Oceanological and Hydrobiological Studies

International Journal of Oceanography and Hydrobiology

Volume 50, No. 3, September 2021
pages (269-277)

sciendo

ISSN 1730-413X
eISSN 1897-3191

Growth parameters of *Poecilia latipinna* (Lesueur, 1821) (Actinopterygii, Poeciilidae) – an introduced species in brackish water of Wadi Al-Bahayes (Oman)

by

Salim Serkan Güçlü[1,*],
Saud M. Al Jufaili[2],
Laith A. Jawad[3]

DOI: **10.2478/oandhs-2021-0023**
Category: **Original research paper**
Received: **February 16, 2021**
Accepted: **April 2, 2021**

[1]*Isparta University of Applied Sciences, Faculty of Eğirdir Fisheries, Basic Sciences Department, Inland Water Biology Division, 32260 East Campus, Isparta, Turkey*

[2]*Sultan Qaboos University, Department of Marine Science and Fisheries, P.O. Box 34, Al-Khod 123, Sultanate of Oman*

[3]*School of Environmental and Animal Sciences, Unitec Institute of Technology, 139 Carrington Road, Mt Albert, Auckland 1025, New Zealand*

* Corresponding author: salimguclu@isparta.edu.tr

Abstract

This work is one of the first studies on the growth of *Poecilia latipinna* outside its natural habitat. The objective of our study was to investigate the growth parameters of the population of *P. latipinna*, which is an alien species in Oman (Wadi Al-Bahayes). The population structure of *P. latipinna* in Wadi Al-Bahayes (Oman; 23°40'47"N; 58°11'36"E) was studied in June and August 2020, using 124 fish. In the course of this study, the number of individuals of each sex, age, weight and size composition were determined. In addition, the total length–weight relationship (LRW) was calculated, as well as the von Bertalanffy growth equation. The mean growth performance (phi prime) and the condition factor were calculated. Males accounted for 37.10% and females for 62.90% of the population. The length–weight relationship and the von Bertalanffy growth equation were $W = 0.0214 \times L^{2.7889}$ $R^2 = 0.9212$, $Lt = 11.46\ (1 - e^{-0.127\ (t + 2.71)})$ for males and $Lt = 14.51\ (1 - e^{-0.072\ (t + 3.98)})$ for females. The mean growth performance and the condition factor were calculated as 1.22 for males and 1.18 for females and 1.54 for all specimens.

The study shows that the population of the species is characterized by a wide age range. Consequently, monitoring of this alien species is highly recommended.

Key words: Arabian Peninsula, alien species, sailfin molly, growth, LRW parameters

1. Introduction

Poecilia is one of the genera that occupies an important place in the aquarium trade worldwide, is used in biological control of insects and as a source of protein, and is distributed to many countries around the world (Al Jufaili & Jawad 2020). The genus *Poecilia* is represented by 40 valid species native to the Americas; some species in this genus are euryhaline (Al Jufaili & Jawad 2020). *Poecilia latipinna* is native to the southeastern US and southern Mexico, but due to its wide environmental tolerance (Nunes et al. 2015) and popularity as an aquarium fish, *P. latipinna* has been widely introduced (Al-Faisal & Abdullah 2014) and has established breeding populations in most countries. In their native range, sailfin mollies are common in ponds, marshes, roadside ditches, and thrive under poor water quality conditions (Al Jufaili & Jawad 2020). The sailfin molly is a small species, rarely exceeding 12.5 cm in length, but can sometimes reach 15 cm in length (Abu El-Regal & Al-Solami 2020). Several countries have reported adverse ecological effects of *P. latipinna* following its introduction (Smith 1997). To date, the sailfin molly has been introduced in 29 countries located mainly in Asia, Oceania, Central and South America. The only record from Europe has been reported from a brackish geothermal lagoon (Lake Vouliagmeni near Athens) in Greece (Koutsikos et al. 2017). In Asia, the species has been introduced to some countries in the Middle East. It has been reported from Al-Hammar Marsh in Iraq (Hussain et al. 2009), estuaries in the Gulf of Oman (Randall 1995; Al Jufaili & Jawad 2020), Iran (Sabet 2018), Saudi Arabia (first record comes from Ank from 1983), the Wadi Haneefah Stream, Riyadh (Al-Akel et al. 2010), and Lake Manzala in Egypt (Abu El-Regal & Al-Solami 2020). Al-Jufaili et al. (2010) reported the presence of this species in inland waters of Oman, but no locality was assigned to this record, which is considered incomplete. However, Al Jufaili & Jawad (2020) reported the occurrence of *P. latipinna* in two freshwater localities (Wadi Al-Bahayes and Al-Amirat) and reported the first record from Oman in their study.

Although the potential impact of the sailfin molly on the aquatic life in Wadi Al-Bahayes may seem insignificant at first glance, it is important to the fish fauna there due to the introduction of new species, predation, competition, habitat and genetic changes, and the emergence of parasites and diseases. Research is needed to obtain basic information about the population of the sailfin molly, as well as the causes of introduction of the species and its effects on local and endemic fish communities in Wadi Al-Bahayes.

There are very few studies on breeding and feeding characteristics (Al-Ghanim 2005; Alkahem et al. 2007; Al-Akel et al. 2010) and growth parameters of sailfin mollies (Klassen et al. 2004; Morris 2005; dan Hasnidar 2019) in the natural environment, and among them there is no study on their population in Oman. Such data are lacking from Oman and could be useful for management of this invasive species. The sailfin molly is a robust species that shows great plasticity in its life cycle. Due to the fact that this species is currently well established in Omani waters, an assessment of its impact and ecological role is indeed worthwhile and necessary. Therefore, the objective of our study was to investigate the growth parameters of the *P. latipinna* population in Wadi Al Bahayes, where the species was recorded for the first time in Oman. The present study represents the first step in that direction.

2. Materials and methods

The care of experimental animals was in compliance with the Animal Welfare Law issued by the Sultanate of Oman, as well as other guidelines and policies approved by the Sultan Qaboos University Animal Ethics Committee (Project name: Omani Freshwater Fish, Classification and Biology – permit reference number: SQU/AEC/2020-2021/2).

The study was carried out in Wadi Al-Bahayes (Oman; 23°40′47″N; 58°11′36″E; Fig. 1). Wadi Al-Bahayes is a densely vegetated flat brackish water body. Sampling was carried out in June and August 2020 using a hand net-fish trap and a crab net baited with bread. A total of 124 individuals were caught from Wadi Al-Bahayes (Fig. 2). The fish species *Aphaniops stoliczkanus* and *Cryptocentroides arabicus* were found at the same locality. They are endemic to the Arabian Peninsula. Specimens were measured to the nearest 0.01 cm (total length, TL) and weighted to the nearest 0.01 g (total weight, W). The age was determined from scales taken from the left side of the body, between the end of the pectoral fin and the beginning of the dorsal fin.

The distribution of females and males was determined according to age. The overall ratio of males to females was estimated using χ^2 (0.05) test (Düzgüneş et al. 1995). Total length (in cm) and weight (in g) frequency distribution for all specimens was calculated. The relationship between weight and total length was determined using the exponential regression equation $W = a \times TL^b$, where W is the body weight in g, TL is the total length in cm, "a" is the intercept and "b" is the regression coefficient. The coefficient of determination (R^2) was also estimated (Ricker 1975). The growth of the *P. latipinna* population

Figure 1

Sampling area – Wadi Al-Bahayes in Oman (photo by Dr. Saud Al Jufaili)

was estimated using the following von Bertalanffy growth equation: $Lt = L\infty\ (1 - e^{-k\ (t - to)})$, where Lt is the total length in cm at age "t", L∞ is the average asymptotic length in mm, k is the body growth coefficient, "to" is the hypothetical age, and "a" and "b" are constants (Le Cren 1951). The measured and calculated (von Bertalanffy growth equation) total length was evaluated by t test (0.05). Average growth performance (Ø', phi prime) was calculated using the following formula $Ø' = \text{Log } k + 2 \times \text{Log } L\infty$ (Gayanilo et al. 1988). Fulton's coefficient of the condition factor was calculated by $Cf = (W/TL^3) \times 100$ (Sparre & Venema 1992).

3. Results

The age of the fish ranged from 1 to 4 years. The dominant age groups were I and II (Table 1). Of the total fish examined, 46 (37.10%) were males and 78 (62.90%) were females. The overall ratio of males to females was 0.59:1.00 and χ^2 analysis showed that it

Figure 2

Poecilia latipinna, Wadi Al Bahayes (Oman), 49.6 mm SL ♂, 50.6 mm SL ♀ (photo by Dr. Salim Serkan Güçlü)

was significant ($p < 0.05$; Table 2). The distribution of total length classes by age is shown in Table 2, and the frequency distributions of total length and total weight are shown in Figure 3. The total length ranged from 3.70 to 7.50 cm (Table 2). The body weight range was 0.77–4.81 g (Fig. 3).

The following von Bertalaffy growth equations were obtained for males $Lt = 11.46\ [1 - e^{-0.127\ (t + 2.71)}]$ and females $Lt = 14.51\ [1 - e^{-0.072\ (t + 3.98)}]$ (Fig. 4). The differences between the observed and expected total lengths were statistically not significant in all age groups (t test, $p > 0.05$; Table 3). Average growth performance (Ø', phi prime) was 1.22 for males and 1.18 for females.

Total length–weight relationships were calculated for females, males and all *P. latipinna* specimens. Length–weight relationships are presented in Fig. 5. The estimated values of parameter b in the length–weight relationships were 2.5907 (males),

Table 1

Age and sex distribution for females (F), males (M) and all *P. latipinna* specimens from Oman (N – Number of samples, N% – Percent of samples)

Age	Females		Males		All		M:F
	N	%N	N	%N	N	%N	
1	37	29.84	24	19.35	61	49.19	0.65:1.00 ($p < 0.05$)
2	28	22.58	12	9.68	40	32.26	0.43:1.00 ($p < 0.05$)
3	11	8.87	4	3.23	15	12.10	0.36:1.00 ($p < 0.05$)
4	2	1.61	6	4.84	8	6.45	3.00:1.00 ($p < 0.05$)
∑	78	62.90	46	37.10	124	100	0.59:1.00 ($p < 0.05$)

Table 2

Size and age composition for females (F) and males (M) of *P. latipinna*

Age class	I		II		III		IV		Total
Total length (cm)	♀	♂	♀	♂	♀	♂	♀	♂	
3.70–4.20	9	8							17
4.21–4.70	26	11							37
4.71–5.20	2	5	21	5					33
5.21–5.70			7	7	1				15
5.71–6.20					10	4	1	1	16
6.21–6.70							1	3	4
6.71–7.20								1	1
7.21–7.70								1	1
∑	37	24	28	12	11	4	2	6	124
TL ± sd (min.–max)									
♀	4.44 ± 0,04 (3.70–4.78)		5.13 ± 0.03 (4.83–5.56)		5.81 ± 0.02 (5.61–5.99)		6.41 ± 0.17 (6.16–6.66)		4.93 ± 0.06 (3.70–6.66)
♂	4.34 ± 0.07 (3.70–4.79)		5.20 ± 0.04 (4.99–5.45)		5.93 ± 0.02 (5.85–5.99)		6.61 ± 0.19 (6.15–7.50)		5.00 ± 0.12 (3.70–7.50)

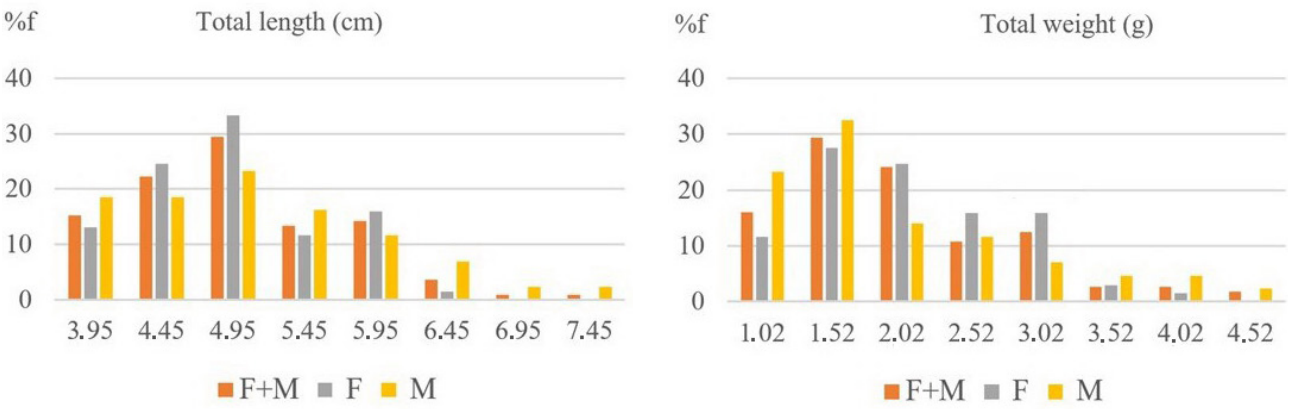

Figure 3

Total length and weight in frequency distributions for *P. latipinna* in Oman (F = females, M = males, F + M = all specimens)

Table 3

Measured and calculated average total length values for each age in the von Bertalanffy growth equation

Age (Year)	Observed average length (cm)	Expected average length (cm)	t test
1	4.34 ♂ 4.44 ♀	4.30 ♂ 4.37 ♀	$p > 0.05$
2	5.20 ♂ 5.13 ♀	5.15 ♂ 5.07 ♀	$p > 0.05$
3	5.93 ♂ 5.81 ♀	5.91 ♂ 5.73 ♀	$p > 0.05$
4	6.61 ♂ 6.41 ♀	6.57 ♂ 6.34 ♀	$p > 0.05$

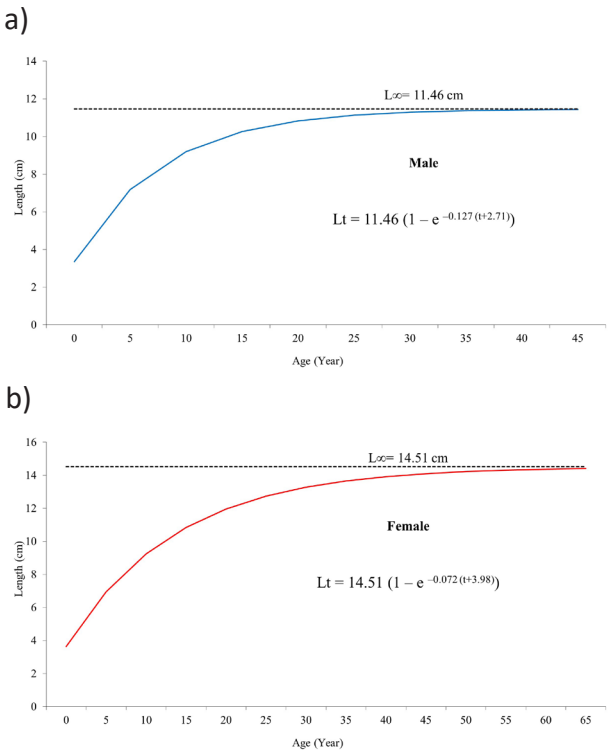

Figure 4

L∞ value according to the von Bertalanffy growth equation (a – males, b – females)

3.0398 (females) and 2.7889 (all specimens). The determination coefficient (R^2) values were close to 1 for all specimens (Fig. 5). The mean values of the condition factor were 1.61 (females), 1.42 (males) and 1.54 (all specimens).

4. Discussion

Research conducted on *Poecilia* species primarily involves aquaculture. There are few studies designed to determine population characteristics in the natural environment. Most of them report only length–weight relationships (Table 4). There are very few studies that report all population characteristics of species. In this respect, very few studies addressed *P. latipinna* (Table 4). There are only one or two studies from the USA and Mexico, where the species has natural distribution areas, and two studies from countries where it has been introduced for aquarium trade or mosquito control.

In this study, the age of *P. latipinna* from Wadi Al-Bahayes (Oman) ranged from 1 to 4 years. The age range of small fish species is limited (Nikolsky 1980). Nevertheless, the age range of the studied population is wide. Nikolsky (1980) suggested that the wide

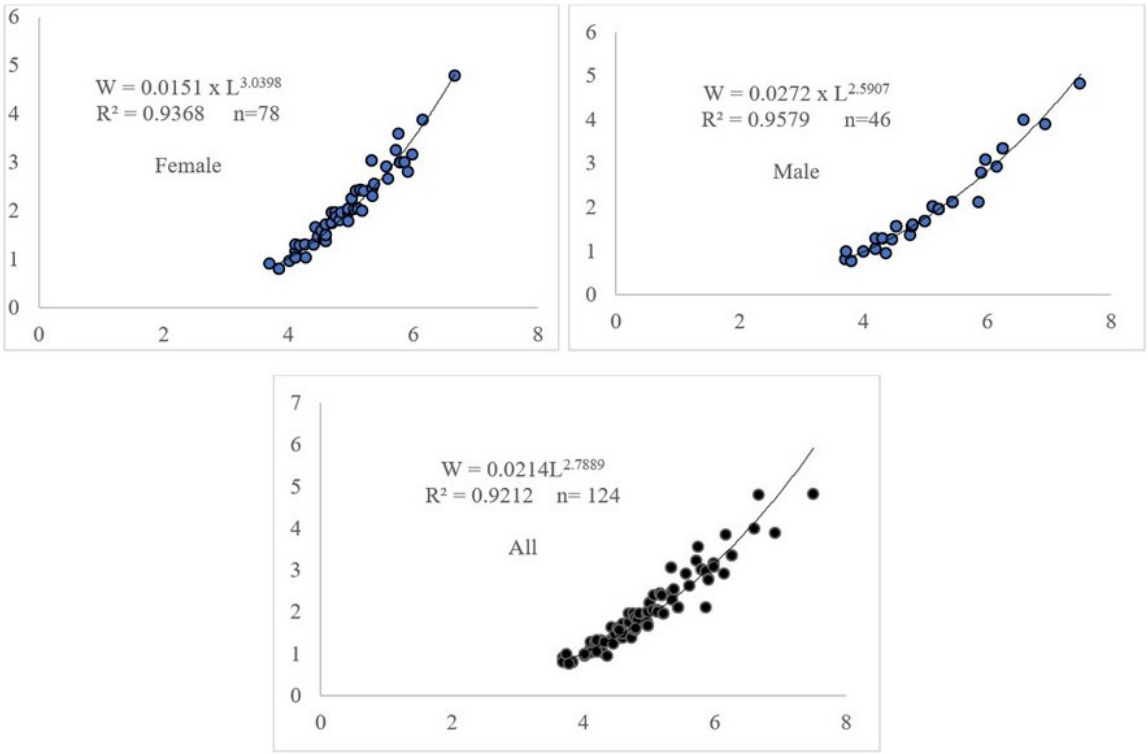

Figure 5

Total length–weight relationships (females, males and all specimens) of *P. latipinna* from Oman

Table 4

Comparison of the growth parameters of *Poecilia* species reported in different studies

Species	Status	Locality	Ref.	N	TL (range)	W (range)	M:F	L∞	k	t_0	Ø '	*a*	*b*	R^2
P. butleri	native	South Pacific, Mexico	1	1868	1.5–6.1	-	-	-	-	-	-	0.023	3.27	0.968
P. butleri	native	Gulf of California, Mexico	2	44	1.75–5.54	0.18–5.54	-	-	-	-	-	0.0026	3.13	0.99
P. gillii	native	Chocó region, Ecuador	3	601	1.36–5.21	0.06–4.52	-	-	-	-	-	0.0233	3.16	0.969
P. mexicana	native	Jalpan River, Mexico	4	762	0.8–5.0	1.7–3.6	1.00:1.00	-	-	-	-	0.22	7.41	0.84
P. mexicana	native	Grijalva River Basin, Mexico	5	158	3.3–7.1	-	-	-	-	-	-	0.0038	2.782	0.941
P. reticulata	native	Santa Marta, Colombia	6	231	-	-	0.69:1.00	39.8	0.21	–0.91	2.52	0.008	3.045	-
P. reticulata	native	Bodoquena Plateau, Brazil	7	49	1.50–3.29	0.083–1.03						0.0219	3.09	0.965
P. reticulata	native	Mundaú River Basin, Brazil	8	204	1.0–2.6	0.01–0.17	-	-	-	-	-	0.009	2.982	0.807
P. reticulata	native	Humid forest enclaves, Brazil	9	840	0.63–4.13	0.004–1.85	-	-	-	-	-	0.0216	3.107	0.966
P. sphenops	native	South Pacific, Mexico	1	1604	1.8–7.1	-	-	-	-	-	-	0.034	3.00	0.978
P. sphenops	native	Grijalva River Basin, Mexico	5	58	3.0–7.5	-	-	-	-	-	-	0.0028	2.970	0.979
P. velifera	native	Yucatan, Mexico	10	89	1.4–5.2	0.10–6.40	-	-	-	-	-	0.022	3.302	0.972
P. velifera	alien	Songkhla, Thailand	11	6.033	0.7–6.9	-	1.00:1.80	73.58	0.82	0.99	-	0.000013 ♂ 0.000014 ♀	3.237 ♂ 3.194 ♀	0.986 ♂ 0.987 ♀
P. vivipara	native	Coastal Lagoons, Brazil	12	318	1.0–6.0	0.01–3.27	-	-	-	-	-	0.008	3.368	0.96
P. vivipara	native	Guaratiba Mangrove, Brazil	13	555	1.8–7.8	0.07–6.48	-	-	-	-	-	0.0078	3.28	0.97
P. vivipara	native	Atlantic coastal drainage, Brazil	14	24	2.06–4.07	0.11–0.95	-	-	-	-	-	0.00795	3.49	0.961
P. latipinna	native	Everglades, USA	15	1671	0.6–5.4	-	0.31:1.00	-	-	-	-	0.0267	2.880	0.930
P. latipinna	native	Gulf of Mexico, USA	16	14	2.6–.5.0	-	-	-	-	-	-	0.6674	2.90	0.94
P. latipinna	alien	Indonesia	17	1062	2.6–7.6	-	0.53:1.00	-	-	-	-	0.00003	3.02	0.85
P. latipinna	alien	Wadi Al-Bahayes, Oman	This study	124	3.7–7.5	0.77–4.81	0.59:1.00	11.46 ♂ 14.51 ♀	–0.127 ♂ –0.072 ♀	–2.71♂ –3.98♀	1.22 ♂ 1.18 ♀	0.0272 ♂ 0.0151 ♀ 0.0214 ♂+♀	2.5907 ♂ 3.0398 ♀ 2.7889 ♂ + ♀	0.9579 ♂ 0.9368 ♀ 0.9212 ♂ + ♀

References; 1: Velázquez-Velázquez et al. 2009; 2: Moreno Sa´nchez et al. 2012; 3: Jiménez-Prado et al. 2018; 4: Bermúdez-González et al. 2020; 5: Velázquez-Velázquez et al. 2015; 6: Garcia et al. 2008; 7: Severo-Neto et al. 2018; 8: Terra et al. 2017; 9: Gurgel-Lourenço et al. 2017; 10: Vega-Cendejas et al. 2017; 11: Sa-nguansil 2009; 12: Franco et al. 2014; 13: da Costa et al. 2014;; 14: Gasparini et al. 2016; 15: Klassen et al. 2004; 16: Morris 2005; 17: dan Hasnidar 2019

www.oandhs.ug.edu.pl
Journal owner: Faculty of Oceanography and Geography, University of Gdańsk, Poland

range of age distribution in a population should be considered as an indication of sufficient food resources in the aquatic environment. A reduction in the number of individuals from old age groups in the population will result in an increase in the number of individuals from young age groups, reducing competition for food. Individuals from age group I account for 49.19% of the population, which is almost half of the population. Fish in the 4.203–5.204 cm length groups account for 56.45% of the population. These length groups also include individuals from age groups I and II.

The sex ratio of females to males of *P. latipinna* from Wadi Al-Bahayes (Oman) is 0.59:1.00 (χ^2, $p < 0.05$). It is different from the ratios of 1.00:1.00 or 1.00:3.00 reported by Nikolsky (1980). According to Nikolsky (1980), the sex ratio varies considerably from species to species, but in the majority of species it is close to one. The fact that the M:F ratio was outside the expected ratio in our study is probably due to the sampling method. Due to the short sampling time, it can be concluded that it is not a selective method. To confirm the sex ratio, samples should be collected from different areas of the wadi. In this study, sampling was restricted to one area. The M:F ratio in our study was found to be consistent with other studies on *P.latipinna* and *Poecilia* species (Table 4). Females were almost 50% more abundant than males. This is consistent with what has been found for wild populations by e.g. Rodd & Reznick (1997), who also observed that females were frequently more abundant than males. Petersson et al. (2004), who studied wild populations, found that the sex ratio was a dynamic feature varying in time and space (Garcia et al. 2008).

Differences in the growth parameters may be due to ecological differences between the study areas, water temperature, water quality and the amount of nutrients in the environment (Atar & Mete 2009). Differences between the observed and expected total lengths were statistically not significant (t test, $p > 0.05$) for *P. latipinna*. The population reaches 11.46 cm ($L\infty$) for males and 14.51 cm ($L\infty$) for females at the age of approximately 40 years and 60 years, respectively. The average growth performance (Ø', phi prime) was calculated as 1.22 for males and 1.18 for females. There are no studies with the von Bertalanffy growth equation for *P. latipinna,* which is the subject of our study. There are studies on *P. reticulata* and *P. velifera* (Table 4). The differences in $L\infty$ values across the studies suggest that it may vary depending on species, environment, feeding and season.

Length–weight relationship parameters are important parameters for management and proper exploitation of fish populations (Dutta et al. 2012). The exponent b in the length–weight relationship in the present study varies between 2 and 4, but often reaches a value close to 3; a value of 3 indicates isometric growth and values other than 3 indicate allometric growth (Tesch 1971). According to Le Cren (1951), the b value in the length–weight relationship also varies with season, depending on the development of gonads in fish. The exponent of the total length–weight relationship is b = 2.7889 for all specimens of *P. latipinna*, with males (b = 2.5907) showing positive allometric growth and females (b = 3.0398) showing isometric growth. Typically, a narrower length range and reduced abundance of smaller fish can result in a higher b value because small and juvenile fish tend to have a more "pumpkin" body shape and become more fusiform with age (Froese 2006). In studies involving both *P. latipinna* and other *Poecilia* species, positive allometric growth was generally observed (Table 4). The overall regression coefficient of the length–weight relationship for all samples is $R^2 = 0.9212$. The value of the regression coefficient R^2 is generally similar to other studies. The differences may also vary with sample homogeneity, season and environment (Table 4).

Among the methods of introducing alien species is the aquarium trade, which turns out to be the main route of introduction (Nunes et al. 2015). In Wadi Al-Bahayes, where the fish specimens were collected, there are aquarium shops that trade in any freshwater fish species. There are two possibilities for the presence of sailfin mollies in the inland waters of Oman. The first high-probability possibility is that molly fish may have been released in the area by an ornamental fish hobbyist. The second low-probability possibility is that they may have come from samples of mixed fish from neighboring countries to control malaria-carrying mosquitoes.

In general, poeciliids are affected by salinity (Meffe & Snelson 1989; Martin et al. 2009). Sailfin molly populations in the brackish water system of Wadi Al-Bahayes adapted well to changes in salinity in the environment. Due to the brackish aquatic environment, lentic conditions and the ground covered with muddy vegetation, Wadi Al-Bahayes provides a very suitable habitat for the sailfin molly to establish a population.

P. latipinna has adapted quite well and established a growing population in this environment. A single female can easily colonize a new area as she carries sperm and gives birth to live young. Because sailfin mollies easily adapt and thrive, they may have a negative effect on *A. stoliczkanus* and *C. arabicus*, both of which are endemic species with whom they share the same habitat. Therefore, further spread of the alien

species *P. latipinna* in Wadi Al-Bahayes, one of the two localities in Oman, should be prevented. Aquarium fish trading places around Wadi Al-Bahayes should be controlled. Consequently, monitoring of this alien species is highly recommended.

Acknowledgements

This project was funded by Geo-Resources Environmental and Earth Science Consultants owned by Mr. Ahmed Al Ghafri whom we thank for his support for science, under the SQU consultant project (No. CR/AGR/FISH/20/03).

References

Abu El-Regal, M.A. & Al-Solami, L.S. (2020). First record of non-native sailfin molly *Poecilia latipinna* (Lesueur, 1821) (Cyprinodontiformes: Poeciliidae) in Africa (Lake Manzala, Egypt). *BioInvasions Records* 9(3): 580–587. DOI: 10.3391/bir.2020.9.3.14.

Al-Akel, A.S., Misned, F.A., Al-Kahem-Al-Balawi, H., Al-Ghanim, K.A., Ahmad, Z. Et al. (2010). Reproductive biology of sailfin molly, *Poecilia latipinna* (Lesueur, 1821) in Wadi Haneefah Stream, Riyadh, Saudi Arabia. *Pakistan Journal of Zoology* 42 (2): 169–176.

Al-Faisal, A.J.M., Mutlak, F.M. & Abdullah, S.A. (2014). Exotic freshwater fishes in the Southern Iraq. *Marsh Bulletin* 9(1): 65–78.

Al-Ghanim, K. (2005). *Ecology of sailfin molly, Poecilia latipinna (Lesueur, 1821) in Wadi Haneefah Stream, Riyadh, Saudi Arabia*. Unpublished doctoral dissetation. King Saud University, Riyadh, KSA.

Al-Jufaili, S.M., Hermosa, G., Al-Shuaily, S.S. & Al Mujaini, A. (2010). Oman fish biodiversity. *Jornal of King Abdulaziz University* 21(1): 3–51. DOI: 10.4197/Mar.21-1.1.

Al Jufaili, S.M. & Jawad L.A. (2020). First confirmed record of an established population of sailfin molly, *Poecilia latipinna* (Actinopterygii: Cyprinodontiformes: Poecillidae), in the freshwater areas of Oman, with description of an imperfect albinizm incidence. *Electronic Journal of Polish Agricultural Universities* 23(4): 1–5. DOI: 10.30825/5.ejpau.195.2020.23.4.

Alkahem, H.F., Al-Ghanim, A.A. & Ahmad, Z. (2007). Studies on feeding ecology of sailfin molly (*Poecilia latipinna*) dwelling in Wadi Haneefah stream, Riyadh. *Pakistan Journal of Biological Sciences* 10 (2): 335–341. DOI: 10.3923/pjbs.2007.335.341.

Atar, H.H. & Mete, T. (2009). Mersin Körfezi'nde dağılım gösteren barbunya balıklarının (*Mullus* sp., Linnaeus, 1758) bazı biyolojik özelliklerinin incelenmesi. [Investigating of Some Biological Features of Red Mullet (*Mullus* sp. Linnaeus, 1758) Distributing in Mersin Bay]. *Biyoloji Bilimleri Araştırma Dergisi* 2 (2): 29–34. (In Turkish).

Bermúdez-González, M.P., Ramírez-García, A., Velázquez-García, E.C., Queijeiro-Bolaños, M.E. & Ramírez-Herrejón, J.P. (2020). Population structure of *Poecilia mexicana* (native) and *Poeciliopsis gracilis* (non-native) in a subtropical river. *Latin American Journal of Aquatic Research* 48 (3): 357–369. DOI: 10.3856/vol48-issue3-fulltext-2423.

Da Costa, M.R., Pereira, H.H., Neves, L.M. & Araujo, F.G. (2014). Length–weight relationships of 23 fish species from Southeastern Brazil. *Journal Applied Ichthyology* 30: 230–232. DOI: 10.1111/jai.12275.

Dan Hasnidar, A.T. (2019). Aspek biologi reproduksi ikan molly, *Poecilia latipinna* (Lesueur 1821) di tambak Bosowa Kabupaten Maros. [Reproductive biology of sailfin molly, *Poecilia latipinna* (Lesueur, 1821) in tambak Bosowa Kabupaten Maros]. *Jurnal Iktiologi Indonesia* 19(3): 375–390. DOI: 10.32491/jii.v19i3.503. (In Indenosian).

Dutta, S., Maity, S., Chanda, A., Akhand, A. & Hazra, S. (2012). Length–weight relationship of four commercially important marine fishes of Northern Bay of Bengal, West Bengal, India. *Journal of Applied Environmental Biological Sciences* 2(2): 52–58.

Düzgüneş, O., Kesici, T. & Gürbüz, F. (1995). *İstatistiki Metodlar,* (II. Baskı). *[Statistical Methods,* 2nd Edn*]*., Ankara: Ankara Üniversitesi Ziraat Fakültesi Yayınları (In Turkish).

Franco, T.P., Araujo, C.E.O. & Araujo, F.G. (2014). Length–weight relationships for 25 fish species from three coastal lagoons in Southeastern Brazil. *Journal Applied Ichthyology* 30: 248–250. DOI: 10.1111/jai.12271.

Froese, R. (2006). Cube law, condition factor and weight–length relationships: history, meta analysis and recommendations. *Journal Applied Ichthyology* 22: 241–253. DOI: 10.1111/j.1439-0426.2006.00805.x.

Gasparini, J.L., Gomes, L.C. & Macieira, R.M. (2016). Length–weight relationships of five fish species from an Atlantic coastal drainage in Brazil. *Journal Applied Ichthyology* 32: 989–990. DOI: 10.1111/jai.13132.

García, C.B., Troncoso, W., Sánchez, S. & Perdomo, L. (2008). Contribution to vital statistics of a guppy *Poecilia reticulata* Peters (Pisces: Cyprinodontiformes: Poecillidae) pond population in Santa Marta, Colombia. *Pan-American Journal of Aquatic Sciences* 3(3): 335–339.

Gayanilo, F.C., Jr., Soriano, M. & Pauly, D. (1988). A draft guide to the Compleat ELEFAN, ICLARM Software 2. (International Center for Living Aquatic Resources Management: Manila, Philippines).

Gurgel-Lourenço, R.C., Rodrigues-Filho, C.A.S., Bezerra, L.A.V., Garcez, D.S. & Sánchez-Botero, J.I. (2017). Length-weight relationships for freshwater fish species from humid forest enclaves at the Brazilian semiarid. *Journal of Applied Ichthyology* 33: 1254–1257. DOI: 10.1111/jai.13444.

Hussain, N.A., Mohamed, A.R.M., Al-Noo, S.S., Mutlak, F.M., Abed, I.M. et al. (2009). Structure and ecological indices of

the fish assemblages in the recently restored Al-Hammar Marsh, southern Iraq. *BIORISK-Biodiversity and Ecosystem Risk Assessment* 3: 173–186. DOI: 10.3897/biorisk.3.11.

Jiménez-Prado, P.J., Molinero, J. & Vásquez, F. (2018). Length-weight relationships of six native and one introduced species in small perennial watercourses of the Chocó region of Ecuador. *Journal of Applied Ichthyology* 35: 587–589. DOI: 10.1111/jai.13825.

Klassen, J.A., Gawlik, D.E. & Botson, B.A. (2014). Length-weight and length-length relationships for common fish and crayfish species in the Everglades, Florida, USA. *Journal of Applied Ichthyology* 30(3): 564–566. DOI: 10.1111/jai.12406.

Le Cren, E.D. (1951). The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). *Journal of Animal Ecology* 20(2): 201–219. DOI: 10.2307/1540.

Koutsikos, N., Economou, A.N., Vardakas, L., Kommatas, D. & Zogaris, S. (2017). First confirmed record of an established population of sailfin molly, *Poecilia latipinna* (Actinopterygii: Cyprinodontiformes: Poeciliidae), in Europe. *Acta Ichthyologica et Piscatoria* 47: 311–315. DOI: 10.3750/AIEP/02234.

Martin, S.B., Hitchi, A.T., Purcell, K.M., Klerks, P.L. & Leberg, P.L. (2009). Life history variation along a salinity gradient in coastal marshes. *Aquatic Biology* 8 (1): 15–28. DOI: 10.3354/ab00203.

Meffe, G. & Snelson, F.F.J. (1989). An ecological overview of Poeciliid fishes. In G. Meffe & F. F. J. Snelson (Eds), *Ecology and Evolution of Livebearing Fishes (Poeciliidae)* (pp. 13–31). New Jersey, USA: Englewood Cliffs, Prentice Hall.

Moreno Sánchez, X.G., Lluch-Cota, S.E., Hernández-Olalde, L. & López Rasgado, L. (2012). Weight–length relationships of mangrove fishes from Bahı´a de La Paz, Gulf of California, Mexico. *Journal of Applied Ichthyology* 28: 671–672. DOI: 10.1111/j.1439-0426.2012.01943.x.

Morris, A.D. (2005). *Length-weight relationships for twenty marine fishes of Texas. Management data series*. Texas: Texas Parks and Wildlife Department Coastal Fisheries Division. (No: 227).

Nikolsky, G.V. (1980). *Theory of Fish Poulation Dynamics as the Biological Background for Rational Exploitation and Management of Fishery Resources*. Koenigstein: Otto Koeltz Science Publishers.

Nunes, J., Seale, T., Fraser, M., Burton, T., Fortson, T. et al. (2015). Population genomics of the euryhaline teleost *Poecilia latipinna*. *PloS one* 10(9): e0137077. DOI: 10.1371/journal.pone.0137077.

Petersson, L., Ramnarine, I., Becher, S.A., Mahabir, R. & Magurran, A. (2004). Sex ratio dynamics and fluctuating selection pressures in natural populations of the Trinidadian guppy *Poecilia reticulata*. *Behavioral Ecology and Sociobiology* 55: 461–468. DOI: 10.1007/s00265-003-0727-8.

Randall, J.E. (1995). *Coastal fishes of Oman*. Honolulu. Hawai'i: University of Hawaii Press.

Ricker, W.E. (1975). *Computation and interpretation of biological statistics of fish populations*. Ottowa: Bulletin of the Fisheries Research Board of Canada. (No: 191).

Rodd, F.H. & Reznick, D.N. (1997). Variation in the demography of guppy populations: the importance of predation and life histories. *Ecology* 78: 405–418. DOI: 10.2307/2266017.

Sabet, H.M. (2018). Range extension of an exotic sailfin molly *Poecilia latipinna* (Lesueur, 1821) in Iran. *Poeciliid Research* 8: 18–23.

Sa-nguansil, S. (2009). *Population Characteristics and diet of sailfin molly Poecilia velifera (Regan, 1914) (Poeciliidae: Cyprininodontiformes): an alien fish invading Songhla Lake Basin, South Thailand*. Master Thesis, Prince of Songkla Enivesity, Songkhla.

Severo-Neto, F., Lopes, D.A., Ferreira, A., Martínez, B.T. & Roque, F.O. (2018). Length–weight relations of fishes (Actinopterygii) from karst streams in the Bodoquena plateau, western Brazil. *Acta Ichthyologica et Piscatoria* 48(4): 419–422. DOI: 10.3750/AIEP/02500.

Smith, R.J.F. (1997). *Avoiding and deterring predators*. Behavioural Ecology of Teleost Fishes. 163–190.

Sparre, P. & Venema, S.C. (1992). *Introduction to tropical fish stock sssament*, Part I. Rome: FAO, Fisheries Technical Paper. (No. 306/1).

Sultan Mohideen, A.K., Asrar Sheriff, M. & Altaff, K. (2014). Effect of three different feeds on the growth and survival of sailfin molly *Poecilia latipinna* (Lesueur, 1821). *Revelation and Science* 4(1): 45–48.

Terra, B.F., Teixeira, F.K. & Rezende, C.F. (2017). Length–weight relationships of 10 freshwater fish species from an intermittent river basin, semi-arid region, Brazil. *Journal of Applied Ichthyology* 33: 832–834. DOI: 10.1111/jai.13357

Tesch, F.W. (1971). Age and growth. In W.E. Ricker (Ed), *Methods for assessment of fish production in fresh waters* (pp. 99–130). Oxford: Blackwell Scientific Publications.

Vega-Cendejas, M.E., Peralta-Meixuiero, M.E. & Hernández De Santillana, M. (2017). Length–weight relations of fishes inhabiting a hyperhaline coastal lagoon in Yucatan, Mexico. *Acta Ichthyologica et Piscatoria* 47 (4): 411–415. DOI: 10.3750/AIEP/02239.

Velázquez-Velázquez, E., Navarro Alberto, J., Domínguez Cisneros, S.E. & Vega Cendejas, M.E. (2009). Length–weight relationships for 24 fish species in a coastal lagoon of the Mexican South Pacific. *Journal of Applied Ichthyology* 25: 228–229. DOI: 10.1111/j.1439-0426.2008.01199.x.

Velázquez-Velázquez, E., Maza-Cruz, M., Gomez-Gonzalez, A.G. & Navarro-Alberto, J.A. (2015). Length-weight relationships for 32 fish species in the Grijalva River Basin, Mexico. *Journal of Applied Ichthyology* 31: 413–414. DOI: 10.1111/jai.12676.