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Interannual and seasonal variation in the metazoan parasite community of the white mullet *Mugil curema* (Valenciennes 1836) in a tropical coastal lagoon

Jonatan Carbajal-Violante[2], Juan Violante-González[1,2], Aldo Díaz-Gallegos[2], Yesenia Gallegos-Navarro[1], Princessa J. Villalba-Vasquez[3], Carlos Valencia-Cayetano[3] and Erick Rodríguez-Ibarra[3]*

[1] Facultad de Ecología Marina, Universidad Autónoma de Guerrero, Acapulco, Guerrero, México.
[2] Centro de Ciencias de Desarrollo Regional, Universidad Autónoma de Guerrero, Acapulco, México.
[3] Postdoctoral de la Secretaría de Ciencia, Humanidades, Tecnología e Innovación (SECIHTI), Facultad de Ecología Marina, Universidad Autónoma de Guerrero, Acapulco de Juárez, Guerrero, Mexico.

* Corresponding author: erickrodrigueziba@gmail.com

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ABSTRACT

Interannual and seasonal variation in the metazoan parasite community of the white mullet *Mugil curema* (Valenciennes 1836), in a tropical coastal lagoon.

Four hundred and sixty-eight specimens of white mullet *Mugil curema* (Valenciennes, 1836) were collected over a four-year period (February 2021 to February 2024), although sampling was not continuous, in Tres Palos lagoon, Guerrero, Mexico. The aim of this study was to assess the factors influencing the interannual dynamics of parasite communities associated with this fish species. A total of 14 metazoan parasite species were recorded, including one Monogenea, four Digenea, four Acanthocephala, one Cestoda, two Nematoda, and two Crustacea (one copepod and one branchiuran). Three species (*Ligophorus mugilinus*, *Floridosentis pacifica*, and *Ergasilus lizae*) were classified as specialists of mugilid fishes, whereas the remaining eleven species were acquired opportunistically during the host's residence in the lagoon. Digeneans and acanthocephalans were the most diverse groups, with four species each. The abundance of certain parasite species increased with host body size, while others were more prevalent in smaller individuals. Interannual and seasonal variation in infection levels was associated with fluctuations in biotic and abiotic conditions driven by seasonal dry and rainy cycles, which likely influence both the population dynamics of intermediate hosts and the feeding behavior of *M. curema*.

KEY WORDS: euryhaline fishes, parasite fauna, biotic and abiotic factors, community structure, mexican Pacific.

RESUMEN

Variación interanual y estacional en la comunidad de parásitos metazoos de la lisa blanca** Mugil curema **(Valenciennes 1836) en una laguna costera tropical.

Se recolectaron 468 ejemplares de lisa blanca Mugil curema *(Valenciennes, 1836) durante un período de cuatro años (de febrero de 2021 a febrero de 2024), aunque el muestreo no fue continuo, en la laguna Tres Palos, Guerrero, México. El objetivo de este estudio fue evaluar los factores que influyen en la dinámica interanual de las comunidades de parásitos asociadas a esta especie. Se registraron un total de 14 especies de parásitos metazoos, incluyendo un Monogenea, cuatro Digenea, cuatro Acanthocephala, un Cestoda, dos Nematoda y dos Crustacea (un copépodo y un branquiuro). Tres*

*especies (*Ligophorus mugilinus*,* Floridosentis pacifica *y* Ergasilus lizae*) fueron clasificadas como especialistas de peces mugílidos, mientras que las once especies restantes fueron adquiridas durante la estancia del hospedero en la laguna. Los digéneos y los acantocéfalos fueron los grupos más diversos, con cuatro especies cada uno. La abundancia de algunas especies de parásitos aumentó con el tamaño corporal del hospedero, mientras que otras fueron más prevalentes en individuos más pequeños. La variación interanual y estacional en los niveles de infección se asoció con fluctuaciones en las condiciones bióticas y abióticas impulsadas por ciclos estacionales secos y lluviosos, que probablemente influyen tanto en la dinámica poblacional de los hospederos intermediarios como en el comportamiento alimenticio de* M. curema*.*

PALABRAS CLAVE: *peces eurihalinos, fauna parasitaria, factores bióticos y abióticos, estructura de la comunidad, Pacífico mexicano.*

INTRODUCTION

Fish are considered the vertebrate group with the highest diversity of parasite species, largely due to their long evolutionary association with a wide range of invertebrates that serve as intermediate hosts (Falkenberg et al., 2022). The aquatic environment facilitates parasitism by enhancing larval dispersal, reproduction, and the successful completion of parasite life cycles (Falkenberg et al., 2022).

Several parasitological studies indicate that parasite communities in freshwater fishes may exhibit temporal and spatial variation in their structure in response to seasonal and local fluctuations in biotic and abiotic environmental conditions. These changes are often reflected in shifts in species composition and infection parameters over time (Garcias et al., 2001, Henríquez & González, 2012, Villalba-Vásquez et al., 2018). In tropical regions, such variation is driven by multiple processes, including changes in temperature, salinity, and dissolved oxygen, as well as fluctuations in the abundance of intermediate hosts. Additionally, host-related traits such as age, body size, feeding behavior, population density, and vagility can increase exposure to parasite species and enhance colonization rates (Luque et al., 2004, Zander, 2004, Villalba-Vásquez et al., 2018).

Mugil curema is one of the most intensively exploited species by coastal fisheries in the Mexican Pacific (Salgado-Cruz et al., 2021, Rodríguez-Ibarra et al., 2025, Díaz-Gallegos et al., 2026). It has a broad geographic distribution, ranging from California (USA) to Chile, in the Eastern Pacific, and from Nova Scotia to Argentina in the Atlantic Ocean (Salgado-Cruz et al., 2021, Rodríguez-Ibarra et al., 2025). This species spends most of its life cycle in sheltered environments such as coastal lagoons and estuaries, where it feeds primarily on microscopic and filamentous algae, as well as zooplankton. Upon reaching maturity, individuals form large schools and migrate to coastal pelagic waters to reproduce (Trape et al., 2009, Salgado-Cruz et al., 2021, Santos et al., 2021).

Due to the species' ecological and economic importance, some studies of its parasites have been conducted in estuaries and coastal lagoons along the Mexican Pacific (Fajer-Avila et al., 2006, Violante-González & Aguirre-Macedo, 2007, Violante-González et al., 2007, Morales-Martínez et al., 2022, Rodríguez-Ibarra et al., 2025, Díaz-Gallegos et al., 2026). However, although the parasite fauna of *M. curema* has been described in coastal lagoons of Guerrero, no studies have addressed the temporal dynamics of its parasite communities. Therefore, the present study aimed to characterize the interannual and seasonal variation of the parasite community of this species in Tres Palos lagoon. We hypothesized that the *M. curema* parasite community would exhibit significant changes in its structure and species composition, because parasite species can react differently to the environmental changes generated by the dry-rainy cycle.

MATERIALS AND METHODS

Study area

The Tres Palos lagoon (16°47′N, 99°39′W) is located on the Pacific coast of Mexico, approximately 25 km east of Acapulco. It has a surface

area of 55 km² (5500 ha) and a depth ranging from 0.5 to 8 m. Continuous discharge of urban waste via the Sabana River has led to hypertrophic conditions, resulting in high primary productivity, particularly during the rainy season (de la Lanza-Espino et al., 2008). The region is characterized by two distinct climatic seasons: a rainy season from June to November (total precipitation ≈ 980 mm) and a dry season from December to May (total precipitation < 70 mm) (Violante-González et al., 2009).

Fish collection and biometric data

Individuals of *M. curema* were obtained from local fishers across five sampling events conducted over a four-year period (February 2021 to February 2024), although samplings were not continuous. For each specimen, sex, total length, and body weight were recorded. Individuals were subsequently classified into three size classes: immature (5-12 cm), pre-adult (12-15 cm), and adult (>15 cm). Digestive tract contents were analyzed to identify consumed prey items using the frequency of occurrence method (Muñoz et al., 2006). Differences in fish body size among sampling periods were evaluated using one-way ANOVA.

Parasite collection and infection parameters

All specimens were subjected to a complete necropsy, and parasites were collected from both external and internal organs. Infection parameters for each parasite species were quantified following standard descriptors: prevalence (percentage of infected hosts), mean abundance (average number of individuals per examined host), parasite load (total number of parasites per host), and intensity (number of parasites per infected host, expressed as a range) (Bush et al., 1997). Differences in infection levels among sampling periods were assessed using likelihood ratio G-tests and factorial ANOVA (General Linear Model, GLM) for abundance data. Spearman's rank correlation coefficient (rs) was used to evaluate relationships between host total length and parasite abundance for species with prevalence greater than 10% (sensu Bush et al., 1990).

Study levels

Analyses were conducted at two hierarchical levels: infracommunity (all parasite species within an individual host) and component community (all parasite species within the host population at a given sampling period). Infracommunities were characterized by the mean number of parasite species per host and the mean abundance of each species. Relationships between host size and parasite abundance were assessed using Spearman's correlation. Generalized linear models (GLMs) were applied to evaluate the effects of host body size and sampling period on parasite species richness and parasite load. A Poisson distribution with a log link function was used for species richness, whereas a negative binomial distribution was applied to parasite load due to aggregation in abundance data. Overdispersion in Poisson models was evaluated using the ratio of residual deviance to degrees of freedom.

Component community metrics included total species richness, total abundance per parasite species, parasite diversity (^1D, exponential of Shannon entropy), and numerical dominance measured by the Berger–Parker index. Community similarity among sampling periods was assessed using Bray–Curtis similarity coefficients based on square-root-transformed abundance data. Non-metric multidimensional scaling (nMDS) was used to visualize patterns of similarity in species composition. Differences among component communities were evaluated using Student's t-tests, considering each sampling period as a distinct community. The statistical programs SPSS (IBM SPSS Statistics for Windows, Ver. 20.0), R v. 2.5-7, and PRIMER v6. were used for statistical analyses.

RESULTS

Composition of the parasite fauna

A total of 468 specimens of *M. curema* were examined during the study period, of which 90% were infected with one to six parasite species. Most infected hosts (52%) harbored two to three parasite species, whereas only 2.7% presented infections with five or six species (Fig. 1). The

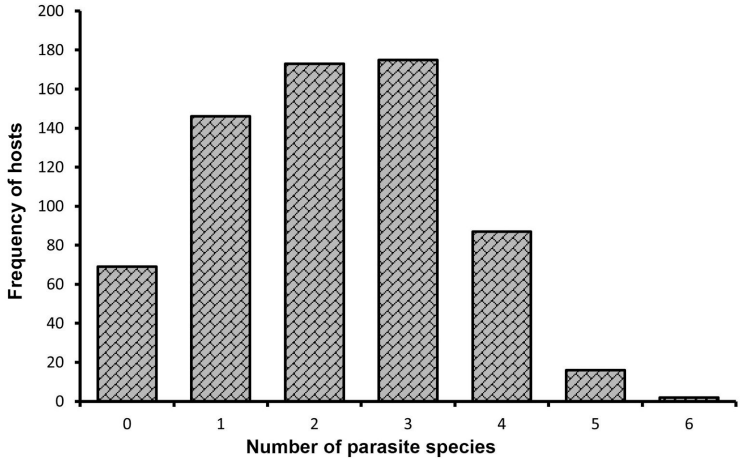

Figure 1. Distribution of parasite species among infected hosts, in *Mugil curema* of the Tres Palos lagoon. *Distribución de especies de parásitos entre hospederos infectados, en* Mugil curema *de la laguna Tres Palos.*

parasite assemblage of *M. curema* comprised 14 taxa, including one monogenean, four digeneans, one cestode, four acanthocephalans, two nematodes, and two crustaceans (one copepod and one branchiuran). Based on their site of infection, three species were classified as ectoparasites and eleven as endoparasites (Table 1). Six endoparasite species were recorded in their larval stages, infecting organs such as eyes, heart, liver, mesentery, and, less frequently, muscle tissue [*Ascocotyle (Phagicola) longa*, *Austrodiplostomum ostrowskiae*, *Clinostomum tataxumui*, *Parvitaenia cochlearii*, *Southwellina hispida*, and *Contracaecum multipapilatum*]. In all samples, endoparasites were numerically more abundant than ectoparasites.

Temporal variation in parasite infection levels

Only three parasite species [*Ligophorus mugilinus*, *A. (Ph.) longa*, and *C. multipapilatum*] were consistently detected throughout the entire sampling period (Table 1). The prevalence of eight species showed significant temporal variation across sampling years and/or seasons. The digeneans *A. (Ph.) longa* ($G = 9.71$, $p<0.05$) and *A. ostrowskiae* ($G = 8.31$, $p<0.05$) exhibited higher prevalence during February 2021 (dry season), whereas *Saccocoelioides lamothei* ($G = 22.2$, $p<0.05$) and the acanthocephalan *Floridosentis pacifica* ($G = 23.2$, $p<0.05$) were more prevalent in October 2021 (rainy season). Additionally, the monogenean *L. mugilinus*, the acanthocephalan *Pseudoleptorhynchoides lamothei*, the nematode *C. multipapilatum*, and the copepod *Ergasilus lizae*, showed significantly higher prevalence ($p<0.05$) in February 2024 (dry season). Abundance values for these species also exhibited significant temporal variation (GLM: $p<0.01$), reaching higher values in the same years and climatic seasons in which they were most prevalent (Table 1). Furthermore, prevalence and abundance were strongly and positively correlated ($rs = 0.930$, $p<0.01$), indicating that the most prevalent species were also the most abundant.

Characteristics of the hosts

Mean total length of the fish varied significantly among sampling periods, ranging from 14.1 ± 8.1 cm to 21.4 ± 1.3 cm (ANOVA: $F_{4,467} = 22.37$, $p<0.01$). Through sex determination, 100 males, 192 females, and 176 immature individuals were identified. Female fish were significantly larger than males (ANOVA $F_{1,291} = 26.7$, $p<0.01$). Males exhibited a mean length of 22.4 ± 1.85 cm (range: 18.5–27.8 cm), females 23.9 ± 2.62 cm (range: 18.5–31.9 cm), and immature individuals 7.25 ± 1.9 cm (range: 4.2–12 cm). Body size frequency distributions differed markedly among groups: males showed a relatively narrow distribution concentrated between 20 and 25 cm, whereas fe-

Table 1. Infection parameters for parasites of *Mugil curema* from Tres Palos lagoon. P = prevalence, (A) = mean abundance, T = total number of parasites [range] = minimum and maximum number of parasites. *Parámetros de infección para parásitos de* Mugil curema *de la laguna Tres Palos. P = prevalencia, (A) = abundancia media, T = número total de parásitos [rango] = número mínimo y máximo de parásitos.*

	Infection	$^{D}2021_{Fec}$		$^{R}2021_{Oct}$		$^{D}2022_{May}$		$^{R}2022_{Oct}$		$^{D}2024_{Feb}$	
Parasites	**site**	**P%(A)**	**T[range]**	**P%(A)**	**T[range]**	**P%(A)**	**T[range]**	**P%(A)**	**T[range]**	**P%(A)**	**T[range]**
Digenea											
Ascocotyle (*Phagicola*) *longa* [L](Al, G)	He, H, M	73(32.6)	1793[1-487]	53(32.3)	3900[1-406]	68.5(38.7)	2091[3-636]	57(25)	3930[1-393]	67(61.1)	4950[1-808]
Austrodiplostomum ostrowskiae [L](Al, G)	Ey	3.6(0.04)	2[0-1]	0.83(0.02)	3[0-3]					1.23(0.01)	1[0-1]
Saccocoelioides lamothei [A](Au, G)	I			9.92(1.06)	237[1-94]	5.6(1.5)	81[6-59]	16.6(1.30)	204[1-23]	7.4(1.08)	88[2-36]
Clinostomum tataxumui [L](Al, G)	Ms	0.5(0.01)	1[0-1]								
Monogenea											
Ligophorus mugilinus [A](Au, E)	Gi	1.8(0.02)	1[0-1]	27.3(2.34)	283[1-62]	22.2(0.96)	52[1-18]	3.8(0.28)	44[1-31]	32.1(1.97)	160[1-86]
Cestoda											
Parvitaenia cochlearii [L](Al, G)	H							0.64(0.01)	1[0-1]		
Acanthocephala											
Floridosentis mugilis [A](Au, E)	I	7.3(0.25)	14[1-6]			19(0.60)	72[1-13]	2.5(0.06)	9[1-6]	2.5(0.02)	2[0-1]
Neoechinorhynchus brentnickoli [J](Au, G)	I	1.8(0.02)	1[0-1]	1.6(0.08)	10[1-9]						
Pseudoleptorhynchoides lamothei [J](Au, G)	I	3.6(0.05)	3[1-2]	2.5(0.05)	6[1-3]					12.3(0.22)	18[1-4]
Southwellina hispida [L](Al, G)	H, Ms			19.1(2.39)	289[1-48]						
Nematoda											
Raillietnema sp. [A](Au, G)	I			10.7(1.11)	134[1-112]	20.4(1.15)	62[1-32]				
Contracaecum multipapilatum [L](Al, G)	Ms, M	29.1(0.44)	24[1-3]	28.1(0.54)	65[1-8]	38.9(0.70)	38[1-7]	23.6(0.45)	71[1-6]	53.1(1.3)	101[1-22]
Copepoda											
Ergasilus lizae [A](Au, E)	Gi	54.5(1.78)	98[1-24]	42.1(2.72)	329[1-19]	22.2(0.96)	52[1-18]	28.7(1.64)	257[1-27]	77.8(4.28)	347[1-33]
Branchiura											
Argulus sp. [A](Au, G)	Gi, Sk	1.82(0.02)	1[0-1]	0.83(0.01)	1[0-1]	1.85(0.02)	1[0-1]	1.9(0.02)	1[0-1]		

Climatic season: D = dry season, R = rainy season. P = prevalence, (A) = mean abundance, T = total number of parasites [range] = minimum and maximum number of parasites, Development stage: A = Adult, J = Juvenile, L = Larva, Colonization strategy: Au = Autogenic, Al = Allogeneic, Host specificity: E = Specialist, G = Generalist, Site = Site of infection: Gi = Gills, He = Heart, H = Liver, Ey = Eyes, I = Intestine, Ms = Mesentery, M = Muscle, Sk = Skin.

males displayed a broader range (18-32 cm) with higher frequencies between 22 and 25 cm (Fig. 2). In contrast, immature individuals exhibited a distinct pattern, with sizes predominantly between 6 and 7 cm (Fig. 2). Diet composition varied across size classes and climatic seasons, but not between sexes (p>0.05). Adult fish displayed a more diverse diet, whereas juveniles primarily consumed microcrustaceans (ostracods, copepods, and amphipods) and insect larvae (Fig. 3). Overall, certain dietary items were more representative in one of the two climatic seasons (Fig. 4).

Influence of total host length

The total length of the fish was positively correlated with the abundance of six parasite species: *E. lizae* (rs = 0.567, p<0.01), *L. mugilinus* (rs = 0.279, p<0.01), *A. ostrowskiae* (rs = 0.109, p<0.01), *A. (Ph.) longa* (rs = 0.442, p<0.01), *F. pacifica* (rs = 0.138, p<0.01) and *C. multipapilatum* (rs = 0.442, p<0.01). In contrast, significant negative correlations were observed between host length and the abundances of *Neoechinorhynchus brentnickoli* (rs = -0.093, p<0.01) and *Southwellina hispida* (rs = -0.304, p<0.01). At the infracommunity level the host's sex had no effect on any of the parameters (p>0.05). The host body size emerged as the primary predictor of both parasite species richness and parasite load (Table 2). Species richness exhibited a significant positive association with body size (Poisson GLM: β = 0.056, p<0.001), indicating that each unit increase in total length resulted in an

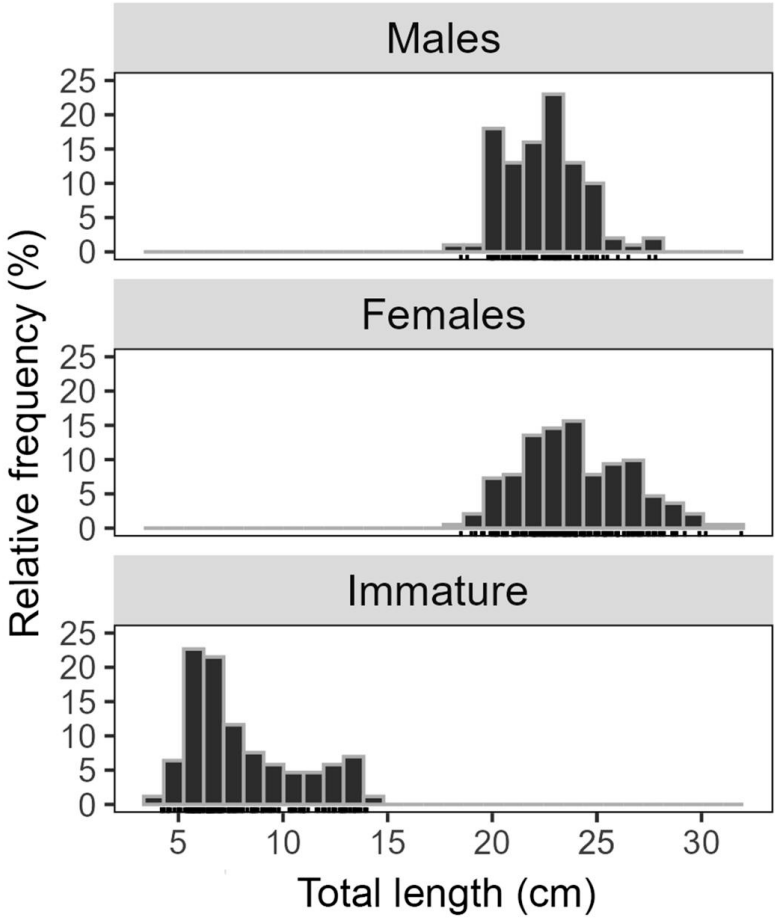

Figure 2. Frequency distribution of total lengths by sex for *Mugil curema* in the Tres Palos lagoon. *Distribución de frecuencias de longitudes de acuerdo al sexo para* Mugil curema *en la laguna de Tres Palos.*

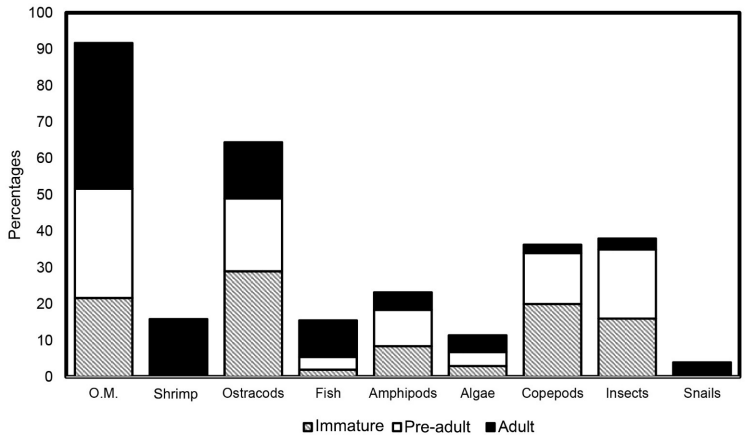

Figure 3. Diet composition between different size classes of *Mugil curema*. *Composición de la dieta entre diferentes clases de tamaño de* Mugil curema*.*

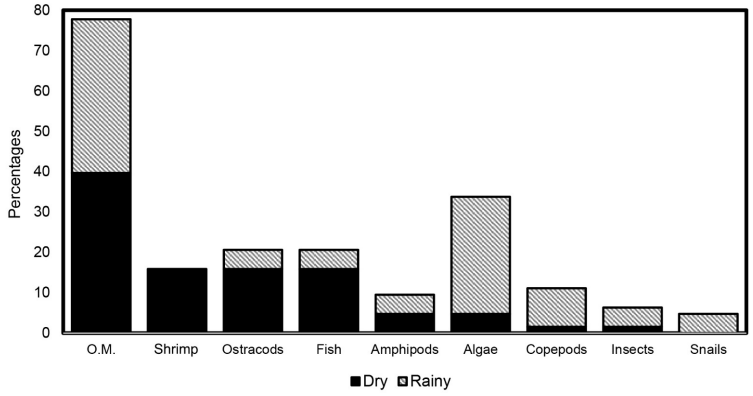

Figure 4. Variation in the diet composition of *Mugil curema* according to the climatic season. *Variación en la composición de la dieta de* Mugil curema*, de acuerdo a la temporada climática.*

approximate 5.8% increase in expected richness (Fig. 5A1). Likewise, parasite load increased significantly with host size (negative binomial GLM: $\beta = 0.129$, $p<0.001$), corresponding to an increase of 13.8% per unit of length (Fig. 5A2). These findings indicate that larger hosts support not only a higher number of parasite species but also a greater overall abundance of parasites. Sampling year and climatic season had a significant effect on parasite species richness (Table 2), but did not significantly influence parasite load ($p>0.05$; Fig. 5B2), suggesting that temporal variation primarily affects parasite community composition rather than total parasite abundance. The mean richness was higher during the seasons of rainy 2021 and dry 2024 (Fig. 5B1). The dispersion parameter of the negative binomial model ($\theta = 0.512$) revealed a high degree of aggregation in parasite distribution among hosts, indicating that a small proportion of individuals harbored the majority of parasites.

Characteristics of the component communities

Parasite species richness across the five component communities examined (Table 3) varied significantly, ranging from 7 to 11 species (t-test = −2.99, $p<0.01$). The total number of parasites also differed markedly, from 527 to 5666 individuals (t-test = 3.05, $p<0.01$), while species diversity (1D) ranged from 2.37 to 18.82 (t-test = −3.90, $p<0.01$). The heterophyid *A. (Ph.) longa* was numerically dominant in the parasite assemblages of *M. curema* (Table 3). Similarity among component communities showed considerable variation, ranging from 13.92% to 91.48% (mean =

Table 2. Results of the generalized linear models (GLM) for parasite species richness (GLM Poisson) and parasite load (negative binomial GLM, BN) as a function of body size and sampling year. *Resultados de los modelos lineales generalizados (GLM) para la riqueza de especies de parásitos (GLM Poisson) y la carga parasitaria (GLM binomial negativa, BN) en función del tamaño corporal y el año de muestreo.*

	Richness (GLM Poisson)			Parasite load (GLM, BN)		
Predictor	*B*	*Z*	*p*	*β*	*z*	*p*
Intercept	-0.626	-4.09	<0.001	0.731	2.67	0.008
Body size	0.056	10.48	<0.001*	0.129	14.07	<0.001*
Samples						
$^{R}2021_{Oct}$	0.340	2.86	0.004*	0.431	1.85	0.064
$^{D}2022_{May}$	-0.115	-0.77	0.438	0.292	1.08	0.278
$^{R}2022_{Oct}$	0.035	0.28	0.779	0.362	1.57	0.117
$^{D}2024_{Feb}$	0.286	2.32	0.020*	0.351	1.43	0.154
AIC	1356.2			3986.4		
Null deviance	489.64			740.07		
Residual deviance	317.55			555.76		
θ	—			0.512		

Nota: β = estimated coefficient; z = z-statistic, AIC = Akaike information criterion, θ = Dispersion parameter of the Negative Binomial distribution. The reference category is the first sampling year (D2021Feb), $p<0.01$.

Table 3. Characteristics of the parasite component communities of *Mugil curema*, from Tres Palos lagoon. *Características de las comunidades componente de* Mugil curema*, de la laguna Tres Palos.*

Year/date	No. of fish	Length (cm)	M	F	I	Species richness	No. of parasites	IBP	Dominant species	^{1}D
$^{D}2021_{Feb}$	55	21.4±1.4	19	33	3	10	1938	0.925	Asco	2.37
$^{R}2021_{Oct}$	121	16.9±8.6	23	50	48	11	5257	0.742	Asco	6.32
$^{D}2022_{May}$	54	21.2±1.8	19	35		8	527	0.369	Asco	18.82
$^{R}2022_{Oct}$	157	14.0±8.1	16	38	103	8	4517	0.8707	Asco	3.20
$^{D}2024_{Feb}$	81	21.2±7.8	23	36	22	7	5666	0.874	Asco	3.18

Climatic season: D = Dry, R = Rainy, M = Male, F = Female, I = Immature, IBP = Berger-Parker index, 1D = exponential of the Shannon-Wiener index, Asco = *Ascocotyle (Phagicola) longa*.

49.67%). Notably, higher similarity values were observed between samples collected during the same season in consecutive years (e.g., 2021Oct–2022Oct). Non-metric multidimensional scaling (nMDS) analysis revealed a clear clustering of communities at the 60% similarity level, whereas one annual sample (2022May) was distinctly separated at the 80% similarity level (Fig. 6).

DISCUSSION

Although parasite species composition remained relatively stable throughout the study period, the structure of the community exhibited notable variation, particularly over multi-year intervals. Environmental fluctuations in Tres Palos lagoon associated with the seasonal dry–rainy cycle likely influenced the availability of intermediate hosts and the feeding behavior of *M. curema*, thereby affecting the recruitment dynamics of several endoparasite species.

Composition of parasite species

The parasite community of *M. curema* was characterized by a predominance of digeneans and acanthocephalans, each represented by four species (Table 1), together accounting for 57% of the total recorded richness. In tropical systems, digeneans are typically the most diverse group of helminths infecting fish across aquatic environments (Luque & Poulin, 2007, Violante-

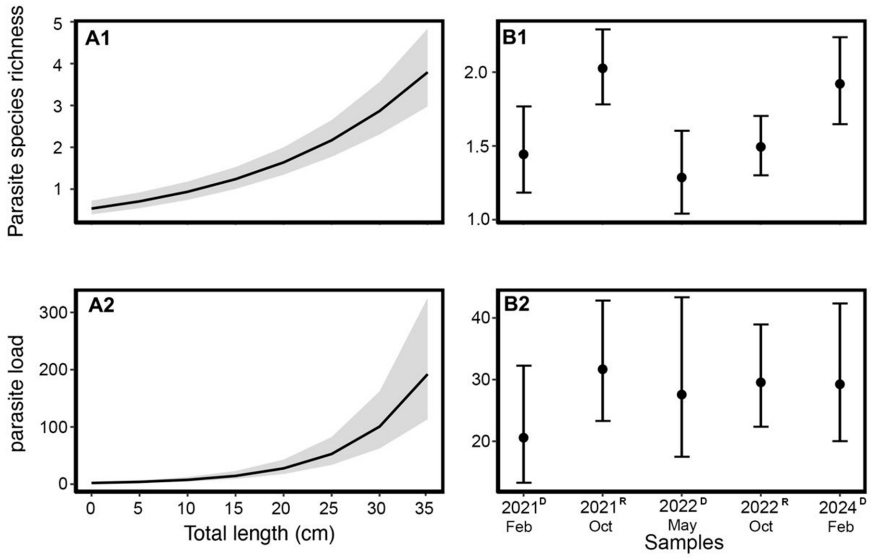

Figure 5. Predicted effects of host total length and study period on parasite species richness (Poisson GLM: A1, B1) and total parasite load (Negative Binomial GLM: A2, B2) in *Mugil curema*. Shaded areas represent 95% confidence intervals. Lines represent predicted values for each sampling year/season. Climatic season: D = Dry season, R = Rainy season. *Efectos predichos de la longitud total del hospedero y el período de estudio, sobre la riqueza de especies de parásitos (GLM de Poisson: A1, B1) y la carga total de parásitos (GLM Binomial Negativa: A2, B2) en* Mugil curema*. Las áreas sombreadas representan intervalos de confianza del 95%. Las líneas representan los valores predichos para cada año/estación de muestreo. Estación climática: D = Estación seca, R = Estación lluviosa.*

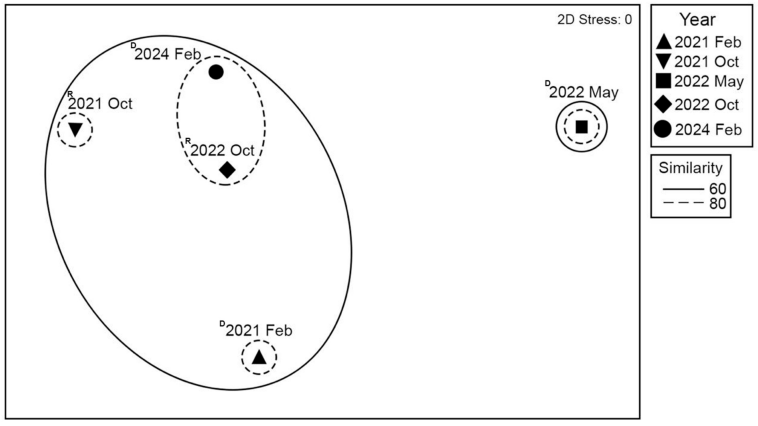

Figure 6. Non-metric multidimensional scaling (nMDS) plot for parasite communities in *Mugil curema* from Tres Palos, Mexico. The ellipses represent the levels of similarity between the sampling years and climatic seasons. *Gráfica de escalamiento multidimensional no métrico (nMDS) para las comunidades de parásitos en* Mugil curema *de la laguna de Tres Palos, México. Las elipses representan los niveles de similitud entre los años de muestreo y estaciones climáticas.*

González et al., 2007, Carpio et al., 2024, Díaz-Gallegos et al., 2026). Their high diversity has been associated with warm temperatures and elevated productivity, which promote large populations of mollusks serving as first intermediate hosts (Violante-González et al., 2007, Díaz-Gallegos et al., 2026). In contrast, acanthocephalans are generally considered uncommon in freshwater fishes in Mexico (Salgado-Maldonado et al., 2004). However, the presence of four species (*F. pacifica*, *N. brentnickoli*, *Ps. lamothei*, and *S. hispida*) in this study may be related to the high productivity of the lagoon, which supports abundant populations of benthic microcrustaceans acting as intermediate hosts (Marcogliese, 1995, Violante-González et al., 2007, Díaz-Gallegos et

al., 2026).

With the exception of *L. mugilinus*, *F. pacifica*, and *E. lizae*, which are recognized as specialist parasites of mugilid fishes (Fajer-Avila et al., 2006, Falkenberg et al., 2022), the remaining eleven species are likely acquired opportunistically by *M. curema* during its residence in Tres Palos lagoon (Violante-González et al., 2007, Díaz-Gallegos et al., 2026). Furthermore, the presence of up to six larval parasite species (Table 1) suggests that this host plays an important role in the transmission and dispersal of endoparasites within the lagoon ecosystem (Negreiros et al., 2024, Díaz-Gallegos et al., 2026). These larval stages typically use ichthyophagous birds, such as *Nannopterum brasilianum*, *Ardea alba*, and *Nyctanassa violacea*, as definitive hosts (Violante-González et al., 2015, Díaz-Gallegos et al., 2026).

Variation in the parasite infection levels

Parasite populations may exhibit temporal or spatial variation in infection levels in response to seasonal fluctuations in biotic and abiotic factors. These changes are commonly reflected in variations in prevalence and abundance over time (Poulin, 2006, Villalba-Vásquez et al., 2018). Endoparasites such as *F. pacifica*, *C. multipapilatum*, and *Ps. lamothei* are transmitted to their definitive hosts through the ingestion of infected prey or aquatic vegetation containing encysted larval stages (e.g., haploporid metacercariae such as *Saccocoelioides lamothei*) (Andrade, 2022). Consequently, temporal shifts in host diet composition or in the availability of infected prey driven by environmental variability, may explain the observed fluctuations in infection levels of these parasite species (Luque et al., 2004, Carpio et al., 2024).

Host characteristics

Mugilids such as *M. curema* play a key role in energy transfer within lagoon ecosystems, as they feed primarily on fine particulate organic matter, microalgae, and components of the micro- and meiofauna, as well as other organic material present in sediments (Trape et al., 2009, Navarrete-Salgado et al., 2017, Salgado-Cruz et al., 2021, Díaz-Gallegos et al., 2026). However, their diet may vary across ontogenetic stages and between climatic seasons within coastal lagoons (Figs. 3, 4), indicating opportunistic feeding behavior. Despite these variations, individuals at juvenile, pre-adult, and adult stages consistently consumed high proportions of organic matter, as indicated by the present results.

Relationship between host body size and infection parameters

Host body size is widely recognized as a key factor influencing the structure of parasite infracommunities (Baia et al., 2018, Villalba-Vásquez et al., 2018, Carpio, 2020, Díaz-Gallegos et al., 2026). In general, parasite abundance tends to increase with host size, as larger individuals consume more food and have longer lifespans, thereby accumulating parasites over time (Sasal et al., 1997, Tavares & Luque, 2008, Villalba-Vásquez et al., 2018). However, the negative correlations observed between host length and the abundance of acanthocephalans such as *N. brentnickoli* and *S. hispida* indicate a decrease in infection levels in larger individuals. Similar negative relationships have been reported in other studies, suggesting that, in some cases, parasite abundance may decline with increasing host size (Iyaji et al., 2009, Villalba-Vásquez et al., 2018, Carpio et al., 2024). Higher infection levels in smaller fish may result from several factors: parasites acquired during early life stages may later be eliminated; dietary differences may expose younger individuals to specific intermediate hosts; or schooling behavior may decrease as fish grow, reducing transmission rates (Luque & Chaves, 1999, Campos et al., 2009, Villalba-Vásquez et al., 2018). In *M. curema*, ontogenetic dietary differences between juvenile and pre-adult individuals may account for the higher abundance of certain endoparasites in smaller fish (Fig. 3).

Characteristics of the component communities

At this level of study, the species richness (7-11 species) and diversity were comparable to values reported for this species in other regions of the Mexican Pacific (7-9 species; Fajer-Avila et

al., 2006, Violante-González & Aguirre-Macedo, 2007, Violante-González et al., 2007). Component communities were consistently dominated numerically by the heterophyid *A. (Ph.) longa* throughout the study period (Table 1). This species has been reported in at least ten fish species from Tres Palos lagoon, with *M. curema* exhibiting the highest infection levels (prevalence = 100%, mean abundance >200 metacercariae; Violante-González et al., 2007). The most pronounced changes in parasite community structure were observed over multi-year intervals (e.g., 2022May–2024Feb), whereas differences between consecutive years within the same season were less marked (Table 4). These findings suggest that parasite communities in *M. curema* may exhibit greater variability over longer temporal scales.

CONCLUSIONS

The hypothesis was supported by the results obtained. The *M. curema* parasite community exhibited significant changes in its structure and species composition; however, no clear pattern of seasonal variation was observed. Although the parasite community is highly dominated by a single species, the remaining species respond differently to the environmental changes generated by the dry-rainy cycle. This climatic cycle is likely to affect the availability of intermediate hosts and drive changes in the feeding behavior of *M. curema* in Tres Palos lagoon. These processes, in turn, can influence the recruitment dynamics of endoparasites transmitted through the ingestion of infected prey.

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AUTHOR CONTRIBUTIONS

J.V.G.: Contributed to the Collection of Fish; J.C.V., A.D.G., Y.G.N., P. J.V.V., E.R.I.: Contributed to the Dissection of Fish and the Collection of Parasites; J.V.G., Y.G.N., E.R.I.: Contributed to the Taxonomic Identification of the Parasites; J.V.G.: Contributed to the Data Analysis; Y.G.N., C.V.C.: Contributed to Some Statistical Analyses and Edited the Figures. J.C.V., A.D.G., J.V.G., P. J.V.V., E.R.I.: Wrote the First Version of the Manuscript. All Authors Contributed to the Revision and Final Editing of the Manuscript.

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