

INVENTORY OF AQUATIC HETEROPTERA IN PONDS NEAR THE VILLAGES OF SIX HEALTH DISTRICTS, ENDEMIC TO BURULI ULCER IN CÔTE D'IVOIRE (WEST AFRICA)

Abstract

Some studies implicate certain aquatic Heteroptera in the transmission to human of *Mycobacterium ulcerans*. It's in this context that this study was initiated in Côte d'Ivoire; in six endemic health districts in 2008 and 2009. Its purpose was to make an inventory of aquatic Heteroptera in ponds located near the villages. Water bugs were monthly collected in ponds where there are human activities with nets. The identification has been made under a dissecting microscope and using determination keys of aquatic insects. The different species in each sample were counted. 7190 specimens of aquatic Heteroptera have been collected, which they were composed by 19 taxa belonging to 8 families have been identified. Those families were: Belostomatidae, Naucoridae, Ranatridae, Nepidae, Notonectidae, Corixidae, Gerridae et Pleidae. The most abundant taxa and who were present in all sites with a high frequency belong to the genera *Diplonychus*, *Micronecta*, *Naucoris*, *Ranatra* and *Laccotrephes*. The majority of those genera and taxa are carnivorous and predatory. They can bite accidentally human and transmit *Mycobacterium ulcerans* to him, during his activities in the aquatic environment. Some genera and taxa are strong fliers that are attracted by light at night and can bite humans in homes and thus transmit to them *Mycobacterium ulcerans* out of the water

Key words: Aquatic Heteroptera – Implication - *Mycobacterium ulcerans* - Buruli ulcer - Côte d'Ivoire – West Africa

1. Introduction

Aquatic insects have always worried man, both for their economic role and for their medical importance^{1, 2}. In Côte d'Ivoire, many studies have been conducted on aquatic insects, as part of the fight against aquatic insect vectors of diseases to humans^{3, 4, 5, 6}. Similarly studies on migration of Belostomatidae⁷ and faunal inventory of some aquatic environments were conducted^{9, 10}. But surveys in the stagnant water has been erratic over current water⁸. From 2002, Marsollier and al were detected DNA sequences of *Mycobacterium ulcerans*, the causative agent of Buruli ulcer in the salivary glands of the water bugs belonging to the of Naucoridae and Belostomatidae families, who they were collected from an endemic area of Côte d'Ivoire¹¹. Indeed, some water bugs are fierce predators and do not hesitate to bite humans when it passes near or seizes them². It is therefore necessary to know the different aquatic Heteroptera that inhabit stagnant water collections widely used by man in his daily activities. It is in this context that the monthly samples were collected from ponds frequented by humans into six health districts, endemic for Buruli ulcer between 2008 and 2009. This study is a contribution to the study of aquatic Heteroptera from ponds, who could be involved in transmission to human of *M. ulcerans* in Côte d'Ivoire.

2. Materials and methods

2.1. Study sites

The study was carried out in the health districts of Dabou, Tiassalé, Yamoussoukro, Didiévi, Tiébissou and Bouaké-East (Bamoro) (Figure 1). Preliminary surveys in the health districts of Dabou and Tiassalé have identified several water bugs such as *Micronecta* (Corixidae) *Diplonychus* (Belostomatidae) and *Naucoris* (Naucoridae)¹².

2.2. Collection of insects in ponds

Monthly surveys were conducted from January to October 2008 and again in September and November 2009. The samples were held in the afternoon, in water collections frequented by humans. Each sample in a pool lasted 30 minutes and was performed at different points of contact of the pond by populations. Aquatic insects were collected using dip nets. small Taxa that are confined to the edges of the ponds were taken using a white enameled tray and collected by sieving through a fine mesh sieve (0.5 mm). A first selection was done on the ground and all the insects in each sample was packed in jars with substrates of the pond to allow insects to settle there. This saves them drowning in transit. A sticker with the sample number, the place of harvest, the harvest date and the number or the name of the mare was attached to each sample.

2.3. Identification and enumeration of aquatic Heteroptera collected

The insects were identified and counted in the laboratory, to the lowest taxonomic level when this was made possible under a dissecting microscope type CETI with magnification x 10 (0.7 to 4.5) and using books determination^{13, 14, 15, 16, 17, 8, 18}. After identification, aquatic Heteroptera preserved in laboratory jars containing alcohol 90.

2.4. Statistical analyzes

Statistical analyzes were performed using the R software version 3.0.1

3. Results and Discussions

A total of 7190 specimens of aquatic Heteroptera were collected. They are divided into eight families, 15 genera and 19 taxa (Table 1). Our results are comparable to those of Dejoux and al who reported that aquatic Heteroptera can be found in all water collections⁸ and that their diversity is greater in still and calm waters in the aquatic environment⁸. Plate 1 shows the main aquatic Heteroptera collected during this study in the different sites. *Diplonychus sp* and *Naucoris sp*, were taken from the 6 health districts ($p < 0.001$). The taxon *Diplonychus sp* was collected during all sampling periods ($p < 0.001$). *Diplonychus sp* (Belostomatidae) is present in all the stagnant water collections and in all seasons, with a large proportion^{21, 6}. Our results confirm those of Dejoux and Duviard who described such as more abundant and present in all areas of Côte d'Ivoire^{8, 7}. *Naucoris sp* (Naucoridae) is also found in the same habitats as Belostomatidae but with low proportions. *Anisops sp* (Notonectidae) has not been taken from the pool selected in Yamoussoukro. *Laccotrephes ater* was not taken from the ponds chosen in Didiévi and Tiébissou.

In the district of Tiassalé, 18 taxa were identified, except *Laccotrephes sp*. In Dabou, 12 taxa were identified; except *Limnogeton fieberi* and *Belostoma cordofana*, the Corixidae and *Rhagadotarsus hutchinsoni*. In Bamoro (Bouaké), 12 taxa were identified except *Limnogeton fieberi* and *Belostoma cordofana*, *Micronecta scutellaris* and Gerridae. In Didiévi, 10 taxa were identified (Table 1). The difference between the number of taxa obtained in the different districts is not significant ($p > 0.05$).

Aquatic Heteroptera collected consist of 3125 (43.46%) *Micronecta sp*; 2344 (32.60%) *Diplonychus sp*, 462 (6.43%) *Ranatra fusca*, 451 (6.27%) *Anisops sp*, 244 (3.39%) *Plea pullula*, 210 (2.92%) *Enithares sp* and 178 (2.48%) *Naucoris sp*. The difference between the apparent densities from Dabou and Tiassalé is significant ($p < 0.05$). Out of all the sampling periods, taxa *Micronecta sp* (Corixidae) and *Diplonychus sp* (Belostomatidae) dominate the samples. These results are comparable to those of Hazarik²² and Ebong²³.

In April, 1467 (46.94%) *Micronecta sp* were collected, 421 (13.47%) in February and 407 (13.02%) in May and 12 47% in March. As for *Diplonychus sp*, 421 (21.25%) specimens were taken. *Diplonychus sp* was collected monthly

with more in April and September. *Micronecta sp* was collected every month except October and peaking in April. *Naucoris sp* was also taken every month except September. *Anisops sp* and *Enithares sp* are also present over time, but not taken in March and October respectively (Figure 2). About these two taxa, Poisson, said that they can invade concrete tanks as well as outdoor swimming pools and become harmful to humans¹⁸.

Diplonychus sp (Belostomatidae) was present in all the ponds studied with 1222; 768 and 165 specimens collected respectively in Dabou, Tiassalé and Bamoro (Bouaké Northeast). The taxon *Naucoris sp* (Naucoridae) was also present in all districts where 116; 27 and 19 specimens were respectively harvested in Tiassalé, Dabou and Bamoro. In Tiassalé, 3118 specimens of *Micronecta sp* (Corixidae) were harvested and 3 specimens were collected in Tiébissou. This species has not been collected in Dabou and Yamoussoukro. *Ranatra fusca* (Ranatridae) was collected everywhere except in Yamoussoukro. 230 and 182 specimens of this species were collected respectively to Dabou and Tiassalé. To Didiévi, Tiébissou and Bamoro; 14, 8 and 28 specimens were respectively collected. 323 specimens of *Anisops sp* (Notonectidae) were collected in Tiassalé. The taxon *Laccotrephes sp* (Nepidae) is present in the pools, but little was taken. *Plea pullula* (Pleidae) was encountered in three districts. They are: Tiassalé, Dabou and Bamoro (Figure 3).

The majority of taxa described as *Diplonychus sp*, *Belostoma cordofana*, *Naucoris sp*, *Laccotrephes ater*, *Laccotrephes sp*, *Anisops sp*, *Enithares sp*, *Ranatra fusca*, etc., is predatory and does not hesitate to bite humans²⁴.²⁵. Some have already been mentioned in Côte d'Ivoire as carriers *M. ulcerans* in their salivary glands. This is *Micronecta sp* and *Diplonychus sp*. They could be considered as such as hosts and probable potential vectors^{12, 26, 20}. They are also strong fliers and attracted to light at night, perform migrations^{27, 14, 7}. Those Aquatic Heteroptera collected from ponds near villages could present risk factors for contamination to human of *Mycobacterium ulcerans*, the etiological agent of Buruli ulcer in Côte d'Ivoire. Indeed, because of their ability to fly⁷, they could leave the water at night and attracted to lights in our homes, they could enter and accidentally poking men. If they are infected with *M. ulcerans*, they could spread it to humans during their bite. Indeed, the molecular signatures of *M. ulcerans* were detected in *Diplonychus sp* (Belostomatidae) collected in homes in Benin²⁶. Under these conditions, aquatic Heteroptera would ensure the dissemination of *M. ulcerans* from one pond to the other and contaminate man out of aquatic environments.

4. Conclusion

This study identified 19 taxa divided into 8 families (Belostomatidae, Naucoridae, Ranatridae, Nepidae, Notonectidae, Corixidae, Gerridae and Pleidae) and 15 genera (*Diplonychus*, *Belostoma*, *Limnogeton*, *Naucoris*, *Laccocoris*, *Micronecta*, *Corixini*, *Ranatra*, *Enithares*, *Anisops*, *Laccotrephes*, *Plea*, *Rhagadotarsus*, *Limnogonus* et *Eurymatra*). The taxon *Diplonychus sp* was taken in time and space and sometimes well above the other numbers. Among these taxa, some are predators and can bite humans and transmit him *M. ulcerans* in the water. Still others are able to fly at night and attracted to light can sometimes be found in homes. The presence of these aquatic Heteroptera in ponds near villages could then constitute risk factors for contamination.

5. Declaration of conflict of interest

The authors wish to declare that there is no conflict of interest.

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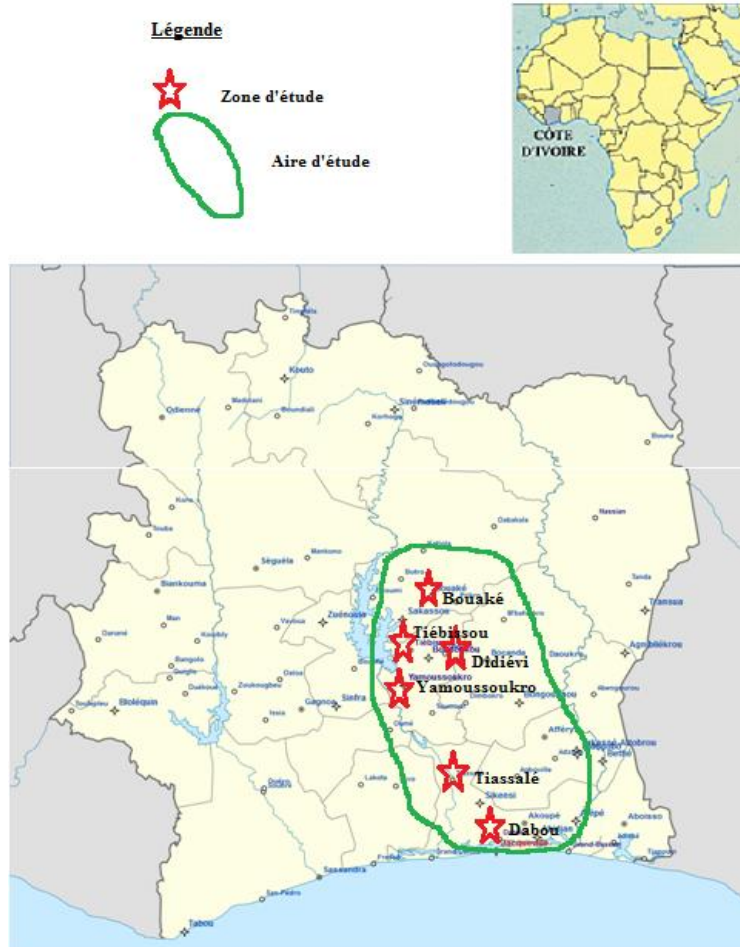


Figure1. The six endemics health districts to Buruli ulcer localization where the study was realized during 2008 and 2009.



Figure 2.a. *Diplonychus sp*



Figure 2.b. *Naucoris sp*



Figure 2.c. *micronecta sp*



Figure 2.d. *Belostoma cordofana*



Figure 2.e. *Limnogston fieberi*



Figure 2.f. *Enithares sp*



Figure 2.g. *Plea pullula*



Figure 2.h. *Gerridae*



Figure 2.i. *Laccotrephes sp*



Figure 2.j. *Ranatra fusca*

Table 1. Biological diversity and assessment of aquatic Heteroptera genera and species collected in the different sites of the six endemic health districts during 2007 and 2009

Family	Taxons	Dabou	Tiassalé	Yakro	Didiévi	Tiébissou	Bouaké Est
Belostomatidae	<i>Diplonychus sp</i>	+	+	+	+	+	+
Belostomatidae	<i>Limnogeton fieberi</i>	-	+	+	+	-	-
Belostomatidae	<i>Belostoma cordofana</i>	-	+	+	-	-	-
Naucoridae	<i>Naucoris sp</i>	+	+	+	+	+	+
Naucoridae	<i>Laccocoris sp</i>	+	+	-	-	-	-
Corixidae	<i>Micronecta sp</i>	-	+	-	+	+	+
Corixidae	<i>Micronecta scutellaris</i>	-	+	-	-	-	-
Corixidae	<i>Corixini sp</i>	-	+	-	+	+	+
Ranatridae	<i>Ranatra fusca</i>	+	+	-	+	+	+
Notonectidae	<i>Enithares sp</i>	+	+	-	+	-	+
Notonectidae	<i>Anisops sardea</i>	+	+	-	-	+	+
Notonectidae	<i>Anisops sp</i>	+	+	-	+	+	+
Nepidae	<i>Laccotrephes ater</i>	+	+	+	-	-	+
Nepidae	<i>Laccotrephes sp</i>	-	-	+	+	+	+
Pleidae	<i>Plea pullula</i>	+	+	-	-	-	+
Gerridae	<i>Rhagadotarsus hutehinsoni</i>	-	+	-	-	-	-
Gerridae	<i>Limnogonus chopardi</i>	+	+	-	-	-	-
Gerridae	<i>Limnogonus sp</i>	+	+	-	-	-	-
Gerridae	<i>Eurymatra sp</i>	+	+	-	+	-	+
Total		12	18	6	10	8	12

NB : + = collected ; - = non collected

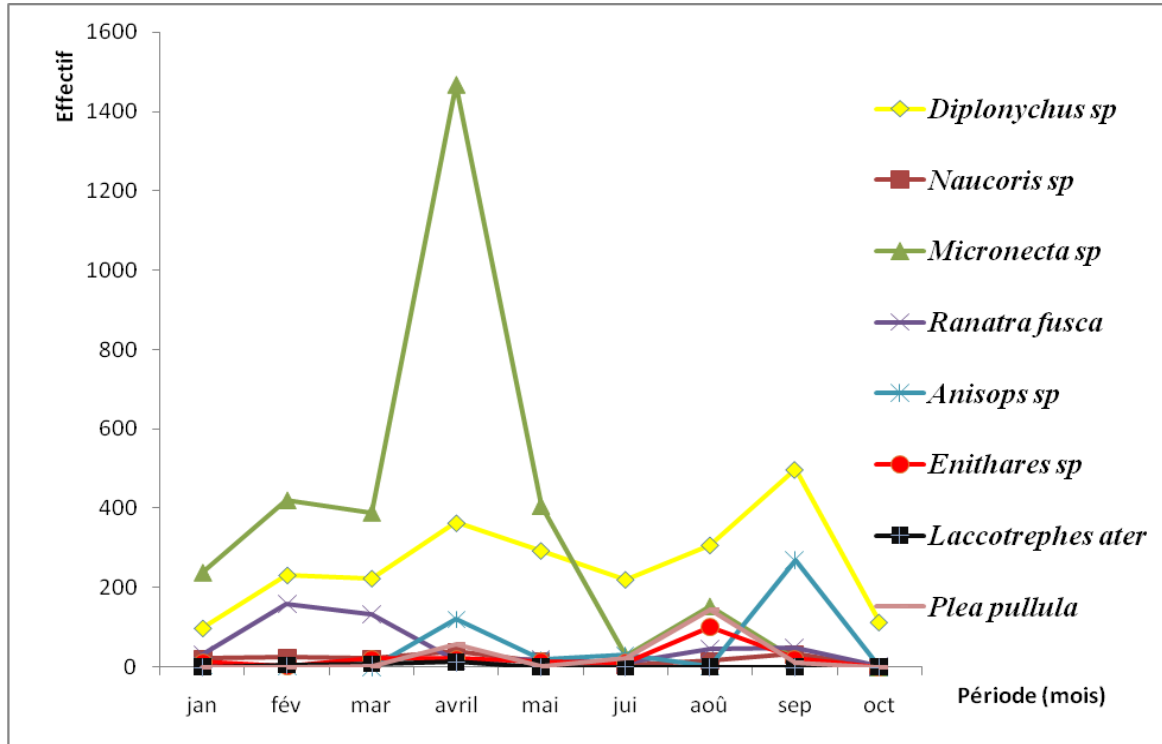


Figure 2. Population dynamic of the differents aquatic species collected during the study during 2008 and 2009

- son traitement au témiphos. 1. Equilibres faunistiques, données brutes. Rapp. ORSTOM, Bouaké ; 1979 ; 28: 70 pp. multigr.
5. Elouard, JM, Dejoux C & Troubat JJ. Action de Tephrosia vogelii (Leguminosae) employé dans les pêches traditionnelles sur les invertébrés benthiques de la Marahoué (Côte d'Ivoire). Revue Hydrobiol. Trop 1982 ; 15: 177-188.
 6. Lévêque C, Dejoux C & Iltis A. Limnologie du fleuve Bandama, Côte d'Ivoire. Hydrobiologia 1983 ; 100, 113-141
 7. Duviard D. Flight activity of Belostomatidae in Central Ivory Cost. Oecologia (Berl.) 1974 ; 15; 321-328
 8. Dejoux C, Elouard JM, Forge P et Maslin JL. Catalogue iconographique des insectes aquatiques de Côte d'Ivoire. Rapport n°42; Document ORSTOM 1981 ; 178 p
 9. Diomandé D, Bony K Y, Edia O E Konan KF et Gourène G. Diversité des Macroinvertébrés Benthiques de la Rivière Agnèby (Côte d'Ivoire; Afrique de l'Ouest). European Journal of Scientific Research 2009 b ; 35 (3): 368-377.
 10. Stazner B., Dejoux C., Elouard J. M. Field experiments on the relationships between drift and benthic densities of aquatic insects in tropical stream (Ivory Coast). Revue d'Hydrobiologie Tropicale 1984 ; 17 (4): 319-334
 11. Marsollier L, Robert R, Aubry J, Saint Andre J P, Kouakou H, Legras P et al. Aquatic Insects as a Vector for Mycobacterium ulcerans. Appl Environ Microbiol 2002 ; 68:4623-28.
 12. Doannio JMC, Konan KL, Nansou FD, Koné AB, Konan YL, Sankaré Y et al. Micronecta sp (Corixidae) et Diplonychus sp (Belostomatidae), deux hémiptères aquatiques hôtes et/ou vecteurs potentiels de Mycobacterium ulcerans agent pathogène de l'ulcère de Buruli en Côte d'Ivoire (Afrique de l'Ouest). Médecine Tropicale 2011 ; 71 ; 53-57
 13. Andersen NM. et Weir TA. Australian water bugs : their biology and identification (Hemiptera-Heteroptera, Gerromorph & Nepomorpha), Apollo Books, Danemark, CSIRO Publishing Australia; 2004
 14. Choate PM. Giant water bugs, electric light bugs, Lethocerus, Abedus, Belostoma (Insecta: Hemiptera : Belostomatidae). 2003. Available from <http://creatures.ifas.ufl.edu>.
 15. Estévez AL & Polhemus JT. The small species of Belostoma (Hemiptera: Belostomatidae). I. Introduction, Key to species groups and a revision of the denticolle group. Inheringia 2001; 91: 151-158.
 16. Dethier M. Hémiptères aquatique et ripicoles. Genres et principales taxons in Introduction pratique à la systématique des organismes des eaux continentales françaises. Bulletin mensuel de la Société Linnéenne de Lyon 1986 ; 54 ; 10.
 17. Dethier M. Hémiptères, In Durand Jean-René, Lévêque Christian. Flore et faune aquatiques de l'Afrique Sahélo-soudanienne : tome 2. Insectes et vertébrés. (Initiations-Documentations Techniques ; 45). ISBN 2-7099-0585-X Paris : ORSTOM, (45), 1981 ; p. 390-873.
 18. Poisson R. Hémiptères aquatiques, Faune de France, 61. Editions Paul lechevalier, 12 Rue de Tournon (VI^e). 1957 ; 267 pages.
 19. Chambon, Chevin, Cocquemot, Dommanget, Giustina, Maatinez, Caupenne et Matocq. Contribution à

l'inventaire des arthropodes de la réserve naturelle du « Pinail » (Vouneuil-sur-vienne 86) 1^{ère} partie. Cah. Liaison O.P.I.E Vol. 21 (1), 1987 ; 64, 3-19. 17 pages.

20. Marion E, Eyangoh S, Yeramian E, Doannio J, Landier J, Aubry J et al. Seasonal and regional dynamics of Mycobacterium ulcerans transmission in environment context : Deciphering the role of water bugs as host and vectors. Plos Trop Dis 2010; 4 (7) : e731
21. Dejoux C. Les insectes aquatiques du lac Tchad - Aperçu systématique et bio-écologique Verh. Intemat. Verein. Limnol 1969., 17, 900-906
22. Dethier M. Les Hétéroptères aquatiques de la collection Cerutti. Mitt. Schw. ent. Ges 1973 ; 46 (3-4) : 297-312.
23. Ebong S.M.A., Eyangoh S., Marion E., Landier J., Marsollier L., Guégan J.F. and Legall P. Survey of Water Bugs in Bankim, a New Buruli Ulcer Endemic Area in Cameroon. Journal of Tropical Medicine 2012 ; 8 pages
24. Hazarika R. & Goswami M. M. Aquatic Hemiptera of Gauhati University, Guwahati, Assam, India. Journal of Threatened Taxa 20102 ; (3): 778-782
25. Silva MT, Portaels F et Pedrosa J. Aquatic Insectss and Mycobacterium ulcerans: An Association Revelant to Buruli Ulcer Control? PloS Medecine 2007; 4; Issue 2; e63; 229-231
26. Marion E, Deshayes C, Chanty A, Cassisa V., Tchibozo S., Cottin J. Detection of Mycobacterium ulcerans DNA in water bugs collected outside the aquatic environment in Benin. Med Trop 2011; 71 ; 2 : 169-72
27. Yoon TJ, Kim DG, Kim SY, Jo SI and Bae YJ. Light-attraction flight of the giant water bug, Lethocerus deyrolli (Hemiptera: Belostomatidae), an endangered wetland insect in East Asia, Aquatic Insects 2010; 32:3, 195-203

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