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Update of the Mosquito Fauna (Diptera: Culicidae) of Sancti Spíritus and Villa Clara Provinces, Cuba

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Research Article

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Abstract

Mosquito borne diseases constitute one of the priority health problems in most tropical countries, with emphasis on species with marked entomoepidemiological importance. The objective of this research was to update the mosquito entomofauna of Sancti Spíritus and Villa Clara provinces, Cuba. The research covered a period of 15 years (2007-2022). For the collection of the data used in the study, they were organized in the Excel application for Windows (years, months, municipalities and accumulated of both provinces), for which a database was created with all the documentary review of the records and statistical files existing in the Provincial Unit of Surveillance and Antivectorial Fight (UPVLA) of Sancti Spíritus and Villa Clara, as well as in the Provincial Departments of Health Statistics of both provinces, where all the entomological history of the work cycles conceived in the municipalities that make up both provinces is compiled. A total of 42 species of mosquitoes (59.15%) distributed in 12 genera were found in Sancti Spíritus province, while in Villa Clara, the figure amounted to 45 species (63.38%) distributed in 13 genera, all this, taking into account the 71 species of mosquitoes currently registered for Cuba. The most frequent and best represented species in both provinces were *Anopheles albimanus, Aedes aegypti, Ae. albopictus, Culex quinquefasciatus, Cx. nigripalpus and Psorophora confinnis*. The species *Ae. vittatus* was recorded in the two provinces under investigation, which is a highly invasive species. The results showed the great ecological plasticity of the entomofauna of culicidae in both provinces of Cuba.

Keywords: *Aedes vittatus*; Invasive Species; Mosquito Fauna; Sancti Spíritus; Villa Clara

Introduction

Humanity has suffered throughout history from the scourge of potentially fatal viral and parasitic diseases, including: Yellow Fever, Dengue, Zika, Chikungunya, Malaria, Chagas, Leishmaniosis, Onchocercosis, Angiostrongylosis, Fasciolosis, among many others, and most of them often involve a vector organism as a common factor [1-3]. These diseases are widespread in the tropics, with local variations in risk, so they are highly dependent on rainfall, temperature and rapid unplanned urbanization, among others [4-6].

To these problems, we can now add global warming and the intensification of extreme meteorological disturbances, which has brought about changes in the behavior of diseases and their transmissions, with the establishment of vector species in places never recorded before [7-9]. Climate change is considered one of the main environmental problems, and its effects undoubtedly have a negative impact on human health [7,10-12]. There are several studies that relate climatic variables with the increase of infectious diseases, where arbovirosis has been one of the most studied, and it has been shown that there is a positive relationship between climate variation and the incidence of these infectious entities [13-17].

All vector-borne diseases in the world have very high incidence rates; for example, it is estimated that between 50-100 million cases of Dengue fever occur each year [5,18,19]. This viral entity has been considered for many years as a public health problem in the world, especially in tropical countries where the influences of environmental variables favor the increase of cases each year [5,19,20].

However, the main health problem in terms of vectors continues to be Malaria, with 500 million reported cases and three million deaths each year, of which one million are children under five years of age [20-23]; this entity causes the death of one person every 60 seconds [22,24-26]. Cuba, due to its geographic location and climatological characteristics, has a wide fauna of culicidae with proven vectorial capacity, making them of great interest for human and other animal health [26,27].

Efforts to control vector-borne diseases have been hampered in part by the development of drug-resistant etiologic agents, insecticide-resistant mosquitoes, environmental contamination, residual effect of chemicals, high prices of insecticides in the market and operational failures [21,28-32].

Consequently, there is a growing need to develop and implement other strategies for the control of infectious entities and their vectors, which can complement existing methods in a more effective and efficient way [23,33]. All of the above shows the urgent need for constant updating, both in the systematics and taxonomy of the entomofauna of culicidae, especially those of veterinary medical interest [32,34-36].

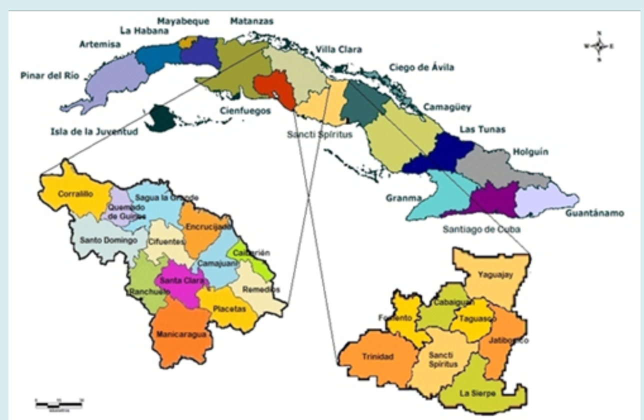
The objective of the research was to identify the current fauna of culicidae existing in the provinces of Sancti Spíritus and Villa Clara, Cuba.

Materials and Methods

Study Area

The research covered two provinces in the center of the country (Sancti Spíritus and Villa Clara) (Figure 1). In the case of Sancti Spíritus, this province is made up of eight municipalities, its provincial capital being the municipality of Sancti Spíritus. It is bordered to the west by Villa Clara province, to the east by Ciego de Avila province, and to the south by Cienfuegos province. Its geographic coordinates are as follows (Latitude: 21°56'3'' N, Longitude: 79º26'37'' W).

The Villa Clara province, whose provincial capital is Santa Clara municipality and covered the 13 municipalities that comprise. This province is located in the central region of the island of Cuba (Latitude: 22º 29'40'' N, Longitude: 79º28'30'' W), and has the following geographical limits; to the west, with Matanzas province, to the east, with Sancti Spíritus province and to the south, with Cienfuegos province.



Source: Provincial Meteorological Center of Sancti Spíritus and Villa Clara, Cuba.
Figure 1: Administrative map of the provinces of Sancti Spíritus and Villa Clara.

Regarding Data Collection

The data were organized in the excel application for windows, by years, months, municipalities and the accumulated of both provinces, for which a database was created with all the documentary review of the records and statistical files existing in the Provincial Unit of Surveillance and Antivectorial Fight (UPVLA) of Sancti Spíritus and Villa Clara, as well as the provincial departments of health statistics of both provinces, where the entire entomological history of the work cycles conceived in the municipalities that make up both provinces 8/Sancti Spíritus and 13/Villa Clara is compiled and periodically reported through statistical tables established for such purposes to the National Direction of Surveillance and Antivectorial Control (DNVLA) and the Department of Health Statistics of the Ministry of Public Health (MINSAP) of Cuba.

The information collected is based on the work cycles established for surveillance and vector control, aimed at focal work in the universe of dwellings and premises, both in urban and rural areas of each municipality in the provinces under study. The periodicity of the cycles is monthly for the urban universe and bimonthly for the rural universe. For this research, the period from 2007 to June 2022 was taken into account.

Collection and Identification of Mosquitoes

Fluvial ecosystems (rivers, streams, ditches, gullies, lagoons, marshes and marshes) were sampled, with emphasis on the banks, which constitute the mosquito oviposition and breeding sites (effective breeding area); In addition, for the collection of mosquito larvae, pupae and adults, the trees and bushes associated with the margins of the reservoirs (including bamboo) were taken into account, as well as disused artificial containers (cans, bottles, knobs, tires, among others) for the immature stages. We also consulted the records/passive archives and maps existing in the provincial units of both provinces, where we were able to obtain all the information on the mosquito species *Aedes aegypti* (Linnaeus, 1762), a species clearly circumscribed to urban ecosystems, as well as the results accumulated over the years on the capture of resting mosquitoes (adults). Mosquito larvae and pupae were collected by the ladle method [37], and were transferred to the respective laboratories in plastic bottles with a capacity of 250 mL, duly labeled, according to each breeding site.

The identification of the specimens collected was carried out according to dichotomous and pictorial keys for such purposes [38-40], and was performed in the Medical Entomology Laboratories of the Provincial Surveillance and Vector Control Units in Sancti Spíritus and Villa Clara, by specialists from both centers.

Results and Discussion

To date, 45 species of mosquitoes distributed in 13 genera have been identified in Villa Clara province, while in Sancti Spiritus, 42 species were identified, distributed in 13 genera, the same as in the former province of Sancti Spiritus (Table 1). Being the best represented and distributed species in both provinces were *Anopheles albimanus*, *Aedes aegypti*, *Ae. albopictus*, *Culex quinquefasciatus*, *Cx. nigripalpus and Psorophora confinnis*, for being present in all of the municipalities of the two provinces, followed by *Cx. corniger*, *Ae*. *scapularis, Ae. mediovittatus* and *Ps ciliata*.

Species of mosquitoes	Sancti Spíritus									Villa Clara												
	1	2	3	4	5	6	7	8	Total	1	2	3	4	5	6	7	8	9	10	11	12	13
Aedeomyia squamipennis (Lynch-Arribálzaga,1878)	x	x		x	x	x	x	x	7									x			x	
Anopheles albimanus (Wiedemann,1821)	x	x	x	x	x	x	x	x	8	x	x	x	x	x	x	x	x	x	x	x	x	x
An. atropos (Dyar & Knab,1906)	x				x	x	x	x	5					x	x							
An. grabhamii (Theobald,1901)		x			x	x	x		4					x	x					x		
An. vestitipennis (Dyar & Knab,1906)	x		x	x	x	x	x	x	7			x		x	x	x	x	x		x		
An. crucians (Wiedemann,1828)	x	x	x	x	x	x	x	x	8					x			x				x	
Aedes aegypti (Linnaeus, 1762)	x	x	x	x	x	x	x	x	8	x	x	x	x	x	x	x	x	x	x	x	x	x
Ae. albopictus (Skuse, 1894)	x	x	x	x	x	x	x	x	8	x	x	x	x	x	x	x	x	x	x	x	x	x
Ae. mediovittatus (Coquillett,1906)	x				x	x	x		4	x	x	x	x	x	x	x	x	x	x	x	x	x
Ae. scapularis (Rondan,1848)	x	x		x		x	x	x	6	x	x	x	x	x	x	x	x	x	x	x	x	x

Ae. serratus (Theobald,1901)									0	-	-	-	-	-	-	-	-	-	-	-	-	-
Ae. sollicitans (Walker,1856)	x	x				x	x	x	5	x		x	x	x	x	x			x	x	x	
Ae. taeniorhynchus (Wiedemann,1821)	x	x				x	x	x	5	x	x	x	x	x	x	x			x	x		
Ae. tortilis (Theobald,1903)	x				x	x	x		4			x	x	x		x		x				
Coquillettidia nigricans (Coquillett, 1904)	x				x		x	x	4									x		x		
Culex atratus (Theobald, 1901)	x	x	x	x	x	x	x	x	8				x	x	x		x	x	x			
Cx. americanus (Neveu-Lemaire, 1902)	x				x		x	x	4						x		x					
Cx. bahamensis (Dyar & Knab,1906)	x					x		x	3						x		x					
Cx. cancer (Theobald,1901)	x					x	x	x	4	x				x	x							
Cx. chidesteri (Dyar,1921)		x	x		x	x	x	x	6	x	x				x		x	x		x	x	
Cx. corniger (Theobald,1903)	x			x	x	x	x	x	6	x	x	x	x	x	x	x	x	x	x		x	x
Cx. erraticus (Dyar & Knab,1906)	x	x	x	x	x	x	x	x	8				x	x	x	x	x	x	x		x	x
Cx. iolambdis (Dyar,1918)			x		x	x	x	x	5								x	x				
Cx. nigripalpus (Theobald,1901)	x	x	x	x	x	x	x	x	8	x	x	x	x	x	x	x	x	x	x	x	x	x
Cx. panocossa (Neveu Lemaire,1902)								x	1													
Cx. pilosus (Dyar & Knab,1906)	x		x	x	x	x	x	x	7	x		x	x	x	x		x					x
Cx. quinquefasciatus (Say,1823)	x	x	x	x	x	x	x	x	8	x	x	x	x	x	x	x	x	x	x	x	x	x
Cx. secutor (Theobald, 1901)									0								x					x
Cx. sphinx (Dyar & Knab, 1915)									0						x							
Howardina walkeri (Theobald, 1901)									0		x				x					x	x	
Limatus durhamii (Theobald, 1901)									0									x		x	x	
Mansonia titillans (Walker,1848)	x	x	x		x	x	x	x	7			x			x		x	x	x	x	x	
Orthopodomyia signifera (Coquillett, 1896)	x						x	x	3								x				x	
Psorophora ciliata (Fabricius,1794)			x	x	x	x	x	x	6	x	x	x	x		x	x	x	x	x	x	x	x
Ps. confinnis (Lynch Arribálzaga,1891)	x	x	x	x	x	x	x	x	8	x	x	x	x	x	x	x	x	x	x	x	x	x
Ps. ferox (Humboldt,1819)	x	x			x	x	x	x	6	x					x							
Ps. howardii (Coquillett,1901)	x		x	x	x	x	x		6						x	x	x	x	x		x	x
Ps. infinis (Dyar & Knab, 1906)	x	x	x	x	x	x	x	x	8								x				x	
Ps. insularia (Dyar y Knab, 1906)									0						x							
Ps. johnstonii (Grabham, 1905)	x					x			2						x							
Ps. pygmaea (Theobald, 1903)									0	x			x	x	x	x		x	x			x
Ps. santamarinai (González Broche, 2000)	x								1						x		x					
Toxorhynchites portoricensis (von Röder, 1885)	x			x			x		3					x	x							
Uranotaenia lowii (Theobald,1901)	x	x	x	x	x	x	x	x	8													

Ur. sapphirina (Osten-Sacken,1868)	x				x	x	x	x	5			x	x	x	x	x	x	x	x	x	x	
Wyeomyia aporonoma (Dyar & Knab,1906)									0													
Wy. mitchelli (Theobald,1905)	x			x	x	x	x	x	6								x	x				
Wy. nigritubus (Galindo, Carpenter & Trapido, 1951)							x	x	2													
Wy. vanduzeei (Dyar & Knab,1906)	x		x	x	x	x	x	x	7									x				
* *Aedes vittatus* (Bigot, 1861)							x	x	2				x				x					

Legend: municipalities of Sancti Spíritus province **(**1: Yaguajay, 2: Jatibonico, 3: Taguasco, 4: Cabaiguán, 5: Fomento, 6: Trinidad, 7: Sancti Spíritus, 8: La Sierpe**)**. Municipalities of Villa Clara province: 1 Corralillo, 2 Quemado de Güines, 3 Sagua la Grande, 4 Encrucijada, 5 Camajuaní, 6 Caibarién, 7 Remedios, 8 Placetas, 9 Santa Clara, 10 Cifuentes, 11 Santo Domingo, 12 Ranchuelo and 13 Manicaragua.
*(New report)

Table 1: Distribution of the mosquito fauna of Sancti Spíritus and Villa Clara provinces, Cuba.

Of the 71 species of mosquitoes registered for Cuba [41], in Villa Clara, the number of identified species is 45/63.38%, while in Sancti Spíritus, 42 species were identified, equivalent to 59.15%. That species was collected in all the fluvial ecosystems sampled, as well as a wide range of deposits, which evidenced the great ecological plasticity of the entomofauna of culicidae existing in our country, in spite of being an archipelago, which corroborates the results obtained by García [42]; González [43].

The genera best represented and with a marked presence in the municipalities studied were *Aedes*, *Anopheles*, *Culex* and *Psorophora*, because they were distributed in almost all the ecosystems sampled, where they appeared in relatively high abundance, a fact that agrees with the results obtained by Marquetti [27], specifically for *Cx. quinquefasciatus* in the urban ecosystem; this result also confirms the criteria of Mattingly [44], Scorza [44] and Cruz, et al. [45] in relation to the extraordinary adaptive capacity and high ecological plasticity of *Cx. quinquefasciatus* in the most diverse and possible habitats provided by man.

The fact that *Ae. aegypti* and *Ae. albopictus* are gaining ground and space in Sancti Spíritus and Villa Clara provinces is notorious and relevant. These species are of high entomoepidemiological risk because of their involvement in several infectious entities [46-49], among which Dengue, Yellow Fever, West Nile virus, Chikungunya and Zika virus stand out; but reality has shown us, that at present, these two species are practically present throughout the length and breadth of the national geography, expanding increasingly, colonizing an important number of breeding sites generated by human activity together with environmental variables [50], thus showing their high ecological plasticity and high capacity to adapt to the most dissimilar ecological niches [27,50].

The association between temperature and population dynamics of culicidae has been investigated in many studies, particularly in tropical and sub-tropical areas. The results of this study are consistent with previous studies in other regions of the world [51-54].

In relation to the analysis of climatological variables, there was concordance between the results of the study and others reviewed, in which temperature and relative humidity are variables with high correlation with the incidence of Dengue, Zika and Malaria [55-59].

The detection of the species *Ae. vittatus* (Bigot, 1861) in both provinces is noteworthy. This species was first identified as *Culex vittatus*. It was later placed in the genus *Aedes*, passing through several subgenera, such as *Stegomyia* and *Aedimorphus*, and is currently placed in a new subgenus described for the genus *Aedes*: (*Fredwardsius*) [60-62].

Regarding the history of detection, reporting and registration of *Ae. vittatus* in the Caribbean region, the first record of the species was made in the Dominican Republic [63], while in Cuba, the first detection of the species occurred outside the Guantánamo Naval Base (June 2019). The second detection was in Santiago de Cuba province, in January 2020 [35,64]; by September of that year, the referred mosquito species had been detected in 31 localities in four municipalities of the province, where larval specimen collections were in a marked variety of reservoirs, with emphasis on low and elevated tanks, followed by artificial, puddles and other reservoirs. The third detection occurred in the rural locality "Isabel Hortensia", Camagüey province [65], in the first days of December 2020 (34 larvae and 9 pupae), where specimens were collected in animal feeders, low tanks and disused tires, and in association with the species *Ae. aegypti*, *Ae. albopictus*, *An. albimanus*, *Cx. coronator*, *Cx.*

nigripalpus, *Cx. quinquefasciatus* and *Culiseta inornata*. The fourth detection occurred in the municipalities of Jatibonico, Sancti Spíritus and La Sierpe, belonging to the province of Sancti Spíritus (larvae, pupae and adults); collecting in buckets, low tanks and holes for construction of buildings, but always in rural ecosystems and framed within the rainy period (1st collection: December 2021, and then, specimens were collected in larval stage, and in greater quantity during the months of May-June 2022), something very similar also occurred in the province of Ciego de Avila (December 2021). Finally, and more recently, in the municipalities Encrucijada and Placetas belonging to Villa Clara province (June 2022), where larvae and pupae were also collected, which are pending taxonomic confirmation by IPK entomologists. The presence of *Ae. vittatus* in other provinces of the country is not ruled out, but has not yet been detected.

Everything seems to indicate that the movement of *Ae. vittatus*, from East to West is related to the geographical location of Cuba, within the northern portion of the tropical zone, very close to the limit between the tropical and subtropical zones, linked to the processes of intensification and weakening of the winds of the Northeast region, called Alisios, whose seasonal fluctuation is caused by the changes in the position and intensity of the North Atlantic Subtropical Anticyclone, where an important characteristic of this seasonal fluctuation is the decrease of the Atlantic anticyclonic influence over Cuba in winter. Such decrease allows the irruption of extratropical weather systems that impose a significant frequency of frontal events, cold air invasions and other events typical of higher latitudes, which considerably increase the seasonal contrast between climatic elements [66]. It is also accepted that changes in the frequency and characteristics of circulation patterns are the main cause of fluctuations in climatic elements [63,64]. Consistent with the previous process, there is evidence of an increase in the baric gradients in the surroundings of Cuba that has caused increases in the intensity of the zonal current from the East linked to the trade wind regime over our area. Therefore, the regional atmospheric circulation (formed by the superposition, among other components, of cyclic signals of different frequencies), has allowed us to isolate a quasi-decadal signal and another one of 5 to 6 years of period, closely linked to the influence of the El Niño/Southern Oscillation (ENSO) event on the circulation systems in the vicinity of Cuba. In this sense, a clear variability of the ENSO influence on the region has been detected, with a significant tendency to increase its impact [67,68].

Conclusion

The increase in the number of species in both provinces was considerable in relation to the study published in 2015; 42 against 34 for Sancti Spíritus province, and 45 against 43 for Villa Clara, with a highlight for the record of the species *Ae. vittatus* in both provinces, which corroborates the diversity and richness of culicid species in these two provinces. The marked representativeness and wide distribution of *Ae. aegypti* and *Ae. albopictus* in these two provinces, which raises the entomoepidemiological risk for the proliferation and transmission of arbovirosis in which the two species are involved.

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Conflict of Interest

The authors declare that they have no conflict of interest.

Contribution

All the authors contributed substantially to the concrescence of the manuscript.

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