

POPULATION DYNAMICS OF THE GENUS *Culicoides* LATREILLE, 1809 (DIPTERA: CERATOPOGONIDAE), APURE STATE, VENEZUELA**DINÂMICA POPULACIONAL DO *Culicoides* LATREILLE, 1809 (DIPTERA: CERATOPOGONIDAE), ESTADO DE APURE, VENEZUELA**Andrés Eloy Chacón-Ortiz¹<https://orcid.org/0000-0003-2951-0920>Gustavo Perruolo Laneti²<https://orcid.org/0000-0003-3861-9258>

Submetido: 06/03/2024 / Aprovado: 24/08/2025 / Publicado: 08/09/2026.

Abstract

Culicoides are small nematoceran insects, usually dark in color and with short legs. The genus has spots on its wings with specific patterns that allow its identification. *Culicoides* populations were studied in "Campo Alegre at municipio Páez, Apure state, Venezuela, from January to November 2022, using a light trap operated near young bulls in corral. Of the 55.560 specimens collected, *Culicoides insignis* was most abundant with 49.098 individuals (88.4%), followed by *Culicoides guttatus* 2.721 (4.89%), *Culicoides flavivenula* 1.869 (3.36%), *Culicoides pusillus* 1.424 (2.56%), *Culicoides diabolicus* 175 (0.31%), *Culicoides antunesi* 164 (0.29%) and *Culicoides foxi* 109 (0.19%). The predominant species followed two different activity patterns: a) low numbers during the period of low rainfall and high temperature and b) high numbers during the period of low temperature and heavy rainfall.

Keywords: *Diversity*. Cattle. Population abundance. Mosquitoes.

Resumo

Os *Culicoides* são insetos nematóceros de pequeno tamanho, geralmente de cor escura e pernas curtas. O gênero apresenta manchas nas asas com padrões específicos que permitem sua identificação. Populações de *Culicoides* foram estudadas em "Campo Alegre, município de Páez, Estado de Apure, Venezuela, desde janeiro até novembro de 2022, utilizando uma armadilha luminosa operada próximo a touros jovens em curral. Dos 55.560 espécimes coletados, *Culicoides insignis* foi o mais abundante com 49.098 indivíduos (88,4%), seguido por *Culicoides guttatus* 2.721 (4,89%), *Culicoides flavivenula* 1.869 (3,36%), *Culicoides pusillus* 1.424 (2,56%), *Culicoides diabolicus* 175 (0,31%), *Culicoides antunesi* 164 (0,29%) e *Culicoides foxi* 109 (0,19%). As espécies predominantes seguiram dois padrões de atividade diferentes: a) números baixos durante o período de baixa pluviosidade e alta temperatura e b) números elevados durante o período de baixa temperatura e chuvas fortes.

Palavras-chave: *Diversidade*. Gado. Abundância da população. Mosquitos

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DOI: <http://dx.doi.org/10.24021/raac.v20i1.7888>

V. 23, N. 1 (2026)



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1. INTRODUCTION

The richness of a place and its potential interactions (Carvalho *et al.*, 2020) are usually relevant data, being part of the knowledge of the biological heritage of a country.

Owing to veterinary importance of the genus *Culicoides* (Latreille), the biology of these insects has been relatively well known in North America (Mayo *et al.*, 2014, Erranm, Burkett 2021, McGregor; Shults; Mcdermott, 2022, Allen *et al.*, 2023) and Central America (Mo *et al.*, 1994). Important studies on the bionomics of *Culicoides* has been published in Brasil (Farias *et al.*, 1976; Silva; Felipe-Bauer; Almeida; Figueiredos, 2001; Lopes; Gorayeb, 2010; Carvalho; Silva, 2014; Farias *et al.*, 2020; Rios *et al.* 2021) and, in Argentina (Veggiani; Dantur; Lizarralde; Spinelli, 2011; Veggiani *et al.*, 2016; Ayala *et al.*, 2018). The research on the population dynamics of *Culicoides* in Venezuela was reported by (Mirsa, 1954; Perruolo, 2001; Cazorla, 2014; Portela; Maldonado; Diniz, 2015; Perruolo, 2016; Perruolo, 2018).

The goal of this research is to study the population dynamics of the common species of *Culicoides* in Apure state, to obtain information about the relationships among species composition, rainfall, and temperature. This information may identify species that could be involved in the transmission of Blue tongue virus to cattle.

2. MATERIALS AND METHODS

Collections were made in Apure state, the southwestern province of Venezuela. The study area is situated in the municipio Páez the western part of the state at 7° 28'N, 71° 45' W. The altitude is 210 m above sea level, typical of a tropical rain forest (Ewel; Madriz; Tosi, 1976).

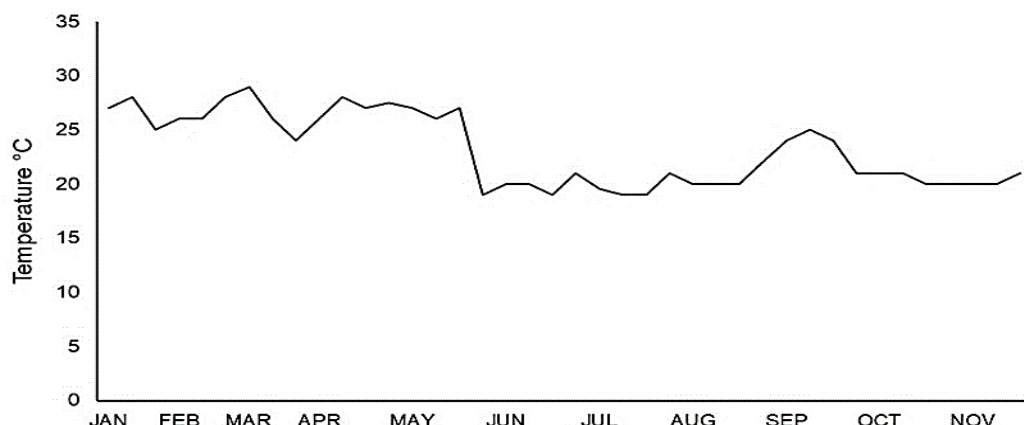
The collections were made during 298 trap nights, during the rainy and dry seasons from 18.00 and 06.00h in the months of January to November 2022. One New Jersey light trap (20 w light bulbs) was placed in a corral, where young bulls slept. The light trap was equipped with a photocell, which switched the trap on each night and off in the morning.

The insects were killed by heat and collected dry. Each week the trap was emptied and the insects stored in ethanol (70%). The material was sorted using a stereoscope and some specimens were mounted on slides which have been deposited in the museum of the University of Táchira (UNET) in Táchira, Venezuela. Temperature was recorded continuously using a thermograph. Rainfall was measured weekly using a pluviometer.

3. RESULTS AND DISCUSSION

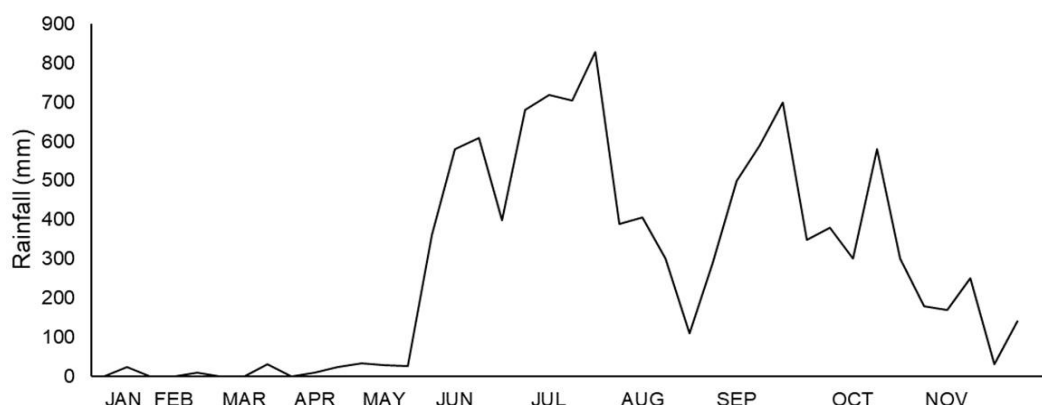
Two main weather periods were defined. The first between January and May was characterized by high temperature, whereas the second, between June and November, was characterized by low temperature (Figure 1).



Figure 1. Weekly mean temperature, Campo Alegre, state Apure, Venezuela. 2022

Source: Own analysis of this research

Rainfall was seasonal; however, an increase was observed from May to July and in September to October (Figure 2).

Figure 2. Weekly rainfall, Campo Alegre, state Apure, Venezuela. 2022

Source: Own analysis of this research

Seven species of *Culicoides* were identified among the 55.560 specimens collected. *Culicoides insignis* Lutz, was the most abundant, representing 49.098 (88.4%) of the total number collected, followed by *Culicoides guttatus* Coquillett with 2.721 (4.89%), *Culicoides flavivenula* Costa Lima, 1.869 (3.36%), *Culicoides pusillus* Lutz 1.424 (2.56%), *Culicoides diabolicus* Hoffman 175 (0.31%), *Culicoides antunesi* Forattini. 164 (0.29%) and *Culicoides foxi* Ortiz 109 (0.19%).

3.1 *Culicoides* population dynamics

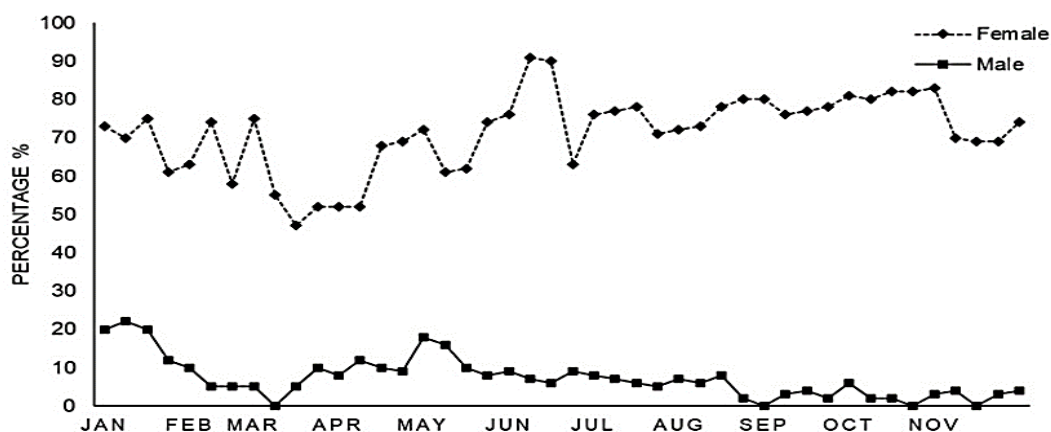
3.1.1 *Culicoides insignis*

This species comprised a high percentage of females and males throughout the year. When abundance data were transformed using percentage, different activity patterns of were observed: 1)



Low numbers during the period of low rainfall and high temperature, and 2) high numbers during the period of low temperature and heavy rainfall (Figure 3).

Figure 3. Weekly light trap collections of females (♦) and males (■). *Culicoides insignis*. Campo Alegre, state Apure, Venezuela. 2022

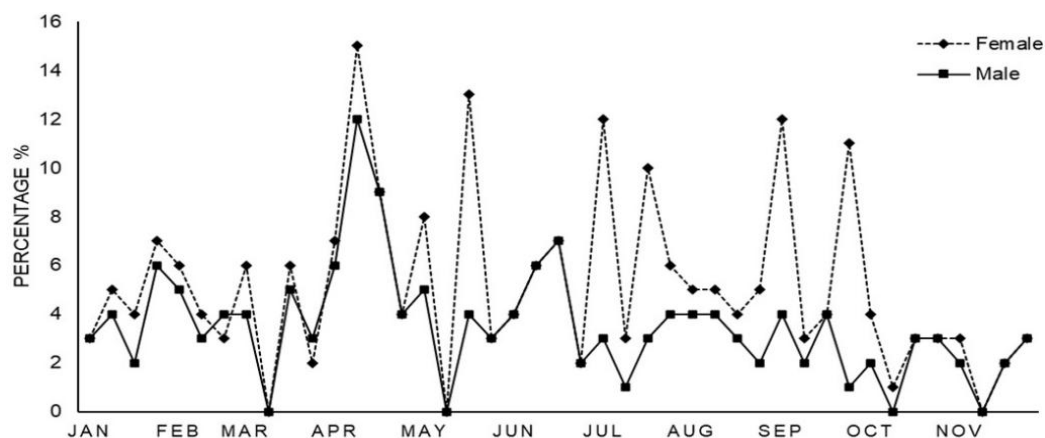


Source: Own analysis of this research

3.1.2 *Culicoides guttatus*

Females were especially abundant in May, June, July, and September although present most part of the year, tending to disappear in October and November. Males were present throughout the year. The presence of males and females throughout the year indicated that breeding sites for this species may be found near the light trap (Figure 4).

Figure 4. Weekly light trap collections of females (♦) and males (■). *Culicoides guttatus*. Campo Alegre, state Apure, Venezuela. 2022



Source: Own analysis of this research

The temperature and rainfall dependence in the pattern is similar to that observed in *C. insignis*.

3.1.3 *Culicoides flavivenula*

DOI: <http://dx.doi.org/10.24021/raac.v20i1.7888>

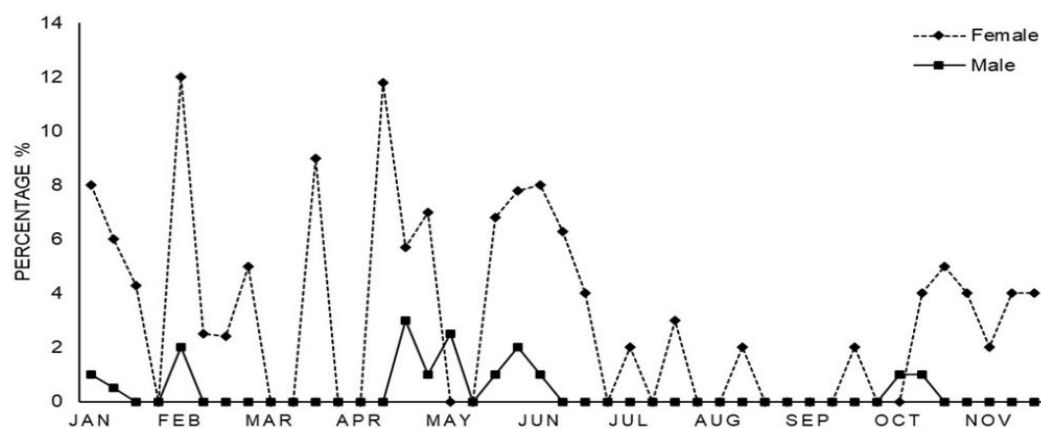
V. 23, N. 1 (2026)



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The weekly numbers of male and females of this species collected in “Campo Alegre” varied markedly over time and were inversely related to rainfall. Most specimens were collected when rainfall was low (January to May) and temperature high (June to November (Figure 5).

Figure 5. Weekly light trap collection of females (♦) and males (■) *Culicoides flavivenula*, Campo Alegre, state Apure, Venezuela. 2022.



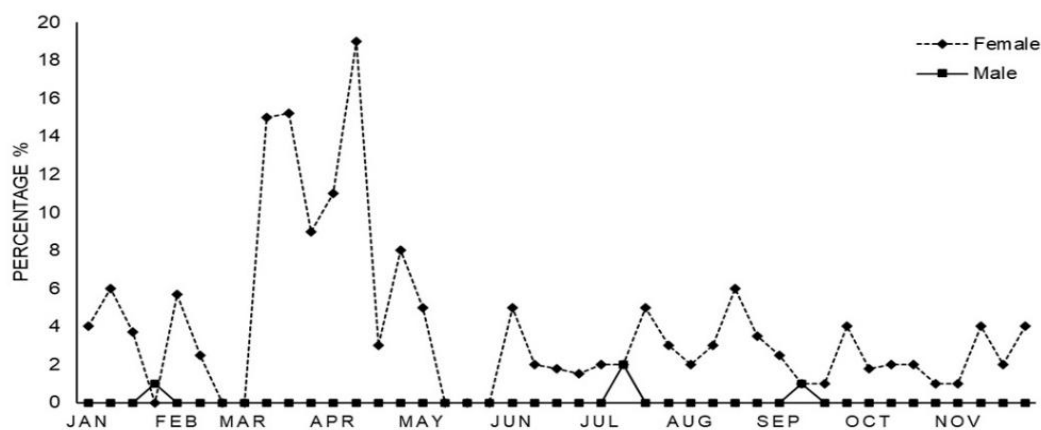
Source: Own

analysis of this research

3.1.4 *Culicoides pusillus*

Females of this species increased in numbers in March and April, at the beginning of the rainy season, and there after decreased to about the same level the rest of the year. Males were collected in low numbers throughout the year (Figure 6).

Figure 6. Weekly light trap collections of females (♦) and males (■), *Culicoides pusillus*. Campo Alegre, state Apure, Venezuela. 2022.



Source: Own

analysis of this research

3.1.5 *Culicoides antunesis*

Females of this species were collected only in June and July (n:164).

3.1.6 *Culicoides diabolicus*

This species appeared three times in the months of June, July, and August (n: 175)

3.1.7 *Culicoides foxi*

Females of this species were collected only in October (n:109).

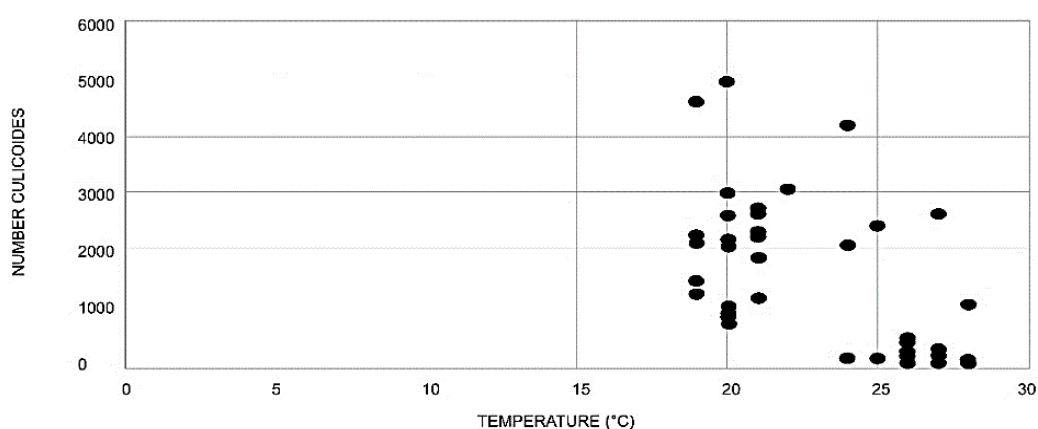
3.2 Influence of the rainfall on the *Culicoides* populations

The influence exerted by the rainfall on the populations of these species, *C. insignis*, *C. guttatus*, *C. flavivenula* and *C. pusillus* when the two variables, number of *Culicoides* and rainfall were related, a value of r : 0.58 for *C. insignis*, r : 0.32 in *C. guttatus*, r : -0.21 for *C. flavivenula* and r : -0.43 for *C. pusillus* were obtained, which were not significant.

3.3 Influence of the temperature on the *Culicoides* populations

Temperature seems to be a factor that influences the abundance of the populations of species *C. insignis*, *C. guttatus* and *C. pusillus*. It can observe the influence of high temperature in January and May, when lowest number of *Culicoides* were collected during the whole study period; while since June on, we can see an increase of the number of collected specimens, beginning to stabilize in July to keep appreciatively the same level until the end of the year (November). Temperature was low during the period when the number of *Culicoides* increases. The dispersion diagram (Figure 7), indicates that the number of *Culicoides* varies in relation to the mean weekly temperature, indicating a negative tendency, since that confirmed is additionally by r : -0,67 (*C. insignis*). r : 0,42 (*C. guttatus*), r : 0,30 (*C. flavivenula*) and r : 0,52 (*C. pusillus*) which is highly significant ($p < 0.01$). A lineal functional relation exists between the two variables (Temperature and Number of *Culicoides*).

Figure 7. Dispersion diagram *Culicoides*, Campo Alegre, state Apure, Venezuela. 2022.



Source: Own analysis of this research



A model that considers multiple regressions was used. The analysis of variance shows that the model is not linear. Temperature and rainfall were the independent variables and the outcome F value for number of *Culicoides* for each species were: *C. insignis* 10.69, *C. guttatus* 3.50, *C. pusillus* 13.77 and *C. flavivenula* 0.02, with the regression's equations:

$$Y: a+nRnT;$$

where R: Rainfall, T: Temperature.

$$C. insignis \text{ Y: } 5763.41 + 15.9644 \text{ rainfall} - 197.731 \text{ }^{\circ}\text{C}$$

$$C. guttatus \text{ Y: } 249.427 + 0.63775 \text{ rainfall} - 8.51192 \text{ }^{\circ}\text{C}$$

$$C. pusillus \text{ Y: } 176.616 + 0.81868 \text{ rainfall} - 6.14170 \text{ }^{\circ}\text{C}$$

$$C. flavivenula \text{ Y: } 59.4811 + 0.4048 \text{ rainfall} - 0.4167 \text{ }^{\circ}\text{C}$$

3.4 Discussion

3.4.1 Species composition

The species composition and broad seasonal trends shown by our light trap data confirmed that *C. insignis* was the most abundant species near cattle. This agrees with the data in USA (Mayo *et al.*, 2014; Erram; Burkett, 2021), Central America (Mo *et al.*, 1994), Brasil (Silva *et al.*, 2001; Lopes; Gorayeb, 2010; Carvalho; Silva, 2014; Farias *et al.*, 2020; Rios *et al.*, 2021), Argentina (Veggiani; Dantur; Lizarralde; Spinelli, 2011; Veggiani *et al.*, 2016; Portela; Maldonado; Diniz, 2015; Ayala *et al.*, 2018), and Venezuela (Perruolo, 2001; Cazorla, 2014; Perruolo, 2016; Perruolo, 2018).

The influence of temperature on the species *C. insignis*, *C. guttatus* and *C. pusillus* was significant, tending to alter the number of collected specimens in two ways: increasing it in the following periods: January-June, when temperatures were high, decreasing it in the period when temperature were low, in the final months of the year. This phenomenon was studied by Mirsa (1954), in "Los Chorros", Miranda State, Venezuela. She related the temperature in the studied area, oscillating between 19°C and 21.8°C during the year, with the total number of collected *Culicoides*.

Seasonal variation in USA, (Mayo *et al.*, 2014; Erram; Burkett, 2021), noticed that, while the adults were active all year long, except periods of very low temperature in December and January (5 at 15°C), changes in temperature occurring between June and November (15 at 30°C) increased the numbers of insects collected.

Studied *Culicoides* populations of the species *C. insignis* at localities in Argentina (Veggiani; Dantur; Lizarralde; Spinelli, 2011; Portela; Maldonado; Diniz, 2015; Veggiani *et al.*, 2016; Ayala *et al.*, 2018), and Brasil (Silva *et al.*, 2001; Lopes; Gorayeb, 2010; Carvalho; Silva, 2014; Portela; Maldonado; Diniz, 2015; Farias *et al.*, 2020; Rios *et al.*, 2021), observed that the mean temperature influenced the number of specimens collected and that they were usually more abundant when temperatures were high (25 to 30°C).

Mo *et al.* (1994) and Perruolo (2001) studied the population of *C. insignis* in ruminants in Central America and the Caribbean and observed that the mean temperature influenced the number



of specimens collected and that they were usually more abundant when temperatures were low (10 to 18°C).

The influence of rainfall on the populations of *C. insignis*, and *C. guttatus* in “Campo Alegre” can be easily observed. When the rainfall is lower, the reproductive activity of these insects is reduced and, on the other hand, during the rainy season their population density increases, and remains high, despite temporary breaks in rainfall. This phenomenon was observed in Miranda State by Mirsa (1954) in the Táchira State (Perruolo 2011; Perruolo 2018) in Venezuela. They observed that *Culicoides* population density of the species *C. insignis* was maintained at low level during the first months of the year when the rains were sporadic, whereas that the populations densities started suddenly to increase when the rainy season set in, and kept stable the rest of the year, no matter the rainfall fluctuations in the studied area. Only at the end of the year, when rainfall diminished drastically, occurred a sudden fall of the total number of *Culicoides* observed.

4. FINAL CONSIDERATIONS

The study of the population dynamics of the species of *Culicoides* in Apure State reveals that the influence of the temperature is favorable, such as to maintain throughout the year, the abundance of females *C. insignis*, *C. guttatus* and *C. pusillus*. These species are suspected of being potential vectors of bluetongue virus in the Apure State.

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