on correlations was the best method.

(6) For continuous data, standardization worsened the results of R-type analyses based on covariance and correlation matrices and, to a lesser extent, Q-type analyses of covariances; principal coordinate analysis of taxonomic distances was not affected. On the other hand, for qualitative data, standardization improved both Q-mode and R-mode analyses and especially a principal coordinate analysis based on taxonomic distances. The reason for these results must be at least two-fold: (i) *Sudanoiassus* and *Batracomorphus* s.str. differ significantly in overall size; and (ii) in contrast to the analyses performed with qualitative data, the first component in the ordinations involving continuous data was usually highly correlated with size. Therefore, whenever the size factor present on the first component was removed

by standardization, the discriminatory power in respect of *Batracomorphus* vs. *Sudanoiassus* was considerably lowered.

(7) The following pairs of methods appeared to be nearly identical. For continuous data: (i) a principal coordinate analysis of taxonomic distances and a Q-mode principal component analysis of covariances both with data standardized by characters; (ii) two R-mode principal component analyses with data standardized by species and based respectively on covariances and correlations; and (iii) two R-mode principal component analyses of covariances and correlations both based on unstandardized data. On the other hand, for qualitative data, two R-mode principal component analyses of correlations, respectively with data unstandardized and with data standardized by species, also proved to be near identical.

(j) General Discussion and Conclusions

The following are the main conclusions reached from a set of different numerical methods applied to the clustering of variables and of taxa, that is thirty nine different clustering analyses and eighteen ordinations. Details should be looked for in "General Discussion" for "Assessment of Character Associations" [Section (c)] as well as in "General Conclusions" either for "Cluster analysis of OTU's" or for "Ordination of OTU's" (Sections (f) and (i), respectively).

The purpose of applying a battery of numerical methods to the taxonomy of a group of Ethiopian species of genus Batracomorphus was, as stated in the "General Introduction", four-fold: first, to test if the placement of species into subgenera by numerical methods matched the author's impressions of subgeneric entities obtained by traditional approaches; second, to determine the relative taxonomic importance of the male genital and abdominal apodemal characters; third, to assess the different resulting classifications produced by different numerical modifications; and fourth, to apply the best selected method (that is, the one in closest agreement with traditional views) in order to reach a satisfactory phenetic classification of all Ethiopian species and subspecies of the genus Batracomorphus.

On the whole the analyses carried out, which were based on different suites of characters and on different numerical methods, supported the traditional views on the classification of this genus.

The results achieved here with qualitative data have shown that the classifications more closely resembling conventional ideas of relationships were based either on the male genitalia and abdominal apodemes, or on all available characters, or classifications where invariant characters within species were weighted. On the other hand, non-congruence was found between the classifications derived from external structural characters only and the classifications based on the male genitalia and the abdominal apodemes. Such discordance should not be seen as an inconsistency between classifications but merely as expressions of different components of the phenetic affinity of this group of leafhoppers. Loosely speaking, if one wishes to use similarity mainly due to convergence in Batracomorphus, then external structural characters should be used. Such classifications would mainly represent measures of homoplastic similarity (Simpson, 1961). On the other hand, if one seeks classifications mostly based on patristic similarity (Cain & Harrison, 1960), genitalia and abdominal apodemes alone should be used.

In general, qualitative data produced more effective phenetic classifications (i.e., ones nearer conventional views) than did continuous data. As the former included many more characters this may well be a direct effect of the number of characters, a result which therefore offers some support for the matches asymptote hypothesis of Sokal & Sneath (1963).

The most effective similarity coefficients in cluster analysis, both for continuous and qualitative data, appeared to be Gower's coefficient and taxonomic distances. On the other hand, for ordinations, the most effective measure was the product-moment correlation coefficient.

Standardization of characters to zero mean and unit variance generally improved the clustering methods. In the ordinations, the effect of standardization (by characters or by species, according to whether a Q-mode or a R-mode analysis was undertaken) seemed to depend on the types of characters: the analyses involving continuous data were in general worsened, whereas in the analyses carried out with qualitative data an improvement was achieved through standardization.

The following phenetic classifications are in best general accord with traditional views and, as referred to before, are based on qualitative, coded data: (a) for cluster analysis, a phenogram computed from a distance matrix with standardized data and clustered by WPGMA (weighted-pair group method with arithmetic averaging); and (b) for ordinations, a R-mode principal component analysis based on correlations with data standardized by species. These two general methods are seen as complementary and if one is faced with the choice between the two, a number of problems may be raised, since no general criterion of merit seems to be available. Principal component analysis allows the relationships of the OTU's to be viewed in a two or three-dimensional space with relatively little loss of information, and the characters influencing the separation of the OTU's along each axis can be determined in R-mode analyses from the eigenvector elements. This has been the preferred approach of several recent studies, where the advantages of this procedure over hierarchical clustering methods have been emphasized (Rohlf, 1968; Boratynski & Davies, 1971; Moss et al., 1977). However, ordination has also its drawbacks since it can distort close-relative relationships (Rohlf, 1972; Cavalli-Sforza & Piazza, 1975) and, especially with large taxa, the resulting diagrams are either difficult to comprehend or open to visual misinterpretations (Moss et al., 1977). On the other hand, cluster analysis depicts the relationships of the OTU's within clusters in a one-dimensional space with reasonable accuracy and clarity but, unlike ordinations, may distort the relationships between clusters by imposing an artificial taxonomic structure according to the specifications of the clustering algorithm (generally hierarchical) (Moss, 1967; Rohlf, 1967; Ivimey-Cook, 1969a,b; Sneath & Sokal, 1973; Moss et al., 1977). On account of the distortion-prone character of the phenogram, there has been a recent shift from such clustering techniques to the ordination methods. In view of the facts outlined above, the simultaneous use of the two techniques appears as the best approach, since it would enable us to extract and present as much information as it is possible from the original data. The present study supports this view, both for the assessment of covariation among characters and for the clustering of species. However, if one is faced with a large taxon, principal component analysis can lead to results that are difficult to interpret visually. In such circumstances, therefore, and on grounds of clarity alone, the phenogram rather than the ordination would be the method of choice. This decision was taken here when a phenetic diagram for all Ethiopian species of this genus was presented (Chapter III).

III. PHENETIC CLASSIFICATION OF THE ETHIOPIAN SPECIES OF BATRACOMORPHUS LEWIS

(a) Introduction

Taking into consideration the facts outlined in the "General Discussion and Conclusions" (Section (j), Chapter II) and the conclusions drawn from the cluster analyses carried out with the qualitative data (Section (e), Chapter II), i.e., (a) the most effective similarity coefficients were either the taxonomic distance or the Gower's coefficient, and (b) the best suites of characters were firstly the genitalia combined with the abdominal apodemes, and secondly all available characters (external structures, genitalia and abdominal apodemes), a cluster analysis was performed involving all the species and subspecies of Batracomorphus known for the Ethiopian area.

This was done using all available characters (*), that is the first 90 of Table 3 (+) and comprising both the external structures and the genital characters for all species and subspecies of Batracomorphus treated in Linnavuori & Quartau (1975) together with the new forms described in Chapter I. Both the taxonomic distance with standardized data and Gower's coefficient were used with WPGMA as the clustering method. Of these two similarity coefficients, the latter yielded slightly better results hence such an analysis was chosen to be presented here as the "best" phenetic classification.

* The analysis which fitted best the relationships based on conventional views for the sample of species studied in Chapter I was no. 9 (distances based on standardized data from the male genitalia and from the abdominal apodemes). It has, however, no counterpart in the analyses involving all Ethiopian species since (a) there are two species based on females only (punctatissimus (Mel.) and leontion Lv. & Quart.) and (b) the abdominal apodemes were treated de novo in the present study and were therefore unknwon before this.

\+ On account of redundancy, variables number 4 and 44 were omitted.

This phenogram, comprising 127 OTU's (121 species and 6 subspecies) and based on 88 characters is depicted in Fig. 70 and can be summarized as follows.

(b) Results

The isolation of B. (s.str.) distinctissimus (117) is not consistent with the author's view and is again interpreted as it was elsewhere (Section (e) Chapter II) as a result of the over-emphasis given by Gower's coefficient to its conspicuous dark colouring pattern. Except for this misplacement, the general picture given by the phenogram seems to be quite satisfactory.

1. Subgenera

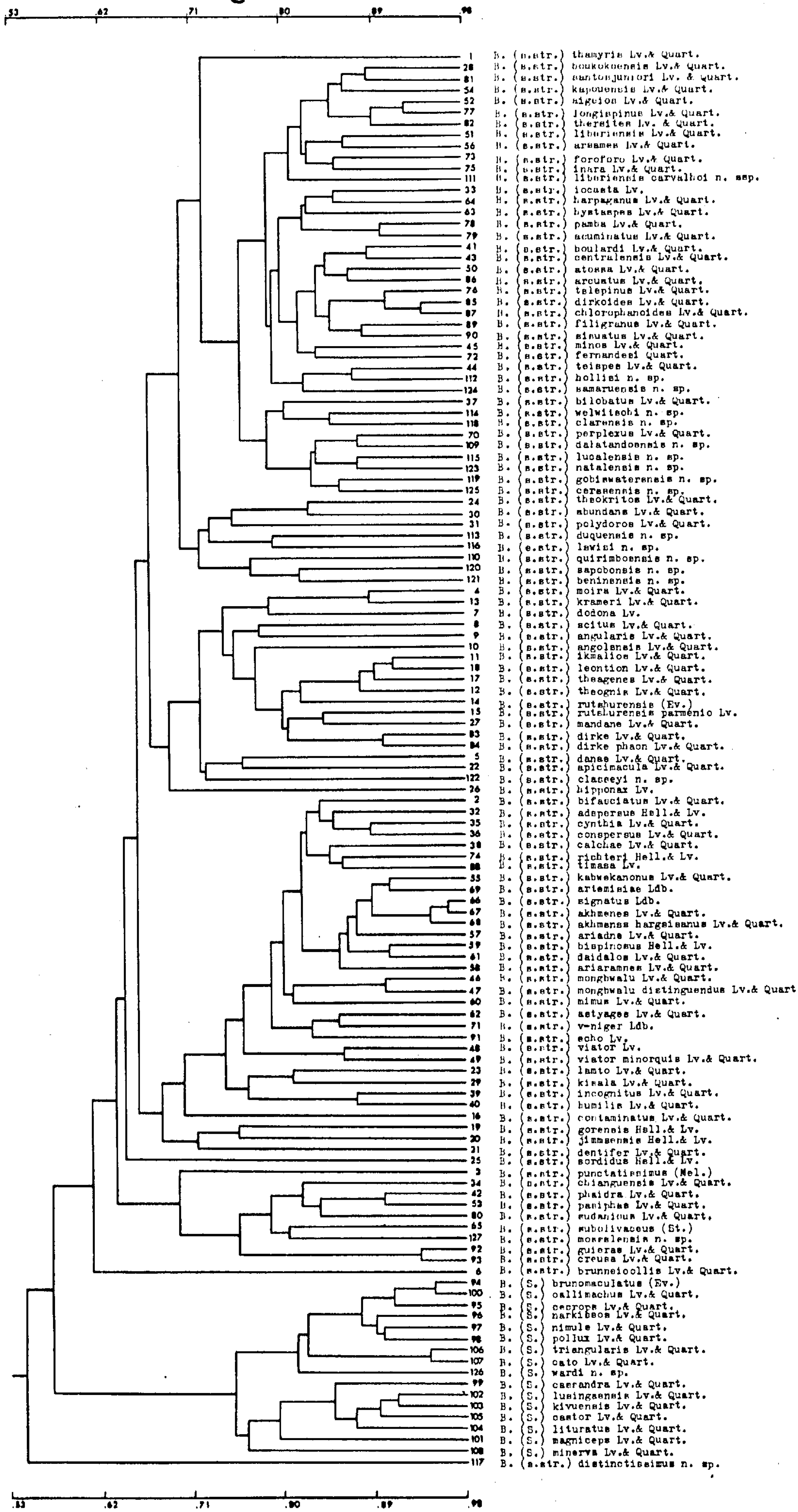
There are two main branches in the phenogram, which correspond to the two recognized subgenera of Batracomorphus in the Ethiopian area: (a) species thamyris (1) to brunneicollis (6), which form Batracomorphus s.str. and (b) brunomaculatus (94) to minerva (108), which form the subgenus Sudanoiassus Lv. & Quart. It is therefore possible to draw a straight line across the phenogram, which will give the subgenera recognised at present, at any value between the 0.57 and 0.61 phenon lines.

2. Species groups within Batracomorphus s.str.

The isolation of brunneicollis (6) is quite understandable because of the unique colour pattern of the elytra. Of the remaining species there are two groups, the species thamyris (1) to sordidus (25), forming by far the major cluster, and punctatissimus (3) to creusa (93), forming a smaller cluster. The relatively isolated position of punctatissimus (3) due to its dark colouring pattern and to the elytra with coarse dark brown puncturing is consistent with the traditional view, the same holding for the clustering of pairs of closely related species such as, phaidra (42) and pasiphae (53), subolivaceus (65) and mosselensis (127), or guierae (92) and creusa (93). However, kabwekanonus

Fig. 70. Phenetic classification of the Ethiopian species of *Batracomorphus* Lewis: Gower's coefficient phenogram of 127 OTU's based on the weighted pair-group method of cluster analysis using arithmetic averages for 88 variables (Matrix III).

G


.53
.62
.71
.80
.89
.98
1 B. (s.str.) thamyris Lv.& Quart.
28 B. (s.str.) boukokoensis Lv.& Quart.
81 B. (s.str.) santosjuniori Lv. & Quart.
54 B. (s.str.) kapouensis Lv.& Quart.
52 B. (s.str.) sigeion Lv.& Quart.
77 B. (s.str.) longispinus Lv.& Quart.
82 B. (s.str.) thersites Lv. & Quart.
51 B. (s.str.) liberiensis Lv.& Quart.
56 B. (s.str.) arsames Lv.& Quart.
73 B. (s.str.) foroforo Lv.& Quart.
75 B. (s.str.) inara Lv.& Quart.
111 B. (s.str.) liberiensis carvalhoi n. ssp.
33 B. (s.str.) iocasta Lv.
64 B. (s.str.) harpaganus Lv.& Quart.
63 B. (s.str.) hystaspes Lv.& Quart.
78 B. (s.str.) pamba Lv.& Quart.
79 B. (s.str.) acuminatus Lv.& Quart.
41 B. (s.str.) boulardi Lv.& Quart.
43 B. (s.str.) centralensis Lv.& Quart.
50 B. (s.str.) atossa Lv.& Quart.
86 B. (s.str.) arcuatus Lv.& Quart.
76 B. (s.str.) telepinus Lv.& Quart.
85 B. (s.str.) dirkoides Lv.& Quart.
87 B. (s.str.) chlorophanoides Lv.& Quart.
89 B. (s.str.) filigranus Lv.& Quart.
90 B. (s.str.) sinuatus Lv.& Quart.
45 B. (s.str.) minos Lv.& Quart.
72 B. (s.str.) fernandesi Quart.
44 B. (s.str.) teispes Lv.& Quart.
112 B. (s.str.) hollisi n. sp.
124 B. (s.str.) samaruensis n. sp.
37 B. (s.str.) bilobatus Lv.& Quart.
114 B. (s.str.) welwitschi n. sp.
118 B. (s.str.) clarensis n. sp.
70 B. (s.str.) perplexus Lv.& Quart.
109 B. (s.str.) dalatandoensis n. sp.
115 B. (s.str.) lucalensis n. sp.
123 B. (s.str.) natalensis n. sp.
119 B. (s.str.) gobiswaterensis n. sp.
125 B. (s.str.) cerasensis n. sp.
24 B. (s.str.) theokritos Lv.& Quart.
30 B. (s.str.) abundans Lv.& Quart.
31 B. (s.str.) polydoros Lv.& Quart.
113 B. (s.str.) duquensis n. sp.
116 B. (s.str.) lewisi n. sp.
110 B. (s.str.) quirimboensis n. sp.
120 B. (s.str.) sapobonsis n. sp.
121 B. (s.str.) beninensis n. sp.
4 B. (s.str.) moira Lv.& Quart.
13 B. (s.str.) krameri Lv.& Quart.
7 B. (s.str.) dodona Lv.
8 B. (s.str.) scitus Lv.& Quart.
9 B. (s.str.) angularis Lv.& Quart.
10 B. (s.str.) angolensis Lv.& Quart.
11 B. (s.str.) ikmalios Lv.& Quart.
18 B. (s.str.) leontion Lv.& Quart.
17 B. (s.str.) theagenes Lv.& Quart.
12 B. (s.str.) theognis Lv.& Quart.
14 B. (s.str.) rutshurensis (Ev.)
15 B. (s.str.) rutshurensis parmenio Lv.
27 B. (s.str.) mandane Lv.& Quart.
83 B. (s.str.) dirke Lv.& Quart.
84 B. (s.str.) dirke phaon Lv.& Quart.
5 B. (s.str.) danae Lv.& Quart.
22 B. (s.str.) apicimacula Lv.& Quart.
122 B. (s.str.) classeyi n. sp.
26 B. (s.str.) hipponax Lv.
2 B. (s.str.) bifasciatus Lv.& Quart.
32 B. (s.str.) adspersus Hell.& Lv.
35 B. (s.str.) cynthia Lv.& Quart.
36 B. (s.str.) conspersus Lv.& Quart.
38 B. (s.str.) calchae Lv.& Quart.
74 B. (s.str.) richteri Hell.& Lv.
88 B. (s.str.) timasa Lv.
55 B. (s.str.) kabwekanonus Lv.& Quart.
69 B. (s.str.) artemisiae Ldb.
66 B. (s.str.) signatus Ldb.
67 B. (s.str.) akhmenes Lv.& Quart.
68 B. (s.str.) akhmenes hargeisanus Lv.& Quart.
57 B. (s.str.) ariadne Lv.& Quart.
59 B. (s.str.) bispinosus Hell.& Lv.
61 B. (s.str.) daidalos Lv.& Quart.
58 B. (s.str.) ariaramnes Lv.& Quart.
46 B. (s.str.) monghwalu Lv.& Quart.
47 B. (s.str.) monghwalu distinguendus Lv.& Quart.
60 B. (s.str.) mimus Lv.& Quart.
62 B. (s.str.) astyages Lv.& Quart.
71 B. (s.str.) v-niger Ldb.
91 B. (s.str.) echo Lv.
48 B. (s.str.) viator Lv.
49 B. (s.str.) viator minorquis Lv.& Quart.
23 B. (s.str.) lamto Lv.& Quart.
29 B. (s.str.) kisala Lv.& Quart.
39 B. (s.str.) incognitus Lv.& Quart.
40 B. (s.str.) humilis Lv.& Quart.
16 B. (s.str.) contaminatus Lv.& Quart.
19 B. (s.str.) gorensis Hell.& Lv.
20 B. (s.str.) jimmaensis Hell.& Lv.
21 B. (s.str.) dentifer Lv.& Quart.
25 B. (s.str.) sordidus Hell.& Lv.
3 B. (s.str.) punctatissimus (Mel.)
34 B. (s.str.) chianguensis Lv.& Quart.
42 B. (s.str.) phaidra Lv.& Quart.
53 B. (s.str.) pasiphae Lv.& Quart.
80 B. (s.str.) sudanicus Lv.& Quart.
65 B. (s.str.) subolivaceus (St.)
127 B. (s.str.) mossalensis n. sp.
92 B. (s.str.) guierae Lv.& Quart.
93 B. (s.str.) creusa Lv.& Quart.
6 B. (s.str.) brunneicollis Lv.& Quart.
94 B. (S.) brunomaculatus (Ev.)
100 B. (S.) callimachus Lv.& Quart.
95 B. (S.) cecrops Lv.& Quart.
96 B. (S.) narkissos Lv.& Quart.
97 B. (S.) nimule Lv.& Quart.
98 B. (S.) pollux Lv.& Quart.
106 B. (S.) triangularis Lv.& Quart.
107 B. (S.) cato Lv.& Quart.
126 B. (S.) wardi n. sp.
99 B. (S.) cassandra Lv.& Quart.
102 B. (S.) lusingaensis Lv.& Quart.
103 B. (S.) kivuensis Lv.& Quart.
105 B. (S.) castor Lv.& Quart.
104 B. (S.) lituratus Lv.& Quart.
101 B. (S.) magniceps Lv.& Quart.
108 B. (S.) minerva Lv.& Quart.
117 B. (s.str.) distinctissimus n. sp.

(55), which is closely related to pasiphae (53), did not cluster with it.

In the remaining major cluster, sordidus (25) is also quite isolated due again to the peculiarities of its dark colouring pattern especially in the crown, ocellocular area and upper margin of frontoclypeus. Of the other species a straight line drawn at about the 0.65 phenon level appears to give the following two large groupings of species: thamyris (1) to hipponax (26) and bifasciatus (2) to dentifer (21). Among this latter the following pairs or groups of species seem to be consistent with the orthodox view: cynthia (35) and conspersus (36); artemisiae (69), signatus (66), akhmenes (67), a. hargeisanus (68), aridne (57), bispinosus (59), daidalos (61) and ariaramnes (58); mongbwalu (46) and m. distinguendus (47); viator (48) and v. minorquis (49); incognitus (39) and humilis (40); and to a lesser extent gorensis (19) and jimmaensis (20). However v-niger (71) seems to be slighly misplaced since it belongs undoubtedly to the signatus (66) group.

The cluster comprising thamyris (1) to hipponax (26) can be divided into the two following groups by a straight line at for instance the 0.67 phenon level: one group is made up of species thamyris (1) to beninensis (121) and a second comprises species moira (4) to hipponax (26). Of this latter cluster, the following pairs or groups of related species conform with the traditional view: moira (4) and krameri (13); ikmalios (11), leontion (18), though its male genitalia is unknown, theagenes (17) and theognis (12); dirke (83) and d. phaon (84). However, rutshurensis (14) and its subspecies r. parmenio (15) appear to be slightly misplaced.

The cluster comprising thamyris (1) to beninensis (121) is made up again of two sub-clusters: one including thamyris (1) to ceresensis (125) and the second including theokritos (24) to beninensis

(121). This latter sub-cluster grouped species which seem not to be particularly related in a classical view such as quirimboensis (110), sapobensis (120) and beninensis (121), though, on the other hand, it linked theokritos (24) with abundans (30) which seem to be somewhat related.

The cluster from thamyris (1) to ceresensis (125) placed the former species into an isolated position on account of its distinctive general appearance (resembling Iassomorphus cederanus in colouring) and includes the two following groups: species boukokoensis (28) to samaruensis (124) and bilobatus (37) to ceresensis (125). Among this latter the pair welwitschi (114) and clarensis (118) is a satisfactory clustering but the same does not apply to the pairs perplexus (70) in relation to dalatandoensis (109) or gobiswaterensis (119) to ceresensis (125).

Finally, the group of boukokoensis (28) to samaruensis (124) is again made up of two branches, that is species boukokoensis (28) to liberiensis carvalhoi (111) and iocasta (33) to samaruensis (124). The former branch comprises pairs of species which seem to have clustered quite satisfactorily, such as longispinus (77) and thersites (82) but, on the other hand, it did not cluster forms which are undoubtedly closely related, such as liberiensis (51) and l.carvalhoi (111). Among the remaining branch there are pairs of species which seem to be related in a conventional view such as: pamba (78) and acuminatus (79), boulardi (41) and centralensis (43), or dirkoides (85) and chlorophanoides (87) though such pairs or groups of species as filigranus (89) and sinuatus (90), or teispes (44), hollisi (112) and samaruensis (124) seem to be artificial.

3. Species groups within Sudanoiassus Lv. & Quart.

This subgenus consists of two branches, one comprising species brunomaculatus (94) to wardi (126) and a second one with species cassandra (99) to minerva (108). The former quite rightly placed wardi (126) in an isolated position and clustered together brunomaculatus (94), callimachus (100), and cecrops (95) which seem by traditional views to form a group of closely related species. Among the second branch, lusingaensis (102), kivuensis (103) and lituratus (104) clustered according to orthodox views. An example of a doubtful placement is the position of the pair triangularis (106)/cato(107) within the former major group.

(c) Conclusions

As stated in Section (j), (Chapter II) phenogrmas tend to impose a clearly hierarchical structure even where there is a continuum of variation rather than clear-cut discontinuities.

Furthermore, Batracomorphus is a large genus particularly difficult to interpret. Some groups shown on the phenogram are easily confirmed by conventional views, whilst others do not seem particularly close structurally.

Moreover, the species with conspicuous dark markings were, in some instances, too strongly isolated, as if the analysis had produced centrifugal shifts of the more unusual species. The apparent reason for this seems to have been that the coding for darker colours corresponds to higher states and that Gower's coefficient tends to give emphasis to the size component of the phenetic affinity.

On the whole, however, the phenogram summarized quite satisfactorily the phenetic relationships between these species, confirmed the subgenera recognized by traditional methods, and permitted a better insight into the inter-species relationships than would otherwise have been possible.

IV. BIOLOGY AND ECONOMIC IMPORTANCE

(a) Food plants

Although very little is known about the biology of the species of Batracomorphus, there are a few references in the literature to several plants on which these insects have been taken. The plants on which specimens have been recorded, together with the country and author are listed in Table 14 for the African region. There is, therefore, some evidence that in Africa Batracomorphus is essentially an arboreal group, tending to be associated with leguminous trees and shrubs.

(b) Habitat and species diversity

Species have been found in a diversity of habitats ranging from arid areas to moist forests, from sea-side to montane areas, in several types of savanna, etc. This information is, however, very scanty and most records consist only of brief notes about where the material was collected.

Only 40 out of the 108 species and subspecies described in Linnavuori & Quartau (1975) have some ecological information recorded. It is interesting to note that 15 of these were collected in rain and gallery forests (including undergrowth of the same), that 15 were taken in several types of savanna, 6 in arid areas, 3 in combinations of previous types and 1 in a forest at high altitude. On the other hand, in the sample of the 37 Ethiopian species and subspecies described in Chapter I the numbers of species collected on different vegetation types are as follows:

Moist tropical forest - 23

Woodlands, savannas and steppes - 10

Temperate forests and Mediterranean types - 1

Grasslands - 1

Variable - 2

Table 14 LIST OF PLANTS ON WHICH AFRICAN SPECIES OF BATRACOMORPHUS HAVE BEEN COLLECTED

Species of Batracomorphus	Plant Family	Plant	Country	Author
akhmenes hargeisanus	Leguminosae	Acacia	Somalia	Linnavuori & Quartau (1975)
ariaramnes	Leguminosae	Acacia	Sudan	Linnavuori & Quartau (1975)
artemisiae	Compositae	Artemisia gorgonum	Cape Verde Islands	Lindberg (1958)
astyages	Combretaceae	Terminalia catappa	Angola	Linnavuori & Quartau (1975)
	Anacardiaceae	Anacardium occidentale	Angola	Linnavuori & Quartau (1975)
guierae	Combretaceae	Guiera senegalensis	Sudan	Linnavuori & Quartau (1975)
santosjuniori	Combretaceae	Terminalia catappa	Angola	Linnavuori & Quartau (1975)
signatus	Leguminosae	Acacia	Egypt	Lindberg (1923b)
	Leguminosae	Acacia Farnesiana	Cape Verde Islands	Lindberg (1958)
villiersi	Leguminosae	Acacia raddiana	Tunisia	Linnavuori (1971)
v-niger	Leguminosae	Acacia	Egypt, Sudan, Eritrea, Somalia	Linnavuori & Quartau (1975)

The highest numbers are again for the tropical forests and for the savannas, there being some evidence that the former vegetation type is the richest in species of Batracomorphus. Taking into consideration the vegetation map of Africa this seems to conform with what appears to be a general rule, that for most groups of organisms there is a gradient of decreasing species diversity from the equator to high latitudes (see, e.g., Owen, 1976). Fischer (1960) also gives many examples of this tendency and few groups seem to fail to increase in diversity in the tropical areas.

The diversity of Batracomorphus in Africa therefore appears to be associated with plant diversity, which is not of course uniform in this continent. Highlands and dry areas generally have fewer species than low, wet regions. Holdridge (1967) has shown that in tropical areas tree diversity decreases with altitude or lowered temperature and reduced rainfall. In the moist tropical forest of Africa, where the majority of species of Batracomorphus seem to have been taken, more than 2,000 trees species occur (Vos, 1975). If we consider that the known number of species and subspecies of Batracomorphus is 127, and that this must be hardly more than half of the total for the African continent alone, with the majority of species apparently occurring in the Guinean zone, then there is no doubt that this group of leafhoppers had an extraordinary evolutionary success in tropical Africa. Such success must depend on several factors, such as: (i) their small size, which enabled to fill the smaller ecological niches (*); (ii) the predominantly greenish to

* This applies to Batracomorphus s.str., which is smaller and much richer in species than Sudanoiassus Lv. & Quart. or than the related genera Jassulus Ev. or Afroiassus Lv. & Quart. However, Iassomorphus Th., which resembles Batracomorphus s.str. in size and general appearance, does not conform with this since it includes only a few forms.

yellowish colouration, which may act in concealment against some of the predators; (iii) their effective powers of flight, as suggested by the fact that most species were collected at light, and by the presence of some elements in islands such as the Cape Verde Islands; and (iv) possibly their capacity for sympatric speciation has played an important role in the evolution of Batracomorphus as very likely also took place in the Typhlocybinae (Evans, 1962).

(c) Vegetational changes in relation to Batracomorphus distribution

Future trends in the distribution and evolution of the present African Batracomorphus fauna will be largely dependent on changes in the African vegetation.

Africa is undergoing an unprecedently explosion in its human population, especially in the northern and southern areas. As a result of unbalanced human activities such as in forestry, and animal husbandry, two main phenomena are expected to affect the distribution of Batracomorphus: retraction of tropical forests in favour of savannas, and chronic overgrazing causing the expansion of more xerophytic vegetation everywhere.

The moist forest of the Guinean zone has been heavily subjected to human activities during the last few centuries, resulting in wooded savanna and agricultural lands. Ecologically speaking, these changes have caused a degradation and a reduction in the stability of the ecosystem with the resultant forest retraction (Vos, 1975). On the other hand, other factors such as climatic changes must also have been acting in Africa during the last two millennia. There is some evidence showing that a general retrenchment of the forest area has been occurring, caused partly by increasing aridity (Livingstone, 1975). If this process of forest retraction goes on, an expansion of the savanna Batracomorphus species is expected, with the likely disappearance of some of the strictly Guinean species.

On the other hand, chronic overgrazing inevitably modifies the original herbaceous cover. In Southern Africa natural grass, tree and woodland savannas have been largely replaced by trees, shrubs and herbs typical of a more arid climatic regime (Vos, op. cit.). Even the present bare condition of the Karoo is an artificial one. Perennial grasses and palatable Karoo bushes have practically disappeared because they have been grazed by goats and sheep. As a result, only the more xerophytic veld type as the "Ngongoni Veld" develops (Acocks, 1975). This will undoubtedly permit the expansion of the more xerophil species of *Batracomorphus*.

If one may attempt to predict future changes in the distribution of the African fauna of *Batracomorphus*, it seems likely that a reduction in the abundance and diversity of the moist forest species will occur, with an expansion of the savanna forms as well as those of the drier habitats. This calls for a priority of research effort on the taxonomy of the Guinean fauna in an attempt to discover and describe many yet unknown species before they become extinct.

(d) Natural enemies

Leafhoppers have predators such as spiders and insects, e.g., chrysopids, some predaceous Hemiptera and Hymenoptera, etc. (DeLong, 1971). They are parasitized by species of several families of the Hymenoptera (Dryinidae, Mymaridae, Chalcididae, etc.), by Pipunculidae of the Diptera, the Epipyropidae of the Lepidoptera, by species of Strepsiptera and by some fungi (DeLong, op. cit.).

Concerning *Batracomorphus*, we have practically no knowledge, since there are only a few general references available. For the Nearctic fauna, Oman (1949a) mentions that some Iassinae are parasitized by Pipunculidae and Strepsiptera. Haupt (1941a) gives Dryinidae as parasites of *Iassus lanio*, a Palaearctic member of the Iassinae related to *Batracomorphus*. What may seem surprising is the fact that during the present study, the author has only very rarely had evidence of the specimens being parasitized. This does not mean that Batracomorphus is rarely attacked by parasites in Africa. In fact, it is often not easy to recognize, for instance, in dryinized specimens, since the only evidence present is the weakly sclerotized and thinner abdominal walls or by the genitalia producing flabby preparations in KOH. On the other hand, the majority of the Batracomorphus material was collected at light and what happens with some typhlocybids may as well apply to this genus: as noted by Ross & Moore (1957), dryinized specimens of Empoasca were especially abundant in material gathered directly from the host plant while few were encountered in samples collected at light.

(e) Attendance by ants

Associations with ants, which are of general occurrence among Aetalionidae, Eurymelidae and Membracidae, are rare among Cicadellidae (Evans, 1947a). Lamborn (1914a) reports Ossana bicolor Distant, now Batracomorphus punctatissimus (Mel.), as being attended by the ant Camponotus akwapimensis poultoni For., which therefore constitutes one of the few examples of Cicadellidae being attended by ants.

(f) Economic importance

In spite of some references to the damage caused by representatives of Batracomorphus, there have been no serious instances in Africa. Iassomorphus cederanus (Naudé), formerly within Batracomorphus, was thought to cause the disease known as "froghopper" among wattles (Acacia spp.) in Southern Africa (Evans, 1952a; Skaife, 1953a) but this was dismissed later by Connell (1970). In Angola the author collected specimens of Batracomorphus astyages Lv. & Quart. on Anacardium occidentale L., a shelterbelt species, and on Terminalia catappa L., an ornamental tree, but no damage to either of these trees was attributable to this leafhopper.

Outside Africa, however, there are some references to damage caused by _Batracomorphus_. Ghauri (1964) described two new species, _Batracomorphus szentivanyi_ and _B. blotei_, reported as causing serious attacks on coffee plantations in New Guinea. _Batracomorphus brunki_ (Schmidt) is also recorded on coffee in West Irian, New Guinea, without, however, causing any appreciable injury (Le Pelley, 1968). On the other hand, _Batracomorphus indicus_ (Leth.) has been suspected of being one of the vectors of the spike-disease of sandal in India (Appanna & Dover, 1932a; Chatterjee, 1932d; Dover, 1932c; Singh-Pruthi, 1934a). Moreover, Oishi (1938a) reported _Batracomorphus mundus_ (Uhler) as injuring grape-vines in Japan.

This shows that _Batracomorphus_ represents a potentially injurious insect in Africa and observations on crops such as coffee plantations should be carried out periodically.

LITERATURE CITED

All the dates of the references on leafhoppers up to 1955 are given as they appear in Metcalf (1964).

Acocks, J.P.H. 1975. Veld types of South Africa. Mem.bot. Surv. S. Afr. 40: 1-128.

Anufriev, G.A. 1971. New species of Cicadellidae (Homoptera) from the Primorsky District. Zool. Zh. 50: 677-685.

Apanna, M., & Dover, C. 1932a. Investigations on the spike disease of sandal. Entomological investigations by the Forest Research Institute. J. Indian Inst. Sci. 6: 12-14.

Aubréville, A., Duvigneaud, P., Hoyle, A.C., Keay, R.W.J., Mendonça, F.A. & Pichi-Sermolli, R.E.G. 1959. Vegetation map of Africa South of the Tropic of Cancer. Clarendon Press, Oxford.

Beamer, R.H. & Lawson, P.B. 1945a. A revision of the genus Stragania (Bythoscopus of authors) in America north of Mexico. J. Kans. ent. Soc. 18: 49-66.

Beirne, B.P. 1956. Leafhoppers (Homoptera: Cicadellidae) of Canada and Alaska. Can. Ent. 88 (Suppl. 2): 1-180.

Blöte, H.C. 1964. On some New-Guinean Batracomorphus species (Hemiptera, Jassidae). Zool. Meded. Leiden. 39: 464-470.

Boratynski, K. & Davies, R.G. 1971. The taxonomic value of male Coccoidea (Homoptera) with an evaluation of some numerical techniques. Biol. J. Linn. Soc. 3: 57-102.

Boyce, A.J. 1964. The value of some methods of numerical taxonomy with reference to hominoid classification, pp. 47-65. In Heywood, V.H. & McNeill, J. (eds.), Phenetic and Phylogenetic Classification. Syst. Ass. Pub. 6, London.

Buckton, G.B. 1890c. Monograph of the British Cicadae or Tettigiidae. Vol. I. London.

Cain, A.J. & Harrison, G.A. 1960. Phyletic weighting. Proc. zool. Soc. Lond. 135: 1-31.

Cavalli-Sforza, L.L. & Piazza, A. 1975. Analysis of evolution: evolutionary rates, independence and treeness. Theoret. Pop. Biol. 8: 127-165.

Chatterjee, N.C. 1932d. Investigations of the spike-disease of sandal. Entomological Investigations by the Forest Research Institute. II. J. Indian Inst. Sci. 6: 15-16.

Cheetam, A.H. 1968. Morphology and systematics of the bryozoan genus Metrarabdotus. Smithson. misc. Collns. 153(1): 1-121.

Chui, V.W. & Thornton, I.W.B. 1971. A numerical taxonomic study of the endemic Ptycta species of the Hawaiian islands (Psocoptera: Psocidae). Syst. Zool. 20: 7-22.

Connell, A.D. 1970. Aspects of the morphology and bionomics of Batrachomorphus cederanus (Naudé) and Lygidolon laevigatum Reut. (Hemiptera) on black wattle (Acacia mearnii De Wild). Unpublished Thesis, Univ. Natal. Pietermaritzburg.

Davies, R.G. 1971. Computer Programming in Quantitative Biology. Academic Press, London and New York.

Davis, J.C. 1973. Statistics and Data Analysis in Geology. John Wiley & Sons, New York.

DeLong, D.M. 1971. The bionomics of leafhoppers. A. Rev. Ent. 16: 179-210.

DeLong, D.M. & Davidson, R.H. 1937a. Methods in study and preservation of leafhopper genitalia. J. econ. Ent. 30: 372-374.

Distant, W.L. 1914m. Homoptera (Membracidae and Jassidae) collected in the Lagos District by W.A. Lamborn. Trans. ent. Soc. London. 1913: 515-520.

Dlabola, J. 1954a. Auchenorrhyncha-Homoptera. (In Czech with German summary). Fauna ČSR. 1: 1-339.

———— 1963. Typen und wenig bekannte Arten aus der Sammlung H. Haupt mit Beschreibungen einiger Zikadenarten aus Siberien (Homoptera). Acta ent. Mus. natn. Pragae. 35: 313-331.

Dover, C. 1932c. Entomological investigations on the spike-disease of sandal (*Santalum album* Linn.). Part I. An introductory survey of the problem. Indian Forest Rec. 17(1): 1-52.

Eades, D.C. 1965. The inappropriateness of the correlation coefficient as a measure of taxonomic resemblance. Syst. Zool. 14: 98-100.

———— 1970. Theoretical and Procedural Aspects of Numerical Phyletics. Syst. Zool. 19: 142-171.

Edwards, J. 1886a. A synopsis of British Homoptera-Cicadina. IV. Trans. ent. Soc. London. 1886: 41-129, pls. 1-2.

———— 1894d. The Hemiptera-Homoptera of the British Islands (Part III). London.

Emeljanov, A.F. 1967. Cicadinea (Auchenorrhyncha), pp. 421-551. In Bei-Bienko, G.Y. (ed.), Keys to the Insects of the European USSR. Israel Program for Scientific Translations, Jerusalem.

Evans, J.W. 1946a. A natural classification of leaf-hoppers (Jassoidea, Homoptera). Part 1. External morphology and systematic position. Trans. R. ent. Soc. Lond. 96: 47-60.

——————— 1946b. A natural classification of leaf-hoppers (Homoptera, Jassoidea). Part 2. Aetalionidae, Hylicidae, Eurymelidae. Trans. R. ent. Soc. Lond. 97: 39-54.

——————— 1947a. A natural classification of leaf-hoppers (Jassoidea, Homoptera). Part 3. Jassidae. Trans. R. ent. Soc. Lond. 98: 105-271.

——————— 1952a. The injurious insects of the British Commonwealth (except the British Isles, India and Pakistan) with a section on the control of weeds by insects. Commonwealth Institute of Entomology, London.

——————— 1954a. Les Cicadellidae de Madagascar (Hompteres). Mém. Inst. scient. Madagascar. (E) 4: 87-137.

——————— 1955a. Cicadellidae (Hemiptera, Homoptera). Explor. Parc natn. Upemba Miss. G.F. de Witte. 37: 1-44.

——————— 1955b. Cicadellidae (Hemiptera, Homoptera). Explor. Parc natn. Albert Miss. G.F. de Witte. 84: 3-23.

——————— 1962. Evolution in the Homoptera, pp. 250-259. In Leeper, G.W. (ed.), The Evolution of Living Organisms. Melbourne University Press, Melbourne.

——————— 1966. The Leafhoppers and Froghoppers of Australia and New Zealand (Homoptera: Cicadelloidea and Cercopoidea). Mem. Aust. Mus. 12: 1-347.

——————— 1975. The external features of the heads of leafhoppers (Homoptera, Cicadelloidea). Rec. Aust. Mus. 29: 407-440.

Farris, J.S. 1966. Estimation of conservatism of characters by constancy within biological populations. Evolution, Lancaster, Pa. 20: 587-591.

——————— 1973. On comparing the shapes of taxonomic trees. Syst. Zool. 22: 50-54.

Fischer, A.G. 1960. Latitudinal gradients in organic diversity. Evolution, Lancaster, Pa. 14: 64-68.

Fisher, L. & Ness, J.W. van. 1971. Admissible clustering procedures. Biometrika. 58 (1): 91-104.

Ghauri, M.S.K. 1964. Two new species of Cicadelloidea (Homoptera) attacking coffee in New Guinea. Ann. Mag. nat. Hist. (13)7: 635-639.

Goodman, M.M. 1969. Measuring evolutionary divergence. Jap. J. Genet., 44 (Suppl. 1): 310-316.

Gower, J.C. 1966. Some distance properties of latent root and vector methods used in multivariate analysis. Biometrika. 53: 325-338.

__________ 1971a. A general coefficient of similarity and some of its properties. Biometrics. 27: 857-871.

__________ 1971b. Statistical methods of comparing different multivariate analyses of the same data, pp. 138-149. In Hodson, F.R., Kendall, D.G. & Tăutu, P. (eds.), Mathematics in the Archaeological and Historical Sciences. Edinburgh University Press, Edinburgh.

Gower, J.C. & Ross, G.J.S. 1969. Minimum spanning trees and single linkage cluster analysis. Appl. Statist. 18: 54-64.

Gurney, A.B., Kramer, J.P. & Steyskal, G.C. 1964. Some Techniques for the Preparation, Study and Storage in Microvials of Insect Genitalia. Ann. ent. Soc. Am. 57: 240-242.

Hamilton, K.G.A. 1975. Additional characters for specific determinations in Nearctic Xerophloea (Rhynchota, Homoptera: Cicadellidae). Can. Ent. 107: 943-946.

Haupt, H. 1927a. Homoptera Palestinae I. Bull. agric. Exp. Stn, Tel-Aviv. 8: 5-43, pls. 1-5.

——————— 1935a. *In* Brohmer, P., Ehrmann, P. & Ulmer, G. Homoptera. *Tierwelt Mitteleur*. *4*: 115-262.

——————— 1941a. Zur Kenntnis der Dryinidae II (Hymenoptera-Sphecoidea). *Z. Naturw*. *95*: 27-67.

Heller, F. & Linnavuori, R. 1968. Cicadelliden aus Aethiopien. *Stuttg. Beitr. Naturk*. *186*: 1-42.

Holdridge, L.R. 1967. *Life zone ecology*. Tropical Science Center, San Jose, Costa Rica.

Holm, E. 1975. Insect taxonomy in South Africa: How can we cope? *Proc. I. Congr. ent. Soc. sth. Afr.*: 35-40.

Ivimey-Cook, R.B. 1969a. Investigations into the phenetic relationships between species of *Ononis* L. *Watsonia*. *7*: 1-23.

——————— 1969b. The phenetic relationships between species of *Ononis*, pp. 69-85. *In* Cole, A.J. (ed.), *Numerical Taxonomy*, Academic Press, London.

Jacobi, A. 1910b. Homoptera. *In* *Sjöstedts Kilimandjaro-Meru-Expedition Stockholm*. *12*: (7): 97-136, pls. 1-2.

Jago, N.D. 1969. A revision of the systematics and taxonomy of certain North American gomphocerine grasshoppers (Gomphocerinae, Acrididae, Orthoptera). *Proc. Acad. nat. Sci. Philad*. *121*: 229-335.

Jardine, N. & Sibson, R. 1968. The construction of hierarchic and non-hierarchic classifications. *Comput. J*. *11*: 177-184.

1971. *Mathematical Taxonomy*. Wiley, London.

Johnston, R.F. & Selander, R.K. 1971. Evolution in the house sparrow. II. Adaptive differentiation in North American populations. *Evolution, Lancaster, Pa*. *25*: 1-28.

Keay, R.W.J. 1959. *Vegetation map of Africa South of the Tropic of Cancer. Explanatory notes*. Oxford University Press, Oxford.

Knight, W.J. 1965. Techniques for use in the identification of leaf-hoppers (Homoptera: Cicadellidae). *Entomologist's Gaz*. *16*: 129-136.

——————— 1968. A Revision of the Holarctic Genus Dikraneura (Homoptera: Cicadellidae). Bull. Br. Mus. nat. Hist. (Ent.). 21 (3): 101-201.

Kramer, J. 1963. A key to the New World genera of Iassinae with reviews of Scaroidana and Pachyopsis (Homoptera: Cicadellidae). Bull. Brooklyn ent. Soc. 58: 37-50.

Kramer, S. 1950a. The morphology and phylogeny of Auchenorhynchous Homoptera (Insecta). III. Illinois biol. Monogr. 20 (4): 1-111.

Kusnezov, V. 1929d. Révision des espèces du genre Batrachomorphus Lewis (Homoptera, Jassidae). Russk. ent. Obozr. 23: 251-261.

Lamborn, W.A. 1914a. On the relationships between certain West African insects, especially ants, Lycaenidae and Homoptera. Trans. ent. Soc. London. 46: 436-498, 1 pl.

Le Pelley, R.H. 1968. Pests of Coffee. Tropical Science Series. Longmans, London and Harlow.

Le Quesne, W.J. 1965. Hemiptera Cicadomorpha (excluding Deltocephalinae and Typhlocybinae). Handbk. Ident. Br. Insects 2: 1-64.

——————— 1977. A new species of Alebra Fieber (Hem., Cicadellidae). Entomologist's mon. Mag. 112(1976): 49-52.

Lewis, R.H. 1834a. Descriptions of some new genera of British Homoptera. Trans. R. ent. Soc. Lond. 1: 47-52, pl. 7.

Lindberg, H. 1923b. Zur Kenntnis der Cicadinengattung Batracomorphus Lew. Notul. ent. 3: 68-71.

——————— 1948b. On the insect fauna of Cyprus. Results of the expedition of 1939 by Harald Håkan and P.H. Lindberg. I-II. I. Introduction. II. Heteroptera and Homoptera Cicadina der Insel Zypern. Commentat. biol. 10(7): 1-175.

——— 1958. Hemiptera Insularum Caboverdensium. Systematik, Ökologie und Verbreitung der Heteropteren und Cicadinen der Kapverdischen Inseln. Commentat. biol. 19 (1): 1-246.

Linnavuori, R. 1957. Remarks on the Iassinae (Hom. Cicadellidae). Suom. hyönt. Aikak. 23: 144-150.

——— 1958. On some new or little known Mediterranean Homoptera. Boll. Soc. ent. ital. 88: 34-38.

——— 1959. Revision of the Neotropical Deltocephalinae and some related subfamilies (Homoptera). Suomal. eläin-ja kasvit. Seur. van. elain Julk. 20: 1-370.

——— 1960. Homoptera: Cicadellidae. Insects Micronesia. 6: 231-344.

——— 1961. Hemiptera (Homoptera) Cicadellidae. S. Afr. anim. Life. 8: 452-486.

——— 1969. Contribution à la faune du Congo (Brazzaville). Mission A. Villiers et A. Descarpentries XCIII. Hémiptères Hylicidae et Cicadellidae. Bull. Inst. Fr. Afr. noire (A). 31: 1129-1185.

——— 1971. A leafhopper material from Tunisia, with remarks on some species of the adjacent countries. Annls. Soc. ent. Fr. 7(1): 57-73.

Linnavuori, R. & Quartau, J.A. 1975. Revision of the Ethiopian Cicadellidae (Hemiptera-Homoptera): Iassinae and Acroponinae. Etud. Cont. afr. 3: 1-170.

Littlejohn, M.J. 1969. The systematic significance of isolating mechanisms, pp. 459-482. In Systematic Biology. National Academy of Sciences, publ. 1692, Washington.

Livingstone, D.A. 1975. Late quaternary climatic changes in Africa. A. Rev. Ecol. Syst. 6: 249-280.

Mayr, E. 1965. Numerical phenetics and taxonomic theory. Syst. Zool. 14: 73-97.

———— 1970. Populations, Species, and Evolution. The Belknap of Harvard University Press, Cambridge, Mass.

Melichar, L. 1896a. Cicadinen (Hemiptera-Homoptera) von Mittel-Europa. Berlin.

———— 1908b. Nové rody a druhy Homopter z východní Afriky. Cas. csl. Spol. ent. 5: 1-15.

Metcalf, Z.P. 1964. General Catalogue of the Homoptera. Fasc. VI. Cicadelloidea. Bibliography of the Cicadelloidea (Homoptera: Auchenorrhyncha). U.S. Department of Agriculture, Washington, D.C.

Minkoff, E.C. 1965. The effects on classifications of slight alterations in numerical technique. Syst. Zool. 14: 196-213.

Moss, W.W. 1967. Some new analytic and graphic approaches to numerical taxonomy, with an example from the Dermanyssidae (Acari). Syst. Zool. 16: 177-207.

———— 1968. Experiments with various techniques of numerical taxonomy. Syst. Zool. 17: 31-47.

Moss, W.W., Peterson, P.C. & Atyeo, W.T. 1977. A multivariate assessment of phenetic relationships within the feather mite family Eustathiidae (Acari). Syst. Zool. 26: 386-409.

Nast, J. 1972. Palaearctic Auchenorrhyncha (Homoptera). An annotated check list. Polish Academy of Sciences, Warszawa.

Naudé, T.J. 1926a. Cicadellidae of South Africa. A taxonomic and faunistic study. Entomology Mem. Dep. Agric. Un. Sc. Afr. 4: 1-106, 10 pls.

Oishi, T. 1938a. Macropsis munda Uhler injures grape. J. Pl. Prot., Tokyo. 25: 913-914.

Oman, P.W. 1949a. The Nearctic Leafhoppers (Homoptera: Cicadellidae). A Generic Classification and Check List. Mem. ent. Soc. Wash. 3: 1-253, 44 pls.

——————— 1972. A new megophthalmine leafhopper from Oregon, with notes on its biology and behaviour (Homoptera: Cicadellidae). J. Ent. (B), 41(I): 69-76.

Ossiannilsson, F. 1946a. On the sound production and the sound producing organ in Swedish Homoptera Auchenorrhyncha. Opusc. ent. 11: 82-84.

——————— 1949a. Insect drummers. Opusc. ent. (Suppl.). 10: 1-145.

——————— 1951d. On the shape of the apodemes of the second abdominal sternum of the males as a specific character in the genus Macrosteles Fieb. (Hom., Auchenorrhyncha). Opusc. ent. 16: 109-111.

Ossiannilsson, F., Russel, L.M. & Weber, H. 1956. Homoptera, pp. 148-158. In Tuxen. S.L. (ed.), Taxonomist's Glossary of Genitalia in Insects. Ejnar Munksgaard, Copenhagen.

Owen, D.F. 1976. Animal Ecology in Tropical Africa. Tropical Ecology Series, Longman, London.

Phillips, J. 1959. Agriculture and Ecology in Africa. Faber and Faber, London.

Phipps, J.B. 1971. Dendrogram topology. Syst. Zool. 20: 306-308.

Power, D.M. 1971. Statistical analysis of character correlations in Brewer's Blackbirds. Syst. Zool. 20: 186-203.

Quartau, J.A. 1968. Two new species of genus Batracomorphus Lewis from the Cape Verde Islands (Homoptera, Cicadellidae). Archos Mus. Bocage. 2: 1-8.

Ralston, A. & Wilf, H.S. 1967. Mathematical Methods for Digital Computers. Wiley, New York.

Ribaut, H. 1936b. Homoptères Auchénorhynques. I. (Typhlocybidae). Faune Fr. 31: 1-231.

——————— 1952a. Homoptères Auchénorhynques. II. (Jassidae). Faune Fr. 57: 1-474.

Rohlf, F.J. 1963. Congruence of larval and adult classifications in Aedes (Diptera: Culicidae). Syst. Zool. 12: 97-117.

——————— 1967. Correlated characters in numerical taxonomy. Syst. Zool. 16: 109-126.

——————— 1968. Stereograms in numerical taxonomy. Syst. Zool. 17: 246-255.

——————— 1972. An empirical comparison of three ordination techniques in numerical taxonomy. Syst. Zool. 21: 271-280.

——————— 1973. Hierarchical clustering using the minimum spanning tree. Comput. J. 16: 93-95.

——————— 1974. Methods of comparing classifications. A. Rev. Ecol. Syst. 5: 101-113.

Rohlf, F.J. & Sokal, R.R. 1965. Coefficients of correlation and distance in numerical taxonomy. Kans. Univ. Sci. Bull. 45: 3-27.

Ross, H.H. 1963. An Evolutionary Outline of the leafhopper Genus Empoasca Subgenus Kybos with a Key to the Nearctic Fauna (Hemiptera, Cicadellidae). Ann. ent. Soc. Am. 56: 202-223.

Ross, H.H. & Moore, T.E. 1957. New species in the Empoasca fabae complex (Hemiptera, Cicadellidae). Ann. ent. Soc. Am. 50 (2): 118-122.

Schnell, G.D. 1970. A phenetic study of the suborder Lari (Aves) II. Phenograms, discussion and conclusions. Syst. Zool. 19: 264-302.

Scudder, G.C.E. 1971. Comparative morphology of insect genitalia. A. Rev. Ent. 16: 379-406.

Simpson, G.C. 1961. Principles of Animal Taxonomy. Columbia University Press, New York.

Singh-Pruthi, H. 1925b. The morphology of the male genitalia in Rhynchota. Trans. ent. Soc. London. 1925: 127-267, pls 6-32.

———— 1934a. Entomological investigations on the spike disease of sandal (14). Jassidae (Homopt.) Indian Forest Rec. (Ent. Ser.) 19 (4): 1-30.

Skaife, S.H. 1953a. African insect life. Longmans Green, Cape Town.

Smith, J.D. 1972. Systematics of the Chiropteran family Marmoopidae. Univ. Kans. Publs. Mus. nat. Hist. 56, 1-132.

Sneath, P.H.A. 1969. Evaluation of clustering methods, pp. 257-271. In Cole, A.J. (ed.), Numerical Taxonomy. Academic Press, London.

Sneath, P.H.A. & Sokal, R.R. 1973. Numerical Taxonomy. The Principles and practice of numerical classification. W.H. Freeman & Co., San Francisco.

Sokal, R.R. & Camin, J.H. 1965. The two taxonomies: areas of agreement and conflict. Syst. Zool. 14: 176-195.

Sokal, R.R. & Michener, C.D. 1967. The effects of different numerical techniques on the phenetic classification of bees of the Hoplitis complex (Megachilidae). Proc. Linn. Soc. Lond. 178: 59-74.

Sokal, R.R. & Sneath, P.H.A. 1963. Principles of Numerical Taxonomy. W.H. Freeman and Company, San Francisco.

Solomon, H. 1971. Numerical Taxonomy, pp. 62-68. In Hodson, F.R., Kendall, D.G. & Tăutu, P. (eds.), Mathematics in the Archaeological and Historical Sciences. Edinburgh University Press, Edinburgh.

Stål, C. 1855a. Hemiptera från Kafferlandet. Öfvers. K. VetenskAkad. Forh. Stockh. 12: 89-100.

——————— 1866a. Hemiptera, Homoptera Latr. Hemiptera Africana . (Tom. IV). Stockholm.

Theron, J.G. 1972. The Naudé species of South African Cicadellidae. (Hemiptera). I. Species assigned to the genera Bythoscopus Germar, 1833, Parabolitus Naudé, 1926, and Gcaleka Naudé, 1926. J. ent. Soc. sth. Afr. 35: (2): 201-210.

Thornton, I.W.B. & Kai, W.S. 1967. A numerical taxonomic analysis of the Peripsocidae of the Oriental region and the Pacific basin. Syst. Zool. 16 (3): 217-240.

Tyron, R.C. & Bailey, D.E. 1970. Cluster Analysis. McGraw-Hill Book Co., New York.

Vilbaste, J. 1968. On the Cicadina of the Primorye region. Akademy of Sciences of the Estonian SSR.

Vos, A. de. 1975. Africa, the devastated continent? Man's impact on the ecology of Africa. Dr. W. Junk b.v. Publishers, The Hague. Netherlands.

Webster, R. 1977. Quantitative and numerical methods in soil classification and survey. Clarendon Press, Oxford.

Williams, W.T., Lance, G.N., Dale, M.B. & Clifford, H.T. 1971. Controversy concerning the criteria for taxonometric strategies. Comput. J. 14 (2): 162-165.

Young, D.A. 1952b. A reclassification of Western Hemisphere Typhlocybinae (Homoptera, Cicadellidae). Kans Univ. Sci. Bull. 35: 1-217.

APPENDIX

Computer outputs of data matrices I, II and III:

MATRIX I (CONTINUOUS DATA). 39 OTU'S BY 23 CHARACTERS

1.	72.0	101.4	11.0	55.4	55.9	65.7	35.6	12.7	111.1	78.7	59.2	85.9	97.3	74.3	31.0	43.1	16.2	79.6	13.9	25.4	36.2	3.7	21.6
	88.5	119.5	12.5	68.5	68.5	75.0	38.5	14.3	132.0	96.0	72.0	109.3	122.0	95.5	47.0	52.5	16.5	94.5	11.0	31.5	42.5	4.0	20.3
	53.0	96.0	12.0	50.0	46.0	57.0	31.0	11.0	97.0	71.0	50.0	69.5	79.0	59.0	20.0	39.0	13.0	70.0	10.0	19.0	29.0	3.5	21.0
	75.0	102.0	11.0	58.0	57.0	65.0	33.0	13.0	109.0	74.0	61.0	81.5	92.5	63.0	24.0	40.0	19.0	81.0	11.0	30.0	41.0	5.0	24.0
	77.0	110.0	10.0	64.0	57.0	71.0	36.0	16.0	125.0	83.0	63.5	68.0	78.5	55.0	22.0	33.0	25.0	80.0	14.0	24.0	38.0	4.0	19.5
	75.0	105.0	12.0	58.0	57.0	66.0	33.0	12.0	114.0	82.0	62.0	86.5	99.5	69.0	38.0	32.0	17.0	93.0	9.0	35.0	44.0	3.5	19.0
	72.0	98.3	11.0	53.0	54.8	59.3	30.3	12.1	107.3	75.5	58.1	87.6	97.9	73.0	15.5	56.0	29.5	85.8	11.8	23.0	34.8	4.1	20.6
	84.0	115.0	10.0	65.0	65.0	70.5	35.0	13.8	128.0	89.5	69.5	107.0	119.5	84.5	36.0	48.5	13.0	83.0	16.5	31.5	48.0	4.3	22.5
	74.0	100.0	11.5	56.5	56.0	63.5	33.0	12.3	111.5	77.5	60.5	77.8	90.5	67.0	31.0	35.0	18.0	85.5	16.5	26.0	36.5	3.5	22.3
10.	70.0	97.0	9.0	56.0	56.0	62.0	33.0	12.0	108.0	78.0	58.0	72.0	84.0	62.0	16.0	45.0	24.0	85.0	20.0	21.0	41.0	4.5	19.5
	80.0	111.0	11.0	60.0	61.0	70.0	35.0	13.0	121.0	85.0	66.5	96.0	119.5	85.0	35.0	51.0	16.0	85.0	7.0	32.0	39.0	4.0	24.5
	75.0	99.0	12.0	59.0	54.0	60.0	31.0	12.5	112.0	76.0	60.5	79.5	91.5	61.0	32.0	29.0	11.0	89.0	21.0	24.0	45.0	3.5	19.0
	70.0	99.0	13.0	56.0	52.0	62.0	35.0	12.0	109.0	72.0	56.0	77.0	87.0	59.0	29.0	30.0	16.0	62.0	14.0	28.0	42.0	2.5	22.5
	70.0	103.0	12.0	57.0	55.0	67.0	35.0	13.0	116.0	81.0	56.0	77.0	90.0	59.0	30.0	28.0	17.0	78.0	19.0	26.0	35.0	8.0	20.5
	69.0	96.0	10.0	52.7	51.7	58.3	31.7	11.7	105.0	72.3	55.3	87.0	97.2	75.0	12.7	62.3	36.0	78.3	17.3	17.3	34.7	4.0	23.5
	76.0	103.0	11.0	58.0	60.0	64.0	37.0	12.0	112.0	79.0	62.0	82.0	94.5	63.0	31.0	32.0	13.0	91.0	17.0	20.0	37.0	4.0	25.0
	75.0	108.0	12.0	62.0	59.0	68.0	36.0	13.0	122.0	40.0	59.0	84.5	99.0	69.0	25.0	44.0	20.0	87.0	21.0	20.0	41.0	3.5	18.5
	73.0	106.0	11.0	60.0	55.0	67.0	36.0	13.0	116.0	82.0	57.5	96.0	117.5	81.0	18.0	63.0	37.0	88.0	19.0	22.0	41.0	3.5	20.0
	60.0	87.0	10.0	62.0	47.0	56.0	32.0	9.0	95.0	67.0	47.5	68.0	77.5	56.0	26.0	30.0	11.0	69.0	15.0	16.0	31.0	3.0	21.5
20.	57.0	84.0	10.0	46.0	44.0	52.0	28.0	10.0	90.0	64.0	45.5	63.5	74.5	55.0	25.0	29.0	10.0	68.0	15.0	15.0	30.0	2.5	25.5
	84.0	118.0	13.0	63.0	64.0	74.5	37.0	17.0	129.0	61.0	68.3	102.2	117.3	66.0	35.7	50.0	17.7	98.3	13.7	33.7	47.7	4.5	18.3
	64.8	91.3	11.5	50.3	49.3	57.6	32.8	10.3	99.0	68.7	51.3	75.0	84.8	59.0	14.2	44.8	26.8	74.2	10.7	23.0	33.7	2.7	24.2
	71.3	103.0	12.3	52.7	55.0	65.0	35.0	13.0	106.3	77.0	56.3	81.3	92.6	66.7	21.3	45.3	21.0	77.5	14.0	25.3	39.3	3.5	23.5
	89.0	125.0	14.0	72.0	65.0	81.0	48.0	14.0	137.0	98.0	71.0	86.0	101.0	81.0	27.0	53.0	22.0	97.0	18.0	36.0	54.0	2.5	17.5
	78.0	114.0	13.0	60.0	64.0	71.0	40.0	12.5	121.0	87.0	64.0	102.0	115.5	89.0	13.0	77.0	45.0	99.0	12.0	31.0	43.0	3.5	21.0
	77.6	107.5	13.2	55.5	54.8	68.8	36.7	14.2	116.5	80.2	62.8	83.6	98.6	67.8	17.8	50.0	24.3	80.8	15.3	22.2	37.5	4.3	20.3
	64.0	91.0	10.0	51.0	46.0	54.0	28.0	9.0	98.0	65.0	50.0	62.0	72.5	53.0	28.0	24.0	11.0	73.0	10.0	22.0	32.0	2.5	25.5
	66.6	90.9	11.7	46.6	48.9	59.0	31.7	11.9	95.4	69.5	51.8	70.1	81.7	60.4	13.6	46.4	24.8	74.8	12.1	23.2	35.3	2.9	24.9
	83.0	111.0	13.0	60.0	62.0	71.0	35.0	14.0	120.0	-1.0	66.5	82.0	97.0	68.0	18.0	51.0	28.0	87.0	11.0	25.0	36.0	3.0	23.0
30.	90.0	117.0	14.0	74.0	70.0	75.0	44.0	14.0	135.0	95.0	74.0	75.0	86.0	69.0	15.0	52.0	21.0	94.0	20.0	30.0	50.0	2.5	19.5
	74.5	109.0	11.0	60.5	57.0	69.0	37.0	13.0	119.0	81.0	61.0	81.5	92.8	61.5	25.5	36.0	17.5	80.0	12.0	25.5	37.5	4.8	21.0
	71.0	100.0	10.0	56.0	56.0	62.0	33.0	12.5	112.0	76.0	57.0	69.0	83.5	60.0	12.0	48.0	30.0	79.0	9.0	25.0	35.0	3.0	21.0
	77.0	102.0	10.0	59.0	56.0	62.0	33.0	12.0	115.0	85.0	63.0	83.0	96.0	71.0	15.0	56.0	37.0	88.0	8.0	32.0	40.0	4.5	23.5
	77.0	106.0	14.0	63.0	59.0	66.0	37.0	13.5	107.0	82.0	62.0	101.0	115.5	82.0	23.0	59.0	24.0	87.0	12.0	30.0	42.0	3.0	25.5
	76.0	101.0	12.0	55.0	61.0	64.0	33.0	13.0	116.0	82.0	62.5	80.5	91.5	69.0	30.0	39.0	14.0	89.0	11.0	23.0	34.0	3.0	23.5
	91.4	120.0	12.0	71.2	65.8	77.2	42.2	15.2	133.8	93.6	75.3	71.7	87.5	57.4	18.8	43.8	19.8	97.4	16.6	33.8	50.6	3.3	18.7
	89.0	125.0	12.0	76.0	72.0	82.0	46.0	14.0	135.0	104.0	72.0	82.0	96.5	70.0	22.0	46.0	21.0	104.0	24.0	32.0	57.0	2.5	20.0
	89.0	115.0	12.5	71.0	66.0	74.0	42.0	14.8	129.0	91.0	73.8	65.3	79.0	45.0	19.0	29.5	16.0	86.5	13.0	36.0	49.0	3.5	18.5
	63.2	89.6	18.2	43.4	47.6	58.2	35.6	12.2	97.2	64.6	49.6	60.2	70.5	41.4	15.8	26.8	16.0	74.6	12.2	31.6	44.0	2.3	29.9

MATRIX II (QUALITATIVE DATA). 39 OTU'S BY 116 CHARACTERS

1.

10.

20.

	2	1	1	3	2	2	2	3	2	2	3	3	3	2	2	2	2	-1	2	-1	2	2	2	2	2	2	1	2	2	2	2	2	2	4	1	1
	1	2	2	2	2	2	2	2	1	1	2	2	1	2	2	3	2	2	2	4	2	2	2	1	2	3	2	2	1	1	2	2	2	2	1	2
	2	2	3	2	2	2	2	2	7	2	2	2	2	1	2	3	3	2	2	10	4	-1	-1	1	1	2	-1	1	1	2	2	1	2	1	2	1
	2	1	2	1	2	1	1	2																												
	1	2	2	6	5	2	2	-1	2	5	3	3	3	2	2	2	5	1	2	1	2	2	2	2	2	2	1	2	2	2	2	2	2	4	3	1
	1	1	1	2	2	2	2	2	1	2	1	1	1	1	2	2	2	2	1	5	2	2	1	-1	2	2	2	2	-1	1	2	1	2	4	1	2
	3	1	-1	2	1	1	2	2	7	2	2	2	2	2	3	3	1	2	3	4	3	1	1	1	1	2	2	1	-1	2	2	1	-1	1	2	1
	2	1	2	2	2	2	1	2																												
	2	-1	1	6	2	2	2	2	2	2	3	3	3	2	2	2	2	1	2	1	2	2	2	2	2	2	1	2	2	2	2	2	2	4	1	1
	3	1	3	2	2	2	2	2	1	2	2	-1	1	1	2	2	2	2	2	5	2	2	1	2	2	2	1	2	1	4	2	2	2	3	1	1
	2	2	2	2	2	2	2	2	7	2	2	2	2	1	2	3	2	2	7	12	3	1	1	1	1	2	2	1	2	2	2	2	2	1	2	1
	2	1	2	2	2	2	1	3																												
	3	2	2	3	2	2	2	2	2	2	2	3	3	2	2	1	2	1	2	1	2	2	2	2	2	2	1	2	1	2	2	2	2	4	1	1
	1	1	2	2	2	2	2	2	1	1	2	1	1	2	2	3	1	2	1	5	2	2	1	1	1	2	2	2	4	6	3	1	1	1	2	1
	3	2	3	3	1	2	2	2	4	2	2	2	2	2	1	3	2	2	3	4	-1	-1	-1	2	2	2	2	2	2	2	2	1	1	1	2	1
	1	2	2	3	1	2	2	3																												
	2	2	1	3	2	2	2	2	2	2	3	3	3	2	2	2	2	1	2	1	2	2	2	2	2	2	1	2	2	2	2	2	2	4	1	1
	1	1	2	2	2	2	2	2	1	2	2	2	1	1	2	3	3	2	3	4	2	2	1	2	2	3	2	2	1	2	2	2	2	3	1	2
	2	2	3	2	2	2	2	2	7	2	2	1	2	2	2	3	1	3	3	4	3	1	2	1	2	1	2	2	1	2	2	1	2	1	2	1
	2	1	2	2	2	2	1	3																												
	2	2	2	6	5	2	2	1	2	3	3	3	3	2	2	2	5	1	2	1	2	2	4	2	1	2	1	2	2	2	3	2	2	4	-1	1
	2	2	-1	5	2	5	2	2	-1	1	2	3	1	2	2	2	4	2	1	6	2	2	1	-1	1	2	2	2	3	-1	2	2	2	2	1	2
	1	2	2	2	2	2	2	2	7	2	2	2	2	1	2	1	1	2	8	13	2	1	2	1	1	1	3	1	2	2	2	2	2	1	2	1
	2	1	2	2	1	2	1	2																												
	1	2	3	3	2	2	2	2	2	2	3	3	3	2	2	2	2	1	2	1	2	2	2	2	2	2	1	2	2	2	2	2	2	4	3	2
	1	2	2	2	2	2	2	2	1	2	2	1	1	1	2	2	3	2	3	5	2	2	1	2	2	1	1	2	1	2	3	2	2	1	1	2
	2	2	1	2	1	2	2	2	7	2	2	2	2	2	2	1	3	2	4	6	2	1	1	1	1	1	3	1	1	2	2	2	2	1	2	1
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	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	5	3	3	3	2	2	2	2	1	2	1	2	2	2	2	2	2	1	2	2	2	2	2	2	4	1	1
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	2	1	2	1	1	2	2	4	2	1	6	2	2	1	2	2	2	2	2	3	2	2	2	2	2	1	2
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7	2	2	2	2	1	2	3	1	3	8	13	2	1	1	1	1	2	2	1	1	2	2	1	1	1	2	1
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]																												
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	3	3	3	3	2	2	2	3	2	2	1	2	2	2	2	2	2	1	2	2	2	2	2	2	4	1	1
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	1	2	2	1	1	2	2	3	2	1	5	2	2	1	2	2	2	2	2	3	2	2	2	2	2	1	2
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7	2	2	2	2	2	1	3	1	3	7	12	2	1	-1	1	1	2	1	1	2	2	2	1	1	1	2	1
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]																												
30.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	2	2	3	3	2	1	1	2	1	2	1	2	2	2	2	1	2	1	1	2	2	2	2	2	4	1	1
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	1	2	1	1	2	2	2	1	2	2	5	2	2	1	1	2	2	2	2	4	6	3	1	1	1	2	1
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	5	2	2	2	2	1	1	3	1	3	4	7	4	1	1	2	2	2	2	2	2	2	2	1	2	1	2	2
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]																												
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	1	3	3	3	2	2	2	5	2	2	-1	2	2	2	1	2	2	1	2	1	2	2	2	2	3	1	1
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	1	-1	-1	-1	-1	2	2	2	2	2	5	2	2	3	1	2	2	2	2	1	2	2	2	2	2	2	1
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7	2	2	2	2	2	-1	3	3	1	3	9	4	1	1	1	1	1	2	1	2	2	2	1	1	1	2	1
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]																												
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	2	3	3	3	2	2	2	2	1	2	1	2	2	2	2	2	2	1	2	2	2	2	2	2	4	3	1
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	2	2	2	2	1	2	2	1	2	2	1	2	2	1	1	2	2	2	2	3	3	2	2	2	2	1	2
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7	2	2	1	2	1	2	1	1	3	4	6	2	1	2	1	1	2	2	1	1	2	2	1	2	1	2	1
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]																												
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	2	3	3	3	2	2	2	2	1	2	1	2	2	2	2	2	2	1	1	1	1	2	2	2	4	1	1
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	1	2	2	2	1	2	2	1	2	2	2	2	2	2	2	2	2	2	2	3	3	3	2	2	2	1	-1
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7	2	2	2	1	2	1	2	1	3	4	5	3	1	1	1	2	2	2	2	2	2	2	1	2	1	2	1
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]																												
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	2	3	3	2	2	2	2	2	1	2	1	2	2	2	2	1	2	1	2	2	1	1	1	1	1	3	1
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	1	1	1	2	1	2	3	1	2	2	5	2	2	2	1	1	3	1	2	1	2	3	2	2	2	1	2
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7	2	2	2	2	2	2	3	1	3	3	4	-1	-1	-1	1	1	1	2	1	1	2	2	-1	-1	1	2	1
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]																												
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	2	3	3	3	2	2	2	2	1	2	1	2	2	3	2	2	2	1	2	2	2	2	2	2	4	3	2
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	1	2	3	1	1	2	2	1	2	3	5	2	2	1	2	1	2	2	2	1	1	3	1	2	2	2	2
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7	2	2	2	2	1	2	1	3	2	4	6	3	1	2	1	1	3	3	1	1	2	1	1	1	2	1	1
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]																												
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	2	3	3	3	2	2	2	2	1	2	1	2	2	2	2	1	2	1	2	2	2	2	2	2	4	1	1
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	1	3	1	2	2	2	2	1	2	1	5	2	2	1	1	1	2	2	2	4	6	3	1	1	1	2	1
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	4	2	2	2	2	2	1	3	2	3	4	6	3	1	1	2	2	-1	2	2	2	2	2	2	1	1	2	1
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]																												
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	2	2	3	3	2	1	1	1	1	2	1	2	2	2	2	1	2	1	1	2	2	2	2	2	4	1	1
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	1	3	1	2	2	1	2	1	2	1	4	2	2	1	1	1	2	1	2	4	1	3	1	1	1	2	1
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	2	2	2	2	2	1	3	2	3	3	8	-1	-1	-1	2	2	2	2	2	2	1	1	1	1	1	1	1
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]																												
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	2	3	3	3	2	2	2	2	1	2	1	2	2	2	2	1	2	1	2	2	2	2	2	2	2	-1	1
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	1	-1	1	-1	2	2	2	1	2	3	5	2	2	1	1	2	-1	2	2	4	6	3	1	1	1	2	1
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	2	2	2	2	2	1	3	2	2	4	6	4	1	1	2	2	2	2	1	2	2	2	1	2	1	2	1
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]																												
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2	1	2	3	3	2	2	2	1	1	2	1	2	2	3	2	2	2	1	1	1	1	2	2	2	4	1	1
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1	1	1	3	1	1	1	2	4	3	2	-1	3	2	-1	-1	-1	1	1	3	2	4	1	3	1	1	2	1
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	7	2	2	2	2	1	2	3	2	3	6	1	3	1	1	1	1	1	3	1	1	2	2	2	1	1	2	2
	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]																												

MATRIX III (QUALITATIVE DATA). 127 OTU'S BY 90 CHARACTERS

```
1. 2 3 2 3 2 2 2 2 1 2 3 2 2 2 2 2 2 3 2 2 2 2 2 2 2 2-1 2 2 2 1 1 1 1 3-1
   1-1 1 2 2 2 2 2-1 2 2 2 1 1 2 2 3 2 1 5 2 2 2 1 2 2 1 2 1 2 3 2 2 3 1 2
   2 2 3 2 2 2 2 1 7 2 2 2 2 2 1 3 1 3
   2-1-1 2 1 2 2-1 2 1 3 3 3 2 2 2 1 1 2 1 2 2 1 1 2 2-1 2 2 2 2 2 2 4 2-1
   2-1 3 1 2 1 2 2 1-1 2 2 1-1 2 2 2 2 2 5 2 2 1 2 2 2 1 2 2 3 2 2 2 2 2 2
   2 2 2 2 1 2 2 2 7 2 2 2 2 2 2 1 3 1
   1 1 2 6 4 1 2 2 2 4 1 1 3 2 2 2 4 1 1 1 1 2 5 2 2 2-1 2 2 2 2 2 2 4 1 1
   3-1 3 5 2 5 2 2-1-1 2 2 1 2-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1
   1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1
   1 1 1 3 3 2 1 2 2 4 1 1 3 2 2 2 4 1 1 1 1 2 2 2 2 2 1 2 2 2 2 2 2 4 3-1
   1 1 3 4 1 3 1 1-1-1 2 2 2 2 2 2 1 2 3 5 2 2 1 2 2 2 2 2 1 2 2 2 2 2 1 1
   2 2 1 2 1 2 2 2 7 2 2 2 2 2 2 3 3 2
   1 1 2 3 2 2 2 2 2 2 3 3 1 2 2 2 3 1 1 1 2 2 2 2 2 2 1 1 1 2 2 2 2 2 1 1
   1-1 3 2 2 2 2 2-1 2 2 2 1 2 2 1 1 2 2 5 2 2 1 1 2 1 2 2 2 3 1 1 2 3 1 1
   2 2 1 2 1 1 2 2 7 2 2 2 2 2 2 3 3 1
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