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Environmental Factors Affecting the Distribution of Selected Free-Living Isopods in the Southern Coast of Kerala, India

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ABSTRACT:
Intertidal isopods are a group of successfully surviving organisms in the littoral region of the sea. The continuous exposure to human activities and other botic and abiotic stresses can influence their distribution and diversity along the seashore. Air and water temperature, salinity, pH, and presence of nutrients such as silicate, nitrate and phosphate are studied for their influence on some of the selected intertidal isopods found in three different beaches of the southern Kerala. Monthly data was collected for the water samples and four different isopod species found in the intertidal region and the significance of their interaction was calculated with the help of SPSS, using two-way ANOVA. The statistics shows a vivid relationship between these abiotic factors and isopods under study.

Keywords:
Isopod, Intertidal, Abiotic factors

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INTRODUCTION

Isopods are crustaceans which constitutes the most species rich order of the superorder Peracarida. The limited, but existing phylogenetic analyses and the fossil record suggest that this group is present from at least the Carboniferous Period of the Paleozoic. With the approximately 300 million years of existence, isopods have managed to cope up with the maximum range of habitats possible. They can be seen in terrestrial, fresh water and marine environments. The sea-dwelling isopods are distributed in benthic as well as littoral regions.

The littoral zone (intertidal region) is the area which is close to the shore and experience heavy tidal activity and where the seabed gets exposed at the time of low tides. It has a huge diversity of biotic (vegetation, sessile organisms) and abiotic (rock, sand) substrates, forming habitats to a large variety of organisms of varying complexity. Many creatures use these resources for varying needs of their lives such as for food, attachment, refuge (Zohary. T and Gasith. A, 2014) Here, the inhabitant organisms have to be well equipped for facing the sudden, harsh changes taking place in their habitat (Joshi, 2010). The water level fluctuations are the major factor behind the instability possessed by this habitat. Along the intertidal region, inhabitants arrange themselves vertically, based on their adaptations and abilities. They might consider the risk of drying out and avoiding predators and the competition for space.

A vast range of limiting factors other than predator activity can influence the successful establishment of organisms in here. They are; the availability of nutrients, oxygenated water, tidal activities, air and water temperature, salinity and acidity of the water.

For the successful survival in the littoral region, isopods exhibit some physiological and ecomorphological adaptations such as pleopodal lungs and cuticle, in addition to the seasonal and diurnal behavioral patterns which help them for better adaptation. The relation between the surface activity of isopods and rainfall rate is noteworthy and the rainfall can influence many other factors such as pH, salinity, nutrient surge and many more, indirectly.

MATERIALS AND METHODS

Isopod collection

Most isopods live in benthic habitats under rocks, in rock crevices and rock rubble, and amongst rocks and shells previously bored by other organisms like sponges, mollusks, and worms. Since isopod habitat preferences are diverse and many species have extremely patchy distributions, the need to cover considerable ground and sort through large enough samples should be taken into account. Various collection methods were tried, including handpicking and usage of traps. Bait traps, net and frame, cast net, etc. were used to collect specimens. We engaged divers and rock scrappers also. From the collected samples, four isopod species were selected for the study, which fall in four different genuses. They are *Ligia dentipes, Cirolana bovina, Alloniscus perconvexus* and *Dynamenella scaptocephala.*

Water sample collection

Water samples were collected from February 2018 to January 2020. Both animal and water samples were collected from the sites in pre-monsoon (February- May), monsoon (June-September) and post-monsoon (October-January) seasons. The collection was done between 8 am and 10 am, every month. To satisfy one of the objectives – to find the limiting factors controlling the distribution of isopods-physicochemical characteristics such as water temperature, pH, salinity, dissolved oxygen, nitrate, phosphate and silicate were estimated for the collected samples, following standard methods and procedures.

Using a digital thermometer, water temperature was measured on site. A handheld digital pH meter was used for measuring the pH of the sample and salinity was measured using a refractometer. For studying all other parameters, sea water was collected in polyethene bottles. Dissolved oxygen was fixed immediately at the study site during the collection process, and in the laboratory, it was determined using Winkler's method. Nutrient limiting factors such as Nitrate, Phosphate and Silicate were analysed as per procedure by Bendschneider and Robinson (1952), Strickland and Parsons (1968) and Koroleff (1983).

Statistical analysis was done in SPSS software; for the two-way analysis of variance (ANOVA), followed by post-hoc test (Duncan's multiple range test) to determine the significance ($P<0.05$) for the data obtained.

RESULTS

In order to check the number of species corresponding to the sample spaces inferential analysis was done. Accordingly uni-variate general linear model (two-way ANOVA) was done to examine its statistical significance. According to the categorical variable species, the F test value is 67.622 and the corresponding *p* value is 0.000 which is lower than 5%, which means the isopod species which have been selected as the sample based on the species wise classification are showing the difference.

Similarly, according to the three different sample stations, where the isopods were collected from, the F test value is 33.298 and the corresponding *p* value is 0.000 which is lower than 5%, hence statistically significant. That is, there is a difference in the number of isopods present in each beach under study.

The interaction effect of species with place was also examined; the corresponding F test value is 19.874 and the corresponding *p* value is 0.000 which is lower than 5% that is based on the interaction of the variable species with the three beaches, the study is statistically significant. The R^2 value of the above model is which is showing the coefficient of determination as 61.3%; which implies that there is a variance in the isopod number based on the species and place, accountable as true to the extent of 61.3% (Table 1).

Table 1: Tests of Between-Subjects Effects

Dependent Variable: Isopod					
Source	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Corrected Model	19464.250[a]	11	1769.477	35.337	.000
Intercept	51091.130	1	51091.130	1020.301	.000
Species	10158.390	3	3386.130	67.622	.000
Place	3334.779	2	1667.389	33.298	.000
Species * Place	5971.082	6	995.180	19.874	.000
Error	42663.509	852	50.075		
Total	113218.889	864			
Corrected Total	62127.759	863			
a. R Squared = .613 (Adjusted R Squared = .604)					

In order to know the statistical significance of isopods based on their species, a post hoc test based on the Scheffe analysis was performed. In this, each species was compared with the other three collected and *Ligia dentipes* was found to be the dominant species of all. The difference between *L. dentipes* and the other two species, except *Cirolana bovina* was statistically significant as the *p* value was less than 5%. The second dominant species was found to be *C. bovina* followed by *Alloniscus perconvexus* and *Dynamenella scaptocephala* respectively (Table 2).

Table 2: Multiple Comparisons

Dependent Variable: Isopod						
Scheffe						
(I) Species	**(J) Species**	**Mean Difference (I-J)**	**Std. Error**	**Sig.**	**95% Confidence Interval**	
					Lower Bound	**Upper Bound**
Ligia dentipes	*D. scaptocephala*	8.01*	.681	.000	6.11	9.92
	A. perconvexus	6.81*	.681	.000	4.90	8.71
	C. bovina	1.35	.681	.273	-.56	3.25
Dynamenella scaptocephala	*L. dentipes*	-8.01*	.681	.000	-9.92	-6.11
	A. perconvexus	-1.21	.681	.371	-3.11	.70
	C. bovina	-6.67*	.681	.000	-8.58	-4.76
Alloniscus perconvexus	*L. dentipes*	-6.81*	.681	.000	-8.71	-4.90
	D. scaptocephala	1.21	.681	.371	-.70	3.11
	C. bovina	-5.46*	.681	.000	-7.37	-3.55
Cirolana bovina	*L. dentipes*	-1.35	.681	.273	-3.25	.56
	D. scaptocephala	6.67*	.681	.000	4.76	8.58
	A. perconvexus	5.46*	.681	.000	3.55	7.37
Based on observed means. The error term is Mean Square (Error) = 50.075.						
*. The mean difference is significant at the .05 level.						

Here the first comparison is done with *L. dentipes* and *D. scaptocephala.* The mean difference is 8.01, which is statistically significant. At 95% confidence interval this difference may lower to 6.11 or increase up to 9.92. When *L. dentipes* and *A. perconvexus* were compared, the former was found to be dominant with a statistically significant mean difference of 6.81, which may range from 4.90 to 8.71 at 95% confidence interval.

The comparison of *L. dentipes* with *C. bovina* was found to be statistically insignificant as the *P* value was greater than 5%, with a mean difference of 1.35. That means, the numbers of these two species are not showing much difference in the sites under study. Similarly, *D. scaptocephala* and *A. perconvexus* are not showing significant difference in their numbers and the mean difference was found to be 1.21, with a *p* value of .371, which proves their comparison in statistically insignificant (Figure 1).

Unlikely, the numbers of *D. scaptocephala* was found to have larger variation from that of *C. bovina,* with a statistically significant *p* value of 0.000 showing the mean difference as -6.67, denoting that out of the two, *C. bovina*is abundant.

Finally, *A. perconvexus* was compared with *C. bovina* and found that the later exceeds the former in numbers, with a mean difference of -5.46 which is statistically significant.

A further attempt was made to examine the number of isopods, based on the categorical variable ‘place’, which are Kovalam, Thirumullavaram and Varkala. The post hoc done was done based on Scheffe’s test. The first comparison was done between Kovalam and Thirumullavaram, and the mean difference resulted was 1.49 with a significance of 0.042. It may vary from 0.04 to 2.93 at 95% Confidence Interval. Which implies, compared to Thirumullavaram, Kovalam has a higher number of isopods present (Table 3).

Table 3: Multiple Comparisons

Dependent Variable: Isopod						
Scheffe						
(I) Place	(J) Place	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
Kovalam	Thirumullavaram	1.49*	.590	.042	.04	2.93
	Varkala	4.71*	.590	.000	3.26	6.15
Thirumullavaram	Kovalam	-1.49*	.590	.042	-2.93	-.04
	Varkala	3.22*	.590	.000	1.77	4.67
Varkala	Kovalam	-4.71*	.590	.000	-6.15	-3.26
	Thirumullavaram	-3.22*	.590	.000	-4.67	-1.77
Based on observed means. The error term is Mean Square (Error) = 50.075.						
*. The mean difference is significant at the .05 level.						

When Kovalam and Varkala are compared, a mean difference of 4.71 was occurred, which is statistically significant at 5% level of significance (p value=0.000). It was clear that Kovalam is having more number of isopod species than Varkala. In the comparison of Thirumullavaram with Varkala, a statistically significant mean difference of 3.22 was resulted, which indicates Thirumullavaram is richer in the number of isopods than Varkala. Altogether, it is found that the most number of isopods are seen in Kovalam, than the other two studied. Presence of all the species that are collected, in different depths was compared to understand in which water levels the isopods are seen in maximum. According to the categorical variable species, the F test value is 94.800 and the corresponding p value is 0.000, which is significant statistically. Similarly, when the three depths from where the isopods were collected are analyzed, the F test value resulted was 131.722 and the corresponding p value is 0.000 which is lower than 5%, hence statistically significant. That is, there is clearly a difference found in the number of isopods present in various depths considered. In addition to this, the interaction effect of species with depth was also examined; the corresponding F test value was found to be 56.588 which are significant at 5% with a p value of 0.000. The R^2 value of the above model is showing the coefficient of determination as 61% (Table 4).

Table 4: Tests of Between-Subjects Effects

Dependent Variable: Isopod					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	31695.599[a]	11	2881.418	80.670	.000
Intercept	51091.130	1	51091.130	1430.383	.000
Species	10158.390	3	3386.130	94.800	.000
Depth	9409.843	2	4704.922	131.722	.000
Species * Depth	12127.365	6	2021.228	56.588	.000
Error	30432.160	852	35.718		
Total	113218.889	864			
Corrected Total	62127.759	863			
a. R Squared = .610 (Adjusted R Squared = .604)					

Following this, the significance of the number of isopods, based on the categorical variable 'depth' was analyzed from the data. The isopods were collected from three various intertidal regions; high tide, medium and low tide area. It was found that the higher region, where the moisture content is significantly less has the lowest number of isopods found. (Table 5)

Table 5: Multiple Comparisons

Dependent Variable: Isopod						
Scheffe						
(I) Depth	**(J) Depth**	**Mean Difference (I-J)**	**Std. Error**	**Sig.**	**95% Confidence Interval**	
					Lower Bound	**Upper Bound**
High	Medium	-7.18*	.498	.000	-8.40	-5.96
	Low	-6.80*	.498	.000	-8.03	-5.58
Medium	High	7.18*	.498	.000	5.96	8.40
	Low	.38	.498	.751	-.84	1.60
Low	High	6.80*	.498	.000	5.58	8.03
	Medium	-.38	.498	.751	-1.60	.84
Based on observed means. The error term is Mean Square (Error) = 35.718.						
*. The mean difference is significant at the .05 level.						

When high and medium depths were compared, there was a significant difference of -7.18, which may vary up to a lower limit of -8.40 and an upper limit of -5.96 at 95% Confidence Interval. Similarly, the comparison of high and low regions show a mean difference of -6.8, indicating that the higher ranges are having comparatively poor presence of isopods than the lower intertidal regions. At 95% Confidence Interval, this may vary in between a range of -8.03 to -5.58. In contrary to this, when the lower and medium intertidal depths are compared, no difference in the number of isopods were observed, as the mean difference was not statistically significant (*p* value= 0.751).

If we are considering each of the beaches separately, the data follows the same trend. Out of the 96 samples taken from each one of them, in higher areas of Kovalam, the mean value was 3.55±3.748 and in medium and lower intertidal regions it was 13.12±7.483 and 12.59± 8.781 respectively.

In Thirumullavaram, it is 3.99±5.398, 10.94± 9.165 and 9.87±10.090 for higher, medium and lower depths. Similarly in Varkala, the higher region has the lowest richness of 1.54±3.498, middle region has 6.57±7.968 and the lower area has a richness of 7.03±8.692.

Further the interactive effect of various stations and depths on the isopod numbers was also taken into account, and it was also found significant, statistically (F value= 2.685; *p*= .030). The R^2 value of the above model is showing the coefficient of determination as 41.5%.

From the study, the descriptive statistics was done for different seasons; pre-monsoon, monsoon and post monsoon. The influence of these independent variables on the number of different species of isopods was calculated and the mean value of the species *Ligia dentipes* in all the three seasons were premonsoon=10.14± 6.600, monsoon= 8.15±3.620 and post-monsoon= 16.90±9.232. For *D. scaptocephala* the mean values were 1.34±2.675 for premonsoon, 5.94±10.034 for monsoon and 3.87±7.926 for postmosoon. Thirdly, for *A. perconvexus* the seasonal mean values of isopods present in the collection sites are 4.50± 4.694, 4.74± 5.103 and 5.54± 6.569 for premonsoon, monsoon and postmonsoon respectively. Finally for the *C. bovina*, the mean values are 8.95±7.410, 8.19± 7.831 and 14.02± 11.727, following the same order of seasons mentioned above. The integrated effect of species and seasons is found to be statistically significant (F= 8.429) (*p*= .000).

Multiple comparisons done on the effect of three seasons to understand which of them can have the maximum number of isopods (Table 6). It was found that there is no significant difference between pre-monsoon and monsoon (*p*=0.701). The post-monsoon season was found to be the one with maximum abundance of isopod species. There was a mean difference of 3.85, between pre-monsoon and post-monsoon and that of 3.33 with monsoon season.

Table 6: Multiple Comparisons

Dependent Variable: Isopod						
Scheffe						
(I) Monsoon	**(J) Monsoon**	**Mean Difference (I-J)**	**Std. Error**	**Sig.**	**95% Confidence Interval**	
					Lower Bound	**Upper Bound**
Pre-Monsoon	Monsoon	-.52	.617	.701	-2.03	.99
	Post-Monsoon	-3.85*	.617	.000	-5.36	-2.34
Monsoon	Pre-Monsoon	.52	.617	.701	-.99	2.03
	Post-Monsoon	-3.33*	.617	.000	-4.84	-1.82
Post-Monsoon	Pre-Monsoon	3.85*	.617	.000	2.34	5.36
	Monsoon	3.33*	.617	.000	1.82	4.84
Based on observed means. The error term is Mean Square (Error) = 54.797.						
*. The mean difference is significant at the .05 level.						

Further study was done to find if there is any combined effect of monsoon and sites, and it was clear that there is no such relation existing (F= 0.655 and *p*=0.623).

The relative importance of the individual predictors on the dependent variable based on the normalized importance is shown in the below table. Accordingly there are four predictors considered here; place, species, depth and season (Table 7). The relative importance of the place is 0.138 and its normalized importance is 33.1%. Seasonal changes have a cumulative importance of 36.6% and its individual normalized importance is 3.5%, with a relative importance of 0.152. Thirdly, the depth of sample collection is having its relative importance as 0.295, with a cumulative importance of 71% (independent importance 33.4%). The species type itself has a normalized importance of 30% and relative importance of 0.415.

Table 7: Independent Variable Importance

	Importance	**Normalized Importance**
Place	.138	33.1%
Species	.415	100.0%
Depth	.295	71.0%
season	.152	36.6%

The following graph (Figure 1) depicts the independent variable importance.

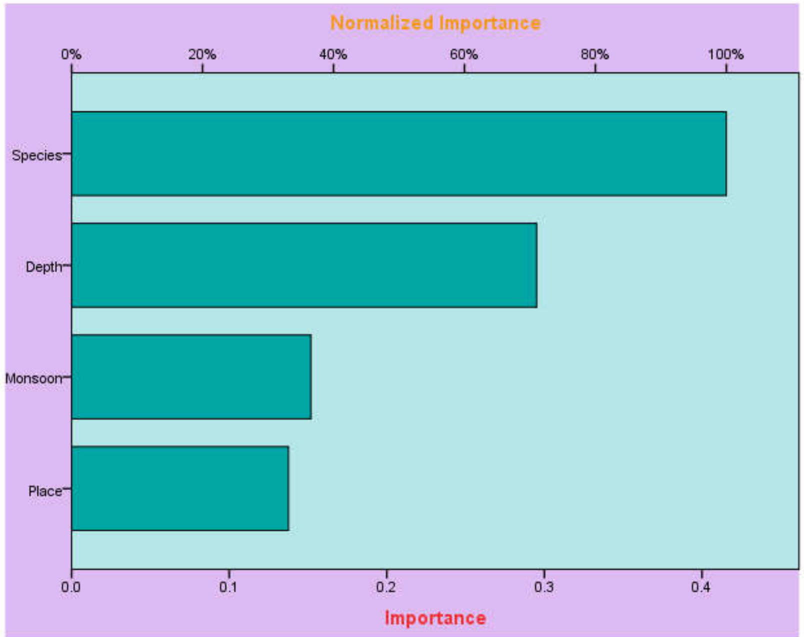

Figure 1: Explains the independent and cumulative effects of variables.

Regression analysis

Regression analysis was done to find out the cause-effect relationship between different variables under study. From the results obtained from water quality studies, the independent variables such as air and water temperature, Salinity, pH, DO, Silicate, Phosphate and Nitrate were taken as predictors and the isopod numbers were kept as dependent variable. The variance in the isopod number due to the influence of predictors is statistically true to the extent of 42.3% as per the R^2 value. The correlation between the variable is 65.1. The Durbin-Watson value is 2.09, which is greater than adjusted R^2 value; the given regression is not spurious (Table 8).

Table 8: Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Durbin-Watson
1	.651[a]	.423	.414	8.426	2.09
a. Predictors: (Constant), Silicate, Tempair, Phosphate, pH, DO, Tempwater, Nitrate, Salinity					
b. Dependent Variable: Isopod					

The model is fit for explaining the influence of independent variables on the dependent variable isopod as the F test value is 2.496 and the *p* value is 0.011(Table 9).

Table 9: ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1417.722	8	177.215	2.496	.011[b]
	Residual	60710.037	855	71.006		
	Total	62127.759	863			
a. Dependent Variable: Isopod						
b. Predictors: (Constant), Silicate, Tempair, Phosphate, pH, DO, Tempwater, Nitrate, Salinity						

DISCUSSION

Species inhabiting an ecosystem usually does not show a uniform distribution pattern, and they prefer to be living in some restricted parts of environmental gradients. Similarly, intertidal community also usually occupies only specific zones, i.e. they are abundant only in a part of the total tidal range. The dispersion of a species in a geographical region can be linked to particular environmental and habitat variables. The species distribution pattern may vary with in different beaches which do not so far exist since the local and regional conditions over geographic location can affect the lives. This is already stated through different studies in all these years by Al-Kandari et al.(2022), Mottaghi. A (2019), and Bakalem et al. (2021).

The entireorganism inhabiting the intertidal region is inclined towards a particular height level. That is, all of them regardless whether mobile or sessile, exhibit a zonation pattern along the seashore. (Ingólfsson. A and Agnarsson, 2003)

The vertical zonation patterns of sessile or slowly moving algae and animals in the rocky intertidal have been much studied in the past, both by observation and experiments (Little and Kitching 1996; Raffaelli and Hawkins 1996). The distributional patterns of more mobile animals have received less attention. The few available studies, however, have shown that mobile species show a characteristic abundance distribution along the environmental gradient of the shore, although typically less distinct than that of sessile or slow-moving species. (Ingólfsson. A, 1977)

The abundant centre hypothesis (ACH) provides a mechanistic explanation for geographic trends in species abundance (Brown 1984). The ACH states that species abundance is highest in the centre of the range and decreases towards the limits in response to spatial trends in physiological (e.g. thermal) and ecological (e.g. biological interactions) performance (Brown 1984, Sagarin & Gaines 2002a). However, species exhibit variable distribution patterns across their geographic ranges (Sagarin & Gaines 2002b).

The statistical analysis indicated that the most dominant species found in all the study sites is *Ligia dentipes* and there are some characteristics which did help the species to achieve the successful establishment in various habitats. The genus *Ligia* exhibits both the terrestrial and marine characteristics such as; easy drying out, need of moisture and proximity to water source. The presence of gills makes them able to breathe under water but they prefer not to and only submerge occasionally; when escaping terrestrial predators or being dislodged by wave action. They are well adapted to rocky surfaces but avoid sand, which exposes them to terrestrial predation and desiccation (Hurtado, L. A., 2010). Individuals can osmo-regulate well and are found in full salt water habitats to near fresh water seeps area (Wilson, W. J.1970). They store calcium in $CaCO_3$ deposits visible as white regions in the anterior sternites to fulfill the biphasic moult, which is different with most crustaceans (Ziegler, A., et al., 2007). Besides, *Ligia* transports water only by using open capillaries in its legs containing hair- and paddle-like microstructures, and this passive water transport mechanism may inspire novel biomimetic fluid manipulations with or without a gravitational field.

The study indicates that the climate plays a key role in the distribution of isopod species in the intertidal region and interplay of temperature variation with precipitation rates and humidity patterns affect isopod distributions. The post-monsoon season is found to have the most diverse isopod community in the intertidal zone based on the statistical analysis done. Climatic factors can modify the quality and quantity of substrate and food supply for isopods (Kumar et al. 1992), just like the precipitation level influence the diversity, duration of dry periods between rainfalls is a more important determinant of organic matter decomposition than total precipitation (Austin et al. 2004, Cable et al. 2008). Previous studies have also proved that increased rainfall and temperature might allow for range expansion of southern species, enriching diversity. A correlation between the rainfall and isopod surface activities was also found in another study. Present study also supports the finding that the species abundance increase about one month after the onset of rainy season (Warburg et al. 1984). Temperature fluctuations also can regulate population size (McQueen and Carnio 1974).

With many other agents, abiotic factors also play a major role in setting the optimum conditions for a species to thrive. In the intertidal zone, particularly the upper limit of intertidal marine species appears to be set by abiotic environmental factors such as prolonged exposure to air (causing desiccation or damage from ultraviolet radiation), extreme temperatures, and reduced feeding and respiration time. The lower limits of intertidal species, however, appear to be less strict, in accordance with the generally less harsh environmental conditions at the lower levels. The lower limits, where environmental conditions change less abruptly than at the uppermost intertidal levels (Beukema and Flach, 1995).

With the statistical analysis of the data collected, it was found that the physical factors such as temperature, salinity and pH can affect the isopod distribution. The rise in temperature to an optimum level can affect the plant and animal community in a positive way by having a catalytic effect on the enzymes which are taking part in the metabolism ((Peterson et al., 2007; Tattersall et al., 2012). Beyond the optimum temperature level of maximum productivity, further temperature increases can cause the denaturing of same enzymes and thus can affect the physiological processes negatively. A study carried out in the intertidal isopod *Cirolana harfordi* claims that the temperature increase can control reproductive capacity of these isopods. Those who were maintained in higher temperatures were having a reduced development time to the juvenile stage and increased the number of young produced. (Gavel. I et al., 2022)

The temperature gradients are found to be capable of the behavioural patterns as well. In a study carried out in 2007 by Dailey T.M. it is found that locomotion and speed of isopods can be affected by abiotic factors such as desiccation. The effect of salinity changes on the intertidal isopod community is less studied, but there were studies carried out on crabs (Dehnel. P.A., 1960), trematode parasites (Lei. F and Poulin. R., 2011) and plants (Song. J et al., 2008) inhabiting the intertidal region. The atmospheric CO2 getting dissolved in seawater can affect the pH of water and it can influence the life in it. Fluctuating pH conditions influenced survival, oxygen consumption, harassment response, and swimming speed of isopods differently relative to stable pH conditions (Alenius and Munguia, 2012). In a study done by Osuana *et al.,* in 2013, it was found that the development of some intertidal larvae can get affected at the embryonic stage if they are continuously exposed to low pH.

CONCLUSION

From the study carried out on the influence of various abiotic factors on the distribution if selected isopod species in the intertidal region, it was found that;

- There is a variance in the isopod number based on the species and place.
- Out of the four species studied, *Ligia dentipes* was found to be the dominant species established in all the three beaches.
- When compared to Varkala and Thirumullavaram, Kovalam has a higher number of isopods present. Thirumullavaram is richer in the number of isopods than Varkala.
- A difference was found in the distribution of isopods vertically in the water column. It was found that the higher region, where the moisture content is significantly less has the lowest number of isopods found.
- The post-monsoon season was found to be the one with maximum abundance of isopod species. It was found that there is no significant difference between pre-monsoon and monsoon.
- Abiotic factors such as air and water temperature, Salinity, pH, DO, Silicate, Phosphate and Nitrate can influence the isopod number.
- From the analysis it was found that *A. perconvexus* needs the highest range of air and water temperatures, pH, salinity and lowest

phosphate content to exhibit the maximum abundance. *D. scaptocephala* is found to be abundant in waters with relatively high oxygen content. *L. dentipes* needs the water support with a high nitrate, phosphate and silicate reserve.

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Conflict of Interest
The Authors declare that there is no conflict of interest.

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