

New records of *Anopheles* (Diptera: Culicidae) in Puerto Carreño, Vichada, Colombia

Helena Brochero^{1*} and Jan E. Conn^{2,3}

1 Facultad de Agronomía, Universidad Nacional de Colombia, Carrera 30 No. 45 -03, Edificio 500, campus, Bogotá, Colombia

2 Wadsworth Center, New York State Department of Health, Albany, NY 12159, USA

3 Department of Biomedical Sciences, School of Public Health, State University of New York, Albany, NY 12222, USA

* Corresponding author. E-mail: embrochero@unal.edu.co

Abstract: Malaria is endemic in Vichada department in the Orinoquia region of Colombia. Reports of species in the genus *Anopheles* Meigen 1818, responsible for transmission of *Plasmodium* spp. parasites leading to malaria cases, should result in strengthened entomological surveillance and a clearer focus on the most effective vector control strategies. Here we present new records of *Anopheles* (*Anopheles*) *shannoni* Davis, 1931 and *A.* (*A.*) *costai* & *forattini* for Vichada department, Colombia. Additionally, we have new records of *A.* (*Nyssorhynchus*) *triannulatus* Neiva & Pinto, 1922, and *A.* (*A.*) *mattogrossensis* Lutz & Neiva, 1911 for Puerto Carreño, the capital of Vichada department.

Key words: *Anopheles*, species distribution, Vichada, Orinoquia, Colombia

Colombia and Brazil together are responsible for the highest number of malaria cases in South America (WHO 2013). Malaria is a life-threatening disease caused by parasites that are transmitted to people through the bites of infected mosquitoes in the genus *Anopheles* Meigen, 1818. The main malaria vectors in Colombia are *Anopheles darlingi* Root, 1926, *A. albimanus* Wiedemann, 1920, and *A. nuneztovari* Gabaldón, 1940 (Montoya-Lerma *et al.* 2011). Nevertheless Colombia reports secondary vectors and other *Anopheles* species involved in the transmission of malaria locally or regionally (Brochero and Quiñones 2008). Because one of the main malaria control strategies is vector control, reports of anopheline species can provide associated bionomic and ecological data, improve focal entomological surveillance and more clearly define and help to evaluate local control activities.

The department of Vichada is located in the Orinoquia region of Colombia where all municipalities have geographical and ecological conditions that are appropriate for endemic malaria transmission (Chaparro *et al.* 2013; Padilla *et al.* 2011). Entomological studies were carried out for eight months in 2009 and five months in 2012 in urban and periurban Puerto Carreño (06°11'16" N, 062°28'23" W), the capital of Vichada department, located at the confluence of the Orinoco and Meta rivers and along the border of Venezuela (Figure 1). As a result of identification of

field specimens, we present two new records of *Anopheles* mosquitoes for Vichada department and five for Puerto Carreño municipality.

Adult mosquitoes collections were conducted during three consecutive nights in a house where malaria cases were previously reported, using a human landing catch (HLC) method indoors and outdoors from 18:00 to 06:00 h, by a team of four collectors (WHO 1975). The HLC protocol was approved by the New York State Department of Health Institutional Review Board. Breeding sites for anophelines were inspected during 2009 using 500 mL ladles every 5 m, for a total of 50 dips per breeding site. Adult females were collected and entomological series were obtained from immature forms identified using the taxonomic keys of Faran and Linthicum (1981), González and Carrejo (2009) and Rubio-Palis (2000). Specimens were deposited in the Museo de Entomología, Universidad del Valle, Valle del Cauca, Colombia.

New specimen records were collected in 2012; these correspond to adult female mosquitoes captured by HLC (Tables 1 and 2). *A.* (*Anopheles*) *shannoni* Davis, 1931 and *A. costai* & *forattinii* are new records for Vichada department, Colombia. *A. triannulatus* Neiva & Pinto, 1922, *A. mattogrossensis* Lutz & Neiva, 1911 and *A. peryassui* Dyar & Knab, 1908 are new record for Puerto Carreño.

Anopheles shannoni is a member of Neotropical Arribalzagia Series (Reid and Knight 1961) described from specimens collected in Belém, Pará, Brazil. Distribution has been reported to include Bolivia, Brazil, Guyana, Peru, Suriname (Wilkerson *et al.* 1997) and Vaupés department, Colombia (González and Carrejo 2007). Although this species has been observed to be zoophilic, commonly collected in animal shelters or collected inside the jungle (Wilkerson *et al.* 1997), in Puerto Carreño the specimen was collected outside dwellings using HLC between 17:30 – 19:00 hours. Interestingly, even though *A. shannoni* has been associated with *A. darlingi* Root in several larval habitats (Wilkerson *et al.* 1997), in Puerto Carreño it has not previously been recorded despite *A. darlingi* being the most abundant local species.

Anopheles costai Fonseca & Silva Ramos, 1939 and *A. forattinii* Wilkerson & Sallum, 1999 are in the subgenus *Anopheles* Meigen Arribalzagia Series and have been misidentified as *A. mediopunctatus* (Lutz, 1903) (Sallum *et al.* 1999). In Colombia

A. costai has a wider geographical distribution than *A. forattini*, having been reported in twenty departments, whereas *A. forattini* only has been reported in Meta and Vaupés (González and Carrejo 2009). Diagnostic characters based on morphology are only supported for eggs, pupa and male genitalia (Sallum and

Flores 2004; Sallum *et al.* 1999; Wilkerson and Sallum 1999). Therefore, we are reporting the adult specimen we collected as *A. costai* & *forattini*. These species are sympatric in Colombia and Venezuela (Sallum *et al.* 1999; Wilkerson and Sallum 1999; Moreno and Rubio-Palis 2003); Vichada shares a frontier with

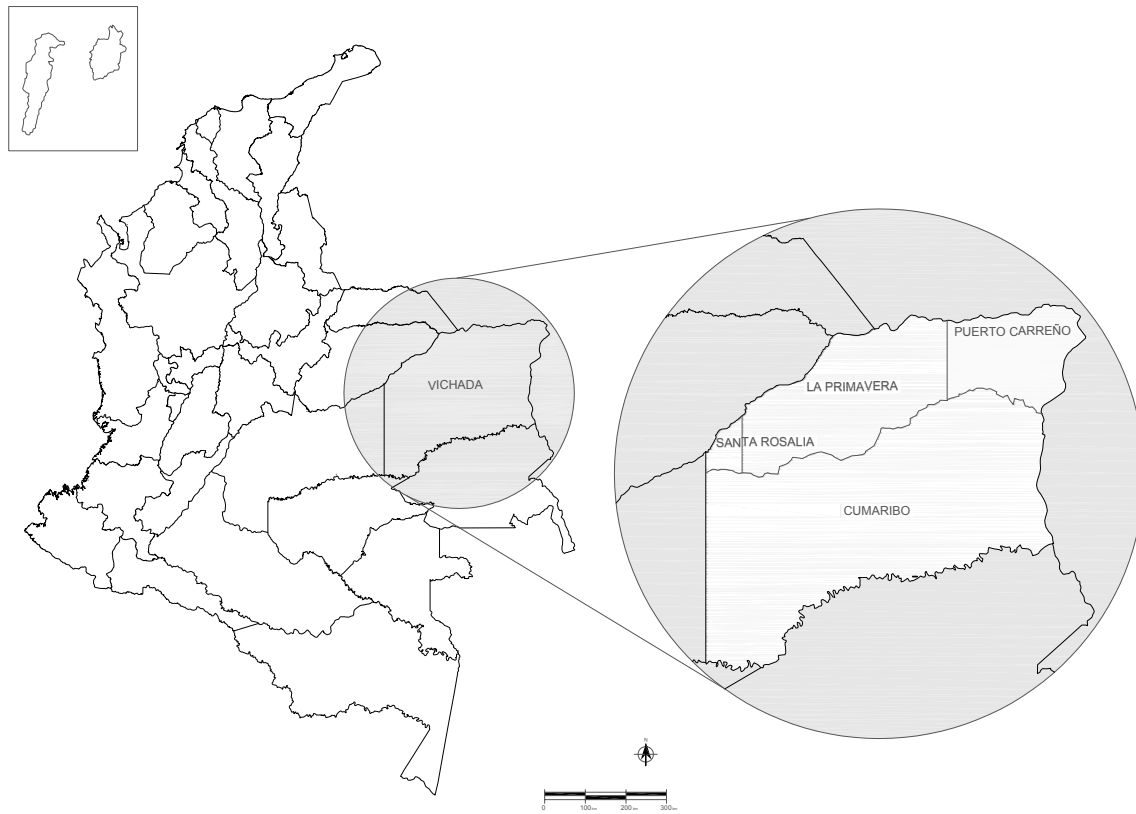


Figure 1. Geographical location of Puerto Carreño, Vichada, Orinoquia, Colombia.

Table 1. Absolute abundance of monthly collections of several species of *Anopheles* captured indoors and outdoors in 2009 and 2012 from Puerto Carreño, Vichada, Orinoquia, Colombia. Abbreviations: I = indoor; O = outdoor.

Species	May		June		July		August		September	
	I	O	I	O	I	O	I	O	I	O
<i>Anopheles peryassui</i>	0	0	0	0	0	1	1	7	0	1
<i>A. triannulatus</i>	0	0	0	4	1	0	1	1	0	20
<i>A. mattogrossensis</i>	0	0	0	0	0	0	0	1	0	0
<i>A. shannoni</i>	0	0	0	0	0	0	0	1	0	0
<i>A. costai & forattini</i>	0	0	1	0	0	0	0	0	0	0
Total	0	0	1	4	1	1	2	10	1	21

Table 2. Neighborhoods, geographic coordinates, altitude and abundance of five species of *Anopheles* newly reported from Puerto Carreño, Vichada, Colombia.

Neighborhood	Geographic coordinates	Altitude (m)	Species				
			<i>A. triannulatus</i>	<i>A. peryassui</i>	<i>A. shannoni</i>	<i>A. costai & forattinii</i>	<i>A. matogrossensis</i>
Gabriel Robledo	06°11'44.7" N 067°29'29.2" W	32	1	1	0	1	0
La Primavera	06°10'46.9" N 067°29'21.6" W	51	0	1	0	0	1
Simón Bolívar	06°11'51.9" N 067°28'49.7" W	56	4	0	0	0	0
Antonio Nariño	06°10'43.4" N 067°29'31.4" W	50	1	7	1	0	0
San Jorge	06°11'37.2" N 067°28'43.3" W	44	21	1	0	0	0

Venezuela. It is important to collect additional specimens to obtain series or isofamilies (Estrada *et al.* 2003) to determine whether one or both species are present in eastern Colombia.

Anopheles mattogrossensis, *A. peryassui* and *A. triannulatus* are reported for Puerto Carreño, the capital of Vichada department. *Anopheles mattogrossensis* is distributed in Brazil, Bolivia, Colombia, Peru, Trinidad, Guiana, and Venezuela (Forattini 1962). It is usually sylvatic, but also opportunistic, because it feeds on humans even when animals are nearby (Brochero *et al.* 2006). Because this species has been reported naturally infected with *Plasmodium vivax* (De Arruda *et al.* 1986; Tadei *et al.* 1998), and in Colombia its distribution across departments east of the Eastern Cordillera includes Vichada where malaria is endemic (González and Carrejo 2009), *A. mattogrossensis* should be reported during routine entomological surveillance.

Anopheles triannulatus is a species complex (Rosa-Freitas *et al.* 1998), and individual cryptic species differ in their roles in *Plasmodium* transmission (Silva-Do-Nascimento *et al.* 2006). Although *A. triannulatus* is often opportunistic, depending on host availability and abundance (De Arruda *et al.* 1986; Rubio-Palis 2000), it has been incriminated as a vector in Peru and Brazil (Aramburu-Guarda *et al.* 1999; Galardo *et al.* 2007). In Colombia, *A. triannulatus* was found naturally infected with *Plasmodium falciparum* and *P. vivax* (Rosero *et al.* 2013); its local epidemiological importance has not been ascertained. In Puerto Carreño, *A. triannulatus* was caught during four of the five months sampled (June to September) between 17:30 and 21:30 hr.

The geographical position of Puerto Carreño, Vichada, is strategic because it shares a border with western Venezuela, where malaria is endemic, and is part of the Guiana Shield where biodiversity is high (Funk *et al.* 1999). The present study not only provides information for entomological surveillance of malaria but also contributes to the biodiversity of *Anopheles* mosquitoes in Puerto Carreño, Vichada, Orinoco, Colombia.

ACKNOWLEDGMENTS

We thank Johanna Fernandez, Pilar Jimenez and Ranulfo Gonzalez for taxonomic determination of entomological specimens and the Entomologic Unit and technical personnel of the Departmental Health Secretary of Vichada for logistic support during specimen collections.

Financial support was provided by the National Institutes of Health, USA (AI 2R01AI54139) to JEC and, the Universidad Nacional de Colombia (Quipu 201010012197) to HB.

LITERATURE CITED

- Aramburu-Guarda, J., C. Ramal-Asayag and R. Witz. 1999. Malaria reemergence in the Peruvian Amazon Region. *Emerging Infectious Diseases* 5(2): 209–215 (doi: [10.3201/eid0502.990204](https://doi.org/10.3201/eid0502.990204)).
- Brochero, H. and M. Quiñones. 2008. Retos de la entomología médica para la vigilancia en salud pública en Colombia: reflexión para el caso de malaria. *Biomedica* 28: 18–24 (doi: [10.7705/biomedica.v28i1.105](https://doi.org/10.7705/biomedica.v28i1.105)).
- Brochero H, Pareja P, Ortíz G, Olano V. 2006. Sitios de cría y actividad de picadura de especies de *Anopheles* en el municipio de Cimitarra, Santander, Colombia. *Biomedica* 26: 269–77 (doi: [10.7705/biomedica.v26i2.1416](https://doi.org/10.7705/biomedica.v26i2.1416)).
- Chaparro, P., J. Padilla, A.F. Vallejo and S. Herrera. 2013. Characterization of a malaria outbreak in Colombia in 2010. *Malaria Journal* 12: 330 (doi: [10.1186/1475-2875-12-330](https://doi.org/10.1186/1475-2875-12-330)).
- De Arruda, M., M. Carvalho, R. Nussenzweig, M. Maracic, A. Ferreira and A. Cochrane. 1986. Potential vectors of malaria and their different susceptibility to *Plasmodium falciparum* and *Plasmodium vivax* in northern Brazil identified by immunoassay. *The American Journal of Tropical Medicine and Hygiene* 35(5): 873–881 (doi: [10.1186/1475-2875-9-15](https://doi.org/10.1186/1475-2875-9-15)).
- Estrada, D., M. Quinones, D. Sierra, F. Ruiz, H. Erazo, Y. Linton. 2003. Utilidad de la morfología de los huevos como un método indirecto para identificar *Anopheles benarrochi* Gabaldón, Cova García & López, *Anopheles oswaldoi* (Peryassu) y *Anopheles rangeli* Gabaldón, Cova García & López, (Diptera: Culicidae) en Putumayo, Colombia. *Biomedica* 23: 388–395 (doi: [10.7705/biomedica.v23i4.1232](https://doi.org/10.7705/biomedica.v23i4.1232)).
- Faran, M. and K. Linthicum. 1981. A handbook of the Amazonian species of *Anopheles* (*Nyssorhynchus*) (Diptera: Culicidae). *Mosquito Systematics* 13: 1–81.
- Forattini O. 1962. *Entomología Médica*, Vol. 1. São Paulo: University of São Paulo. 662 pp.
- Funk, V., F. Zermoglio and N. Nasir. 1999. Testing the use of specimen collection data and GIS in biodiversity exploration and conservation decision making in Guyana. *Biodiversity and Conservation* 8: 727–751 (doi: [10.1023/A:100887722842](https://doi.org/10.1023/A:100887722842)).
- Galardo, A., M. Arruda, A. D'Almeida, R. Wirtz, L. Lounibos and R. Zimmerman. 2007. Malaria vector incrimination in three rural riverine villages in the Brazilian amazon. *The American Journal of Tropical Medicine and Hygiene* 76(3): 461–469.
- González, R. and N. Carrejo. 2009. *Introducción al estudio taxonómico de Anopheles de Colombia, claves taxonómicas y notas de distribución*. Cali: Programa Editorial Universidad del Valle. 209 pp.
- Knight, K.L. and A. Stone. 1977. *A Catalog of the Mosquitoes of the World (Diptera: Culicidae)*. Second edition. Washington, DC: Thomas Say Foundation. 611 pp.
- Montoya-Lerma, J., Y. Solarte, G. Giraldo-Calderon, M. Quinoñes, F. Ruiz-López, R. Wilkerson, R. González. 2011. Malaria vector species in Colombia — A review. *Memórias Instituto Oswaldo Cruz* 106(Suppl. I): 223–238 (doi: [10.1590/S0074-02762011000900028](https://doi.org/10.1590/S0074-02762011000900028)).
- Moreno, J. and Y. Rubio-Palis. 2003. Primer reporte de *Anopheles* (*Anopheles*) *costai* y *A. (A.) forattinii* (Diptera: Culicidae) en Venezuela. *Entomotrópica* 18(3): 211–213.
- Padilla, J.C., G. Álvarez, R. Montoya, P. Chaparro and S. Herrera. 2011. Epidemiology and control of malaria in Colombia. *Memórias do Instituto Oswaldo Cruz* 106: 114–122 (doi: [10.1590/S0074-02762011000900015](https://doi.org/10.1590/S0074-02762011000900015)).
- Reid, J. and L. Knight. 1961. Classification within the subgenus *Anopheles* (Diptera: Culicidae). *Annals of Tropical Medicine and Parasitology* 55: 474–488.
- Rosa-Freitas, M., R. Lourenco-de-Oliveira, C. De Carvalho-Pinto, M. Flores-Mendoza and T.F. Silva-do-Nascimento. 1998. Anopheline species complexes in Brazil. Current knowledge of those related to malaria transmission. *Memórias do Instituto Oswaldo Cruz* 93(5): 651–655.
- Rosero, D., N. Naranjo-Díaz, N. Alvarez, A. Cienfuegos, C. Torres, S. Luckhart and M. Correa. 2013. Colombian *Anopheles triannulatus* (Diptera: Culicidae) naturally infected with *Plasmodium* spp. *ISRN Parasitology* 2013: 927453 (doi: [10.5402/2013/927453](https://doi.org/10.5402/2013/927453)).
- Rubio-Palis, Y. 2000. *Anopheles (Nyssorhynchus) de Venezuela: Taxonomía, Bionomía, Ecología e Importancia Médica*. Maracay: Escuela de Malariología y Saneamiento Ambiental Dr. Arnoldo Gabaldon, Proyecto Control de Enfermedades Endémicas. 121 pp.
- Silva-Do-Nascimento, T., R. Wilkerson, R. Lourenco-De-Oliveira and F. A. Monteiro. 2006. Molecular confirmation of the specific status of *Anopheles halophylus* (Diptera: Culicidae) and evidence of a new cryptic species within *An. triannulatus* in central Brazil. *Journal of Medical Entomology* 43(3): 455–459 (doi: [10.1603/0022-2585](https://doi.org/10.1603/0022-2585)).
- Tadei, W.P., T. Dutary and M. Santos. 1998. Ecologic observations on anopheline vectors of malaria in the Brazilian Amazon. *American*

- Journal Tropical Medicine and Hygiene* 59: 325–335.
- Sallum, M.A., R. Wilkerson and O. Forattini. 1999. Taxonomic study of species formerly identified as *Anopheles mediopunctatus* and resurrection of *An. costai* (Diptera: Culicidae). *Journal of Medical Entomology* 36: 282–300.
- Sallum M, Flores D. 2004. Ultrastructure of the eggs of two species of *Anopheles* (*Anopheles*) Meigen (Diptera: Culicidae). *Revista Brasileira de Entomologia* 48:185-192 (doi: 10.1590/S0085-562620040000200005).
- Wilkerson, R. and M. Sallum. 1999. *Anopheles* (*Anopheles*) *forattinii*: a new species in Series Arribalzagia (Diptera: Culicidae). *Journal of Medical Entomology* 36: 345–354.
- Wilkerson, R., M. Sallum, and O. Forattini. 1997. Redescription of *Anopheles* (*Anopheles*) *shannoni* Davis; a member of the Arribalzagia series from the Amazon Basin (Diptera: Culicidae). *Proceedings of the Entomological Society of Washington* 99: 461–471.
- WHO, World Health Organization. 1975. *Manual of Practical Entomology in Malaria: Vol. II. Methods and Techniques*. Geneva: WHO. 13 pp.
- WHO, World Health Organization. 2013. *World Malaria Report 2013*. Accessible at http://www.who.int/malaria/publications/world_malaria_report_2013/report/en/index.html. Captured on 15 January 2013.
- Authors' contribution statement:** HB collected the data. HB and JEC wrote the manuscript.
- Received:** February 2014
- Accepted:** December 2014
- Editorial responsibility:** Marco Gottschalk