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# Food Consumption and Assimilation of The Adult Dog Conch *Laevistrombus canarium* (Linnaeus 1758) at Different Temperatures

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**ABSTRACT** *Laevistrombus canarium* (Linnaeus 1758) or the dog conch is a highly important fishery species with great potential for introduction into aquaculture. The present study evaluates food consumption and assimilation by the adult conch at different temperatures (i.e. 22°C, 26°C, 30°C and 34°C). The conchs were acclimated for one week in stocking tanks with well-aerated seawater of 30 PSU salinity and at ambient temperature of 26°C. Prior to experimentation, the gastric emptying level of the conchs were standardized by allowing them to feed till satiation, followed by 24 h starvation. Ten similar sized aquaria (20 x 15 x 15 cm) were used, each containing one individual conch. Each conch was provided with similar quantity of food (~ 102.13 ± 0.45 mg of sinking pellets) and they were allowed to feed within a 24 h period. The food consumption rate for adult conchs was significantly different ($p<0.05$) between different temperature regimes. Hence, the food absorption efficiency was also affected ($p<0.05$), which ranged from 55.21% to 74.75%. The food energy absorbed showed significant variations between temperatures ($p<0.05$). Higher food consumption and assimilation was recorded at 26°C followed by 30°C, 34°C and 22°C. Adult *L. canarium* can adapt well in captive conditions by efficiently digesting particularly food pellets. However, more studies are still needed, particularly by adopting longer exposure times as well as higher temperature ranges, in order to better understand the effect of temperatures on the species.

**Keywords:** Absorption efficiency, energy absorbed, laboratory condition, Merambong shoal, siput gonggong.

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## INTRODUCTION

Dog conch or locally addressed as 'siput gonggong' is a marine gastropod mollusk species of high economic value (Cob et al., 2008a, Cob et al., 2008b, Cob et al., 2014). It is traditionally collected by the locals for food (Cob et al., 2005; Chuang, 1973) and therefore has great aquaculture potential (Castell, 2003; Cob et al., 2011). Abbott (1960), Amini and Pralampita (1987), Cob et al. (2005) and Erlambang and Siregar (1995) in their studies revealed that this herbivorous (microphagous) mollusk species is generally abundant wherever it occurs and were mostly associated with nearshore sandy mud bottoms areas. Other studies described this species as a tropical marine gastropod closely associated to seagrass bed ecosystems (Cob et al., 2012; Robertson, 1961). Theyare among the dominant herbivorous mollusks in the seagrass bed areas (Cob et al., 2005; 2008c; 2009a; 2009b; 2009c), grazing on delicate filamentous algae or thin layers of organic material from seagrass blades or sand grains (Cob et al., 2014). They were also more active at night than daytime andwere constantly searching for food even when their shells were partially exposed during ebb tide (pers. obs.).

Information regarding important physiological parameters such as food consumption, food absorption efficiency and food energy conversion are vital and urgently needed if the species is to be introduced into aquaculture. According to Staikou and Lazaridou-Dimitriadou (1989), consumption and assimilation are fundamental stages of energy transport from one trophic level to another, and many terrestrial gastropods being primary consumers, play an important role in the functioning of ecosystems. In addition, energy budgets were determined taking into account acquisition (consumption and absorption) (Navarro et al., 2002). Thus, essential to perform a quantitative study if food ingestion and assimilation in marine snails due to assess their role in ecosystems dynamics (Mason, 1970; Charrier & Daguzan, 1980; Staikou & Lazaridou-Dimitriadou, 1989). Nevertheless, preliminary observations on this tropical conch species showed that they readily consumed the introduced food pellet, which allowed for direct measurements of food consumption rate.

Water temperature is one of the major environmental factors that play an important role in determining the scope for growth (SFG) and reproduction of marine organisms (MacDonald & Thompson, 1986; Bayne & Hawkins, 1990; Navarro & Torrijos, 1995). In addition, temperature is also among the most important environment factors crucial in the study of physiology (Resgalla et al., 2007). To date, information regarding the food consumption and assimilation of this species is very limited due to lack of studies and knowledge about their ecological importance. The objectives of this study were to determine the food consumption rate and food absorption efficiency of adult *L. canarium* at different temperatures.

## MATERIALS AND METHODS

### *Sampling and Acclimation*

Conch samples were collected from the Merambong shoal seagrass bed, which is located within the Sungai Pulai estuary, Malaysia (01º19.778´N, 103º35.798´E) (Figure 1). Merambong shoal has one of the most extensive seagrass beds in Malaysian waters and probably the largest in South East Asia (Bujang et al., 2006). Adult *L. canarium* were randomly collected during extremely low tide, i.e. between 1.5 to -2.7 MSL tide levels. Adult conch can easily be recognized by their thick and flared outer columella lip (CFMS, 1999; Cob et al., 2009b). Samples were immediately transported to the hatchery facility at Universiti Kebangsaan Malaysia, Bangi, Selangor, Malaysia.

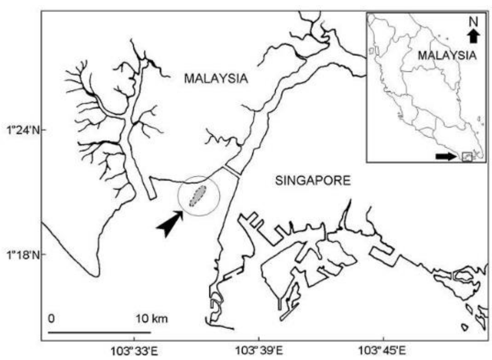


**Figure 1.** Merambong shoal seagrass bed at the western Johor Straits, Malaysia.

In the hatchery, *L. canarium* were acclimated in stocking aquaria (length x width x height = 1.2 x 0.5 x 0.58 $m^3$, 400 L) for one week prior to the experiment. The stocking aquaria were supplied with well-aerated seawater of 30 PSU salinity, and at ambient temperature of 26°C. Commercial sinking pellets (®HIKARI MARINE MARINE-S-™, crude protein min.48%) were offered daily by allowing them to feed to satiation. A known weight of food was supplied ad-libitum to the individual conch. Water quality parameters such as water temperature, pH, dissolved oxygen and salinity were monitored twice daily by using a mercury thermometer, pH meter, an oxygen meter (YSI Model 59, Yellow Springs Instrument Company OH, USA), and a portable refractometer (ATAGO) respectively. Total ammonia nitrogen ($NH_3$-N) was measured by using the salicylate method for seawater (HachTM method 8155). The seawater was changed once every three days to prevent accumulation of metabolic wastes and dead individuals were immediately removed if encountered.

***Experimental Set Up***

After acclimation, only healthy conchs were selected, which was based on their activeness. The selected individuals were then measured (total shell length, mm) and weighed (total weight, g), and transferred into individual experiment tank of 20 cm length, 15 cm width and 15 cm height. Shell length and total weight for the conchs used in the experiment ranged between 54.00 to 69.00 mm, and 18.00 to 41.00 g, respectively.

A continuous re-circulating system was set up to measure food consumption at each temperature as shown in Figure 2. The conchs were exposed to four different temperatures i.e. 22, 26, 30 and 34°C. The system comprised of ten experimental tanks (T1 to T10) and one control tank (T0), in a temperature-controlled water bath. For the treatments with temperature above ambient the water bath temperature was gradually raised to the target temperature at a rate of 1°C day$^{-1}$ by using a thermostat heater (E-JET heater 200 W, Penang, Malaysia) and a heating circulator (Grant Optima$^{TM}$ T100, Grant Instruments, Cambridge, England). On the other hand, for the treatment with temperatures below ambient a chiller fitted with a circulator (HS-28 A, 250-1200L/H, Guangdong Hailea Grouph Co. Ltd) was used.

The conchs were maintained in their respective experimental temperature for a week. Prior to laboratory experimentation, the hunger levels (gastric emptying levels) of the conchs were standardized by 24 h starvation after a satiated meal. One animal was placed in each tank (T1 to T10) containing 4 L of well aerated and filtered seawater (0.45 µm). The control tank (T0), which was setup to obtain a correction factor for each treatment, also contained one animal but no food was given. Screens of 1.00 mm mesh size were fitted at the inflow and outflow of each tank to prevent the food and faeces from escaping. Each tank was provided with similar quantity of food pellets (102.13 ± 0.45 mg) and the conchs were allowed to feed within a 24 h period. After the 24 h feeding period, the seawater flow was stopped and the remaining uneaten pellets and faeces were collected and weighed to the nearest 0.1 mg using an analytical balance (A & D Company, Limited). Throughout experimentation, all conchs survived under the different temperature treatments.

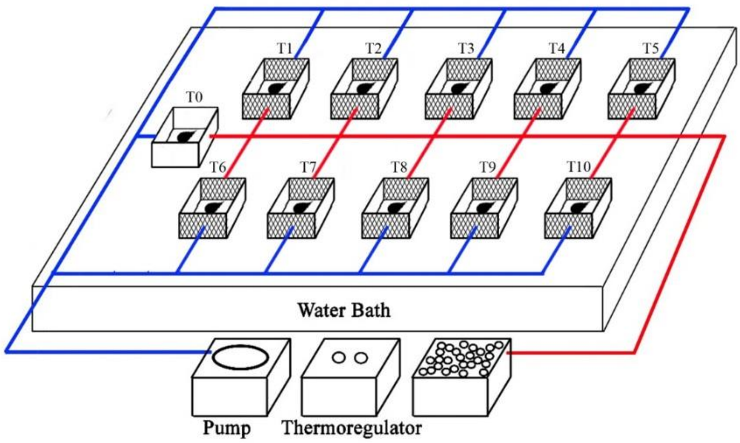


**Figure 2.** The experimental setup for measurement of food consumption in *Laevistrombus canarium*. Experimetal tanks (T1 to T10) were provided with sinking pellets, while T0 is a control experiment without food.

### *Laboratory Analyses*

The food consumption (FC) was calculated using the equation below (Britz, 1995):

$$FC\ (mg) = F - R \quad \ldots(1)$$

where, *FC* = consumption (mg), *F* = initial food weight (mg) and *R* = weight of food remaining (mg) after feeding.

The conch faeces were collected at every four hours till the end of the experiment (the next 24 to 48h), using a Pasteur pipette. The faeces were rinsed with filtered seawater (47 mm diameter, 0.45 µm, Whatman GF/F). The remaining salt that adhered to the faeces were washed using distilled water (Smaal & Widdows, 1994) before oven-dried at 60°C for 24 h to a constant weight. The dried faeces were allowed to cool to room temperature in a desiccator and then re-weighed. Afterwards, they were ashed in a muffle furnace at 550°C for 3 h, cooled to room temperature in desiccators and finally re-weighed to estimate the organic content. Food absorption efficiency (AE) was determined by calculating the organic and inorganic (ash) content of the ingested food and faeces. The AE was calculated following Conover (1966), Bayne and Newell (1983), Kesarcodi-Watson et al. (2001) and Resgalla et al. (2007), using the formula of:

$$AE\ (\%) = (F - E)/[(1 - E)F]\ x\ 100 \quad \ldots(2)$$

where, *F* = ash-free dry weight: dry weight ratio of food (g), and *E* = ash-free dry weight: dry weight ratio of the feaces (g).

The food energy content was determined by using bomb calorimetry (PARR6100, Parr Instrument). The fecal samples were pounded to a fine powder using pestle and mortar. The food energy absorbed were measured following Sobral and Widdows (1997) and Widdows and Johnson (1988) using the formula of:

$$EA\ (J/h) = FC\ x\ AE\ x\ E \quad \ldots(3)$$

where, *EA* = food energy absorbed (J/h), *FC*= food consumption rate (g $h^{-1}$), *AE* = food absorption efficiency (%) and *E*= Energy content of food (J $g^{-1}$). In this study the conversion factor of 1 g dry pellet weight = 16469.46 J was used throughout.

### *Statistical Analysis*

Prior to any statistical analyses, data distributions were tested for normality and homogeneity of variances. Differences in food consumption, food absorption efficiency and food energy absorbed between the four experimental temperatures were then further analyzed via the univariate method, non-parametric Kruskal-Wallis tests. A Kruskal-Wallis nonparametric analysis was conducted for data that depart from the assumptions of normality and homogeneity of variance. Then, post-hoc analyses (Dunn's test for non-parametric) comparison tests were performed to examine the differences among temperature regimes with all parameters at 0.05 probability level. Statistical analyses were conducted using MINITAB® release 14.1 statistical software.

## RESULTS

Food consumption (FC) by adults *L. canarium* at different temperatures is illustrated in Figure 3. Result indicates that temperature have a highly significant effect on food consumption of adult conchs (Kruskal-Wallis, $p<0.05$) where the mean FC values at 22°C (2.16 ± 0.23 mg $h^{-1}$) was significantly lower than all the other temperatures tested. The mean FC values of conchs cultured at 26°C (4.04 ± 0.12 mg $h^{-1}$) and 30°C (4.03 ± 0.06 mg $h^{-1}$) did not differ significantly (Kruskal-Wallis, $p>0.05$), but both were significantly higher (Kruskal-Wallis, $p<0.05$) compared with treatment at 34°C (3.42 ± 0.16 mg $h^{-1}$).

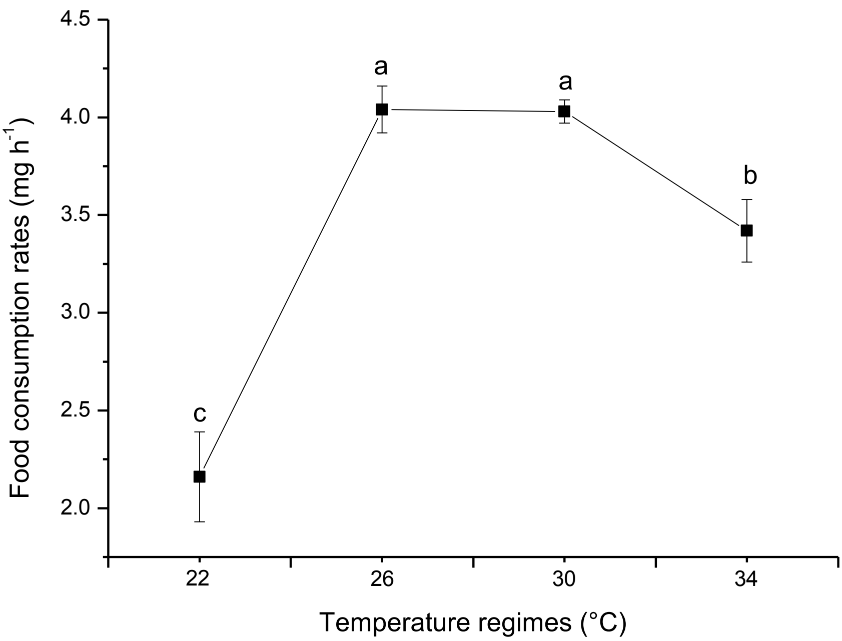


**Figure 3.** Food consumption rate (mg $h^{-1}$) by adults *Laevistrombus canarium* at different temperatures. Values are means **±** standard errors (N=10). Different letters indicate significant difference between treatments at p = 0.05 probability levels.

Food absorption efficiency (AE) for adults *L. canarium* is presented in Figure 4. There was also significant different in adult conch's AE values when cultured in different temperatures (Kruskal-Wallis, $p<0.05$). The AE values recorded at 26°C (74.75 ± 3.35 %) and 30°C (73.85 ± 1.50 %) were significantly higher compared with AE at 22°C (55.21 ± 4.95 %) and 34°C (55.69 ± 3.18 %) ($p<0.05$). There was no significant different in AE values between 26°C and 30°C ($p>0.05$); and between 22°C and 34°C ($p>0.05$) temperature treatments.

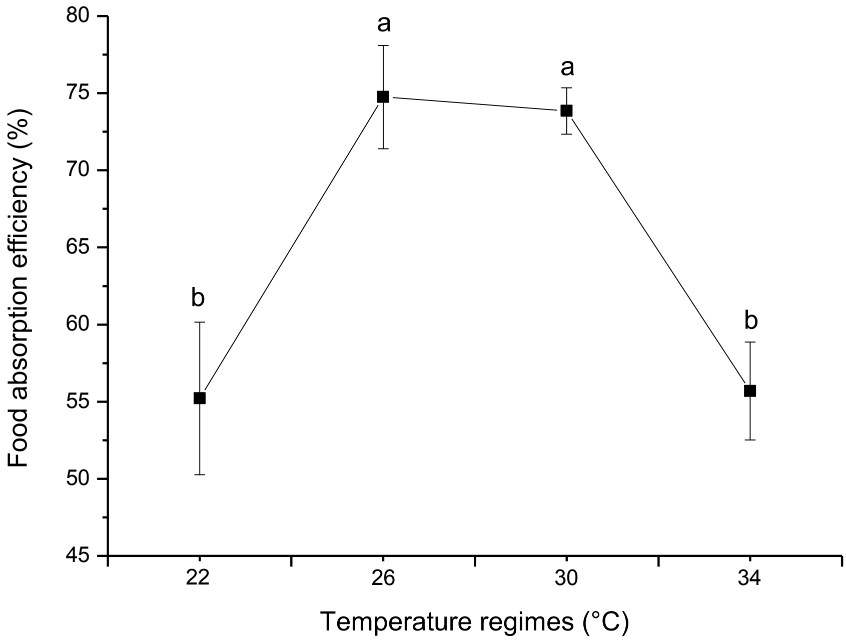


**Figure 4.** Food absorption efficiency (%) of adults *Laevistrombus canarium* at different culture temperatures. Values are means **±** standard errors (N=10). Different letters indicate significant difference between treatments at p = 0.05 probability levels.

Different culture temperatures affected the amount of food energy absorbed (EA) by adult conchs (Kruskal-Wallis, $p<0.05$), as demonstrated by Figure 5. The mean EA values recorded at 26°C (50.14 ± 3.43 J $h^{-1}$) and 30°C (49.09 ± 1.46 J $h^{-1}$) culture temperatures did not differ significantly ($p>0.05$) but were significantly higher than EA at 22°C (19.14 ± 2.41 J $h^{-1}$) and 34°C (31.15 ± 1.99 J $h^{-1}$). There was no significant difference in mean EA values between 22°C and 34°C ($p>0.05$).

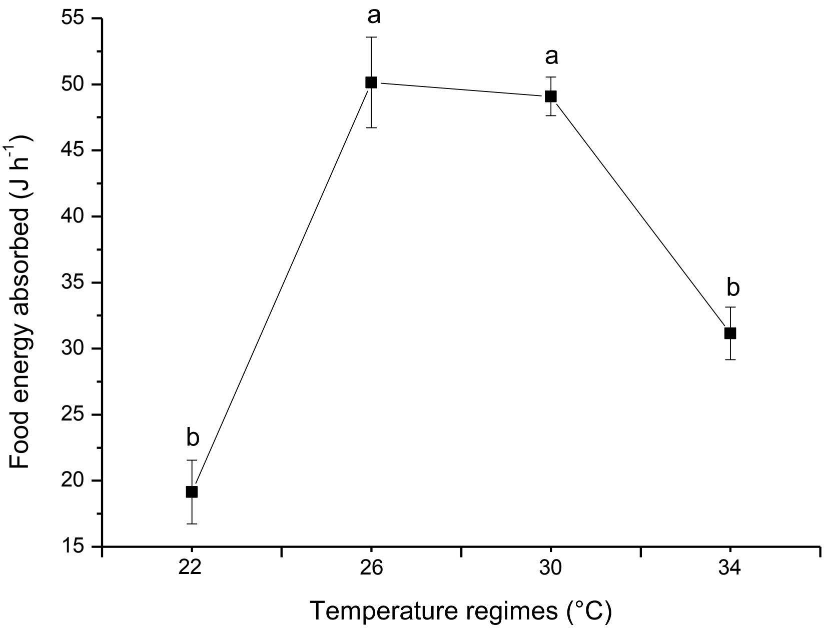


**Figure 5.** Food energy absorbed (J h$^{-1}$) by adults *Laevistrombus canarium* at different temperatures. Values are means **±** standard errors (N=10). Different letters indicate significant difference between treatments at p = 0.05 probability levels.

## DISCUSSION

This study shows that the food consumption (FC values) of adult conch increased with increasing temperature (22 to 30°C), but then decreased again at a much high temperature (34 °C). This pattern of fluctuations in FC values against temperatures was similar when compared with previous studies reported by several authors such as Kideys (1997), Navvaro et al. (2002), Resgalla et al. (2007) and Yukihira et al. (2000). The natural habitat where the conch was sampled has a temperature ranged fluctuate between 27 to 30°C (Cob, 2008a; Husna et al., 2017). Temperatures lower or higher than these optimum values are expected to affect the conch's overall activity and performance. Husna et al. (2019) reported that the conch can tolerate and become acclimatized to temperatures between 26 to 30°C. Marine mollusk in general can regulate their activity in response to changes in temperatures through acclimatization, which may increase their capability to survive (Kinne, 1971: Sobral & Widdows, 1997). This study showed lower activity at lower and higher end of tested temperatures, which indicates that temperatures beyond the optimal value can be stressful to the species studied. Previous study on carpet clam (*Ruditapes decussatus*) by Sobral & Widdows (1997) also reported a decline in FC values with increasing temperatures, while Walne (1972) revealed that mollusc species are very vulnerable to reduction in temperatures.

In this study, the AE values for adult conch ranged between 55.21% to 74.75%, which was relatively low compared with other herbivorous gastropods. Peck et al. (1987) reported AE values ranged from 78% to 81% in abalone *Haliotis tuberculate*, while Navarro & Torrijos (1995) reported AE values from 81 to 95% for Chilean abalone *Concholepas concholepas*. On the other hand, Cox and Murray (2006) reported low AE values for the turban snail *Lithopoma undosum*, which ranged between 34.9% and 61.2%.

Carnivorous and scavenging gastropods normally show higher values of AE. For example, reported AE values for *Clione limacina* ranged from 82 to 98% (Bayne & Newell, 1983), and for *Thais haemastoma* ranged from 81 to 97% (Bayne & Newell, 1983). The scavenging gastropod *Nassarius festivus* that consumed on excise *Tapes philippinarum*, their reported AE values ranged from 94% to as high as 98% (Cheung et al., 2008). However, some predatory gastropod does show wide range of AE such as the muricid snail *Chorus giganteus* with AE valuesranged from 47% to 83% (Navarro et al., 2002); and the trumpet shell *Charonia suguenzae* with AE ranged from 45% to 93.5% (Doxa et al., 2013).

The relatively lower AE values for *L. canarium* recorded in this study could be related to the low concentration of ash in the food pellets used, compared with other types of food. This was in agreement with Cox & Murray (2006), who attributed the low AE for *L. undosum* because they preferentially consume kelps, which has low energy value compared with other macrophytes.

The food energy absorbed (EA) by adult *L. canarium* increased with increasing temperature (22 to 30°C) and then declined when the temperature increased to 34°C. Results from this study was quite similar with the previous study by Yukihira et al. (2000) on the effect of different temperatures (ranged from 19°C to 32°C) on pearl oysters. They found that the upper temperature tested (32 °C), although showed a decline in EA values, was not sufficiently near the lethal temperature of the oysters. Earlier study by Sobral and Widdows (1997) showed that *R. decussatus*, was in stress condition and showed lower EA values at higher temperatures (above 27°C). They concluded that temperature is one of the factors limiting the distribution of marine animal through its effect on their activity level and energy balance.

For the declined EA values recorded at lower temperature limit, the present finding is quite similar with the previous study by Bashevkin and Pechenik (2015) who demonstrated that the food energy absorbed by *Crepidula fornicate* was significantly depressed at lower temperatures. On the other hand, Sobral and Widdows (1997) reported that food energy absorbed by *R. decussatus* was higher at low temperature (20°C) as compared with high temperature (32°C). This previous finding quite similar with Navarro et al. (2002) who also reported lower food energy absorption at higher temperature but the temperature appears not to influence food absorbed for *C. giganteus.* As indicated by Ansell, (1981) and Bayne & Newell, (1983), absorption rate is not strongly affected by temperature across normal range.

## CONCLUSION

The optimum temperature for food consumption and assimilation by adult *L. canarium* is between 26°C to 30°C. This likely indicates that *L. canarium* is well adapted to its natural habitat where the temperature ranges roughly between 26°C to 30°C. Thus, any increase or decrease in temperatures from this optimal range most likely will affect their physiological traits. *Laevistrombus canarium* can adapt well within this optimal temperature range, as showed by their efficiency in consuming and digesting the given food pellet. This study not only determined the optimal temperature range for the best culture practice of this edible marine snail, but more importantly allows us to understand the physiological characteristics of the conch, which is temperature dependent like most other ectothermic organisms. However, more studies are still needed, particularly by adopting longer exposure times as well as higher temperature ranges, in order to better understand the effect of temperatures on the species.

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