Phototaxis Mechanism and Morphometric Characteristic of American Crayfish (Procambarus clarkii)

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Research Article

Phototaxis Mechanism and Morphometric Characteristic of American Crayfish (*Procambarus clarkii*)

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ABSTRACT

American crayfish (*Procambarus clarkii*) supports beneficially for aquaculture industry and is also considered as invasive species due to their adverse impacts on the native species and ecosystems. This study aimed at investigating Phototaxis mechanism, length-weight relationship and condition factor of *P. clarkii* from the pond. Crayfish were collected using the four light traps with different light intensities (215-2,050 lx). The traps made of 6-mm iron frames (60×50×25 cm) and black 3/5 inch hexagonal mesh wire. Data on body sizes and sex of crayfish were analyzed. A total of 256 specimens (74-112 mm TL) comprising 157 males (61%) and 99 females (39%) were collected. There were no significant differences in the average total length (TL), carapace length (CL), chelae length (ChL) and weight (W) of males or females among the four traps ($p > 0.05$). The CL/TL and ChL/TL ratios and condition factor of males were considerably higher than females ($p < 0.001$). Males showed negative allometric growth ($b = 2.757$), while females exhibited isometric growth ($b = 3.002$). The positive group responses of crayfish were more pronounced at 90-94 mm TL and 20-29 g weight. *P. clarkii* positively responded to different light intensities. The light traps can be used to improve the harvesting procedures of commercial aquaculture.

INTRODUCTION

The American crayfish (*Procambarus clarkii* Girard, 1852) is the most prominent crayfish that supports beneficially not only for an aquaculture industry in Louisiana, USA (Romaire, 1995; Hobbs and Lodge, 2010) but also for remarkable commercial successes in Kenya (Harper *et al*., 2002), Egypt (El Zein, 2005), Portugal (Anastácio and Marques, 1995), China (Li *et al*., 2005) and Spain (Alcorlo *et al*., 2008) due to its rapid growth and ecological tolerance (Huner and Lindqvist, 1995). However, many states have regulations prohibiting the introduction of such invasive species due to their frequently reported adverse impacts on native species and ecosystems (Mito and Uesugi, 2004; Banci *et al*., 2013), including damage to rice plants, interference with fishing operation (e.g. cutting through nets to get fish), consumption of fish eggs (Anastácio *et al*., 2005) and being considered a pest in many fish ponds (Maezono and Miyashita, 2004). Hence, invasion management options include the elimination or reduction of the populations using physical, chemical or biological methods and the use of legislation to prohibit the transport and release of specimens are needed (Freeman *et al*., 2010; Gherardi *et al*., 2011).

In all parts of the world, many active and passive gears are being used to collect crayfish from their habitats such as baited traps (Harper *et al*., 2002), baited stick (Policar and Kozak, 2005), seines (D' Abramo and Niquette,1991), electrofishing (Alonso, 2001), throw-trap (Dorn *et al*., 2005), tangle traps (Welch and Eversole, 2006), sex-pheromone-baited traps (Stebbing *et al*., 2004), fyke-nets (Balik *et al*., 2005), and light traps (Ahmadi, 2014). *P. clarkii* occupies an important position in the trophic structure of invaded environments, interacting with different trophic levels and changing the whole ecosystem functioning (Cruz *et al*., 2008). They interact with multiple trophic levels as prey, predator, and scavenger (Momot, 1995). The growth of crayfish is affected by environmental factors such as temperature (Parkyn and Collier, 2002), the availability and quality of food resources (McClain *et al*., 1992), water chemistry (Lowery, 1988), shelter availability (Figler *et al*., 1999), and density dependent factors (Morrissy *et al*., 1995). These factors may differentially affect the size of moult increment and length of intermoult period of crayfish growth (Acosta and Perry, 2000).

The knowledge of the length-weight relationship of a species is very useful for estimating the characteristics of a crayfish population, the growth rate and size at sexual maturity (Lindqvist and Lathi, 1983), calculating the standing stock biomass (Froese, 1998), differentiating sexes (Yang and Chen, 2003), and analyzing ontogenetic changes (Safran, 1992) or condition factor in prawns (Enin, 1994). Mazlum *et al*. (2007) suggested that length-weight data are more easily measured and standardized in field sampling. Some crayfish species show allometric differences in growth whereby males develop larger chelae and females develop wider abdomens when they become reproductively mature (Lowery, 1988). Allometric or relative growth patterns in various crayfish species have been observed widely (Austin, 1995; Rajković *et al*., 2006; Aydin *et al*., 2015; Anderson and Simon, 2015), and most of crayfish species in this study area were collected by the conventional fishing methods without a direct implication to commercial aquaculture. For this reason, we carried out trapping experiment with lights to ascertain phototaxis mechanism and morphometric characteristic of American crayfish as well as improvement of harvesting procedure for this species.

MATERIALS AND METHODS

Data on the length-weight relationship of *P. clarkii* were collected from the pond using light traps. The experiments were conducted at night in a concrete pond (10.0×5.8×0.7 m, 55 cm deep) at the Faculty of Fisheries, Kagoshima University. A total of 200 adult crayfish (68-111 mm TL) with 1:1 male to female sex ratio were bought from a local supplier. Animals received by research facilities were immediately acclimatized (generally for a minimum of 7 days) to a new environment (light, water, noise, food, etc.) and also to permit the animals recover from any stress associated with transportation before they are used. Crayfish were kept in 3,200 l tap water at 16-28 °C and were fed twice a week with commercial prawn feed at feeding ratio of 0.5-1.0% of their body weight. Water grass *Hydrilla verticillata* and zooplankton *Daphnia pulex* were also given to them as natural dietary item. Polyethylene nets were placed above the pond to reduce solar radiation. The PVC pipes (approx. 15 cm long and 6 cm diameter) were kept in the pond bottom as shelters. Aeration was applied for 24 h. Dissolved oxygen (DO) was 6.65 mg l^{-1}, while turbidity of clear water and turbid water was 1 FTU and 14.6 FTU.

Four box-shaped traps were made of 6-mm iron frames (60×50×25 cm) and black 3/5 inch hexagonal mesh wire (16 gauge PVC-coated wire). The traps had four large entry funnels located on each side with a 6 cm inside ring entrance. A trap door on top (48×25 cm) was used to release of the crayfish. Each trap was associated with SIL-1 (215 lx), SIL-2 (398 lx), DIM (1,010 lx) and LIGHT (2,050 lx) determined with an illuminometer (IM-2D, Topcon, Ltd. Tokyo). SIL-1 (0.75 W) and SIL-2 (1.5 W) were typical squid fishing tackles (Yo-zuri Co. Ltd. Japan). For DIM and LIGHT, 4.5 W lamp was placed inside a waterproof acrylic box (14×8×15 cm). For DIM, the walls of the box were lined with a white-paper. The lamps were powered by 1.5–6 V dry-cell battery (Fig. 1).

The traps were lowered on the pond before sunset and retrieved next morning. The traps were spaced 6 m apart and rotated at each night with the soaking time varied from 13 to 14 h. Total number of trials was 15 (60-trap hauls). The catch was checked for sex, carapace length, chelae length, total length, weight, and released back into the pond. Carapace length (CL) was measured from the anterior tip of the rostrum to the posterior edge of the carapace; chelae length (ChL) was from the base of the first pair of walking legs to the anterior tip the pincers; and total length (TL) from the tip of the rostrum to the end of the telson, with the abdomen fully stretched were measured to the nearest mm using a ruler. Individual animal was weighed to the nearest g using a digital scale (DL-9003, KAI, China). Specimens with damaged or regrown chelae were not used for any chelae measurements.

The relationship between length and weight was calculated for both sexes. A linear regression analysis was used to determine if the length-weight relationships differed between males and females. The total length, carapace length, chelae length (independent variables) and the weight (dependent variable) were plotted for males and females. We fitted the power equation for allometric growth to the data:

$$W = aL^b \quad (1)$$

Where W is the weight, L is total length, *a* is constant and *b* is exponent. Frota *et al*. (2004) reported that the parameter '*b*' of the length-weight relationship equation, also known as allometry coefficient has an important biological meaning, indicating the rate of weight gain in relation to growth in length. According to Bagenal (1978), the *b* exponent with value between 2.5 and 3.5 is used to describe typical growth dimensions of relative wellbeing. The proper fit of the growth model is given by the coefficient of determination (R^2). The coefficient of correlation (r) between variables was computed by the square regression. Characteristic of the length-weight relationship in fishes and invertebrates is that the value of the *b* exponent is 3 when growth in weight is isometric (without changing shape). If *b* value is different, from 3, weight growth is said to be allometric (fish changes shape as it grows larger). Allometric growth may be negative ($b < 3$) or positive ($b > 3$) (Enin, 1994). Positive allometic growth means that weight increases more than length. Negative allometric means that length increases more than weight. Isometric means that length and weight are growing at the same rate. Individual of crayfish without chelae or with regenerated ones have been excluded from the calculations. The condition factor of male and female crayfish was calculated using Fulton's condition factor (Froese, 2006):

$$CF = 100W/L^3$$

Where W is weight, L is total length. Average condition factors were calculated to determine if there were significant differences in the light responsiveness of crayfish among the four lighted traps tested. The Mann-Whitney test was employed to compare the body parts of males and females. The Kruskal-Wallis test was used to see if the total catches or the sizes of body parts among the four lighted traps were significantly different. The Multiple Comparisons test was conducted to determine which catch or size differed among traps. All tests were evaluated at the 0.05 level of significance. SPSS for windows version 16.0 statistical software was used for all data analysis.

RESULTS AND DISCUSSION

A total of 256 individuals of crayfish were collected from trapping experiment with the lights in the pond, consisted of 157 males (61%) and 99 females (39%) with the sex ratio of 1.6:1 (Table 1). It is well defined that male were more responsiveness toward the lights than female across all treatment during sampling periods. The followings are the sex ratio of male to female for each trap tested dealing with the acquisition catch i.e. 1.2:1 for LIGHT (n = 79), 2.7:1 for DIM (n = 56), 1.4:1 for SIL-2 (n = 59) and 1.7:1 for SIL-1 traps (n = 62) respectively. Male crayfish was most often found associated with DIM trap. There was no significant difference in the number of catch among the four traps ($p > 0.05$). For male, the largest and the heaviest crayfish was collected in the LIGHT trap (112 mm TL and 56 g), as well as the smallest and the lightest individual (74 mm TL and 13 g). The mean total length of male gained was 91.4 ± 7.96 mm (74 - 112 mm). For female, the largest and the heaviest crayfish was caught by the SIL-1 trap (109 mm TL and 44 g), while the smallest and the lightest individual was found in the SIL-2 trap (76 mm TL and 12 g). There was no significant difference in the body weight between male and female ($p > 0.05$). The mean weight of male was 26.9 ± 7.67 g (13 - 56 g), while for female was 25.7 ± 7.07 g (12 - 44 g).

No statistical difference was observed in average TL, CL, and ChL of male or female among the four traps ($p > 0.05$). For comparison (Figs. 2A, 2B), the CL/TL and ChL/TL ratios of male crayfish were significantly higher than those of female across the trials ($p < 0.001$). The values of CL/TL and ChL/TL for male were ranged of 0.47 - 0.56 and 0.57 - 1.19, while those for female were ranged of 0.47 - 0.52 and 0.64 - 1.01 respectively. The sex specific differences were found in the ChL. Male had the ChL approximately 1.2 times longer than female of the same length. The mean ChL of male and female obtained was 89.6 ± 12.40 mm (58 - 133 mm) and 74.6 ± 9.41 mm (50 - 97 mm) respectively. The chelae length seemed to be proportionally increased with the total length. Male have larger chelae than female of the same size and it might inhibit female from entering the traps. It is very likely why females comprised only 39% of total catch in the present study. Furthermore, the function of chelae is closely linked to social behavior. Svensson and Gydemo (1996) reported that male with the larger chelae resulted in higher reproductive success during copulation and in competing for mates. In this study, an increase of males' chelae size with 38 mm CL is considered higher than other crayfish species, for instance, *A. pallipes* with 29 mm CL (Rhodes and Holdich, 1979) and *A. torrentium* with 24 mm CL (Streissl and Hödl, 2002). The correlation index in all examined length-weight relations is positive and ranges from 0.8681 to 0.9506 (Table 1). The lower correlation index in males than in females is legitimate considering the fact that the increase of chelae growth causes weight to change corresponding to the length. The sexual dimorphism in crayfish is also reflected as the difference in the ratio of CL/TL. In larger individual of male, the ratio of ChL/TL began to rise over 76 mm TL (38 mm CL) and kept rising in male, but it didn't occur in female. In the current study, the values of CL/TL ratio in *P. clarkii* male and female were 51.5% and 49.5% respectively. Westman and Savolainen (2002) found the ratio values in *Pacifastacus leniusculus* male and female were 49% and 51%. In *Astacus astacus*, it was 47.3% for male and 48.4% for female (Pursiainen *et al*., 1989). While in *A. leptodactylus,* the estimated ratio was 47.8% for male and 45.5% for female (Deniz *et al*., 2010). Carapace length increased allometrically with total length for the species. It is found that the carapace length is half of the total length regardless the sex.

The size distribution of crayfish caught by the light traps was presented in Table 2. Regardless the sex, it was clearly demonstrated that the light traps collected more individuals of crayfish at size classes between 80 - 84 mm and 100 - 104 mm TL, as well as between 15 - 19 g and 35 - 39 g weight. In other word, positive group responses of crayfish were more pronounced in the middle size classes as compared to higher classes. The highest number of catch for both male (28.03%) and female (27.55%) was found between 90 - 94 mm TL. Meanwhile the heaviest catch was recorded at 20 - 24 g for male (27.39%) and 25 - 29 g for female (29.59%). None of crayfish captured at higher class of 115 - 119 mm TL was observed. The size distributions of catches described here are defined as marketable sizes.

Fig. 3 clearly shows that male grew allometrically (b = 2.7567), while female grew isometrically (b = 3.002). The b values can be seen from the following parabolic equations: $W = 10^{-4}\ TL^{2.7567}$ ($R^2 = 0.7536$) and $W = 3\times10^{-5}\ TL^{3.002}$ ($R^2 = 0.9037$). The index of correlation (r) of male and female were 0.8681 and 0.9506, found to be higher than 0.5, showing the length weight relationship was positively correlated. No significant difference was observed between the slopes of male and female's growth ($p > 0.05$). In the present study, the b values were generally in good agreement with the results obtained from other geographical areas (see Table 3). According to Bagenal (1978), the b exponent values should normally fall between 2.5 to 3.5, suggesting that result of this study is valid. A negative allometric growth of male in the current study was also reported in *Astacus leptodactylus* in Turkey (Deniz *et al*., 2010) and *P. clarkii* in China (Wang *et al*., 2011). It is contrary to other crayfish species that exhibited positive allometric growth such as *P. zonangulus*, *P. alleni* and *Orconectes rusticus* in USA (Romaire *et al*., 1977; Acosta and Perry, 2000; Anderson and Simon, 2015), *P. clarkii* in Portugal and Italy (Correia *et al*., 1994, Dorr *et al*., 2006), *P. acutus acutus, Cherax quadricarinatus* and *C. destructor* in Turkey (Mazlum *et al*., 2007; Deniz *et al*., 2010), and *Austropotamobius torrentium* in Austria (Streissl and Hödl, 2002).). Female grew isometrically in the present was also documented for *P. fallax* in USA (Klassen *et al*., 2014) and *A. leptodactylus* in Turkey (Aydin *et al*., 2015). Dealing with allometric differences in growth for some crayfish species, from all appearances male develop larger chelae, while females develop wider abdomens when they become reproductively mature (Lowery, 1988). Regardless the sex, data presented in Table 3 clearly confirms that *P. clarkii* had the CL/W ratio greater than *P. clarkii* in Italy, China and Morocco (Dorr *et al*., 2006; Wang *et al*., 2011; El Qoraychy *et al*., 2015), *P. alleni* and *P. fallax* in USA (Klasssen *et al*., 2014), *Pacifastacus leniusculus* in Finland (Westman and Savolainen, 2002), *A. leptodactylus* in Turkey (Aydin *et al*., 2015), and *A. torrentium* in USA and Austria (Rhodes and Holdich, 1984; Streissl and Hödl, 2002). However, this value was lower than the value reported for *P. acutus acutus* in Turkey (Mazlum *et al*., 2007), *O. limosus* and *O. rusticus* in USA (Duris *et al*., 2006; Anderson and Simon, 2015). This meant that the weight for a given length is not constant over the entire year and varies according to factors such as the availability and quality of food resources (McClain *et al*., 1992), temperature (Lopez-Martinez *et al*., 2003), feeding rate, gonad development and spawning period (Amin *et al*., 2010).

Furthermore, the data points of total length and condition factor relationship of crayfish were plotted in Fig. 4. No statistical difference was observed in condition factor of female caught among the four lighted traps. The K values for male and female obtained were ranged of 0.79 - 1.32 and 0.85 - 1.19, respectively. *P. clarkii* is defined as nocturnal species (Gherardi, 2001) and this condition factor can be used as a simple approach to provide reliable information on the internal condition of crayfish particularly when they are subjected to different light intensities. In the present study, condition factor of male was significantly higher than female across the trials ($p < 0.001$). This is in line with the fact that male was more pronounced to the lights as compared to female (1.6:1). This finding strengthened our conclusion that American crayfish had a positive phototactic response to different light intensities (Ahmadi *et al*., 2008). It is acceptable scientific evidence that lighted traps can be effectively used to harvest crayfish at different sizes from the pond. Further research, the phototactic response of *P. clarkii* would be examined with different illumination levels of colored LED underwater lamps.

It is generally accepted that the efficiency of lighted traps in clear water was greater than in turbid water. The light attenuation is gradually declining with increasing of turbidity that would reduce the effective sampling radius of the traps (Lindquist and Shaw, 2005). In the present study, the use of incandescent squid fishing tackle with diamond shape in its surface (e.g. SIL-1, 0.45 W) was able to increase the distribution of the amount of lights and showed an equal effective to the acrylic box-shaped lamps with all directional luminous (DIM/LIGHT, 4.5 W). The current light traps were also effectively used for sampling fish and shrimp in turbid water of Barito River, South Kalimantan (Ahmadi and Rizani, 2012). The optical characteristic of a lamp is one of important components in designing a light trap and critical to success in fishing operation, so the use of higher intensities corresponding to the depth is recommended and the results are still open for discussion.

Table 1: The estimated parameters of length-weight relationship of *P. clarkii* taken from the pond using the lighted traps

Parameters	**Type of Lighted Traps**				**Overall calculation**
	LIGHT	**DIM**	**SIL-2**	**SIL-1**	
Sex ratio F:M	1.2 : 1	2.7 : 1	1.4 : 1	1.7 : 1	1.6 : 1
Male	43	41	34	39	157
TL (mm)	74-112 (90.8±8.56)	80-110 (92.7±7.67)	78-101 (88.8±6.31)	76-110 (92.8±8.50)	74-112 (91.4±7.96)
CL (mm)	37-57 (45.8±4.90)	39-57 (46.9±4.22)	38-51 (44.6±3.47)	38-57 (46.9±4.97)	37-57 (46.1±4.52)
ChL (mm)	66-133 (91.3±13.27)	58-112 (89.9±10.29)	61-102 (84.6±9.11)	61-132 (91.8±14.89)	58-133 (89.6±12.40)
CL/TL	0.48-0.53 (0.5±0.01)	0.47-0.54 (0.5±0.01)	0.48-0.56 (0.5±0.02)	0.48-0.53 (0.5±0.01)	0.47-0.56 (0.5±0.01)
ChL/TL	0.82-1.19 (1.0±0.08)	0.57-1.13 (1.0±0.10)	0.78-1.11 (1.0±0.09)	0.84-1.04 (1.0±0.89)	0.57-1.19 (1.0±0.09)
W (g)	13-56 (27.4±8.47)	17-41 (26.7±6.41)	13-35 (24.0±4.90)	14-56 (29.0±9.25)	13-56 (26.9±7.67)
Cond. factor	0.91-1.26 (1.06±1.07)	0.87-1.17 (0.99±0.06)	0.79-1.32 (1.02±0.06)	0.91-1.32 (1.06±0.08)	0.79-1.32 (1.0±0.07)
Female	36	15	25	23	99
TL (mm)	92-108 (92.2±8.30)	83-109 (94.1±7.74)	76-106 (92.7±8.32)	76-109 (95.1±8.30)	76-109 (93.3±8.19)
CL (mm)	38-54 (45.7±4.14)	41-54 (46.9±3.74)	37-54 (46.1±4.39)	38-54 (47.1±4.37)	37-54 (46.3±4.18)
ChL (mm)	60-97 (73.2±9.41)	63-90 (76.5±9.25)	50-90 (73.9±9.66)	62-97 (76.3±9.41)	50-97 (74.6±9.41)
CL/TL	0.47-0.52 (0.5±0.01)	0.49-0.51 (0.5±0.01)	0.48-0.51 (0.5±0.01)	0.47-0.52 (0.5±0.01)	0.47-0.52 (0.5±0.01)
ChL/TL	0.68-0.90 (0.8±0.05)	0.72-0.87 (0.8±0.05)	0.64-1.01 (0.8±0.07)	0.70-0.89 (0.8±0.05)	0.64-1.01 (0.8±0.06)
W (g)	13-44 (24.7±7.09)	17-41 (27.0±7.66)	12-38 (25.2±5.83)	14-44 (26.8±8.00)	12-44 (25.7±7.07)
Cond. factor	0.85-1.16 (1.01±1.07)	0.90-1.15 (1.04±0.06)	0.90-1.19 (1.03±0.07)	0.89-1.12 (1.00±0.07)	0.85-1.19 (1.02±0.07)
	a	**b**	**R^2**	**r**	**Growth Pattern**
Male	0.0001	2.7567	0.7536	0.8681	Negative allometric
Female	0.00003	3.0021	0.9037	0.9506	Isometric

Table 2: The size classes of crayfish male (n=157) and female (n=99) caught by light traps

Total length	**Male**		**Female**		**Weight**	**Male**		**Female**	
Interval (mm)	**Number**	**%**	**Number**	**%**	**Interval (g)**	**Number**	**%**	**Number**	**%**
70-74	1	0.64	-	-	10-14	4	2.55	4	4.08
75-79	9	5.73	5	5.10	15-19	21	13.38	18	18.37
80-84	25	15.92	12	12.24	20-24	43	27.39	21	21.43
85-89	24	15.29	11	11.22	25-29	42	26.75	29	29.59
90-94	44	28.03	27	27.55	30-34	23	14.65	13	13.27
95-99	34	21.66	17	17.35	35-39	17	10.83	8	8.16
100-104	11	7.01	17	17.35	40-44	4	2.55	5	5.10
105-109	3	1.91	9	9.18	45-49	-	-	-	-
110-114	6	3.82	-	-	50-54	-	-	-	-
115-119	-	-	-	-	55-59	3	1.91	-	-

Table 3: Descriptive statistics and estimated parameters of carapace length-weight relationships of crayfish species from different geographical areas

Species	Sex	CL/W	a	b	R^2	Equations	Growth Type	Country	References
P. clarkii	M	1.71	0.000	2.43	0.880	Y=2.43X+0.0004	A-	Japan	Present study
	F	1.80	0.002	2.88	0.900	Y=2.88X+0.002	A-		
P. clarkii	M	0.38	-8.459	3.03	0.993	Y=3.03X-8.459	I	Morocco	El Qoraychy *et al*., 2015
	F	0.42	-7.603	2.78	0.994	Y=2.78X-7.603	A-		
P. clarkii	M	0.20	1.126	3.54	0.970	Y=3.54X-1.180	A+	Italy	Dorr *et al*., 2006
	F	0.19	-1.180	3.38	0.950	Y=3.38X+1.126	A+		
P. clarkii	M	1.48	-1.853	3.63	0.955	Y=3.63X-1.853	A+	China	Wang *et al*., 2011
	F	1.99	-1.699	3.35	0.935	Y=3.35X-1.699	A+		
P. alleni	M	0.37	0.229	2.82	0.873	Y=2.82X+0.229	A-	USA	Klasssen *et al*., 2014
	F	0.35	0.209	2.84	0.929	Y=2.84X+0.209	A-		
P. fallax	M	0.33	0.188	3.06	0.924	Y=3.06X+0.188	I	USA	Klasssen *et al*., 2014
	F	0.34	0.193	3.07	0.971	Y=3.07X+0.193	I		
P. acutus acutus	M	4.57	0.000	3.26	0.950	$Y=3.26X+6x10^{-9}$	A+	Turkey	Mazlum *et al*., 2007
	F	4.97	0.000	3.50	0.980	$Y=3.50X+6x10^{-4}$	A+		
Pacifastacus leniusculus	M	0.74	8.475	1.80	0.970	Y=1.802X+8.475	A-	Finland	Westman and Savolainen, 2002
	F	0.99	3.873	1.96	0.970	Y=1.964X+3.873	A-		
Astacus leptodactylus	M	1.44	-3.734	3.079	0.925	Y=3.079X-3.734	I	Turkey	Deniz *et al*., 2010
	F	1.77	-3.460	2.906	0.915	Y=2.915X-3.460	A-		
Astacus leptodactylus	M	1.64	0.000	3.302	0.973	$Y=3.302X+8x10^{-6}$	A+	Turkey	Aydin *et al*., 2015
	F	1.38	0.000	3.011	0.972	$Y=3.011X+3x10^{-5}$	I		
Austropotamobius torrentium	M	0.88	0.000	3.379	0.994	$Y=3.379X+8x10^{-6}$	A+	Austria	Streissl and Hödl, 2002
	F	1.29	0.000	3.136	0.990	$Y=3.136X+2x10^{-5}$	A+		
Austropotamobius pallipes	M	1.02	-5.107	3.324	0.993	Y=3.324X-5.107	A+	USA	Rhodes and Holdich, 1984
	F	0.88	-4.823	3.319	0.998	Y=3.139X-4.823	A+		
Orconectes rusticus	M	4.64	-3.597	3.005	0.962	Y=3.005X-3.596	I	USA	Anderson and Simon, 2015
	F	6.23	-3.710	3.104	0.963	Y=3.104X-3.710	A+		
O. limosus	M	2.33	-0.031	0.091	0.980	Y=0.091X-0.031	A-	USA	Duris *et al*., 2006
	F	2.38	-0.036	0.089	0.981	Y=0.089X-0.036	A-		

A+ = positive allometric, A- = negative allometric, I = isometric

Fig. 1: American crayfish, trap and typical lamps used in the trapping experiment

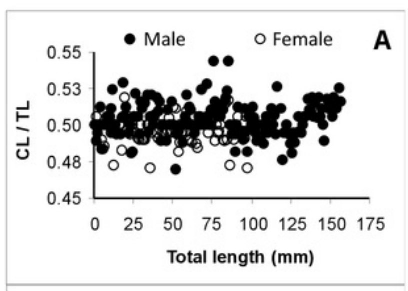

Fig. 2:
A: the ratio of carapace length to total length (CL/TL), and

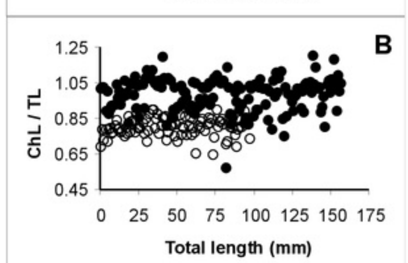

Fig. 2:
B: the ratio of chelae length to total length (ChL/TL). Male crayfish had the CL/TL and ChL/TL ratios greater than female ($p < 0.001$).

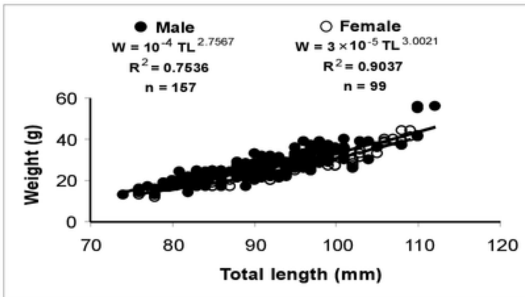

Fig. 3: The length-weight relationship of American crayfish. Male displayed a negative allometric growth, while female showed an isometric growth.

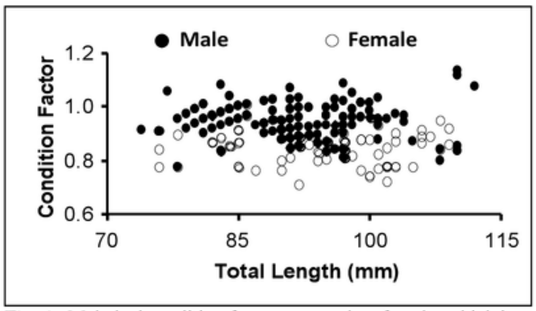

Fig. 4: Male had condition factor greater than female, which is proportional to total length.

CONCLUSION

The present study revealed that *P. clarkii* male was more responsive toward lights, larger body size and better condition factor as compared to female. Male grew allometrically, while female grew isometrically. The positive group responses of crayfish were more noticeable between 90 mm and 94 mm TL. The perceptible improvement of light traps could support beneficially for commercial aquaculture and other fishing purposes.

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