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The first population structure survey of the wood-rasping *Tropichelura gomezi* (Amphipoda: Cheluridae)

Sergio Cházaro-Olvera, Ignacio Winfield, Beatriz Ariadna Martínez-López and Manuel Ortiz

Laboratorio de Crustáceos, Facultad de Estudios Superiores Iztacala, Universidad Nacional Autónoma de México, Estado de México, México

ABSTRACT

Cheluridae represents small marine and shallow amphipods composed of three genera: *Chelura, Nippochelura* and *Tropichelura*. The genera *Tropichelura* has been characterised as stenohaline and active burrowers occurring at around 3 m depth. The goal of the present study was to evaluate the population structure of *Tropichelura gomezi* collected in a few sunken pieces of wood in the Tuxpan Lobos Coral Reef System, south-western Gulf of Mexico. The amphipods were manually removed from the substrate, measured and organised as juveniles, females and males. A total of 710 specimens of *Tropichelura gomezi* were collected, and the juveniles represented the highest portion (37%). Based on Bhattacharya's method, four and five age classes were found for males and females, respectively; using multi-model inference, the males had a maximum length of 6.06 to 6.82 mm, while the length of females was 6.06 to 6.12 mm. The overall sex ratio in this study was 1.47 females per male ($p < .001$). The survival rate was 27.8% for females and 14.9% for males, which corresponds to species characterised as following an 'r' strategy. The results showed a cost–benefit relationship between the population parameters, given a slow growth rate and a greater number of age class es.

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cost–benefit relationship; growth; Peracarida; sex ratio; survival

Introduction

Marine wood borers can live sympatrically by sharing scattered deadwood as food and habitat (Nishimoto *et al*. 2015). This is the case for amphipods in the family Cheluridae (Amphipoda), bivalves in the family Teredinidae (Myida), and isopods in the family Limnoriidae (Isopoda) (Velásquez and Shipway 2018). Their coexistence can be explained because the settlement of the bivalves and colonisation by the isopods do not necessarily depend on biofouling, but the amphipods can only colonise pieces of wood when they have a dense epibiota that includes the isopod (Charles *et al*. 2020). Limnoriid isopods and chelurid amphipods can cause damage to the wooden structures of homes located on the beach (Cookson *et al*. 2012).

Cheluridae are a small group of three genera: *Chelura* Philippi, *Nippochelura* Barnard, and *Tropichelura* Barnard (World Register of Marine Species 2025). Species of *Tropichelura* occur in tropical and subtropical ecosystems, including harbours, bays, and coastline, where they live in excavations in wooden logs together with limnoriid isopods (Barnard 1955; Thomas 1979).

Tropichelura contains two species, *Tropichelura insulae* (Caiman, 1910) and *T. gomezi* Ortiz, 1976, which are characterised by a biramous second uropod and a uniramous third uropod. Chelurid amphipods are gonochoric and sexually dimorphic. During mating, the male detects the pheromone of the female using his antennae. When the female is ready, the male pushes the sperm into the marsupium. A few hours later, the female releases her eggs into the marsupium for fertilisation. The eggs hatch and the juveniles remain in the marsupium for a few days. After 20 moults, they complete their life cycle in one year (Bisby *et al*. 2005).

The only study concerning the population ecology of *T. gomezi* was published by Thomas (1979), who investigated the species as a stenohaline inhabitant in protected coastal bays and other shallow habitats, where they are found about 3 m deep. It is a very active burrower, connecting and enlarging limnoriid burrows into large, unroofed galleries by rasping and furrowing the softer early wood. There is no information about the species' growth and survival.

CONTACT Sergio Cházaro-Olvera schazaro@gmail.com

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Growth and survival are two life history attributes that determine population structure (Kim 2005) and contribute to understanding population dynamics (Simoes *et al*. 2013) of a species. Quantifying growth in crustaceans is complicated because structures are lost with each moult and growth is discontinuous, occurring in a 'stepwise' manner (Chang *et al*. 2012). Length–frequency analyses help resolve the problem of the lack of morphological markers (Gulland and Rosenberg 1992). Mathematical models (Bhattacharya 1967) that separate the various peaks of one length–frequency sample, the peaks being assumed to represent distinct age classes (Pauly 1983), and Von Bertalanffy (VB), Gompertz, logistic, and bent-line growth models (Petriella and Boschi 1997; Hartnoll 2001; Chang *et al*. 2012), are often used to obtain the growth parameters. Recent progress has been made in studying the individual growth of crustaceans. For example, the technique for developing VB growth models of the striped shore crab has been applied to other species of Peracarida, obtaining results based on the environmental conditions where peracarids are found (Mauchline 1976; Somerton 1980; Easton and Misra 1988; Mees *et al*. 1994; Winkler and Greve 2002). However, growth studies of chelurids are still incipient. Therefore, the objective of the present study was to evaluate the population structure, growth, and survivorship of *T. gomezi* from the Tuxpan Lobos Coral Reef System in the south-western Gulf of Mexico.

Materials and methods

The Tuxpan Lobos Coral Reef System is located on the continental shelf off Veracruz State, Mexico, at 21.0143 to 21.552 N and -97.175 to -97.300 W (Figure 1). Sunken wood substrates (about 0.05 m^3) with *T. gomezi* inside were obtained manually by scuba diving between 3 and 25 m depth during in June and July 2011. Identifications and measurements were carried out with a stereomicroscope equipped with a Walfront HD industrial camera free drive 5MP and the ImageView X64 programme with the tool multipoint connection following the curvature of the organism (Chávez and Hidalgo 1988; Figure 1).

Field work

The collected wood pieces were placed in plastic bags with an alcohol/formaldehyde (1:1) solution. The individuals of *Tropichelura gomezi* were separated from the wood and preserved with 70% ethanol. They were then transported to the crustacean laboratory of the Facultad de Estudios Superiores Iztacala, Universidad Nacional Autónoma de México (FESI-UNAM).

Laboratory work

Individuals were examined using a Motic SMZ-168 stereoscopic microscope and a Leica DM750 optical microscope at the crustacean laboratory at FESI-UNAM.

The amphipods were identified and classified into juveniles (no secondary sex characteristics, body size, gnathopod 2 size and the distance between the tip of the telson and the tip of uropod 3), males and females (in females: antennal flagellum 2 setose distally, uropods 1–3 with very long setae, uropod 3 shorter than in males, 4 notches on telson with long terminal setae; oostegites presents on pereopods 2–5) (Thomas 1979). The specimens were measured to determine the total length (from the anterior tip of the face to the posterior tip of the telson) in millimetres. Identifications and measurements were carried out using a stereomicroscope equipped with a Walfront HD industrial camera free drive 5MP and the ImageView X64 program with the tool multipoint connection following the curvature of the organism.

Data analysis

To analyse the growth of *T. gomezi*, the number of age classes and the average length of each age class were obtained using Bhattacharya's (1967) method. The validation of the cohorts was done using the separation index (SI) of Sparre and Venema (1997):

$$1.SI = 2 \times ((Li_1 - Li_2)/(SDi_1 + SDi_2))$$

Figure 1. Location of the sampling zone in the Tuxpan Lobos Coral Reef System.

where Li_1 is the average length of the cohort 1, Li_2 is the average length of the cohort 2, SDi_1 is the standard deviation of cohort 1, SDi_2 is the standard deviation of cohort 2.

The growth parameters maximal length (L_{max}), growth coefficient (K), and the hypothetical age or time when length was equal to zero (t_0) were determined using the multi-model inference (MMI), VB, logistic, Gompertz (Smart *et al*. 2016), and bent-line (Chang *et al*. 2012) growth models:

$$2.L_t = L_{max}\left(1 - e^{-K(t-to)}\right) = \text{vonBertalanffymodel}$$

$$3.L_t = L_{max}e^{-e-K(t-to)} = \text{Gompertzmodel}$$

$$4.L_t = L_{max}/\left(1 + e^{-K(t-to)}\right) = \text{Logisticmodel}$$

$$1muMI = a + bLicLi' = \text{Bent} - \text{Line model}$$

where L_t = length at time or age class t; L_{max} = maximal length; K = growth rate; t_0 = theoretical time when length is zero; MI = moult increment; Li = length of age class; Li' = difference between Li and the length of the preceding age class; and a, b, and c are constants. The means of the results from each model, the standard error, and the residual sum of squares were computed. The best-fit model was selected with Akaike´s information criterion (AIC) (Burnham and Anderson 2002), using the negative logarithm of the maximum-likelihood method (Cerdenares-Ladrón de Guevara *et al*. 2011).

To determine survivorship (S), the exponential model of Ricker (1975) was used, which relates the number of individuals of the modal class (Nt) with the time (t) that represents each modal class, such that Nt = No × (EXP(-zt)), where No is the initial theoretical number of individuals and -z is the mortality rate. The survivorship percentage was obtained as S% = 100 (EXP-z).

To calculate the sex ratio, the following equation was used: males/(males + females) (Chavance *et al*. 1984). For the sex ratio, the Ji quadrate (Chi-square) test was used, considering the hypothesis of equality with the proportions 1:1 (Sokal and Rohlf 2012).

Results

The dimensions obtained for the differentiation in the population structure were the following: the length of gnathopod 2 was 1.37 ± 0.13, 0.99 ± 0.03 and 0.59 ± 0.04 mm in males, females and juveniles, respectively. The distance between the tip of the telson and the tip of uropod 3 was 0.307 ± 0.05, 0.16 ± 0.014 and 0.042 ± 0.005 mm in males, females and juveniles, respectively. A total of 710 specimens of *Tropichelura gomezi* were collected, comprising 262 juveniles (36.9%), 274 females (38.6%, of which 30 individuals were ovigerous) and 174 males (24.5%) (Figure 2).

With the Bhattacharya method the males presented four age classes with sizes of 2.62, 4.64, 5.8 and 6.46 mm. In the analysis among the cohorts of the males there was no overlap (SI, values >2). With the application of the MMI model the Lmax was 6.06 mm. The highest Lmax was found with the VB model (6.82 mm) followed by Gompertz (6.63 mm). The rate of growth had an interval of 0.80 to 1.49 in the VB and logistic model, respectively. The lowest value of t_0 was found with the VB model (0.383) followed by Gompertz (0.91). The four models applied all fit with the observed data (Figure 3); however, the bent-line model had the best fit (with AIC = −31.03; weight = 94.95%) (Table 1).

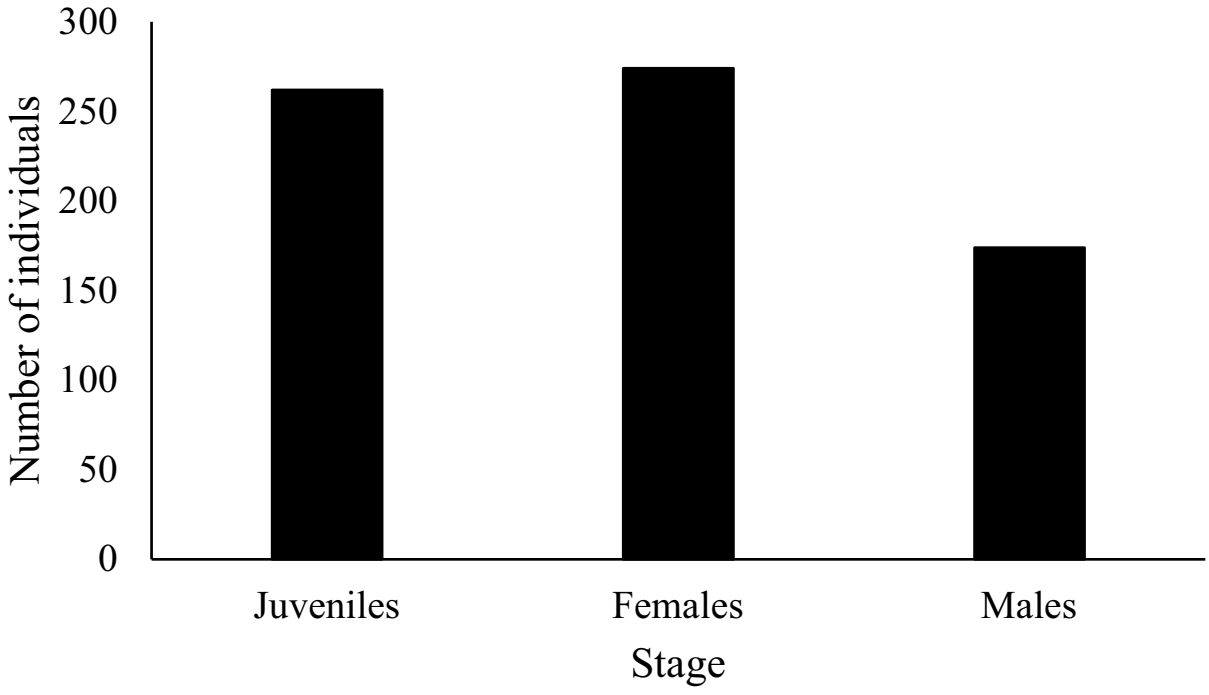

Figure 2. Population structure of *Tropichelura gomezi* in the Tuxpan Lobos Coral Reef System.

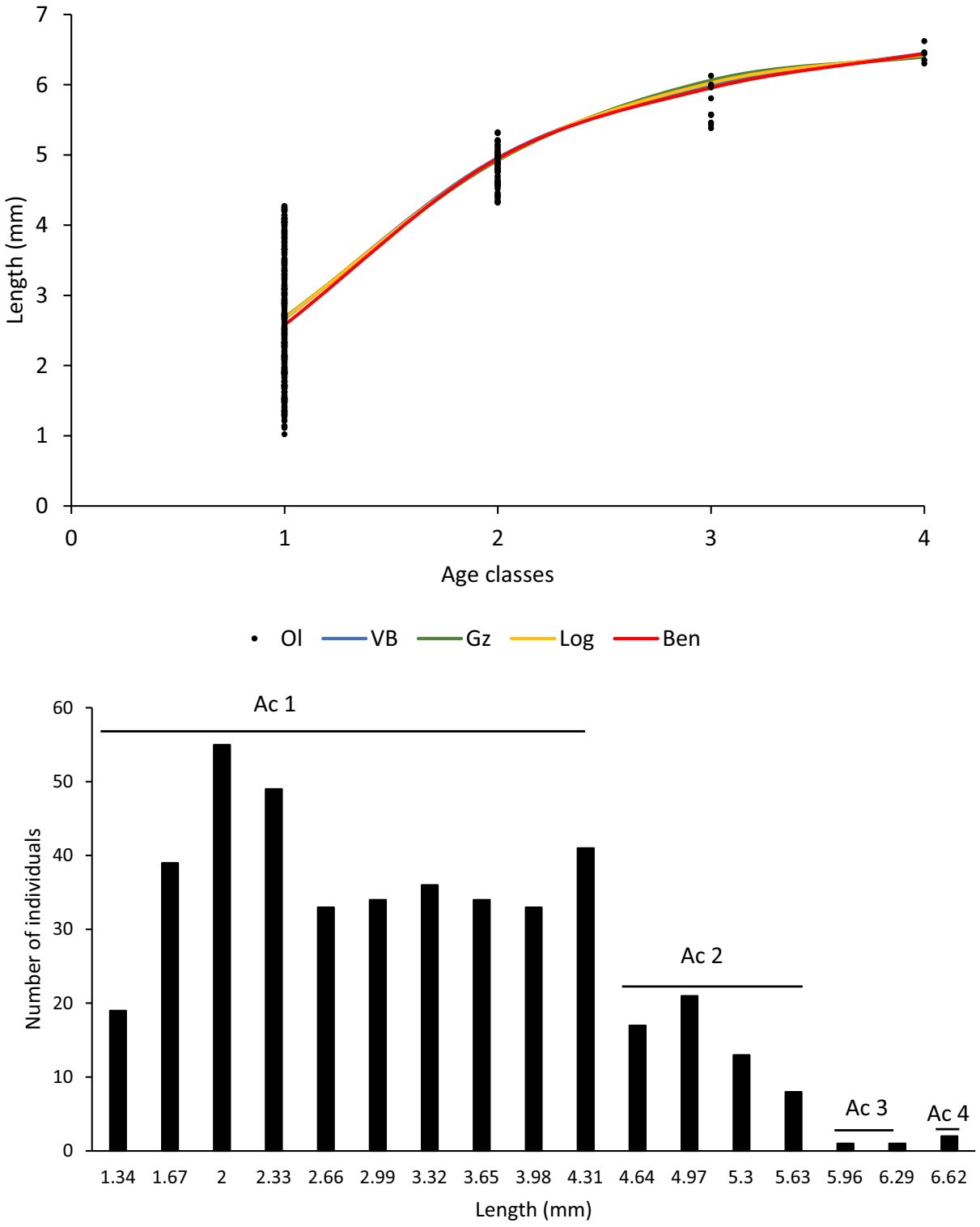

Figure 3. Size frequency distribution (total length, mm) and Von Bertalanffy, Gompertz, logistic, and bent-line growth models for male *Tropichelura gomezi* from the Tuxpan Lobos Coral Reef System. Ac = age class; Ol = observed length; vB = von Bertalanffy; Gz = Gompertz; Log = logistic; Ben = bent-line. Black circle = lengths by age class.

The females presented five age classes with sizes of 2.09, 3.72, 4.53, 5.07 and 5.6 mm. The analysis among the cohorts of the females found no overlap (values >2). With the MMI model the Lmax obtained was 6.06 mm. With the VB model the highest Lmax was found (6.16 mm), followed by Gompertz (5.82) mm. The rate of growth had an interval of 0.47 and 0.98 in the VB and logistic model, respectively. The lowest value of

Table 1. Multi-model inference (MMI), von Bertalanffy, Gompertz, logistic, and bent-line growth models for male *Tropichelura gomezi* collected from the Tuxpan Lobos Coral Reef System and test of fit with the Akaike information criterion method.

Comparison	SI		
Size 1 to size 2	3.24		
Size 2 to size 3	3.03		
Size 3 to size 4	3.03		
Parameter	MMI	SD	
Lmax	6.06	1.29	
	VB		
Lmax	6.82	0.18	
K	0.80	0.09	
t0	0.38	0.07	
RSS	0.15		
	Logistic		
Lmax	6.50	0.11	
K	1.49	0.12	
t0	1.27	0.04	
RSS	0.26		
	Gompertz		
Lmax	6.63	0.13	
K	1.13	0.10	
t0	0.91	0.04	
RSS	0.22		
	Bent-line		
A	3.69	0.09	
B	0.46	0.02	
C	−0.03	0.02	
RSS	0.05		
AIC			
Model	AIC	AIC diff	Weight
Bent-line	−31.03	0	94.95
Logistic	−23.42	7.61	2.11
Von Bertalanffy	−22.83	8.12	1.58
Gompertz	−22.54	8.49	1.37

AIC = Akaike´s information criterion; A, B, C, constants of the Bent-Line model; K = growth rate; Lmax = maximal length; RSS = Residual Sum of Squares; SD = standard deviation; SI = separation index; t0 = hypothetical age or time when length was equal to zero..

t_0 was found with the Gompertz model (0.01), followed by the ogistic model (0.46). As for the males, the four models fit with the observed data (Figure 4); however, the bent-line model had the best fit with the observed data of the females (AIC = −25.79; weight = 53.93%) (Table 2).

The sex ratio in this study was 1.47 females per male, which showed statistically significant differences ($X_2 = 15.29$, $p < .001$) from the hypothesis of a proportion of 1:1. The mortality rate for females was −1.33, corresponding to a 26.4% survival rate (Figure 5(a)). The mortality rate for males was −1.91, corresponding to a 14.85% survival rate (Figure 5(b)). The negative exponential relationship between the number of the age class and the number of individuals was statistically significant ($p < .001$).

Discussion

In population ecology, it is important to determine the life history of a species as well as its development, reproduction, storage and growth (Begon *et al*. 2006). The individual growth of crustaceans is discontinuous, given the rigid conformation of their exoskeleton (Scarfe and Steele 2019). However, using a frequency distribution across sizes, the age classes can be obtained by indirect methodologies (Bhattacharya 1967; Cházaro-Olvera *et al*. 2017).

After determining the age classes, the maximum size and growth speed can be calculated with mathematical models, such as that of von Bertalanffy (Hartnoll 2001). The most studied and commonly applied model among all the length–age models is the VB growth model, which has been applied to other peracarid species, because its results are related to environmental conditions (Cházaro-Olvera and Peterson 2004; Jelassi *et al*. 2014; Alegretti *et al*. 2016; Bastos-Pereira and Bueno 2016; Castiglioni *et al*.

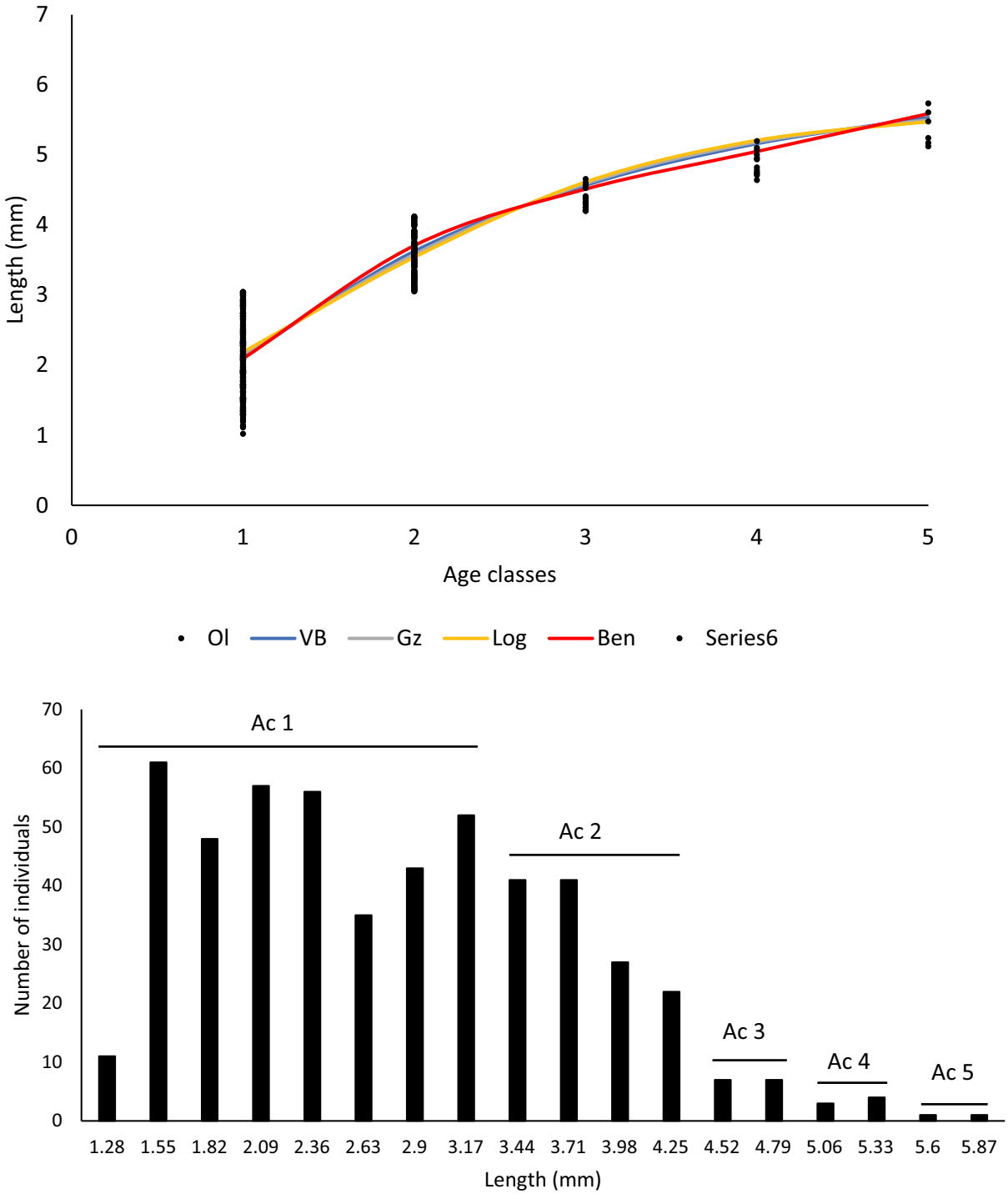

Figure 4. Size frequency distribution (total length, mm) and the Von Bertalanffy, Gompertz, logistic, and bent-line growth models for female *Tropichelura gomezi* from the Tuxpan Lobos Coral Reef System. Ac = age class; Ol = observed length; VB = von Bertalanffy; Gz = Gompertz; Log = logistic; Ben = bent-line. Black circle = lengths by age class.

2016; Medeiros and Weber 2016; Cházaro-Olvera *et al*. 2017), However, other commonly used alternatives are the Gompertz model and the logistic model. On the other hand, MMI has been used recently to obtain more robust inferences about the average parameters of a population, such as the maximal length (Katsanevakis 2006). Many models have been generated based on different biological principles and types of data available. Chang *et al*. (2012) found that the best model for crustaceans was fitting separate lines to post-moult and pre-moult as proposed by Somerton (1980); this is known as the bent-

Table 2. Multi-model inference (MMI), von Bertalanffy, Gompertz, logistic, and bent-line growth models for female *Tropichelura gomezi* collected from the Tuxpan Lobos Coral Reef System and test of fit with the Akaike information criterion method.

	SI		
Size 1 to size 2	3.21		
Size 2 to size 3	3.03		
Size 3 to size 4	2.83		
Size 4 to size 5	2.83		
	MMI		
Lmax	6.06	1.29	
Parameter	Von Bertalanffy	SD	
Lmax	6.16	0.23	
k	0.47	0.06	
t0	2.12	0.08	
RSS	0.24		
	Logistic		
Lmax	5.65	0.15	
K	0.98	0.07	
t0	0.46	0.10	
SSE	0.19		
	Gompertz		
Lmax	5.82	0.17	
K	0.72	0.08	
to	0.01	0.06	
RSS	0.32		
	Bent-Line		
A	1.69	0.36	
B	0.73	0.07	
C	−0.49	0.26	
RSS	0.11		
AIC			
Model	AIC	AIC diff	Weight
Bent-line	−25.79	0	53.93
Logistic	−24.53	1.26	28.74
Von Bertalanffy	−22.83	2.96	12.29
Gompertz	−21.04	4.74	5.03

AIC = Akaike´s information criterion; A, B, C, constants of the Bent-Line model; K = growth rate; Lmax = maximal length; RSS = Residual Sum of Squares; SD = standard deviation; SI = separation index; t0 = hypothetical age or time when length was equal to zero.

line growth model. We found that the three non-linear models fit the data well. However, based on AIC analysis, the bent-line model presented the best fit, so it was possible to calculate the moult increments of male and female of *T. gomezi*.

The largest proportion of the collected population of *T. gomezi* was composed of juveniles and females. Juveniles comprised the highest percentages of population of the amphipods *Nototropis minikoi* (Walker, 1905) and *Ampithoe longimana* Smith, 1873 (Cházaro-Olvera *et al.* 2021). The isopod *Limnoria platycauda* Menzies, 1957 also occurs in marine wood burrows (Ortiz *et al*. 2013). Menzies and Glynn (1968) reported that the males of this species have a length of 2.3 mm, which is similar to the size of *T. gomezi* juveniles. This suggests that there may be competition for space, which may be reflected in a lower percentage of juveniles of *T. gomezi* in our sample. Thiel (1999, 2003) mentioned that it is common to see intraspecific and interspecific competition for space within and between species of amphipods that habit the same maternal burrow, and this may lead to a decrease of juvenile numbers (Thiel 2003).

Growth analyses using frequency methods have been applied in other amphipod species, such as *N. minikoi* (Cházaro-Olvera *et al*. 2017, 2021), *A. longimana* (Cházaro-Olvera *et al*. 2021) and *Ericthonius fasciatus* (Stimpson 1853) (Collie 1985). Thus, it was possible to apply this methodology in *T. gomezi*, where the Lmax obtained in this study for females was similar to the value in the original description by Ortiz (1976). Regarding the frequency methods, the males of *T. gomezi* were grouped into four age classes. However, five age classes of females were obtained, because females had a lower growth rate. The first female age class had an average of 2.7 mm, which corresponds to the juvenile stage, before sexual maturity. Some chelurids,

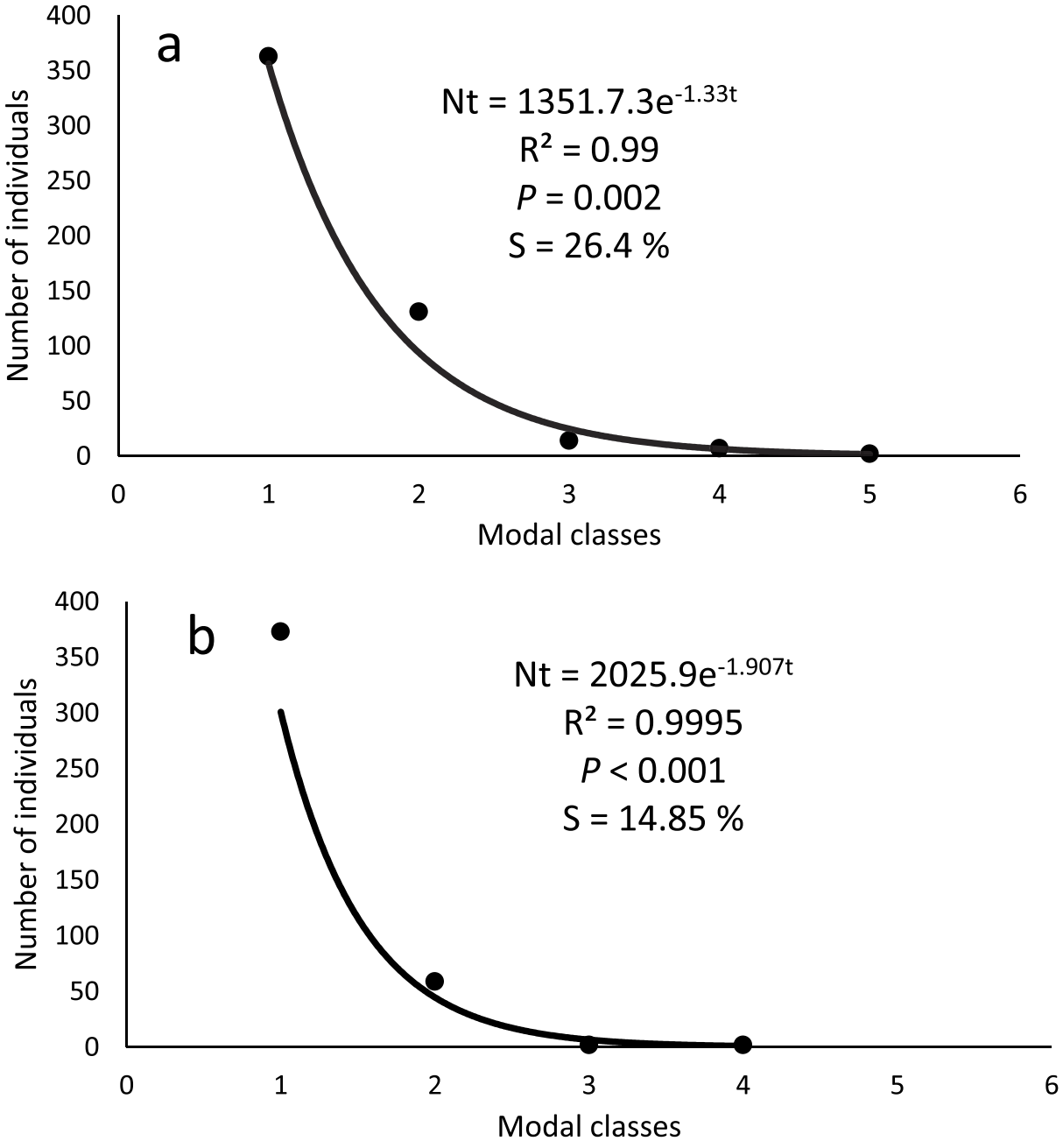

Figure 5. Mortality rates of *Tropichelura gomezi*. Relationship between age classes and the number of individuals collected from the Tuxpan Lobos Coral Reef System: (a) females; (b) males.

such as *Chelura terebrans* Philippi, 1839, mature at about 3.5 mm (Becker 1971), a size that corresponds to the second age class of *T. gomezi* (3.4 mm). Also, some species of amphipods have about nine adult moults, some of which could fall into the same age class. In our study of *T. gomezi*, four sizes (3.3, 3.6, 3.9, and 4.1 mm) were grouped in the second age class, two sizes (4.39 and 4.66 mm) in the third age class, two sizes (4.9 and 5.2 mm) in the fourth age class, and two sizes (5.5 and 5.7 mm) in the fifth age class.

The growth rates (K) of *T. gomezi*, as determined by the VB model, were 0.3 for females and 0.6 for males. The growth rates are consistent with those of other amphipod species, such as *Charcotia obesa* Chevreux, 1906, *N. minikoi*, *A. longimana*, *Bovallia gigantea* Pfeffer, 1888, and *Gammarus wilkitzki* Birula, 1897, which had K values between 0.20 and 0.67 (Bone 1972; Poltermann 2000; Bluhm *et al*. 2001; Cházaro-Olvera *et al*. 2017).

Low growth rates are related to low temperatures of the environment (Bone 1972). Therefore, *T. gomezi* has a higher growth rate than that of species from temperate climates. In the present study, the sex ratio obtained for *T. gomezi* was skewed towards females. In other amphipods, higher growth rates, early maturation, differential longevity rates, and predation can all result in skewed sex ratios (Prato and Biandolino 2006). The survival curves for *T. gomezi* were type III for males and females, showing a relatively high mortality rate in the initial stages and a later decline) (Pianka 2000). Thus, a population strategy that produces many offspring with low survival rates when mortality is catastrophic and independent of density tends towards an 'r' strategy (Begon *et al*. 2006), which is consistent with what we observed in our study of *T. gomezi*. Based on survival analysis, *T. gomezi* showed an 'r' strategy, with low survival rate in the initial growth stages.

In summary, this work has provided more information on the *T. gomezi* population. Having analysed their sizes, the four age classes presented here for males are consistent with other amphipod species. An intermediate growth rate was observed compared to that reported in other amphipod species. The total length obtained for *T. gomezi* was similar to that found by other authors. Based on survival analysis, *T. gomezi* showed an 'r' strategy, with low survival rate in the initial growth stages.

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ORCID

Sergio Cházaro-Olvera http://orcid.org/0000-0002-0667-0043
Ignacio Winfield http://orcid.org/0000-0003-3937-7772
Beatriz Ariadna Martínez-López http://orcid.org/0009-0003-8906-0519
Manuel Ortiz http://orcid.org/0000-0003-4969-021X

References

Alegretti L, Umbuzeiro G, Flynn M. 2016. Population dynamics of *Parhyale hawaiensis* (Dana, 1853) (Amphipoda: Hyalidae) associated with an intertidal algal belt in southeastern Brazil. J Crustac Biol. 36(6):785–791. doi: 10.1163/1937240x-00002480.

Barnard JL. 1955. The wood boring habits of *Chelura terebrans* Philippi in Los Angeles harbor. In: Essays in the natural sciences in honor of Captain Allan Hancock. Los Angeles: Allan Hancock Foundation, University of Southern California; p. 87–95.

Bastos-Pereira R, Bueno AAP. 2016. Reproductive biologyand egg production of *Hyalella longistila* (Faxon, 1876) (Amphipoda: Hyalellidae), a freshwater amphipod insoutheastern Brazil. J Crustac Biol. 36(5):724–730. doi: 10.1163/1937240x-00002465.

Becker G. 1971. On the biology, physiology, and ecology of marine wood-boring crustaceans. In: Gareth J, and Eltringham S, editors. Brussels; p. 303–326.

Begon M, Harper JL, Townsend CR. 2006. Ecology. From individuals to Ecosystems. Fourth ed. Malden (Massachusetts, USA): Willey Blackwell Publishing Ltd.

Bhattacharya CG. 1967. A simple method of resolution of a distribution into Gaussian components. Biometrics. 23 (1):115–135. doi: 10.2307/2528285.

Bisby FA, Ruggiero MA, Wilson KL, Cachuela-Palacio M, Kimani SW, Roskov YR, Soulier-Perkins A, van Hertum J 2005. Species 2000 & ITIS catalogue of life: 2005 annual checklist. Reading (U.K): CD-ROM; Species 2000. [accessed 2025 April 09]. https://www.sealifebase.se/country/CountrySpeciesSummary.php?c_code=084&id=19818&lang=english

Bluhm BA, Brey T, Klages M. 2001. The autofluorescent age pigment lipofuscin: key to age, growth, and productivity of the Antarctic amphipod *Waldeckia obesa* (Chevreux, 1905). J Exp Mar Biol Ecol. 258(2):215–235. doi: 10.1016/s0022-0981(01)00214-3.

Bone DG. 1972. Aspects of the Antarctic amphipod *Bovallia gigantea* Pfeffer at Signy Island. Br Antarct Surv Bull. 27:105–122.

Burnham KP, Anderson DR. 2002. Model selection and multimodel inference. New York: Springer.

Castiglioni DS, Ozga AV, Rodrigues SG, Bueno AAP. 2016. Population dynamics of a freshwater amphipod from South America (Crustacea, Amphipoda, Hyalellidae). Nauplius. 24:1–9. doi: 10.1590/2358-2936e2016028.

Cerdenares-Ladrón de Guevara G, Morales-Bojórquez E, Rodríguez R. 2011. Age and growth of the sailfish *Istiophorus platypterus* (Istiophoridae) in the Gulf of Tehuantepec, Mexico. Mar Biol Res. 7(5):488–499. doi: 10.1080/17451000.2010.528201.

Chang Y, Sun C, Chen Y, Yeh S. 2012. Modelling the growth of crustacean species. Rev Fish Biol Fish. 22(1):157–187. doi: 10.1007/s11160-011-9228-4.

Charles F, Riera P, Sauriau PG, Lantoine F, Lebreton B, Agogué H, Hourdez S. 2020. Trophic niche partitioning in marine wood-borers revealed by stable isotope analysis. Aquat Biol. 29:33–43. doi: 10.3354/ab00723.

Chavance P, Flores-Hernández D, Yáñez-Arancibia A, Amezcua-Linares F. 1984. Ecología, biología y dinámica de las poblaciones de *Bairdiella chrysoura* en la Laguna de Términos, Sur del Golfo de México. (Pisces: scianidae). An Inst Cienc Mar Y Limnol. 11(1):123–162.

Chávez EA, Hidalgo V. 1988. Los arrecifes coralinos del Caribe noroccidental y Golfo de México en el contexto socioeconómico. An Inst Cienc Mar Y Limnol. 15:167–175.

Cházaro-Olvera S, García-Delgado X, Winfield I, Ortiz M. 2017. A population study of the amphipod *Nototropis minikoi* (Gammaridea, Atylidae) in the Sian Ka'an Biosphere Reserve, Quintana Roo, Mexico. Crustaceana. 90(3):337–348. doi: 10.1163/15685403-00003655.

Cházaro-Olvera S, Ortiz M, Winfield I, Viveros-Villaseñor B. 2021. Parámetros poblacionales de *Nototropis minikoi* y *Ampithoe longimana* (Crustacea: Amphipoda) en dos Islas del Mar Caribe mexicano. Rev Biol Mar Y Ocean. 56 (1):1–12. doi: 10.22370/rbmo.2021.56.1.2794.

Cházaro-Olvera S, Peterson MS. 2004. Effects of salinity on growth and molting of sympatric *Callinectes* spp. from Camaronera lagoon, Veracruz, Mexico. Bull Mar Sci. 74(1):115–127.

Collie J. 1985. Life history and production of three amphipod species on Georges Bank. Mar Ecol Prog Ser. 22:229–238. doi: 10.3354/meps022229.

Cookson LJ, Cragg SM, Hendy IW. 2012. Wood-boring limnoriids (Crustacea, Isopoda) including a new species from mangrove forests of the Tukang Besi Archipelago, Indonesia. Zootaxa. 3248(1). doi: 10.11646/zootaxa.3248.1.2.

Easton MDL, Misra RK. 1988. Mathematical representation of crustacean growth. ICES J Mar Sci. 45(1):61–72. doi: 10.1093/icesjms/45.1.61.

Gulland JA, Rosenberg AA. 1992. A review of length-based approaches to assessing fish stocks 323. FAO Fish Tech Pap.

Hartnoll RG. 2001. Growth in Crustacea: twenty years on. Hydrobiologia. 449(1–3):111–122. doi: 10.1023/A:1017597104367.

Jelassi R, Fadhel Bouslama M, Khemaissia H, Nasri-Ammar K. 2014. Population structure and dynamics of *Orchestia montagui* (Crustacea: Amphipoda) in the Bizerte lagoon (northern Tunisia). Ital J Zool. 82(1):101–111. doi: 10.1080/11250003.2014.966163.

Katsanevakis S. 2006. Modelling fish growth: model selection, multi-model inference and model selection uncertainty. Fish Res. 81(2–3):229–235. doi: 10.1016/j.fishres.2006.07.002.

Kim S. 2005. Population structure, growth, mortality, and size at sexual maturity of *Palaemon gravieri* (Decapoda: Caridea: Palaemonidae). J Crustac Biol. 25(2):226–232. doi: 10.1651/c-2510.

Mauchline J. 1976. The Hiatt growth diagram for crustacea. Mar Biol. 35(1):79–84. doi: 10.1007/bf00386676.

Medeiros BT, Weber LI. 2016. Aspects of the reproductive biology of the freshwater/brackish amphipod *Quadrivisio lutzi* (Crustacea, Amphipoda) from an unstable coastal lagoon of Southeastern Brazil. Nauplius. 24:1–12. doi: 10.1590/2358-2936e2016003.

Mees J, Abdulkerim Z, Hamerlynck O. 1994. Life history, growth and production of *Neomysis integer* in the *Westerschelde estuary* (SW Netherlands). Mar Ecol Progr Ser. 109:43–57. doi: 10.3354/meps109043.

Menzies RJ, Glynn PW. 1968. The common marine isopod crustacea of Puerto rico: a handbook for marine biologists. Stud on the Fauna of Curacao and Other Caribb Islands. 27(104):1–133.

Nishimoto A, Haga T, Asakura A, Shirayama Y. 2015. An experimental approach for understanding the process of wood fragmentation by marine wood borers in shallow temperate waters. Mar Ecol Prog Ser. 538:53–65. doi: 10.3354/meps11454.

Ortiz M. 1976. Un nuevo Anfipodo perforador de Madera (Amphipoda, Gammaridea, Cheluridae) de Aguas Cubanas. Ciencias Ser 8, Inv Marinas. 27:21–26.

Ortiz M, Winfield I, Cházaro-Olvera S, Río B, Aburto M. 2013. Isópodos (Crustacea: Peracarida) del Área Natural Protegida Arrecife Tuxpan-Lobos, Veracruz, México: lista de especies y registros nuevos. Novitates Caribaea. 6:63–75. doi: 10.33800/nc.v0i6.108.

Pauly D. 1983. Some simple methods for the assessment of tropical fish stocks. FAO Fish Tech Pap. 234:52.

Petriella AM, Boschi EE. 1997. Crecimiento en crustáceos decápodos: resultados de investigaciones realizadas en Argentina. Invest Marinas. 25:135–157. doi: 10.4067/s0717-71781997002500010.

Pianka ER. 2000. Evolutionary ecology. San Francisco (USA): Addison Wesley Longman. EUA.

Poltermann M. 2000. Growth, production, and productivity of the Arctic sympagic amphipod *Gammarus wilkitzkii*. Mar Ecol Prog Ser. 193:109–116. doi: 10.3354/meps193109.

Prato E, Biandolino F. 2006. Life history of the amphipod *Corophium insidiosum* (Crustacea: Amphipoda) from Mar Piccolo (Ionian Sea, Italy). Sci Marina. 70(3):355–362. doi: 10.3989/scimar.2006.70n3355.

Ricker WE. 1975. Computation and interpretation of biological statistics of fish populations. Bull. Fish Res Bd Can. 191:1–382.

Scarfe AD, Steele CW. 2019. Theoretical considerations in determining allometric growth within instars of crustaceans, with special reference to *Americamysis bahia*. J Exper Zool Part A. 331(9):467–477. doi: 10.1002/jez.2313.

Simoes SM, D'incao F, Franzoso A, Castilho AL, Da Costa RC. 2013. Sex ratio, growth and recruitment of the pelagic shrimp *Acetes americanus* on the southeastern coast of Brazil. J Crustac Biol. 33(1):1–9. doi: 10.1163/1937240x-00002108.

Smart JJ, Chin A, Tobin AJ, Simpfendorfer CA. 2016. Multimodel approaches in shark and ray growth studies: strengths, weaknesses and the future. Fish and Fish. 17:955–971. doi: 10.1111/faf.12154.

Sokal RR, Rohlf FJ. 2012. Biometry: the principles and practice of statistics in biological research. New York (USA): WH Freeman, New York.

Somerton DA. 1980. Fitting straight lines to hiatt growth diagrams: a re-evaluation. ICES J Mar Sci. 39(1):15–19. doi: 10.1093/icesjms/39.1.15.

Sparre P, Venema SC. 1997. Introducción a la evaluación de recursos pesqueros tropicales. Parte 1. FAO. Manual. Documento técnico de pesca. No 306 1 Rev. 2:420.

Thiel M. 1999. Duration of extended parental care in marine amphipods. J Crust Biol. 19(1):60–71. doi: 10.1163/193724099x00259.

Thiel M. 2003. Extended parental care in crustaceans an update. Rev Chilena Hist Nat. 76:205–218. doi: 10.4067/s0716-078x2003000200007.

Thomas JD. 1979. A Redescription of the Wood-Rasping Amphipod *Trophichelura gomezi* Ortiz, 1976 (Cheluridae) from the Florida Keys, with Notes on its Distribution and Ecology. Proc Biol Soc Wash. 4:863–872.

Velásquez M, Shipway JR. 2018. A new genus and species of deep-sea wood-boring shipworm (Bivalvia: Teredinidae) *Nivanteredo coronata* n. sp. from the Southwest Pacific. Mar Biol Res. 14(8):806–815. doi: 10.1080/17451000.2018.1544421.

Winkler G, Greve W. 2002. Laboratory studies of the effect of temperature on growth, moulting and reproduction in the co-occurring mysids *Neomysis integer* and *Praunus flexuosus*. Mar Ecol Prog Ser. 235:177–188. doi: 10.3354/meps235177.

WoRMS Editorial Board. 2025. World Register of Marine Species. VLIZ; [accessed 2025 Apr 09. https://www.marinespecies.org.