Report to : WHO/OCP

SAMPLING FRESHWATER SHRIMPS (Macrobrachium) IN WEST AFRICA

Nov-Dec 1985

J.A.B.BASS

Freshwater shrimps of the rivers of central Togo and Ivory Coast - sampling methods, species recorded and assessment of abundance

J.A.E. Bass*

Summary:

1. In Togo, Macrobrachium vollenhovenii was widely dispersed in the river systems. M. sollaudii (?) and Caridina africana were recorded at one site. Other species, not recorded in this study, are considered likely to occur. No shrimp were captured in Ivory Coast.

2. Figures and morphometric data of the two Macrobrachium species collected permit separation of juveniles, females and immature males (currently, keys apply to large males only).

3. Shrimp capture rates were low throughout Togo. Anecdotal information suggests populations are considerably larger during the wet season, when shrimp are collected by local fishermen.

4. Any future monitoring of shrimp populations should be conducted in the wet season using baited traps.

* Address: The Freshwater Biological Association
River Laboratory
East Stoke
WAREHAM, Dorset
BH20 6BB

Introduction

The development and extension of the Onchocerciasis Control Programme area and deployment of an increasing range of larvicides in West African rivers has prompted studies on product toxicity to non-target organisms. The present study was instigated to establish the species of freshwater shrimp occurring in the rivers of central Togo (Fig. 1) and the rivers Haraoué, Sassandra and Comoé (later revised to Bandama) in the Ivory Coast (Fig. 2), together with an assessment of methods to establish population size.

Around ten species of Macrobrachium Bate have been recorded from "West Africa", as summarised by Holthuis (1949) (Table 1) and four species are considered to provide fisheries of limited commercial importance (Miller 1971, Holthuis 1980). Smaller species, representatives of the Atyiidae De Haan, have also been recorded from this region (Monod 1980, Holthuis 1980, Lévêque, Dejoux and Iltis 1983) (Table 1). In parallel with this study, the potential toxicity of two recently introduced larvicides (permethrin and carbosulfan) to freshwater shrimps was investigated (Wahle 1986).

Methods and Results

A description of each sampling method and trap design is given (Appendix I, Fig. 3). Sampling sites are briefly described, the dates visited noted, methods employed and success/failure recorded (Appendix II, Tables 2, 3 and 4). The comparative success rates of different sampling methods are tabulated (Table 5) and anecdotal information from local villagers and fishermen is summarised (Table 6). The characteristics of the two Macrobrachium species captured are figured

and morphometric data tabulated (Appendix III, Figs 4 and 5, Tables 7 and 8).

Discussion

1. Species occurrence

Shrimp were captured at nine of the twelve river sites visited in Togo and local villagers reported them present at the other three sites. One species, Macrobrachium vollenhovenii (Herklots), was identified from the R. Mono and its tributaries the Anié, Ougou, Amoutchou, Amou and Culé. Two species, M. sp. (close to sollaudii (De Man)) and Caridina africana Kingsley were found in the R. Oua Oua (referred to as R. Wawa in Wahle, 1986) on the Ghana border. No specimens were captured at the six sites visited in Ivory Coast, though their presence was reported at four of these and Lévêque, Dejoux and Iltis (1983 have previously recorded M. vollenhovenii, M. raridens and M felicinum in the R. Bandama catchment.

A variety of sampling methods was employed so as to reduce the possible selectivity of any one method for species or a particular size range of individuals. However, within the constraints of the present study other species are likely to have been overlooked. This is supported by the presence of M. sp. (close to sollaudii) and M. raridens (?) in samples previously taken from the Mono catchment and stored in the Hydrobiology laboratory in Ouagadougou.

Sampling effort was concentrated on the larger rivers and streams which are treated with insecticide. Small, torrential streams, the typical habitat of certain Atya spp. (Fryer 1977) were not sampled.

2. Species Recognition

Various keys and publications were employed (see bibliography). These generally use morphological characters of large males for species separation. In Macrobrachium examination of gravid females allows the species to be assigned to either the group with many small eggs or the group of species with few large eggs. The form of young and immature individuals are regarded as variable and unreliable for species separation. However in the present case some consistent differences between species were found and are presented (Figs 4 and 5).

3. Population Size

The sampling methods yielded comparatively small numbers of shrimp in the rivers of Togo, (Tables 2 and 4), such that for comparative purposes, no significant differences between sites on the R. Mono and its tributaries could be demonstrated. However the R. Oua Oua, where M. sp (close to sollaudii) and C. africana were found, appeared to have a higher population density. This impression was supported by repeated success of electro-shocking, carried out by B. Wahle in his recovery of shrimp from this site (see Wahle Report 1986). No gravid female M. vollenhovenii were recovered and very few juveniles were captured. This is not consistent with the previously described breeding period of July to January (Miller 1971) but may be explained by the extremely low percentage of gravid females recorded in the latter study.

The intensity of trapping with baited traps was greater in the rivers of Ivory Coast (Table 3) but, despite this, no shrimp were captured. It may be inferred from this that the populations are lower here than in Togo at this particular season.

A consistent assertion from fishermen in Togo and Ivory Coast was

that shrimp were present in high numbers and were very active only during the wet season, from July to September, at which time they are exploited as a source of food. No shrimp trapping or netting was currently being pursued by fishermen (November and December) as it was not considered worth the effort or, in the case of the Bandama sites and upper site on the Sassandra, shrimp were believed to be rare or non-existent at all times. The sudden appearance of large numbers of shrimp may be attributed to upstream migration, downstream migration or increased levels of activity or possibly a combination of these factors. Fishermen consider an upstream migration occurs and that a greater level of activity allows the shrimp to be captured in the wet season.

4. Recommendations

The present study has demonstrated that only small numbers of shrimp can be captured during the dry season and that no easy solution presents itself to permit an accurate assessment of populations in Togo and Ivory Coast, at this time of year. With a large increase in shrimp activity reported during the wet season (July-September) the most suitable monitoring method is considered to be multiple trapping using standardised techniques (Appendix IV). Results are highly dependent on shrimp behaviour, influenced by the reputed migration activity. Therefore trapping success will vary over comparatively short periods of time. For this reason, trapping one night per week, for a period of weeks at each site would be preferable to a short intensive period which may coincide with a peak or trough in activity. The responsibility for operating traps could be delegated to a local

fisherman at each of the sites that required monitoring. In this way data and material could be collected comparatively cheaply and conveniently.

References

Fryer G. (1977) Studies on the functional morphology and ecology of the atyid prawns of Dominica. Phil. Trans. R. Soc. Lond. 277, 57-129.

Holthuis L.B. (1949) On some species of Macrobrachium (Crustacea, Decapoda) from West AFrica. Eos, XXV, 175-185.

Holthuis L.B. (1980) Shrimps and prawns of the World. An annotated catalogue of species of interest to fisheries. FAO Fisheries Synopsis No. 125, 1, 271 pp.

Lévêque C., Dejoux C. & Iltis . (1983) Limnologie du fleuve Bandama, Cote d'Ivoire. Hydrobiologie, 100, 113-141.

Miller G.C. (1971) Commercial fishery and biology of the freshwater shrimp, Macrobrachium, in the Lower St Paul River, Liberia, 1952-53. Spec. Sci. Rep. U.S. Fish Wildl. Serv. (Fish.), (626), 1-13.

Monod T. (1980) "Decapodes" pp. 369-389. In Durand J.R. & Lévêque C. (eds) Flore et faune aquatiques de l'Afrique sahelo-soudanienne. Tome 1, ORSTOM, Paris.

Victor R. & Agbeibu A.E. (1985) Macrobenthic invertebrates of a stream flowing through farmland in Southern Nigeria. Environ. Poll. (A) 39, 337-349.

Wahle B. (1986) Effects of carbosulfan and permethrin on fresh-water shrimp, (Decapoda:Caridea) in southern Togo, West Africa. WHO, CCP, Ouagadougou. Burkina Faso 32 pp.

Acknowledgements

For the efficient and friendly help and advice provided by O.M.S. staff I am most grateful. Bruce Wahle donated shrimp from his concurrent toxicology studies, which made a useful contribution to my data. The Freshwater Biological Association (U.K.) permitted my temporary secondment to the Onchocerciasis Programme. I wish to thank Mrs Valerie Palmer for typing the report.

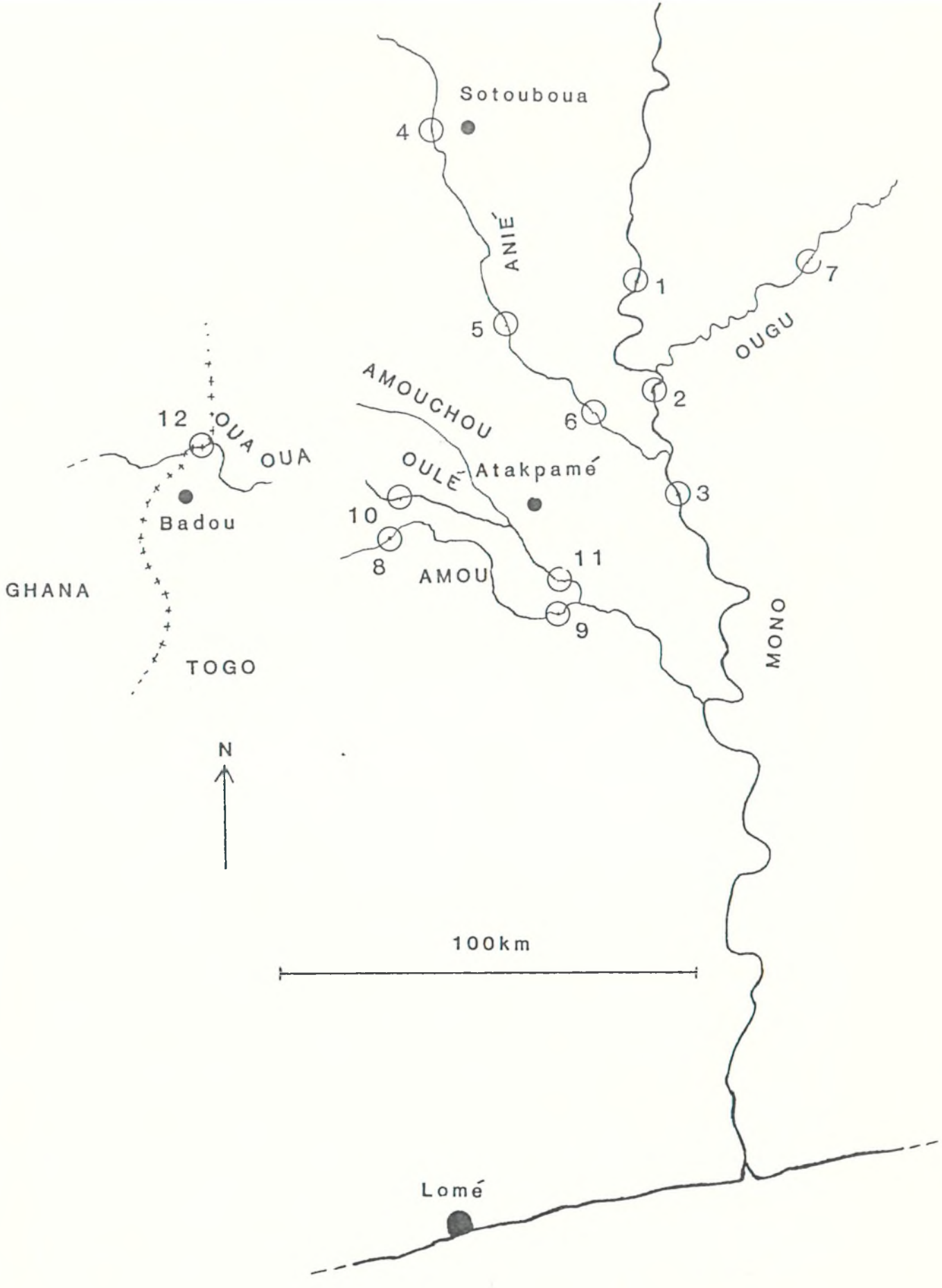

Fig. 1 Togo. Numbered sampling sites

Fig. 2 Ivory Coast. Numbered sampling sites

Table 1

Freshwater shrimps recorded from "West Africa"

Species	Authority	Reported occurrence	Source
Macrobrachium		Estuaries, Liberia	
macrobrachion	(Herklots)	to Angola	Holthuis (1949)
M. vollenhovenii	(Herklots)	Liberia to Angola,	Holthuis (1949)
		Cape Verde Islands	Monod (1980)
		I. Coast	Lévêque et al. (1983)
M. sollaudii	(De Man)	Spanish Guinea	Holthuis (1949)
M. chevalieri	(J. Roux)	Angola,	Holthuis (1949)
		Cape Verde Islands	
M. zariquieyi	Holthuis	San Thome, Fernando Poo	Holthuis (1949)
M. felicinum	Holthuis	Ashanti, Angola	Holthuis (1949)
		Ghana	Monod (1980)
		I. Coast	Lévêque et al. (1983)
M. dux	(Lenz)	Southern Nigeria	Victor & Ogbeibu (1985)
			Holthuis (1949)
M. lujae	(De Man)		
M. raridens	(Hilgendorf)	Guinea, Nigeria	Monod (1980)
		(Cameroon?)	
		I. Coast	Lévêque et al. (1983)
Caridinopsis			
chevalieri	Bouvier	Guinea, Ivory Coast	Monod (1980)
Caridina		Rivers & lakes,	
africana	Kingsley	W. Africa	Monod (1980)
		I. Coast	Lévêque et al. (1983)

C. gabonensis	Roux	Southern Nigeria	Victor & Ogbeibu (1985)
Atya gabonensis	Giebel	Throughout W. Africa	Monod (1980)
A. africana	Bouvier	in small rocky	Monod (1980)
A. sulcatipes	Newport	rivers and streams	Holthuis (1980)
(Syn. *A. scabra* (Leach))		R. NZi (I. Coast)	Lévêque et al. (1983)

Appendix I

Sampling Methods

1. Baited Traps

Three types of trap were tested.

a) A rigid trap consisting of a metal frame (4 mm steel rod) covered with 8 mm (knot to knot) netting (Fig. 3A).

b) A soft trap of collapsible design, its shape maintained by a moderate current of water or by the use of anchoring points (Fig. 3B). Materials were, nylon rod (6 mm diameter), knitted mesh netting (8 mm aperture) as used in anglers' keepnets.

c) A drop-net, stiffened by two hoops of nylon rod, the smaller hoop forming the base and the larger (60 cm diameter) the rim, connected to a rope by three attachment points for a rapid vertical recovery (Fig. 3C). Materials were the same as for the soft trap (b).

All traps were baited with banana, a) and b) were positioned with their entrances facing downstream, c) was operated in slow flowing areas.

2. Kick-sampling

A modified pond net (Fig. 3D) was held vertically in the water, its rim resting on the substrate. Where water velocity was sufficient, material disturbed by 'kicking' was carried into the net. In slower velocities the net was moved in a series of sweeps over the disturbed substrate.

3. Snag-sampling

A pondnet was carefully positioned close to and slightly downstream

of leaf-packs, trapped debris, rock crevices etc. A stout pole was thrust vigorously into the 'snag' to drive out shrimps.

4. Electro-shocking

A large generator was employed. Anode and cathode were held 15-30 cm apart and thrust into areas of trapped debris at the river margins. A second person was required to collect the partially immobilised shrimp in a pond net.

5. Anecdotal Information

Fishermen and villagers were questioned on the occurrence of shrimp, methods of capture, levels of success throughout the year and, where appropriate, were shown drawings of different species for their comments.

Sampling methods considered

6. Netting

The use of a 10 m (15 mm mesh) seine net was considered but rejected because of the predominance of uneven rocky substrates and the behaviour of the shrimp, which remained hidden in snags during the hours of daylight.

7. Poisoning

Deliberate poisoning of shrimp, in the river, in conjunction with a fixed net downstream may be considered for obtaining a representative sample, but was not attempted during the present study.

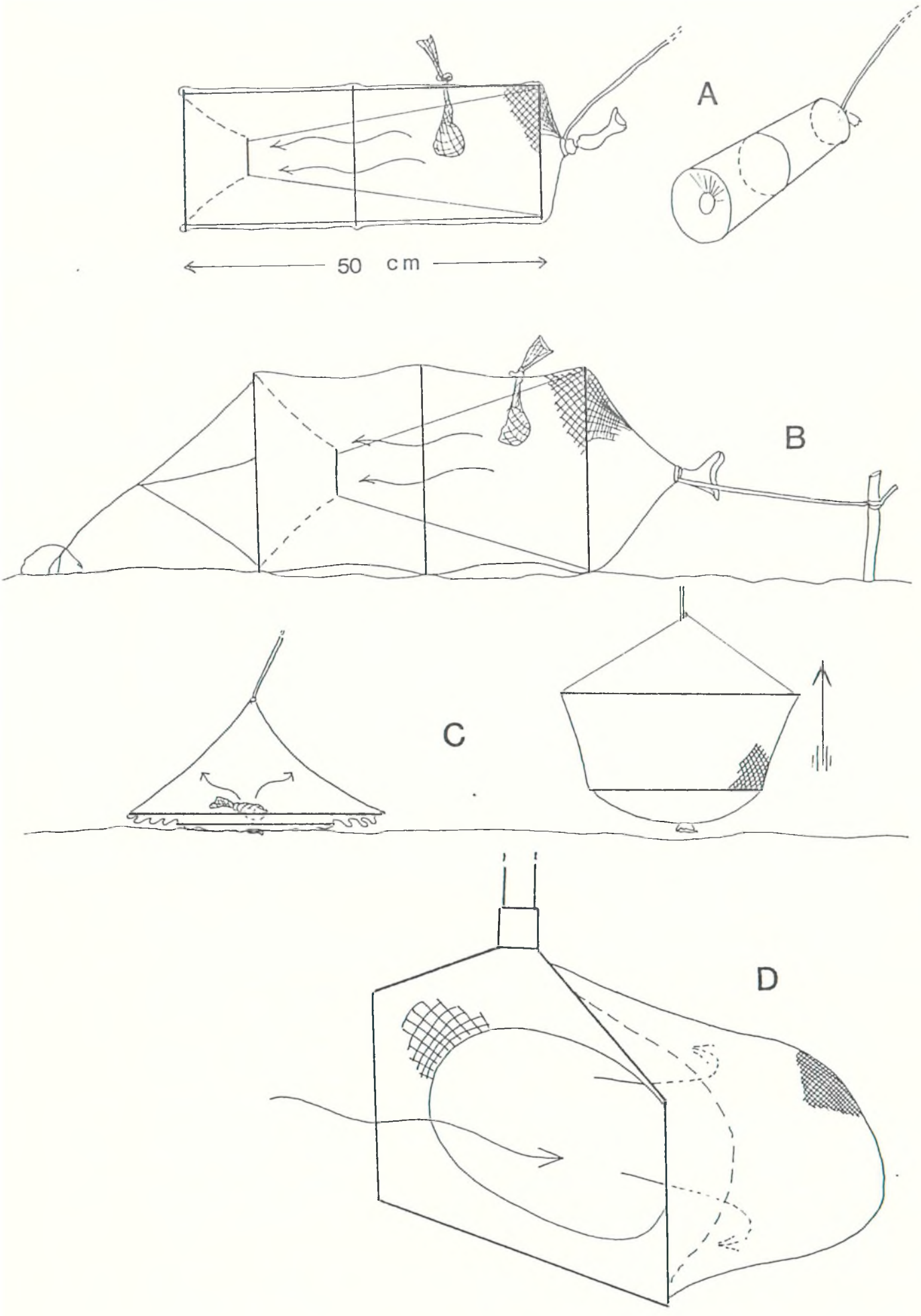

Fig. 3 Sampling devices. A - rigid trap B - collapsible trap
C - drop-net D - modified pondnet

Terminology

'Trap hours' is here defined as the number of hours one trap is deployed. E.g. in the case of three traps being present for 24 hrs there are 72 trap hours.

Appendix II

Sampling Sites

Togo (25 November 5 December 1985) (Fig. 1)

1. R. Mono (Kpessi) (28, 29 Nov, 2 Dec)

The river at this point was 30-45 m wide, large areas of smooth bedrock and a few boulders dominate the substrate type. Bankside vegetation provided some cover in the form of sunken trees in the margins. Traps were set, one for part of one day and a night, three for one 24 h period. M. vollenhoveni was captured.

2. R. Mono (Kolo Kopé) (28 Nov)

River width varied from 15-50 m, some bedrock and boulders but predominantly large sand banks, upstream of the bridge. Some kick sampling attempted, unsuccessfully. The site was judged unsuitable for trapping at the prevailing water height.

3. R. Mono (Atchinédji) (4 and 5 Dec)

River here 60-70 m wide, downstream of the road there were many tree roots and leaf debris under the west bank. Three traps were set in this location for 24 h. M. vollenhovenii was captured.

4. R. Anié (Sotouboua) (2 Dec)

A deeply cut river channel, 10-15 m wide with large boulders, bedrock and some sand and gravel. A complete canopy of large trees was present. Snag sampling disturbed two large shrimp which evaded capture.

5. R. Anié (Akaba) (26 Nov)

River with variable channel width ranging from torrential flow over coarse gravel (15 m wide) to very slow flow over bedrock or sand banks (25-30 m wide). Two traps were set in daylight - no success. Kick-sampling in coarse gravel yielded some small M. vollenhovenii. A large exuvial skin of the same species was recovered downstream of a section treated with pesticide (see report of B. Wahle).

6. R. Anié (Anié) (27, 28, 29, 30 Nov, 2 Dec)

Steep-sided river channel, sandy sediments above the road bridge and the remains of an old bridge downstream, with boulders present. Channel width 30-35 m. Snag-sampling, drop-net and trapping in daylight were unsuccessful. Trapping overnight yielded M. vollenhovenii.

7. R. Ougu (nr Ogouala) (28 Nov)

Discharge very low, upstream of the road bridge a natural gorge had been cut into earth banks. There was a mean water depth of 20 cm and a sandy substrate. No shrimp were recovered by snag sampling, though their presence was reported by local villagers.

8. R. Amou (Amou Oblo) (3 Dec)

A turbulent, fast flowing, clear stream of 5-7 m width. Some large boulders and coarse gravel, marginal areas shallow with some debris. Electro-shocking was conducted for approximately one hour.

M. vollenhovenii were recovered.

9. R. Amou (nr Gléi) (27, 28 Nov, 4, 5 Dec)

A fast flowing river of 20-25 m width, large boulders and bedrock. Many fallen trees and areas of submerged tree roots. Trapping conducted

by day and at night, one shrimp was captured overnight. Snag sampling provided another specimen but the area suitable for wading was restricted by the water level. Shrimp identified as M. vollenhovenii.

10. R. Oulé (Ezimé) (3 Dec)

A small shallow stream with flat bedrock and small areas of gravel. Generally fast flowing with marginal areas containing tree roots and stranded leaves. Electro-shocking for 30 minutes produced M. vollenhovenii.

11. R. Amoutchou (Amoutchou) (3, 4, 5 Dec)

River 15-20 m wide. Upstream of the road bridge the water velocity was slow, much fine sediment was present and the water highly turbid. Three traps were set on two occasions and M. vollenhovenii collected.

12. R. Oua Oua (Ghana-Togo border) (25 Nov)

River level elevated by recent storms, water turbid and fast-flowing, channel width 35-40 m. Three traps and a drop-net were set in daylight, without success, despite simultaneous recovery of shrimps by electro-shocking (see report of B. Wahle, site referred to as R. Wawa). A small sidestream yielded Caridina africana Kingsley and M. sollaudii (?) (De Man), to snag sampling with a pond net.

Ivory Coast 10-16 December 1985 (Fig. 2)

1. R. Maraoué (nr Koudougou) (10, 11, 12 Dec)

Upstream of an outcrop of bedrock the river had a width of 25-30 m, appeared deep and was slow flowing. Dense undergrowth covered the banks

and overhung the water on both banks. Five traps were set adjacent to the N.E. bank. No shrimp captured.

2. R. Maraoué (nr Danangoro) (10, 11, 12 Dec)

The river is split into many channels by large rocks and outcrops of bedrock. Five traps were set on the east and west banks of the main channel, situated at some distance from the access point. No shrimp captured.

3. R. Sassandra (12 km N. Sémien) (12, 13, 14 Dec)

Upstream of the road bridge the river width varied from 80-110 m with bedrock and boulders present. Five traps were set among tree roots under the west bank. No shrimp captured.

4. R. Sassandra (nr Linguékoro) (12, 13, 14 Dec)

At the sampling point the river was 70-80 m wide and upstream the flow was constricted by an extensive outcrop of bedrock and boulders. Five traps were set adjacent to the east bank among tree roots. No shrimp captured.

5. R. Bandama (80 km S.S.E. Korhogo) (14, 15 Dec)

A shallow stony river with boulders, depth averaging 0.4 m in midstream, width 20-25 m, with sloping banks indicating a wet season width of 45-50 m. Eight traps set adjacent to both banks. No shrimp captured.

6. R. Bandama (32 km S.E. Korhogo) (15, 16 Dec)

Upstream of the disused road bridge the river was 35-40 m wide, of

slow velocity and overhung with trees on the east bank. Eight traps were set above and below the old bridge on the east bank. No shrimp captured.

Table 2

Togo

Sampling Methods and Intensity

River Site	No.	Trapping			Snag sampling (Hours)	Kick sampling (Hours)	Electro-shocking (Hours)	Drop Net (Hours)
		No. of Traps	Total Trap Hours (Day)	(Night)				
MONO (KPESSI)	1	4	24	48	0.5	0.2	-	-
MONO (KOLO KOPÉ)	2	-	-	-	0.2	0.2	-	-
MONO (ATCHINÉDJI)	3	3	36	36	-	-	-	-
ANIÉ (SOTOUBOUA)	4	-	-	-	1.0	0.5	-	-
ANIÉ (AKABA)	5	2	8	-	0.5	1.0	-	-
ANIÉ (ANIE)	6	4	148	180	0.2	0.2	-	4
OUGU (Nr OGOUALA)	7	-	-	-	0.8	-	-	-
AMOU (AMOU OBLO)	8	-	-	-	-	-	1.25	-
AMOU (Nr GLEI)	9	3	108	108	0.5	-	-	-
OULÉ (EZIMÉ)	10	-	-	-	-	-	0.5	-
AMOUTCHOU (AMOUTCHOU)	11	3	72	72	-	-	-	-
OUA OUA	12	3	12	-	0.4	0.2	-	4
TOTAL (hours)			408	444	4.1	2.3	1.75	8

Table 3

Ivory Coast

Sampling Methods and Intensity

River Site	No.	Trapping			Snag Sampling	Kick Sampling
		No. of Traps	Trap Hours (Day)	(Night)		
R. MARAOUÉ (nr KOUDOUGOU)	1	1	100	120	-	-
R. MARAOUÉ (nr DANANGORO)	2	5	94	120	0.5	0.2
R. SASSANDRA (12 Km N. SÉMIEN)	3	5	80	120	-	-
R. SASSANDRA (nr LINGUÉKORO)	4	5	80	120	-	-
R. BANDAMA (80 Km SSE KORHOGO)	5	8	24	96	-	-
R. BANDAMA (35 Km SE KORHOGO)	6	8	40	96	-	-
TOTAL (hours)			418	672	0.5	0.2

Shrimp captured - zero

Table 4

TOGO

Numbers of shrimp* captured

RIVER SITE NO.	TRAPPING day	TRAPPING night	Snag Sampling	Kick sampling	Electro-shocking	Drop Net (Day)
1	-	4	-	-	-	-
2	-	-	-	-	-	-
3	-	2	-	-	-	-
4	-	-	-	-	-	-
5	-	-	-	4	-	-
6	-	8	-	-	-	-
7	-	-	-	-	-	-
8	-	-	-	-	6	-
9	-	1	1	-	-	-
10	-	-	-	-	3	-
11	-	2	-	-	-	-
12	-	-	12	-	-	-
TOTALS	-	17	13	4	9	-

*All specimens were identified as M. vollenhovenii except those from site (12), which were M. sp (close to sollaudii) (4) Caridina africana (8)

Table 5

TOGO

Rate of shrimp capture by successful methods (hours/shrimp)

	Site											
Method	1	2	3	4	5	6	7	8	9	10	11	12
Night trapping	24		18			22.5			108		36	
Snag sampling	-								0.50			0.033
Kick sampling	-				0.25							
Electro-shocking	-							0.21		0.17		

Table 6

Anecdotal information on shrimps

Data were obtained from fishermen (F) or villagers (V) when the opportunity arose.

In Togo the local name for shrimps was "bolo" or "bollow", similar or the same as "bolu", an Ewe name for a particular coastal shrimp (Holthuis 1980).

TOGO

River Site No.	Shrimp reported present	Methods of capture	Best time of year	A good trap catch?	Other comments
1	(V)	netting & trapping (away from bridges)	wet season	20 shrimp per trap	recommended baits were any vegetable or fruit peelings
2	(F)	-	-	-	-
3	(F)	-	-	-	-
4	(V)	stun/crush with a stake driven under rock crevices	-	-	-
5	(F)	-	-	-	-
6	(V)	trapping	wet season	-	shrimp reported as numerous
7	(V)	-	-	-	-
8	(V)	-	-	-	-
9	(V)	trapping	wet season	-	shrimp reported as numerous
10	(V)	-	-	-	-
11	no-one questioned				
12	no-one questioned				

Table 6 (continued)

IVORY COAST

River Site No.	Shrimp reported present	Methods of capture	Best time of year	A good trap catch	Other comments
1	(F)	trapping	wet season	up to 10 per trap	shrimp activity not confined to hours of darkness in the wet season
2	(F)	-	wet season		only modest catches expected
3	(F)	trapping	wet season		
4	(V)	-	-	-	No fishing specifically for shrimp as numbers are low
5	no-one questioned				
6	(V)				no shrimp believed present
7*	(F)	netting & trapping	wet season	up to 20 per trap	report upstream migration. three large species regarded as present

* This site on the R. Bandama (E. of Bouaflé) was visited briefly to obtain information. The fishermen refrain from shrimp fishing during the dry season a) because shrimp capture rates are low, b) fish are comparatively easy to catch. When shown drawings of the claws of different species of Macrobrachium they were confident that M. vollenhovenii, M. macrobrachion were common in the wet season and that small numbers of a species close to M. raridens were present throughout the year.

Appendix III

Macrobrachium spp. are separated on the morphological characteristics of the adult males. The proportions and appearance of structures and appendages change as the animals grow, causing difficulties in the identification of females and immature specimens. For this reason various counts and measurements were made over the complete size range of individuals captured to see if any characters were constant or remained useful in species separation (Tables 8 and 9).

Summary of useful characters for species recognition

M. vollenhoveni - Counts of rostral teeth gave a range of 10-15 dorsal teeth and 3-6 ventral teeth, modal values were 13 and 4. These counts were independent of the size of the animal. The distal portion of the large claw of the 2nd walking leg was black or blue-black contrasting with the rest of the exoskeleton which was colourless (but occasionally covered by epiphytes, in the largest individuals). Preserved animals showed this character most clearly as underlying tissue became orange-red, except where obscured at the claw tips. However the claw tips were not darker in the smallest individuals examined.

M. sollaudii (?) - Rostral teeth were less numerous, dorsally the range was 6-10, ventrally 1-3 with modal values of 8 and 3, respectively. Again these values were independent of animal size. The large 2nd walking leg was unicolourous in all individuals, a rich orange/red on preservation. Other characters useful for species separation are illustrated (Figs 4 and 5); these are dependent on the size of the animal.

Females bearing eggs carried about 25 large (2.5-3 mm diameter) eggs. M. vollenhovenii females were not observed in the present study but

they are reported to carry many thousands of minute (0.2 mm) eggs (Miller 1971).

C. africana - a comparatively small shrimp, all specimens examined were less than 30 mm total length. It could be distinguished rapidly from the Macrobrachium spp. recorded, by its longer rostrum (consistently exceeding the length of the scaphopodite) and more numerous rostral teeth, modal numbers, 18 dorsal and 6 ventral.

Table 7

M. vollenhovenii (measurements in mm)

River Site Number (Togo)	Total body length*	Carapace length*	Rostral teeth count dorsal	Rostral teeth count ventral	Rostral length v. scaphopodite length	2nd walking leg (length) palm	carpus	merus
1	122	49	13	4	<	47	20	24
	115	41	12	4	<	48	19	21
	102	35	14	4	=	44	15	16
	94	31	13	4	<	36	13	14
Benech —	126	43	13	4	<			
5	?	37	13	4	<	incomplete exuvium		
Wahle	?	38	14	6	<	"		"
	?	40	13	4	<	"		"
	27	7.5	13	3	<	1.5	3	2
	26	7.5	14	3	<	3.5	2.5	2.5
	26	7.5	14	3	<	1.5	3	2.5
	26	7.5	14	4	<	3	2.5	2.5
6	84	27	10	4				
	79	23	13	4				
	76	26	12	4	=			
	54	17	13	4	=			
	115	42	12	4	<	73	23	25
	112	39	14	4	<	60	17	20
	100	34	13	4	<	48	16	16
	43	14	13	4	=	16	6	7
	103	35	13	4	=	50	17	18
8	110	34	12	4	<	40	13	14
	69	22	13	4	<	23	9	10
	54	17	13	4	=	15	6	7
	47	15	12	3	=	13	6	7
	46	15	13	3	=	13	6	6
	32	9	13	4	=	5	3	3
Wahle —	117	42	13	4	<	50	16	20
9	55	17	13	5	=			
	82	27	12	4	<			
10	66	22	14	4	<	26	9	10
	47	15	13	4	<	14	6	7
	37	11	14	4	=	11	4	4
11	55	20	13	4	=	23	8	9

* Anteriorly from the rear of the eye socket.

Rostral teeth counts do not include the terminal spine.

Table 8

M. sollaudii (?) (measurements in mm)

River Site Number (Togo)	Total body length*	Carapace length*	Rostral teeth count dorsal	Rostral teeth count ventral	Rostral length v. scaphopodite length	2nd walking leg (length) palm	2nd walking leg (length) carpus	2nd walking leg (length) merus
12 Snag sampling	33	9	8	2	<	2	3.5	4.5
	36	14.5	9	3	<	11	6	6
	37	11	8	2	<	2	5	4
	29	9	9	3	<	7	5	5
	44	13.5	8	3	<	10	6.5	6.5
	68	21	8	2	<			
	58	19	10	3	<			
	58	18	8	3	<			
	60	17	8	3	<			
	60	18	8	2	<			
(♀,gravid)								
Electro-shocking (Wahle)	73	29	7	2	<	41	23	20
	60	19	6	2	<			
	47	14	9	3	<			
	49(♀)	15	8	2	<	12	8	7.5
	50	13	8	2	<	11	8	6
(♀,gravid)								
	36(♀)	13	8	1	<	10	6	7
	53	15	8	2	<	13	9	8
	36	12	9	3	<	12	6	5
	50	15	8	3	<	18	9	9
	47	13	9	3	<	10	8	6
(♀,gravid)								
	47	13	9	3	<	14	7	7
	45	13	8	3	<	10	8	7
	44	12	8	2	<			
	65	20	10	3	<	16	20	20
	44	13.5	8	3	<	10	6.5	6.5

* Anteriorly from the rear of the eye socket.

Rostral teeth counts do not include the terminal spine.

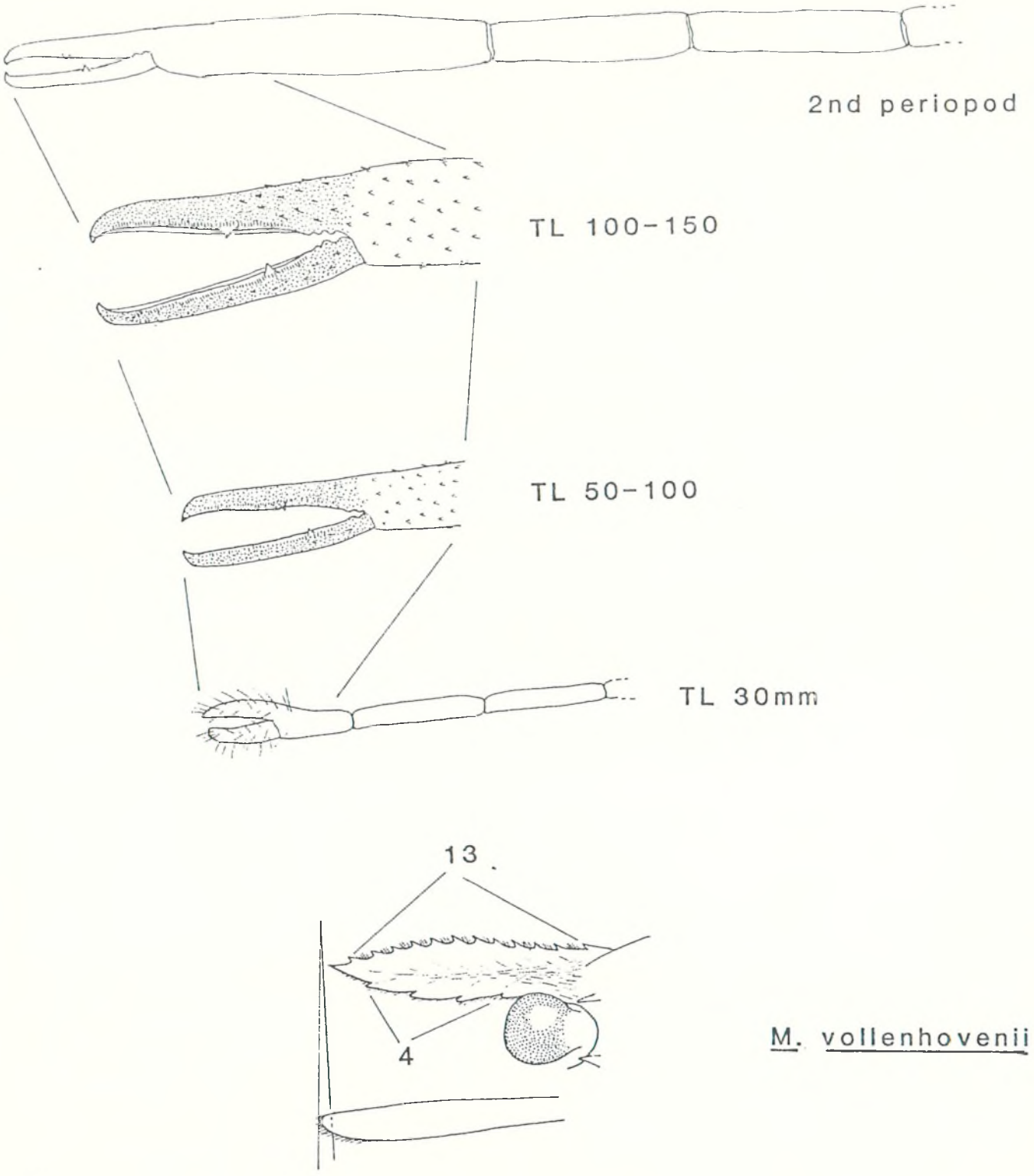

Fig. 4 M. vollenhovenii. Morphological features (T.L. - total length, rear of eye socket to tip of telson)

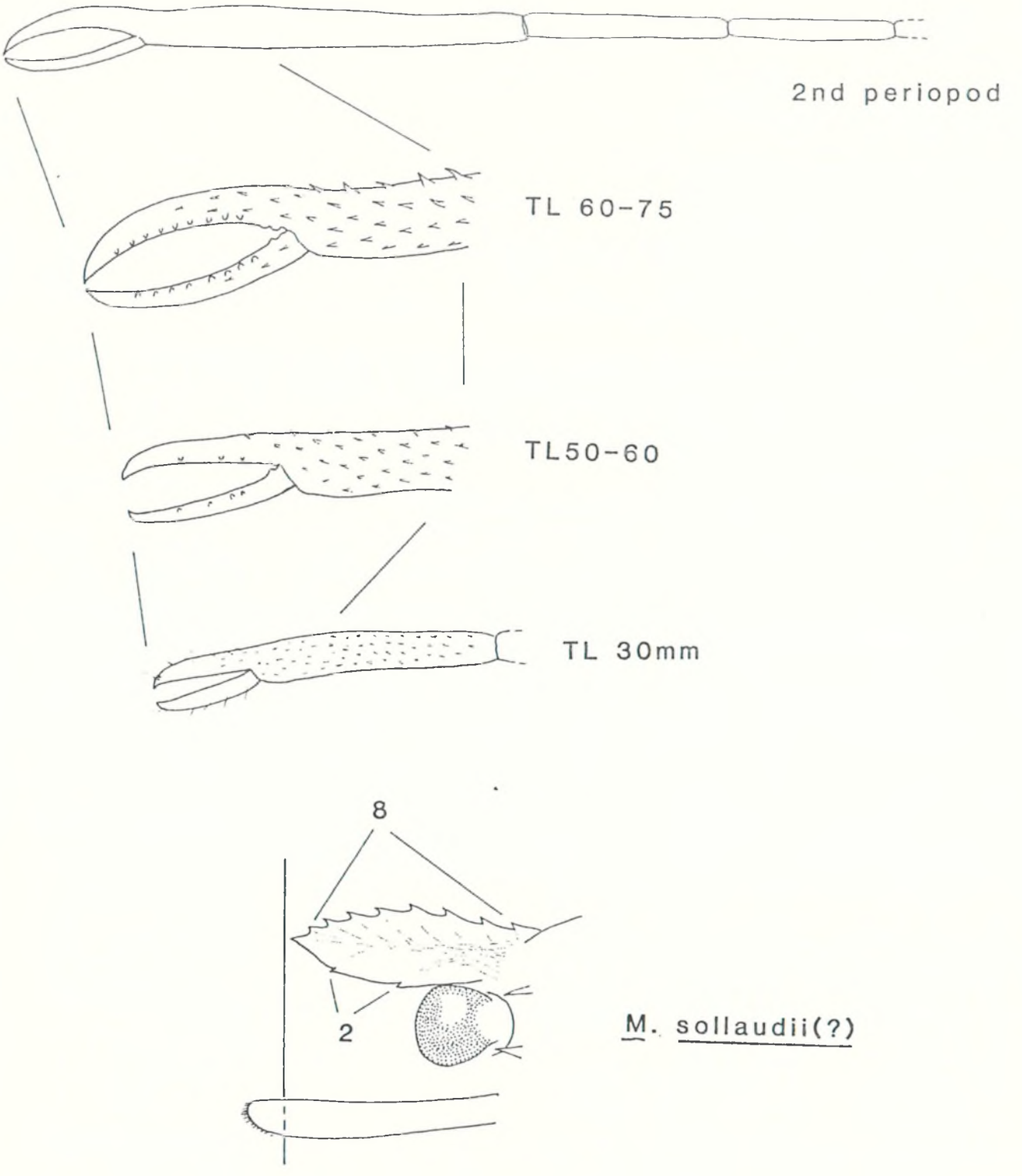

Fig. 5 M. sollaudii (?). Morphological features (T.L. - total length, rear of eye socket to tip of telson)

Appendix IV

Recommended trap design and operation

Materials: Netting, 8 mm knot to knot

galvanised steel rod, 4 mm diameter, 3 x 500 mm lengths

3 x 200 mm diameter rings

1 x 6 mm diameter ring

(construction details, Fig. 3A)

The netting is sewn to form a tube, the small ring attached to one end and the tube of netting stretched over the trap frame. The funnel is formed by attaching two elasticated restraining cords to the opposite end of the frame, internally. The other end of the netting is gathered tightly and knotted to maintain an even tension. From this point the trap may be attached to a rope and it is also the point of entry for emptying the trap.

Some discretion can be allowed for positioning the traps, but in general they should be placed in slow flowing areas to minimise damage from drifting debris. They should be adjacent to areas of cover such as submerged vegetation, rocks etc., arranged in a discrete group of five traps spaced over no more than 10 m of bank, with their entrances facing downstream and baited with freshly sliced fruit or vegetable. (During the present study banana was used successfully but whatever is universally available at the time of trapping should be used exclusively.)