



Original article

SURVEY OF THE DISTRIBUTION AND DIVERSITY OF COCKROACHES (INSECTA: BLATTARIA) ON THE CAMPUS OF A HIGHER INSTITUTION IN SOUTH-WESTERN NIGERIA

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ABSTRACT

Cockroaches are insect pests of medical and public health importance. They play a role in disseminating pathogens, serve as intermediate hosts of parasites, causes allergic effects like asthma and could cause entomophobia. This study was conducted to investigate species composition, relative abundance, and population diversity of cockroaches in Obafemi Awolowo University, (OAU) Ile-Ife, Nigeria. The insects were trapped between 2015 and 2017 in locations within Obafemi Awolowo University Campus, Ile-Ife, Nigeria. These were identified and biodiversity index was calculated. A total of 867 cockroaches was trapped from various locations during the survey period (2015-2017) and seven species of cockroaches from two families were identified. The Blatellidae family include German cockroach, (*Blattella germanica* L.), brown-banded cockroach (*Supella longipalpis* F.), and field cockroach (*Blattella vaga* Hebard) while the Blattidae family include American cockroach (*Periplaneta americana* L.), oriental cockroach (*Blatta orientalis* L.), Australian cockroach (*Periplaneta australasiae* F.), and smokey brown cockroach (*Periplaneta fuliginosa* Serville). The *B. germanica* and *P. americana* accounted for 78% of the total specimens collected. The proportion of other species included *B. orientalis* (7.2%), *S. longipalpis* (5.0%), *B. vaga* (4.0%), *P. fuliginosa* (3.7%) and *P. australasiae* (2.1%). The relative abundance of the insects are in the order, *B. germanica* > *P. americana* > *B. orientalis* > *S. longipalpis* > *B. vaga* > *P. fuliginosa* > *P. australasiae*. The species diversity was low for all sampling years and there existed the dominance of German and American cockroach over other species. This study provided baseline information on the cockroach species present and their prevalence in the University community, thereby giving an insight into the likely incidence of diseases caused by infestation of different cockroach species that could pose health risks to humans.

Keywords: cockroach species; relative abundance, diversity, dominance

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INTRODUCTION

Cockroaches are insects, which have been in existence since ancient times [1]. There are about 4,600 valid species of cockroach but only 30 species are considered pests [2, 3].

The American (*Periplaneta americana*), German (*Blattella germanica*), oriental (*Blatta orientalis*), smokey brown (*Periplaneta fuliginosa*), and brown-banded (*Supella longipalpis*) cockroaches are the common species that inhabit homes [4].

The cockroach dwells in any place where food, water and shelter are available and can reside both indoors and outdoors while some often reside in commercial and large buildings such as restaurants, hostels, grocery stores, bakeries, food processing facilities, hotel rooms, nursing home, bathrooms, basements and plumbing areas and kitchen [5, 6]. Their biology such as filthy habits, indiscriminating diet, feeding mechanisms and morphology, make them suitable to at least acquire, mechanically transport and spread pathogens [7]. They contaminate the food by leaving an oily lipid that has offensive odour or contain bacteria that can cause food poisoning [8] probably because they frequently feed on human faeces [9].

Cockroaches are pests of medical and public health importance and they play an important role in disseminating bacteria and serve as intermediate hosts for pathogenic helminths, viruses, protozoa and fungi that affects human [1, 7, 10, 11, 12, 13] and thus regarded as insects recognized to be mechanical vectors of disease-causing agents [14]. For instance, the cockroach-borne pathogenic bacteria causes typhoid fever, food poisoning, amoebiasis, shigellosis, dysentery, and urinary infections [15, 16]. In Nigeria, the incidence, species composition and relative abundance of parasites and pathogens present in one or two most common cockroaches and their potential to cause diseases have been reported [17, 18, 19]. Studies have reported robust association between cockroach infestation and development of asthma as relevant allergens have been identified in the body and secretions from the insect body [20]. Exposure to cockroach allergens (through saliva, fecal material, secretions, cast skins, debris, and dead bodies) are connected with asthma-related health problems [9, 15, 21, 22, 23]. The allergen and potential health hazard associated with cockroaches can also cause entomophobia [1, 24].

Most of the species of cockroach are found in the tropics but only few occur in temperate regions [2, 3]. Nigeria is an afro-tropical country in which vast majority of insects are unknown [25], whereas, in other countries of

the world, there are records of different insects' species available within any geographical region. For instance, the records and biodiversity of cockroaches in other countries of the world have been documented; In Yasuj City, south-western Iran, only five species of cockroaches have been reported [26] and a checklist of 26 species of cockroaches reported in all part of the country [27]. In Pakistan, four species were reported [15] while in Malaysia, 10 species and 6 species respectively were reported [28, 29]. In Thailand, 12 cockroach species were noted [30] but in Turkey and Cameroon, only 3 species were identified [31, 32]. However, there is dearth of information on species composition, relative abundance and biodiversity of cockroaches in Nigeria most especially in the study area. Therefore, the present study was undertaken to investigate species composition, relative abundance, and population diversity of cockroaches in OAU, Ile-Ife, Nigeria with a view to updating the existing information on this insect.

MATERIALS AND METHODS

Study area

The study was carried out at Obafemi Awolowo University campus, Ile-Ife, Nigeria. Ile-Ife is an ancient town in southwest Nigeria located on Latitude 7° 31' 06"N, Longitude 4° 31' 22"N and 244 m above sea level. The University is located within the tropical climate with rainy season which starts from April to October and the dry season which runs from November to March.

Obafemi Awolowo University (OAU) formerly University of Ife was established in 1962 and situated on a vast expanse of land and comprises of central campus area, the student residential areas, the staff quarters, and a Teaching and Research Farm (T&RF). There are nine halls of residence in the University with an estimated population of about 40,000 students with the rooms originally designed for between 2 and 4 students but now officially have between 8 and 10 students per room due to large increase in student admission without corresponding increase in

hostel facilities [33]. This has resulted in an increased pressure on existing facilities with increased garbage accumulation which could lead to the spread of cockroaches in the halls of residence. Another feature among OAU students as common in most Nigerian University hostels is the stocking of foodstuffs by individual students inside their rooms, especially under their beds and inside the wardrobe [33, 34]. These practices among others, largely contribute to the proliferation of cockroaches in the students' halls of residence.

Sample collection

Surveys were carried out in halls of residence of the University between 2015 and 2017 as part of the student collection for Agricultural Entomology course. For each year, students were divided into 10 groups to search and collect cockroaches. The insects were collected randomly with the help of sticky traps and hand catch method using sterile hand-gloves. The yellow sticky traps were placed at strategic locations where cockroaches were likely to be found, such as under beds, bathrooms, toilets, kitchenettes, near rubbish bins, cupboards, in drawers and in the corners of rooms. The collections were made for a period of 30 days with the sticky traps set up and damaged or spoilt traps frequently replaced. Traps were examined from time to time for the collection of trapped cockroaches which were counted and recorded. Using sterile hand gloves, trapped cockroaches that are whole and alive were killed in labelled insect jar containing cotton soaked in diluted 10% chloroform and preserved in 70% alcohol. The sticky trapped roaches were removed using absolute ethanol.

Insect identification

The collected specimens were regularly examined under the dissecting microscope at the Insectarium of the Department of Crop Production and Protection for identification up to species level using standard and reliable taxonomic keys [3, 35, 36] and compared with reference specimens maintained in the Department. Some of the identified species

were placed in labelled collection boxes for preservation at the insectarium.

Data analysis

The data on individuals trapped were normalized using square root transformation and subjected to Analysis of Variance (ANOVA). The means were separated using Fisher's Least Significant Difference (LSD) at $p = 0.05$ using the SAS statistical package [37]. Bar chart was also used to show trend of cockroaches' population encountered during the sampling period.

Abundance and biodiversity indices

Relative abundance (RA) is the population of individual species divided by total population of species in percentage.

$$RA = \frac{\text{population of individual species}}{\text{total population of species}} \times 100$$

Shannon Diversity Index (H) is an index that is commonly used to characterize species diversity in a community. It accounts for both abundance and evenness of the species present. It is the proportion of species i relative to the total number of species (p_i), and then multiplied by the natural logarithm of this proportion ($\ln p_i$). The resulting product is summed across species, and multiplied by -1 [38, 39]. The higher scores show higher diversity.

$$H = -\sum_{i=1}^s P_i \ln P_i$$

Simpson's Dominance Index (D) is a measure of diversity which takes into accounts both the number of species per sample as well as relative abundance of the different species [40]

$$D = 1 - \frac{\sum_{i=1} n(n-1)}{N(N-1)}$$

Where: D = Dominance index, n_i = number of individuals in the i th species, N = total number of entities in the dataset.

RESULTS

Results revealed that seven cockroaches (*Periplaneta americana*, *Periplaneta australasiae*, *Blattella germanica*, *Blattella orientalis*, *Blattella vaga*, *Supella longipalpis*, and *P. fuliginosa*) were trapped from the various locations within OAU campus

between year 2015 and 2017. The abundance and distribution of cockroaches based on years of collection are presented in Table 1. The total cockroaches trapped in the year 2015, 2016, 2017 were 278, 301, and 288 individuals respectively. With regards to total population of cockroach species collected between 2015 and 2017, *B. germanica* and *P. americana* had the highest population of 346 and 331 individuals respectively while *P. australasiae* had lowest population of 18 individuals. For population of individual species of cockroach collected at different years, *B. germanica* increased progressively from 106 individuals (2015) to 128 individuals (2017), *S. longipalpis* also follows the same trend and increased from 12 (2015) to 16 (2017). The *P. americana*, *P. australasiae* and *B. vago* had its peak population in 2016, while the population of *B. orientalis* declined throughout the sampling period.

In terms of relative abundance, *B. germanica* and *P. americana* was most prevalent cockroaches with 39.9% and 38.2% prevalent rate respectively over the three years' period. These two species made up 78% of the total

specimens collected. Other species include *B. orientalis* (7.2%), *S. longipalpis* (5.0%), *B. vago* (4.0%), *P. fuliginosa* (3.7%) and *P. australasiae* (2.1%) as the least species recorded. The Diversity Index of cockroaches trapped in selected locations decrease with years of collection with the Diversity Index for year 2015, 2016 and 2017 was 1.45, 1.43 and 1.30 respectively. A similar trend was observed for the dominance index that reduced from 0.70 in (2015) to 0.65 in (2017). The *P. americana* had the highest dominance index of 0.1581 in year 2016 while *B. germanica* had highest dominance index of 0.1445 in 2015 and 0.1967 in 2017. The *P. australasiae* had the least dominance index of 0.0003, 0.0008 and 0.0001 for year 2015, 2016, and 2017 respectively (Table 1).

The analysis of variance (ANOVA) results presented in Table 2 showed that the model explained 80% of variation observed in trapped cockroach species from the university halls of residence and coefficient of variation (CV) of 23% which indicates low levels of variations across the sampling locations and periods.

Table 1: Species composition and relative abundance of cockroaches trapped in Obafemi Awolowo University, Ile-Ife, Nigeria

Species/indices	Total population	Relative Abundance (%)	Mean population /Year	Abundance (%) of cockroaches			Dominance index (D)		
				2015	2016	2017	2015	2016	2017
<i>B. germanica</i>	346	39.9	115.3	106 (38.1)	112 (37.2)	128 (44.4)	0.1445	0.1377	0.1967
<i>P. americana</i>	331	38.2	110.3	102 (36.7)	120 (39.9)	109 (37.8)	0.1338	0.1581	0.1424
<i>B. orientalis</i>	62	7.2	20.7	28 (10.1)	19 (6.3)	15 (5.2)	0.0098	0.0038	0.0025
<i>S. longipalpis</i>	43	5.0	14.3	12 (4.3)	15 (5.0)	16 (5.6)	0.0017	0.0023	0.0029
<i>B. vaga</i>	35	4.0	11.7	14 (5.0)	15 (5.0)	06 (2.1)	0.0024	0.0023	0.0004
<i>P. fuliginosa</i>	32	3.7	10.7	11 (4.0)	11 (3.7)	10 (3.5)	0.0014	0.0012	0.0011
<i>P. australasiae</i>	18	2.1	6.0	05 (1.8)	09 (3.0)	04 (1.4)	0.0003	0.0008	0.0001
Total	867			278	301	288			
Shannon diversity index							1.45	1.43	1.30
Simpson dominance (1-D)							0.70	0.69	0.65

Table 2: Analysis of variance of cockroaches trapped in Obafemi Awolowo University, Ile-Ife, Nigeria

Source of Variation	Degree of freedom	Mean Square	F value
Group	9	0.158	0.70 ns
Year (Y)	2	0.097	0.44 ns
Insect Species (S)	6	29.41	130.73**
Error	192	0.225	-
Total	209	-	
R ²	0.80 (80%)		
CV	23.5%		

** = significant at $p=0.01$
 ns = not significant.

The species of cockroaches were highly significantly different from one another while group and years of collection were not significant at $p \leq 0.05$. The mean population of cockroaches trapped is presented in Table 3. The mean population of *B. germanica* and *P. americana* were not significantly different but higher than other species of insects detected/trapped ($p \leq 0.05$). However, no significant difference in mean population of *S. longipalpis* and other species of cockroaches with exception of *B. orientalis* which recorded higher population than *B. vaga*.

The total population of cockroach species collected by student groups between 2015 and 2017 is shown in Fig 1. In 2015, group 10, 7, and 3 trapped a total of 36, 33 and 31 cockroaches while group 4 and 6 recorded 20 and 21 cockroaches respectively. In 2016, group 2, 7, 5, and 8 trapped a total of 44, 39, 35 and 33 cockroaches respectively while group 1 and 6 had lowest number of trapped cockroaches of 20 and 19 respectively. In 2017, three groups (4, 1, and 7) trapped highest number of 37, 36 and 32 cockroaches respectively while group 10, 9, and 8 only trapped 18, 20 and 21 cockroaches respectively.

Table 3: Mean population* of cockroaches trapped in Obafemi Awolowo University, Ile-Ife, Nigeria

Species	Means
<i>P. americana</i>	10.799a
<i>B. germanica</i>	11.039a
<i>S. longipalpis</i>	1.224bc
<i>P. australasiae</i>	0.493bc
<i>B. vaga</i>	1.028cd
<i>P. fuliginosa</i>	0.946bc
<i>B. orientalis</i>	1.825b

* Mean from Back- transformed (Original Data)
 Means in same column followed by the same letter(s) are not significantly different at $p \leq 0.05$

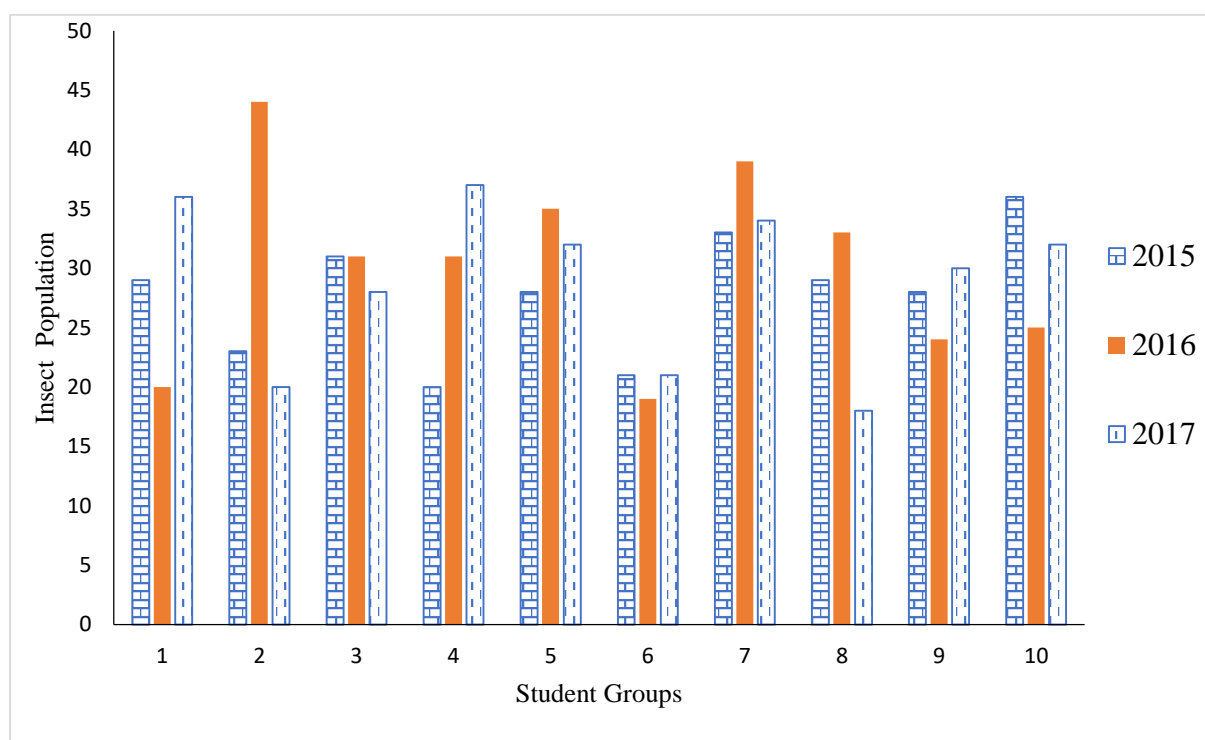


Fig. 1: Total population of cockroach species trapped by student groups between 2015 and 2017

DISCUSSION

Cockroaches are important insect pests due to their ubiquitous habits and association with humans and are reported to be serious vectors of pathogens. The species of cockroaches encountered in this study belong to two families; Blattellidae [German cockroach (*B. germanica*), brown-banded cockroach (*S. longipalpis*), and field cockroach (*B. vaga*)] and Blattidae [American cockroach (*P. americana*), oriental cockroach (*B. orientalis*), Australian cockroach (*P. australasiae*) and smoky brown cockroach (*P. fuliginosa*)]. The species diversity was low for all sampling years and there was dominance of German and American cockroaches over other species. The population abundance of the insects was in the order, *B. germanica* > *P. americana* > *B. orientalis* > *S. longipalpis* > *B. vaga* > *P. fuliginosa* > *P. australasiae*. Three of the identified cockroaches (*P. americana*, *B. germanica* and *B. orientalis*) were earlier reported in Abraka, Delta State, Nigeria [41]. However, the number of species encountered in this study was found to be more than those reported in earlier studies in Jos, Nigeria [42] with only two species of the cockroaches (*P. americana* and *B. germanica*) found in human habitations in the sampled localities [42, 43]. Only one species of cockroach (*P. americana*) was reported in Cross River, Nigeria [44, 45]. In Cameroon, three species of cockroaches (*P. americana*, *B. germanica*, and *B. orientalis*) were known to be dominant in human habitations in the Melong Subdivision of the country [32]. This is similar to what was observed in the present study in terms of ranking based on population of trapped insects.

The decrease in biodiversity and dominance index over the three year period could be as a result of environmental effect as abundance and population fluctuations of cockroaches are linked to various environmental factors such as cleanliness and human population density [46].

The observed trend in the study could also be due to the improvement in the environmental sanitation, recent reduction of number of students allowed in hostel rooms which drastically reduced overcrowding and congestion, and the new fumigation plan of the University management might have also contributed to the number of the dominant species which also affected other species considerably.

Blattella germanica population increased progressively throughout the sampling period which might be attributed to conducive environment for its reproduction or its relatively short life cycle and ability to reproduce rapidly. German cockroach is capable of establishing a sizable population within a short period of time due to its highest reproductive potential (number of eggs laid and short life cycle) of the house-infesting cockroaches and the females carry their egg capsule for as long as one month before hatching [47, 48]. On the other hand, a fluctuation in the population of *Periplaneta americana* could be as a result of food availability and conducive environment for reproduction that resulted into population rise while the drop in population could be due to recent implementation of general pest control and management programs in the University.

The American cockroach, *Periplaneta americana* and the German cockroach, *Blattella germanica* are cosmopolitan in distribution and able to reproduce and survive more easily in tropical climate region. They have been reported to be two of the most common and notorious cosmopolitan pest species in Nigeria [49], and other parts of the world [9, 15, 28]. The higher relative abundance of *B. germanica* over *P. americana* recorded in this study is consistent with other study in Iran [50]. These species of cockroaches have been noted to be the most frequent species in the human dwellings in West Malaysia followed by *P. americana* [29,

51]. However, in Nigeria, *P. americana* (66.51%) was reported as the dominant cockroach species in Sokoto followed by *B. orientalis* (33.49%) [34] while *P. americana* was the most predominant cockroach species in Markurdi that accounted for 50.6% of total cockroaches caught [52]. The species, *P. americana* (81.33%) was also noted as the most prevalent cockroach followed by *B. germanica* (11.53%) in Abraka, Delta State, Nigeria [41]. The difference in location and environmental factors could be likely reason for the variation observed in the number of species trapped since environmental factors is known to influence the rate of reproduction of the insect. Also, the degrees of sanitation, cleanliness and pest management are linked to the spatial distribution and abundance of cockroaches in residences [53].

The German cockroach is known to have the greatest potential for being persistent and troublesome. The insects have also been implicated in the spread of typhoid and dysentery [54]. A total of 12 *Salmonella*, two each of *Shigella* and *Escherichia coli*, 17 *Staphylococcus aureus* and 24 *Bacillus cereus* were isolated from this particular species in Addis Ababa, Ethiopia [55] and *Entamoeba histolytica* that causes amoebiasis was detected in *P. americana* and *B. germanica* in Sokoto, Nigeria [52].

The third in the ranking in terms of abundance is oriental cockroaches *Blattella orientalis* (L.) and have been earlier reported in Nigeria [41, 52]. This species occurs commonly in and around houses and around moist, dark sites especially in floor and storm drains, water-meter boxes, around plumbing fixtures, moist crawl spaces, sewers, damp basements, around garbage, sewers, and forage mostly on the first floors of building [48, 56, 57]. The *P. americana*, *B. germanica* and *B. orientalis* were found to be carriers of nematodes eggs and protozoan oocysts [32] while American cockroaches have

been reported to be reservoir and mechanical transmitters of pathogenic microorganisms [44], *E. coli*, *Salmonella shigella*, *Staphylococcus*, *Streptococcus* were detected in *P. americana* collected from different kitchens in Lahore, Pakistan [58] while different forms of gastroenteritis (food poisoning, dysentery, diarrhoea, etc.) are known to be the principal diseases transmitted by oriental cockroaches [59].

The Brown banded cockroach *Supella longipalpa* (F.) is a small size insects and has ability to evade predation as well as ability to adapt to wide habitat increase. The moderate population recorded for this insect may be due to its small size and ability to evade predation as well as ability to adapt to wide habitat. They are also referred to as tropical cockroach [60] and are regarded as peri-domestic and obligate domiciliary insect [56], that are generally found in drier areas of the household, apartments, hotels, and hospitals, particularly in bedroom, furniture, television, clothes cabinets, in dining room areas, on ceilings, high on walls, behind picture frames, and near motors of refrigerators and other appliances. etc. [28, 61, 62]. About 15% of the insects were trapped in Benue University student hostels in Markurdi, Nigeria [34].

Other cockroach species encountered in this survey include the field Cockroach (*Blattella vaga*) population that is similar to German cockroach in mode of reproduction as it also carries the ootheca until nymphs emerge [48, 61] and prefers outdoor locations but invade indoor areas when it is hot or dry outdoors and can be seen around streetlights and in lighted display windows [61]. They are not repelled by light and has ability to fly [63, 64] and usually found in leaf litter and plant debris feeding on decaying vegetation. The smoky brown Cockroach *Periplaneta fuliginosa* (Serville), one of the least abundant species are native to temperate regions of Asia [64] which

indicates that there is possibility of being recently introduced into Nigeria.

The Australian cockroach (*P. australasiae*), the least abundant, are peridomestic cockroaches (cockroaches that live mostly outdoors, but occasionally found indoors) [65] and are most likely attracted into residential areas due to attraction of light at night [28], food [66] and warmth as the species are not cold tolerant [57]. This species is believed to have originated from Africa [65]. There is likelihood that the insect might have been introduced into the country but yet to be effectively established as introduced household insect pest in Nigeria.

CONCLUSION

This study provided information on the cockroach species present and their prevalence in a University community. The major roles of the predominant species of cockroaches recorded in this survey which are known to serve as a reservoir and potential vectors of some food-borne diseases call for a further investigation into linking infestation of these insects with incidence and spread of specific diseases. Nonetheless, a substantial effort is necessary to raise peoples' awareness on the need to safeguard themselves and their food sources from contamination by cockroaches. This will go a long way in minimizing the incidence and spread of infectious diseases that are linked to these insect pests in our environment.

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