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Environmental influences on *Aedes aegypti* (Diptera: Culicidae) population densities across 2 urban communities on the U.S.–Mexico border

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The mosquito species *Aedes aegypti* (Linneaus) is the vector of multiple arboviruses, including dengue, Chikungunya, Zika, and yellow fever. Risk of infections associated with these arboviruses continues to expand as the geographical range of *Ae. aegypti* extends into temperate regions. Although *Ae. aegypti* is abundant along the U.S.–Mexico border, the ecology of this mosquito species in this temperate/subtropical desert is not well understood. Our study objective was to estimate the seasonal population density in 2 urban communities: Sparks, El Paso, Texas and Anapra, Ciudad Juárez, Chihuahua, Mexico. Estimates of the population density of adult *Ae. aegypti* were obtained by month (June to December) and across years (2016 to 2018) using gravid traps. Mosquitoes were collected inside and outside a total of 108 and 101 participating homes in Sparks and Anapra, respectively. We determined multiple environmental and climatic factors influencing annual population trends. Generally, an increase in the abundance of *Ae. aegypti* was associated with an increase in precipitation, moderate temperatures, and high humidity, while months with temperatures below 4.4°C led to near absence of adults. Across months, we found low densities of *Ae. aegypti* during June and July, followed by near 100-fold increases in abundance from August to October before rapidly decreasing to near zero in subsequent cold season months. Our study sheds light on population dynamics and response variables at the leading edge of *Ae. aegypti* range, which require the development of targeted vector control measures for this mosquito species in this and other regions.

Key words: disease ecology, surveillance, Texas–Mexico border, vector-borne diseases

Introduction

The *Aedes aegypti* mosquito is the primary vector of dengue (DENV), Zika (ZIKV), Chikungunya (CHIKV), and yellow fever (YFV) viruses and is highly anthropophilic in nature (Lambrechts and Failloux 2012, Marinho et al. 2016). With all of these viral pathogens having a major impact on human health (Legros et al. 2016), understanding the distribution and monitoring the expansion of *Ae. aegypti* continues to be a public health priority (Wilder-Smith et al. 2017). Dengue transmission can fluctuate through climatic factors through effects on *Ae. aegypti* abundance, where overall increased abundance increases dengue transmission (Chuang et al. 2017, Ng et al. 2018). This mosquito is predominantly found in tropical and subtropical regions where its population abundance is closely associated with amounts of precipitation, vegetation canopy greenness, temperature, and humidity (Eisen et al. 2014, Ding et al. 2018, Liu-Helmersson et al. 2019).

The influence from these exogenous factors can impact population abundance through varying developmental or physiological changes (Chaves et al. 2012, 2014). The highly associative behavior with humans has enabled *Ae. aegypti* to spread beyond its original geographic distribution in Africa (Christophers 1960, Tabachnick and Powell 1979, Ernst et al.,2017, Walker et al. 2018). Although the distribution of *Ae. aegypti* is restricted globally by temperature, more recently, its range has expanded into cooler temperate regions (Brady et al. 2013, Gardner et al. 2017, Metzger et al. 2017, Gloria-Soria et al. 2018, Lubinda et al. 2019, Mullens et al. 2021).

Generally, *Ae. aegypti* demographics are closely linked to climatic conditions, including warming water temperatures resulting in decreased developmental periods and more adults in shorter timeframes (Rueda et al. 1990, Marinho et al. 2016, Andriamifidy et al. 2019, Portilla Cabrera and Selvaraj 2020). However, in more temperate regions where temperature fluctuates seasonally, the extreme decrease in temperature during winter months can result in complete absence of the mosquito (Soper 1967, Portilla Cabrera and Selvaraj 2020). Conversely, months with ambient air temperatures between 15°C and 30°C and precipitation can cause spikes in the abundance of *Ae. aegypti* populations; especially when accompanied by anthropogenic factors such as water holding containers that provide oviposition sites (Alto and Juliano 2001, Yang et al. 2009, Walker et al. 2011, Brady et al. 2013, Baskoro et al. 2017, Myer et al. 2020, Marina et al. 2021). Each of these exogenous factors can influence *Ae. aegypti* development differently (Chaves et al. 2012, 2014). Together, estimates of relative mosquito population densities, both temporally and spatially can provide information on how population abundance responds to annual weather patterns, which is not only required to develop future distribution predictions but also to develop effective vector control strategies for the prevention of vector-borne diseases (Brown et al. 2008, Andreo et al. 2021). To accomplish the latter, it is essential to couple environmental factors with mosquito density data at the local or regional levels to increase overall predictiveness when developing models (Jansen and Beebe 2010). For temperate regions, it is evident that understanding *Ae. aegypti* population cycles are necessary, as *Ae. aegypti* populations have been shown to be positively associated with temperatures during summer monsoon seasons (Landau and van Leeuwen 2012, Martin et al. 2019).

We attempted to further our understanding of how *Ae. aegypti* populations may be expanding their range past the northern edge of their range by determining environmental factors associated with seasonal fluctuations of *Ae. aegypti* populations in 2 communities along the U.S.–Mexico border. Range expansion can be led by the ability to persist in different temperatures leading to a small change in fundamental biological processes to include survivability, developmental rates, and reproduction rates (Dell et al. 2014; Couret et al. 2014, Khan et al. 2020) Importantly, whereas *Ae. aegypti* inhabits both communities, DENV infection of humans has been documented only in Anapra, Mexico (Palermo et al. 2019); thus, emphasizing the need to understand the ecology of this mosquito species in the region for developing effective mosquito control measures.

Methods

House Participation and Ae. *aegypti* Collection

Sampling of *Ae. aegypti* populations was conducted from June to December of 2016 to 2018. Each year, mosquitoes were collected inside and outside a minimum of 140 participating family households spread across the Anapra (Ciudad Juárez, Chihuahua, Mexico) and Sparks (El Paso County, Texas, USA) study areas. A total of 71 and 70 households participated in Sparks and Anapra communities each year in 2016 and 2017, respectively. A total of 72 and 73 households participated in Sparks and Anapra in 2018, respectively. To maximize collection resources, participating family homes were assigned to groups ranging from 12 to 15 households with each being sampled a total of 3 times per year. The households assigned to each group were geographically separated throughout the entire community to ensure adequate collections of each community during each collection period with 24–30 houses sampled each month from each community.

Adult mosquitoes were captured using CDC gravid traps (BioQuip Products, Inc., California), where mosquitoes were attracted with tap water in a basin mimicking a container, then aspirated into a collection chamber via a battery powered fan located inside the trap. These traps were placed for 24 hours inside and outside of each house. These gravid traps utilized tap water as an attractant for container ovipositing female mosquitoes. The selection for the use of these traps was based on the traps ability to target adult container mosquitoes, which oviposit in water holding containers such as *Ae. aegypti* (Acevedo et al. 2021). The targeted collection of ovipositing *Ae. aegypti* with gravid traps was preferred over larval collections for larval indices or autocidal gravid ovitraps, as this method used *Ae. aegypti* oviposition seeking behavior to monitor adult populations to provide insight to overall abundance and the transmission risk of associated arbovirus transmission in the area (Day 2016, Barrera et al. 2020, Ong et al. 2020). Moreover, larval indices were not used due to the inability to accurately estimate overall adult mosquito populations and autocidal traps can damage collected mosquitoes hindering the ability to be used for future analyses. A dichotomous key based on morphological features was used to determine mosquito species (Darsie and Ward, 2005).

Meteorological and Environmental Data Recording

EasyLog, EL-USB-2-LCD Relative Humidity/Temperature Data Loggers were placed inside gravid traps to record temperature and humidity of the gravid traps placed inside and outside houses throughout the communities of Sparks and Anapra during each collection period. The average of the minimum and maximum temperature and humidity were calculated for each collection period and used for analysis. A Davis Instruments 6322 Vantage Pro2 Wireless Sensor Suite was placed near the center of each community to record rainfall. We also used the GRS Densitometer (Geographic Resource Solutions, CA, USA) to estimate both canopy and ground coverage of the vegetation above and horizontal vegetation immediately adjacent to the placement of the mosquito trap. The densitometer was placed 1.5 m over each corner of the gravid trap to record both the canopy and ground cover for any vegetation or obstruction at each point. We then calculated the average coverage from the 4 recordings for each trap to estimate the overall canopy or ground cover during the placement of each mosquito trap.

Statistical Analyses

First, we conducted a multivariate analysis using R 4.0 statistical computing software to determine the influence of temperature, humidity, and rainfall on *Ae. aegypti* abundance. In addition, a zero-inflated generalized linear mixed-effect model (ZIGLMM) with Poisson regression (α = 0.05 for statistical significance) using R package "glmmADMB v.0.6.4" (Fournier et al. 2012) was performed to evaluate the influence of the recorded variables. We determined the response variable of captured *Ae. aegypti*, which included several parameters (n = 2,934 in Sparks; n = 978 in Anapra): (i) random effect of participant house, and month, (ii) mixed effect of year, season (dry, rainy, cold), inside/outside, temperature, humidity, and both canopy and ground cover of trap placement. The ZIGLMM included the estimation of zeros (Min and Agresti 2005), or the absence of *Ae. aegypti*. The ZIGLMM used the number of collected *Ae. aegypti* to produce a descriptive ecological model to estimate the probability

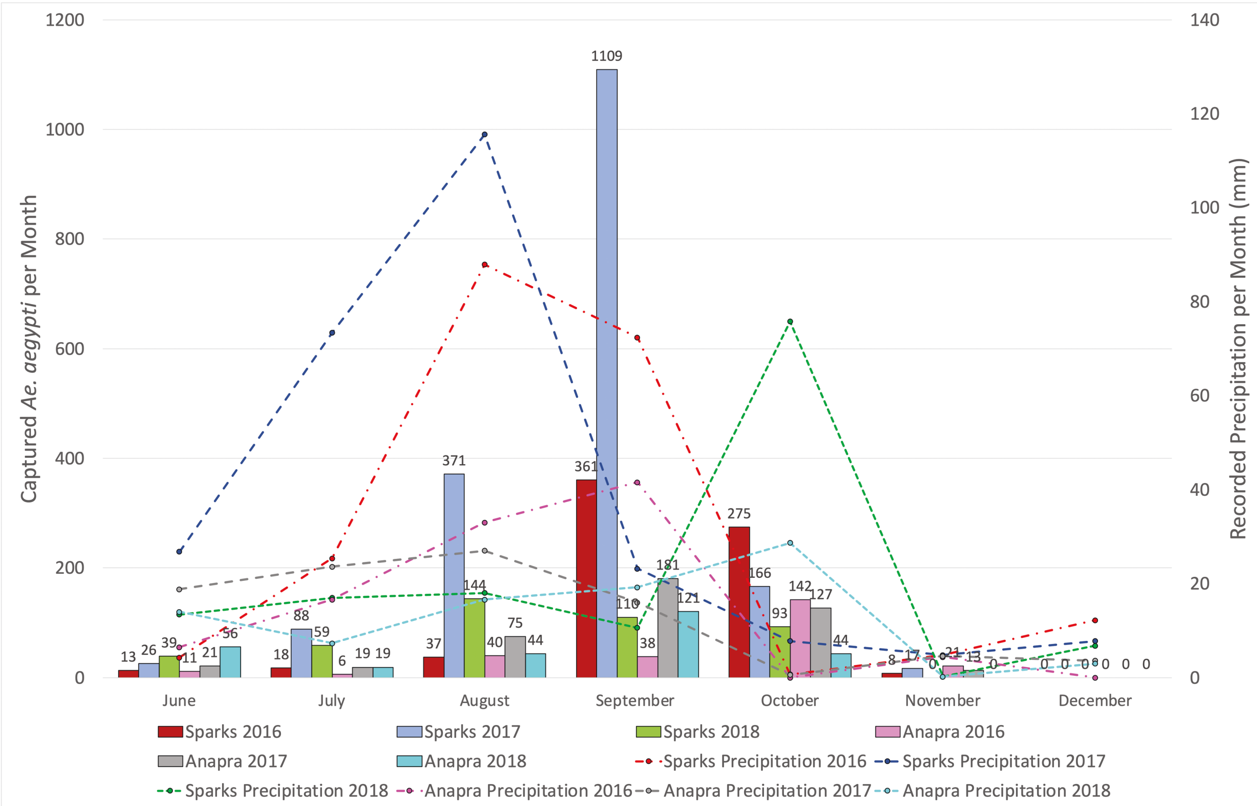

Fig. 1. Monthly totals of captured *Ae. aegypti* and recorded precipitation (mm) in Sparks, Texas and Anapra, Chihuahua, Mexico from 2016 to 2018.

of events to occur through temporal changes (Monod 2014, Chaves and Friberg 2021). In addition, ZIGLMM allowed for simultaneous calculations to estimate both ideal and adverse conditions on populations (Buu et al. 2012).

We conducted additional analyses to identify the best fit for the most influential environmental conditions based from the ZIGLMM findings. For each successfully identified variable from the ZIGLMM, we fitted each using multi-model inference (MuMIn) (R "MuMIn" package, Barton 2009) to support the successful identification for the most influential environmental factors on *Ae. aegypti* populations. The selected model was based on the lowest Akaike Information Criterion (AIC) score. Cross-correlation analysis was conducted to determine time lags associated with weather variables. This included calculating correlations between *Ae. aegypti* counts and weather variables, such as rainfall, over various time lags. The lag with the highest correlation was then identified. To better handle the count data, Spearman's rank correlation was used in this procedure.

Results

Ae. aegypti Capture Rates and Locations

In total, 108 and 101 families participated across years in Sparks and Anapra, respectively. In Sparks, from 2016 to 2018, a total of 2,934 male and female *Ae. aegypti* were captured and included 67.5% (1,982/2,934) and 10% (94/2,934) of females being captured outside and inside houses, respectively (Figs 1 and 2). In 2016, a total of 712 *Ae. aegypti* were captured and included 71.3% (508/712) and 5.3% (38/712) of females captured outside and inside houses, respectively (Fig. 1). In 2017, a total of 1,777 *Ae. aegypti*, including 66.5% (1,183/1,777) and 1.7% (31/1,777) of females captured outside and inside houses, respectively (Fig. 1). In 2018, a total of 445 *Ae. aegypti* were captured, including 59.7% (266/445) and 5.6% (25/445) of females captured outside and inside houses, respectively (Fig. 1).

In Anapra, from 2016 to 2018, a total of 978 *Ae. aegypti* were captured with 79.1% (774/978) and 8.1% (79/978) of females captured outside and inside houses, respectively (Fig. 1). In 2016, a total of 258 *Ae. aegypti* were captured with 76.3% (197/258) and 9.3% (24/258) of females captured outside and inside houses, respectively (Fig. 1). In 2017, a total of 436 *Ae. aegypti* were captured with 83.4% (364/436) and 8.9% (39/436) of females captured outside and inside houses, respectively (Fig. 1). In 2018, 284 *Ae. aegypti* were captured with 68.3% (194/284) and 5.6% (16/284) of females captured outside and inside houses, respectively (Fig. 1).

Meteorological and Environmental Data

The annual precipitation recorded from June to December of each year in the Sparks community was 207.7 mm, 259.4 mm, and 141.8 mm in 2016, 2017, and 2018, respectively (Table 1) and were consistent with the 30-yr annual average rainfall for the greater El Paso region of Texas of 237.5 mm (US Department of Commerce 2022). Although the 30-yr annual rainfall for Cd. Juárez averages around 225 mm (Weather and Climate 2022), below average rainfall was recorded from June to December of each year in Anapra, including 102.1 mm, 94.2 mm, and 89.02 mm for 2016, 2017, and 2018, respectively (Table 1).

In 2016 among the summer months, the lowest *Ae. aegypti* abundances were observed in July for both Sparks and Anapra (Fig. 1). July generally had the highest average temperatures (Avg Sparks ~ 42.4°C, Avg. Anapra ~ 41.75°C) but also was the drier months with average humidity hovering around 16.1% with 38.6 mm of

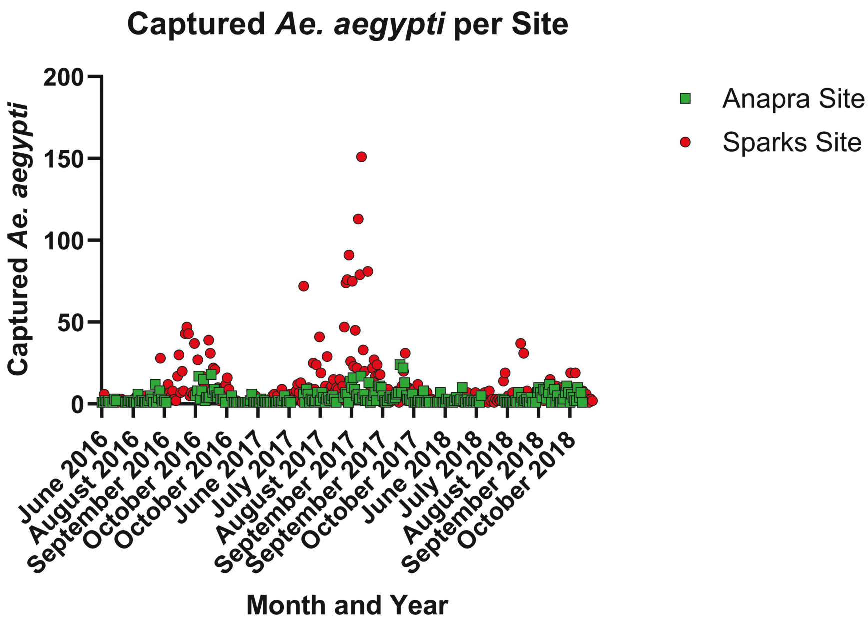

Fig. 2. Captured monthly *Ae. aegypti* per site from Sparks, Texas and Anapra, Chihuahua, Mexico from 2016 to 2018.

Table 1. Recorded monthly precipitation in the communities of Sparks and Anapra in millimeters (mm) from 2016 to 2018.

Year	June		July		August		September		October		November		December	
Community	Sparks	Anapra	Sparks	Anapra	Sparks	Anapra	Sparks	Anapra	Sparks	Anapra	Sparks	Anapra	Sparks	Anapra
2016	4.3	6.5	25.4	16.6	87.9	33	72.4	41.6	0.7	0	4.8	4.4	12.2	0
2017	26.8	18.8	73.4	23.6	115.6	27	23.2	16	7.8	0.6	5.8	4.6	7.8	3.6
2018	13.4	14.0	17.0	7.32	18.0	16.6	10.60	19.2	75.8	28.7	0.2	0.2	6.8	3.0

precipitation and 16.8% with 15.84 mm of precipitation in Sparks and Anapra, respectively. Interestingly, despite consistently having the largest amounts of rainfall in August, 73.83 mm in Sparks and 25.53 mm in Anapra (Fig. 1), *Ae. aegypti* abundances spiked in September in both communities that typically had the highest average humidity of 81.3% and 75.6% in Sparks and Anapra, respectively. *Ae. aegypti* abundances then decreased to or near zero by December in both communities when temperatures dipped below 5°C (Fig. 1). Although these trends remained, slight differences were noted in the months of peak humidity and precipitation between the 2 studied locations (Table 1).

During the summer months of 2017, the lowest *Ae. aegypti* abundance were observed in June and July for both Sparks and Anapra (Fig. 1). The highest average temperature of 41.1°C and lowest humidity of 15.7% were recorded in Sparks, and the lowest average humidity of 21.8% was recorded in Anapra. As precipitation increased in August in Sparks and Anapra (Table 1), humidity increased with an average high of 76% and 78%, respectively, along with an increase in the abundance of *Ae. aegypti* (Fig. 1). However, the highest average outdoor temperature in Anapra of 42.4°C was recorded in September. This period was followed by decrease in temperatures and *Ae. aegypti* abundance until absence (Tables 1 and 2) with the lowest average outdoor temperatures in December (Sparks ~ 3.2°C and Anapra −1.3°C.

The lowest summer population abundance of *Ae. aegypti* was observed during 2018 (Fig. 1), which included generally higher outdoor temperatures (i.e., Sparks ~ 41.4°C and Anapra ~ 41.39°C) and low humidity (i.e., Sparks 12.8% and Anapra 10.8%) averages in June. However, there was a gradual increase in *Ae. aegypti* abundance through September that had the highest outdoor humidity of 92%, but record precipitation did not occur until October in both study areas in 2018 (Table 1). Despite the increase in precipitation in September, the abundance of *Ae. aegypti* declined with decreasing outdoor temperatures (i.e., 0.45°C in November in Anapra and 4.4°C in December in Sparks; Fig. 1).

Statistical Analyses

The ZIGLMM was used to analyze the potential impact of environmental factors on *Ae. aegypti* abundance. Similar environmental factors, including season, temperature, trap placement inside houses, and canopy and ground cover of the gravid trap placement were found to influence the population abundance of *Ae. aegypti* in both Sparks and Anapra: (Tables 2 and 3). The rainy season within each community was found to have a statistical significance influence on the population abundance of *Ae. aegypti*: Sparks (P-value = 0.012) increased capture probability by 105% compared to the dry season; Anapra (P-value < 0.05) had an increased probability of 65%. However, the cold season only had a weak influence in Sparks (P-value = 0.07) for reducing capture probability by 60.1%. Moreover, a reduction in temperature alone in both communities had a weak influence: Sparks (P-value = 0.072) 1.9% reduction of capture; Anapra (P-value = 0.084) for a 2.8% capture reduction. Variations in the probability of capturing *Ae aegypti* were associated with an increase in humidity in Sparks that had a statistical significance (P-value < 0.05) of increasing the capture probability by 1.7%.

Table 2. Output results from zero-inflated generalized linear mixed-effect model (ZIGLMM) with Poisson regression the capture of *Ae. aegypti* in the Sparks community.

Community	Variable:	Estimate	Std. Error	z value	Pr(<|z|)	Exponential $e^{Estimate}$
Sparks, El Paso, Texas	Year–2017	0.57734	0.32332	1.79	0.07416	1.7812939
	Rainy Season (Aug–Oct)	0.71944	0.28675	2.51	0.01211*	2.0532831
	Cold Season (Nov–Dec)	−0.91957	0.51241	−1.79	0.07272	0.3986904
	Max Humidity	0.0166	0.00321	5.17	2.40E−07*	1.0167385
	Min Temperature	−0.01903	0.01079	−1.76	0.07779	0.9811499
	Captured Inside	−0.94205	0.09759	−9.65	2.00E−16*	0.3898279
	25% Canopy Cover	0.28276	0.11485	2.46	0.01382*	1.3267867
	50% Canopy Cover	0.72014	0.11327	6.36	2.00E−10*	2.0547209
	75% Canopy Cover	0.65091	0.11386	5.72	1.10E−08*	1.9172848
	100% Canopy Cover	0.7186	0.08272	8.69	2.00E−16*	2.051559
	50% Ground Cover	−0.1173	0.06932	−1.69	0.09064	0.8893184
	75% Ground Cover	−0.45309	0.08892	−5.1	3.50E−07*	0.6356609
	100% Ground Cover	−0.26749	0.07818	−3.42	0.00062*	0.765298

* Statistically significant (P < 0.05)

Table 3. Output results from zero-inflated generalized linear mixed-effect model (ZIGLMM) with Poisson regression for the capture of *Ae. aegypti* in the Anapra community.

Community	Variable:	Estimate	Std. Error	z value	Pr(<|z|)	Exponential $e^{Estimate}$
Anapra, Cd. Juárez, Mexico	Rainy Season (Aug–Oct)	0.50403	0.13624	3.7	0.00022*	1.655379024
	Min Temperature	−0.02882	0.0167	−1.73	0.08441	0.971591335
	Captured Inside	−0.63116	0.14073	−4.48	0.0000073*	0.531974353
	25% Canopy Cover	0.24154	0.14058	1.72	0.08576	1.273208382
	75% Canopy Cover	0.38728	0.15293	2.53	0.01133*	1.472968865
	100% Canopy Cover	0.30811	0.12639	2.44	0.01478*	1.360850674
	100% Ground Cover	−0.34319	0.16767	−2.05	0.04067*	0.709503393

* Statistically significant (P < 0.05)

Table 4. Output results for multi-model inference (MuMIn) analysis results to determine the best fit model that influenced the *Ae. aegypti* population density.

Model Name Function	(Intercept)	df	logLik	AICc	Δ	Weight
Community, Season	−0.06049	4	−3,608.02	7,224.08	0	1.00E + 00
Community, Month	−0.68375	3	−3,844.41	7,694.853	470.7726	5.93E−103
Community, Year	256.6895	3	−3,939.04	7,884.107	660.0269	4.75E−144
Community, Min Temperature	1.357396	3	−3,940.83	7,887.676	663.5958	7.98E−145
Community, Min Humidity	0.934926	3	−3,957.31	7,920.641	696.5602	5.54E−152
Community, Max Temperature	0.825746	3	−3,957.57	7,921.162	697.0819	4.27E−152
Community, Rainfall	0.882448	3	−3,957.65	7,921.331	697.2509	3.93E−152
Community, Max Humidity	0.857176	3	−3,957.69	7,921.4	697.3195	3.79E−152

The calculation of AIC scores through MuMIn identified the best fit model for the influential factors on *Ae.* aegypti populations as both season and community (AIC = 7224.08, Δ = 0 with a weight of 1; Tables 4 and 5). In short, these findings further supported our ZIGLMM, which identified both the rainy season (*P*-value = 0.006) and the community of Sparks (*P*-value < 0.05) had increased *Ae. aegypti* populations. Moreover, the seasonal variation during the rainy season provided conditions to increase the overall abundance while the differing conditions between the 2 communities also impacted the overall population sizes of *Ae. aegypti* proving insight into a complex system.

Discussion

Although the overall *Ae. aegypti* population densities was greater in the Sparks community, the population abundance tended to predictably cycle through seasonal variability. In short, peak densities occurred with near 100-fold increases in abundance from August to October before rapidly decreasing to near-zero in subsequent cold season months across evaluated years and communities. Importantly, these seasonal population cycles were closely tied to monsoonal months, with peak population densities occurring in months following the wettest month (Fig. 1). Specifically, seasonal

Table 5. Output results from the best fit model affecting the population density of *Ae. aegypti*.

Variable	Estimate	Std. Error	*t* value	Pr(>|t|)
Ae. Aegypti Captured in Sparks	3.24642	0.50537	6.424	2.13e−10*
Dry Season	−0.32065	1.30635	−0.245	0.80616
Rainy Season	3.36495	1.23807	2.718	0.00669*

* Statistically significant (P < 0.05)

population fluctuations varied depending on temperature, humidity, and microhabitats. Moreover, microhabitats have been found to influence *Ae. aegypti* populations in Arizona, where microclimatic changes in vegetation can increase population density (Hayden et al. 2010). Here, we identified the importance of canopy and ground cover for increased abundance in these environments along with the favorable conditions during the rainy season, consistent with previous research also conducted in southwestern United States (Hayden et al. 2010). Atmospheric fluctuations and ocean temperature changes caused by El Niño–Southern Oscillation (ENSO) phenomena can cause variation in temperatures and precipitation globally and occurs in phases with El Niño ("hot ENSO phase" with warmer waters in the Pacific Ocean) and La Niña ("cold ENSO phase" with cool water) (Johansson et al. 2009; Poh et al. 2019). These local changes in weather influenced possible dengue and leishmaniasis transmission (Johansson et al. 2009; Yamada et al. 2016). Specifically, mosquito populations increased following cold ENSO phases, which may be attributed to increased precipitation during this phase (Ng et al. 2018; Poh et al. 2019). This study was conducted during weak to moderate cold ENSO phases; therefore, the annual fluctuations from this phase could influence the annual population abundance of *Ae. aegypti* in this region.

In 2016 and 2017, there were predictable trends in which *Ae. aegypti* populations of Sparks and Anapra started with low numbers in June, gradually increasing until peak abundance in either September and October that was followed by a decrease to complete absence by December (Fig. 1). Interestingly, we did not find the same trend in 2018 as peak abundance occurred before peak rainfall (Fig. 1 and Table 1). However, 2018 had the lowest overall abundant as compared to the other 2 years. Although, our ZIGLMM analysis revealed several factors that showed that environmental changes between each season were found to be an important explanatory variable when estimating the variation on *Ae. aegypti* populations within each community (Tables 2 and 3). These findings were further corroborated through our MuMIn analyses indicating meteorological patterns and environmental conditions during the rainy season are the most influential factor on *Ae. aegypti* populations of the region (Tables 4 and 5). Together, we concluded that abundance was clearly limited by cold temperatures but that the totality of peak abundance was dictated by the amount of rainfall in August.

Temperature fluctuations, specifically cooler temperatures, have been shown to limit *Ae. aegypti* survival and reproduction in the temperature region of Argentina (De Majo et al. 2017, 2019), also in both Thailand and Puerto Rico (Scott et al. 2000). Precipitation allows for the persistence and creation of oviposition sites for larval development (Stewart Ibarra et al. 2013, Valdez et al. 2018). Specifically, after rainfall events the abundance of either captured *Ae. aegypti* adults or eggs increased in Brazil (Santos et al. 2020), Ecuador (Stewart Ibarra et al. 2013, Martin et al. 2021), and Malaysia (Wee et al. 2013). Therefore, the occurrence for seasonal fluctuations of temperature and humidity can influence the risk for dengue transmission throughout the year through a vector–climate relationship (Brady et al. 2014) as have been documented in Mexico (Carreto et al. 2022) and in Brazil (Xavier et al. 2021).

As *Ae. aegypti* expands northward in the Northern Chihuahuan Desert, arbovirus transmission risks increase to naïve populations (Vera et al. 2024a). A serological study conducted in 2015 in Anapra found 12% (10/78) serological positivity for DENV antibodies (Palermo et al. 2019). In addition, dengue cases have been reported in Anapra, 1 in 2016 and 9 in 2017 (DGE 2016, 2017). Highlighting a need to develop targeted vector control measures for the control of arbovirus transmission in this region. Our study shedded light on how environmental and meteorological factors influenced *Ae. aegypti* abundance at the leading edge of their range through a binational longitudinal mosquito surveillance study. In fact, we found that the employment of gravid traps for both vector control and active surveillance provided accurate estimates of overall mosquito populations (Day 2016).

Population abundance and possible range expansion of this medically important mosquito species were shown to be facilitated by the exploitation of the favorable conditions associated with the seasonal variation of meteorological patterns. Our longitudinal study, which compared 2 nearby communities successfully identified potential environmental influences that impact *Ae. aegypti* populations, with more favorable conditions being found in the Sparks community. Overall, the Sparks community had higher *Ae. aegypti* abundance, therefore an increased risk for arbovirus transmission existed in this community. A possible explanation for this increased abundance could be attributed to increased oviposition containers available in Sparks than in Anapra (Vera et al. 2024b). Additional explanations for the increased overall abundance in this community could be related to increased vegetation near houses such as shrubs, flowering plants, and trees in Sparks. Lastly, rain water harvesting was observed in both communities, but the frequency for usage or length of storage was not recorded throughout this study. These two additional environmental factors would need to be explored to better understand the difference in *Ae. aegypti* population sizes in these two communities.

The successful identification of favorable conditions provides the opportunity evaluate *Ae. aegypti* populations in cooler and drier regions during the periods both environmental and meteorological conditions are ideal as overall population density would be expected to be greater. In addition, the understanding of periods with peak population abundance for medically important mosquitoes can be utilized to implement a targeted vector method and initiative to reduce arbovirus transmission risk in these cooler and drier regions with naïve human populations. Moreover, additional studies need to explore the variation for arbovirus risk between the 2 communities, especially with the presence of DENV in Anapra and not in Sparks. Future research should continue to monitor meteorological and environmental conditions that influence *Ae. aegypti* populations in this region, particularly as climates continue to rapidly change and which will be required when attempting to develop targeted vector control measures.

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