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DESCRIPTION OF THE LARVAL STAGES OF THE DESERT DRAGONFLY *PARAGOMPHUS SINAITICUS* (MORTON), WITH NOTES ON THE LARVAL HABITAT, AND A COMPARISON WITH THREE RELATED SPECIES (ANISOPTERA: GOMPHIDAE)

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From a sample taken at Aguelman Timia (Niger) in 1980, 103 larvae pertaining to this sp., the only gomphid known from that area, were extracted. The ultimate instar and the 5 preceding instars were distinguished biometrically and morphologically. A detailed description of the ultimate instar, including scanning E.M. micrographs, is presented. By a morphological comparison with *P. cognatus* (Ramb., 1842), *P. genei* (Sel., 1841) and *P. lineatus* (Sel., 1850), it is shown that the structure of the prementum and of the last antennal segment are highly diagnostic. It appears that *P. sinaiticus* is more closely related to *P. genei* than to other spp. Some remarks on the larval habitat are also provided.

INTRODUCTION

Prior to 1978, *P. sinaiticus* was known in the literature from the types only. DUMONT (1978) added 4 new localities, 1 in Sinai and 3 from Air mountains (Niger), and transferred a former record of *P. cognatus* by FRASER (1950) from Mts Taraouaji (Niger) to this species. Table I gives further details on these localities. The morphology of the larval stages, however, remained unknown.

On 7 May 1980 a sample of 103 larvae, belonging to the genus *Paragomphus* (Cowley, 1934) was taken at a large Aguelman (= lake) in Timia, Central Air Mountains (Niger) (Figs 1-3). At the same locality, a number of ♂ *P. sinaiticus* were captured in 1977, this species being the only gomphid known from this station. Therefore, the larvae could unequivocally be equated with that species.

On 5 March 1977, a single exuviae, clearly belonging to the same species, had been found at Aguelman Teguiddâmo, Northern Air, Niger (Figs 5-6). There were no adults captured at this place. Three exuviae were collected in ghor Arbaat, close to the city of Port Sudan (Red Sea Hills, Sudan) on 21 December 1981. An adult specimen was seen but not captured.

Table 1
List of all known localities of *Paragomphus sinaiticus*

Locality	Specimens	Date	References
Wadi Isle, Sinai	♂♀	5-VII-1926	MORTON, 1929
Wadi Feiran, Sinai	♂	12-VII-1926	MORTON, 1929
Taraouaji Mts, Niger	♂	8-IX-1947	FRASER, 1950
Wadi Tlash, Sinai	♂♂	15-VII-1974	DUMONT, 1978
Aguelman Timia, Air, Niger (Figs 1-3)	♂♂	21-IX-1977	DUMONT, 1978
	larvae	7-V-1980	this paper
A. Tokolokouzet, Air, Niger	♂♂	12-IX-1977	DUMONT, 1978
A. Agamgam, Air, Niger (Fig. 4)	♂♀♂♂	17-IX-1977	DUMONT, 1978
A. Teguiddâmo, Air, Niger (Figs 5-6)	exuviae	5-III-1977	this paper
Ghor Arbaat, Red Sea Hills, Sudan	exuviae	21-XII-1981	this paper

For the description of the larval stages, both Scanning E.M. and Stereo L.M. techniques were used.

After a comparison with the exuviae it turned out that only one full-grown larva was present in the sample from Aguelman Timia, the other specimens belonging to different preceding instars. In order to reveal the exact number of instars, biometrical data were collected.

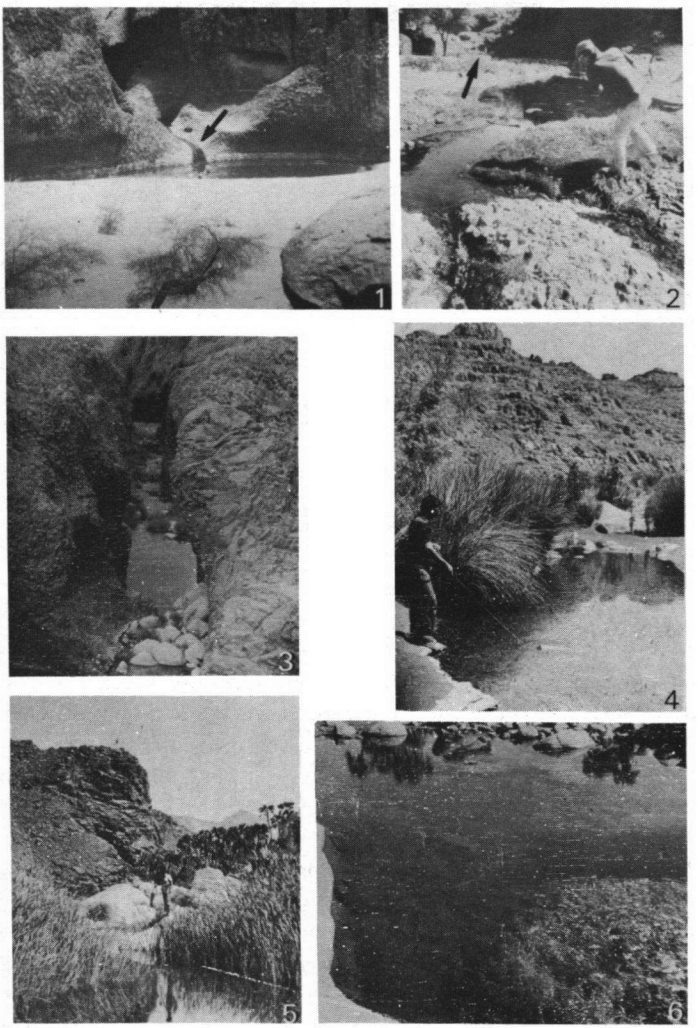
NOTES ON LARVAL HABITAT

Paragomphus sinaiticus belongs to the minority of gomphid species that breed in stagnant or near-stagnant permanent waters, a feature which it shares with its congener *P. genei*. However, it should be pointed out that at least the Air-biotopes are situated in a zone subject to summer monsoon rains. During summer, when adults are on the wing, oviposition occurs in conditions when temporary as well as permanent waterbodies are filled. How females distinguish between both is unknown.

The larvae collected in Timia were partly found in dense macrophyte vegetation, partly in bottom mud. All biotopes from which collections of larvae were made had moreover either dense stands of macrophytes or littoral fringes of *Typha*. Since submerged and emergent macrophytes tend to occur on permanent waterbodies only, their presence might be the indicator used by ovipositing females, and possibly oviposition takes place amidst the macrophytes themselves.

BIOMETRICAL DATA

The abdomen of the specimens preserved in formaldehyde was contracted and length and width of this part of the body turned out to be quite variable. Therefore only non-segmented, sclerotized parts were measured. Through correlation tests we could show that length and width of prementum and length of the third antennal segment were very suitable for our purpose.



Figs 1-6. Larval habitat of *Paragomphus sinaiticus:* (1-3) The main guelta (= lakelet) of Timia, situated at the foot of a huge basaltic wall (Fig. 1), through which a steep canyon has been cut (Fig. 3) by the waters of the spring of Timia (Fig. 2). The entrance of the canyon is indicated by an arrow in (2). Its end is the famous "waterfall" of Timia (1). A large number of larvae were collected at this site. (4) A richly vegetated guelta at Agamgam, Eastern Air. (5) Guelta of Teguiddamo in the fault valley of Tamgak, Northern Air, fringed by a rich *Typha*-stand. (6) Detail of the open water of Teguiddamo, showing the submerged and partly floating macrophyte beds. At this site an exuviae was collected.

The figures are plotted as histograms. Due to paucity of data it was not possible to split each graph into a number of Gaussian components by the method of BHATTACHARYA (1967). However, investigations on dragonfly life cycles (e.g. HASSAN, 1976 for *Urothemis assignata*) have shown that larval growth is exponential. Therefore the x-axis in the histograms was made logarithmic, and Figure 7 shows how this affects our data on the width of the prementum: 6 clearly distinct components appear.

The other measurements, if plotted in the same way, give analogous results. Our interpretation is thus that the material contains the full-grown larva and 5 preceding instars. These instars can also be distinguished on a morphological basis (cf. infra).

DESCRIPTION OF THE LAST INSTAR LARVA

Figures 8-11, 13, 15-22, 27

Material.— 1 specimen from Aguelman Timia and 1 exuviae from A. Teguiddâmo.

Measurements.— Total length: 26.30 mm (exuviae: 26.20 mm); length of abdomen: 18.71 mm (exuviae: 17.90 mm); maximum width abdomen: 7.69 mm; length of third antennal segment: 1.63 mm; length of prementum: 3.62 mm; maximum width of prementum: 3.19 mm.

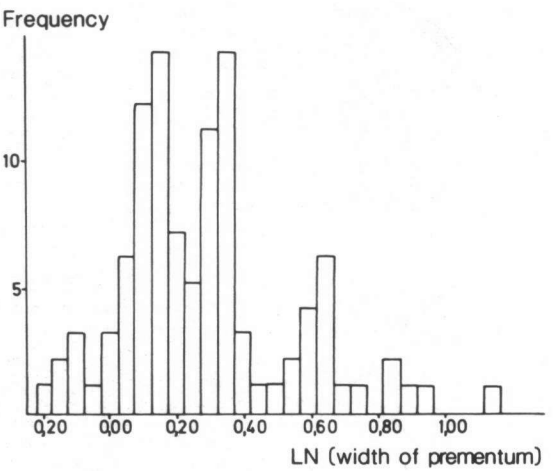


Fig. 7. *Paragomphus sinaiticus:* distribution of the width (in dorsal view) of the prementum of 103 larvae (six instars).

Description.— Colour ochraceous, abdomen with a well-marked brown pattern on segments 3-8: one short median streak, flanked on each side by one dot on the third segment and by 2 dots on segments 4-8. The 10 th segment bears 2 clearly marked dots at its base.

Hind-wing stubs about halfway along the fourth abdominal segment; both pairs of wing stubs rather divergent. Lateral spines well developed on segments 5--9, dorsal abdominal spines small.

Legs relatively short and stout. Femur of third leg with a triangular brown dot on the dorsal side, flanked by 2 longitudinal rows of spines.

Antenna four-segmented, with a crown of long hairs on top of the penultimate segment. Fourth segment relatively stout, about three times as long as wide.

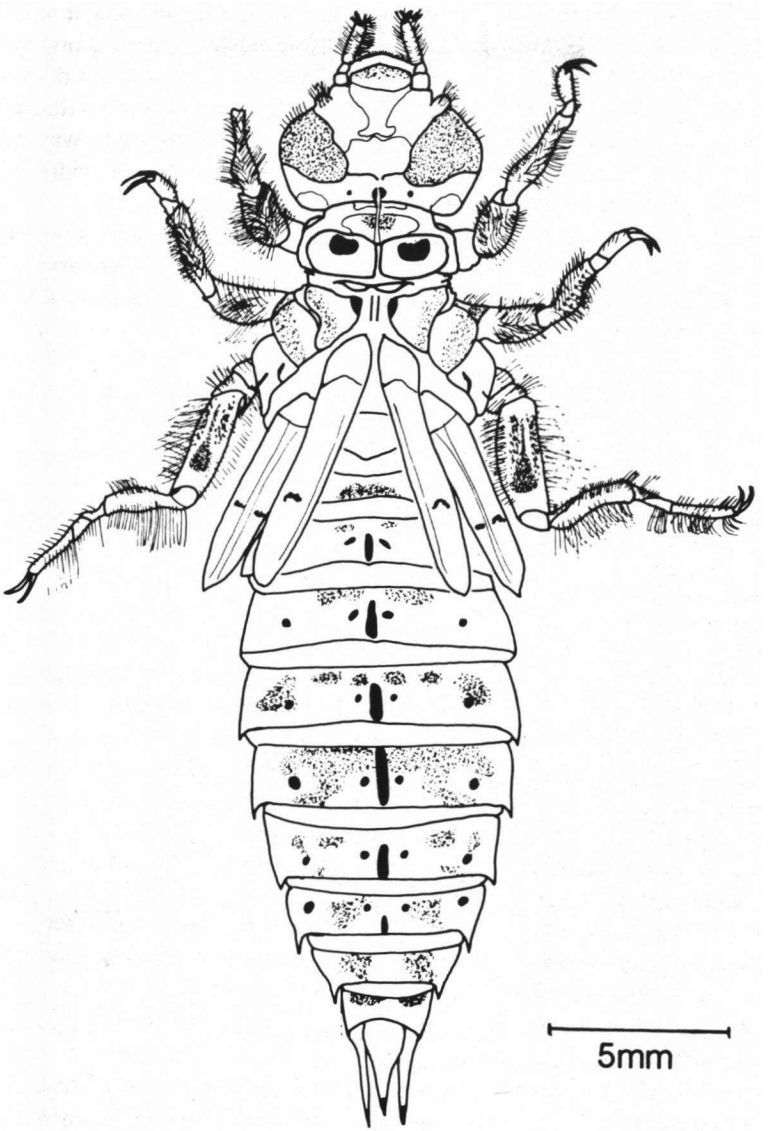


Fig. 8. *Paragomphus sinaiticus:* full-grown larva, dorsal view.

Anal pyramid: epiproct shorter than cerci, length of the paraprocts about 2.3 times the length of the tergite of the 10th abdominal segment. Left mandible (Figs 17, 19) in medial view with 4 stout, unequally sized teeth on the apex and

subapically with a crown of 2 stout and 4 smaller teeth. Near the base of this subapical crown, a broad field of both pointed and rounded papillae occurs. The former papillae are uni-, bi- or even trifurcate. The right mandible (Figs 18, 20) has 4 stout teeth on the apex. In mesial view, there is a subapical crown, formed by three relatively sharp teeth, and one isolated tooth near the base of the largest apical tooth.

Prementum robust, maximum width about 0.85 times the length. This part of the mask is studied as seen in a dorsal view. Median sulcus clearly marked, on the sides of the latter 2 elevations, on which a number of sense hairs occur. Two tufts of hairs are situated near the articulation of the palps; latero-apically 3 or 4 spines and a rat-tail like hair are present. Sides of the prementum each bearing a row of stout spines.

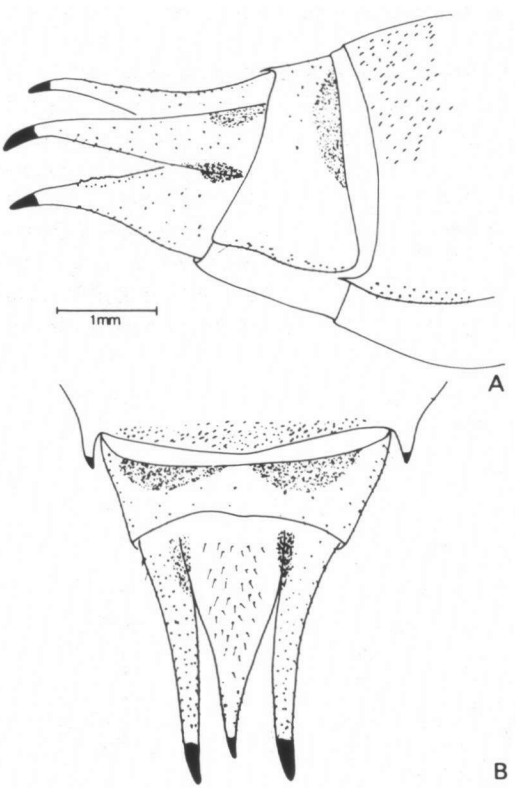


Fig. 9. *Paragomphus sinaiticus:* anal pyramid: (A) lateral view (right cercus and paraproct shown only); — (B) dorsal view (paraprocts omitted).

Median lobe rounded and projecting, with one row of piliform setae. A high concentration of sense papillae is found near the margin of the lobe (S.E.M.). The number of papillae decreases gradually at a certain distance from the border. Palps two-segmented, surface densely set with the same type of papillae, mainly on the inner margin of the proximal segment and scattered over the distal segment. It is noteworthy that these papillae occur in areas where contact with the prey is made. Papillae on the inner margin of the proximal joint are grouped in short linear series, perpendicular to its border. The proximal segment bears a processus on the middorsal side of the distal margin. On the side of the distal segment, near the joint, a field of small bumps can be detected. Its function is unknown.

COMPARISON WITH THREE RELATED SPECIES

PARAGOMPHUS GENEI (SELYS, 1841)
Figures 4 CD, 5 B, 14, 23-26, 28

The ultimate instar larva of this species is smaller: 20-23 mm (CORBET, 1957), 25 mm (CONCI & NIELSEN, 1956). The pattern of the abdomen differs also: the median streaks on segments 3-7 as well as the two dots on the basal side of the tenth segment are absent.

Left mandible (Figs 23, 25) with 4 stout, unequally sized apical teeth and with a subapical crown, consisting of 2 larger and 4 smaller teeth. In frontal view the curve of the latter is distinctly different from *P. sinaiticus*. Instead of a broad field of papillae (cf. *P. sinaiticus*), a narrow ridge of mainly pointed, unifurcate papillae occurs (Fig. 26). The right mandible also has 4 stout apical teeth and

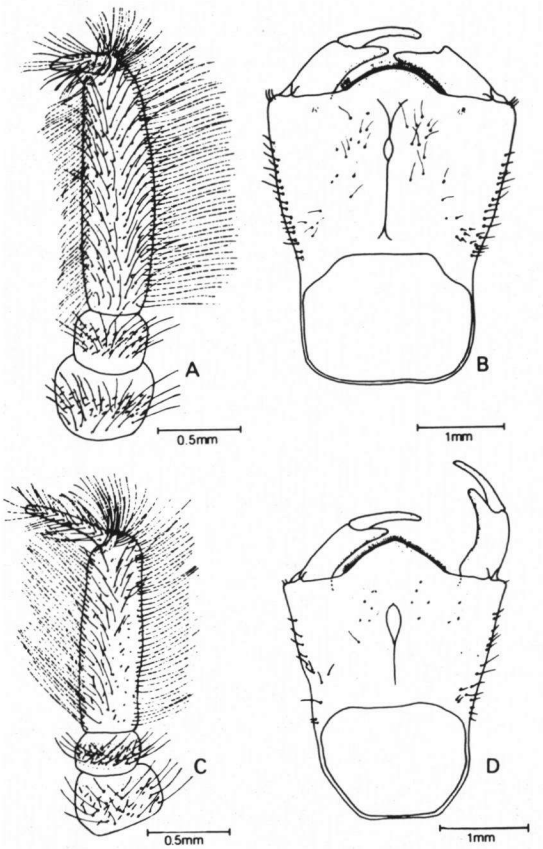


Fig. 10. *Paragomphus sinaiticus* (A-B) and *P. genei* (C-D): (A, C): antenna; — (B, D): prementum.

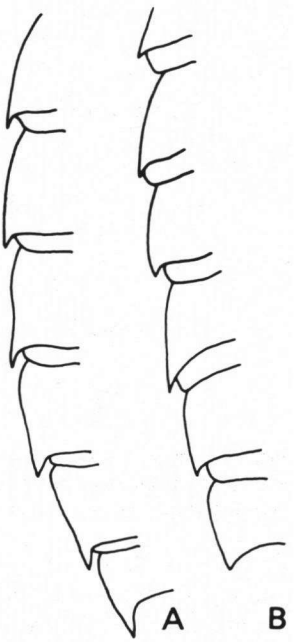


Fig. 11. Sides of abdomen in dorsal view: (A) *Paragomphus sinaiticus;* (B) *P. genei.*

a subapical crown, consisting of 3 pointed teeth, as well as an isolated subapical tooth near the base of the largest apical tooth. The morphology of the subapical crown in frontal view (Fig. 28) is somewhat different from that in *P. sinaiticus* (Fig. 20).

The last antennal segment is 5-6 times as long as broad.

The margin of the median lobe of the prementum clearly forms an obtuse angle. The two tufts of hairs near the articulation of the palps are absent in this species.

Paraprocts in lateral view about 2.5 times as long as the tergite of the tenth segment.

According to the morphology of the larva, *P. sinaiticus* is closely related to *P. genei.*

PARAGOMPHUS COGNATUS (RAMBUR, 1842)

In this species, the margin of the median lobe is rounded too, although it can easily be distinguished from *P. sinaiticus* by the very different shape of the terminal joint of the antenna (CORBET, 1957). The length of the paraprocts is about twice the length of the tenth segment. *P. cognatus* bears one row of middorsal dots on the abdomen.

PARAGOMPHUS LINEATUS (SELYS, 1850)

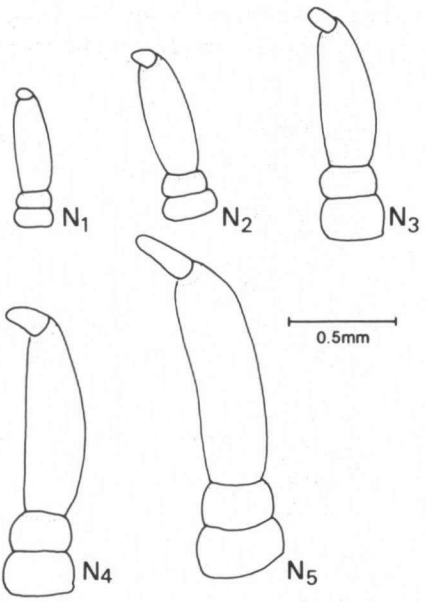
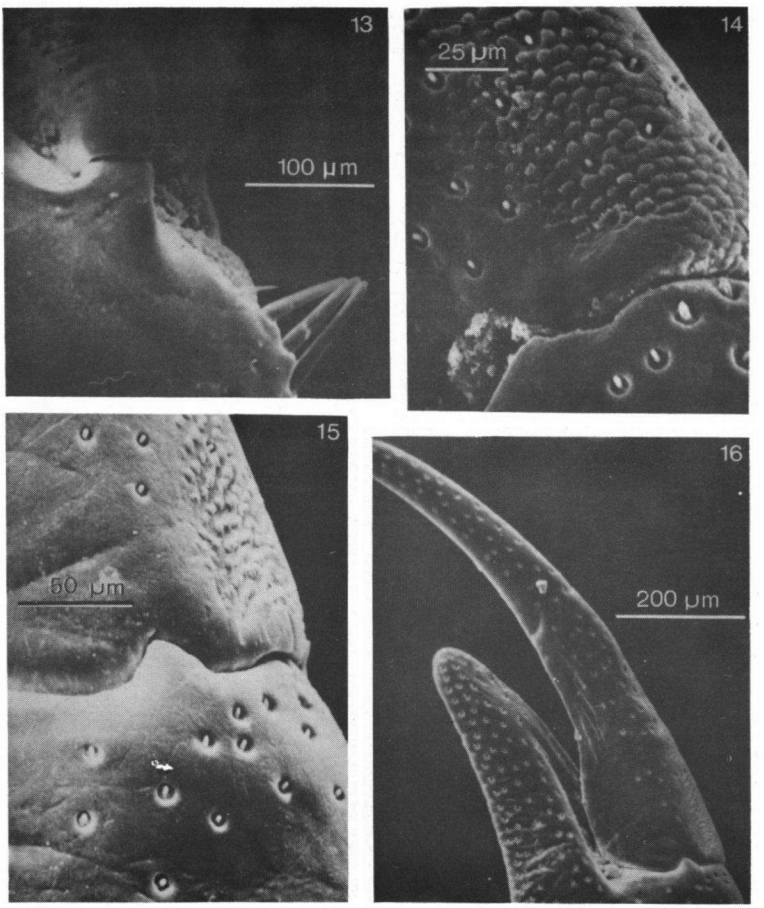


Fig. 12. *Paragomphus sinaiticus:* antennae of instars "N_1-N_5". (For definition of the instars cf. text).

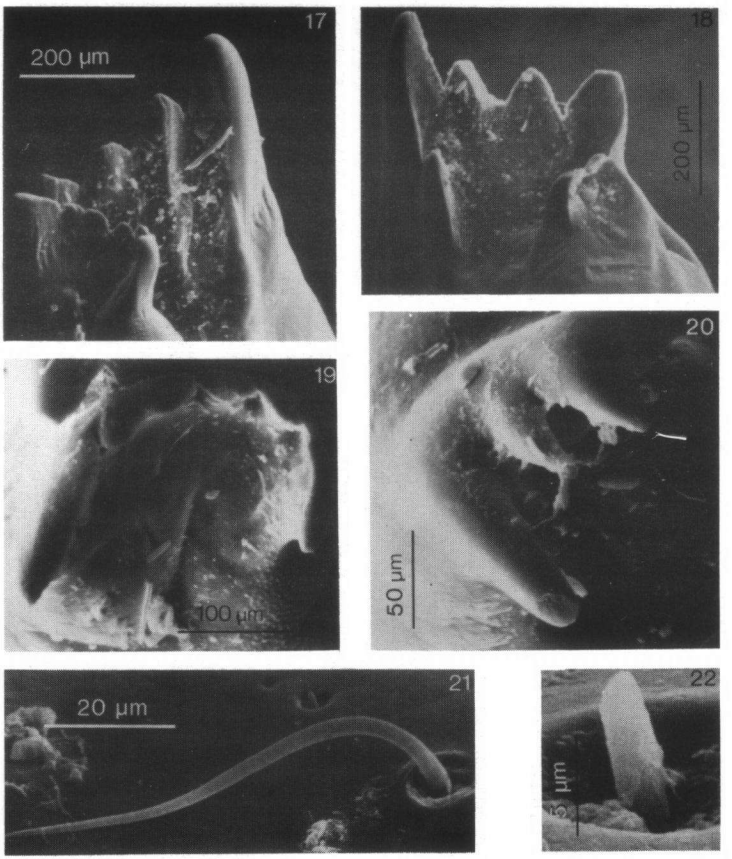
WATERSTON (1980) recently placed *P. sinaiticus* in synonymy with *P. lineatus,* stating that he compared specimens of the latter from various origins, but above all from the Arabian peninsula, with MORTON's (1929) types, but offering no figures and no morphological arguments for his decision. Upon comparing adult specimens of *P. lineatus* of both sexes from the Indian subcontinent (Nepal, terra typica) with topotypical examples of *P. sinaiticus,* marked differences were found in the structure of the anal appendages and the hamuli in the male, and in the armature of the vulvar aperture of the female. Waterston's synonymy is thus untenable and it would be interesting to find out how many of his Arabian specimens are really



Figs 13-16. *Paragomphus sinaiticus* (Figs 13, 15, 16) and *P. genei* (Fig. 14), full grown larvae: (13) articulation of premental palp; — (14-15) articulation of distal segment of premental palp; — (16) distal segment of premental palp.

P. sinaiticus. Arabia is indeed an area where this species can naturally be expected to occur.

We were unable to investigate the full-grown larvae of *P. lineatus*, but relying on the description by LIEFTINCK (1934), striking differences with *P. sinaiticus* occur: abdomen slender, lateral sides almost parallel, median lobe of prementum with an obtuse angle as in *P. genei*, terminal antennal joint about 4 times as long as its basal width and body-length scarcely reaching 23 mm.

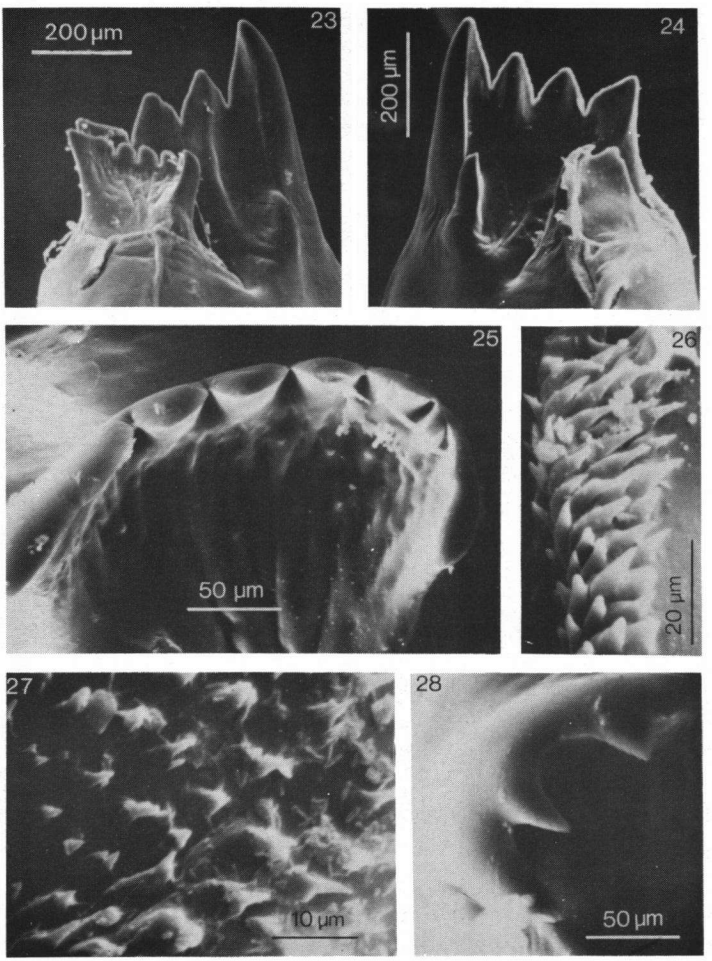


Figs 17-22. *Paragomphus sinaiticus*, full grown larva: (17) tip of left mandible, inner surface; — (18) right mandible, inner surface; — (19) left mandible, frontal view of subapical crown; — (20) right mandible, frontal view of subapical crown; — (21) rat tail-shaped hair on flanc of prementum, close to apex; — (22) sensitive papilla on prementum.

DESCRIPTION OF THE FIVE PRECEDING INSTARS

As the total number of instars in this species is unknown, the larval stages available will be referred to as N_1-N_5, N_6 being the full-grown larva. All material from Aguelman Timia (Niger). Number of specimens & measurements are presented in Table II.

N_1 (Figs 25-26). — Terminal segment of the antenna almost spherical; wing stubs not reaching the first abdominal segment. Lateral abdominal spines present, abdominal colour pattern not specific. Processus on the middorsal side of the distal border of the proximal segment (prementum palp) absent. This segment clearly notched on its inner margin. There are only three hairs present as



Figs 23-28. *Paragomphus genei* (Figs 23-26, 28) and *P. sinaiticus* (Fig. 27), full grown larvae: (23) tip of left mandible, inner surface; — (24) tip of right mandible, inner surface; — (25) left mandible, frontal view of subapical crown; — (26) ridge of papillae situated near the base of the subapical crown of the left mandible; — (27) field of papillae situated near the base of the subapical crown of the left mandible; — (28) right mandible, frontal view of subapical crown.

a small tuft, near the attachment of the palp.

N_2. — Hind-wing stubs reaching first abdominal segment. Terminal antennal segment longer than broad. Colour pattern on the third to tenth abdominal segments clearly marked and specific.

N_3. — Hind-wing stubs reaching halfway along the first abdominal segment. Terminal joint of the antenna cylindrical.

Table II
Measurements (mm) of larval instars of *Paragomphus sinaiticus*

Instar	Number of specimens	Length of prementum	Width of prementum	Length of 3rd antennal joint
N_1	7	0.98 ± 0.05	0.89 ± 0.04	0.41 ± 0.02
N_2	45	1.29 ± 0.08	1.14 ± 0.07	0.52 ± 0.04
N_3	31	1.57 ± 0.07	1.40 ± 0.06	0.64 ± 0.04
N_4	14	2.07 ± 0.10	1.85 ± 0.09	0.85 ± 0.04
N_5	5	2.68 ± 0.12	2.30 ± 0.15	1.10 ± 0.07

N_4. — Hind-wing stubs reaching halfway along the second abdominal segment. Fore-wing stubs reaching halfway along the first segment. Terminal joint of antenna about 1.5 times as long as broad.

N_5. — Hind-wing stubs reaching caudal side of the second abdominal segment. Fore-wing stubs about halfway along this segment. Terminal segment of the antenna about 2.5 times as long as broad, and more narrow at its tip.

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