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The C.P. Ramaswami Aiyar Foundation,
1, Eldams Road, Alwarpet, Chennai - 600018.
Phone: 24346526 / 24337023 Fax: 91-44-24320756
E.mail: cpreec@vsnl.com
Websites: www.cpreec.org / www.ecoheritage.cpreec.org

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Environmental Lessons from Coral Reefs

P.J. Sanjeeva Raj*

ABSTRACT

Coral polyps, despite their tiny size, give rise to large inhabitable islands and even to some of the most coveted tourists spots in the world. They also attract on incredible biodiversity. Their life styles, for this amazing success are analyzed, so as to learn lessons for a similar survival and contributing success of humanity on this planet.

Key words: Coral polyps, Coral reefs, Sustainable life styles, Mutualism, Zooxanthellae, Coral bleaching.

Coral reefs are said to be biologically the most productive ecosystems on this planet, more productive than even rain forests. In the inshore (coastal) waters of the seas, the tiny coral polyps, as keystone species, attract thousands if not lakhs of species of marine organisms to their vicinity. They are distributed in the warmers regions of the oceans, within the temperature range of 20°C to 30°C, which prevails usually between the 30° north and south latitudes. They grow on continental shelves from about a 100 meter depth upwards to the sea surface.

In India, we have all the three types of coral reefs, namely the fringing reefs, barrier reefs and the atolls, scattered in the Gulf of Mannar in Tamil Nadu, Gulf of Katch in Gujarat, Malvan region near Goa on the west coast, around the Andaman and Nicobar Islands in the Bay of Bengal, and around the Lakshadweep Islands in the Arabian Sea (Venkataraman, 2006).

Small is Great!

Writing about termites, Thomas Elliott Snyder (1948) said, "Many of the greatest marvels of nature are to be observed in the smaller forms of life." According to James Lovelock's (1979) Gaia Hypothesis, it is the biosphere, particularly the microscopic organisms of the tropical inshore (coastal) waters, that maintain the right atmosphere for life (biosphere), which in turn, maintains the atmosphere, reciprocally and homeostasiscally (in a regulated way).

The sustainable life styles of the tiny coral polyps and their associated communities offer to us several valuable environmental lessons or rather 'eco-philosophies' or 'eco-ethics' for emulation to aim at a sustainable human survival, particularly in the current critically endangered environment of our planet Earth. Let us recollect the ancient adage, "Nature is the best Teacher".

MODEL LIFE STYLES OF CORAL POLYPS

Choice of Habitat and Resources

Coral polyps have chosen to inhabit the tropical coastal waters, where luxurious solar energy flashes all round the year, promoting the highest primary productivity.

*Consultant Ecologist, Email : rajsanjeeva@gmail.com

Solar energy never fails, nor is in short supply and is not subject to inflation. We, in India, are blessed with such abundant solar energy which we should harness to the fullest extent.

Corals flourish in inshore (coastal) waters which are vigorously churned by violent waves, bringing in abundant oxygen and plankton, and hence coastal waters are known to be more productive than any other region of the oceans. Coastal waters therefore, are also to be harnessed not only for extensive mariculture and ranching but also for tidal energy.

Adaptive Life Styles

Coral polyps live in colonies, because colonial life is more secure and efficient than isolated individual life. Humans, though not organically, yet are emotionally (psycho-socially) and spiritually interlinked, for greater solidarity and strength.

Coral polps are tentacular as well as ciliary filter-feeders, feeding both on live plankton as well as on dead detritus (particulate decomposing organic matter) so abundant in the inshore waters. Such an omnivorous diet is more opportunistic than a fastidious diet, for survival. Also, coral polyps are nocturnal feeders, thus exposed to less competition and predation.

Mutualism, the Key for the Future

The master key for the great success of coral reefs is the ingenious mutualism that the coral polyps have adopted with the chlorophyll-bearing unicellular symbiotic organisms called Zooxanthellae. Zooxanthellae, by photosynthesis, supply not only food as liquid carbon for the polyps, but also by sequestering carbon dioxide from the sea water release oxygen. Chlorophyll-bearing phytoplankton of the ocean is supposed to release 60-70% of the total oxygen of our planet. To facilitate such great planetary ecosystem function of regulating our atmosphere, oceanic phytoplankton is much more important than the terrestrial vegetation. Coral polyps are said to be having an amazing chemical communication with their symbiotic Zooxanthellae regulating their photosynthetic rate as well as a regulated supply of food and oxygen to their polyp hosts, according to their needs (Molles, Jr., 1999).

Agriculture, through which humans have learnt to harness the solar energy, is said to be an ingenious entrepreunership in symbiosis between humans and green vegetation for mutual survival on this planet. Ecosystems have evolved and are being sustained chiefly through symbiotic relations between organisms. Life bereft of all other biodiversity suffers from a sense of emptiness and deprivation (Lovelock, 1979). Future survival or evolution of humanity is an 'ecological' or 'planetary evolution', based on mutualistic or cooperative relations at all levels, rather than a confrontational or competitive 'darwinian evolution'.

Keystone Niches

Coral skeletons of diverse sizes and shapes with crevices are excellent keystone niches (Sanjeeva Raj, 2008 a and b), providing anchorage and shelters for a wide variety of marine organisms, thus establishing a unique kind of biome, consisting of producers, decomposers and consumers of all levels, a self-sustaining community, indeed. The most significant aspect of such a rich and heterogeneous community is that all nutrients and wastes are shared and recycled within the community itself, so that there is zero wastage of nutrients.

Some commensal crabs of the *Trapezia* spp. that live as commensals of the pocilloporid coral polyps are known to provoke the polyps with their feet to get their lipid-laden mucus pellets released, on which the crabs feed (Molles Jr., 1999). Such nutritious mucus, released into waters, would certainly attract lot of biodiversity, thus rendering coral polyps as the most efficient 'keystone species' (Sanjeeva Raj, *et al.*, 2002).

Keystone Habitat Modifiers

Coral reefs are incredible habitat modifiers also, or 'ecosystem engineers' or 'landscape (Sanjeeva Raj, 2008b). They can transform aquatic habitats of tropical inshore waters into terrestrial habitats of coral islands and atolls, which provide not merely human habitations but some of the most sought-after tourist destinations of the world.

Coral reefs, as natural reefs, attract very rich biodiversity, including hundreds of species of fishes, thus serving as Fish Aggregating Devices (FADs) also. Nearly 40 countries on the six continents (Grove and Sonu, 1991) have exploited this of principle in evolving Artificial Fish Habitat de (AFH) or Artificial Reef (AR) technologies, wherein a variety of junk materials are deployed into the inshore waters to attract fish, for recreational or game-fishing in the developed countries, but for sheer sustenance fishing in the developing countries. Coral reefs are excellent centres for watching and photographing brilliantly coloured fish, molluscan shells and cowries.

Survival Threats

However, like any other living beings, even such highly successful coral polyps need a clean environment for survival. Their survival today particularly is threatened by siltation (sedimentation) on polyps, pollution, dynamite-blasting for coral skeletons, and above all, through coral- bleaching, all of which are essentially anthropogendic threats. Their symbiotic Zooxanthellae cannot withstand water temperatures above 30°C. During such rising temperatures, as is anticipated during the ensuring 'Global Warming', Zooxanthellae are expelled from the polyps, and consequently their host coral polyps lose their green or other colours, when they are said to be bleached out of their colours (Venkataraman, 2006). Loss of these obligatory symbionts is a sure death knell for their host coral polyps also.

Object Lessons

If students cannot afford to visit our coral reef assets, they can atleast be educated through videos or DVDs on live coral reefs. Aquaria for coral skeletons, with green algae encrusted, and with live animals around, would excite student imagination. Students should explore our environment to discover newer and newer mutualistic or symbiotic relations in nature, to study their significance in depth, to promote them and to cull out of them, lessons for human adoption and survival.

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Attitudes of the Sultan Qaboos University Students Towards Some Environmental Problems

Ahmed bin Hamad Al-Rabaani* and Mohammed S.S. Al-Mekhlafi*

ABSTRACT

Attitudes of the Sultan Qaboos University students to some environmental problems, and their willingness to take action to ameliorate these problems were investigated. A total of 317 respondents from five different faculties of the university, participated in this study. Data were collected using a questionnaire containing 48 items distributed over five areas: energy, water, air pollution, waste and desertification. Validity and reliability were examined. The results showed generally that the students hold positive attitudes towards the issues raised. Women students showed more positive attitudes than did men. The results also indicate that students' attitudes towards the environmental problems are not influenced by the university faculties in which they are studying, except in the case of energy, where significant differences were observed between the attitudes of students from the Faculty of Education and the Faculty of Agriculture, the former showing more positive attitudes than the latter. The results also indicate that students are willing to take action to reduce environmental problems; this was also not affected by gender or faculty.

Keywords: Environmental problems, University students, Sultanate of Oman.

Educational concerns about environment can be viewed as a logical consequence of the change in the relationship between human beings and the natural world over the last two centuries, which has resulted in the view that Earth and its resources are valuable only insofar as they satisfy human needs. Clark (1989) explains that this attitude has a greater negative influence on Nature than one natural hazard, such as earthquakes and volcanoes. This change has resulted in the overexploitation of both renewable and non-renewable natural resources and the resulting unwanted waste materials which have lead to pollution of the environment (Soussan, 1992; Lowe and Thompson, 1992; Yardley, 2004). Dunlop and Van Liere, (1978), Angel & Rock (2000) argue that this view has been challenged by the new environmental paradigm of the exploitation of nature; and that the growth of the human economy should be balanced with environmental protection, so that people can live again in harmony with nature. Meinhold and Malkus (2005) stated that the environment that supports mankind's survival has always been a heated topic of discussion to insure building up individuals who will take responsibile decisions about the environment in future, creating programs, fighting for policies and laws to protect the environment.

This challenge contributed to the development of environmental education at the end of the 1960s, which later received international acceptance as one of the crucial means to develop people's understanding, awareness, beliefs and attitudes concerning the environment. Since that time various studies have been conducted concerning the effect of environmental education on the development of student attitudes towards the environment.

* College of Education, **Environmental Studies and Research,** Sultan Qaboos University, P.O. Box. 50, Muscat 123, Sultanate of Oman.

The results of research are inconsistent: Silberstein (1981), Cohen and Wingerd (1993), Stoney (1995), Surbrook (1997) and Zelezny (1998) found that education has a positive effect on student attitudes, while other studies showed no relation between education and attitude (Al-Najede, 1990; Lyons and Breakwell, 1994). Some studies, on the other hand, found that environmental attitudes are influenced by gender (Kuhn, 1979; Schahn and Holzer, 1990, Worsley & Skrzypiec, 1998).

The relationship between attitudes to environment and willingness to take action has been questioned by some researchers. Dunlap *et al.* (1993) in a study which included 24 countries, both rich and poor, found that 64% of the participants believe that environmental problems will affect their health; 50% of the participants in 21 of these countries said that the environment should be given priority, even if it leads to a slowdown in economic growth; over 50% of the respondents in 17 countries expressed their willingness to pay more to improve the quality of the environment. Inglehart (1995) found that 93% of respondents showed a high level of concern for the protection of the environment. However, 64% of them expressed their willingness to pay more tax for this purpose and 45% of them rejected the idea of any sacrifice in order to protect the environment. Thus, people who hold positive attitudes do not consistently engage in behavior congruent with these attitudes. Some studies by researchers concerned about the reasoning behind that, such as Hines *et al* (1986) concluded that environmental behaviour is affected by many components: knowledge, attitudes, verbal commitment and a sense of personal responsibility.

The present study is an investigation of the effect of B.A. level academic courses at the Sultan Qaboos University in the Sultanate of Oman on the development of student attitudes towards environmental problems, and also on their willingness to take action that would contribute to reducing them. The selection of the university level reflects an international trend that emphasises the importance of environmental literacy and awareness (Kyridis, *et al*, 2005; Stelmack, *et. al,* 2005; Moody & Hartel, 2007).

This university was selected on the basis that it is the only government university in Oman and it is the main source of the development of human resources in this country. The selection of environmental problems was based on their urgency in Oman: namely, shortage of water, desertification, air pollution, waste and energy. This study was also concerned with examining the effect of different academic courses taken by students of various faculties. The following section presents the research questions.

The aim of this study was to answer the following questions:-

1. What are the attitudes of the Sultan Qaboos University students towards environmental problems?

2. Are there differences in students' attitudes towards environmental problems that can be attributed to the variable of (a) gender or (b) college?

3. Are the Sultan Qaboos University students willing to take action to reduce environmental problems?

4. Is there any difference between students' willingness to take action that can be attributed to the variable of (a) gender or (b) college?

5. Is there a relationship between students' attitudes towards environmental problems and their willingness to take action to reduce them?

Method

Sample

The sample for this study consisted of students in five colleges, namely: Education, Arts, Science, Agriculture and Medicine, whose total number in 2002/2003 was 1,700 students. The sample of the study consisted of 317 students drawn mainly from students of the final year in each college. Table (1) shows the distribution of the sample.

Table 1- Distribution of the study sample

Gender	Faculties					
	Education	Arts	Science	Agriculture	Medicine	Total
Male	27	27	28	17	17	116
Female	58	58	32	36	17	201
Total	**85**	**85**	**60**	**53**	**34**	**317**

Instrument

In this study, a Likert scale was used because it allows for the use of sub-scales and also facilitates investigating the different dimensions of attitudes. This scale is also a popular technique and students are more likely to be familiar with it (Likert, 1967; Oppenheim, 1992). The questionnaire consisted of 48 items distributed into five areas: energy problems (13 items), water problems (12 items), air pollution problems (8 items), waste problems (8 items) and desertification problems (7 items). The items within each area examine two different facets of each area: students' attitudes towards environmental problems and their willingness to take action to reduce those problems. Validity of the questionnaire was examined by a panel of ten experts in the Social Studies Curriculum and Psychology Departments at the Sultan Qaboos University. Reliability was established by using Cronbach's alpha coefficient for analysing the results of a pilot study and the results proved that the questionnaire was reliable as the level of reliability reached 0.824.

The Results

Question 1: What are the attitudes of the Sultan Qaboos university students towards environmental problems?

Table (2) shows that the students hold positive attitudes at a high level towards the environmental problems. It can be observed from the table that water problems come first, with a mean of 3.914, followed by air problems with a mean of 3.910, the waste problems coming third with a mean of 3.790, then the energy problems at a mean of 3.650, and finally the desertification at a mean of 3.507. High concern about the shortage of water could be attributed to the fact that water shortage has become a daily problem that Omani people face in all regions, particularly in the interior areas which do not benefit from the desalination plants that have been built in the coastal area. Air pollution due to the economic development and transportation is one of the problems which has recently become a cause for concern, and this could have led students to the belief that it should be reduced. Students' attitudes towards desertification could raise the question of why it receives less concern from students, and this can be explained by the fact that some students may see the desert as a natural phenomenon. It also could be affected by their view that desertification does not form a danger to people, and that it can be developed economically, as a tourist attraction.

Question 2(a): are there differences between students' attitudes towards environmental problems due to their gender?

Table (3) indicates that women students hold a statistically significant higher level of positive attitudes towards environmental problems than men students, particularly in the areas of desertification (0.24) and air pollution (0.26). These results may be attributed, as the literature indicates, to the fact that women are more interested in environmental issues than men (Kuhn, 1979; Schahn and Holzer, 1990;

Table 2 - The means and SD of the students' attitudes

Problem	Minimum	Maximum	Mean	SD
Energy	2.38	4.62	3.6503	.4492
Water	1.92	5.00	3.9146	.4822
Air	1.75	5.00	3.9101	.5331
Wastes	2.00	5.00	3.7906	.5517
Desertification	1.86	4.86	3.5074	.5699

Table 3 - Means, SDs and T-Test results for students attitudes by gender

Gender		Energy	Water	Air	Waste	Desertification
Male	Mean	3.5882	3.8858	3.8222	3.7985	3.4126
	SD	0.4677	0.5544	0.5796	0.5152	0.5670
Female	Mean	3.6862	3.9308	3.9608	3.7861	3.5622
	SD	0.4353	0.4358	0.4988	0.5729	0.5657
P <0.05		0.061	0.425	0.026*	0.847	0.024*

Table 4 - Means scores and SDs for students' attitudes by college

College		Energy	Water	Air	Waste	Desertification
Education	Mean	3.7529	4.0216	3.9485	3.7294	3.5160
	SD	.41256	.40257	.47999	.55227	.53547
Art	Mean	3.6190	3.8333	4.0000	3.8544	3.5630
	SD	.49196	.57606	.58120	.59225	.61814
Science	Mean	3.6026	3.8722	3.8521	3.8625	3.4881
	SD	.43356	.39490	.57004	.55555	.47438
Agriculture	Mean	3.5312	3.8742	3.7972	3.7264	3.3935
	SD	.43704	.45309	.53889	.52409	.62453
Medicine	Mean	3.7421	3.9853	3.8676	3.7574	3.5588
	SD	.42467	.55636	.42855	.47268	.59825
Total	Mean	3.6503	3.9143	3.9101	3.7906	3.5074
	SD	.44917	.48221	.53312	.55170	.56987

Zelezny, 1998; Worsley and Skrzpiec, 1998; Chin, 1993; Bissonnette, 1999). It may also be attributed to the common belief that women have to work harder than men to survive.

Question 2(b): is there any difference between students' attitudes towards environmental problems that can be attributed to their college?

Table (4) shows the means and SDs for students' scores according to their college of study.

The table shows that Education and Medicine students hold a higher level of positive attitudes toward environmental problems in the areas of energy and water, than do students from other colleges. In the case of air, waste and desertification problems, higher levels of attitudes are held by the students of Arts, Education and Medicine. Students from the Science and Agriculture colleges come at the average, lower than 3.5 for the desert problems. To determine whether the differences in the means are significant, the ANOVA is used, the results of which are shown in Table (5).

Table (6) shows that there are no statistically significant differences in the students' attitudes toward environmental problems which can be attributed to the college of study, except in the case of energy problems, for which differences exist at the level of (0.029). In order to determine the source of these differences, the Tukey Test was used, the results of which are presented in Table (6).

Table (6) shows that the differences appear to be between Education students and Agriculture students, where Education students' attitudes are higher than Agriculture students' attitudes. The mean for the former reached (3.7529) whereas that of the latter is (3.5312). This difference may be attributed to the higher academic level of the students accepted in Education (90%+), and to the fact that Education programs include environmental education courses and also environmental topics are integrated in many courses.

Question 3: Are the Sultan Qaboos university students willing to take action to reduce environmental problems?

Table (7) shows the mean scores and standard deviation of students' willingness to take part in reducing environmental problems.

It can be seen from this table that students hold a high level of positive attitudes toward environmental problems, particularly the problems connected with water (3.618) and waste (3.495). This high level of positive attitudes may be attributed to students' realization of the seriousness of these problems, and the importance of individuals' participation in confronting them. Students may have realized too that the country is facing serious problems in the area of water. It can be noticed too that the level of students' willingness to participate in reducing energy and desertification problems is low, with a mean of (2.941) and (2.998) respectively. This result may be attributed to the fact that people feel that they cannot live without air-conditioning because of the extremely hot weather, and possibly because of the reasonable cost of electricity.

Question 4(a): Is there any difference between students' willingness to take action that can be attributed to gender?

In table (8) there are no statistically significant differences in students' willingness to participate in reducing environmental problems that can be attributed to the variable of gender, though the level for women students' is higher than for men students.

Question 4 (b): Is there any difference between students' willingness to take action that can be attributed to their college?

The results presented in table (9) shows no statistically significant differences between students' attitudes towards environmental problems and their willingness to participate

Table 5 - ANOVA results

		Sum of square	Df	Mean square	F	Sig
Energy	Between group	2.154	4	0.538	2.727	0.029*
	Within group	61.601	312	0.197		
	Total	63.755	316			
Water	Between group	1.899	4	0.475	2.068	0.085
	Within group	71.579	312	0.229		
	Total	73.477	316			
Air	Between group	1.752	4	0.438	1.552	0.187
	Within group	88.061	312	0.282		
	Total	88.813	316			
Waste	Between group	1.230	4	0.308	1.011	0.402
	Within group	94.950	312	0.304		
	Total	96.180	316			
Desertification	Between group	1.069	4	0.267	0.821	0.513
	Within group	101.552	312	0.325		
	Total	102.620	316			

*** P <0.05**

Table 6 - Tukey test results

	Education	Arts	Science	Agriculture	Medicine
Education	-----			✷	
Art		-----			
Science			-----		
Agriculture	✷			-----	
Medicine					-----

Tukey✷ P <0.05

Table 7 - Means and SDs of students' willingness to take action to reduce environmental problems

Environmental problems	Mean	SDs
Water	3.6183	.62753
Waste	3.4953	.72956
Air	303375	.89987
Desertification	2.9989	.92910
Energy	2.9411	.87353

Table 8 - Mean, SDs and T-test results

		Energy	Water	Air	Waste	Desertification
Male	**Mean**	2.8994	3.5841	3.2974	3.4224	2.867
	SD	0.8882	0.7132	0.9623	0.7507	0.9699
Female	**Mean**	2.9652	3.6381	3.3607	3.5373	3.074
	SD	0.8663	0.5733	0.8634	0.7158	0.8984
P <0.05		0.519	0.461	0.547	0.177	0.056

Table 9 - One way ANOVA Results

		Sum of square	df	Mean square	F	Sig
Energy	Between group	3.532	4	0.883	1.159	0.329
	Within group	237.591	312	0.762		
	Total	241.123	316			
Water	Between group	1.934	4	0.483	1.231	0.297
	Within group	122.505	312	0.393		
	Total	124.439	316			
Air	Between group	1.424	4	0.356	0.436	0.782
	Within group	254.459	312	0.816		
	Total	255.883	316			
Waste	Between group	1.087	4	0.272	0.507	0.730
	Within group	167.156	312	0.536		
	Total	168.243	316			
Desertification	Between group	1.626	4	0.407	0.468	0.759
	Within group	271.151	312	0.869		
	Total	272.777	316			

Table 10 - Correlation scale between students' attitudes towards environmental problems and their willingness to participate in reducing them

Attitudes	Pearson correlation coefficient	Sig.
Contribution	0.340	0.01

Table 11 - Correlation coefficient of students' attitudes and their willingness to participate in reducing them

Willing to contribution		Energy	Water	Air	Waste	Desertification
Attitudes	Pearson correlation coefficient	0.347	0.475	0.324	0.335	0.133
	Sign	0.000	0.000	0.000	0.000	0.018
	N	317	317	317	317	317

in facing those problems which can be attributed to the variable of the college of their study. This convergence of results, in particular in the areas of air (0.782) and waste (0.730), may be attributed to the fact that all students live in the same urban environment where air pollution is becoming increasingly dangerous.

Question 5: Is there a relationship between students' attitudes towards environmental problems and their willingness to take action to reduce them?

Table (10) shows a correlation between students' attitudes towards environmental problems and their willingness to participate in reducing those problems. More information on this positive relation and its scale in each area is presented in the table (11).

The results indicate the existence of a correlative relation between students' attitudes towards environmental problems and their willingness to participate in facing those problems. This result supports the results reached in a number of previous studies conducted on the same issues (Mathew, 1990; Dunlap et al, 1993, Buhemann, 1998).

Conclusion

The results of this study support the literature which indicates that positive attitudes towards reducing environmental problems are growing. This is promising, as people become more and more aware and understand the danger facing our planetary environment and their role in determining the deterioration of the situation. However, more effort is needed to raise students' awareness of the importance of their individual and community roles in tackling environmental problems, in order to give future generations the chance to live in a healthy environment.

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THE QUESTIONNAIRE

SQU students' attitudes toward some environmental problems and their willingness to participate in reducing them

Name (optional):.....

Sex: male ☐ **female** ☐

College:.....

Specialization:.....

Please put (X) in the relevant column that express your chosen answer.

SA= Strongly Agree: A= Agree; NS= Not Shore; DA= Disagree, SDA= Strongly Disagree

	Statement	**Acceptance alternatives**				
		SA	**A**	**NS**	**DA**	**SDA**
	Energy Problems					
1	I believe the energy problem is confined to oil importing countries.					
2	I feel worried for the future of non-renewable energy sources.					
3	I don't believe that ordinary individuals can take part in limiting energy problems.					

	Statement	Acceptance alternatives				
		SA	A	NS	DA	SDA
4	I believe the individual has the right to consume energy as much as he/she likes, as long as he/she pays the bills.					
5	I prefer sharing a car with others, to reduce petrol consumption.					
6	I prefer sharing a room with my siblings in order to reduce electricity consumption.					
7	I like to put all light in our house on so as to feel safe, even if that means consuming more energy.					
8	I prefer to dry my clothes in the sun instead of electrical drying machines.					
9	I would rather use fans in my house than air conditioners					
10	I believe that reducing oil and gas production won't reduce the danger of their depletion.					
11	I am in favour of producing electricity from the Solar Energy instead of present environment polluting sources.					
12	I am in favour of producing electricity from the solar energy instead of present depleting sources.					
13	I am willing to pay extra money on my electricity bill so as to help in producing solar energy.					
	Water Problem					
1	I am not bothered by the amount of water I use, as long as I pay my bill.					

	Statement	Acceptance alternatives				
		SA	A	NS	DA	SDA
2	I prefer to have my own swimming pool even if that means consuming more water.					
3	I support the use of modern irrigation techniques, even if expensive, in order to reduce consumption of water.					
4	I am in favour of using treated sewage-water for irrigation instead of drinking water.					
5	I am ready to participate in paying for treating the sewage water of my own house.					
6	I believe that the individual's consumption of as much water as he/she likes is a natural right in life, as water is a blessing from God.					
7	Individual persons cannot do anything that would reduce water consumption.					
8	The individual is not responsible for increasing the problem of water scarcity in the Sultanate.					
9	I am in support of using tight measures on the use of water for irrigation, in order to curb its consumption.					
10	I am willing to participate financially in water improving projects (eg: treating sea water).					
11	I do my best not to waste much water when bathing, washing and doing ablutions.					
12	I would rather use traditional clothes-washing methods instead of the modern washing machine.					
	Air Pollution Problem					
1	I would share a car with others so as to reduce air pollution.					

	Statement	Acceptance alternatives				
		SA	A	NS	DA	SDA
2	I believe ordinary individuals can do something to reduce air pollution.					
3	I support the idea of a tight monitoring system on all kind of machines that send smoke					
4	I am in favour of preventing private cars entering city centres, and promoting the use of public transport, to reduce pollution.					
5	I support the prohibition of smoking in public places.					
6	I am willing to participate financially in new ways of treating waste, instead of burying it.					
7	Factories must be obliged to curb the waste they produce in their operations.					
8	The production of all gasses that affect the ozone layer must be prohibited					
	Waste Problem					
1	I feel worried about the negative effects on the environment of the burning waste.					
2	I feel worried about the negative effects on the environment of the dumping of waste.					
3	I prefer the recycling of waste.					
4	I would rather use materials and articles of longer duration in order to reduce waste.					

	Statement	Acceptance alternatives				
		SA	A	NS	DA	SDA
5	I am in support of putting special taxes on waste production that results from industrial activities.					
6	I am in support of putting special taxes on waste that results from agricultural activities.					
7	I am in support of putting special taxes on waste that results from household activities.					
8	I am ready to pay extra tax on waste that results from my household activities.					
	Desertification Problem					
1	I do not think individuals are responsible for the deterioration of the earth's ecological system					
2	The process of grazing must be well-organized so as to protect plants and prevent desertification.					
3	I think the role of individuals in preventing desertification is not effective.					
4	I feel really upset when others ignore the phenomenon of the shrinking of the earth's green belt					
5	I am in favour of paying extra tax by every citizen for covering the cost of watering plants.					
6	I am ready to participate financially in any project for irrigating plants in my area.					
7	I am willing to donate part of my salary towards the cost of the prevention of desertification and the renewal of forests					

Role of Sacred Natural Sites in the Conservation of Tropical Dry Evergreen Forests of the Tamil Nadu Coast

M. Amirthalingam

ABSTRACT

Sacred natural sites are prominent feature of many cultures across the world and include sacred groves, gardens, water bodies, caves and mountains. Many such sacred natural sites are important repositories of rich biodiversity. Sacred groves have played a vital role in the conservation of the environment and local ecology. They are linked to important traditional values as well as linked to the identities of societies that venerate them. Indigenous communities have long realised the value of the natural resources and sacred natural sites. This paper is an attempt to discuss the importance of conserving sacred natural sites and their role in protecting the Tropical Dry Evergreen Forests on the east coast of Tamil Nadu.

Keywords: Sacred groves, Cultural heritage, Tropical Dry Evergreen Forest, Biodiversity

Introduction

Sacred places play an important social role in many cultures across the world. They are often linked in some way with trees, groves, gardens, water bodies, caves, sites and mountains. Sacred Natural Sites (SNS) and their traditional belief systems play a significant role in conservation of biodiversity, especially rare, endangered and threatened plant and animal species protect fresh water sources (Ramakrishnan, et.al., 1998).

Distribution of Tropical Dry Evergreen Forests (TDEF)

Tropical Dry Evergreen Forests in Tamil Nadu are restricted to the east coast. They are spread from Pulicat in the north to Vedaranyam in the south. TDEFs generally occur along the sandy coast, interior coastal plains with red laterite soil or isolated hillocks scattered along the east coast. Natural vegetation on the south-eastern coast of Peninsular India has now been highly degraded and reduced to patches. Only a few isolated fragments of TDEFs exist, mostly in the form of sacred groves that are mainly protected due to religious and cultural beliefs (Meher-Homji, 1986).

Puthupet Sacred Grove (PSG)

The grove is dedicated to Manjaneeswara Ayyanaar. The name of the village is Puttupatha Chavadi, but is commonly referred to as Puthupet. The name of the village is derived from the Tamil word *puttu* which means an ant hill. There is a large anthill in the grove, with two horses dedicated to Ayyanaar. According to local belief, a string tied below the knee of the horse has the power to do well or to cause harm to an adversary. The sacred *puttu* (termite mound) is situated under an Ironwood tree (*Memecylon umbellatum*), on which numerous cradles are tied and hung in order to be blessed with a child.

Mythology of the grove

Bhasmasura had received a boon from Lord Shiva that anyone he touched would burn into ash. He wanted to test that boon with Shiva himself. To save himself, Shiva hid inside the seed of an Ivelan kodi (*Diplocyclos palmatus*) in the Ivelankaadu, presently known as Puthupattu. Vishnu in the form of Mohini saved Shiva and, from their union, the deity of the grove - Ayyanar - was born in the same grove (Ramakrishnan, 2002).

Every Tuesday and Friday, the local people and those from neighbouring villages offer *pongal* (made with rice and jaggery) and also light lamps made of rice flour and jaggery. It is interesting to note that animal sacrifice does not form a part of the rituals of any of the communities belonging to Puthupattu or the neibouring villages.

Biodiversity of the grove

The grove extends over an area of 25 acres and is one of the conserved patches of tropical dry evergreen forests. The soil is alluvial or sandy loam in texture. The annual rainfall is same as that at Pondicherry (1254 mm). The grove is relatively less disturbed with a dense vegetation cover. Around 104 plant species belonging to 44 families are found in the grove. The major species occurring are *Albizia amara, Azadirachta indica, Canthium dicoccum, Carissa spinarum, Eugenia bracteata, Flacourtia indica, Garcinia spicata, Lepisanthes tetraphylla, Memecylon umbellatum, Pongamia pinnata, Pterospermum canescens, Syzygium cumini* and *Ziziphus oenoplea*. The common lianas include *Combretum albidum, Mimosa intisia, Plecospermum spinosum,* and *Strychnos lenticellata* (Visalakshi, 1994).

Threats

In general, the threats are mainly anthropogenic due to the development in and around the temple. According to Pandurangan, trustee of the Manjaneeswarar temple at Puthupet sacred grove, large numbers of devotees visit the temple. The devotees dump garbage and throw plastic cups and other waste materials inside the grove and thus the sacred grove is facing a serious threat. Cattle browsing is high in the grove because of the water body close to the grove.

Oorani Grove

Oorani is a small hamlet situated 35 km north-west of Pondicherry on the east coast. This sacred grove is dedicated to goddess Selliamman and extends over an area of 1.8 ha. A large canal that connects Kaluveli tank runs close by; besides, a few springs are found in the surroundings. Ponds that occur around the village ensure perennial water supply and thus the hamlet has the name Oorani.

Mythology of the grove

The local people believe that their ancestors still live the grove. They please their ancestors through special prayers and by sacrificing goats and fowls. Every Tuesday, local people also worship the Goddess to get rid off evil spirits and for obtaining wealth. The rituals include tonsuring the head and boring their children's ears. The annual festival is celebrated during the month of *Vaikasi* (May – June).

Biodiversity of the grove

The grove houses about 74 flowering plant species distributed in 71 genera and 41 families: 30 are woody species, 24 species are shrubs, 4 species herbs and 11 climbers. Parasitic plant species such as *Cassytha filiformis, Cuscutta reflexa Dendrophthoe falcata,* and *Viscum orientale* have also been recorded. Plant species such as *Albizia amara, Commiphora caudata* and *Dalbergia paniculata, Drypetes sepiaria, Garcinia spicata, Memecylon umbellatum* and *Pterospermum suberifolium,* lianas such as *Cansjera rheedi, Capparis zeylanica, Combretum albidum, Derris ovalifolia, D. scandens, Hugonia mystax, Strychnos lenticellata* and *Ventilago madaraspatana* are reported from this grove. Besides, it is a home for many birds and monkeys.

Olagapuram grove

Olagapuram is a small village situated about 35 km north-west of Pondicherry. Since there is no separate idolised image inside the grove, people come to the grove and sprinkle turmeric and saffron on the termite mound (Puthu) and offer worship on specific occations. Sometimes they instal bricks or stones to symbolise the seven Kannimars and worship them with offerings of pongal.

The grove (2.8 ha) is species-rich with 136 species in 121 genera of 58 families. Of these, 21 are woody species, 9 are lianas. *Cassytha filiformis, Dendrophthoe falcata* and *Striga asiatica* are parasites. The major plant species found in this grove are *Acacia leucophloea, Albizia odoratissima, Atalantia monophylla, Azadirachta indica, Borassus flabellifer, Buchanania axillaris, Combretum albidum, Cordia monoica, Hugonia mystax, Lannea coromandelica, Manilkara hexandra,*

Memecylon umbellatum, Strychnos colubrina, Ventilago maderaspatana, Z. xylopyrus, Ziziphus oenoplia and insectivorous plants such as *Drosera burmannii* and *Osbeckia zeylanica* were commonly found plant species of this grove.

Kilbhuvanagiri Grove

It is a small village situaged on the Cuddalore - Chidambaram highway. This grove is dedicated to the deity Udaiyarappan and covers an area of 1.1 ha. But the vegetation cover is limited to 0.12 ha.

The history of this sacred grove may be traced back to more than 200 years. This is believed to be a memorial grove, dedicated to Udaiyarappan, a folk hero. According to a folk tale, he came from Ariyalur to this grove for hunting and stayed permanently in this grove. Udaiyarappan is the main deity and Pavadairayan, Veeran, Muttal Ravuttan, Petchi, Moochi and Saptha Kanniga are the subordinate deities of the grove.

Every Friday, local people perform pooja by offering coconut, banana, tender coconut, rose water, curd, turmeric, sandal powder and sacrifice a goat or fowl. The annual festival is celebrated in the month of Thai (January 15 to February 15). During the festival, people visit the temple premises and cook *pongal* (a mixture of rice, jaggery, moong dhal, ghee, cashew nuts, dry grapes and milk) and perform special *pooja*. The weaving community places bundles of yarn at the deity's feet to get blessings of wealth for the commencing year.

The vegetation cover of this grove includes trees, shrubs and climbers. There are about 55 species belonging to 31 families found in the grove. Major plant species include *Abrus precatorius, Aerva lanata, Andrographis paniculata, Atalantia monophylla, Azadirachta indica, Borassus flabellifer, Capparis sepiaria, C. zeylanica, Cassia fistula, Cayratia pedata, Cissus quadrangularis, Coccinia grandis, Cocculus hirsutus, Creteva adensonii, Flacourtia indica, Glycosmis mauritiana, Hemidemus indicus, Jasminum auriculatum, Lannea coromandelica, Lepisanthes tetraphylla, Pyrenacantha volubilis, Strebulus asper, Tamarindus indica* and *Tinospora cordifolia*.

Threats

The grove is heavily degraded due to sand quarrying and transforming into thrashing yard and to the construction of temporary huts.

Kuzhanthaikuppam and Thirumanikkuzhi Grove

According to Parthasarathy and Karthikeyan (1997), there are two small patches of sacred tropical dry evergreen forest at Kuzhanthaikuppam and Thirumanikkuzhi on the Coromandel Coast of Tamil Nadu.

The vegetation of the Kuzhanthaikuppam sacred grove include woody species such as *Diospyros ebenum, Garcinia spicata, Lepisanthes tetraphylla, Mallotus rhamnifolius, Memecylon umbellatum, Miliusa Montana, Pterospermum canescens* and *Tricalysia sphaerocarpa* among trees, and lianas such as *Combretum ovalifolius, Derris scandens* and *Reissantia indica*. Other species include *Cansjera rheedii, Derris scandens, Grewia rhamnifolia, Premna corymbosa, Tinospora cordifolia* and *Ventilago madraspatana*. Herbs such as *Sansevieria*

roxburghiana in colonies, *Ecbolium viride* and *Amorphophallus sylvaticus* constitute the predominant ground flora (Arul Pragasan and Parthasarathy, 2005).

Tirumanikuzhi is situated 36 km away from Pondicherry. There is a grove which is dedicated to Ayyanar occupying an area of 1.6 ha. The presiding deity is in an open air shrine and statues of huge horses with his assistants and soldiers are found at the entrance of the grove. The local people worship in the grove mostly on Mondays. The major plant species found in the sacred grove of Tirumanikuzhi are *Atalantia monophylla, Canthium dicoccum, Combretum albidum, Derris scandens, Diospyros ebenum, Drypetes sepiaria, Ficus benghalensis, Flacourtia indica, Garcinia spicata, Glycosmis pentaphylla, Lepisanthes tetraphylla, Mallotus rhamnifolius, Memecylon umbellatum, Pleiospermium alatum, Pterospermum canescens, Pterospermum xylocarpum* and *Tricalysia sphaerocarpa*. Understorey is comparatively denser in this grove and consists of *Millusa montana, Sansevieria roxburghiana, Theriophonum* sp. *Selaginella* species and thalli of *Riccia* species found during the monsoon.

A number of birds are reported from these groves: babblers, bulbuls, cuckoos, doves, flower-peckers, jungle crow, koel, tree pie, parakeet, sunbird and warblers. Mammals include bats, Indian hare, field rats, jackal, mongoose, palm civet, small Indian civet, palm squirrels and wild cat. These animals play a major role in seed dispersal (Parthasarathy and Karthikeyan, 1997).

These groves are surrounded by agricultural fields and roads. The grove edges are encroached by advancing agricultural lands.

Conclusion

Tropical dry evergreen forests vary greatly from place to place, mainly due to variation in habitat and disturbance. Human disturbance patterns also affect the structure and composition of tropical dry evergreen forest sites. The present level of plant diversity of these forests is because of their sacred grove status. Sacred groves attract the increasing interest at both national and international level that stresses more on the use of traditional practices for conservation and sustainable use of biological diversity. These forests also contribute to the conservation of biodiversity by conserving habitat for plants and food for faunal communities. These tropical dry evergreen forest patches are subject to various such as includes anthropogenic pressure, cattle browsing, extensive plantation of Eucalyptus, sand quarrying and are encroached by advancing agricultural lands. To protect these groves, the local people have to be educated about their importance and their role in the conservation of biodiversity.

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Seasonal Diets of Small Bee-eater in an Agro-environment of Nagapattinam District, Tamil Nadu, India

S. Asokan* and A. Mohamed Samsoor Ali**

ABSTRACT

A large number of birds and lizards directly or indirectly depend on the crop fields for their food. A total of 250 regurgitate pellets were analyzed and 3152 individual prey items representing 7 arthropod orders were identified. The Bee-eater consumed similar proportions of coleopterans and hymenopterans in our study. Small Bee-eater is an aerial feeder and caught varieties of beetles, butterflies, dragon flies, bees, etc., in the air. In general, Bee-eater preferred coleopteran and hymenopteran insects in all seasons. Caterpillars and other soft-bodied insect larvae are more easily digested than arthropods with hard parts and, therefore, may be underrepresented in bird diet samples (Wheelwright, 1986). In this article we have examined the food and feeding habits of the small Bee-eater in an agro-environment of Nagapattinam District of Tamil Nadu, India.

Key words: Small bee-eater, Insect preys, Arthropods, Insects, Agro-environment

Introduction

A large number of birds directly or indirectly depend on the agricultural fields and hence they are integral part of the agro-ecosystem. As enemies of insects, birds stand supreme among vertebrates because they are highly mobile and are able to congregate quickly in large numbers, as sudden outbreaks of insect pests occur. Avian prey selection is influenced by prey availability, including proximity, detectability, acceptance and ability to successfully capture a potential prey item (Wolda, 1990). Accurately determining prey availability, as perceived by birds, is a research challenge with many potential biases (Johnson, 1980; Cooper and Whitmore, 1990, Wolda, 1990). A bird's ability to capture prey is determined by vegetation structure in the foraging habitat (Robinson and Holmes, 1982), arthropod prey characteristics such as life stage, activity level and palatability (Cooper and Whitmore, 1990) and the bird's behaviour and search tactics (Hutto, 1990).

Food supply plays an important role in determining the breeding biology, dispersion pattern and social system of a species through the natural selection. Detailed analysis of food and feeding behaviour of different bird species of a region is the first and foremost requirement to asses their economic status and to initiate work on bird management in that region (Toor and Saini, 1986). Unfortunately, only limited information is available on the feeding ecology of Indian birds. Our objective was to

* Reader, Dept. of Advanced Zoology and Biotechnology, A.V.C. College, Mayiladuthurai.
** Junior Research Fellow, Owl Research Project, Dept. of Zoology, Saraswathi Narayanan College, Perungudi.
E-mail: amsamsoor@yahoo.co.in

examine the food and feeding habits of Small Bee-eater (*Merops orientalis*) in an agro-environment of Nagapattinam District, Tamil Nadu, India.

Methods

The study was conducted in an area of 150km^2 in Nagapattinam District of Tamil Nadu, Southern India, from 2005 to 2006. Three different transects of 1000 m length and 100 m width of agricultural lands were laid and all the data were collected from the transected area.

Pellet analysis

Repeated analyses of the pellets of insectivorous birds is the most reliable and easy method for studying food habits (Herrera and Ramirez 1974, Asokan 1998). The regurgitated pellets of the Small Bee-eater were collected opportunistically at perch and roost-site where we observed the birds within the targeted study area. The collected pellets were bagged, labeled and dried in hot air oven at 60˚C for later identification of prey remains (Asokan 1998, Sivakumaran and Thiyagesan 2003). Insect prey remains were identified and enumerated following Herrera and Ramirez (1974) and Asokan (1998). Insect remains were identified up to order level by looking at some of the most important exoskeletons such as mandibles, head capsules, elytra, etc. Where identification was not possible, they were grouped into unidentified remains. Jacobs (1974) index was used to evaluate seasonal use of each arthropod order relative to availability:

$$D_{hb} = \frac{r - p}{r + p - 2rp'}$$

where D_{hb} is the index of arthropod use, r represents the percentage of an arthropod order in the pellets and p represents the percentage of a particular arthropod order in the total arthropod sample. Values of D_{hb} range from -1 to 1. The terminology associated with relative values of the index (Morrison, 1982) is as follows: -1 to -0.81 = used much less than availability, - 0.80 to -0.41 = used moderately less than availability, -0.40 to -0.16 = used slightly less than availability, -0.15 to 0.15 = use equals availability, 0.16 to 0.40 = use slightly exceeds availability, 0.41 to 0.80 = use moderately exceeds availability.

Arthropods sampling

The insect preys available in the study area were collected by using a sweep net method (Pradhan 1991). In each transect of 1km length, 50 sweepings were made randomly at an interval of 20 m.

Results

Pellet analysis

Totally 250 regurgitate pellets were analyzed and identified 3152 individual prey items representing seven arthropod orders (Table 1). Pellet measurements ranged from 0.9 to 2.9cm in length (mean = 1.7; SE = 0.02), from 0.1 to 1.7cm (mean = 0.6; SE = 0.24) and from 0.07 to 2.15g in weight (mean = 0.5; SE = 0.01). Mean number of prey per pellets was 11 ± 0.19 (range = 3to 25). The most commonly identified prey was in the order coleoptera (18% of arthropods collected during pellets), hymenoptera (16%), hemiptera (14%), orthoptera (13%), lepidoptera (11%), odonata (10%) and diptera (10%). Together these orders comprised 90% of the arthropods identified in pellets. Remaining 10% of the prey remains are unidentified.

Arthropod sampling

Arthropods in seven orders comprised 92% of all arthropods captured in sweep nets, including orthoptera (20% of total arthropods captured), coleoptera (15%), hemiptera (14%), hymenoptera (13%), lepidoptera (11%), odonata and diptera (10% respectively).

Arthropod use and availability

The order orthoptera were used in proportion to slightly less availability by the Bee-eater in all seasons. The other arthropods orders, viz., odonata, hemiptera, hymenoptera,

coleoptera, lepidoptera and diptera, were used equally in all seasons (Table 2).

Discussion

The Bee-eater consumed similar proportions of coleopterans and hymenopterans in our study. Mathew *et al.* (1978) reported that the Bee-eater consumed almost equal proportions of hymenoptera, coleoptera, odonates and lepidopterans. Asokan (1998) stated that coleopteran insects were the most frequent food items in the diet of Bee-eater the same was recorded in the present study. However, Douthwaite and Fry (1982) and Fry (1984) who studied the Little Bee-eater, reported that hymenopterans formed the principal diet. Douthwaite and Fry (1982) reported that Little Bee-eater in Africa consisted of 57% of hymenoptera and remainders coleoptera, diptera and odonata. Fry (1984) found that hymenopterans constituted more that 75% in the pellets of Bee-eaters, with beetles constituting only 17%. The remaining 8% were termites, assassian bugs, squash bugs, shield bugs, microlepidoptera and so on.

Many researchers have reported that coleopterans, hymenopterans and lepidopterans (Raley and Anderson, 1990; Sillett, 1994; Poulin and Lefebvre, 1996; McMartin *et al.*, 2002; Yard *et al.*, 2004; Asokan *et al.*, 2006, Moorman *et al.*, 2007) are an important food resource for insectivorous birds. The Small Bee-eater is an aerial feeder and caught varieties of beetles, butterflies, dragon flies, bees, etc., in the air. In general, Bee-eater preferred coleopteran and hymenopteran insects in all seasons. Many investigators have described food habits within (Hejl and Verner, 1990) or between (Martin and Karr, 1990) seasons, probably due to changes in food availability. However, arthropod availability was relatively consistent in all the seasons in our study.

Direct observation of avian diets are complicated by variable digestion rates of different arthropods (Swanson and Bartonek, 1970; Rosenberg and Cooper, 1990). Digestibility is affected by body type (soft or hard) and prey size (Custer and Pitelka, 1975). Caterpillars and other soft-bodied insect larvae are more easily digested than arthropods with hard parts and, therefore, may be underrepresented in bird diet samples (Wheelwright, 1986). Thus, proportions of soft-bodied arthropods, such as those in the orders lepidoptera, odonata and diptera were probably underrepresented in our analyses and may be more important in bird diets than indicated in our results. However, we believe that our data represents the wide variety of insect prey items consumed by the Small Bee-eater, which acts as a very active bio-control agent against agricultural insect pests.

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Table 1: Availability and use seasonal use (percent of individuals in arthropod samples and pellets respectively) of arthropod samples and pellets) of arthropods by the Small Bee-eater in Nagapattinam District.

Season	Order	Availability (%)	Use (%)
Post Monsoon		*N=62*	
(Jan - March)	Orthoptera	18	13
	Odonata	10	10
	Hemiptera	14	14
	Hymenoptera	14	17
	Coleoptera	15	18
	Lepidoptera	10	09
	Diptera	11	09
Summer		*N=65*	
(Apr. – June)	Orthoptera	20	13
	Odonata	09	10
	Hemiptera	15	13
	Hymenoptera	14	15
	Coleoptera	15	16
	Lepidoptera	10	12
	Diptera	10	10
Pre Monsoon		*N=74*	
(July – Sep.)	Orthoptera	22	13
	Odonata	09	10
	Hemiptera	14	13
	Hymenoptera	12	16
	Coleoptera	15	20
	Lepidoptera	10	11
	Diptera	09	07
Monsoon		*N=55*	
(Oct. – Dec.)	Orthoptera	20	12
	Odonata	10	10
	Hemiptera	13	17
	Hymenoptera	13	16
	Coleoptera	15	19
	Lepidoptera	11	10
	Diptera	10	08

Table 2: Index of seasonal of arthropod use by Bee-eater relative to availability in an agro-environment, 2005- 2006.

Season	Orth	Odon	Hemi	Hyme	Cole	Lepi	Dipt
Post Monsoon	-	0	0	0	0	0	0
Summer	-	0	0	0	0	0	0
Pre Monsoon	-	0	0	0	0	0	0
Monsoon	-	0	0	0	0	0	0

For each order, D_{hb} values (Morrison, 1982) are represented as follows:
- = - 0.40 to – 0.16; 0 = - 0.15 to 0.15.

Orth = Orthoptera; Hemi = Hemiptera; Hyme = Hymenoptera;
Cole = Coleoptera; Lepi = Lepidoptera; Dipt = Diptera.

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