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# Mosquitoes (Diptera: *Culicidae*) are vectors of vector-borne infections in South Vietnam (materials of the spring expedition 2024)

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ABSTRACT

***BACKGROUND***: Blood-sucking mosquitoes are carriers of many human vector-borne diseases caused by viruses, bacteria, protozoa and helminths. There are the results of entomological studies of the Joint Russian-Vietnamese Tropical Research and Technology Center.

***AIM***: is to study the generic and species composition of mosquitoes in South Vietnam before the rainy season, when mosquito activity is low.

***MATERIALS AND METHODS***: The collection of arthropods was carried out from May 12 to 26, 2024 in two regions of South Vietnam: the coastal mangrove reserve in the Can Gio area of Ho Chi Minh City, as well as in the Bu Gia Map Reserve of Binh Phuoc province. Imago was collected by exhusters "on themselves" and from feeders, entomological nets from plants, as well as inside and outside residential and outbuildings. The larvae were collected by filtering water samples from natural and artificial reservoirs where mosquitoes lay eggs. Arthropods were identified by morphological features.

***RESULTS***: The analysis of the collected material in two regions of South Vietnam showed that before the rainy season, mosquitoes of the genus *Culex* predominate 90.7%, mosquitoes of the genus *Anopheles* and *Aedes* account for 6.1% and 3.2%, respectively.

***CONCLUSION***: Thus, in South Vietnam, at the end of the "dry season", mosquitoes of the genus *Culex* predominate, adapted to development in conditions of reduced breeding sites. The study of the mechanisms of functioning of parasitic systems involving blood-sucking mosquitoes requires further research with the expansion of the research area. It is advisable to conduct entomological monitoring in various landscape and climatic zones during different periods of the epidemic season.

**Keywords**: *Aedes*; *Anopheles*; blood-sucking mosquitoes; *Culex*; *Culicidae*; Malaria; South Vietnam.

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# Комары (Diptera: *Culicidae*) — переносчики трансмиссивных инфекций в Южном Вьетнаме (материалы весенней экспедиции 2024 г.)

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АННОТАЦИЯ

**Актуальность**. Кровососущие комары являются переносчиками множества трансмиссивных заболеваний человека, вызываемых вирусами, бактериями, простейшими и гельминтами. Представлены результаты энтомологических исследований, проводимых в соответствии с планом работы Совместного Российско-вьетнамского тропического научно-исследовательского и технологического центра.

**Цель**: предварительная оценка структуры родового состава переносчиков наиболее актуальных и социально значимых трансмиссивных инфекций на территории Южного Вьетнама в период низкой активности комаров, предшествовавший сезону дождей.

**Материалы и методы**. Сбор членистоногих проводился в период с 12 по 26 мая 2024 г. в двух регионах Южного Вьетнама: прибрежный биосферный заповедник мангровых зарослей в районе Кан Зьо (Can Gio) города Хошимин, а также территория заповедника Бу За Мап (Bu Gia Map) провинции Бинь Фыок (Binh Phuoc). Отлов имаго кровососущих двукрылых проводился при помощи эксгаустеров методом «сбора на себе» и с прокормителей, с использованием энтомологических сачков с растений, а также с внутренних и внешних поверхностей жилых и хозяйственных построек. Преимагинальные стадии собирались путем фильтрации проб воды из естественных и искусственных водоемов, пригодных для выплода комаров. Идентификацию членистоногих проводили по морфологическим признакам.

**Результаты**. Анализ собранного материала в двух регионах Южного Вьетнама показал, что перед началом дождливого сезона среди комаров — переносчиков возбудителей трансмиссивных заболеваний преобладают комары рода Culex 90,7 %, на долю комаров родов *Anopheles* и *Aedes* приходится 6,1 и 3,2 % соответственно.

**Заключение**. Таким образом, анализ полученных данных может свидетельствовать о том, что в регионах Южного Вьетнама видовой состав переносчиков на исходе сухого сезона характеризуется преобладанием комаров рода *Culex*, адаптированных к развитию и сохранению численности в условиях сокращения мест, пригодных для выплода. Изучение механизмов функционирования паразитарных систем с участием кровососущих комаров требует дальнейших исследований с расширением их зоны. Целесообразно проведение энтомологического мониторинга в различных ландшафтно-климатических зонах с учетом непрерывного сезона передачи возбудителей трансмиссивных заболеваний.

**Ключевые слова**: *Aedes*; *Anopheles*; *Culex*; *Culicidae*; кровососущие комары; малярия; Южный Вьетнам.

**Как цитировать**
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# 越南南部传播媒介蚊虫（双翅目：蚊科）—2024年春季考察资料

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**摘要**

***背景。***吸血蚊是多种人类传播疾病的媒介，这些疾病由病毒、细菌、原生动物和蠕虫引起。本文基于俄越热带科学研究与技术合作中心的工作计划，呈现了昆虫学研究的结果。

***研究目的。***初步评估越南南部地区在雨季前低蚊虫活跃期内，与主要社会相关性传播疾病相关的媒介属级组成结构。

***材料和方法。***2024年5月12日至26日，在越南南部的两个地区进行节肢动物采集：胡志明市干焦（Can Gio）地区的红树林沿海生物圈保护区，以及平福省（Binh Phuoc）布贾马普（Bu Gia Map）自然保护区。采样方法包括使用吸捕器进行“自体捕集”和哺血捕集，从植物表面及室内外建筑物表面采用昆虫网捕捉成蚊。此外，通过过滤自然和人工水体样本收集蚊幼虫的前期发育阶段样本。对节肢动物样本根据形态学特征进行鉴定。

***结果。***对越南南部两个地区采集材料的分析显示，在雨季开始前，传播疾病病原体的蚊虫中库蚊属（Culex）占比最高（90.7%），其次为按蚊属（Anopheles，6.1%）和伊蚊属（Aedes，3.2%）。

***结论。***研究结果表明，在越南南部旱季末期，传播媒介的种类组成以适应减少繁殖地条件的库蚊属为主。进一步扩大研究范围以研究血吸蚊参与的寄生系统运行机制具有重要意义。在不同景观和气候区进行昆虫学监测，以应对全年传播疾病病原体的特点，是十分必要的。

***关键词：***伊蚊；按蚊；库蚊；蚊科；吸血蚊；疟疾；越南南部。

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## BACKGROUND

Mosquitoes are widespread dipterous insects of the family *Culicidae*, with over 3,500 species [1]. Adult mosquitoes have one pair of wings, three pairs of legs, one pair of antennas, feelers, a narrow segmented abdomen, and piercing-sucking mouthparts. Mosquitoes are insects with holometabolous development, which includes the egg, larva, pupa, and imago stages. Females need protein for the eggs to develop, which they receive through blood sucking from mammals, birds, reptiles, amphibians, and other animals [1, 2].

Bloodsucking mosquitoes are carriers of numerous vector-borne human diseases caused by viruses, bacteria, protozoa, and parasitic worms [3]. The main groups of mosquitoes differ by the ability to transmit specific pathogens. For example, mosquitoes of the genus *Anopheles* are specific vectors for malaria, wuchereriasis, Malayan filariasis, and o'nyong-nyong fever pathogens. Mosquitoes of the genus *Aedes* are vectors for dengue fever, chikungunya, Zika, Rift Valley fever, and yellow fever viruses, as well as other tropical disease pathogens. Mosquitoes of the genus *Culex* play a critical role in the transmission of socially significant diseases such as Japanese encephalitis and West Nile fever [4]. Mosquito-transmitted diseases have a broad nosorange, with tropical and subtropical regions being hyperendemic for some of these dangerous infections [5]. According to the World Health Organization (WHO), approximately 219 million cases of malaria are reported globally each year, with more than 445 thousand fatal outcomes. The annual incidence of dengue fever is 96 million cases, with approximately 40 thousand fatal outcomes [6]. There are no vaccines against the majority of mosquito-transmitted diseases. Thus, vector control is one of the most important measures of vector-borne disease control [7].

Vietnam is a tropical country in Southeast Asia with a high risk of mosquito-transmitted diseases [8]. Despite extensive malaria control measures, the disease has not been fully eliminated in Vietnam. According to the WHO Regional Office for the Western Pacific, Vietnam is currently one of seven countries (Australia, Cambodia, China, Laos, Malaysia, Singapore, and Vietnam) with the highest incidence of dengue fever. According to the Ministry of Health of Vietnam, the incidence of dengue fever in 2023 was 171,585 cases, with 42 fatal outcomes; in 2022, the incidence was 382,458 cases, with 115 fatal outcomes. In the first quarter of 2024, there were approximately 16 thousand patients with dengue fever, with one fatal outcome.

This study was performed in accordance with the research plan of the Joint Russian-Vietnamese Tropical Research and Technological Center, as part of the projects "Phase-related (seasonal) genetic changes in *Plasmodium falciparum* virulence and drug resistance in the body of vectors: mosquitoes of the genus *Anopheles*" and "Functional patterns of biological systems involving flaviviruses in Southeast Asia." During the first stage of the research, it was planned to visit vector-borne infection centers in Vietnam and collect blood-sucking vector samples. The study provided for testing the methods of collection, storage, and morphological identification of insects for biological sample preparation for subsequent molecular genetic testing.

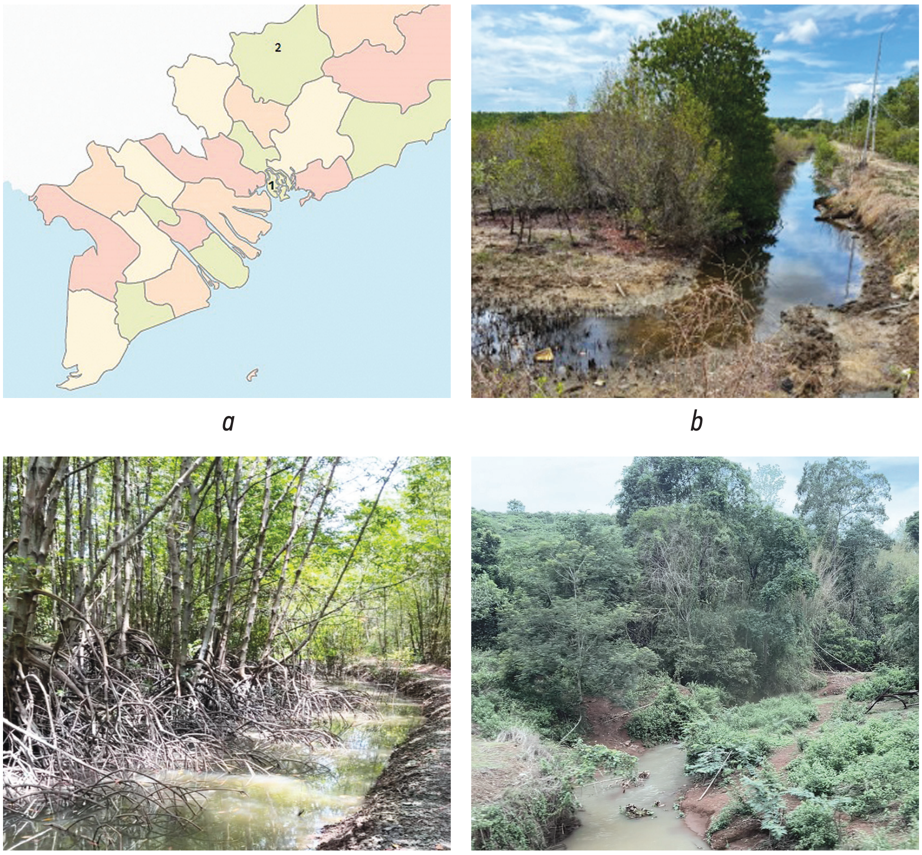
*Study aim*: To perform a preliminary assessment of the genus and species composition of vectors for the most relevant socially significant vector-borne infections in Southern Vietnam during the low mosquito activity period preceding the wet season.

## MATERIALS AND METHODS

The insects were collected on May 12–26, 2024, by a joint research team, which included researchers from the Military Medical Academy and the Southern Department of the Russian-Vietnamese Tropical Research and Technological Center (Table 2; Figure 1, *a*). The studies were performed in two regions of Southern Vietnam. The first study region was Can Gio district (Ho Chi Minh City, 10°27'17.588''N 106°53'30.669''E). The district is located in a coastal lowland, at the mouth of the Saigon and Dong Nai rivers, within the Can Gio Mangrove Biosphere Reserve. Mosquito breeding areas and adult insect habitats around the Tropical Center station were examined (Figure 1, *b*, *c*). The insects were collected from coastal flooded mangrove forests, artificial water bodies (irrigation canals, mollusc hatcheries), residential and household buildings (houses, barns, etc.), and natural and artificial fresh rainwater reservoirs.

The second study region was the Bu Gia Map National Park and the neighboring settlement in the Bu Gia Map district of the Binh Phuoc province (12°5'22.878''N 107°9'26.866''E, 310 m above sea level). Hillside woodlands with rivers and small lakes, as well as infrequent single-story buildings with various water tanks and surrounding rubber tree plantations, were examined (Figure 1, *d*). The settlement is likewise largely made up of single-story houses with household buildings and water collection and storage tanks. Some residents keep livestock and poultry (buffalos, pigs, chickens).

Adult mosquitoes were collected outdoors in the evening, during their peak bloodsucking activity, using small nets with a diameter of 20 cm. Moreover, the insects were collected from hosts using exhausters, which were also used to remove adult insects from nets (Figure 2, *a*). To collect flying mosquitoes, ultraviolet light traps were installed overnight near livestock barns and residential buildings (Figure 2, *b*). Endophagous mosquitoes in residential buildings were collected from windows using an exhauster and a special killing bottle.




*a* *b* *c* *d*

**Fig. 1.** Places of collection of vectors and malarial landscapes; *a* — district of mosquito collection: 1 — Can Gio, coastal district of Ho Chi Minh City; 2 — Bu Gia Map district, Binh Phuoc province; *b* — agricultural irrigation channels, Kang Zyo; *c* — flooded mangrove forests of the coast; *d* — hilly area with a river network, Uezd Bu Za Map

**Рис. 1.** Места проведения сбора переносчиков и маляриогенные ландшафты; *a* — районы сбора комаров: 1 — Кан Зьо (Can Gio), прибрежный район города Хошимин; 2 — уезд Бу За Мап (Bu Gia Map), провинция Бинь Фыок (Binh Phuoc); *b* — сельскохозяйственные оросительные каналы, Кан Зьо; *c* — затопляемые мангровые леса побережья; *d* — холмистый район с речной сетью, Уезд Бу За Мап

**Table 1.** Characteristics of the entomological studies carried out and the volume of activities carried out

**Таблица 1.** Характеристика проведенных энтомологических исследований и объем выполненных мероприятий

| Study methods and procedures | Can Gio | Bu Gia Map |
|---|---|---|
| Determination of the species composition of malaria mosquitoes | 887 | 185 |
| Determination of the daily activity pattern of malaria mosquitoes by human landing catches | 25 | 19 |
| Examination of control daytime rest sites of malaria mosquitoes | 25 | 9 |
| Assessment of the number of vectors in military camps | 54 | 36 |
| Examination of anophelogenous water bodies | 46 | 12 |

Female mosquitoes were collected from daytime rest sites on the walls and ceilings of residential and household buildings, as well as from plants near the houses.

Larvae were collected from nearby natural and artificial water bodies suitable for mosquito breeding (swamps in mangrove forests, tree hollows, puddles, irrigation canals, mollusc hatcheries, rainwater reservoirs, discarded containers filled with water, etc.) (Figure 3, *a*). Mobile larvae were collected using a ladle; any extra water was filtered through a sieve (Figure 3, *b*). The collected larvae were placed in 20–50 mL transport containers with a small amount of water.

Mosquitos caught with exhausters and traps were treated with ethyl acetate. Following suffocation, immobilized insects were placed on a light surface or in a small container for sorting (Figure 4, *a*).

*a* *b*

**Fig. 2.** Methods of collecting imago: *a* — catching using exhausters and nets; *b* — light ultraviolet trap
**Рис. 2.** Методы сбора имаго: *a* — отлов с использованием эксгаустеров и сачков; *b* — световая ультрафиолетовая ловушка

*a* *b*

**Fig. 3.** Collection of mosquito larvae: *a* — artificial house pond with larvae; *b* — use of a ladle and strainer to filter water with larvae from a house well
**Рис. 3.** Сбор личинок комаров: *a* — искусственный придомовой водоем с личинками; *b* — использование ковша и ситечка для фильтрации воды с личинками из придомового колодца

*a* *b*

**Fig. 4.** Morphological identification and storage of collected material: *a* — pickling of captured imagoes with ethyl acetate with subsequent identification; *b* — sorting and marking of collected larvae
**Рис. 4.** Морфологическая идентификация и хранение собранного материала: *a* — замаривание этилацетатом отловленных имаго с последующей идентификацией; *b* — сортировка и маркировка собранных личинок

To preserve the morphological characteristics during sorting, special entomological tools (tweezers, preparation needles, etc.) were used. The selected insects were placed into special boxes with a cotton wool layer. Samples intended for subsequent molecular genetic testing were preserved in test tubes with 70% ethanol. The larvae were preserved in alcohol (Figure 4, *b*). Entomological magnifiers 10x and 20x were used to identify mosquitos in the field. Standard methods were used to identify the genus based on morphological characteristics.

## RESULTS AND DISCUSSION

The research team collected bloodsucking mosquitoes on May 15–18, 2024, in the coastal district Can Gio (Figure 5, *a*–*d*). Table 2 shows the current genus composition of mosquitoes.

Adult insects accounted for 54.6% of all collected mosquitoes. *Culex* was the most common genus (76.7%), followed by *Anopheles* (19.1%) and *Aedes* (4.2%). *Aedes* larvae were not found, while *Culex* larvae were the most commonly detected. Mosquitoes of the genus *Anopheles* at various development stages were most likely more prevalent than *Aedes* (11.4% vs. 2.3%) due to the greatest number of suitable breeding areas in the examined region.

In total, 736 samples were collected over four days in the Bu Gia Map National Park and the neighboring settlement (Figure 6, *a*–*f*; Table 3).

Unlike the first region, there were no significant differences in the proportion of collected insects between

*a* *b*

*c* *d*

**Fig. 5.** Survey of residential buildings in the Can Gio area: *a* — collection of larvae from rainwater tanks; *b* — survey of areas with standing water; *c* — adults during the day; *d* — plants in the local area with mosquitoes on the leaves
**Рис. 5.** Обследование жилых домов в районе Кан Зьо (Can Gio): *a* — сбор личинок из резервуаров с дождевой водой; *b* — обследование мест со стоячей водой; *c* — имаго на дневке; *d* — растения на придомовой территории с комарами на листве

**Table 2.** Distribution of vector mosquitoes collected in the coastal area of Kan Zyo by genera and stages of development
**Таблица 2.** Распределение комаров-переносчиков, собранных в прибрежном районе Кан Зьо по родам и стадиям развития

| Mosquito development stages | Collected mosquitoes by development stage | Mosquito genera | | |
|---|---|---|---|---|
| | | *Culex* | *Anopheles* | *Aedes* |
| Imago | 283/54.6% | 217/76.7% | 54/19.1% | 12/4.2% |
| Larva | 236/45.4% | 231/97.8% | 5/2.2% | – |
| Total | 519/100% | 448/86.3% | 59/11.4% | 12/2.3% |

**Table 3.** Distribution of vector mosquitoes collected in Bu County for Map by birth and stage of development
**Таблица 3.** Распределение комаров-переносчиков, собранных в уезде Бу За Мап, по родам и стадиям развития

| Mosquito development stages | Collected mosquitoes by development stage | Mosquito genera | | |
|---|---|---|---|---|
| | | *Culex* | *Anopheles* | *Aedes* |
| Imago | 463/62.9% | 423/91.4% | 12/2.6% | 28/6.0% |
| Larva | 273/37.1% | 267/97.8% | 6/2.2% | – |
| Total | 736/100% | 690/93.8% | 18/2.4% | 28/3.8% |

*Anopheles* and *Aedes* (2.4% vs. 3.8%), with *Culex* being the most prevalent genus (93.8%).

The analysis of materials collected in two regions of Southern Vietnam revealed that mosquitoes of the genus *Culex* were the most prevalent carriers of vector-borne disease pathogens (90.7%) before the start of the wet season, while *Anopheles* and *Aedes* accounted for 6.1% and 3.2%, respectively (Table 4). The proportion of mosquitoes of the genera *Anopheles* and *Aedes* will probably increase when the high-intensity transmission season begins.

However, it should be noted that our data only cover a limited period of the epidemic season. Thus, they do not represent the annual genus and species composition distribution of mosquitoes transmitting vector-borne infections.


**Fig. 6.** Survey of residential buildings in the Bu Gia Map Nature Reserve and the adjacent commune: *a* — collection of mosquitoes in houses in the reserve; *b* — study of a tree hollow with stagnant water; *c* — buffaloes that feed blood-sucking mosquitoes; *d* — collection of larvae from a container with rainwater in the backyard; *e*, *f* — inspection of yards and houses in the commune, collection of mosquitoes during the day

**Рис. 6.** Обследование жилых домов на территории заповедника Бу За Мап (Bu Gia Map) и прилегающей коммуне: *a* — сбор комаров в домах на территории заповедника; *b* — исследование дупла дерева со стоячей водой; *c* — буйволы-прокормители кровососущих комаров; *d* — сбор личинок из емкости с дождевой водой на заднем дворе; *e*, *f* — обход дворов и домов в коммуне, сбор комаров на дневках

**Table 4.** Distribution of vector mosquitoes by birth, by birth and stage of development collected during the entire expedition

**Таблица 4.** Распределение комаров-переносчиков собранных за все время экспедиции по родам и стадиям развития

| Mosquito development stages | Collected mosquitoes by development stage | Mosquito genera | | |
|---|---|---|---|---|
| | | *Culex* | *Anopheles* | *Aedes* |
| Imago | 746/59.4% | 640/85.8% | 66/8.8% | 40/5.4% |
| Larva | 509/40.6% | 498/97.8% | 11/2.2% | – |
| Total | 1255/100% | 1138/90.7% | 77/6.1% | 40/3.2% |

## CONCLUSION

The study findings indicate that the species composition of vectors at the end of the dry season in Southern Vietnam was dominated by mosquitoes of the genus *Culex*, which are well-adapted to development and population maintenance with limited areas suitable for breeding. The functional mechanisms of parasitic systems involving bloodsucking mosquitoes requires further research with expanded study areas. Entomological monitoring under various terrain and climatic conditions throughout the transmission season of vector-borne disease pathogens will be beneficial.

## ADDITIONAL INFO

**Authors' contribution.** All authors made a substantial contribution to the conception of the study, acquisition, analysis, interpretation of data for the work, drafting and revising the article, final approval of the version to be published and agree to be accountable for all aspects of the study.

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