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FREQUENCY, DIVERSITY, AND PRODUCTIVITY STUDY ON THE *Aedes aegypti* MOST PREFERRED CONTAINERS IN THE CITY OF MANAUS, AMAZONAS, BRAZIL

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SUMMARY

The most preferred containers by *Aedes aegypti* were studied April and July (rainy and dry periods) in two Manaus neighbourhoods. In all, 2,700 premises and 13,912 containers were examined, most (87%) recorded outdoors. Out of the 13,100 inspected premises, only 1.6% showed to be positive for *Aedes aegypti,* summing up to 7,916 collected samples. Most frequently found containers outdoors in either neighbourhood regardless of rain or dry period were Bottles flasks and Storage, and indoors, Fixed, Flowerpots, and buckets. Productivity was estimated according to the number of premises and positive containers investigated, showing the actual container groups productivity.

Considering both rainy and dry periods outdoors at Praça 14 the groups of Tyre, Flask, Bottle, Construction Equipment and Fixed, had the highest averages respectively. Construction Equipment and Flask groups were the most productive in Coroado in April. Flask, Construction Equipment and Storage groups stood out in July.

KEYWORDS: *Aedes aegypti*; Preferred containers; Vector control; Container productivity.

INTRODUCTION

The world-wide large scale reappearance of dengue for the past few decades, has turned this disease into a serious public health problem, especially in countries within the tropical region[12,21,25,26]. Dengue's main vector, *Aedes aegypti,* is a mosquito that uses different artificial containers as breeding sites found in an urban environment. The eggs have great ability for resisting and can remain viable for up to a year[5,6,10,13]. The vector was eradicated from Brazil in 1955, new re-infestations reoccurred in the 60s and 70s, and were controlled without the reoccurrence of the mosquito's expansion[15,29,30]. However, since the 80s, the increase on human population and size of cities and settlements, along with the widespread use of artificial containers has provided the ideal conditions for the dispersion of the *Aedes aegypti* mosquito throughout most of all the Brazilian territory.

In the 1990s there was a significant increase on the occurrence of dengue epidemics in the country - 560 thousand cases in 1998. Presently the notifications remain at over 200 thousand cases, with the circulation of serotypes 1 and 2 in 18 states and the isolation of a third sorotype - DEN-3 – in the city of Rio de Janeiro in January 2001[21]. This led to the elaboration of the *Aedes aegypti* Eradication Program – (AsEP,) PEAs, which has the community's health agents activities as its main strategy[17].

Assays carried out in several parts of the world have shown that *Aedes aegypti* is able to perform its oviposition in the most diverse objects found containing any clean water[4,9,18]. One finds that in Brazil's South-eastern region flowerpots kept with ornamental plants are reported to be the most frequently used breeding sites[14,16,22,23]. But, in arid regions like the Northeast, there is a predominance of the containers allocated for the storage of water, like tanks, tuns and barrels[2,24].

The introduction of the *Aedes aegypti* in the city of Manaus occurred from 1996 onwards and the first dengue epidemic had its beginning in January 1998, totalling 29,033 cases (FMT/IMT-AM, 1998). The city presents conditions which favour the vector's dispersion, such as precarious urbanization with the existence of numerous land invasions, local topographical characteristics with areas intersected by small streams, and climatic factors of high temperature, humidity and rainfall indexes. The association of these factors has created an ideal setting for the establishment of the *Aedes aegypti* in the region. Knowledge of the reproductive conditions developed by the mosquito within this area is a fundamental factor in order to be able to provide appropriate strategies for controlling it. The objective of this study is showing the diversity of the artificial containers used by *Aedes aegypti* in the city of Manaus and identifying breeding potential of the container groups by analyzing the number of larvae and pupae found in them.

MATERIALS AND METHODS

Data were obtained from two concomitant samplings carried out at two city neighbourhoods: Praça 14 de Janeiro and Coroado, being that

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the latter presented lower standard of living conditions relative to the former. Samplings were carried out in April – rainy period - and July – dry period[1]. Rainfall index data for the city of Manaus in 1999 are presented in Fig. 1. In the two months of sampling the value was very high in April – 421.2 mm and low in July – 25.3 mm.

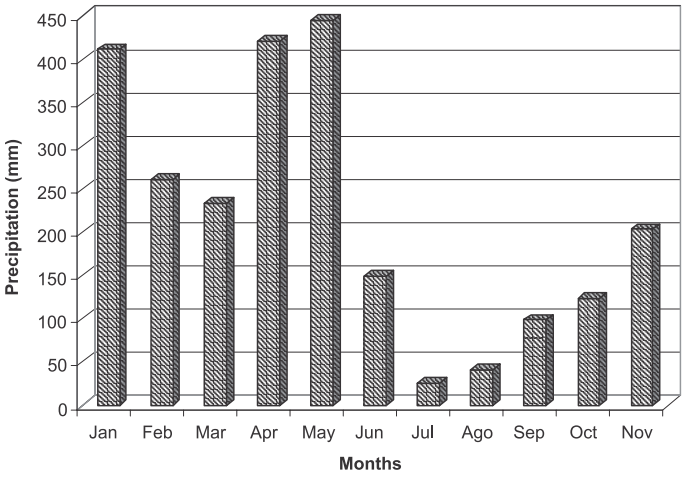

Fig. 1 - Manaus monthly rainfall (mm) in 1999.

Eleven blocks with more than 40 premises were randomly chosen for the samplings in both neighbourhoods, totalling to about 600 in each. All containers containing water and showing any potential for harbouring and breeding *Aedes aegypti* were thoroughly examined according to the booklet of the Health National Foundation[16]. All larvae and pupae were collected and stored in glass vials. This procedure allowed evaluating each container's type actual productivity. The chemical treatment was carried out in breeding sites that couldn't be destroyed or removed. Information on the importance of these procedures for controlling the dengue was conveyed to the residents.

Containers were classified into 9 groups according to PEREIRA[22], with modifications: **1. Flowerpots; 2. Flasks; 3. Tyres**; **4. Bottles**; **5. Storage**; **6. Drinking fountains**; **7. Fixed**; **8. Construction Equipment; 9. Others.** This classification is similar to the one used by the endemic diseases control superintendence of the state of São Paulo – SUCEN. In this paper the groups were put into another order and the Others group was introduced with the objective of recording the diversity of containers found in the Amazon region as compared to that in the South-eastern part of the country. This procedure made it possible for the studies from Manaus to be compared to those from São Paulo, which is a region characterized for being highly infested by the *Aedes aegypti.*

RESULTS

Two thousand seven hundred (2,700) premises were sampled with 13,912 containers recorded (87% outdoors) which showed a high diversity. Among the 13,100 examined containers, 1.6% was positive, totalling 7,916 *Aedes aegypti* specimens; being their highest rate in the rainy period – 2.8%. There was only 0.8% of positive samples recorded in the dry period.

It can be seen in Tables 1 and 2 showing the analysis parameters and container group frequency, that there is a high diversity of containers indoors. As clearly depicted in the frequency graphic plot (Fig. 2), both neighbourhoods are very similar as to the occurrence of found containers, with a remarkable predominance of Bottle, Flask, and storage groups outdoors. Yet, Fixed, Flowerpot, and Flask groups were the most frequent indoors.

The relation between the outdoor container groups productivity and positivity, graphically depicted in Fig. 3, allows establishing them to be very similar in both neighbourhoods. The highest positivity averages occurred in the rainy period on the Flask, storage, and Construction Equipment groups (Fig. 3 A and C). As to productivity, Flasks also showed the highest averages in both neighbourhoods, yet, there were differences on the other groups' behaviour (Fig. 3 B and D). In Praça 14, the Tyre and Bottle groups showed quite high averages, which wasn't verified in Coroado. In the latter, in addition to the Flask there followed the Construction Equipment and Storage groups.

In the dry period there was a positivity and productivity average decrease on practically the same container groups recorded for outdoors the neighbourhoods in the rainy period - Flasks, tyres, Storage and Construction Material. It is established there is a container relation divergence according to the neighbourhood being considered. For instance, there is high productivity and positivity in Coroado on the Storage Group (Fig. 3 C and D), whereas at Praça 14 Tyres are the highest averaged (Fig. 3A and B).

Considering the indoor containers (Table 2), it wasn't possible to make an analysis due the large amount of containers examined with very few showing to be positive. Yet, it must be recorded that excepting for the Fixed group in Praça 14, Flowerpot and flask are the most outstanding in either neighbourhood.

There are still group productivity averages calculated according to positive containers, in Tables 1 and 2. In Praça 14 outdoors in the rainy period (Table 1), the highest average was found on Tyres, whereas in Coroado several groups showed high and relatively similar averages – Storage, Construction Equipment, Flasks and others. The picture changes in the dry period, being Construction Equipment in Praça 14 and Flask in Coroado, the highest averaged groups.

DISCUSSION

Examined and positive container frequency and productivity analysis (larvae + pupae total) was carried out in relation to all inspected premises and all positive containers found in both neighbourhoods. Bottle, Flask, and Storage group predominance was found outdoors in both neighbourhoods, both in winter and summer. The amount of found containers indoors is smaller, representing 13.1% of the found total (13,912), of which Fixed, Flowerpot, and Storage groups were the most frequent. In the city of Rio de Janeiro (RJ)[13], as well as in several cities in the state of São Paulo[16], Flowerpot was also the most frequently found group. In the city of Goiânia (Goiás), findings were similar to those shown in this paper, where Bottles, Cans and Plastic Wrappers were recorded to be the most frequent[27].

Container group productivity/positivity rate relation analysis becomes

Table 1
Total value of the containers studied in relation to all inspected premises (N), *Aedes aegypti* positivity and productivity averages by all inspected and positive premises, outdoors both periods in each district

Container Group	Praça 14 – April						Coroado – April					
	Containers			Productivity			Containers			Productivity		
	Found	Examined	Positive	L + P	Insp. Prem. ($\bar{x}$)	Positive Conts. ($\bar{x} \pm S\bar{x}$)	Found	Examined	Positive	L + P	Insp. Prem. ($\bar{x}$)	Positive Conts. ($\bar{x} \pm S\bar{x}$)
Flowerpot	253	228	5	63	0.10	12.60 ± 1.44	120	111	6	68	0.12	11.33 ± 4.57
Flask	663	617	27	1,076	1.77	39.90 ± 10.50	710	618	28	1,314	2.27	46.90 ± 14.60
Tyre	154	94	9	853	1.40	94.80 ± 31.80	72	59	3	92	0.16	30.70 ± 13.50
Bottle	1,078	1,015	10	360	0.59	36.00 ± 17.10	533	481	0	0	0.0	0.0
Storage	328	311	5	140	0.23	28.00 ± 6.97	544	501	10	490	0.85	49.00 ± 16.50
Drinking Fountain	84	83	0	0	0.00	0.0	203	193	1	17	0.03	17.00 ± -
Fixed	224	212	3	22	0.04	7.33 ± 3.53	123	120	2	25	0.04	12.50 ± 5.50
Construction Equipment	65	65	8	167	0.27	20.88 ± 6.21	84	75	18	849	1.47	47.20 ± 11.90
Others	55	55	3	103	0.17	34.30 ± 17.90	226	214	9	403	0.70	44.80 ± 16.50
Number of inspected premises = 609							**Number of inspected premises = 579**					
Container Group	**Praça 14 – July**						**Coroado – July**					
	Containers			Productivity			Containers			Productivity		
	Found	Examined	Positive	L + P	Insp. Prem. ($\bar{x}$)	Positive Conts. ($\bar{x} \pm S\bar{x}$)	Found	Examined	Positive	L + P	Insp. Prem. ($\bar{x}$)	Positive Conts. ($\bar{x} \pm S\bar{x}$)
Flowerpot	168	164	6	107	0.13	17.83 ± 5.41	129	116	6	175	0.20	29.20 ± 13.10
Flask	967	772	5	144	0.17	28.80 ± 13.00	571	554	4	333	0.65	83.30 ± 48.60
Tyre	151	145	5	170	0.20	34.00 ± 11.00	44	43	2	9	0.01	4.50 ± 2.50
Bottle	940	924	3	20	0.02	6.67 ± 4.18	1,471	1,446	0	0	0.00	0.0
Storage	315	305	0	0	0.00	0.0	516	516	8	235	0.35	29.38 ± 7.60
Drinking Fountain	180	175	1	3	0.003	3.00 ± —	212	210	0	0	0.00	0.0
Fixed	292	280	1	53	0.06	53.00 ± —	198	184	2	20	0.03	10.00 ± 9.00
Construction Equipment	95	94	3	230	0.27	76.70 ± 71.70	82	80	2	123	0.18	61.50 ± 29.50
Others	120	115	2	38	0.05	19.00 ± 11.00	123	123	4	94	0.14	23.50 ± 14.40
Number of inspected premises = 844							**Number of inspected premises = 668**					

L+P = Larvae plus pupae Insp. Prem. = Inspected Premises Conts. = Containers ($\bar{x} \pm S\bar{x}$) = Mean ± Standard Error

useful information for the *Aedes* successful control measures implantation. Several factors are known to influence container availability, hence, even though some groups happen to be very frequent they contribute very little for the larvae and pupae production. In the present study this was verified for the Bottle group, which was found in larger quantity relative to the sampled total, but whose positivity was quite little. Conversely, several seldom found groups might be highly productive as found on Tyres and Construction Material. FOCKS *et al.*[7] also found that the Bottle was the most frequent and lowest positivity group in New Orleans (USA). SOUZA-SANTOS[28] findings on Flowerpot holders, plastic glass or crockery vessels were similar in Rio de Janeiro (Ilha do Governador). The flowerpot group showed high positivity and productivity indexes indoors in the State of São Paulo being one of *Aedes aegypti* most preferred containers[11,16,23]. It did not show very high productivity in Manaus, yet was recorded with similar values both in rainy and dry periods. This profile points out the major role these containers play on the *Aedes* annual cycle maintenance, when considering them not to be dependent on the rainfall seasonallity since they are regularly watered by the residents.

The estimated positive container related productivity was considered in this paper to be the closest way for estimating both the actual container productivity and adult density[7,8,20,31]. This finding is due to the fact most collected larvae were in the third and fourth development instar and pupae were also collected. These productivity findings showed rather high averages occurring indoors on most containers in either period. Tyre, Flask, Construction Material and Storage groups stood out. These findings stress out the studied neighbourhoods' characteristic cultural, social, economical, and topographical differences. The tyre group that showed very high averages at Praça 14 on account of there being a large number of car mechanic garages and tyre fixing street side lots scattered throughout this neighbourhood. These containers remain piled up anywhere storing up rain water, which shows their importance on the *Aedes* dispersion, mainly in the rainy period. Several authors have reported Tyres as being *Aedes aegypti* preferential breeding site[7,19,28].

The Flask group showed high productivity in either period at both neighbourhoods. This is due to the great accumulation of disposable objects throughout the house yards and also vacant lots turning into everyone's garbage dumps. This fact associated to the Amazonian region's high rainfall and relative humidity indexes, is the reason why all these containers keep on storing water most yearlong. Under the Manaus weather conditions a pop bottle is able to house up three *Aedes* fourth instar larvae. At other places these containers only become important as breeding sites during the rainy time[14,28].

The storage group traditionally stands out as an important breeding site in arid regions with little rainfall or in places lacking proper water

Table 2
Total value of the containers studied in relation to all inspected premises (N), *Aedes aegypti* positivity and productivity averages by all inspected and positive premises, indoors both periods in each district

Container Group	Praça 14 – April						Coroado – April					
	Containers			Productivity			Containers			Productivity		
	Found	Examined	Positive	L + P	Insp. Prem. ($\bar{x}$)	Positive Conts. ($\bar{x} \pm S\bar{x}$)	Found	Examined	Positive	L + P	Insp. Prem. ($\bar{x}$)	Positive Conts. ($\bar{x} \pm S\bar{x}$)
Flowerpot	43	28	1	17	0.03	17.00 ± -	20	20	1	16	0.03	16.00 ± —
Flask	12	11	1	21	0.03	21.00 ± -	0	0	0	0	0.0	0.0
Tyre	4	4	0	0	0.0	0.0	0	0	0	0	0.0	0.0
Bottle	0	0	0	0	0.0	0.0	0	0	0	0	0.0	0.0
Storage	13	13	0	0	0.0	0.0	19	19	0	0	0.0	0.0
Drinking Fountain	6	6	0	0	0.0	0.0	0	0	0	0	0.0	0.0
Fixed	188	188	2	18	0.03	9.00	12	11	0	0	0.0	0.0
Construction. Equipment.	0	0	0	0	0.0	0.0	0	0	0	0	0.0	0.0
Others	2	2	0	0	0.0	0.0	2	2	0	0	0.0	0.0
Number of inspected premises = 609							**Number of inspected premises = 579**					
Container Group	**Praça 14 – July**						**Coroado – July**					
	Containers			Productivity			Containers			Productivity		
	Found	Examined	Positive	L + P	Insp. Prem. ($\bar{x}$)	Positive Conts. ($\bar{x} \pm S\bar{x}$)	Found	Examined	Positive	L + P	Insp. Prem. ($\bar{x}$)	Positive Conts. ($\bar{x} \pm S\bar{x}$)
Flowerpot	92	92	1	16	0.02	16.00 ± —	22	22	1	10	0.01	10.00 ± —
Flask	20	20	2	30	0.04	15.00 ± 8.00	8	8	1	16	0.02	16.00 ± —
Tyre	5	5	0	0	0.0	0.0	0	0	0	0	0.0	0.0
Bottle	2	2	0	0	0.0	0.0	14	14	0	0	0.0	0.0
Storage	54	54	0	0	0.0	0.0	15	15	0	0	0.0	0.0
Drinking Fountain	28	28	0	0	0.0	0.0	14	14	0	0	0.0	0.0
Fixed	1,052	1,052	0	0	0.0	0.0	151	151	0	0	0.0	0.0
Construction Equipment	7	7	0	0	0.0	0.0	1	1	0	0	0.0	0.0
Others	9	9	0	0	0.0	0.0	4	4	0	0	0.0	0.0
Number of inspected premises = 844							**Number of inspected premises = 668**					

L+P = Larvae plus pupae Insp. Prem. = Inspected Premises Conts. = Containers ($\bar{x} \pm S\bar{x}$) = Mean ± Standard Error

supply[2,3,4,20,24]. In the present study it reached immature forms average of 49.00 in Coroado, which depicts the residents social-economical level. Productivity average is higher in April, rainy season, on account of there being less constant use or handling of stored water vessels, thus allowing for the *Aedes* reproduction. At Praça 14, where the social-economical level happens to be higher this group only becomes important in the rainy period because it accumulates large amounts of water. The Construction Equipment group presented a small yet highly productive amount of breeding sites in both neighbourhoods. At Praça 14, the same thing happens due to there being lots of car parts and tools left anywhere, out in the open and in the garages located in this area. At Coroado, this is related to the unfinished building sites scattered throughout the neighbourhood on account of the residents' low buying power.

Comparing productivity by the examined premises and positive container totals it is verified that the latter depicts the role-played by the containers on the total larvae and pupae productivity. Hence, these findings are relevant since they show the each group's contribution on housing high *Aedes aegypti* population densities. These findings, based on container type productivity and diversity, provide the means for a more accurate performance by the health agents, who together with the help of the willing residents will aim to reduce the *Aedes aegypti* population density to dengue vectoring incompatible levels.

RESUMO

Estudo da freqüência e produtividade dos recipientes preferenciais de *Aedes aegypti* na cidade de Manaus, Amazonas, Brasil

Estudaram-se os recipientes preferenciais de *Aedes aegypti* em dois bairros da cidade de Manaus nos meses de abril (período chuvoso) e julho (período seco). Foram inspecionados 2.700 imóveis e registrou-se 13.912 recipientes, a maioria (87%) localizados no peridomicílio. Do total de 13.100 recipientes pesquisados, apenas 1,6% foram positivos para *Aedes aegypti,* totalizando 7.916 exemplares coletados. Os recipientes existentes mais freqüentes no peridomicílio dos dois bairros e nos dois períodos, foram os grupos Garrafa, Frascos e Armazenamento e no intradomicílio foram Fixos, Vasos e Armazenamento. Calculou-se a produtividade pelos imóveis pesquisados e também pelos recipientes positivos para obter-se a produtividade real dos grupos de recipientes. Considerando-se o período chuvoso, na Praça, no peridomicílio tiveram as maiores médias os grupos Pneus, Frasco e Garrafa e em julho o grupo Peças e Materiais de Construção e Fixos. No bairro Coroado em abril, foram mais produtivos os grupos Armazenamento, Peças e Materiais de Construção e Frasco. No mês de julho se destacaram os grupos Frasco, Peças e Materiais de Construção e Armazenamento.

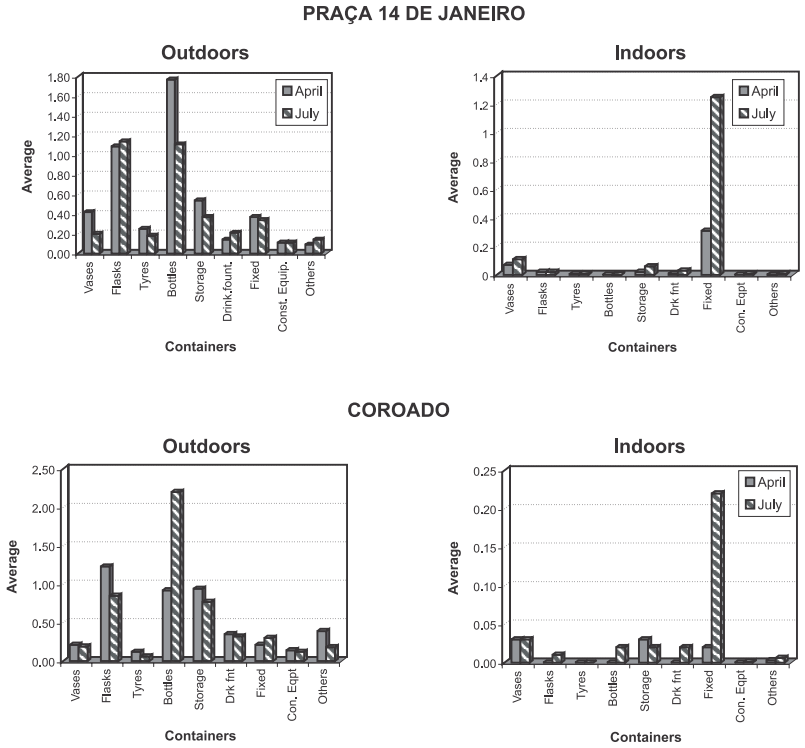

Fig. 2 - Found container average number per inspected premises.

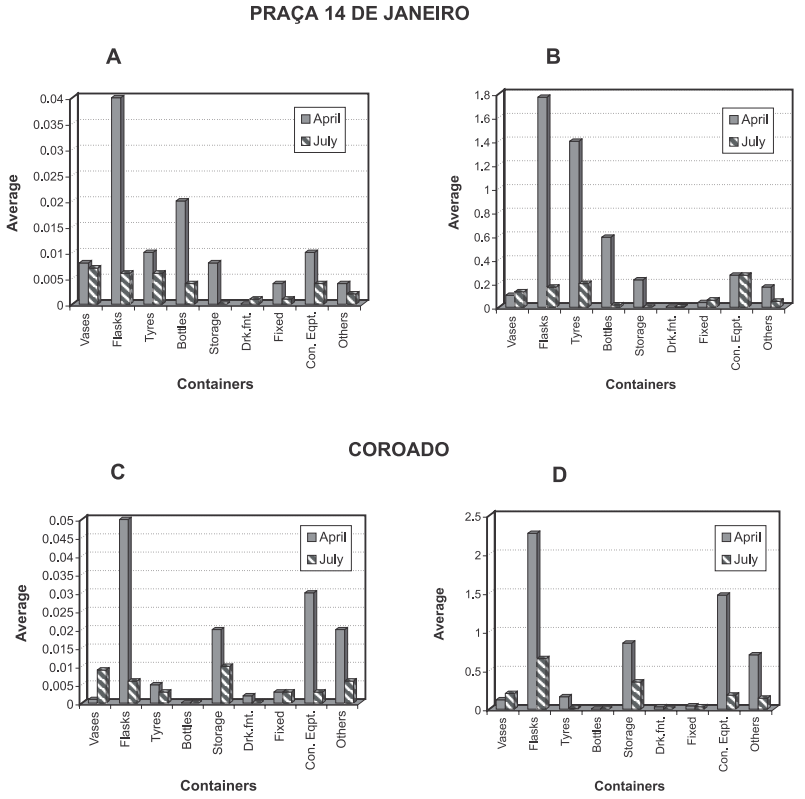

Fig. 3 - Container group positivity (A, C) and productivity (B, D) averages by the premises inspected outdoors.

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