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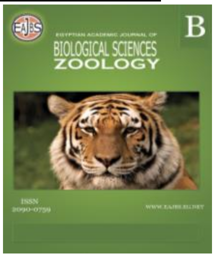

Study of the Effect of Climate Change on Growth of Seawater Snail, *Planaxis sulcatus* in Coast of Yanbu- Saudi Arabia

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ABSTRACT

The most notable indicators of climate change are noticed in many climatic phenomena since the 1950s. Global climate change is manifested by global warming and sea-level rise. This study aimed to detect the effect of temperature on wet weight, shell length and shell aperture of seawater snail *Planaxis sulcatus*. This study is an experimental study that investigated 54 *Planaxis sulcatus* snails. The samples were collected from the beach of Yanbu in western Saudi Arabia then transferred to the lab. Samples were divided into 3 groups control, cure 1 and cure 2. Each group contained 18 snails. Group cure 1 was treated by increasing water temperature to be 28.8°C, while group cure 2 was treated by increasing water temperature to be 32°C. This study showed that, regarding *Planaxis sulcatus*, there were no significant differences between weekly measures of the wet weight, shield length, and shield aperture. Also, there were no significant differences between the three studied groups (control, cure 1 and cure 2) regarding the weekly assessed wet weight, shield length, and shield aperture of snails at any station of the study ($p>0.05$). In conclusion: There is a need for conducting further experimental studies to detect the effects of different climate factors such as high temperature, acidity and salinity.

INTRODUCTION

The most notable indicators of climate change are noticed in many climatic phenomena since the 1950s. Global climate change is manifested by global warming and sea-level rise (Hereher, 2016; Williams, 2013). Recent investigations reported an increase in the global temperature by 0.7 °C and the rise of the sea level by 10–20 cm in the 20th century (Hereher, 2016; IPCC Climate Change, 2007). Climate change is considered natural and unnatural, as humans and nature are considered responsible for the change, as humans use fossil fuels to produce energy and convert natural lands for industrial use and have been caused by nature through volcanoes, emitted gases, and natural disasters, both of which cause the production of greenhouse gases. Heat, continental drift, and change in the sun naturally alter the climate. (Binnaser, 2021a; Binnaser, 2021b; Gravili,2017; Intergovernmental Panel on Climate Change ,2014; IPCC Climate Change, 2007). They are often used interchangeably, but they have different

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meanings. “Global warming” is the current and projected increase in average temperature near the Earth’s surface as a result of increased levels of greenhouse gases in the atmosphere and “climate change”: describes shifts in long-term climate patterns, including air temperature, rain and snow, and atmospheric circulation Air (U.S. Environmental Protection Agency, 2009)

An increase of a few degrees over the average temperature may make a big difference. In a study conducted by climatologists, they found that the average temperature in the last century increased by 1.3 degrees Celsius and is expected to rise from 2.0 to 11.5 degrees Celsius in the current century, and although this does not seem alarming, it has begun to In some areas of the US, severe heat waves, a decrease in air quality, an increase in insects and the transmission of diseases through water, just a few degrees increase in average temperatures can fundamentally change the physical and life cycles of the Earth. (IPCC Climate Change, 2007)

As levels of carbon dioxide and other greenhouse gases increase in the atmosphere, the atmosphere will continue to warm even if we stop emitting greenhouse gases tomorrow. However, it is possible to stabilize productions through policy and behavioral choices by developing plans to reduce productions as well as with new technologies. Setting emissions reduction targets to a large extent is a collective choice and is based on how we judge the risks of climate change (National Research Council America’s Climate Choices, 2011). The Intergovernmental Panel on Climate Change (IPCC) predicts that the partial pressure (PCO2) of carbon dioxide (CO2) in the atmosphere will range from 490 to 1250 ppm in 2100, depending on the social and economic data considered.

One-third of human CO2 production is stored in the oceans, and the ocean pH has decreased by 0.1 compared to its pre-industrial level (Caldeira and Wickett, 2003). It is expected to decrease by 0.4 percent by the end of this century (Orr, *et al.*, 2005)

Increasing the acidity of seawater will lead to a change in the inorganic carbon balance, which leads to an increase in the proportion of co2 and a decrease in the proportion of the carbonate ion (CO3), which is an essential component of calcium carbonate, CaCO3, and a change in its concentration leads to a change in the ability of marine organisms to precipitate CaCO3 and many studies have shown Reduction in calcium deposition and the size of coral reefs, coralline algae, etc (Langdon and Atkinson, 2005). Water temperature is one of the most important factors affecting the growth and representation of other physiological in outdoor waters This heat stress greatly affects the activity of enzymes (Hardewig, *et al.*,2004; Hickey, *et al.*, 2003).

Global warming is expected to continue due to the emissions of carbon dioxide (CO2) gas into the atmosphere (Hereher, 2016; Simas, *et al.*, 2001). It is expected that the sea level will rise about 60 cm by 2100 due to the thermal expansion of seawater and the melting of ice in the arctic glaciers (Hereher, 2016; IPCC Climate Change, 2007). The dependence on the coastal zone is important worldwide as more than 60 % of the world population lives along shorelines (Hereher, 2016; Doukakis, 2005) and a wide range of socio-economic activities occurs at or near coastlines. (Hereher, 2016)

Climate change is related to the strength of the description of extreme phenomena that lead to significant changes in natural habitats and ecosystems (Binnaser, 2021a; Hanley, et al, 2020), where many types of climate change have already led to the extinction of some species. Also, the continuous increase in global warming by 1.5°C - 2.5°C will cause the extinction of 30% of known biological species (Binnaser, 2021a; Binnaser, 2021b; IPCC, 2012; Soto-Correa, *et al.*,2012; Dow and Downing,2011), which may threaten the biodiversity of organisms and human food security. (Hereher, 2016; Somero.2010) Physiological adaptations are important for animals to face changing environmental conditions and play a major role in determining species. (Banerjee, *et al.*, 2018)

Forecasts play an important role in alerting scientists and decision-makers to potential future risks and can support the development of proactive strategies to reduce the effects of climate change on biodiversity, although there is relatively limited evidence of current extinctions caused by climate change, and studies indicate that climate change Habitat destruction could exceed and pose the greatest threat to the world of biodiversity over the next few decades. However, the multiplicity of approaches is shifting expectations and making it difficult to obtain a clear picture of the future of biodiversity. Thus, there is an urgency that needs to review our current understanding of climate impacts and changing biodiversity. Many organisms now live in temperatures close to their thermotolerance limits (Banerjee, *et al.*, 2018; Hereher, 2016). Where, global warming can reduce overall animal biomass by affecting the animal's interaction with the food web due to an increase in energy demand and an increase in metabolic processes (Binnaser, 2021a; Mazurkiewicz, *et al.*,2020; 25. Bruno, m, *et al.*, 2015; Levinton, 2009).

Gastropods are the largest class of mollusks including about 30,000 marine species. *Planaxis sulcatus* belong to the kingdom Anemalia, phylum Mollusca, class Gastropoda; snails order Neotaenioglossa, order, family Planaxis, Species Sulcatus (Born, 1978). This marine species is found in the Red Sea and in the Indian Ocean off Mozambique, Kenya, Madagascar, Tanzania, from Mauritius, Chagos, Waldebra and the Mascarene Basin. It is also found off the Pakistani coast, especially Sunmyani Bay (Miani Hor). The Furrowed Clusterwink (*Planaxis sulcatus*) is found commonly in rocky intertidal environments. The conical shell, speckled with patterns of white spots on a greenish-brown background of P. sulcatus, grows up to a length of 35 mm in adult individuals. *P. sulcatus* are herbivorous, feeding primarily on microalgae that cover the rocky areas. (Williams, 2013; Houbrick, 1987). Females are usually larger than males (Hereher, 2016; OHGAKI, 1997).

The current study aimed to detect the effect of temperature on wet weight, shell length and shell aperture of seawater snail *Planaxis sulcatus*.

MATERIALS AND METHODS

Materials Used in This Study Included*:*

- 54 *Planaxis sulcatus* snails
- 3 Aquaria (10 L to each one) to place snails in them
- Cages to keep snails in the bottom of the aquarium
- Digital thermometer (Aqua Medic with an accuracy of ± 1 º C) to measure water temperatures
- Heaters (50W) to provide suitable temperatures for water
- Measuring ruler cm to measure the snail aperture
- Balance to measure the weight of the snail (DENSI (PC-100W))
- Plastic tie to tie the cage
- Caliper cm to measure the length of the snail
- Air pump to provide oxygen to the aquarium
- Paint to classify and number the snail for easy identification

Collection of Samples*:*

The samples of 54 (*Planaxis sulcatus*) snails were collected from the beach of Yanbu, the coordinates of the site (37.9409090.24.1423170). The surface seawater temperature was 25.5 °C. Seawater salinity at the start of the experiment: 40 ppt. And pH of the seawater at the start of the experiment: 8.2. We sorted the snail in ponds. We put them inside the tanks for 3 days to acclimatize at room temperature. We set the appropriate environment for it from seawater and rocks, and it was transferred to the College of Science - Taibah University - in Madinah.

Grouping:

The researcher sorted the snails into 3 aquariums. Inside each aquarium, 18 snails were placed inside a mesh cage, numbered from No. 1 to No. 18, using paint. We installed air pumps to all aquariums and measured the temperatures of all aquariums. The snails were divided into 3 aquariums, Basin No. 1 is the control group, and Basin 2 and 3 are the ones we conducted the study on with an average temperature of 28.6 and 32 for 3 weeks (Table 1).

Table 1: Grouping of the study.

Aquariums No	Group	Snail	Temperature	Samples
1	Control group	*Planaxis sulcatus*	25.5	18
2	Cure 1 group	*Planaxis sulcatus*	28.8	18
3	Cure 2 group	*Planaxis sulcatus*	32	18

Measurements:

Growth measurements (wet weight, shield length and shield aperture) were evaluated on all samples once per week.

Statistical Analysis:

The collected data were coded, processed and analyzed using the Statistical Package of Social Science (SPSS) program for windows (version 22) (Chicago, IL, USA). Quantitative data were presented as mean and standard deviation (SD). To test significance between different groups, one way ANOVA test was used. Repeated measures ANOVA test was done to test significant differences throughout the study period within each group. Bonferroni post hoc test was performed to detect pairwise significance throughout the study period. A p-value of < 0.05 was considered statistically significant.

RESULTS

One kind of sea snail was included in the current study (*Planaxis sulcatus*) 54 snails, where three measurements were assessed (length, aperture, and weight).

Regarding the results of *Planaxis sulcatus* changes in the weight of studied snails were reported. It was observed that in the control group, the wet weight started at 14.39 ±1.3 at the beginning of the study to reach 13.94 ±1.3by the end of 3rd week without any significant differences between weekly measures of the wet weight. Regarding cure group 1, the wet weight started at 13.86 ± 1.1 at the beginning of the study to reach 13.53 ± 1.1by the end of the 3rd week without any significant differences between weekly measures of the wet weight. In cure group 2, the wet weight started at 13.58 ±1.3 at the beginning of the study to reach 13.69 ± 0.9 by the end of the 3rd week without any significant differences between weekly measures of the wet weight. Comparison between the three studied groups regarding the weekly assessed wet weight of snails revealed no significant difference in the wet weight at any station of the study (Tables 2 & 5).

Changes in shield length of *Planaxis sulcatus* snails were observed that in the control group, the shield length started at 1.3 ±0.4 at the beginning of the study and continue in the same measure 1.3 ± 0.4 by the end of 3rd week without any significant differences between weekly measures of shield length. Regarding cure 1 group, the shield length started at 1.3 ± 0.3 at the beginning of the study to reach 1.2 ± 0.3 by the end of 3rd week without any significant differences between weekly measures of shield length. Regarding cure group 2, the shield length started at 1.3 ± 0.4 at the beginning of the study to reach 1.2 ± 0.3 by the end of 3rd week without any significant differences between weekly measures of shield length. Regarding the shield length, a comparison of the weekly assessment revealed no significant difference in the shield length at any station of the study (Tables 3 & 6).

It was observed that in the control group, the shield aperture started at 1.1 ±0.1 at the beginning of the study and continue in the same measure 1.1 ±0.1 by the end of 3rd week without any significant differences between weekly measures of shield opening. Regarding cure 1 group, the shield aperture started at 1.1 ±0.1 at the beginning of the study and continued in the same measure of 1.1 ±0.1 by the end of 3rd week without any significant differences between weekly measures of shield aperture. Regarding cure group 2, the shield aperture started at 1.1 ± 0.1 at the beginning of the study and continue in the same measure 1.1 ± 0.1 by the end of 3rd week without any significant differences between weekly measures of shield opening. Comparison between the three studied groups regarding their weekly assessed shield aperture of snails showed no significant difference in the shield length at any station of the study (Tables 4 & 7).

Table 2: Comparison between the studied groups of *Planaxis sulcatus* regarding the wet weight throughout the study period (n = 54).

Study period	Wet weight			P value
	Control Mean ± SD	Cure 1 Mean ± SD	Cure 2 Mean ± SD	
Week 1	14.39 ±1.3	13.86 ± 1.1	13.58 ±1.3	P=0.158 P1= 0.638 P2= 0.179 P3= 0.990
Week 2	13.67±1.4	13.29± 1.1	13.61± 0.9	P=0.368 P1= 0.999 P2= 0.703 P3= 0.632
Week 3	13.94±1.3	13.53± 1.1	13.69± 0.9	P=0. 548 P1= 0.834 P2= 0.999 P3= 0.999

One-way ANOVA test was used with Bonferroni post hoc test. A p-value of < 0.05 was considered statistically significant.
P1 compare control vs. cure 1
P2 compare control vs. cure 2
P3 compare cure 1 vs. cure 2

Table 3: Comparison between the studied groups of *Planaxis sulcatus* regarding the length throughout the study period (n = 54).

Study period	Shield length			P value
	Control Mean ± SD	Cure 1 Mean ± SD	Cure 2 Mean ± SD	
Week 1	1.3 ±0.4	1.3 ± 0.3	1.3 ±0.4	P=0.713 P1= 0.999 P2= 0.999 P3= 0.999
Week 2	1.3 ±0.4	1. 2± 0.3	1. 3±0.2	P=0. 415 P1= 0.586 P2= 0.999 P3= 0.999
Week 3	1.3 ±0.4	1. 2± 0.3	1. 2±0.3	P=0.550 P1= 0.837 P2= 0.999 P3= 0.999

One-way ANOVA test was used with Bonferroni post hoc test. A p-value of < 0.05 was considered statistically significant.
P1 compare control vs. cure 1
P2 compare control vs. cure 2
P3 compare cure 1 vs. cure 2

Table 4: Comparison between the studied groups of *Planaxis sulcatus* regarding aperture throughout the study period (n = 54).

Study period	Shield aperture			P value
	Control Mean ± SD	Cure 1 Mean ± SD	Cure 2 Mean ± SD	
Week 1	1.1 ±0.1	1.1 ±0.1	1.1 ±0.1	P=0.705 P1= 0.999 P2= 0.999 P3= 0.999
Week 2	1.1 ±0.1	1.1 ±0.1	1.1 ±0.1	P=0.916 P1= 0.999 P2= 0.999 P3= 0.999
Week 3	1.1 ±0.1	1.1 ±0.1	1.1 ±0.1	P=0.838 P1= 0.999 P2= 0.999 P3= 0.999

One way ANOVA test was used with Bonferroni post hoc test. A p-value of < 0.05 was considered statistically significant.
P1 compare control vs. cure 1
P2 compare control vs. cure 2
P3 compare cure 1 vs. cure 2

Table 5: Comparison between study periods regarding the wet weight throughout the studied groups of *Planaxis sulcatus* (n = 54).

Study period	Wet weight			P value
	Week 1 Mean ± SD	Week 2 Mean ± SD	Week 3 Mean ± SD	
Control	14.39±1.3	13.67± 1.4	13.94±1.3	P=0.272 P1= 0.335 P2= 0.960 P3= 0.999
Cure 1	13.86 ±0.9	13.29 ± 1.1	13.53 ±1.1	P=0.311 P1= 0.390 P2= 0.999 P3= 0.999
Cure 2	13.58 ±1.3	13. 61± 0.9	13.69 ±1.0	P=0.384 P1= 0.686 P2= 0.999 P3= 0.707

One way ANOVA test was used with Bonferroni post hoc test. A p-value of < 0.05 was considered statistically significant.
P1 compare Week 1 vs. Week 2
P2 compare Week 1 vs. Week 3
P3 compare Week 2 vs. Week 3

Table 6: Comparison between study periods regarding the length throughout the studied groups of *Planaxis sulcatus* (n = 54)

Study period	Shield length			P value
	Week 1 Mean ± SD	Week 2 Mean ± SD	Week 3 Mean ± SD	
Control	1.3±0.4	1.3±0.4	1.3±0.4	P=0.995 P1= 0.999 P2= 0.999 P3= 0.999
Cure 1	1.3±0.3	.12 ±0.3	.12 ±0.3	P=0.862 P1= 0.999 P2= 0.999 P3= 0.999
Cure 2	1.3±0.4	1.3±0.2	1.3±0.3	P=0.720 P1= 0.999 P2= 0.999 P3= 0.999

One way ANOVA test was used with Bonferroni post hoc test. A p-value of < 0.05 was considered statistically significant.
P1 compare Week 1 vs. Week 2
P2 compare Week 1 vs. Week 3
P3 compare Week 2 vs. Week 3

Table 7: Comparison between study periods regarding the aperture throughout the studied groups of *Planaxis sulcatus* (n = 54).

Study period	Shield aperture			P value
	Week 1 Mean ± SD	Week 2 Mean ± SD	Week 3 Mean ± SD	
Control	1. 1±0.1	1. 1± 0.1	1. 1±0.1	P=0.585 P1= 0.999 P2= 0.999 P3= 0.989
Cure 1	1. 1±0.1	1. 1± 0.1	1. 1±0.1	P=0.505 P1= 0.999 P2= 0.744 P3= 0.989
Cure 2	1. 1±0.1	1. 1± 0.1	1. 1±0.1	P=0.736 P1= 0.999 P2= 0.999 P3= 0.999

One way ANOVA test was used with Bonferroni post hoc test. A p-value of < 0.05 was considered statistically significant.
P1 compare Week 1 vs. Week 2
P2 compare Week 1 vs. Week 3
P3 compare Week 2 vs. Week 3

DISCUSSION

Marine biodiversity responds to unstable temperatures and other oceans and seas conditions through changes in organismal physiology and phenology, as well as population dynamics and distributions (Wabnitz, *et al.*,2018; PoÈ rtner, *et al.*,2014; Poloczanska, *et al.*,2013; Pauly,2010). These responses to oceans and seas atmospheric variations have been expected to lead to diverse patterns of species richness (Wabnitz, *et al.*,2018; Jones and Cheung,2015; Cheung, *et al.*, 2009) differences in community structure (Wabnitz, et al,.2018; MacNeil, et al,.2010) and ecosystem functions (Wabnitz, *et al.*,2018; Petchey, *et al.*, 1999), and significant deviations in marine supplies and services (Wabnitz, et al,.2018; Madin, *et al.*, 2012; Sumaila, *et al.*, 2011; Cheung, *et al.*, 2010).

The Red Sea which is located in one of the warmest areas in the world has a high rate of biodiversity (Hereher, 2016; Dreano, *et al.*,2016). Even though species found in it are of small size, the marine ecosystem has not been studied sufficiently compared to other water ecosystems such as the Great Barrier Reef and the Caribbean Sea (Hereher, 2016; Bruckner, *et al.*, 2013; Berumen, *et al.*,2013). Where few studies detected the influence of temperature rising on sea snails in the Red Sea mainly at the coast of the kingdom of Saudi Arabia.

This study is an experimental animal study including 54 *Planaxis sulcatus* snails collected from the beach of Yanbu in the kingdom of Saudi. This study aimed to detect the physiological impact of near-future temperature elevation due to climate change on sea snail growth at the coast of the Kingdom of Saudi Arabia on the Red Sea.

To summarize our findings, seawater measurements of temperature were increased gradually in group B and group C. Regarding *Planaxis sulcatus*, there were no significant differences between weekly measures of the wet weight, shield length, and, shield aperture. Also, there were no significant differences between the three studied groups (control, cure 1 and cure 2) regarding the weekly assessed wet weight, shield length, and, shield aperture of snails at any station of the study.

Similar results were reported by Binnaser in his study conducted in Elrys, were no significant differences between weekly measures of the wet weight and shield aperture in intragroup comparison of the three groups A, B and C. Also, when comparing the 3 groups, wet weight, shield length and shield aperture of studied snails also showed no significant differences. (Binnaser,2021b) In Bahrain study, the area around Bahrain is likely to be among the most sensitive areas in the Gulf region regarding temperature elevation, as a result, the marine animals will suffer from these elevated temperatures. Where wet-bulb air temperature is already more than 33 °C at the site. The tropical periwinkle living in the area has modified its behavior in an attempt to cope with increased temperatures. In winter, the periwinkle is mostly found in large clusters clinging to the shady side of rocks and other emergent hard objects in the upper intertidal zone. While, in summer, where substrate temperature in the upper intertidal zone may reach > 52 °C. the species cope with elevated substrate temperatures by forming pyramid-shaped clusters on the surface of the mudflat during the ebbing tide, and by avoiding areas of the mudflat where substrate temperatures are higher than 41 °C (Kaminski and Garrison,2020). In U.A.E. Feulner and Hornby reported that the periwinkles adopt a “stay cool in the pool” strategy, escaping the heat by essentially abandoning the intertidal zone and remaining submerged (Feulner and Hornby, 2006).

These results showing no differences between the control group and others with temperature elevation can be explained by readjustment. Where the previous study reported that snails adapted to 10, 20 and 30C showed reasonable heat and cold adaption (Al-Khateeb,2006). This ability of acclimation helps gastropods to survive in different environments such as the intertidal zone where low tide temperature exceeds 52°C on tropical and rocky coasts (Binnaser,2021b; Marshall, *et al.*, 2013).

Conclusion

In conclusion, all the results in the current study were statistically non-significant, which meant that no relationship between temperature elevation and the three parameters (wet weight, shield length and shield aperture). There is a need for conducting further experimental studies in different seasons to detect the effects of different climate factors such as high temperature, acidity and salinity.

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