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SURVEILLANCE OF POTENTIAL VECTORS OF ARBOVIRUSES IN A SELLING PLACE OF IMPORTED USED TIRES AT OPEN SKY IN KOUMASSI (ABIDJAN, CÔTE D'IVOIRE)

ABSTRACT

This study was conducted from August 2008 to February 2010 in a selling place of imported used tires at open sky, at Koumassi in the city of Abidjan. It is a surveillance of mosquito populations, capital for the prediction and prevention of epidemics. It was conducted to identify the different species of mosquitoes present in the used tires, to determine the abundance and population dynamics of in the used tires.

The sampling of immature stages was carried out by collecting water in used tires, scraping in used tires and a regular monitoring of ovitraps.

Aedes aegypti was the only species encountered at residues collected in used tires and by ovitraps. It has been associated two other species encountered (Culex quinquefasciatus and Culex nebulosus) in the water collected in used tire. The Aedes aegypti density has been important at the beginning of rain season by ovitraps and during the raining season in the water collected in tires.
These variations of Aedes aegypti densities would indicate that an entomological risk of emergence of an epidemic is present, and especially high throughout the raining season.

Keywords: Aedes aegypti, Scraping, Used tires, Imported, Koumassi, Côte d'Ivoire.

INTRODUCTION

Used tires have long been recognized as a breeding site for several species of mosquitoes in rural and urban areas[1] and also as a source for their dispersion[2]. The international trade of used tires is a major factor in spread of Aedes mosquitoes worldwide[3; 4; 5; 2; 6; 7]. It has facilitated the penetration of exotics species and the spread of invasive mosquitoes, particularly Aedes, which are often more difficult to contain[6] through tires containing eggs. Indeed, the eggs of Aedes aegypti and Aedes albopictus are drought resistant and can remain viable for several weeks, allowing them to survive prolonged by sea, air or land over long distances[8]. This is why some countries like Brazil have banned the importation of used tires[9; 8]. The introduction of Aedes albopictus, responsible for some arboviruses such as dengue, the chikugunya, West Nile and yellow fever[10; 11; 8] and/or Aedes aegypti which Vector competence vis-à-vis the dengue virus could vary depending on the geographical origin[12], may alter the epidemiology of arboviruses in a territory. These two species are a continuing to be a public health threat in the countries where they are installed. Following to the dual epidemics of yellow fever and dengue 3 occurred in Abidjan in 2008, an entomological monitoring has been undertaken in several locations of Abidjan city which the selling place of used tires at sky opened. This activity is essential in the early detection and fight against the installation of mosquito exogenous, is crucial for the prediction and prevention of epidemics. This study was conducted to identify the different species of mosquitoes and to detect the presence Aedes invasive in the used tires and then determine the abundance and seasonal population dynamics in the tires.

1. Material and methods

1.1. Study Site

The study was conducted in Abidjan, the economic capital of Cote d'Ivoire, a country located in West Africa. The imported used tires selling site at opened sky (5° 18292 "N° 57853 3" W) is located in Ramblais area at the west of Koumassi. This is a plot of 600 m² (30 x

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20) enclosed, which coexist with a tarpaulin factory, an auto repair garage and an open sky space for the storage of the imported used tires. The municipality of Koumassi, located in the southern part of the city of Abidjan, is limited to the east and north by the Lagoon Ebrié, to the west by the municipality of Marcory and south by that of Port Bouet. The climate of Abidjan is tropical and humid, with a large and a small rainy season, interspersed with two dry seasons[13; 14]. According to data from the SODEXAM (Operating Company and Airports Development, Aerospace Meteorology) for the period from 2005 to 2010, the monthly average variations of rainfall at Abidjan show that the lowest rainfall occurs in January (19 mm) and the highest in June (429 mm). The average monthly temperature ranged between 24 ° C and 28 ° C. The relative humidity varied between 81% and 92%.

1.2. Methodology

1.2.1. Entomological investigation

Sampling of mosquito populations was carried out by collecting immature instar from August 2008 to February 2010 by (3) three techniques: collecting water in used tires, scraping in used tires and a regular monitoring of ovitraps. At each harvest, a sample of water is collected in 10 tires randomly selected using a ladle and kept in plastic jars labeled the date of opening containers. The interior of 10 tires without water were scraped. These tires have been also chosen randomly and sweep with a brush. The residue is collected in Petri dishes, labeled as above. The tires were marked in order to prevent to choose the same tires at the next harvest. Different samples obtained are transported to the laboratory for being put in observation. Twenty-seven (27) standard World Health Organization ovitraps model were used to harvest Aedes eggs including twenty two (22) and five (5) respectively to the inside and outside the site. These ovitraps are black empty cans (33 cl) in which small wooden paddles (12x4 cm) are immersed. These were installed at 1.5 m above the ground. These paddles were collected every 10 days in different bags labeled according to date and each collection point and carried to the laboratory. At the laboratory, Paddles were dried at room temperature, next to each other on a table designed for this purpose according to the different label. These paddles are protected by a mosquito net to prevent egg-laying of external mosquitoes. After drying, the paddles were immersed for 3 days in dechlorinated water with yeast tablets to induce larval hatching. They were then removed, leaving the hatched larvae in the water, and allowed to dry for 5 days before being again immersed for 3 days. This process was repeated three times. Larvae obtained from hatched eggs were also reared for the adults' emergence. The collected water of the tires was also placed under observation. For each techniques used, cat food (Purina, Friskies) finely ground was supplied to feed the larvae. The resulting adults were identified using the morphological identification keys [15] and morphological descriptions of African Aedes species [16].

1.2.2. Data Analysis

The specific composition was made according to the number of specimens per species and the abundance and dynamics determined by the average number of mosquitoes and their standard deviations, per tire and per ovitrap on the site. Statistical analyzes have used t tests and chi 2 tests or Fisher exact applied on the average number using STATISTICA 7.1 software. A probability value $p < 0.05$ was considered statistically significant.

2. Results

2.1. Species composition of mosquitoes collected at the selling place of used tire at open sky

A total of 9 407 mosquitoes was obtained respectively with 515, 2861 and 6031 specimens in residues obtained by scraping, in collected water in used tires and ovitraps. These mosquitoes are divided into two genera; Aedes (98%) and Culex (2%), and three species, Aedes aegypti, Culex quinquefasciatus and Culex nebulosus.

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2.2. Average number of mosquitoes collected by scraping at the selling place of used tire at open sky

A total of 220 tires was scraped between August 2008 and July 2009 during the study. According to the arrival period of the tires, they have accounted for 40 in the stock before 2008, 160 in 2008 and 20 in 2009. In these tires, a total of 515 mosquitoes (271 females) has been identified with the highest proportions in the used tires arrived before 2008 with 345 specimens (66.99%) and 150 (29.12%) in 2008. The average number of Aedes aegypti per tire in the stocks arrived at the site before 2008 was 8.62 ± 2.37 of which 4.62 ± 1.47 female and 0.95 ± 0.36 with 0 46 ± 0.27 female in the tires arrived in 2008. In the used tires of 2009, the average number of mosquitoes collected was 1 ± 0.23 of which 0.45 ± 0.11 female (**table 1**). The average number of Aedes aegypti in stocks before 2008 on the site differs significantly than 2008 ($p = 0.01$) and 2009 ($p = 0.005$). The average number of mosquitoes present in tires in 2008 differs significantly than 2009 ($p = 0.001$).

2.3. Average number of mosquitoes in collected Water of used tires at the selling place of used tire at open sky

A total of 550 tires was collected with 70, 210 and 270 respectively in the tires arrived before 2008, in 2008 and 2009 the average number of mosquitoes was higher in tire stocks which arrived before 2008 than in 2008 and 2009. Aedes aegypti was present in majority of collected water of used tires. It was present with an average number of 4.71 ± 0.80 of which 3.26 ± 0.50 females in the tires which arrived on the site prior to 2008, of 7.15 ± 1.73 with 4.13 ± 0.95 females in the tires of 2008 and 3.12 ± 0.73 (1.65 ± 0.40 female) in the tires of 2009 (**table 2**). It is associated with Culex quinquefasciatus with a respective average number of 18.30 ± 1.01 in tire stocks before 2008 and 10.95 ± 1.86 in the tires of 2008. On the other hand, in 2009, it is associated with Culex nebulosus with an average number of 0.20 ± 0.00. The average number of Aedes aegypti obtained before 2008 differs significantly from 2008 ($p = 0.006$) and 2009 ($p = 0.008$). As against, the average number of Aedes aegypti of 2008 does not differ from that of 2009 ($p = 0.92$) significantly.

2.4. Average number of mosquitoes collected using ovitraps at the selling place of used tire

The average number of Aedes aegypti collected by ovitraps in 2008 was 46.90 ± 1.97. The external ovitraps gave an average of 39.60 ± 2.17 against 54.20 ± 1.78 inside. The average numbers of females collected was respectively 19.40 ± 0.92 and 27.96 ± 0.79 to the outside and inside. There is no significant difference between the average number of mosquitoes collected outside and inside ($p = 0.07$). In 2009, the paddles have given an average number of Aedes aegypti of 212.38 ± 2.08 of which 121.75 ± 1.32 females. This number of Aedes aegypti was 234.95 ± 2.99 outside and 189.82 ± 1.17 inside of the site. The average number of females was 137.26 ± 1.97 outside and 106.24 ± 0.67 inside of the site. The average numbers of mosquitoes inside and outside is not statistically different ($p = 0.66$) significantly. In 2010, the average number of Aedes aegypti was 17.54 ± 1.55. Outside, it was 27.50 ± 2.67 and 0.49 ± 7.58 inside. While females had an average number of 17.50 ± 1.49 outside, this number was 4 ± 0.30 inside the site (**table 3**). No significant difference was observed between the inside and outside in 2009 ($p = 0.20$). However, statistical differences were observed between the mean numbers of Aedes aegypti collected in 2008, 2009 and 2010 ($p \leq 0,0002$).

2.5. Dynamics of mosquitoes collected on the used tire selling site at open sky

The monthly average number of Aedes aegypti collected using ovitraps and the collected water in used tire were respectively 7.9 ± 5.5 and 7.25 ± 7.84. The monthly variation in the density of Aedes aegypti collected was according to rainfall from March 2009 to February 2010 (**figure 1**). The highest densities of mosquito using ovitraps were observed in May during the long raining season. However, they were found in September during the short dry season and in December during the long dry season in the collected water in used tires.

Densities of Aedes aegypti collected by ovitraps were most low during the period from September to November in the dry season. As against, densities were most low during the period from October to November during the minor raining season in the collected water in tires. The monthly variation of Aedes aegypti per ovitraps can be divided into three phases (Figure 1). First, from March to May, the density of Aedes aegypti increases to attain a first peak (17.3). Then, from June to September, this density fall to reach the lowest

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numbers, then it remains stable until November. Finally, in November, it increased again to reach a second peak (11.3) lower in December. In the collected water in tires, the monthly variation of the density of Aedes aegypti, evolves by jerks and jumps (**figure 1**). It increases to reach a first peak at 5.8 in May and fall suddenly with precipitation the increase in June. The density of Aedes aegypti has given a rise again to reach a second peak, hightest, in September to 10.4 with the decreasing of the rainfall. This density decrease again until it annul with the end of rains, in November. Then, it increases to attain a third peak lower than 4.6 in December with increased precipitation and decrease till February during the long dry season.

3. DISCUSSION

The entomological surveillance at the site of tires sell at open sky Koumassi based on collecting residues, gathering water in tires and the monitoring of ovitraps in order to monitor the species composition, abundance of mosquito populations and determine the dynamics of potential vectors of arboviruses. Investigations showed that Aedes aegypti, a major vector of arbovirus such as Chikungunya, yellow fever and dengue has been the predominant species in the mosquitoes collected on this site. This mosquito was the only species encountered at residues collected in the tires and by ovitraps. On the other hand, Aedes aegypti was associated with a Culex quinquefasciatus and Culex nebulosus in water collected in tires. Aedes aegypti presence, in the residuals could be explained by the ability of eggs to withstand desiccation. The eggs of Aedes are capable of supporting several weeks and hatch when re-immersion [17; 18]. The average number of Aedes aegypti was greater in the tires arrived on the site before 2008 than 2008 and 2009. This could be explained by the made these tires have been longer exposed to weather and egg laying mosquitoes than those present during the study period. In the water collected in the used tires, the presence of Aedes aegypti is probably due to the exposure of imported used tires for sale to weather, which become an ideal anthropogenic lodging for this mosquito because of the water and plant present. According to Delaunay [19], an exposition to weather of tires and unprotected by proper packaging receives rain water that persists in it. This creates an ideal egg-laying place for mosquitoes. Also, new stocks of tires may be infected quickly when adults are present in the area [20]. The average number of Aedes aegypti in the water of tires increases at the beginning of rains then when rainfall is abundant until its annulment.

Heavy and continuous rainfall could result in the dilution of the breeding site and reduce the number of specimens in the used tires. Other mosquito species (Culex quinquefasciatus and Culex nebulosus) were collected during dry periods. This could be explained by showers present in the months of September and December 2008. The scarcity of breeding place during these periods constrained these mosquitoes to lay their eggs in the used tires. Aedes aegypti was the only species collected by ovitraps. Its presence is more important in the outside traps than in the interior traps, but without any significant statistical difference. Indeed, exterior of the study site is characterized by the presence of various types of small businesses with an important human activity. This strong human activity outside could explain the abundance of this mosquito which finds board and lodging. It was also without uninterrupted present during all the period of the study. Work on the spatial distribution of Aedes aegypti in other region of the world (Asia, tropical America) showed that this species prefers to colonize environments densely vegetated. In this environment, the immature stages of Aedes aegypti species prefers to colonize artificial lodging located in areas with dense dwelling [21; 22; 23].

CONCLUSION

Aedes aegypti has been the predominant species with all technics used and the year while the other mosquitoes were obtained during the dry season and in the water collected in tires only. Aedes aegypti density has been important at the beginning of rainy periods in ovitraps and during the rainy periods water in the tires. These variations of Aedes aegypti densities would indicate that an entomological risk of an epidemic is present, especially high during the rainy season above all due its abundance without disappearance during the year. It would be important to extend the monitoring to various selling place and storage of used tires, to determine the presence of vectors of arboviruses other than Aedes aegypti.

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Method	**periods**	**Total**	**Female**
Scraping	**Before 2008 N=40**	345 (8,62±2,37)	185 (4,62±1,47)
	In 2008 N=160	150 (0,95±0,36)	77 (0,46±0,27)
	In 2009 N=20	20 (1,00 ±0,23)	(0,45±0,11)
Total		**515 (3,52±0,98)**	**271 (1,84±0,61)**

Table I: Average number of Aedes aegypti collected by scraping at the selling place of used tire at open sky
Mean values are given with their standard deviations in parentheses.

Method	**periods**	**Species**	**Total**	**Female**
Tire with water	**Before 2008 N=70**	Aedes aegypti N=60	283 (4,71±0,80)	163 (3,26±0,50)
		Aedes aegypti & Culex quinquefasciatus N=10	186 (18,60±1,01)	112 (11,20±0,72)
			469 (11,65±0,90)	**275 (7,23±0,61)**
	In 2008 N=210	Aedes aegypti N=190	1359 (7,15 ±1,73)	719 (4,13±0,95)
		Aedes aegypti & Culex quinquefasciatus N=20	219 (10,95±1,86)	77 (3,85±0,98)
			1578 (9,05±1,79)	**796 (3,99±0,96)**
	In 2009 N=270	Aedes aegypti N=260	812 (3,12±0,73)	428 (1,65±0,40)
		Aedes aegypti & Culex nebulosus N=10	2 (0,20±0,00)	1 (0,10±0,00)
			814 (1,66±0,36)	**429 (0,87±0,20)**
Total			**2861 (7,45±1,02)**	**1500 (4,03±0,59)**

Mean values are given with their standard deviations in parentheses.
Table II: Average number of mosquitoes collected in water of tires at the selling place of used tire at open sky

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Method	periods	Harvesting Areas	Total	Female
Ovitraps	In 2008	Outside	198 (39,60±2,17)	97 (19,40±0,92)
		Inside	1355 (54,20±1,78)	699 (27,96±0,79)
			1553 (46,90±1,97)	**796 (23,68±0,85)**
	In 2009	Outside	739 (234,95±2,99)	425 (137,27±1,97)
		Inside	3540 (189,82±1,17)	2003 (106,24±0,67)
			4279 (212,38±2,08)	**2428 (121,75±1,32)**
	In 2010	Outside	55 (27,50±2,61)	35 (17,50±1,49)
		Inside	144 (7,58±0,49)	76 (4,00±0,30)
			199 (17,54±1,55)	**111 (10,75±0,89)**
Total			**6031 (92,27±1,86)**	**3335 (52,06±1,02)**

Mean values are given with their standard deviations in parentheses.

Table III: Average number of mosquitoes collected using ovitraps at the selling place of used tire at open sky

Figure 1: Monthly average variation of Aedes aegypti according to rainfall at the selling place of used tire at open sky

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COULIBALY ZANAKOUNGO IBRAHIMA[1;2*] KONAN YAO LUCIEN[3] KONE ATIOUMOUNAN BLAISE[4] DOANNIO JUILEN MARIE CHRISTIAN[5] ET MIREILLE DOSSO[6]

[1] Laboratory of Environmental Sciences, UTR of Science and Environmental Management, University of Nangui Abrogoua, Abidjan 02, Cote d'Ivoire
[2]Entomology and Herpetology Research Unit,[2,6]Pasteur Institute of Cote d'Ivoire, Abidjan 01, Cote d'Ivoire
[3]Vector Control Department,
[5]Research Unit "Vector-Borne and Neglected Tropical Diseases Research Unit"
[3,4,5] National Institute of Public Health, Abidjan, Cote d'Ivoire