International Journal of Mosquito Research

ISSN: 2348-5906
CODEN: IJMRK2
IJMR 2019; 7(4): 39-44

www.dipterajournal.com
Received: 18-05-2020
Accepted: 20-06-2020

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Breeding substrates and diversity of aedes species in Periurban areas of Côte d'Ivoire

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Abstract
As part of the arboviral disease vectors surveillance in Côte d'Ivoire, a longitudinal entomological prospection was undertaken in five stations. Mosquito larvae collections were carried out monthly from March 2018 to September 2019 in breeding sites and using the WHO-type oviposition trap. These larvae were reared till adult stage at the insectarium of the Institut National d'Hygiène Publique (INHP) in Abidjan. Adult mosquitoes were morphologically identified using standard keys. In total, 896 potential mosquito larval breeding substrates were identified. Aedes larvae were collected from 225 sites. The ideal breeding substrates for Aedes consisted of abandoned containers/objects (39.6%), natural breeding sites (31.6%), and storage containers (22.2%). It was noticed that used tires (5.3%) and other breeding substrates (1.3%) were poorly represented. There was a statistically significant difference (χ^2 = 48.748; ddl = 16; P = 0.000) in the positive proportions of Aedes with breeding substrates. The ideal height for Aedes breeding is 1.5m. In terms of species diversity, 16 Aedes species were identified and the most frequent was *Aedes aegypti* (80.8%). From the Shannon index (H'), Aedes species are not very diversified (H' = 0.42 in the south, H' = 1.08 in the west, H' = 0.38 in the north-west, H' = 0.69 in the north-east and H' = 1.09 in the center). The baseline data obatained from this study could instruct decision makers involved in antivectoral fight to better design and implement control measures against arboviruses vectors.

Keywords: Aedes, species composition, breeding sites, arbovirus, Côte d'Ivoire.

1. Introduction
Within the insect class, Culicidae occupy an important space [1] with more than 3,500 species already described [2]. These insects, represented by two subfamilies (Culicinae and Anophelinae) are considered to be the largest group of arthropods of medical importance [3, 4, 5]. They are involved in the transmission of several parasites and viruses that cause diseases such as malaria and arboviruses [5, 6, 7].
Arboviruses such as dengue fever, Japanese encephalitis, chikungunya, yellow fever and Zika fever threaten nearly 831 million people worldwide, including 70% of the African population [8]. Today, these diseases constitute a major threat to the health of human populations [9].
In Côte d'Ivoire, dengue fever and yellow fever are growing concern for health authorities [10, 11, 12, 13, 14, 15]. Indeed, in recent decades, the country has experienced an increase in cases associated with these vector-borne diseases in both urban and rural areas. In urban areas, the only vector suspected to be implicated in causing arbovirus epidemics is *Aedes aegypti*. *Aedes aegypti* breed in different breeding sites that are mostly encountered around households [15, 16, 17, 18]. In rural and/or Sylvatic areas the following *Aedes* spp. : *Ae. aegypti*, *Ae. africanus, Ae. luteocephalus,* and *Ae. usambara* are encountered [19, 20, 21, 22, 23]. However, in arbovirus monitoring stations of Côte d'Ivoire, very few studies on Aedes have been conducted. This study seeks to impove on the knowledge of the ecology and species diversity of genus *Aedes* in five stations in Côte d'Ivoire.

2. Materials and Methods
2.1 Study zone
This study was conducted from March 2018 to September 2019 in five different stations in Côte d'Ivoire, located in the south (Banco National Park (5 ° 23'40"N and 4 ° 03'07"W)), West (Vapleu village (6 ° 49'N and 8 ° 16'W), northwest (Tron Touba village (9 ° 43'N and 7°

23W)), north east (Toupé village (9 ° 06'53"N and 3 ° 43'49"W)), and center (Sokala Sobara village (8 ° 27 ′ N and 4 ° 31′W)) (Fig. 1). The climate of these stations is generally hot and humid ranging from 20 ° C to 33 ° C. The area has three climates i.e. hot (November to February), hot and dry (March to April), and very hot and dry (June to October). The choice of the different study study stations was based on their differences in relief, vegetation, rainfall and temperature patterns.

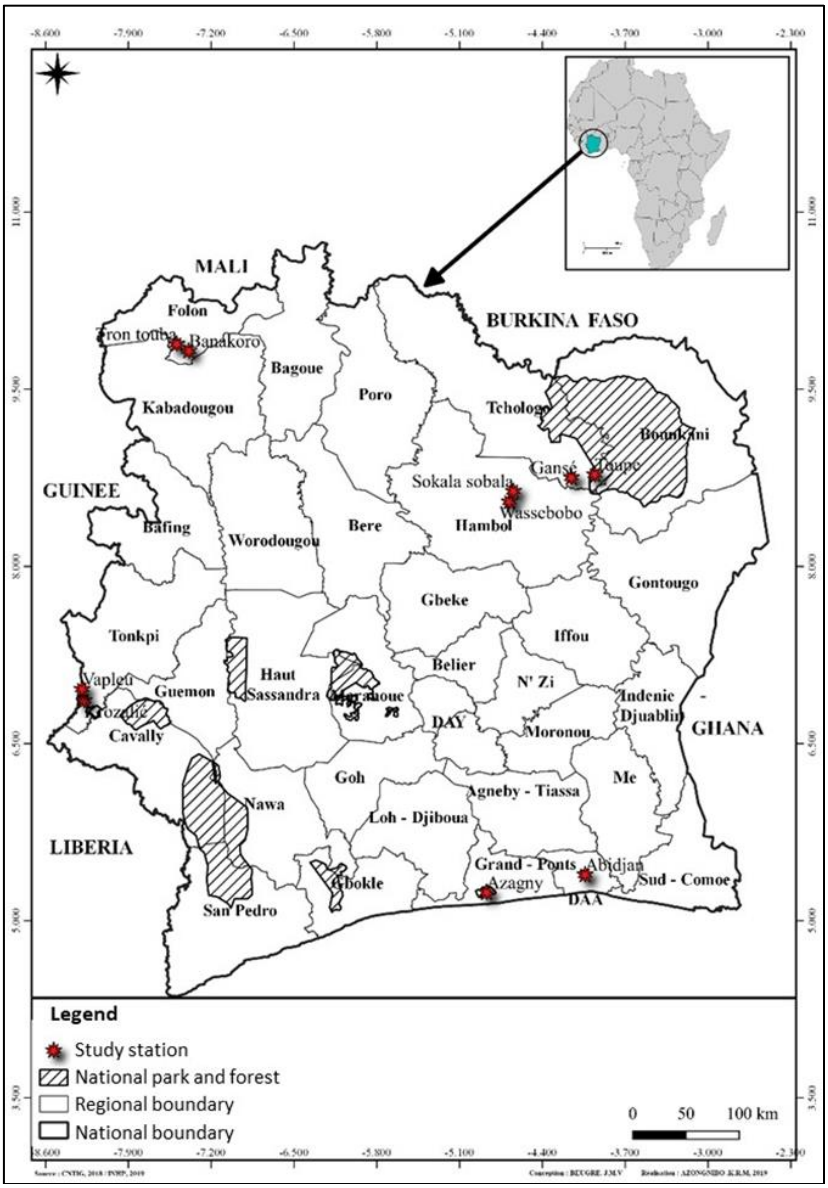

Fig 1: map of Côte d'Ivoire showing the study areas and sites

2.2 Installation of oviposition traps in study stations

In order to establish the species composition of mosquitoes of the genus Aedes, oviposition traps (WHO model) [24, 25, 26] were set in the field. Ninety (90) oviposition traps were set in each of the five stations. The contents of these traps were removed four days after installation. They were transfered to the insectarium of the Institut National d'Hygiène Publique in Abidjan. The larvae from hatched eggs were raised to the adult stage for identification at the species level.

2.3 Identification of *Aedes* breeding sites

This study was done through systematic search and identification of potential Aedes breeding substrates around dwellings, forests, and villages. Water points where Aedes larvae were visually confirmed were considered to be breeding substrates (identified in the forest) [18, 27]. All collected larvae were transferred into labeled containers using pipettes [28, 29]. These different containers were sent to the station laboratory or to the insectarium of the Institut National d'Hygiène Publique in Abidjan for rearing. All the larvae collected were raised to the adult stage for identification at the species level.

2.4 Morphological identification of *Aedes* spp.

All adult mosquitoes were identified under a binocular microscope using morphological identification keys [30, 31, 32].

2.5 Data analysis

The Shannon index was used to establish the heterogeneity in the spatial distribution of *Aedes* spp. as follows:

$$H' = -\Sigma ((Ni / N) \times \ln (Ni / N))$$

Where
Ni= number of individuals of a given species
N= total number of individuals.
The intepretation of the the Shannon index was carried out following Grall and Coïc [33].
The different statistical tests were carried out using the SPSS 25 statistical software. The Fisher's test was used to compare the percentages of larval substrates. The degree of significance was set at 5% ($p<0.05$).

3. Results

3.1 Types of *Aedes* breeding substrates in study stations

Of the 896 potential mosquitoe breeding substrates identified, 317 were positive (35.37%) and 579 were negative (64.63%). The breeding substrates were grouped into 5 types: storage containers, abandoned containers / objects, used tires, natural and others. Among the positive substrates, nearly 225 harbored Aedes larvae while 92 were substrates consisting of *Eretmapodites*, *Anopheles* or *Culex* (Table 1). However, these different Aedes breeding substrates recorded different proportions ranging from 1.3%. to 39.6%. The positive proportion test recorded a statistically significant difference between breeding substrates (P = 0.000; Fisher test).

3.2 Breeding substrate predilection of *Aedes* in prospected stations

In Banco station, the prefered breeding substrate included abandoned containers / objects (35.6%) followed by storage containers (30.6%), natural substrates (16.1%), and used tires (14.5%). Other breeding substrates represented only 3.2% of the total. Furthermore, there was a statistically significant difference (P = 0.000; Fisher test) between the positive proportions of breeding substrates in the area (Table 1).
At Vapleu station, 3 types of substrates harbored Aedes larvae and included storage containers, abandoned containers / objects and natural deposits. Among these different types of breeding substrates, the natural deposits represented the most frequent (52.8%) Aedes breeding substrate. In contrast, storage containers were rare (5.6%). The results of the Fisher test indicated that there was a statistically significant difference (P = 0.001; Fisher test) between the different proportions of identified breeding substrates (Table 1).
In Tron Touba station, most Aedes larvae were encountered in abandoned containers / objects (% = 52.8). Storage containers (22.6%), natural deposits/used tires (1.9%) were rare Aedes breeding substrates (Table 1). There was a statistically significant difference (P = 0.000; Fisher test) in the frequency of Aedes breeding substrates at Tron Touba.
At Toupé station, abandoned containers / objects, storage containers and natural deposits recorded superior Aedes numbers. Among these types of deposits, the most frequent (44.4%) was abandoned containers / objects (Table 1). The results of the Fisher test did not show any statistically significant difference (P = 0.429; Fisher test) between the proportions of different Aedes larval substrates encountered at Toupé.
Finally, at the Sokala Sobara station, natural deposits were the most frequent (52.6%) Aedes breeding substrate. However, the other breeding substrates were rare (2.6%) (Table 1). Statistically, a significant difference (P = 0.000; Fisher test) was noted between the proportions of Aedes breeding substrates in Sokala Sobara.

Table 1: Proportion of Aedes breeding substrates in sampled stations

Study stations	Potential breeding substrates	Positive breeding substrates	*Aedes* breeding substrates					
			Storage containers	Abandonned storage containers/objects	Abandonned tires	Natural	Others	Total
Banco National Park	159	77 (48,42%)	19 (30,6%)	22 (35,5%)	9 (14,5%)	10 (16,1%)	2(3,2%)	62(100%)
Vapleu village	105	52 (49,53%)	2 (5,6%)	15 (41,7%)	0 (0%)	19 (52,8%)	0 (0%)	36 (100%)
Tron Touba village	322	77 (23,92%)	12 (22,6%)	28 (52,8%)	1 (1,9%)	12 (22,6%)	0(0%)	53 (100%)
Toupé village	208	64 (30,76%)	10 (27,8%)	16 (44,4%)	0 (0%)	10 (27,8%)	0 (0%)	36 (100%)
Sokala Sobara village	102	47 (46,07%)	7 (18,4%)	8 (21,1%)	2 (5,3%)	20 (52,6%)	1(2,6%)	38 (100%)
Total	896	317 (35,37%)	50 (22,2%)	89 (39,6%)	12 (5,3%)	71 (31,6%)	3(1,3%)	225 (100%)

Storage containers (kettles, barrels, barrels, canaries, cans, basins, bowls, buckets), **Abandonned storage containers/objects**: disposable cups, abandoned plates, boxes, abandoned calabashes, broken canaries, children's toys, cut cans, broken basins; **Natural** (tree hollows, sheathing plants, tree leaves, rock hollows); **Others** (concrete tanks, hollow bricks).

3.3 *Aedes* species identified at different oviposition trap heights in the stations

During this study, 16 species of the genus *Aedes* were identified including: *Aedes aegypti*, *Aedes africanus*, *Aedes apicoargenteus*, *Aedes denderensis*, *Aedes dendrophilus*, *Aedes fraseri*, *Aedes haworthi*, *Aedes lilii*, *Aedes longipalpalis*, *Aedes luteocephalus*, *Aedes métallicus*, *Aedes opok*, *Aedes palpalisi*, *Aedes schwetzi,* and *Aedes vittatus*. It was noticed that *Aedes aegypti* was most frequent (Table 2). The oviposition traps set in the stations at different levels above the ground, enabled the identification of four species at heights >= 5 m: *Aedes apicoargenteus* (at 5, 10, 15 and 20 meters from the ground), *Aedes aegypti* (at 5 and 20 meters from the ground), *Aedes haworthi* (at 5, 10, 15 and 20 meters from the ground) and *Aedes lilii* (at 5 meters from the ground). It was noticed that the ideal height for Aedes breeding was 1.5m (Table 2).

Table 2 : *Aedes* spp. identified from oviposition traps at different heights in the sampled stations

Species	Height of oviposition trap				
	1.5 m	5 m	10 m	15 m	20 m
Ae. aegypti	452 (55.7%)	12 (21.8%)	0 (0%)	0 (0%)	5 (83.3%)
Ae. africanus	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Ae. apicoargenteus	126 (15.5%)	36 (65.5%)	8 (100%)	7 (87.5%)	1 (16.7%)
Ae. denderensis	62 (7.6%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Ae. dendrophilus	20 (2.5%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Ae. fraseri	79 (9.7%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Ae. haworthi	17 (2.1%)	1 (1.8%)	0 (0%)	1 (12.5%)	0 (0%)
Ae. lilii	37 (4.6%)	6 (10.9%)	0 (0%)	0 (0%)	0 (0%)
Ae. longipalpalis	1 0.1%	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Ae. luteocephalus	16 (2%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Ae. metallicus	1 (0.1%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Ae. opok	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Ae. palpalis	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Ae. schwetzi	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Ae. unilineatus	1 (0.1%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Ae. vittatus	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Species number	11	4	1	2	2
Total	812 (100%)	55 (100%)	8 (100%)	8 (100%)	6 (100%)

3.4 *Aedes* species diversity in prospected stations

The Shannon diversity index (H') calculated for each station indicated that for the south station (Banco national park), 10 Aedes species were collected after oviposition trapping and larval surveys. Here, the H' was 0.42 with a maximum diversity (H' max) of 2.3 (Table 3). In the western station (Vapleu village), 8 species were identified and Shannon's index and H'max were 1.09 and 2.07 respectively (Table 3). In the northwest (Tron Touba village) and northeast (Toupé) stations, 11 species were collected with H' max of 2.39 (Table 3). At the Sokala Sobara station (center), 9 species were identified and the Shannon index and maximum diversity values were 1.09 and 2.19, respectively (Table 3).

Table 3 : Species diversity of Aedes in sampled stations

Species	Study stations				
	PNB	VAP	TRON	TOUP	SOKA
Aedes aegypti	318	502	1076	1104	356
Aedes africanus	1	-	-	38	-
Aedes apicoargenteus	9	189	28	-	54
Aedes denderensis	2	38	12	45	7
Aedes dendrophilus	2	-	3	19	6
Aedes fraseri	6	63	6	50	4
Aedes haworthi	-	-	-	17	2
Aedes lilii	-	6	3	11	68
Aedes longipalpalis	-	-	1	-	-
Aedes luteocephalus	2	5	10	29	-
Aedes métallicus	-	8	5	3	-
Aedes opok	2	-	-	-	-
Aedes palpalis	1	-	-	1	-
Aedes schwetzi	2	2	-	-	1
Aedes uniluneatus	-	-	1	-	-
Aedes vittatus	-	-	11	3	26
Total	345	811	1156	1320	524
Species number	10	8	11	11	9
Shannon index (H')	0,42	1,08	0,38	0,69	1,09
Maximum diversity (H max)	2,3	2,7	2,29	2,39	2,19

PNB: Banco National Park; **VAP**: Vapleu village; **TRON**: Tron Touba village; **TOUP** : Toupé village; **SOKA** : Sokala Sobara.

4. Discussion

Aedes colonize a wide range of breeding places. In this study, Aedes deposits were mainly storage containers, abandoned containers / objects, abandonned tires, natural deposits and other types of deposits. In most prospected sites, the presence of larval stages of Aedes in water collections has been strongly influenced by human activities such as tourist hikes (in Banco National Park), management of water storage materials, construction of houses, and installation of garages. Moreover, majority of these deposits have been encountered around human dwellings [34]. This observation is similar to that made by Tia *et al*. [35] (2016) in Oussou-yaokro and Korhogo (Côte d´Ivoire) and by Koumba *et al*. [28] in Mouila (Gabon). The proximity of individuals to *Aedes* sp. breeding places could pose a health risk to them.

Five Aedes larval breeding substrates were identified in the sampled stations including: storage containers, abandoned containers / objects, abandonned tires, natural deposits and others. These Aedes breeding substrates have already been reported in urban areas of Côte d'Ivoire [16, 15, 17, 18]. Similarly, in the forest environment of Senegal and Côte d'Ivoire Aedes females preferred laying eggs in wide variety of substrates [22, 36].

Sixteen species of Aedes were identified in this study and included *Aedes aegypti*, *Aedes africanus* and *Aedes luteocephalus*, vectors of several arboviruses [37, 38]. *Aedes aegypti* was most frequent in the study area and several studies have established its role in the transmission of yellow fever and dengue viruses in urban and rural areas of Côte d'Ivoire [10, 15, 16, 17, 18, 26]. However, *Aedes africanus* and *Aedes luteocephalus* are vectors of yellow fever virus [23, 37, 38]. The species number in this study is superior to that obtained by Zahouli [8], but inferior to that of Zahouli *et al*. [39] in the south-east of Côte d'Ivoire. This difference in species numbers obtained in the different studies could be related to the differences in sampling methods, the duration of sampling and number of study stations.

All the species of the genus Aedes identified in this study occured in sympatry or allopatry in the different environments. This distribution could be due to the anthropophilic and / or zoophilic traits of these mosquito populations as well as presence of nutritional sources, landscape, and breeding sites. The aforementioned factors, associated with weather variables could be the drivers of the distribution of mosquitoes in an environment [40, 41, 42, 43, 44]. Oviposition traps placed at different altitudinal levels revealed that females of the following: *Aedes aegypti*, *Aedes apicoargenteus*, *Aedes haworthi*, *Aedes lilii* bred at 20 meters above the ground. This could be due to the high plasticity of these species that enables them to adapt to such breed at such a height.

The highest frequency of *Aedes aegypti* in the sampled stations resulted in a relatively low Shannon indices compared to maximum diversity values. The Shannon diversity index of 0.42 was obtained for the Southern station, 1.08 for the western station, 0.38 for the northwest station, 0.69 for the northeast station, and 1.09 for the center station. These low Shannon's diversity indices reflects the poor species diversity in the study area.

5. Conclusion

The main breeding substrates of *Aedes* spp. in the prospected stations consisted of storage containers, abandonned storage containers/objects, abandonned tires, and natural. Sixteen species of *Aedes* spp. were identified in the study area with *Aedes aegypti* recording the highest frequency. The ideal Aedes breeding height in the prospected stations is 1.5 m. Highest Aedes species diversity in the study area was recorded at Sokala Sobara and Wasségbôgbô stations as well as in Vapleu and Kroziale stations. The occurrence of several species of Aedes indicates the risk of arboviruses spillover in the study area.

6. Declaration of interest

The authors declare that they have no competing interest in relation to this article. All the authors read and approved the final version.

7. Acknowledgements

The authors are grateful to the Institut National d'Hygiène Publique (INHP) for its technical and material support.

8. References

1. Rodhain F. Les insectes comme vecteurs : Systématique et Biologie. Revue Scientifique et technique (International office of epizotics). 2015; 34(1):67-82.
2. Guillaumot L. Moustiques et dengue. Réseau International des Pasteurs de Nouvelle Calédonie, 2005, 22.
3. Delaunay P, Fauran P, Marty P. Les moustiques d'intérêt médical. Revue Française des laboratoires. 2001; 338:27-36.
4. Soltani N. Les moustiques: Risques sanitaires, bioessais, et stratégie de contrôle. 1 er séminaire national sur l'entomologie médicale et la lutte biologique, Tébessa, 19-20 octobre 2015, Conférence d'introduction, 2015, 13.
5. Le Déaut JY, Sido B, Courteau R, Commeinhes F. Rapport au nom de l'office parlementaire d'évaluation des choix scientifiques et technologiques sur les maladies à transmission vectorielle. Compte rendu de l'audition publique du 7 avril 2016 et de la présentation des conclusions du 28 juin, 2016, 209.
6. Failloux AB. Les émergences d'arboviroses : Chikungunya et zika. Bulletin de l'Académie Nationale de Médecine. 2016; 200(9):1589-1603.
7. Minkeu FN, Vernick KD. A Systematic Review of the Natural Virome of *Anopheles* Mosquitoes. Viruses. 2018; 10(222):1-21.
8. Zahouli JBZ. Anthropogenic impacts on Aedes mosquito community dynamics in Côte d'Ivoire. PhD Thesis, University of Basel, Switzerland, 2017, 173.
9. Ikram M, Chibani A, Alemad A, Alkhali A, Belala A *et al*. Etude écologique et entomologique des Culicides larvaires des gites de la Province de Kenitra (Maroc). European Scientific Journal. 2016; 12(32):1857-7431.
10. Akoua-Koffi C, Diarassouba S, Benié VB, N'Gbichi JM, Bozoua T *et al*. Investigation autour d'un cas mortel de fièvre jaune en Côte d'Ivoire. Bulletin de Société de Pathologie Exotique. 2001; 94(3):227-230.
11. WHO. La dengue en Afrique : émergence du DENV-3, Côte d'Ivoire, 2008, Weekly Epidemiological Record. 2009; 11(12):85-88.
12. Akoua-Koffi C, Sall AA, Kouadio K, Akran FO, Kouassi KS *et al*. Etats fébriles et dengue 3 dans l'agglomération Abidjanaise (Côte d'Ivoire) en 2008. Revue bio-Africa. 2011; 9:54-61.
13. L'Azou M, Succoa T, Kamagate M, Ouattarac A, Gilbernaird E *et al*. Dengue: etiology of acute febrile illness in Abidjan, Côte d'Ivoire, in 2011-2012. Transactions of the Royal Society of Tropical Medicine and Hygiene, 2015, 1-6.
14. INHP (Institut National d'Hygiène Publique). Epidémie de dengue en Côte d'Ivoire, rapport de situation. INHP/Ministère de la Santé et de l'Hygiène Publique. 2017; 11:1-5.
15. Fofana D, Beugré JMV, Yao-Acapovi GL, Lendzele SS. Risk of dengue transmission in Cocody (Abidjan, Ivory Cost). Journal of Parasitology Research, 2019, 7.
16. Adja AM. Dengue et Zika: situation actuelle et risque épidémique. RENCONTRES Santé Mondiale, Recherche et Afrique francophone, 2017, 26.
17. Koné AB, Konan YL, Coulibaly Z, Fofana D, Guindo-Coulibaly N. Évaluation entomologique du risque d'épidémie urbaine de fièvre jaune survenue en 2008 dans le district d'Abidjan, Côte d'Ivoire. Médecine et Santé Tropicales. 2013; 23:66-71.
18. Coulibaly ZI. Evaluation du risque entomologique d'émergence du virus Chikungunya dans le district d'Abidjan (Côte d'Ivoire) de 2008 à 2010. *Thèse de doctorat : Chimie, Santé et Environnement*. Université Nangui Abrogoua, Côte d'Ivoire, 2015, 217.
19. Cordellier R, Bouchité B, Roche JC, Monteny N, Diaco B *et al*. Circulation selvatique des virus dengue 2 en 1980 dans les zones sub-soudaniennes de Côte d'Ivoire, *Cahier O.R.T.O.M :* Série entomologie médicale et parasitologie. 1983; 21, N°3, 165-179.
20. Mondet B, Montagne L. Présence en Côte d'Ivoire, variations saisonnières et statut épidémiologique d'*Aedes usambara* Mattingly, 1953 (Diptera Culicidae).Annals of the Society of Entomoloby. 1993; 29(3):261-267.
21. Diarrassouba S, Dossou-Yavo J. Rythme d'activité atypique chez *Aedes aegypti* en zone de savane sub-soudanienne de Côte d'Ivoire. Entomologie Médicale. 1997; 1846:1-3.

22. Zahouli JBZ, Koudou BG, Müller P, Malone D, Tano Y *et al*. Effect of land-use changes on the abundance, distribution and host-seeking behavior of *Aedes* arbovirus vecteurs in oil palm-dominated lanscapes, southeastern Côte d'Ivoire. PLoS ONE. 2017a; 12(12):1-26.
23. Guindo-Coulibaly N, Adja AM, Coulibaly JT, Kpan MDS, Adou KA *et al*. Expansion of *Aedes africanus* (Diptera : Culicidae), a selvatic vector of arboviruses into an urban environnement of Abidjan, Côte d'Ivoire. Jounal of vector Ecology. 2019; 44(2):248-255.
24. Hervé JP. Méthodes d'évaluation des densités de population d'*Aedes aegypti. In* La dengue dans les départements Français d'Amérique, Corriveau R, Philippon B & Yébakima A, Edition IRD, collection Expertise Collégiale, 2003.
25. Guindo-Coulibaly N. Biologie, écologie et sensibilité aux insecticides de populations naturelles de formes larvaires marron et blanche de *Aedes* (*Stegomyia*) *aegypti* Linaeus (1762), vecteur majeur de la fièvre jaune en différents sites de la ville d'Abidjan (Côte d'Ivoire)," in Thèse de doctorat: entomologie médicale. Université de Cocody, Abidjan Côte d'Ivoire, 2012, 200.
26. Konan YL, Fofana D, Coulibaly ZI, Diallo A, Koné AB. Investigations entomologiques menées autour de dix cas de fièvre jaune survenus en 2009 dans la région sanitaire du Denguélé, Côte-d'Ivoire. Société de Pathologie Exotique. 2011; 104:296-302.
27. Cordellier R, Germain M, Hervy JP, Mouchet J. Guide pratique pour l'étude des vecteurs de fièvre jaune en Afrique et méthodes de lutte. 33rd ed. Paris: ORSTOM. 1977; http://www.documentation.ird.fr/hor/fdi:08619. Consulté le 07 juin. 2020.
28. Koumba AA, Zinga Koumba CR, Mintsa Nguema R, Salako Djogbenou L, Obame Ondo P. Distribution spatiale et saisonnière des gîtes larvaires des moustiques dans les espaces agricoles de la zone de Mouila, Gabon. International Journal of Biological and Chemical Sciences. 2018 ; 12(4):1754-1769.
29. Pamba R, Koumba AA, Zinga-Koumba CR, Sevidzem SL, Mbouloungou A *et al*. Typology of Breeding Sites and Species Diversity of Culicids (Diptera: Culicidae) in Akanda and its Environs (North West, Gabon). European Journal of Biology and Biotechnology. 2020; 1(1):1-6.
30. Edwards FW. Mosquitoes of the Ethiopian region. III. Culicine adults and pupae. London: British Museum Natural History, 1941, 499.
31. Yiau-Min H. The subgenus Stegomyia of Aedes in the Afrotropical Region with keys to the species (Diptera: Culicidae). New Zealand. Zootaxa 700, Magnolia Press Auckland, 2004.
32. Harbach R. The Culicidae (Diptera): a review of taxonomy, classification and phylogeny. Zootaxa. 2007; 1668:1-766.
33. Grall J, Coïc N. Méthodes annuaires. In, Synthèse des méthodes d'évaluation de la qualité du benthos en milieu côtier. Laboratoire des sciences de l'Environnement MARin, Réseau Bentique, REF. Ifremer DYNECO/VIGIES/06-13/REBENT, 2005, 10-26.
34. Koumba AA, Zinga-Koumba CR, Mintsa Nguema R, Koffivi Ketoh G, Djogbenou SL *et al*. Identification et caractérisation des gîtes larvaires des moustiques en saison sèche à la périphérie de la ville de Mouila, Sud du Gabon. Afrique SCIENCE. 2020; 16(2):192-205.
35. Tia E, Gbalegba NGC, M'bra KR, Kaba A, Boby OAM *et al*. Etude du niveau de production larvaire d'*Anopheles gambiae* s.l. (Diptera : Culicidae) dans les différents types de gîtes à Oussou-yaokro au Centre-Ouest et à Korhogo, au Nord (Côte d'Ivoire). Journal of Applied Biosciences. 2016; 105:10170-10182.
36. Diallo D, Diagne CT, Hanley KA, Sall AA, Bouenemann M *et al*. Larval ecology of mosquitoes in selvatic arbovirus foci in southeastern Senegal. Parasite & Vectors. 2012; 5:286-303.
37. Cordellier R. L'épidémiologie de la Fièvre Jaune en Afrique de l'Ouest. Bulletin de l'organisation mondial de la santé. 1991; 69(1):73-75.
38. WHO. Fièvre jaune, évaluation entomologique rapide sur le terrain pendant les épidémies de fièvre jaune en Afrique. Orientations méthodologiques à l'usage des scientifiques ayant des connaissances de base en entomologie, 2014, 50.
39. Zahouli JBZ, Koudou BG, Mueller P, Malone D, Tano Y *et al*. Urbanization is a main driver for the larval ecology of Aedes mosquitoes in arbovirus endemic settings in south-eastern Côte d'Ivoire. PLoS Neglected Tropical Disease. 2017b ; 11(7).
40. Huber K, Le Loan L, Hoang TH, Tien TK, Rodhain F *et al*. *Aedes aegypti*, le vecteur des virus de la dengue : structure spatio-temporelle de la variabilité génétique. Bulletin de l'Académie Nationale de Médecine. 2002; 186(7):1237-1250.
41. El Ouali LA, Hindi T, Azzouzi A, Elghadraoui L, Maniar S *et al*. Inventaire et répartition saisonnière des Culicidae dans le centre du Maroc. Entomologie Faunistique. 2010; 62(4):131-138.
42. Bouabida H, Djebbar F, Soltani N. Etude systématique et écologique des moustiques (Diptera : Culicidae) dans la région de Tébassa (Algérie). Entomologie faunistique. 2012; 65:99-103.
43. Saliha B, Wafa H, Fatiha M, Hadjer M, Laid MO *et al*. Inventaire des Culicidae des zones arides : cas des Oasis d'Ouled-Djellal (Biskra, Algerie). Revue ElWahat pour la recherche et les études. 2014; 7(2):86-91.
44. Hamaidia H, Berchi S. Etude systématique et écologique des moustiques (Diptera : Culicidae) dans la région de Souk-Ahras (Algérie). Entomologie Faunistique. 2018; 71:8.