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Keys to adult and immature Hydropsychinae in the Ivory Coast (West-Africa) with notes on their taxonomy and distribution¹⁾

(Insecta: Trichoptera)

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Abstract

The caddis fly subfamily Hydropsychinae, almost exclusively represented by its genus *Cheumatopsyche*, is very dominant on rapids of West African streams. It is a predator of the *Simulium damnosum* complex, the vector of human onchocerciasis in this region, and is threatened by a long term insecticide treatment against this vector carried out in the Onchocerciasis Control Programme.

This situation requires some basic work, presented here, which will enable future studies of this subfamily. This study is based on samples collected at more than 100 localities throughout the Ivory Coast.

In addition to taxonomic considerations related mainly to the assignment of larvae, females, and males three new species of the genus *Cheumatopsyche* are described. Then keys, including many illustrations, are presented which deal with females, males, larvae, and, less comprehensively, pupae of Hydropsychinae at present available. The larval key also emphasizes those characters which can be used for the identification of younger instars. The taxonomic results indicate that larval characteristics in particular will be helpful in a future systematic revision of the African forms of the genus *Cheumatopsyche*, which seems necessary as a consequence of this study. Finally the distribution of the Hydropsychinae species in the Ivory Coast is considered. It is generally congruous with the zones of savannah, non-mountainous forest, and mountains. This distribution is assumed to be influenced mainly by the factors: length of periods without flow, interspecific aggression of larvae, stream type, and water temperature.

1. Introduction

Rapids of running waters in West Africa may be populated by a large number of caddis fly larvae of the family Hydropsychidae, most frequently represented by the subfamily Hydropsychinae and its genus *Cheumatopsyche*. In various rivers maximal densities of about 1 000 (HYNES 1975), 7 000 (PETR 1970), 30 000 (STATZNER 1982), or 250 000 (GIBBS 1973) individuals/m² were found at the surface of the substratum in certain seasons, numbers that may be doubled if hyporheic densities are also considered (STATZNER 1982). These high figures, together with the considerable size and thus biomass reached by the representatives of this genus, put *Cheumatopsyche* in a dominant position within the benthic macroinvertebrate communities in rapids.

Apart from the general ecological importance of the genus *Cheumatopsyche* in West Africa special interest is focussed on this group with respect to its predation on immatures of the *Simulium damnosum* complex (BURTON & McRAE 1972, SERVICE & LYLE 1975, SERVICE & ELOUARD 1980), the vector of human onchocerciasis (river blindness) in Western Africa (NELSON 1970).

¹⁾ The field studies and parts of the laboratory studies were carried out during a period of WHO consultancy in the Onchocerciasis Control Programme.

In 1974 regular insecticide spraying against this vector was introduced by the Onchocerciasis Control Programme (OCP), covering up to 14 000 km of rivers in an area of 700 000 km² (DAVIES et al. 1978). In the meantime the operational area has been steadily extended and the whole campaign is planned for a period of 20 years. Naturally this operation was highly controversial giving rise to discussions about human welfare with relation to ecological impacts (ASIBEY 1975, 1977, SERVICE 1976, 1977). The ecological impact of the operation should be ascertained by three hydrobiological teams in a monitoring programme (LEVEQUE et al. 1977).

Since the quality of such a monitoring programme as well as of general ecological studies of streams in non-operational areas of the region depend on the level to which the material studied can be identified, I started to work on keys for the Hydropsychidae in 1977, which for the above mentioned reasons is urgently needed. This paper is restricted to the Hydropsychinae, while a second one, planned for the future, will consider the Macronematinae, the second subfamily of the Hydropsychidae present in the Ivory Coast. If possible I tried to prepare these keys, which consider females, males, larvae, and, with restrictions, pupae, in a way that characters can be seen under the stereomicroscope, in order to accelerate routine identification of large quantities of material. However, the use of a compound microscope is sometimes necessary. Since comparable comprehensive keys to African Hydropsychinae do not yet exist, it is hoped that the keys published here offer characters which will also enable species discrimination within this group in other African regions.

Since some of the species collected in the Ivory Coast are new to science, they will be described here.

Although the necessity of a systematic revision of the current African *Cheumatopsyche* becomes evident from the results presented here, the level of present knowledge is insufficient for this purpose. Thus this topic is only briefly discussed.

Furthermore the distribution of the species considered here, which were collected at more than 100 places scattered over the whole Ivory Coast, will be presented in order to document the presence of this portion of the benthic fauna before the expansion of the operational area of the OCP. Combined with the results of QUILLEVERE (1979) on Simuliidae this gives further information about the general distribution pattern of freshwater insects in this region.

2. Methods and the study area

In the taxonomic part of this study larvae were assigned to adults with the help of mature pupae, from which the larval exuvia and the genitalia can be obtained. In most cases females were assigned to males via the larval exuviae of female and male pupae. If the assignment of sexes was not possible in that way, it was based on sex independent morphological characters as well as on the method of model copulation described by STATZNER (1975).

At each station the material was collected by benthic sampling, light trapping, or both.

Benthic sampling was restricted to periods of medium and low discharge of the stream under study. In the main rainy season a comprehensive sampling of benthos was impossible. Since absolute as well as relative abundances of *Cheumatopsyche* spp. change with the discharge regime (STATZNER 1982), less abundant species, which might have been missed at a particular place, are probably easily found at the same locality in a different hydrological season. Benthic sampling at a station covered a period from about 30 min. (helicopter surveys), up to several hours (field trip with the car) and took into account as many microhabitats as available at that point in a stream. Considerably more emphasis, however, was laid on sampling in swift flowing water than in slow flowing or standing water, since *Cheumatopsyche* usually lives in places with faster currents. Hopefully the objection that the determination of the larvae of stream insects is not sufficiently accurate (MALICKY 1980) to give distribution maps will be negated by the following key on larva.

Lumogaz lamps standing in white plastic basins containing water and detergent were used as light traps. These traps were usually run two to three hours after nightfall, most frequently beside a rapid of a stream. The significance of light trap catches is viewed differently by various authors. While MALICKY (1980) proposed to determine even the saprobic degree of streams based on light trap data, NOVAK (1981) and others demonstrate that light traps missed a certain portion of the caddis fly fauna. The latter may occur especially at certain hydrological seasons in the study area, as is reviewed by BELLEC (1976) for West African Simuliidae. Thus light trap data also have limitations, and

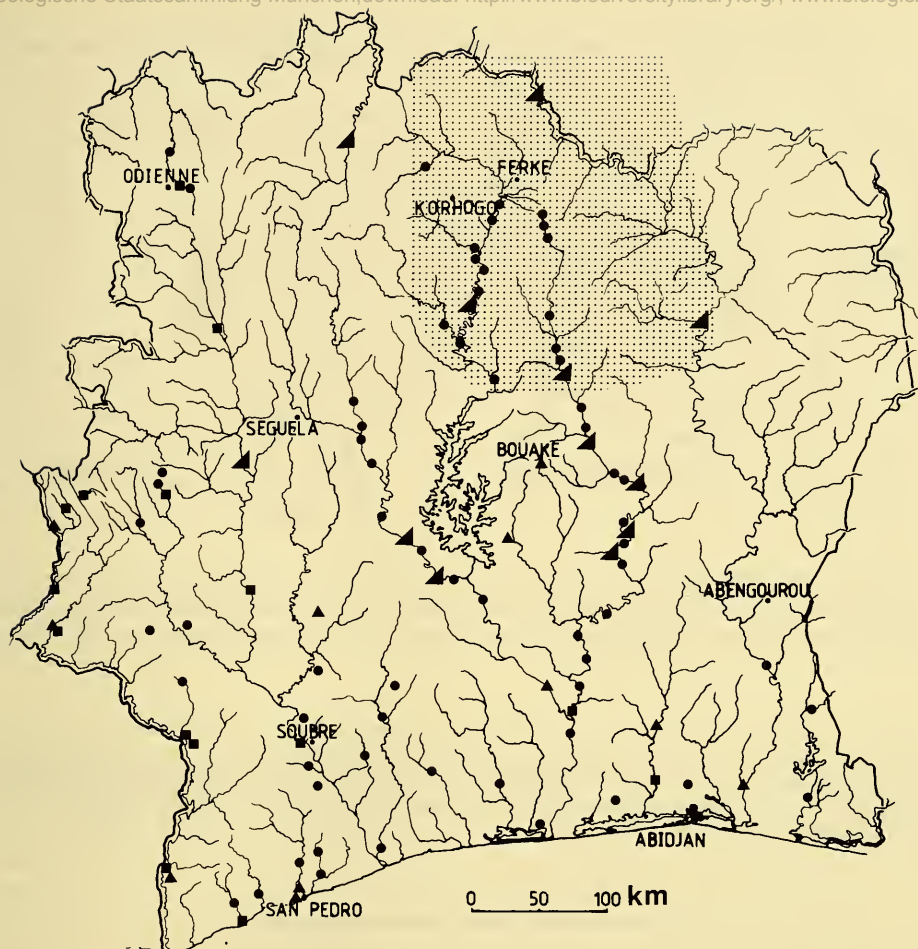


Fig. 1: Streams in the Ivory Coast and the sampling stations. ▲: monitoring station (monthly benthos and light trap sampling over longer periods); ●: benthos samples; ▲: light trap samples; ■: benthos and light trap samples. The shaded area indicates stations, from which no samples from the period before the insecticide treatments of the Onchocerciasis Control Programme were available.

probably the most reliable information in this study was obtained for places where both benthic and light trap samples were collected, especially if the station was visited at monthly intervals. This was the case at the established monitoring stations (Fig. 1), while the other places were usually visited only once or twice.

The distribution of the sampling places over the Ivory Coast is shown in Fig. 1. Apart from a smaller area in the North collections were possible in areas not yet treated by the OCP. Smaller streams, in particular, were more frequently sampled in the South than in the North of the country. This was due to the fact that the duration of the dry season increases from the South to the North, leading to the drying up of these running waters particularly northeast of the annual 1500 mm isohyet (Fig. 2). These intermittent streams could therefore be sampled only during a relatively short period of the year.

The border between forest and savannah, also included in Fig. 2, is to some extent arbitrary since the limit between these two vegetation types cannot be determined very exactly in the areas concerned here. Applying the typology of SIOLI (1975) "black water" streams were found most frequently in the forest region and "white water" streams were found most frequently in the savannah region. "Clear water" streams are typical for the mountain

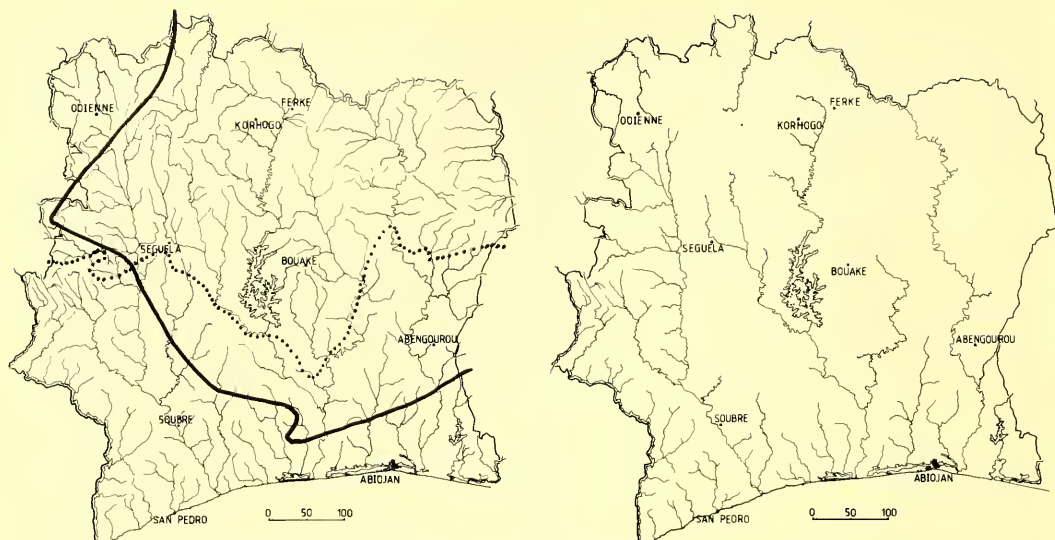


Fig. 2: The stream net in the Ivory Coast in the main rainy season (left) and in the dry season (right). The solid line indicates the annual 1500 mm isohyet, north-east of which lower, and south-west higher, precipitation is recorded. The dotted line marks the borderline between the forest (South) and the savannah (North) region. The stream net maps are drawn from copies of maps prepared by Y. SECHAN.

region near Man, which is situated about 100 km east south east of Seguela (Fig. 1). This classification is, of course, very rough and exceptions to the above distribution of stream types as well as transitions between them occur.

These are the essentials of the structure of the study area, necessary to understand what will be discussed with respect to the distribution data. More abundant and detailed information on the study area was published by QUILLEVERE (1979) and QUILLEVERE et al. (1976, 1977).

3. Taxonomy of the *Cheumatopsyche* spp.

This chapter is not essential for the reader who only wants to use the following keys. It gives brief descriptions of the new species as well as some short notes on already known species. Since most of the information on the individual species is included in the illustrations of the keys, I will restrict this taxonomic part to additional information which is not dealt with in the keys and to a short discussion of taxonomic considerations.

The material is stored partly in my own collection and partly in the collection of the „Zoologische Staatssammlung München“ (Tab.).

Before I deal with individual species or species groups I want to mention that all females possess that “curious reticulated area” on the abdomen described by KIMMINS (1960).

3.1 *C. digitata* (Mosely), *C. falcifera* (Ulmer), *C. copiosa* Kimmins

Probably due to their frequent coexistence as well as to their similar wing colouration some confusion occurred in the literature concerning the assignment of males, females, and larvae of these three species.

The female figured as *C. falcifera* by MARLIER & BOTOSANEANU (1968) is identical to the female of *C. digitata*. I agree with GIBBS (1973) that *C. leloupi* Jacquemart is doubtfully distinct. The anterior

Table: The material is deposited in my collection (x) or in my collection as well as in the collection of the Zoologische Staatssammlung München (O). The numbers refer to the numbers in my collection.

	No.	male	female	larva	pupa
<i>Cheumatopsyche sexfasciata</i>	169	o	o		
" <i>albomaculata</i>	170	x	o	o	x
" <i>digitata</i>	171	o	o	o	o
" <i>gibbsi</i>	172	o	o		
" <i>falcifera</i>	173	o	o	o	o
" <i>akana</i>	174	x	o		
" <i>copiosa</i>	175	o	o	o	o
" sp. II	176			o	x
" sp. I	177				o
" <i>pfundsteini</i>	178	x ^{a)}		x	x
" <i>lestoni</i>	179	x ^{a)}		o	x
" sp. VIII	180			o	
" sp. VI	181			o	
<i>Hydropsyche</i> sp.	182			o	
<i>Cheumatopsyche</i> sp. XI	183			x	
<i>Cheumatopsyche</i> sp. XII	184			x	

a) genitalia from mature pupae

margin of the frontoclypeus of the larva depicted by the same author (JACQUEMART 1957, Fig. 64) under the name *Cheumatopsyche* sp. and depicted by CORBET (1958) under the name *C. falcifera* resembles that of *C. digitata*. The material of CORBET (larvae, male, and female as well as larval exuviae incorporated in the cases from which the adults emerged from) is not available at the moment and therefore no definite conclusions are possible. Nevertheless I am convinced, that the larva described by CORBET was not correctly assigned to the adults and therefore is not *C. falcifera*. A check of adult specimens collected by CORBET in Uganda, which were determined by KIMMINS as *C. falcifera*, showed, that the illustration of the female genitalia of this species given by KIMMINS (1963) seems to be a little simplified with respect to the shape of the clasper receptacle. The material I have seen from Uganda and that from the Ivory Coast is conspecific and must be regarded as *C. falcifera*. This also holds true for the material I have checked, which was collected by GIBBS (1973) in Ghana and is named by that author *Cheumatopsyche* sp. A ("*falcifera* complex").

C. copiosa from the Ivory Coast was compared with paratypes of that species from Uganda and proved to be conspecific. Within the larvae there exists some disagreement in the shape of the anterior margin of the frontoclypeus. While the illustration given by CORBET (1958) is identical with that given for the material from the Ivory Coast here, that given by HICKIN (1956) differs. An investigation of HICKIN's material showed, however, that the shape of the anterior margin of the frontoclypeus is as it is depicted by CORBET and observed in this study if the larva's head is regarded exactly from the dorsal aspect.

3.2 *C. albomaculata* (Ulmer)

In Fig. 88 given by JACQUEMART (1957) two characteristic structures of the female genitalia of this species can be recognized: the large projection on the caudal margin of the ventral sclerite VIII as well as

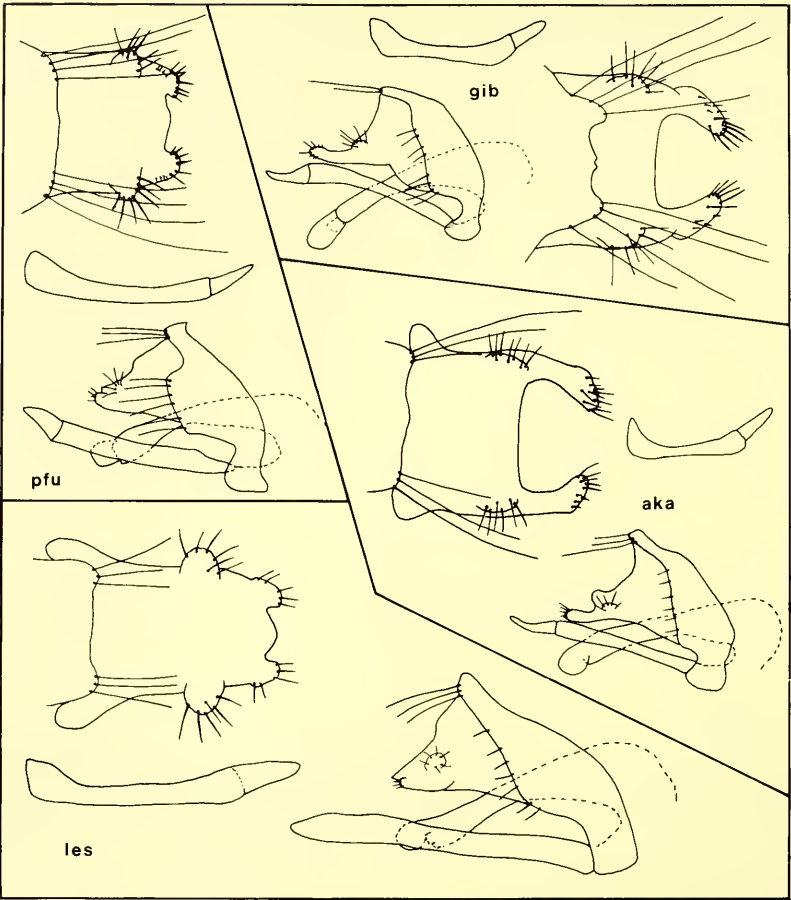


Fig. 3: Male genitalia from the lateral, parts from the dorsal, and clasper from the ventral view of *Cheumatopsyche pfundsteini* n. sp., *C. gibbsi* n. sp., *C. akana* n. sp., and *C. lestoni*.

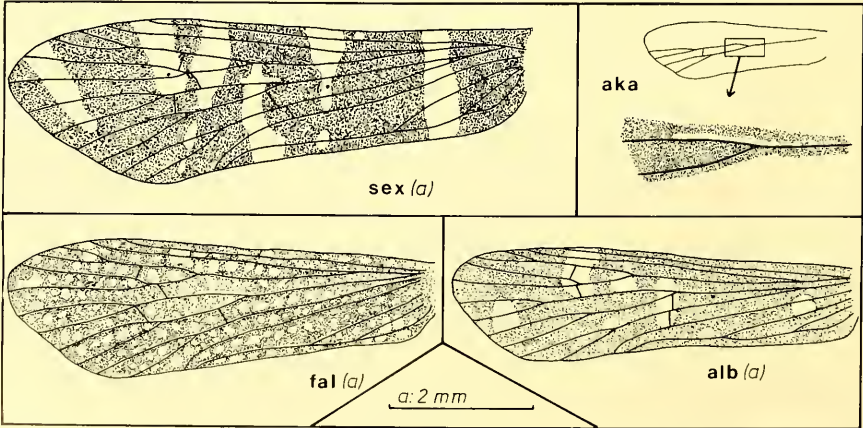


Fig. 4: Colouration of the forewing of *Cheumatopsyche sexfasciata*, *C. akana* n. sp., *C. falcifera*, and *C. albo-maculata*.

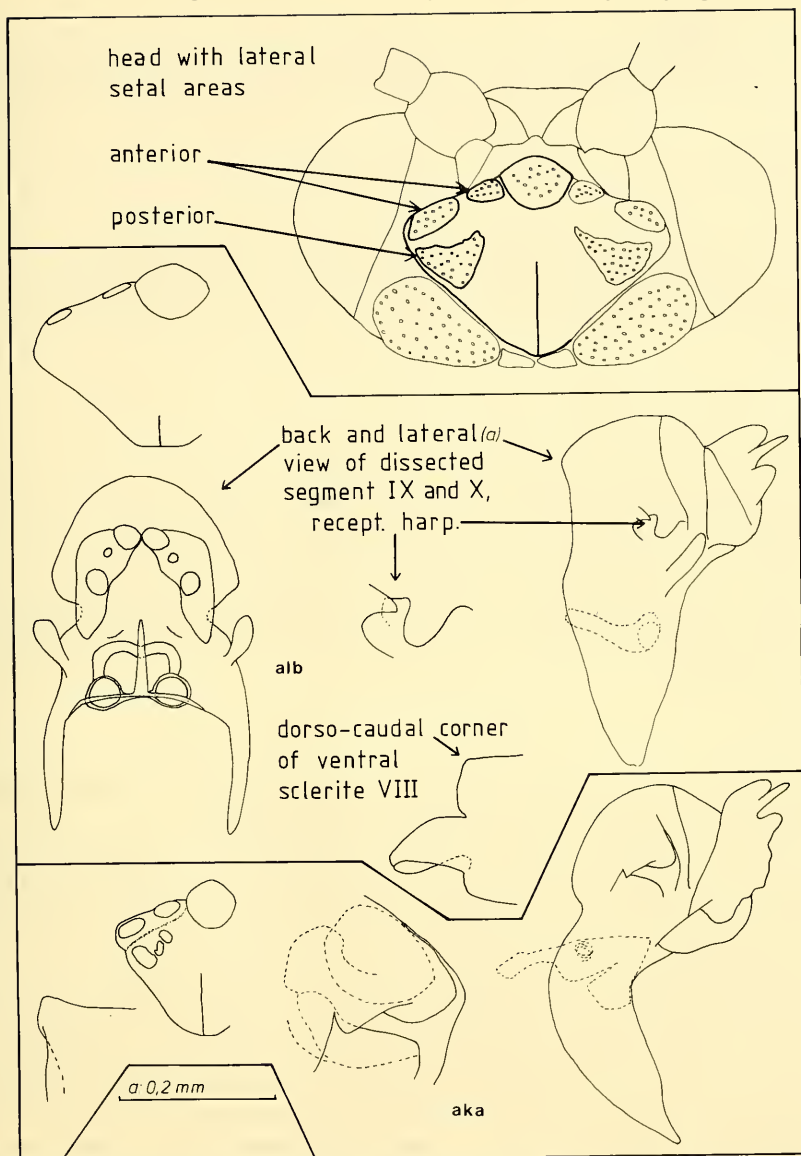


Fig. 5: Characters of the females of *Cheumatopsyche albomaculata* and *C. akana* n. sp.. The area surrounded by a thick line on the dorsal aspect of the head is repeated for each of the species.

the claviform projection at the side of segment IX. Similar structures within African *Cheumatopsyche* are found only in *C. lesnei* (Mosely), described by KIMMINS (1957) as *C. uncata* and synonymized later by the same author (KIMMINS 1960). The male genitalia of *C. lesnei* is similar to that of *C. albomaculata*. The larva of *C. albomaculata*, described here for the first time, is, together with that of *Cheumatopsyche* sp. VIII, very different from the known African *Cheumatopsyche* spp.

3.3 *C. sexfasciata* (Ulmer)

There were no problems in identifying the material from the Ivory Coast with the illustrations given by KIMMINS (1963).

3.4 *C. lestoni* Gibbs

In 1973 GIBBS described and illustrated the male of this species from a single specimen. Since the append. digit. is not visible in the lateral aspect of that description, the second male specimen of this species now known from the Ivory Coast is drawn in Fig. 3 & 7. The larva of *C. lestoni* is described here for the first time.

3.5 *C. gibbsi* n. sp. and *C. akana* n. sp.

GIBBS (1973) reported a *Cheumatopsyche* sp. B from Ghana which he was not able to differentiate from other known species. This sp. B was found in two forms, a "black form" and a "marbled form", which besides differences in the wing colouration have a differently shaped segment X in the male genitalia. Intermediate forms in the wing colouration were also described by GIBBS. Since both forms also seemed to be present in my material, I reexamined males and females collected by GIBBS, thereby assuring conspecificity between the material from Ghana and the Ivory Coast. With the knowledge of the function of the different genital characters now available (STATZNER 1975) it is evident that both forms are distinct new species.

3.5.1 *C. gibbsi* n. sp.

Holotype: 1 male, 17/4/1977, Boa River, about 3 km downstream of the village Vialadougou.

Paratypes: males and females from the same place and the same date.

Setal areas on head as in Fig. 6; segments of maxillary palp in the ratio 1:1.3:1.2:1.4:6.2; length of forewing: 6.2 mm; male genitalia as in Fig. 3 & 7; distance from the articulation between basis of phallus and coxopodit to a) tip of harpago: 0.507 mm, b) tip of append. digit.: 0.400 mm, c) proximal basis of lip at opening of ejaculatory duct (cavit. duct. ejac.)²⁾: 0.271 mm; female genitalia as in Fig. 6; distance from recept. append. digit. to the end of recept. harp.: 0.214 mm.

According to GIBBS (1973) his *Cheumatopsyche* sp. B is close to *C. urema* Mosely and *C. afra* (Mosely). *C. urema* (see MOSELY 1936, KIMMINS 1960, MARLIER 1961) differs from *C. gibbsi* in the following characteristics of the male genitalia: the harpago does not protrude as far beyond the tip of the append. digit. in *C. gibbsi*, and the zona cent. dors. is much less distinct in *C. gibbsi* in lateral view. The holotype of *C. afra* also possesses a much more distinct zona cent. dors. in the lateral view, furthermore the append. digit. are shorter and not so strongly curved (dorsal view) in *C. afra* as in *C. gibbsi*. *C. akana* differs from *C. gibbsi* in that the zona cent. dors. does not protrude (males). The females can be differentiated by the shape of the margin of the recept. harp. (microscope!) and the medial plate.

At the same locality and date the type material was captured, larvae of *Cheumatopsyche* sp. VI were found.

3.5.2 *C. akana* n. sp.

Holotype: 1 male, 2/7/1977, Cavally River, about 3 km downstream of the village Tai.

Paratypes: Females from the same place and date. Setal areas on head as in Fig. 5; segments of maxillary palp in the ratio 1:1.7:2.1:1.8:6.5; length of forewing: 5.2 mm; male genitalia as in Fig. 3 & 7; di-

²⁾ Terms which are not explained in the chapter "keys" are described in STATZNER (1975).

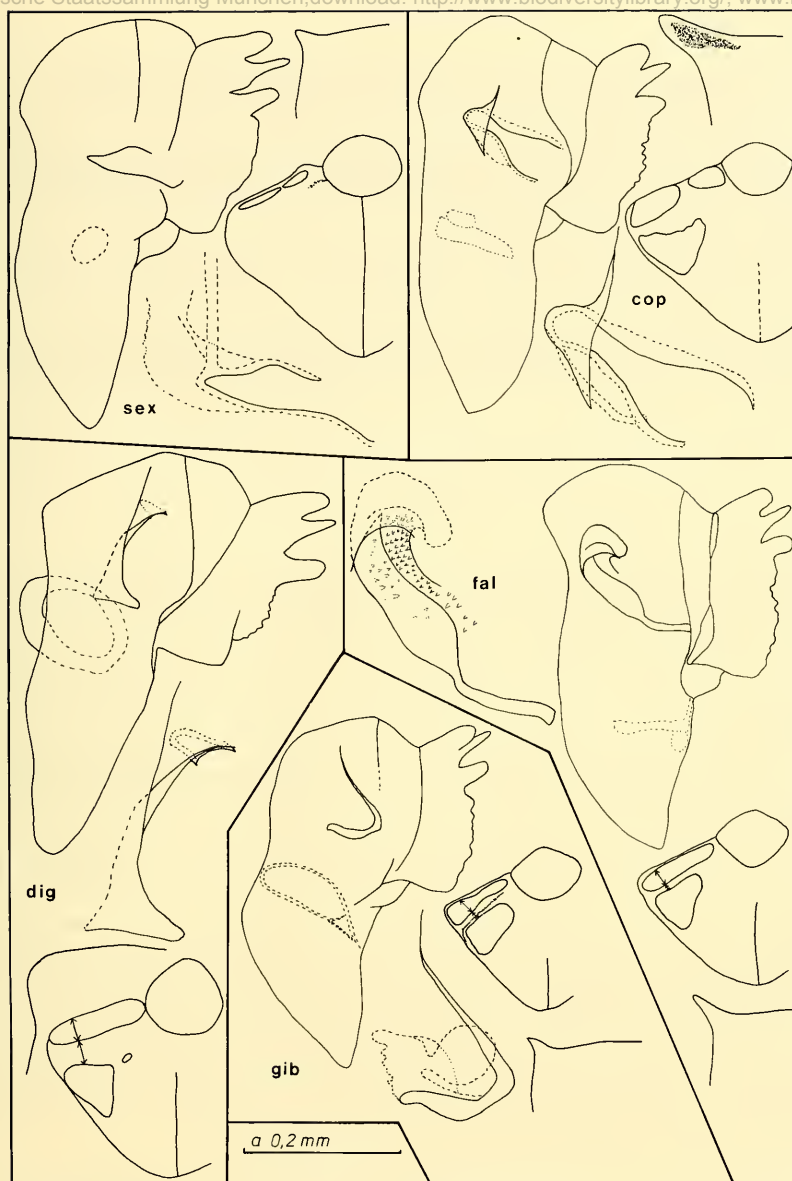


Fig. 6: Characters of the females of *Cheumatopsyche sexfasciata*, *C. copiosa*, *C. digitata*, *C. falcifera*, and *C. gibbsi* n. sp.

stance from the articulation between basis of phallus and coxopodit to a) tip of harpago: 0.484 mm, b) tip of append. digit.: 0.354 mm, c) proximal basis of lip at opening of ejaculatory duct: 0.277 mm; female genitalia as in Fig. 5; distance from recept. append. digit. to the end of recept. harp.: 0.210 mm.

The male genitalia of *C. akana* resembles *C. kissi* Marlier. In the lateral view *C. akana* differs from the illustration of that species (MARLIER 1961) by its longer append. digit. and the position of the zona spinosa.

3.6 *C. pfundsteini* n. sp.

Holotype: 1 mature male pupa, 3/7/1977, brook in the forest near the village Tai.

Paratypes: 1 immature pupa and 1 larva from the same place and date.

Ratio of the segments of the maxillary palp and length of forewing cannot be measured with certainty; male genitalia as in Fig. 3 & 7; distance from the articulation between basis of phallus and coxopodit to a) tip of harpago: 0.754 mm, b) tip of append. digit.: 0.522 mm, c) proximal basis of lip at opening of ejaculatory duct: 0.381; larva as in Fig. 9 & 14.

The lateral aspect of the male segment X of *C. pfundsteini* resembles that of the holotype of *C. afra* (Mosely), *C. aterrima* Marlier, *C. boettgeri* Statzner, and *C. obscurata* (Ulmer). In the holotype of *C. afra* the zona spinosa is closer to the basis of the append. digit. than in *C. pfundsteini*. Apart from the characteristic position of the zona spinosa and the shape of the zona cent. dors. the other three species mentioned above are distinctly different from *C. pfundsteini* in the dorsal aspect of segment X.

4. Keys

Keys to females, males, and larvae are given separately below with additional short notes for the identification of pupae. Each of these separate keys is preceded by a short evaluation of the main characters used for species discrimination. Apart from very familiar terms, those used in the keys will be explained in the first illustration dealing with the group considered. The terminology used here is a mixture of generally accepted terms for the whole order Trichoptera and well-defined terms for Hydropsychidae.

A general introduction to the morphology of Trichoptera is written by MALICKY (1973) and by MARLIER (1962, 1981a) for families present in tropical Africa. The genital morphology of Trichoptera is described in general by NIELSEN (1957, 1980), while TOBIAS (1972) and STATZNER (1975) draw special attention to Hydropsychinae. For further information on the morphology of immatures the reader is referred to BADCOCK (1961), HICKIN (1967), LEPNEVA (1970), WIGGINS (1977), and WILLIAMS & WIGGINS (1981).

Whether the caddis fly in question belongs to the Hydropsychinae or not can be ascertained by using the keys of MARLIER (1962, 1981a) and GIBBS (1973, larvae!). Furthermore a key to the genera of African Hydropsychidae is being prepared by Dr. K. M. F. SCOTT and will be published in the near future.

KIMMINS (1960) has already published a key to the males of African species of *Cheumatopsyche*.

The presence of the genus *Hydropsyche* in the Ivory Coast is documented by larvae, but no adults were collected. Thus the keys to females and males lack the discrimination between the genera *Hydropsyche* and *Cheumatopsyche*. Both genera can be differentiated by a character in the hindwing, where the median cell is closed (*Hydropsyche*) or open (*Cheumatopsyche*).

4.1 Females

The over-all colouration of the forewing is quite constant, the variation is mainly restricted to the size of single coloured patches. The shape and size of the setal areas on the head, a valuable character for species discrimination (MACAN 1973), varies even in specimens from the same locality. However, the characters mentioned in the key proved to be constant in the material investigated in this study. Very little variation (exception: *C. digitata*) was found in the general appearance of the dorso-caudal corner of the ventral sclerite VIII and of the segments IX and X. Only in the shape of the margin of the clasper receptacle (recept. harp.) were there some minor variations, which did not exceed the variation of this structure described for *Hydropsyche* (TOBIAS 1972).

Key

- 1 Colour of forewing dark, with few light patches or only one light area 2
- 1⁺ Colour of forewing lighter, forewing marbled, with many more or less distinct light patches (Fig. 4, fal) 4
- 2 A light area in front of media of forewing; posterior lateral setal area present, frequently divided into smaller single sub-areas, always a dark line between anterior and posterior lateral setal area; one of the two tibial spurs on foreleg very short; caudal margin of ventral sclerite VIII pleated; margin of recept. harp. complicated, with projections; Fig. 4 & 5 *Cheumatopsyche akana* n. sp.
- 2⁺ Light patches on forewing large; no posterior lateral setal area; tibial spurs on foreleg of about equal length 3
- 3 Light patch nearest to forewing basis round or oval, its diameter far smaller than width of wing; anterior lateral setal area distinctly divided into two sub-areas; caudal margin of ventral sclerite VIII with a large projection; segment IX laterally with a distinct, claviform projection; dorsal margin of recept. harp. complicated, with projections; Fig. 4 & 5 *Cheumatopsyche albomaculata*
- 3⁺ Light patch nearest to forewing basis rectangular, across whole width of wing; sub-areas of anterior lateral setal area close together; caudal margin of ventral sclerite VIII without projection, dorso-caudal corner pointed; segment IX laterally without projection; dorsal margin of recept. harp. without projections; Fig. 4 & 6 *Cheumatopsyche sexfasciata*
- 4 Anterior lateral setal area divided into two sub-areas; one of the two tibial spurs on foreleg very short; dorso-caudal corner of ventral sclerite VIII pointed, with a dark patch; upper margin of recept. harp. running in a dorso-ventral direction; Fig. 6 *Cheumatopsyche copiosa*
- 4⁺ Anterior lateral setal area undivided; dorso-caudal corner of ventral sclerite VIII without dark patch; margin of recept. harp. different from that of previous species 5
- 5 Distance between anterior and posterior lateral setal area as long as distance between anterior and posterior margin of anterior lateral setal area, posterior lateral setal area frequently divided into a large and a small sub-area; tibial spurs on foreleg of about equal length; dorso-caudal corner of ventral sclerite VIII generally rounded; recept. harp. dorsally with a small pouch; Fig. 6 *Cheumatopsyche digitata*
- 5⁺ Distance between anterior and posterior lateral setal area shorter than distance between anterior and posterior margin of anterior lateral setal area, posterior setal area undivided; dorso-caudal corner of ventral sclerite VIII pointed; recept. harp. with a large pouch 6
- 6 Dark line between anterior and posterior lateral setal area; one of the two tibial spurs on foreleg very short; inner and outer margin of recept. harp. almost parallel; Fig. 6 *Cheumatopsyche gibbsi* n. sp.
- 6⁺ No dark line between anterior and posterior lateral setal area; tibial spurs on foreleg of about equal length; margins of recept. harp. not parallel; Fig. 4 & 6 *Cheumatopsyche falcifera*

4.2 Males

The key to the males is based solely on the lateral aspect of a part of the genital apparatus, viz. segment X, since this structure is sufficient for species discrimination of this locally restricted material. There is almost no variation in the general appearance of this structure, except that sometimes the distal processes (append. digit.) are slightly more curved upwards than shown on the illustrations. This exception occurs only in species with a relatively long append. digit. and it is probably an artifact. Additional information concerning the colouration of the wings, the character of the setal areas on the head, and the size of the tibial spurs on the foreleg can be derived from the key to females. Moreover, the male genitalia of four species are illustrated more comprehensively under the heading "taxonomy" (3.).

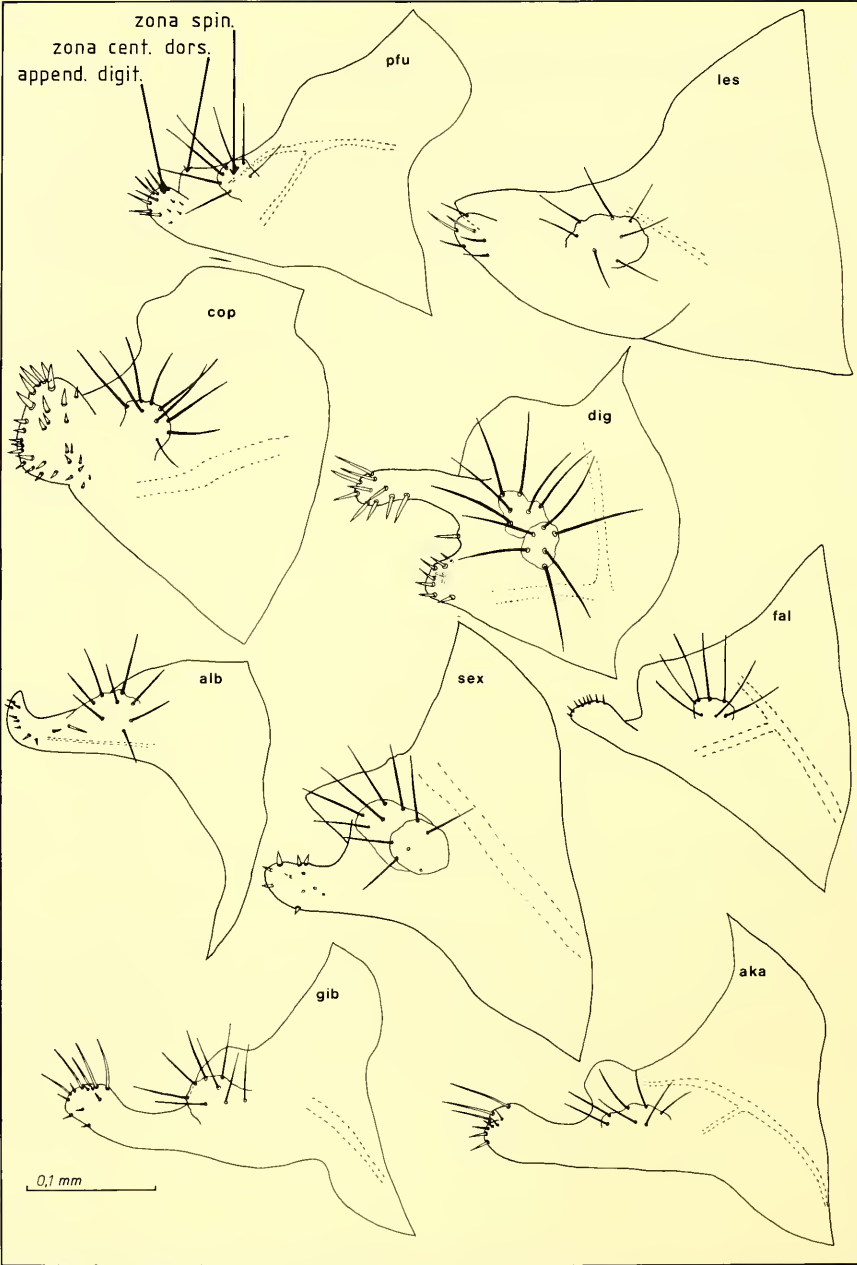


Fig. 7: Segment X (lateral aspect) of the male genitalia of *Cheumatopsyche pfundsteini* n. sp., *C. lestoni*, *C. copiosa*, *C. digitata*, *C. albomaculata*, *C. sexfasciata*, *C. falcifera*, *C. gibbsi* n. sp., and *C. akana* n. sp..

Key

(all characters used here are shown in Fig. 7)

1	Append. digit. split into two branches, the dorsal one longer than the ventral one	
 <i>Cheumatopsyche digitata</i>	
1 ⁺	Append. digit. only one branch	2
2	Append. digit. not projecting beyond end of dorso-central part of segment X (zona cent. dors.)	
 <i>Cheumatopsyche lestoni</i>	
2 ⁺	Append. digit. projecting beyond zona cent. dors.	3
3	Append. digit. curved upwards at its end at almost right angles	
 <i>Cheumatopsyche albomaculata</i>	
3 ⁺	Append. digit. not as distinctly curved upwards at its tip	4
4	Append. digit. short, its length not distinctly exceeding its height	5
4 ⁺	Append. digit. longer, its length distinctly exceeding its height	6
5	Append. digit. higher than long, with numerous stout setae	
 <i>Cheumatopsyche copiosa</i>	
5 ⁺	Append. digit. as high as long, without stout setae	
 <i>Cheumatopsyche pfundsteini</i> n. sp.	
6	Zona cent. dors. closer to tip of append. digit., clearly extending backwards beyond dorso-lateral setose warts of segment X (zona spin.)	7
6 ⁺	Append. digit. exceeding zona cent. dors. more distinctly; zona cent. dors. not extending clearly backwards beyond zona spin.	8
7	Zona cent. dors. pointed; zona spin. approaching basis of append. digit.; append. digit. with several stout setae	
 <i>Cheumatopsyche sexfasciata</i>	
7 ⁺	Zona cent. dors. rounded; zona spin. not as close to basis of append. digit.; append. digit. without stout setae	
 <i>Cheumatopsyche falcifera</i>	
8	Zona cent. dors. a protruding hump	
 <i>Cheumatopsyche akana</i> n. sp.	
8 ⁺	Hump of zona cent. dors. not as distinct as in previous species, not exceeding caudal margin of zona spin.	
 <i>Cheumatopsyche gibbsi</i> n. sp.	

4.3 Larvae

The instar of a larval specimen can be easily determined by means of comparison with other conspecific specimens from the same sampling locality. For this purpose head capsule width and complexity of gill branches (larva I: gills missing; larva II: branches simple; . . . ; larva V: branches very complex) are very helpful. A fifth (= last) larval instar has a head capsule as wide and gill branches as complex as a prepupa (= larva found in a closed pupal cocoon). The characteristics used in the larval key vary mostly according to the larval instar to be determined. If not otherwise stated, the characteristics used here are derived from the last larval instar. Thus, in addition to the variability of a character in larva V, the validity of each character for earlier instars will be briefly discussed.

The shape of the whole head is relatively constant in all larval instars. Even first instar larvae of several species from the same locality can be differentiated by using head width or head width to head length ratios (MACKAY 1978). In some species variations in the shape of the anterior margin of the frontoclypeus (= frontoclypeal apotome) are found within specimens from different river basins, but its general appearance is very constant (STATZNER 1981). This general appearance can be easily recognized in larva IV and, with some practice, also in larva III (Fig. 11, 12, 13). The relative length of the primary setae on the frontoclypeus used here for species discrimination proves to be constant in all larval instars of the three species studied most comprehensively (*C. digitata*, *C. copiosa*, *C. falcifera*). The character of the secondary setae on the head, already used for species discrimination of African *Cheumatopsyche* by GIBBS (1973) and MARLIER (1981 b), resembles that of larva V in the larval instars IV, III, and even II. The shape of the anterior margin of the submentum shows some variation, but the width of the median incision is frequently useful in distinguishing larva V. The character of the transverse stridulatory ridges on the ventral surface of the head can help in the discrimination of larval instar V to II (Fig. 8 & 9).

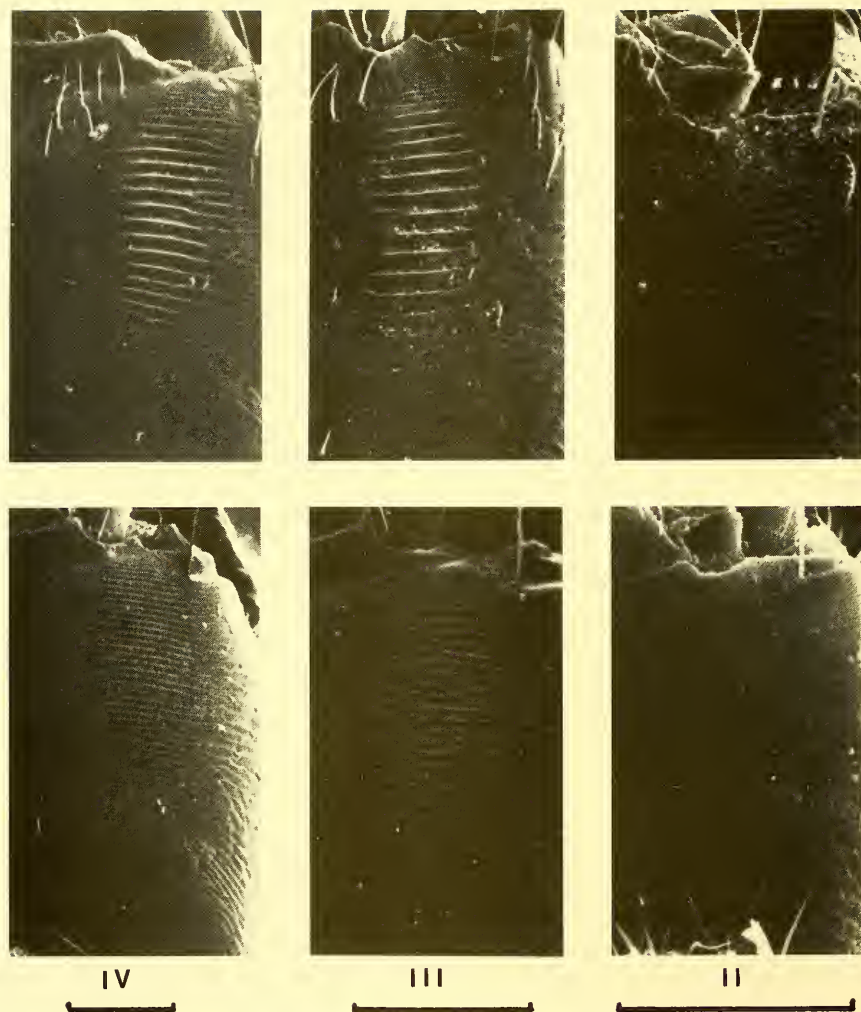


Fig. 8: Stridulatory ridges of the larval instar II to IV of *Chematopsyche copiosa* (above) and *C. falcifera* (below). The scale indicates 0.1 mm.

The shape of the fore trochantin lying at the basis of the first leg shows some variation even in instar V. Nevertheless, it is included in the key as it sometimes provides useful additional information for species differentiation. The character of the plates on the prosternum, especially that of the enlarged posterior sternites caudal of the large transverse prosternal plate, changes from larval instar III to V, but its general appearance enables species discrimination of the last three instars (STATZNER 1976). The number of the gill branches are not variable. There may be some variation in the number of filaments on a single gill branch (cf. WICHARD 1974a, b). As mentioned above, gills appear in larva II.

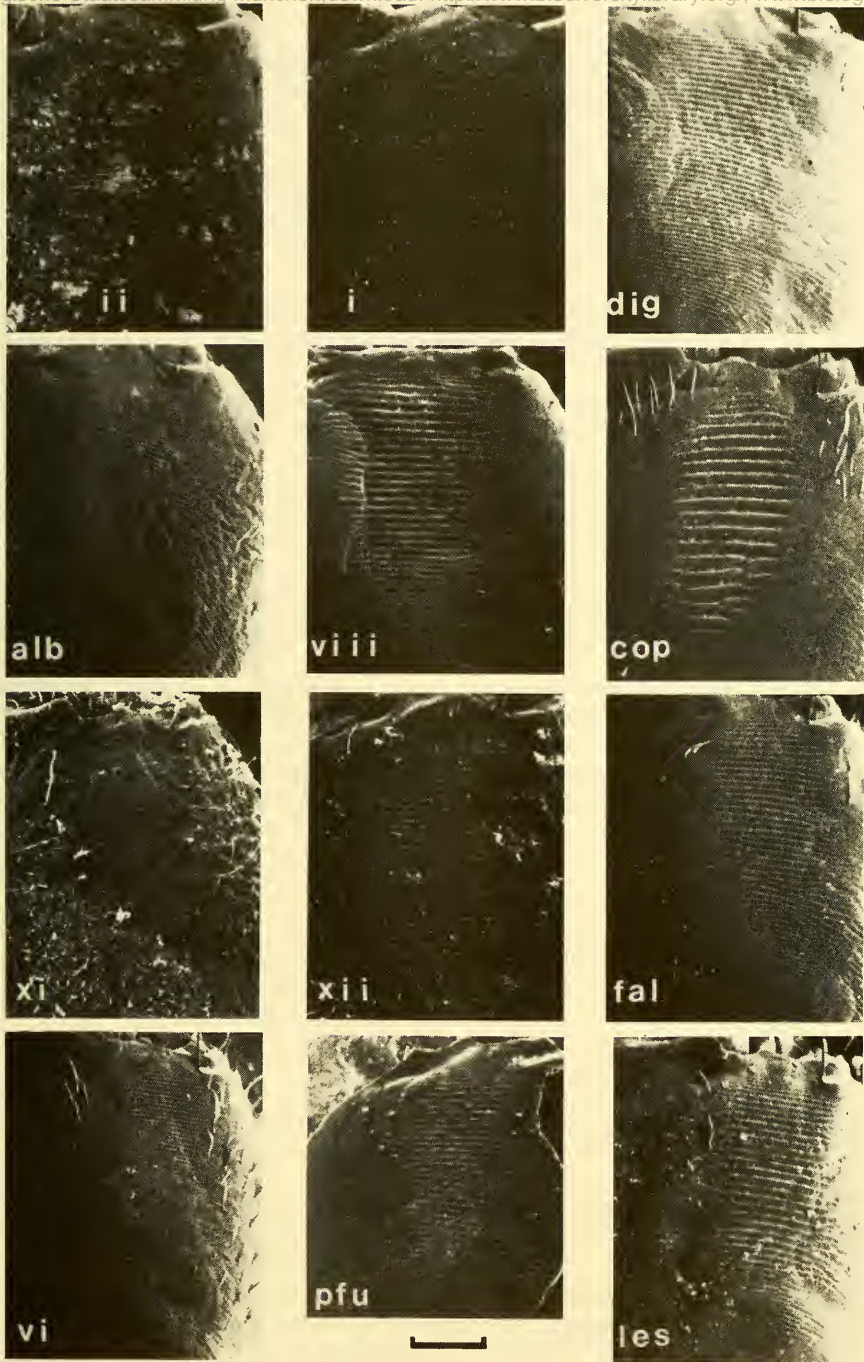


Fig. 9: Stridulatory ridges of larvae V of all *Cheumatopsyche* spp. found in the Ivory Coast. The scale indicates 0.1 mm.

- 1 Four gill branches on metasternum; anterior margin of frontoclypeus symmetrical; posterior sternites on prosternum large; secondary setae on head of two types, one long and thin, the other shorter and very thick; dorsal margin of dorsal branch of trochantin distinctly curved at its basis; Fig. 10 *Hydropsyche* sp.
- 1+ Less than four gill branches on metasternum; large posterior sternites on prosternum only present if anterior margin of frontoclypeus with asymmetrical, deep incisions; secondary setae on head never of the short and thick type as in previous species; dorsal margin of dorsal branch of trochantin straight or only slightly curved at its basis 2
(*Cheumatopsyche*)
- 2 Anterior margin of frontoclypeus with asymmetrical, deep incisions; large posterior sternites on prosternum; secondary setae at posterior end of frontoclypeus thin, undivided; three gill branches on metasternum 3
- 2+ Anterior margin of frontoclypeus without deep incisions or with symmetrical incision(s); without large posterior sternites on prosternum; secondary setae at posterior end of frontoclypeus in most cases branched 5
- 3 Anterior margin of frontoclypeus with three incisions; seta 3 on frontoclypeus short and thick; dorsal branch of trochantin short, not longer than ventral branch; Fig. 9 & 11 *Cheumatopsyche* sp. II
- 3+ Anterior margin of frontoclypeus with two incisions; seta 3 on frontoclypeus long; dorsal branch of trochantin longer than ventral branch 4
- 4 Incisions into anterior margin of frontoclypeus deeper, margin between incisions distinctly curved; median edge of posterior sternite on prosternum broad, rounded; incision into submentum narrower than in following species; Fig. 9 & 11 *Cheumatopsyche* sp. I
- 4+ Incision into anterior margin of frontoclypeus not as deep as in previous species, margin between incisions straighter; median edge of posterior sternite on prosternum tapered; incision into submentum wider than in previous species; Fig. 9 & 11 *Cheumatopsyche digitata*
- 5 Frontoclypeus in front as broad as in the middle; dorsal side of head depressed (lateral view!); a semi-circle of strong secondary setae on head; abdomen densely covered with short, thick, fan-shaped setae 6

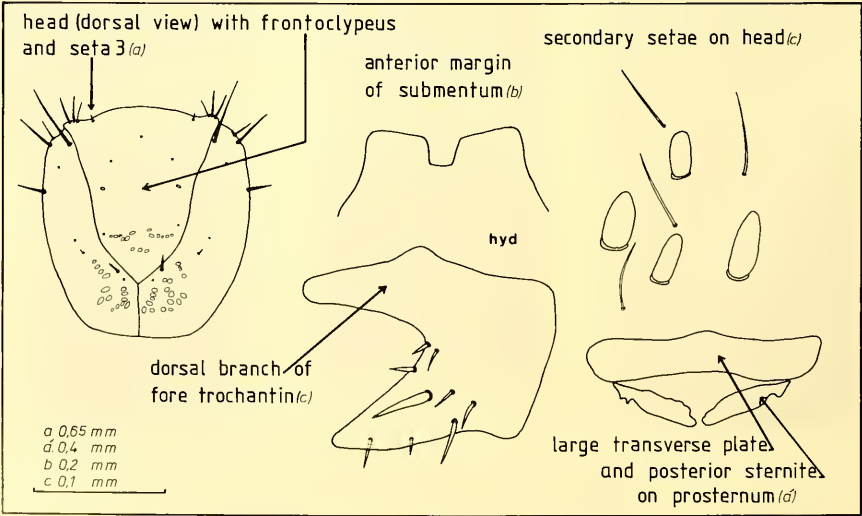


Fig. 10: Larval characters of *Hydropsyche* sp.

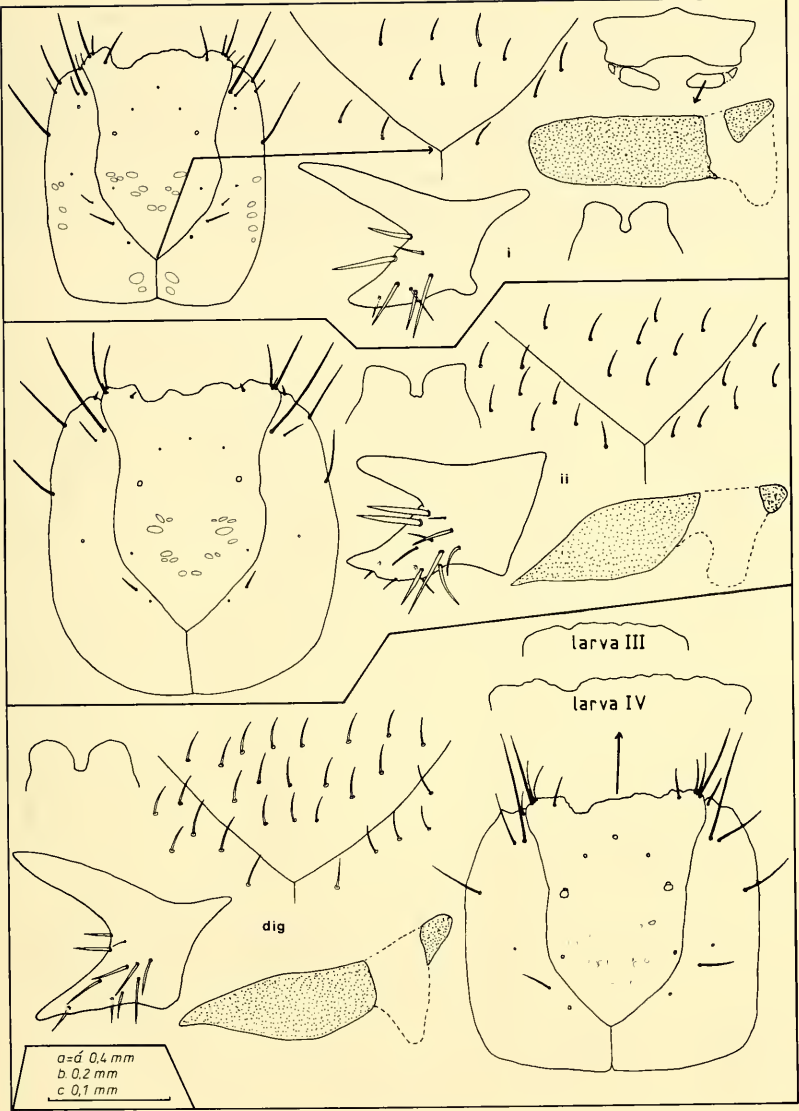


Fig. 11: Larval characters of *Cheumatopsyche* sp. I & II and *C. digitata*

- 5⁺ Frontoclypeus in front distinctly broader than in the middle; dorsal side of head rounded (lateral view!); no semi-circle of strong secondary setae on head; abdomen less densely covered by setae; three gill branches on metasternum 7
- 6 No gill branches on meso- and metasternum; secondary setae at posterior end of frontoclypeus as well as in the whole semi-circle on head stouter, with only short projections; incision into submentum narrower than in following species; setae on abdomen denser than in following species; stridulatory ridges finer than in following species; Fig. 9 & 12 *Cheumatopsyche albomaculata*
- 6⁺ Two gill branches on meso-, three gill branches on metasternum; secondary setae at posterior end of frontoclypeus as well as in the whole semi-circle on head more slender, with longer, thinner projections; incision into submentum wider; setae on abdomen less dense; stridulatory ridges relatively coarse; Fig. 9 & 12 *Cheumatopsyche* sp. VIII

- 7
- Anterior margin of frontoclypeus with two deep, symmetrical incisions; secondary setae at posterior end of frontoclypeus undivided; stridulatory ridges very coarse; Fig. 8, 9, 12 *Cheumatopsyche copiosa*³⁾
- 7⁺
- Anterior margin of frontoclypeus with one median incision or many small crenulations only; secondary setae at posterior end of frontoclypeus branched; stridulatory ridges finer than in previous species 8
- 8
- Anterior margin of frontoclypeus with one median incision; Fig. 9 & 12 . . . *Cheumatopsyche* sp. XI
- 8⁺
- Anterior margin of frontoclypeus with numerous crenulations only 9

³⁾ *Cheumatopsyche* sp. VII in STATZNER 1981, 1982

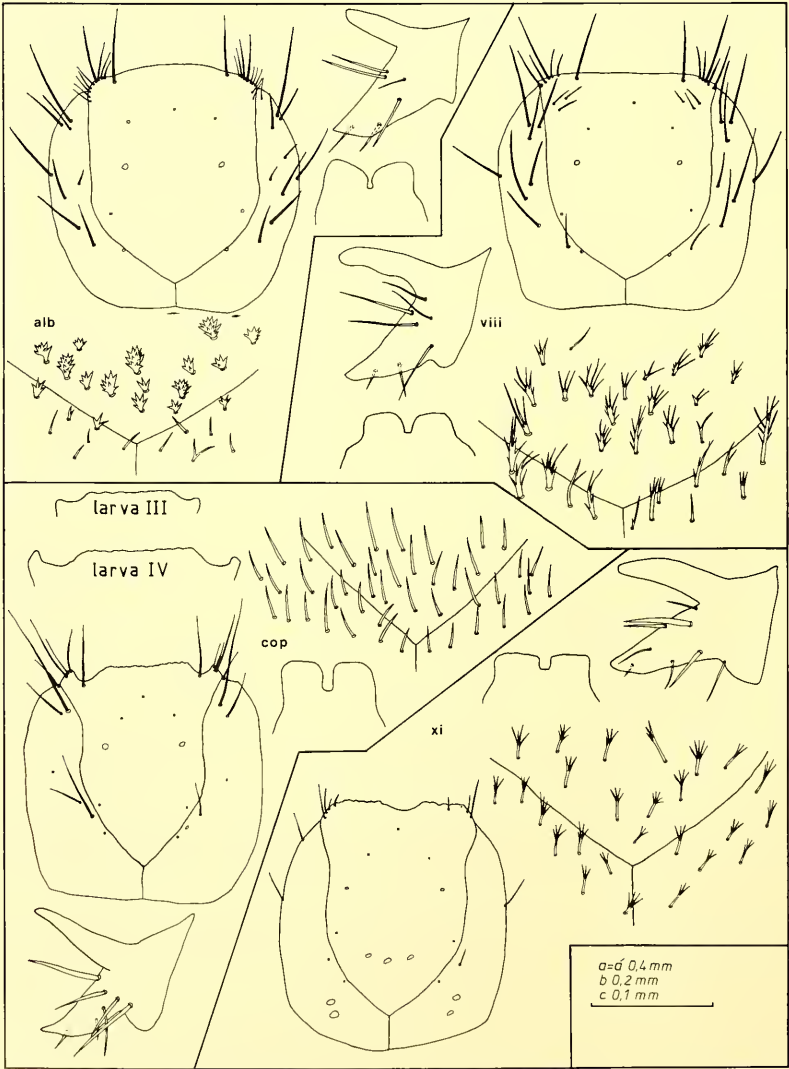


Fig. 12: Larval characters of *Cheumatopsyche albomaculata*, *Cheumatopsyche* sp. VIII & XI, and *C. copiosa*.

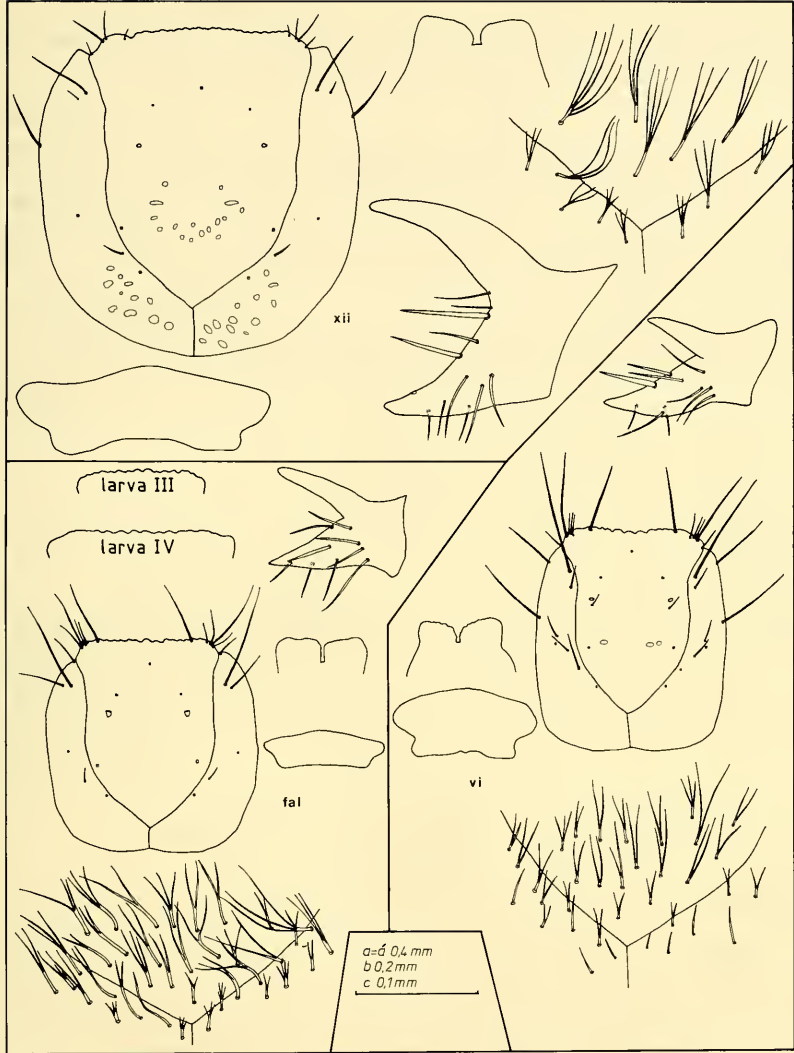


Fig. 13: Larval characters of *Cheumatopsyche* sp. XII & VI and *C. falcifera*.

- 9 Secondary setae on head very long (lateral aspect!), those at posterior end of frontoclypeus branched close to the basis 10
- 9⁺ Secondary setae on head distinctly shorter⁴⁾, those at posterior end of frontoclypeus start to branch in the middle or near the tip of the seta 12
- 10 Colour of head dark-brown; seta 3 on frontoclypeus short; dorsal branch of trochantin longer than ventral one; Fig. 9 & 13 *Cheumatopsyche* sp. XII
- 10⁺ Anterior median area of frontoclypeus lighter than surrounding area, head ventrally completely or almost completely yellow; seta 3 on frontoclypeus long; dorsal branch of trochantin not longer than ventral one 11

⁴⁾ Based on larva IV for *Cheumatopsyche pfundsteini*

- 11 Head roundish oval; near the ventral ecdysial line of head a brownish colouration; incision into submentum of about equal width over its whole length; length-width ratio of large transverse prosternal plate smaller than in following species; dorsal and ventral branches of trochantin of about equal length; stridulatory ridges coarser than in following species; Fig. 8, 9, 13 *Cheumatopsyche falcifera*⁵⁾)
- 11⁺ Head long oval; colouration near ventral ecdysial line of head not darker; incision into submentum wider in front than at its basis; length-width ratio of large transverse prosternal plate larger than in previous species; dorsal branch of trochantin shorter than ventral one; stridulatory ridges fine; Fig. 9 & 13 *Cheumatopsyche* sp. VI
- 12 Seta 3 on frontoclypeus long⁶⁾, as in *C. falcifera*; secondary setae on head start to branch at the middle of their length; stridulatory ridges finer than in previous species; Fig. 9 & 14 *Cheumatopsyche pfundsteini* n. sp.
- 12⁺ Seta 3 on frontoclypeus short and thin; secondary setae on head stouter, in most cases branched immediately below the tip of the seta; stridulatory ridges coarser; Fig. 9 & 14 *Cheumatopsyche lestoni*⁷⁾)

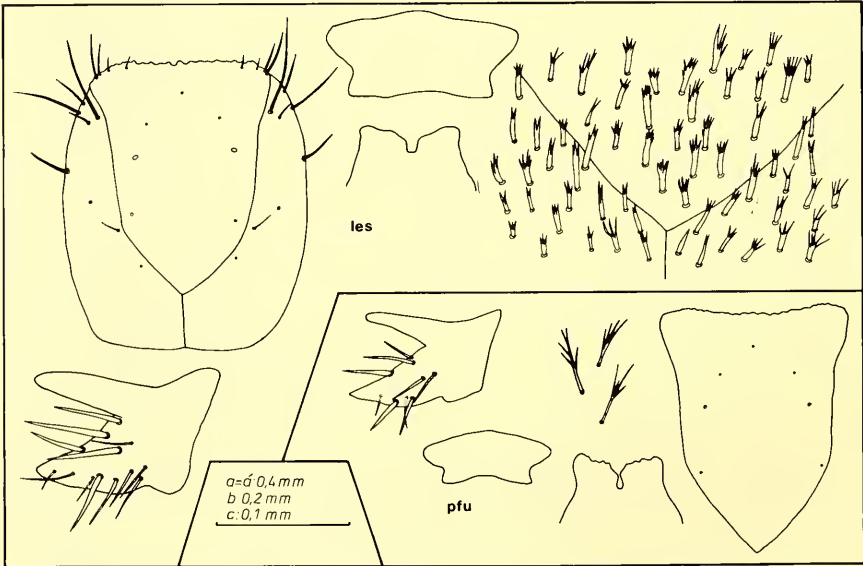


Fig. 14: Larval characters of *Cheumatopsyche lestoni* and *C. pfundsteini* n. sp.

4.4 Pupae

A pupa found in a closed pupal cocoon can be identified with the help of the larval exuvia. If that pupa is mature, the genitalia of the imago can be identified by means of an easy dissection under the stereomicroscope. Species discrimination of a specimen in the stage between pupal and imaginal ecdysis can thus be based on characters given in the keys for females, males, and larvae. Therefore no key to pupae is given below.

⁵⁾ *Cheumatopsyche* sp. III in STATZNER 1981, 1982; the preliminary establishment of *Cheumatopsyche* sp. V (STATZNER 1981) proved to be invalid, this specimen also belongs to *C. falcifera*.
⁶⁾ Based on larva IV
⁷⁾ *Cheumatopsyche* sp. IV in STATZNER 1981

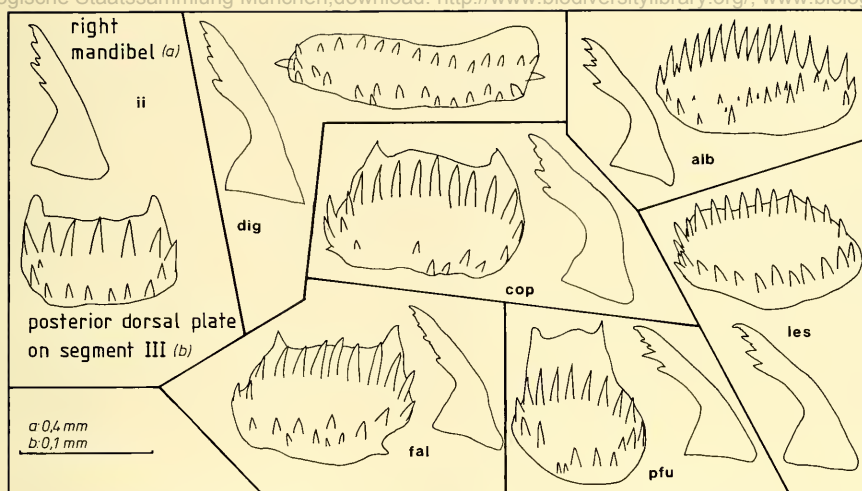


Fig. 15: Characters of all pupae of *Cheumatopsyche* found in the Ivory Coast.

Pupal exuviae alone, material which is found more or less frequently in drift studies, cannot be identified with the help of imaginal and/or larval characters. Therefore the right pupal mandible, the shape of which is relatively constant, and one of the two dorsal presegmental plates on pupal abdominal segment III, whose shape as well as the size of its hooks show some variation, are illustrated here (Fig. 15). Checking these two characters in pupae for the species present at a locality will enable species discrimination of the pupal exuviae.

5. Distribution of Hydropsychinae in the Ivory Coast

The distribution pattern of the species considered here can be roughly classified into five types. There are species, which are

- a) distributed over the whole non-mountainous Ivory Coast: *C. digitata* (Fig. 16).
- b) more or less restricted to the savannah region: *C. copiosa* (Fig. 17) and *C. falcifera* (Fig. 18), the latter also tends to occur in the transition zone between savannah and forest.
- c) more or less restricted to the non-mountainous forest region: *C. albomaculata* (Fig. 17), *Cheumatopsyche* sp. II (Fig. 16), *C. sexfasciata* (Fig. 19), *C. pfundsteini* (Fig. 18) and probably *C. akana* (Fig. 19).
- d) more or less restricted to the transition zone between the savannah and forest area: *C. gibbsi* (Fig. 19) and probably *Cheumatopsyche* sp. VI (which is assumed to be the larva of *C. gibbsi*; Fig. 18).
- e) restricted to the mountainous region around Man: *Cheumatopsyche lestoni* (Fig. 18) and *Hydropsyche* sp. (Fig. 16).

Other species were found only at one locality in the Ivory Coast, one in the Man region, viz. *Cheumatopsyche* sp. XII (Fig. 18), one in the non-mountainous forest region, viz. *Cheumatopsyche* sp. XI (Fig. 17), and one in the savannah region, viz. *Cheumatopsyche* sp. VIII (Fig. 17). The latter I also know from the Red Volta River at the Po-Bridge (Upper Volta).

The principle features of these distribution patterns, i. e. the differentiation into forest species and savannah species, are in agreement with the known distribution of the species of the *Simulium damnosum* complex (QUILLEVERE 1979). The separation of the mountain region around Man, reflected by the

Hydropsychinae, is not found as dear in *Simulium* while the separation into small and large streams of the forest area, reported for *Simulium*, is not found in the Hydropsychinae. The transition zone between forest and savannah can be considered as an ecotone. Here dynamic changes of the *Simulium* fauna occur according to the hydrological seasons (QUILLEVERE 1979). The border between the savannah types, viz. Guinean savannah in the South and Sub-Sudanese savannah in the North, is not clearly reflected by the distribution of the Hydropsychinae.

In my opinion the distribution of the Hydropsychinae is mainly influenced by the following: Probably the most important factor is, whether or not the stream flows permanently. If the stream is intermittent, the length of the period without flow in relation to the ability to survive such periods as a larva or an adult as well as the ability to recolonize such a stream after the resumption of flow by immigration of adults from other localities will decide, whether a species is present or not.

Furthermore the interspecific aggressive behaviour in connection with the stridulation of larvae (JANSSON & VUORISTO 1979) probably influences predominance and the presence of a species in a locality, especially at periods of decreasing discharge and thus decreasing areas with sufficient current

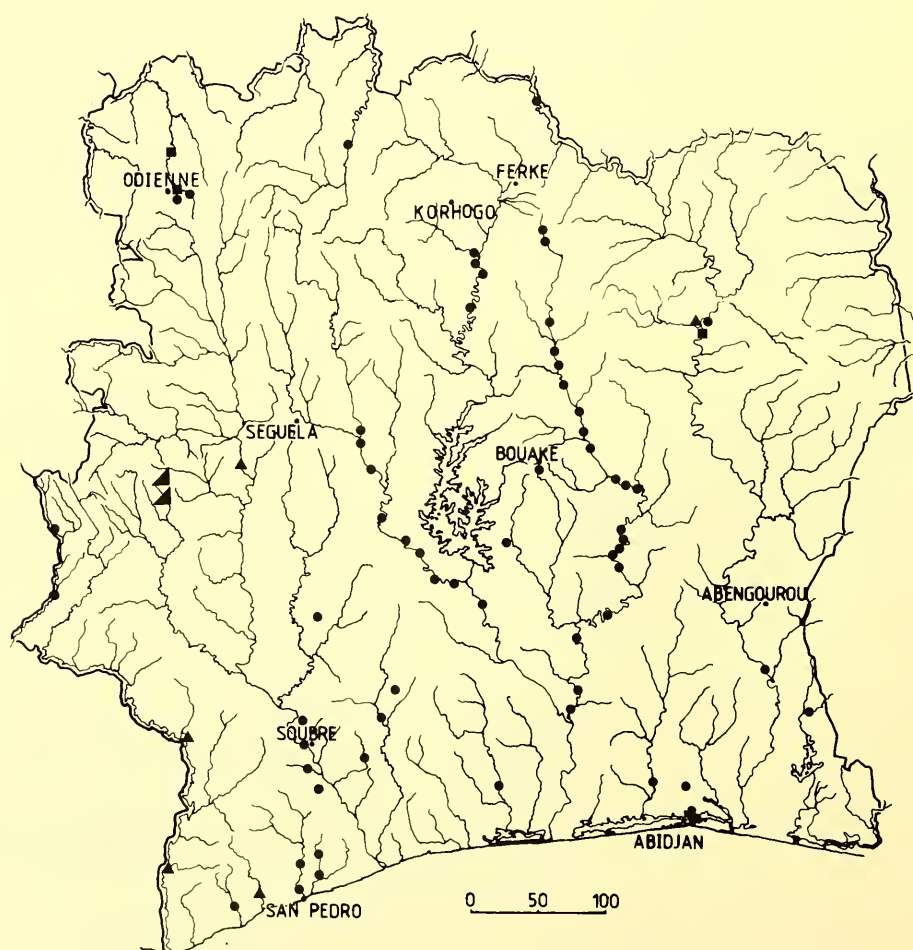


Fig. 16: Distribution of *Hydropsyche* sp. (▲), *Cheumatopsyche* sp. I (■), *Cheumatopsyche* sp. II (▲●), and *C. digitata* (●).

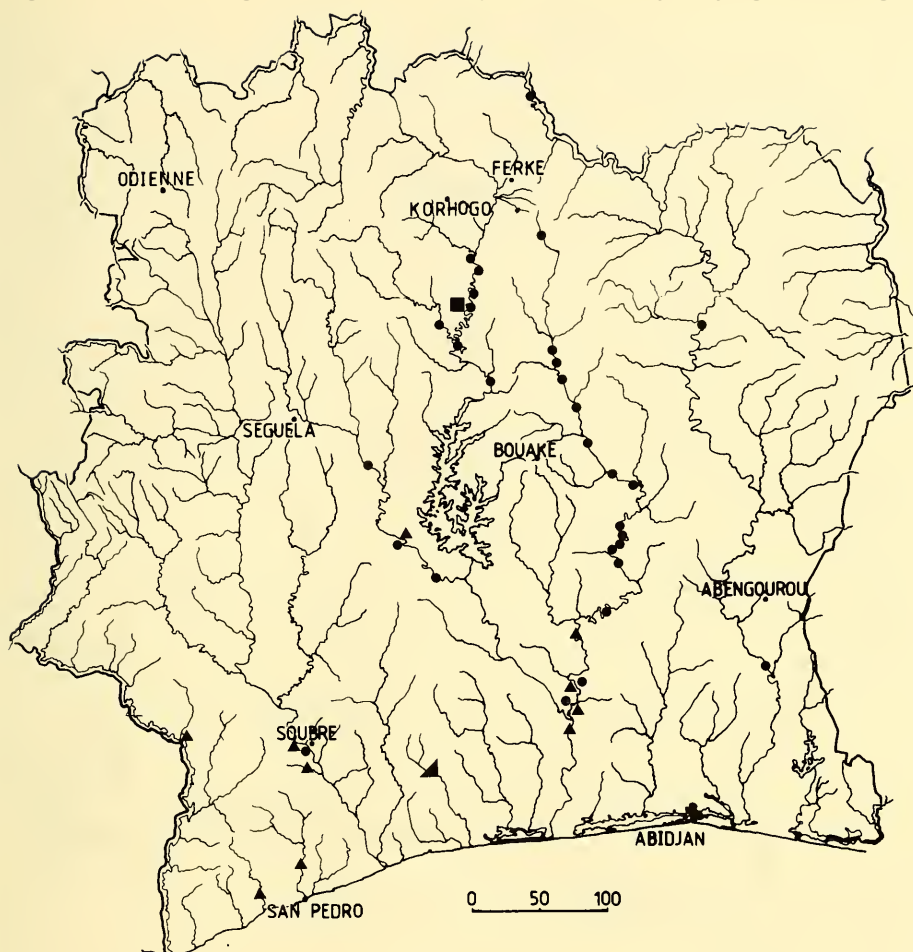


Fig. 17: Distribution of *Cheumatopsyche* sp. VIII (■), *Cheumatopsyche* sp. XI (▲), *C. copiosa* (●), and *C. albomaculata* (▲).

speeds. Obviously the structure of the stridulatory ridges is different within the *Cheumatopsyche* spp. considered here. Whether this causes different stridulation signals and what role they play in the coexistence of species is uncertain at the moment. The significance of this stridulation behaviour for *Cheumatopsyche* in the Ivory Coast is discussed in more detail elsewhere (STATZNER 1982).

pH and, within limits, water temperature and conductivity, which are regarded as major determining factors influencing the distribution of *Simulium* spp. (QUILLEVERE 1979), are also considered as indicators of different environments for the Hydropsychinae. Lower water temperatures may, especially, be responsible for the different fauna found in the mountainous region around Man.

The OCP operational treatment of the streams with the insecticide Abate obviously did not reduce the number of species of Hydropsychinae, since the highest number (6 as larvae, 5 as adults) was found at the treated monitoring station at the Upper Comoe River. However, the insecticide chlorphoxim, used in part of the OCP operation later, affected the Hydropsychinae (STATZNER 1982).

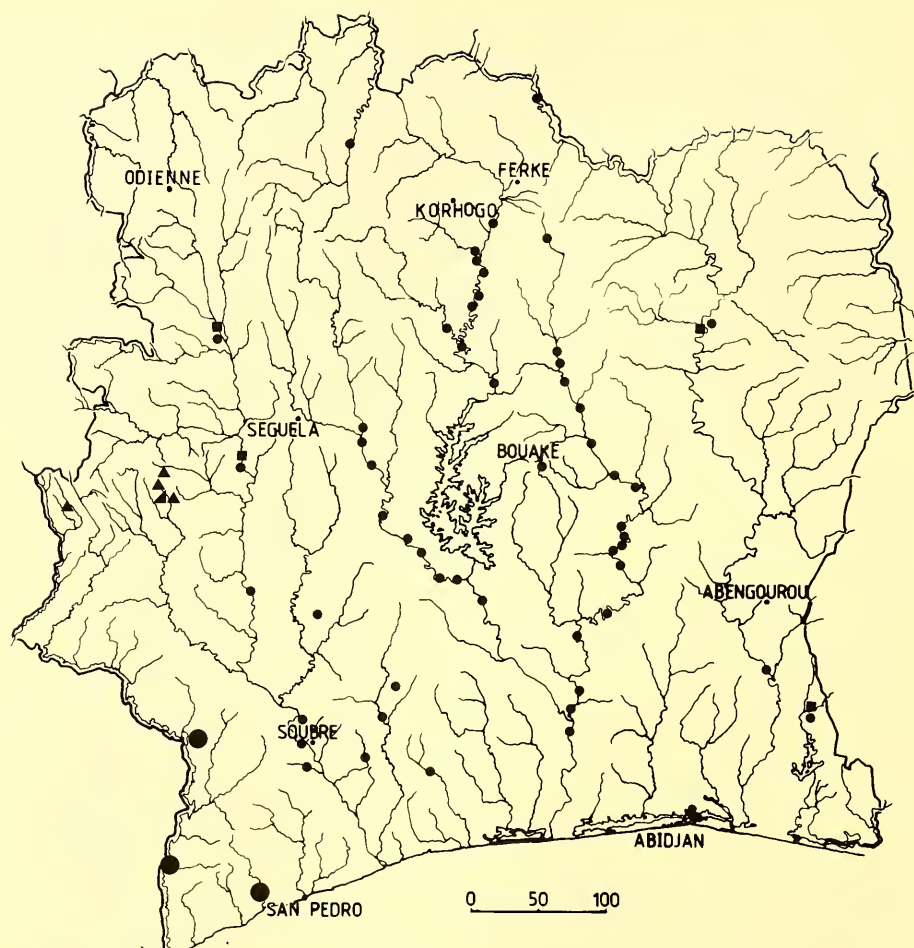


Fig. 18: Distribution of *Cheumatopsyche* sp. VI (■), *Cheumatopsyche* sp. XII (▲), *C. falcifera* (●), *C. lestoni* (△), and *C. pfundsteini* n. sp. (●).

6. Conclusions

The larvae of twelve *Cheumatopsyche* spp., which is in this genus approximately twice the number of African larvae so far assigned to adults and about the half of the number of African larvae illustrated more or less comprehensively up till now, are treated here in an uniform manner. This enables conclusions to be drawn regarding the relevance of the larval stage for systematic considerations. This question led to a heated discussion recently (SCHMID 1979, WIGGINS 1981). Groups within the *Cheumatopsyche* larvae evidently occur, which according to the current practice will justify the establishment of genera. The only reason that this has not yet been done is, that there are still insufficient correlations of larvae with adults to enable a grouping of adults similar to that of the larvae.

Species discrimination, particularly of those species figured in the adult and immature stages, should be easier in the future. If a limited number of species in a certain locality is considered, species discrimination even of young larval instars is possible using some of the characters described here. It was surpri-

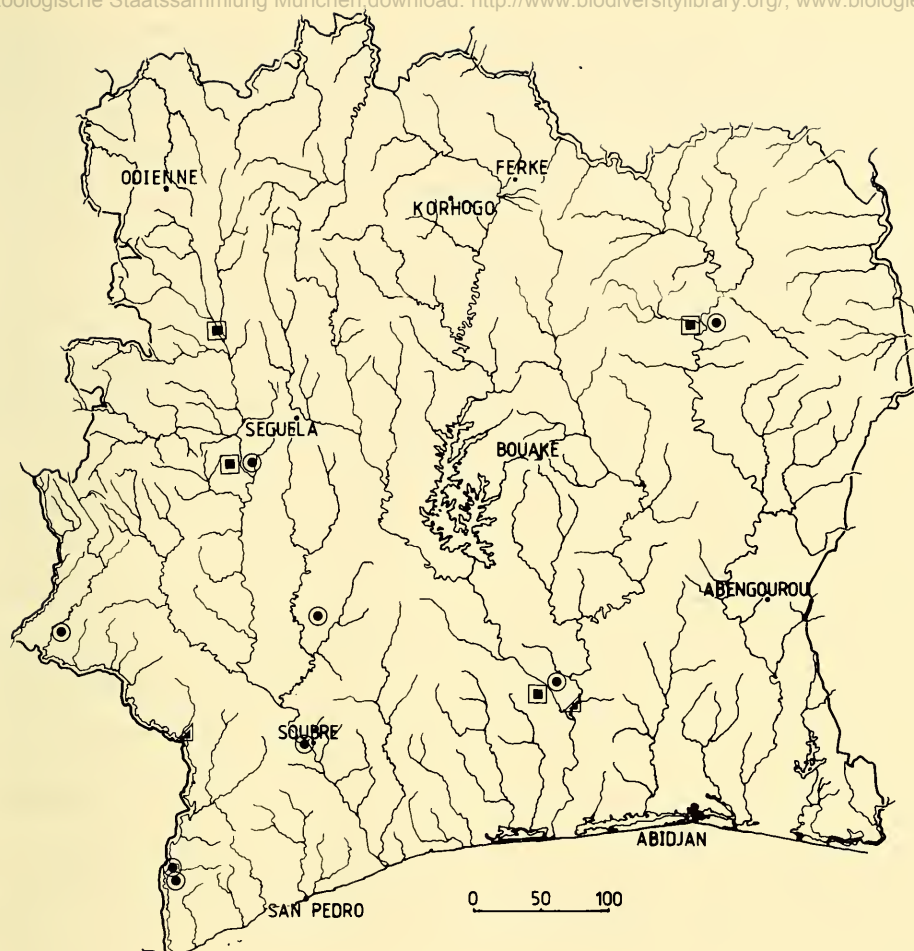


Fig. 19: Distribution of *Cheumatopsyche sexfasciata* (●), *C. akana* n. sp. (▲), and *C. gibbsi* n. sp. (■).

sing to discover during this study, that characters used almost exclusively for species discrimination in tropical caddis flies by taxonomists up to now, viz. the male genitalia, cannot be as easily distinguished as characters of the larvae and the female genital segments in the *Cheumatopsyche* material studied here.

With regard to the distribution of stream insects in the Ivory Coast this study supports the main points of the results on *Simulium* (QUILLEVERE 1979). Within the Hydropsychinae three main distribution areas were found, viz. the mountainous region around Man, the non-mountainous forest region, and the savannah region. How far these patterns can be generalized for streams insects of this country remains undecided at present.

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Appendix

While this paper was in print F. GIBON (O.R.S.T.O.M., Bouaké) (personal communication) assigned the immatures of *Cheumatopsyche* sp. II to adults of *C. sexfasciata*. He found *C. pfundsteini* at a fourth locality in the south west corner of the country and confirmed the above discussed distribution patterns of the rarer species *C. sexfasciata*, *C. akana*, and *C. gibbsi*.

Dr. K. M. F. SCOTT published the announced keys under the title "On the Hydropsychidae (Trichoptera) of Southern Africa with keys to African genera of imagos, larvae and pupae and species lists". – Ann. Cape Prov. Mus. (Nat. Hist.) **14**: 199–422.

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