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Studies on freshwater crab population as influenced by physico-chemical attributes in Gho-Manhasan stream, a tributary of river Chenab

Menakshi Dhar, Seema Langer and Sukanya Rajput

Department of Zoology, University of Jammu, J&K, India

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ABSTRACT

Crustaceans are distributed world-wide and are found in a variety of habitats. Freshwater crabs constitute one-fifth of the brachyurans all over the world. Freshwater crabs are the eminent indicators of good water quality. The present study was carried out with an aim to assess the influence of various physico-chemical parameters such as temperature, pH, depth, dissolved oxygen, free carbon dioxide, calcium, magnesium, bicarbonates and chlorides on the population of crabs in the Gho-Manhasan stream, a tributary of river Chenab. A comprehensive study of these parameters and a comparative analysis with those recorded in last eight years span gave a clear picture of the pollution stress due to anthropogenic activities in the water body that has led to a considerable decline in the population of crabs in this stream. This emphasizes the need to spotlight and improve measures of conservation before there is decline in the crab population to the levels from which they cannot recuperate.

Key words: *Physico-chemical, Freshwater crabs, Abundance, Conservation*

Introduction

Freshwater constitutes only 0.01% of the total water in the world and about 0.8% of the water present on the surface of the earth. About 1 lakh species out of 1.8 million species inhabit this small percentage of the global water. Freshwater ecosystem includes ponds, lakes, streams, springs, bogs and wetlands that provide critical habitat for wide range of fishes, reptiles, amphibians, birds and mammals. At present, there is a great decline in the biodiversity of freshwaters and therefore in the interest of humanity, it is important to manage and conserve the vital taxas inhabiting these natural ecosystems. Worldwide, there are approximately 1564 species of freshwater crabs that are distributed among five families. At present, there are 125 species of freshwater crabs in India that include 35 genera and 2 families (Pati and Thackeray, 2018; Mitra, 2019). Freshwater crabs are important part of food chain as they transfer energy both to the aquatic and terrestrial ecosystems because they are eaten up by fishes, birds and humans ((Litulo, 2004; Pathre and Patil, 2010). The fishing potential of any organism largely depends upon the condition of the water body it lives in. Aquatic organisms are distressed by the addition of both soluble and insoluble impurities in the water bodies. Recently, freshwater crabs have affirmed their high priority for conservation (Cumberlidge *et al.*, 2009). Occurrence of crabs depend upon the physico-chemical parameters such as temperature, pH, depth, dissolved oxygen (Carmona-Saurez *et al.*, 2002) as these parameters have a great impact on the life cycle and abundance of crabs. Correlation be-

tween physico-chemical parameters and the population of the crab imparts knowledge with reference to the ideal conditions required to maintain the population of crabs. Any variation in these parameters instigates change in the immune system of crustaceans. According to the Environmental Protection Policy, monitoring the water quality is most noteworthy. In the present communication an endeavor has been made to determine the effect of variations in physico-chemical parameters on the crab population of the Gho-Manhasan Stream, a tributary of river Chenab.

Methodology

Jammu is in the southern part of J&K, which is situated in the foothills of lower Shiwaliks. Present studies on the influence of physico-chemical parameters on the abundance of crabs have been carried out at Gho-Manhasan stream, a tributary of river Chenab, located at 30 °67′ Lat N; 74° 79′ Long E from the University of Jammu (Figs. 1 & 2). People living in its vicinity use this water for domestic purposes, irrigation, bathing cattle etc. which speaks of the extent of disturbance through anthropogenic activities. Only a single species of crab *i.e., Maydelliathelphusa masoniana* is known to inhabit this water body. Water of this stream was collected on the monthly basis from April, 2019 to March, 2020 and the various physico-chemical parameters were scrutinized. Gradual meter rod was used to measure the depth of the water body. Physical parameters like air temperature, water temperature and pH were recorded using standard °C thermometer and digital pH meter respectively. Chemical parameters such as D.O, FCO_2, CO_3^{2-}, HCO_3^-, Cl^- , Ca^{2+} and Mg^{2+} were analyzed by following the standard methodology of Adoni (1985) and A.P.H.A (2005). Population abundance was calculated as Total catch/ Sum of efforts. To determine the relation between physico-chemical parameters and crab abundance, Pearson's correlation and Principal coordinate analysis was done using Past 4.03 software.

Results and Discussion

Changes in the environmental conditions have great impact on the morphology, geographic distribution, gene frequency and behavior of organisms (Tautz, 2011). As is evident from the Table 4, a considerable decline in air temperature is evident over the period of time (Max temp. 40 °C in 2012-13 and 33.5 °C in 2019-20) in contrast to the water temperature that exhibits more or less a similar range (Max temp. 34 °C in 2012-13 and 31 °C in 2019-20) when a comparison of present observation was drawn with the data of last eight years. Apparently, these observations can be attributed to the anthropogenic activities that have considerably increased over the period of time, as the water body is extensively used for washing cattle, dumping wastes and public sewage. Needless to mention that temperature has a great impact on the growth, oxygen consumption, metabolic activities and survival rate in crustaceans (Gupta, 2017). Depth was maximum (54 m) during monsoon and minimum (28 m) during spring and seemingly it has an adverse effect on crab density, not because it has any negative impact on the growth of crabs but it affects the catch per unit effort values as the availability of the individuals per unit

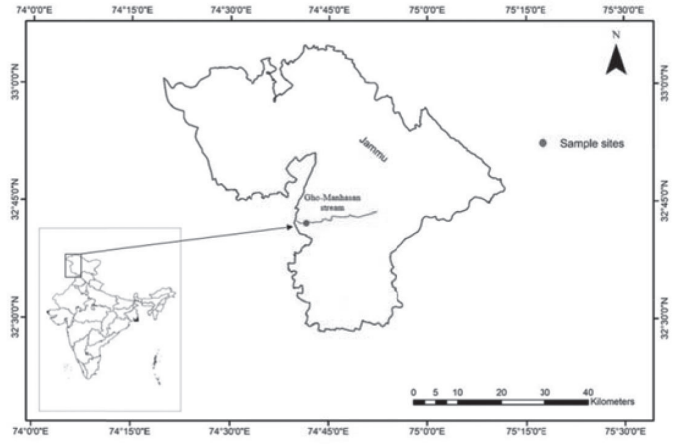

Fig. 1&2. Map showing the study station – Gho-Manhasan, Jammu (J&K)

Fig. 2.

volume falls. Similar relation of crab abundance with depth has also been reported by Marijnissen *et al.*, 2009 and is in line with those witnessed during the present studies where the catch per unit effort depicted a negative correlation with depth *i.e.*, -0.0199 indicating a decline in the population abundance of crabs with the increase in depth of water body. Interestingly, the mean depth recorded during the present investigation is considerably more as compared to the data of previous years. Minima and maxima of pH values remained within a range of 7.0 – 7.4 (Table 4) during the span of last eight years except the comparatively low values recorded presently *i.e.*, 6.6. pH of water body, for sure, is a factor of prime significance that influences the process of maturation and metabolism in crabs as has also been reported by Muthu and Laxminarayana, 1997. Reduction in pH levels affect the life of crabs by lowering down the saturation level of calcium carbonate that in turn affects development of shell as it undergoes molting. Minimum pH *i.e.*, 6.6 was found during the months of March, July and September due to an increase in decomposition rate that leads to acidification and maximum pH *i.e.*, 7.0 was found during the months of August, December and January when the fall in temperature leads to decline in decomposition rate that switches the pH to alkalinity. The present study indicated a positive correlation between pH and crab abundance *i.e.*, +0.18993 as is evident from Table 3. According to Central Pollution Control Board, if DO of the water body is less than 6 mg/l it is classified as polluted water body and is not considered good for the aquatic life. As per the reports of Das (2000), young stages such as zoea and megalopa larva of decapods are greatly influenced by levels of dissolved oxygen in an aquatic ecosystem. During the present study, maximum value of dissolved oxygen (5.4mg/l) was recorded in the month of April and May whereas the minimum value *i.e.*, 3.4 mg/l was observed in months of August and September (Table 1). The study stations indicated a positive correlation (+0.26837) of crab abundance with dissolved oxygen and such observations are in line with those recorded by Manohar and Qureshi (1996) who have conducted similar investigations with respect to the prawn population dynamics. When compared with earlier records (Bandral, 2013), dissolved oxygen to the extent of 9.2 mg/l has been reported from the same water body. Presumably, it can be inferred that the decline in dissolved oxygen as recorded presently has probably resulted because of the addition of biodegradable organic substances such as waste waters from agricultural fields and public sewage which in turn induces the stress in crabs as the resultant anaerobic metabolism of glucose results in the production of lactic acid and causes acidosis. This may have led to the decrease in the abundance of crabs in this water body.

FCO_2 is inversely related to pH and directly related to temperature. Concentration of CO_2 increases in water bodies due to increase in the rate of decomposition at higher temperature. In the earlier reports (Table 4), a maxima of FCO_2 to the level of 7.4 mg/l has been recorded (Bandral, 2015), in the intermediate years (Gupta, 2017), the FCO_2 has remained within a range of 4.4-6.4 (moderate values) in contrast to considerable high values recorded presently (12.2 mg/l) as evident from Table 1, thus clearly emphasizing the role of increased FCO_2 on the decreasing catch per unit values recorded presently. Increase in chloride concentration indicates the pol-

Table 1. Monthly variations of physico-chemical parameters in Gho-Manhasan stream (April 2019-March 2020)

	AT	WT	Depth	pH	DO	FCO_2	Ca^{2+}	Mg^{2+}	HCO_3^-	Cl^-
April	27.5	19.5	28	6.9	5.4	10.2	20.4	20	280.2	30.2
May	29	28	32	6.9	5.4	11	24.8	28.6	300.4	29.8
June	33.5	31	30	6.8	5.0	12.2	24.6	30.2	310.8	28.4
July	32	30.5	26	6.6	4.8	12	16.4	28.2	290.4	37.2
August	32.5	30.5	32	7	3.4	10	19	20	310.8	32.4
September	28.5	24	54	6.6	3.4	10.6	24	19.6	347.6	48.2
October	26	22	38	6.8	5.2	10	20	20.2	352.2	46
November	22.5	16.5	44	6.8	4.8	9.8	22	24	350	37.2
December	17	12	30	7	5.2	9.2	14.4	15.2	328.8	39
January	11	8	32	7	4.8	9	15.4	15	310.6	42.4
February	15.5	10	34	6.8	4.8	8.8	18.2	14.2	296.4	38.2
March	22	14.5	36	6.6	5.2	9.6	18.2	16	290	35.5

lution of water body due to organic wastes of animal origin. According to Whiteley *et al*. (2001) acidosis occurs in crabs due to acid-base imbalance thus leading to decrease in abundance of crabs. Chloride maxima (48.2 mg/l) and minima (28.4 mg/l) were observed during the months of September and June respectively (Table 1). Crab abundance has revealed a negative correlation with chloride, with correlation value being -0.4281 (Table 3). A similar negative relationship of prawn population with chloride is already on record (Manohar and Qureshi, 1996). According to the report of Royal Commission, water bodies having 30 mg/l of chloride is considered as clean water body. In the presently studied water body, chloride levels have recorded an increasing trend which in the year 2012-13 was 36.7 mg/l (Bandral, 2015) and presently recorded values is 48.2 mg/l with values being 40.2 mg/l in the year 2013-14 (Gupta, 2017) and 42.2 mg/l in the year 2014-15 (Gupta, 2017) during the intermediate years. Such an increasing trend may be due to the addition of salts such as potassium chloride, ammonium chloride present in the fertilizers which are increasingly being used in the adjoining agricultural fields. Chlorides leach from the fertilized soils into this water body and has exerted a deteriorating impact on the crabs, which is finally reflected in the form of the observed decline in crab population. Calcium and magnesium are the ions of prime significance in the biology of crustaceans such as crabs as they are unavoidably required during the exoskeleton formation (Neufeld and Cameron, 1994). Both calcium and magnesium levels fluctuated between 14.4-24.8 mg/l and 14.2-30.2 mg/l respectively as is evident from Table 1. Both Ca^{2+} and Mg^{2+} ions in the water body bear a positive correlation with the crab abundance viz., +0.29238 and +0.41982 as witnessed by the observed declining values and their comparison with the previous years, 54.5 mg/l in 2012-13 (Bandral, 2015), 42.4 mg/l in 2013-14 (Gupta, 2017), 30.2 mg/l in 2014-15 (Gupta, 2017) and 54.9 mg/l in 2012-13 (Bandral, 2015), 47.4 mg/l in 2013-14 (Gupta, 2017), 46.4 mg/l in 2014-15 (Gupta, 2017) respectively. Needless to mention, similar declining trend holds true for crab population as well. Calcium levels cause partial calcification in the exoskeleton of crabs and such crabs are at a higher risk to predation, thus limiting their distribution in the water body as observed in this study. Carbonates exist in the free form as FCO_2, bound form as CO_3^{2-} and half bound form HCO_3^-. Presence of bicarbonates is the indicator of absence of carbonates (Adoni, 1985). Carbonates were exclusively absent during the present study. Maxima of bicarbonate was found to be 352.2 mg/l and minima was recorded as 280.2 mg/l during the months of October and April respectively (Table 1) indicating a positive correlation *i.e.*, +0.20836 with the crab abundance. The value of HCO_3^- recorded during the present studies was comparatively very less as compared to the previous records (Table 4). Distribution of crabs is affected if the physico-chemical parameters of the water body are not suitable (Varadharajan *et al.*, 2013).

A picture that emerges after a comprehensive analysis of the physico-chemical parameters very clearly indicates that the observed decline in population structure of native crab species in the Gho-

Table 2. Comparative values of catch per unit effort of crab *Maydelliathelphusa masoniana* (Henderson, 1893) from Gho-Manhasan stream

S. No.	Months	CPUE(2012-13) (Bandral, 2015)	CPUE(2013-14) (Gupta, 2017)	CPUE(2014-15) (Gupta, 2017)	CPUE(2019-20) (Present study)
1.	April	4.3	4.75	4.2	5
2.	May	4.0	4.64	5.2	4.2
3.	June	5.0	7.66	6.8	4.6
4.	July	4.0	5.4	5.4	3.8
5.	August	5.3	4.5	4.6	4.0
6.	September	5.0	4.2	4.8	3.2
7.	October	6.0	4.8	5.0	3.8
8.	November	6.0	5.0	5.6	6.4
9.	December	6.6	6.8	6.2	4.4
10.	January	4.0	5.4	5.4	3.2
11.	February	4.0	4.6	4.8	3.0
12.	March	4.0	4.2	4.4	3.6

Manhasan stream, a tributary of river Chenab is attributable to a wide range of parameters like depth, calcium, magnesium, bicarbonates that have considerably degraded over a span of eight year period (Table 4). There has been a significant decline in the average catch per unit effort (C.P.U.E) values as recorded presently as 4.1 (2019-20) against the higher average C.P.U.E value (4.85, 5.16, 5.2) as recorded in the year 2012-13, 2013-14 and 2014-15 respectively (Table 2 and Fig 3). This may be due to the increase in anthropogenic activities by the people living in the nearby village. Apart from using water for domestic purposes, people use the water of this stream for bathing their cattle, washing clothes, utensils etc. Run-off from the agricultural fields that are located close to the stream also get entry into the river stream thereby leading to an increase in the concentration of pesticides and insecticides in the water body. Due to the non-availability of road transport in the area, people living in these areas cross over to the other side of locality through water thus causing trampling in the stream which also leads to habitat disturbance and destruction.

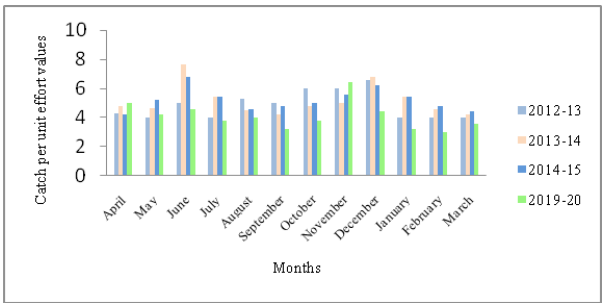

Fig. 3. Graph showing comparative values of Catch per unit effort values of *Maydelliathelphusa masoniana* in the Gho-Manhasan stream over a period of eight years.

Principal component analysis of physicochemical parameters

To identify the important factors that has led to the

Table 3. Pearson's correlation between crab abundance and physico-chemical parameters during study period (2019-20)

	AT	WT	Depth	pH	DO	FCO_2	Ca^{2+}	Mg^{2+}	HCO_3^-	Cl^-	CPUE
AT	1	0.9673	-0.037284	-0.30384	-0.25374	0.84564	0.59287	0.77001	-0.060604	-0.40357	0.22685
WT	0.9673	1	-0.0957	-0.21716	-0.2866	0.87168	0.55005	0.81731	-0.040437	-0.37486	0.13327
Depth	-0.0372	-0.0957	1	-0.41019	-0.51247	-0.16401	0.43359	-0.16082	0.71378	0.62859	-0.0199
pH	-0.3038	-0.2171	-0.4101	1	0.1072	-0.39356	-0.2357	-0.21635	-0.00720	-0.2672	0.18993
DO	-0.2537	-0.2866	-0.5124	0.1072	1	-0.0146	-0.1191	0.10628	-0.31815	-0.32778	0.26837
FCO_2	0.8456	0.87168	-0.1640	-0.3935	-0.0146	1	0.5276	0.91297	-0.1313	-0.37562	0.17409
Ca^{2+}	0.5928	0.55005	0.4335	-0.2357	-0.1191	0.5276	1	0.61836	0.21478	-0.25846	0.29238
Mg^{2+}	0.7700	0.81731	-0.1608	-0.2163	0.10628	0.9129	0.6183	1	-0.03935	-0.48164	0.41982
HCO_3^-	-0.0606	-0.04043	0.7137	-0.0072	-0.3181	-0.1313	0.2147	-0.039355	1	0.64433	0.20836
Cl^-	-0.4035	-0.37486	0.6285	-0.2672	-0.3277	-0.3756	-0.2584	-0.48164	0.64433	1	-0.4281
CPUE	0.22685	0.13327	-0.0199	0.18993	0.26837	0.17409	0.29238	0.41982	0.20836	-0.4281	1

Table 4. Comparative values of various physico-chemical parameters of the Gho-Manhasan stream over a period of eight years.

YEAR		2012-13 (Bandral, 2015)		2013-14 (Gupta, 2017)		2014-15 (Gupta, 2017)		2019 -20 Present study	
PARAMETERS	Unit	Max	Min	Max	Min	Max	Min	Max	Min
Air temperature	ºC	40	16.5	35	12	36	11	33.5	11
Water temperature	ºC	33.5	12	32	11	34	10	31	8
Depth	m	30	18	48	22	44	24	54	30
pH		7.4	7.0	7.4	7.1	7.4	7.2	7.0	6.6
Dissolved oxygen	mg/l	9.2	5.2	6.8	5.2	6.8	5.0	5.4	3.4
FCO_2	mg/l	7.4	4.2	6.4	4.6	6.2	4.4	12.2	8.8
Calcium	mg/l	54.5	12.8	42.4	19.2	30.2	18.2	24.8	14.4
Magnesium	mg/l	54.9	34.5	47.4	36.8	46.4	38.0	30.2	14.2
Bicarbonates	mg/l	764.4	400.2	546.6	390.4	470.5	380	352.2	280.2
Chlorides	mg/l	36.7	17	40.2	23.2	42.2	25.2	48.2	28.4

significant variances in the water quality of the stream, PCA of physicochemical parameters (Air Temperature, Water Temperature, Depth, pH, Dissolved oxygen, Free carbon dioxide, Calcium, Magnesium, Bicarbonates, Carbonates, Chlorides) was performed (Table 5). Based on the scree plot (Fig 4), two physicochemical parameters were identified that accounted for 71.42% of the total variance of the water quality of Gho-Manhasan stream. The PC1 (first principal component) corresponding to the highest eigen value of 4.3641 for total of 43.64% of variance of the water quality data of the stream, possess significant positive loadings (>0.7) on air temperature, water temperature, FCO_2 and Mg^{2+}. Similarly, PC2 (second principal component) corresponding to the next second highest eigen value of 2.77812 accounted for 27.78 % total variance of the data set possess significant positive loading (>0.7) on depth, HCO_3^- and Cl^-. Therefore, after performing loading analysis (Table 6 and Fig 5), it can be established with authenticity that air temperature, water temperature, depth, FCO_2, HCO_3^-, Cl^- and Mg^{2+}

Table 5. Summary of the principal components of physico-chemical parameters of Gho-Manhasan stream

PC	Eigen value	% variance
1	4.3641	43.64
2	2.77813	27.78
3	0.99915	9.99
4	0.89827	8.98
5	0.61722	6.17
6	0.16226	1.62
7	0.11968	1.19
8	0.03710	0.37
9	0.01762	0.17
10	0.00643	0.06

Table 6. Loading scores of the selected principal components having eigen values >1.

Parameters	PC 1	PC 2
AT	0.9369	0.1206
WT	0.9378	0.1007
Depth	-0.1215	0.9405
pH	-0.3074	-0.4431
DO	-0.0751	-0.6316
FCO_2	0.9414	0.0034
Ca^{2+}	0.6749	0.3788
Mg^{2+}	0.9221	-0.0466
HCO_3^-	-0.1513	0.7897
Cl^-	-0.5258	0.7099

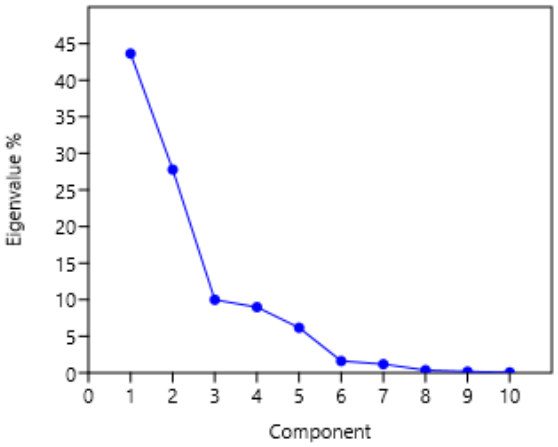

Fig. 4. Scree plot of eigen values versus principal components of physicochemical parameters of the Gho-Manhasan stream.

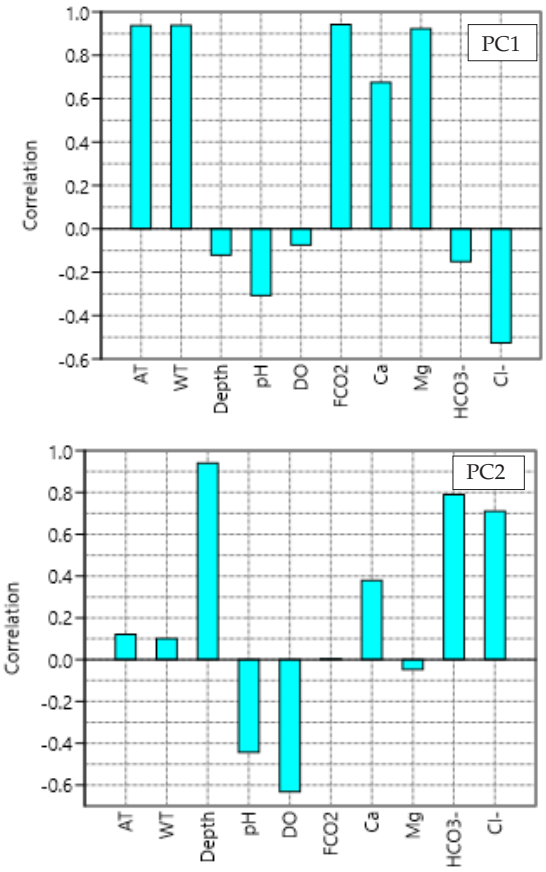

Fig. 5. Loading plot of first two principal components in physicochemical parameters of the Gho-Manhasan Stream.

are the major factors that has contributed to the deteriorating water quality and ultimately the declining crab population of the Gho-Manhasan stream.

Conclusion

The present study highlighted the health status of the water body and its impact on the abundance of crabs. After having compared with earlier reports, it has been found that the habitat of crabs is deteriorating as a cumulative effect of various factors such as increasing human interference, more demand for food, water pollution, dumping of wastes, degradation of habitat, run-off from the agricultural fields, siltation and change in land use pattern. Apart from this, change in water parameters also seems to have played a significant role in decline in the abundance of crabs. The present study depicts the need for conservation of the stream by implementing the effective management strategies. It is therefore, urged upon authorities and stakeholders to adopt such measures to pose a check on the activities that are directly or indirectly contributing towards the deterioration of water quality parameters/ habitat destruction and ultimately responsible for biodiversity loss. Restorative measures therefore, need to be put into place to protect our vital bio resources.

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