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Indian Journal of Biology

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Original Article

Statistical Approach to Analyse the Present Ecological Status of Ichthyofauna of River Churni, West Bengal

Avijit Bakshi*, Ashis Kumar Panigrahi**

Abstract

Fish, one of the most important protein sources for human, is also an important vertebrate member of aquatic medium. Fisheries sector also contributes a major amount of the total economy of India. Fish diversity, an important indicator of the ecological status of any aquatic ecosystem (both lotic and lentic), is estimated by the use of different statistical approaches. Determination of relative abundance, habitat orientation score and trophic level score of the available fish species and also use of biotic index in any aquatic system depict the ichthyofaunal status with a clear indication of the vulnerability of the ecosystem. Owing to this, a study was conducted from January, 2012 to December, 2014 on River Churni, a major source of the surface water of Nadia district of West Bengal to measure the present status of species diversity and seasonal variation of assemblage of fish fauna. Data have been collected throughout the total span of investigation from major catchment sites of different parts (i.e., up stream, mid-stream, downstream) of the river. Studies have revealed that a total of 38 species of 7 orders and 17 families of fishes are there in the river. The number of available fish species has been found to be variable according to the season and part of the river. Trophic level score has revealed that omnivore fishes (34.78%) are predominant in upper stretch of the river and are followed by carnivore (30.43%), planktivore (26.08%) and benthic feeder (8.69%). In mid-stream, the trophic level score is found to be oriented in the following manner i.e., PL (33.33%)> OM (30.55%) > CA (22.22) > BE (8.69%). Apart from this, the values of Shannon-Weiner index (2.62-3.49), Simpson's index (0.034-0.077) have indicated the more stable condition in downstream of the river than the upper parts. As, the river has been cited to have degrading ecological condition by many authors, results from this investigation will be helpful for the implementation of conservation ideas of the fish fauna in the river.

Keywords: Fish; River Churni; Ichthyofauna; Statistical Approaches; Biotic Index.

Introduction

India, an important mega diversity country, holds the ninth rank in the world in terms of freshwater diversity (Mittermeier and Mitemeier, 1997) having about 2500 fish species in total (Kar et al., 2003). This huge diversity of fish is also an important source of economy of our country. But, the production from the fisheries has been found to be constrained due to the increasing problem of pollution. According to the estimate by Kar et. al. (2003), 930 species among the 2500 are freshwater dweller and the rest are marine. This report has been found to be quite similar to the report of Talwar and Jhingran (1991). Talwar and Jhingran (1991) have listed 2546 species of fish

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Author's Affiliation: *Ex- Research Scholar, Ecotoxicology, Fisheries and Aquatic Extension Laboratory, **Professor, Department of Zoology, Kalyani University, Kalyani, Nadia West Bengal, 741235, India.

Reprint's Request: Ashis Kumar Panigrahi, Professor, Department of Zoology, University of Kalyani, Kalyani, Nadia, West Bengal, 741235, India.

E-mail: avijit1986@gmail.com

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belonging to 40 orders, 254 families and 969 genera. Fishes can be widely used as one of the suitable indicators of pollution in aquatic ecosystem (Kumar and Mathur, 1991). Abdel-Baki *et al.*, (2011) considered the position of fishes in trophic level as the most important reason behind their selection as bio-indicator.

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Ecological degradation of any river is indicated by loss of its diversity. Sharp declination in piscian diversity has been found to be an indicator to disturbances in aquatic ecosystem. According to several authors, River Churni has been cited as a river with the problem of ecological degradation (Panigrahi and Bakshi, 2014; Panigrahi et al., 2015). According to Das and Chakrabarty (2007), 63.6% of fish species appeared to have been eliminated from the polluted Churni River since 1983 in 20 years. They have reported about the presence of 44 species of fishes in both River Churni and River Jalangi in 1983. In 2007, the available amount of fish species has been found 16 in River Churni, as reported by Das and Chakrabarty (2007). Bakta and Bandyopadhyay (2007) has reported that River Churni comprises 48 fish species under 29 genera, 18 families and 8 orders including 8 species of exotic fish under 3 orders, 4 families and 6 genera. A long stretch of the lower part of River Ganga resides as the western boundary of this district. Ghosh (2008) has reported that River Ganga comprises about 156 fish species in its lower stretch. According to Bakta and Bandyopadhyay (2007), eight numbers of exotic or alien species viz., Oreochromis mossambicus, O. niloticus, Hypophthalmicthys molitrix, H. nobilis, Cyprinus carpio, Ctenopharyngodon idella, Clarias gariepinus, Pangasius sutchi, have been reported during an extensive survey. According to Das and Chakrabarty (2007), 28 number of fish species viz., Labeo bata, Puntius sophore, Amblypahyngodon mola, Mystus aor etc. have been reported to be eliminated. The recent survey has been done to prepare the recent exact piscian diversity for this river. Statistical approaches have been made to analyse the present status of ecology of the system.

Materials and Methods

Study Area

The fishermen interviews have been conducted in the 3 study areas (or villages or stations) beside River Churni during January, 2012 to Dec, 2014.River Churni, one of the important distributaries of River Mathabhanga, emerges at Krishnaganj, Nadia (West Bengal).Flowing about at 54 kms, it finally pours its content to River Bhagirathi- Hooghly near Mangaldeep, Payradanga of district Nadia. Three villages mostly inhabited by fishers have been selected for this survey by a standard statistical method. The sites for interview programme have been selected in such a manner that all the three parts *viz.*, up-stream, mid-stream and lower-stream must contain a site. Latitude and longitude of those three sites of the sampling has been listed below (Table 1). Table 1: Sites for interview programme (Villages) and Positions

Sites	Latitude	Longitude				
Mamjoan, Nadia	88°58´N	23°30′E				
Gajantala, Nadia	88°53´N	23°15′E				
Kayet Para, Nadia	88°56´N	23°19′E				

Data Collection Method

Pre-tested interview schedule (Panigrahi and Bakshi, 2014) has been used for the collection of information after conducting a preliminary survey to construct a clear idea about the present available fish fauna. The data related to present status of piscian diversity of the river have been collected directly either from the major catchment sites of the river or from the fishermen families through personal discussions and interviews regarding the available fish and their production. Visiting major catchment sites and river side fish markets have been proved to be useful to gather some knowledge on the fish availability. Fishes have been frequently collected from sampling sites and taken to the laboratory for identification. Photographs of the collected samples have also been taken (using Nikon Coolpix, Model: L810) for identification.

Calculations

Trophic level scores have been measured to categories the fishes into different trophic groups based on their feeding habits (Karr et al., 1986; OPEA, 1987). The "trophic level score" (Wichert and Rapport, 1998; Gauch, 1982) represents the relative frequency of the fish using the particulartrophic level among all the trophic level available in thataquatic system. "Habitat orientation score" (Wichert and Rapport, 1998; Gauch, 1982) represents the relative frequency of the fish using the particular habitat among all the habitats available in that aquatic system (Das and Chakrabarty, 2007).

The Shannon Weiner (H) and Simpson indices (D) are the two most widely used species diversity indices for examining overall community characteristics. The formula is given below:

$$H' = \sum_{i=1}^{S} Pi \ln Pi; Pi = \frac{ni}{N}, D = \sum_{i=1}^{S} \frac{ni(ni-1)}{N(N-1)}$$

N= Total Number of organism, n_i = Number of organism of ith Population, s= total number of species

Result and Discussion

Fish fauna study of the River Churni has revealed that there are huge variations in fish availability according to the different part of the stretch or to the seasons.

The study has explored the fact that upper part or upstream of the river is highly affected by the pollution as only 15 species have been found in Pre Monsoon seasons and only 17 in post monsoon time. 22 number of fish species have been evident in the upstream during the monsoon period. The probable reason behind this situation may be the over flow of the water from river side beels or other water bodies. Mid-Stream of the river has found to possess 22, 33 and 21 species in the Pre monsoon, monsoon and post monsoon time respectively. Presence of 6 exotic species has been listed during the study. The total available 38 species of fishes can be grouped into 7 orders and 17 families. Presence of six number exotic species is an indicator of ecological degradation. A total of 23 species have been found in Up-stream, 36 in Mid-stream and 38 in Down-stream in all seasons.

Among 38 numbers of total available fish species, 9 species have been found to be carnivore whereas; planktivore (13 species), benthic eater (5 species) and omnivorous (11 species) have also been found. Presence of 23.68% of carnivore species depicts about river's degrading situation (Table 2).

Trophic level study and habitat orientation study have been done to measure the ecological condition of different part of the river. Trophic level score has revealed that omnivore fishes (34.78%) are predominant in upper stretch of the river and are

Table 2: Trophic level and Habit	te orientation of the available i	fish fauna during the survey (2012-2014)
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Sl. No.	Scientific name	Trophic level nature	Troph Up	ic level s Mid	core (%) Down	Habitat orientation	Habitat Up	orientatio Mid	nscore (%) Down
		DI	26.00	22.22	04.01	nature	10.45	17.00	22.22
1.	Catta catta	PL	26.08	33.33	34.21	P	43.47	47.22	22.22
2.	Labeo ronita	PL	26.08	33.33	34.21	P	43.47	47.22	22.22
3.		PL PE	-	-	34.21	P	-	-	22.22
4.	Labeo calbasu	DE	-	13.88	13.15	B	-	22.22	21.05
5.	Cirrninus mrigala	BE	-	13.88	13.15	В	-	22.22	21.05
6.	Ambiypharyngoaon moia	PL	26.08	33.33	34.21	P	43.47	47.22	22.22
7.	Puntius sarana sarana	PL	-	33.33	34.21	Р	- 70	47.22	22.22
8.	Puntius ticto	PL	-	33.33	34.21	Р	-	47.22	22.22
9.	Chela laubuca	OM	-	30.55	28.94	Р	-	47.22	22.22
10.	Securicula gora	PL	26.08	33.33	34.21	P	43.47	47.22	22.22
11	Cyprinus carpio	BE	8.69	13.88	13.15	В	21.73	22.22	21.05
12.	Hypophthalmichthys molitrix	PL	26.08	33.33	34.21	Р	43.47	47.22	22.22
13.	Aristichthys nobilis	PL	26.08	33.33	34.21	Р	43.47	47.22	22.22
14.	Ctenopharyngodon idella	OM	34.78	30.55	28.94	G	34.78	30.55	28.94
15.	Sperata aor	OM	34.78	30.55	28.94	G	34.78	30.55	28.94
16.	Sperata seenghala	OM	-	30.55	28.94	G	-	30.55	28.94
17.	Rita rita	CA	30.43	22.22	23.68	В	21.73	22.22	21.05
18.	Wallago attu	CA	-	22.22	23.68	G	-	30.55	28.94
19.	Ailia coila	PL	-	33.33	34.21	Р	-	47.22	22.22
20.	Silonia silondia	OM	-	30.55	28.94	G	-	30.55	28.94
21.	Eutropiichthys vacha	CA	30.43	22.22	23.68	Р	43.47	47.22	22.22
22.	Clarias batrachus	OM	34.78	30.55	28.94	Р	43.47	47.22	22.22
23.	Heteropneustes fossilis	OM	34.78	30.55	28.94	В	21.73	22.22	21.05
24.	Awaous grammepomus	BE	-	13.88	13.15	В	-	22.22	21.05
25.	Anabas testudineus	OM	34.78	30.55	28.94	G	34.78	30.55	28.94
26.	Colisa fasciata	OM	34.78	30.55	28.94	G	34.78	30.55	28.94
27.	Channa punctatus	CA	30.43	22.22	23.68	G	34.78	30.55	28.94
28.	Channa striata	CA	30.43	22.22	23.68	G	34.78	30.55	28.94
29.	Channa gachua	CA	30.43	22.22	23.68	G	34.78	30.55	28.94
30.	Oreochromis mossambicus	OM	34.78	30.55	28.94	Р	43.47	47.22	22.22
31.	Oreochromis niloticus	OM	34.78	30.55	28.94	Р	43.47	47.22	22.22
32.	Nandus nandus	CA	30.43	22.22	23.68	G	34.78	30.55	28.94
33.	Macrognathus pancalus	CA	30.43	22.22	23.68	В	21.73	22.22	21.05
34.	Monopterus cuchia	BE	8.69	13.88	13.15	В	21.73	22.22	21.05
35.	Nematalosa nasus	PL	-	33.33	34.21	Р	-	47.22	22.22
36.	Setipinna phasa	PL	-	33.33	34.21	Р	-	47.22	22.22
37.	Xenentodon cancila	PL	-	33.33	34.21	Р	-	47.22	22.22
38.	Notopterus notopterus	CA	-	-	23.68	Р	-	-	22.22

** PL- Planktivore, BE- Benthic Eater, OM- Omnivore, CA- Carnivore, P- Pelagic, G- Generalist, B- Benthic

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followed by carnivore (30.43%), planktivore (26.08%) and benthic feeder (8.69%). In mid-stream, the trophic level score is found to be oriented in the following manner i.e., PL (33.33%) > OM (30.55%) > CA (22.22) > BE (8.69%). Study of average trophic level score confirms that it is higher in the up-sream than mid and lower stream of the river (Table 2). According to Rapport (1995), this situation states that up-stream is much more affected by pollution than the other parts. According to Wichert and Rapport (1998), trophic level study is an important way to evaluate the level of degradation of any ecosystem. They confirmed that omnivore fishes are abundant in disturbed ecosystem as the fishes can consume a wide variety of food sources in changing environment. On the contrary, other trophic levels, in order of sensitivity to degradation, beginning with the least sensitive planktivores followed by pelagic insectivores, benthic insectivores (e.g., benthic feeders) general insectivores or piscivores and finally carnivores at the topmost part of the trophic structure (Karr and Dudley, 1981).

Habitat orientation score has also been measured for each part of the river. But according to Das and Chakrabarty (2007), the habitat orientation score can be used as a useful indicator of ecosystem stress as Wichert and Rapport (1998) also established a similar finding in case of lotic system. The study reveals that most of the fishes in all the three parts of the river are pelagic in nature. Second position is occupied by the generalists or column feeder fishes. Benthic dwellers are least in number in all the three parts. Moderately high diversity of fish species in the downstream of the river represents a variety of appropriate habitat and food types to sustenance many different species, which reflects the similar finding with a report by Washington (1984).

 Table 3: Seasonal variation of the values of different Biodiversity indices

Parameters		Up- stream		Mid-stream			Down-stream		
	prM	М	РоМ	PrM	Μ	PoM	Prm	Μ	РоМ
species diversity	0.59	0.77	0.63	0.72	0.87	0.72	0.94	0.92	0.89
shannaon-weiner index	2.62	2.97	2.67	2.97	3.33	2.98	0.28	3.49	3.18
simpsons index	0.077	0.056	0.067	0.056	0.041	0.053	0.041	0.034	0.045

The study has revealed that most of the fish species (33 species) can be included in "Least concern" category according to IUCN Red list. Only one species, *Cyprinus carpio*, has been found to be categoried as "Vulnerable" in India though it is an exotic species (IUCN, 2007, 2008, 2009).

The Shannon Weiner and Simpson indices are the two most widely used species diversity indices for examining overall community characteristics. Both are derived from a function used in the field of information (mainly insurance companies) and have been adapted by ecologists to describe the average degree of uncertainty of predicting the species of an individual picked at random from the community.

Here, values of Shannon Weiner index (Pre Monsoon, Monsoon and Post Monsoon) are higher in the lower stretch depicting the moderately good ecological condition than upper stretch of the river. Simpson Index values show higher diversity in lower stretch than the up and mid-stream.

Thus, it can be concluded from the above discussion that ecological condition of the upper stream of the river is much more disturbed than the middle and lower stretch. No endemic species has been reported in the fish list. Only extensive pollution control strategies and introduction of fresh fish seed can only change the present scenario.

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References

- Abdel-Baki, A.S., Dkhil, M.A., Al-Quraishy, S., Bioaccumulation of some heavy metals in Tilapia fish relevant to their concentration in water and sediment of Wadi Hanifah, Saudi Arabia. Afr. J. Biotechnol. 2011;10:2541–2547.
- Bhakta J.N., Bandyopadhyay P.K., Exotic Fish Biodiversity in Churni River of West Bengal, IndiaeJBio, 2007;3(1):13-17.
- Das S.K, Chakrabarty, D. The use of fish community structure as a measure of ecological degradation: A case study in two tropical rivers of India, Sciencedirect BioSystems, 2007;90:188–196.

- Gauch, H.G., Multivariate Analysis in Community Ecology. Cambridge University Press, Cambridge, UK. 1982.
- Ghosh, A. Fishes of Hooghly Estuary. Bulletin Number.155, Central Inland Fisheries Research Institute, India. 2008;48. Report Code: 026_GBP_IIT_ ENB_DAT_04_Ver_Jun 2012.
- 6. IUCN, International Union for conservation of Nature and Natural Resources). IUCN Red list of threatened species. 2007. www.iucnredlist.org.
- 7. IUCN, IUCN Red list of threatened species, 2009. Version 2009.1, www.iucnredlist.org.
- 8. Kar, D. A., Kumar, C., Bohra and Singh L.K. (Eds.). Fishes of Barak drainage, Mizoram and Tripura, In: Environment, pollution and management, APH publishimg corporation, New Delhi, 2003;604: 203-211.
- Karr, J.R., Fausch, D., Angermeier, P.L., Yant, P.R., Schlosser, I.J., Assessing Biological Integrity in RunningWaters: AMethod and its Rationale. Illinois Natural History Survey Special Publication 5. Urbana, IL. 1986.
- Kumar, A. and Mathur, R.P. Bioaccumulation kinetics and organ distribution of lead in a fresh water teleost, Colisafasciatus. Environ.Technol. 1991;12:731-735.
- Mittermeier, R.A. and Mitemeier, C.G., Megadiversity Earth's Biological Wealthiest Nation. In McAllister, D. E.A Lttamilition and B. Harvey (Eds). Global Fresh Water Biodiversity. Sea wind Cemex, Mexico City. 1997.p.1-140.
- 12. OPEA, Biological Criteria for the Protection of

Aquatic Life, vol. III. Ecological Assessment Section, Division Water Quality, Planning and Assessment, State of Ohio Environmental Assessment Agency. 1987.

- Panigrahi A K, Bakshi A. A study on profile of fishing community of the river side villages of river Churni, Nadia, West Bengal with special reference to socioeconomic and technological appraisal of fishermen, IMPACT: IJRANSS, ISSN(E): 2321-8851; ISSN(P): 2347-4580, 2014;2(3):97-102.
- Panigrahi, A. K, Bakshi, A, Dutta (Roy), S., Dasgupta, S., Mondal, A., Inter-relationship between physicochemical parameters of river Churni, Nadia, West Bengal, India. Indian Journal of Biology, 2015 January-June;2(2):47-50. ISSN- 2394-1391.
- Rapport, D.J., Ecosystem health: an emerging integrative science. In: Rapport, D.J., Gaudet, C.L., Callow, P. (Eds.), Evaluating and Monitoring the Health of Large-scale Ecosystems. NATO ASI Series
 Global Environmental Change, 1995;28:5-31. Springer-Verlag, Berlin.
- Talwar, P. K. and Jhingran, A. Inland fishes of India and adjacent countries. Oxford and IBH publishing Co Pvt Ltd. New Delhi, Bombay and Calcutta, 1:xxi+1-542 and 1991;2:543-1097.
- 17. Wichert, G.A. and Rapport, D.J. Fish community structure aa measure of degradation and rehabilitation of riparian systems in an agricultural drainage basin. Springer-Verlag New York Inc.-Environ. Manage. 1998;22(3):425-443.
- 18. Washington, H.G. Diversity, biotic and similarity indices: a review with special relevance to aquatic ecosystem. Water Res. 1984;18:653–694.

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Avian Diversity and Conservation Status of Ambazari Lake and Forest area, Nagpur (M.S), India

A.A. Meshram^{*}, S. Mukhmale^{**}, S.I. Nagpure^{***}, T.A. Dhoble^{***}, A.K.R. Zade^{***}, P. Uikey^{***}

Abstract

Ambazari Lake is a major freshwater wetland in Nagpur city. This lake has high avifauna diversity which includes Aquatic (26.70%), Waders (8.7%) and Terrestrial species (64.6%). Area consists of 161 species of birds belonging to 16 Orders, 51 Families. Out of 161 species, 105 species were Resident, 40 species were Resident Migrant and 16 Migrant. Passeriformes is the dominant order which consist of 69 species, followed by Ciconiiformes, Charaniiformes, Anseriformes. Conservation of Wetland by converting it into a Biodiversity Park has been undertaken by State Government of Maharashtra, India.

Keywords: Avifauna; Migrant; Resident; Resident Migrant; Conservation; Ambazari Lake.

Introduction

Biodiversity at present is better understood for birds in many respects than any other major group of organisms because they probably inspire more extreme interest in humans, are often spectacular, relatively easily observed and not too cryptic to identify. Avifauna is one of the most important ecological indicators to evaluate the quality of habitats. Most of the birds are useful to mankind. Birds play a useful role in the control of insect of pests of agricultural crops, as predators of rodents, as scavengers, as seed dispensers and as pollinating agents. Therefore birds are reared not only for preserving ecological balance but also for products of economic importance such as downs feather [7].

Nagpur is a major city in Central India of Maharashtra state. It lies on Deccan Plateau and have attitude of 310.5 meters above the sea level. Ambazari Lake is one of the major freshwater wetland and largest lake in Nagpur city. From geographic point of view, Ambazari lake is situated between 21°12 N' and 79° 04 E'. It has a subtropical monsoon climate condition with temperature range 06°C-47°C and receives an annual rainfall of 1205 mm. It is spread over an area of 15.5 km² and has dry deciduous vegetation [6]. Author's Affiliation: *Assistant Professor ***Research Scholar, Deptt. of Zoology, Dr. Ambedkar College, Deekshabhoomi, Nagpur, Maharashtra 440010, India. **Research Scholar, Dept. of Physics, Savitribai Fule Pune University, Pune, Maharashtra 411007, India.

Reprint's Request: Meshram Archana A., Assistant Professor, Dept. of Zoology, Dr. Ambedkar College, Deekshabhoomi, Nagpur, Maharashtra 440010, India. E-mail:drarchanameshram4517@gmail.com

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Ambazari Lake has adiversity rich ecosystem and harbors a variety of local as well as migratory birds due to abundant food available throughout the year in the form of crustacean, insects, worms, molluscan, fishes as well as aquatic weeds [9].

The earlier studies on birds in Nagpur city and around Nagpur district were under taken by investigators like Kedar (2012) who studied winter birds from Ambazari lake, Nagpur, Wanjari (2012) studied birds of Nagpur city, Chilke (2012), listed birds form Bamanwada lake of Chandrapur district, Harvey (2014) who listed of Dudhala lake and Ghotnimbala lake of Bhadrawati city of Chandrapur district, Wadatkar (2001) studied birds from Amravati University campus. This work was undertaken for the documentation of avifaunal diversity and steps for conservation of Ambazari Lake. A.A. Meshram et. al. / Avian Diversity and Conservation Status of Ambazari Lake and Forest area, Nagpur (M.S), India

Methods and Materials

The study was conducted from September 2015 to June 2016. The observation was carried out by using a binocular (Olympus 8×40) during morning 6 to 10 AM. For making the list of the birds, photographs were taken by Canon 1200D (55mm-250mm lens) which was important to identify birds accurately to the generic and species level [1,3].

Results and Discussion

During the present investigation, a total of 161 birds' species belonging to 16 orders and 54 families were recorded from the Ambazari Lake. The number of recorded different species of birds belong to different orders which are as follows, 69 species belong to Passeriforms, 14 species belong to Ciconiiforms, 13 species belong to Charaniiformes,11 species from Anseriformes, 10 species belong to

Table 1: Abundance of Birds in Lake

Coraciiformes, 8 species from Falconiformes, 7 species belong to Columbiformes, 5 species from Piciformes and Gruifromes each, 4 species belong to Cuculiformes and Galliformes, 3 species belong to Pelecaniformes, Psittaciformes, Strigiiformes each and 1 species belong to Podicipediformes and Apodiformes each (Table 3). Out of 161 birds, 105 were Resident, 40 were Resident Migrant, and 16 were Migrant (Table 1). The resident birds were observed in most of the months of the investigation period (Nov. to Jan.) but the migratory birds were observed mostly in winter's seasons. The occurrence of migratory birds in the area indicates that the critical habitat is important for the organism (Figure 1).

All the species of birds have different habitat as they may be Aquatic, Waders or Terrestrial. Around 43 species of birds are Aquatic which contribute about 26.7% of total birds, 14 species are Waders which contribute about 8.7% of total birds at Ambazari lake and the remaining 104 species of birds are Terrestrial which contribute largest percentage of birds at Ambazari is of 64.6% (Table 2).



(Source: Google Map)

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Fig. 1: Comparison of relative abundance of bird species along the study area (with reference to Table 1).

Table 2: Birds of Ambazari Lake according to Habitat

S. No.	Habitat	No. of Species	% of composition
1.	Aquatic	43	26.7%
2.	Waders	14	8.7%
3.	Terrestrial	104	64.6%

Table 3: Avifaunal Diversity of Ambazari Lake

Orders	Family	Common Name	Scientific Name	Habit
Podicipediformes	Podicipitidae	Little Grebe	Tachybaptus ruficollis	R
Pelecaniformes	Phalacrocoracidae	Great Cormorant	Phalacrocorax carbo	RM
Pelecaniformes	Phalacrocoracidae	Indian Shag	Phalacrocorax fuscicollis	RM
Pelecaniformes	Phalacrocoracidae	Little Cormorant	Phalacrocorax niger	RM
Ciconiiformes	Aedeidae	Large Egret	Casmerodium albus	RM
Ciconiiformes	Ardeidae	Purple Heron	Ardea purpurea	RM
Ciconiiformes	Ardeidae	Grey Heron	Ardea cinerea	RM
Ciconiiformes	Ardeidae	Black-crowned Night-Heron	Nycticorax nicticorax	R
Ciconiiformes	Ardeidae	Indian Pond-Heron	Ardeola grayii	R
Ciconiiformes	Ardeidae	Cattle Egret	Bubulcus ibis	RM
Ciconiiformes	Ardeidae	Median Egret	Mesophoyx intermedia	RM
Ciconiiformes	Ardeidae	Little Egret	Egretta garzetta	R
Ciconiiformes	Ardeidae	Chestnut Bittern	Ixobrychus sinensis	RM
Ciconiiformes	Ciconiidae	Painted Stork	Mycteria leucocephala	RM
Ciconiiformes	Ciconiidae	Asian Openbill-Stork	Anastomus ositans	R
Ciconiiformes	Ciconiidae	White-necked Stork	Ciconia episcopus	R
Ciconiiformes	Threskiornithidae	Black Ibis	Pseudibis papillosa	R
Ciconiiformes	Threskiornithidae	Oriental White Ibis	Threskoinis melanocephalus	R
Anseriformes	Anatidae	Brahminy Shelduck	Tadornaferruginea	RM
Anseriformes	Anatidae	Lesser Whistling-Duck	Dendrocygna javanica	R
Anseriformes	Anatidae	Northern Pintail	Anas acuta	М
Anseriformes	Anatidae	Common Teal	Anas crecca	М
Anseriformes	Anatidae	Spot-billed Duck	Anas poecilorhyncha	RM
Anseriformes	Anatidae	Gadwall	Anas strepera	М
Anseriformes	Anatidae	Eurasian Wigeon	Anas Penelope	М
Anseriformes	Anatidae	Northern Shoverller	Anas clypeata	М
Anseriformes	Anatidae	Garganey	Anas querquedula	М
Anseriformes	Anatidae	Red-crested Pochard	Rhodonessa rufina	М
Anseriformes	Anatidae	Common Pochard	Aythya ferina	М
Falconiformes	Accipitridae	Black-shouldered Kite	Elanus caeruleus	R
Falconiformes	Accipitridae	Oriental Honey-Buzzard	Pernis ptilorhyncus	RM
Falconiformes	Accipitridae	Black Kite	Milvus migrans	R
Falconiformes	Accipitridae	Shikra	Accipiter badius	R
Falconiformes	Accipitridae	White-eyed Buzzard	Butastus teesa	R
Falconiformes	Accipitridae	Crested Serpent-Eagle	Spilornis cheela	R
Falconiformes	Accipitridae	Osprey	Pandion haliaetus	RM
Falconiformes	Falconidae	Common Kestrel	Falco tinnunculus	RM
Galliformes	Phasianidae	Common Quail	Coturnix coturnix	RM

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Galliformes Galliformes Galliformes Gruiformes Gruiformes Gruiformes Gruiformes Gruiformes Charadriiformes Columbiformes Columbiformes Columbiformes Columbiformes Columbiformes Columbiformes Columbiformes Psittaciformes Psittaciformes Psittaciformes Cuculiformes Cuculiformes Cuculiformes Cuculiformes Strigiformes Strigiformes Strigiformes Apodiformes Coraciiformes Piciformes Piciformes Piciformes Piciformes Piciformes Passeriformes Passeriformes Passeriformes Passeriformes

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Phasianidae Phasianidae Phasianidae Rallidae Rallidae Rallidae Rallidae Rallidae Jacanidae Jacanidae Recurvirostridae Burhinidae Charadridae Charadridae Charadridae Scolopacidae Scolopacidae Scolopacidae Charadridae Laridae Laridae Columbidae Columbidae Columbidae Columbidae Columbidae Columbidae Columbidae Psittacidae Psittacidae Psittacidae Cuculidae Cuculidae Cuculidae Cuculidae Tytonidae Striginae Striginae Apodidae Alcedinidae Alcedinidae Alcedinidae Alcedinidae Meropidae Meropidae Meropidae Coraciidae Upupidae Bucerotidae Capitonnidae Picidae Picidae Picidae Picidae Aludidae Aludidae Hirundinidae Hirundinidae Hirundinidae Hirundinidae Daniidae Daniidae Daniidae Oriolidae

Jungle Bush-Quail Grey Francolin Indian Peafowl Brown Crake White-breasted Waterhen Common Moorhen Purple Moorhen Common Coot Bronze-winged Jacana Pheasant-tailed Jacana Black-winged Stilt Stone-Curlew **River Lapwing** Red-wattled lapwing Yellow-wattled Lapwing Common Snipe Wood Sandpiper Common Sandpiper Little Ringed Plover Common Tern River Tern Yellow-legged Green-Pigeon Blue Rock Pigeon Eurasian Collared-Dove Oriental Turtle-Dove Red Collared-Dove Spotted Dove Little Brown Dove Rose-ringed Parakeet Alexandrine Parakeet Plum-headed Parakeet Common Cuckoo Pied Crested Cuckoo Asian Koel Greater Coucal Barn Owl Collared Scops-Owl Spotted Owlet House Swift Lesser Pied Kingfisher Small Blue Kingfisher Stork-billed Kingfisher White-brested Kingfisher Chestnut-headed Bee-eater Green Bee-eater Blue-tailed Bee-eater Indian Roller Common Hoopoe Indian Grey Hornbill Coppersmith Barbet Eurasian Wryneck Yellow-fronted Pied Woodpecker Black-shouldered Woodpecker Lesser Golden-backed Woodpecker Singing Bush-lark Rufous-tailed Finch-Lark Dusky Crag-Martin Common Swallow Streak-Throated Swallow Wire-tailed Sallow Bay-backed Shrike Rufous-backed Shrike Brown Shrike Eurasian Golden Oriole

Perdicula asiatica	R
Francolinus pondicerianus	R
Pavo cristatus	R
Amaurornis akool	R
Amaurornis phoenicurus	R
Gallinula chloropus	RM
Porphyrio porphyria	R
Fulica atra	RM
Metropidius indicus	R
Hydrophasianus chirurgus	R
Himantopus himatopus	R
Burhinus oedicnemus	R
Vanellus duvaucelli	R
Vanellus indicus	R
vanellus malabaricus	K
Gallinago stenura	RM
I ringa glareola	M
Charadrius dubius	KM DM
Churaurius aubius	
Sterna aurantia	
Traron phonicontara	R
Columba lizia	R
Strentonelia decaocto	R
Streptopelia arientalis	RM
	IXIVI
Streptopelia tranquebarica	R
Streptopelia chinensis	R
Streptopelia senegalensis	R
Psittacula krameri	R
Psittacula eupatria	R
Psittacula cyanocephala	K
Cuculus canorus	KM DM
Eudumanus scolonacea	
Contronus sinonsis	R
Tuto alha	R
Otus bakkamoena	R
A thene brama	R
Anus affinis	RM
Cerule rudis	R
Alcedo meninting	R
Halcyon capensis	R
Halcvon pileata	R
Merops leschenaultia	R
Merops orientalis	R
Merops philippinus	RM
Coracias garrulus	R
Upupa epops	RM
Ocyceros birostris	R
Megalaima haemacephala	R
Jynx torquilla	Μ
Dendrocopos mahrattensis	R
Chrusocolantes festivus	R
Dinonium henohalense	R
Dinoprum vengnuiense	R
Mirafra cantillans	R
Ammomanes phoenicurus	R
HIrundo concolor	R
Hirundo rustica	RM
Hirundo fluvicola	R
Hirundo smithii	R
Lanius vittatus	R
Lanius schach	R
Lanius cristatus	М
Oriolus chinensis	RM

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Passeriformes Passeriformes

Oriolidae Dicruridae Dicruridae Sturnidae Sturnidae Sturnidae Sturnidae Sturnidae Corvidae Corvidae Corvidae Campephagidae Campephagidae Irenidae Pycnonotidae Pycnonotidae Timaliinae Timaliinae Timaliinae Muscicapinae Muscicapinae Muscicapinae Muscicapinae Muscicapinae Muscicapinae Muscicapinae Muscicapinae Cisticolidae Cisticolidae Cisticolidae Sylviinae Sylviinae Svlviinae Sylviinae Sylviinae Turdinae Turdinae Turdinae Turdinae Turdinae Turdinae Motacillidae Motacillidae Motacillidae Motacillidae Motacillidae Motacillidae Motacillidae Nectariniidae Nectariniidae Zosteropidae Passerinae Passerinae Ploceidae Estrildidae Estrildidae Estrildidae Emberizidae Emberizidae

Black-headed Oriole Black Drongo White-bellied Drongo Rosy Starling Brahminy Starling Common Myna Grev-headed Starling Asian Pied Starling Indian Treepie House Crow Jungle Crow Common Woodshrike Small Minivet Commom Iora Red-vented Bulbul White-browed Bulbul Yellow-eyed Babbler Large Grey Babbler Jungle Babbler Asian Brown Flycatcher Red-throated Flycatcher Blue-throated Flycatcher Tickell's Blue-Flycatcher Asian Paradise-Flycatcher Verditer Flycatcher Black-naped Monarch-Flycatcher White-throated Fantail-Flycatcher Plain Prinia Ashy Prinia Common Tailorbird Indian Great Reed-Warbler Sulphur-bellied Warbler Greenish Leaf -Warbler Common Lesser Whitethroat Booted warbler Oriental Magpie-Robin Black Redstart Indian Chat Pied Bushchat Indian Robin White-throated Thrush Blyth's Pipit Tawny Pipit Oriental Tree Pipit Yellow Wagtail Grey Wagtail White Wagtail Large Pied Wagtail Purple-rumped Sunbird Purple Sunbird Oriental White Eye Yellow-throated Sparrow House Sparrow Baya Weaver Red Munia Spotted Munia White-throated Munia Red-headed Bunting Black-headed Bunting

Oriolus ranthornus	R
Diaminus magnoconous	D
Dicturus mucrocercus	N D
Dicrurus caerulescens	K
Sturnus roseus	M
Sturnus pagodarum	R
Acridotheres tritis	R
Sturnus malabaricus	R
Sturnus contra	R
Dendrocitta vagabunda	R
Corvus splendens	R
Corvus macrorhynchos	R
Tenhrodornis pondicerianus	R
Pericrocotus cinnamomeus	R
Acoithing tiphig	D
Regimina upnia	K
Pycnonotus cujer	R
Pycnonotus luteotus	R
Chrysomma sinense	R
Turdoides malcolmi	R
Turdoides striatus	R
Muscicapa dauurica	RM
Ficedula parva	М
Cyornis rubeculoides	R
Cuornis tickelliae	R
Ternsinhone paradisi	RM
	D
Eumyias aibicauaata	R
Hypothymis azurea	R
	1.1
Rhipidura aureola	R
Prinia inornata	R
Prinia socialis	R
Orthotomus sutorius	R
Acrocephalus stentoreus	R
Phylloscopus griseolus	R
Phylloscopus trochiloides	М
Sylvia curruca	М
Hippolais caligata	RM
Consuchus saularis	R
Phoenicurus ochruros	RM
Cercomela furca	R
Savicola canzata	P
Saricoloides fulicata	R
Zoothorg citring cugnotus	R D
	K DM
Anthus goulewskii	KM
Anthus campestris	K
Anthus hodgsoni	KM
Notacilla flava	RM
Motacilla cinerea	М
Motacilla alba	RM
Motacilla maderaspatensis	R
Nectarinia zeylonica	R
Nectarinia asiatica	R
Zosterops palpebrosus	R
Petronia xanthocollis	R
Passer domesticus	R
Ploceus philippinus	R
Amandava formosa	R
Lonchura punctulata	R
Lonchura malabarica	R
Emberiza bruniceps	RM
Г	DM

Note: R = Resident, RM = Resident Migrant, M = Migrant.

The overall checklist prepared shows that 161 different kinds of birds use Ambazari Lake and forest area for feeding and breeding activities.

Conclusion

Birds occupy almost all habitat types and diversity of birds often serves as a good indicator of overall diversity of the area. It makes us understand how birds are important for ecosystem. The diversity and abundance of 161 species show that all the birds are fairly distributed throughout the area.

The birds present in and around the Ambazari Lake are affected by many factors such as organic and inorganic pollution of water and land, disturbance by human activities and lack of maintenance of the lake, yet the avifauna of Ambazari Lake is diverse keeping in view the varied avifauna recorded. The project of conservation of the wetland into a Biodiversity Park has been undertaken by the State Government of Maharashtra, India; for the further protection of wetland biodiversity more plantation of trees were carried out at Ambazari by State Government to increase the forest cover.

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References

- 1. Ali S, Ripley SD. A pectoral guide to the Birds of Indian subcontinent. Mumbai: Bombay Natural Society Oxford University Press; 1987.
- Chilke A. Avian Diversity in and around Bamanwada Lake of Rajura, District - Chandrapur (Maharashtra). Annals of Biological Research 2012;3(4):2014–2018.
- Grimmet R, Inskip T, Islam MZ. Birds of Northern India. London: Christopher Helm A and C Bleak Publishers Ltd.; 2004.
- Harney NV. Status and Diversity of Avifauna in Dudhala Lake, Bhadrawati, Distt. Chandrapur (MS), India. Asian Journal of Multidisciplinary Studies 2014;2(3):130-135.
- Harney NV. Avifaunal diversity of Ghotnimbala Lake near Bhadrawati, Chandrapur, Maharashtra, India. Int. J. of Life Sciences 2014;2(1):79-83.
- Kedar GT. Ambazari Lake A Potential Stopover Point of Winter Migrant in Central Indian. Indian Streams Research Journal 2012;2(6).
- Simeone, A, Araya MB, Bernal M, Diebold EN, Grzybowski K, Michaels M, Teare JA, Wallace RS and Willis MJ. Oceanographic and climatic factors influencing breeding and colony attendance patterns of Humboldt Penguins *Spheniscus humboldti* in central Chile. Marine Ecology Progress Series 2002;227:43–50.
- 8. Wadatkar JS. Checklist of Birds from Amravati University Campus, Maharashtra. Zoos' Print Journal 2001;16(5):497-499.
- 9. Wanjari PD. Avifaunal Diversity of Nagpur City, M.S., India. Bionano Frontier 2012;5(2-I):124-126.

Impact of T₃ on Calcium and Phosphorus Metabolism in Tissues of Bufo Melanostictus

Gitanjali Mishra*, Subhasmita Pattnaik**, Kukumeena Mohanty***

Abstract

The two most important macrominerals calcium and phosphorus are required for bone growth and body function of animals. The present study is designed to investigate the role of thyroid hormone i.e. triiodothyronine (T_3) in regulating the levels of calcium and phosphorus in blood, muscle and bone of **Indian toad**, *Bufo melanostictus*. The response of poikilotherms to the thyroid hormones is dose dependent. The calcium and phosphorus content of three extracts of blood, muscle, bone tissues were estimated independently by the method of Kramer and Tisdall (1921) as modified by Clark and Collip (1925) and the method of Fiske and Subbarow (1925) respectively. There is an enhancement of calcium and phosphorus concentrations in blood, muscle and bone tissue at both the dose levels except for bone at higher dose T_3 treated animals show an increased level of calcium and phosphorus levels at higher dose is much more as compared to that of lower dose level in blood and muscle tissue. In contrast to young and immature animals, the adults and old animals may show certain differential response because of the interplay of other hormones such as gonadal and corticosteroids & growth hormone which appears in adult stage.

Keywords: Triiodothyronine(T₃); Calcium; Phosphorus; *Bufo Melanostictus*.

Introduction

Thyroid hormone $(T_4 \& T_3)$ arguably the most important hormone in anuran development and affects through exogenous and endogenous means. It also plays an important role in calcium and phosphorous homeostasis by their action on turnover of bone. The thyroid hormone stimulates the ossification of cartilage, linear growth of bone, maturation of epiphyseal bone centres and closure of epiphyses (Reddy et al., 2012). Thyroid hormone plays a vital role in the metabolic processes of animals.

 T_3 does not act directly on bone cell and cartilage but potentiate the effect of growth hormone or other growth factors on bone growth. Therefore, T_3 does not act directly on bone growth process but helps in bone maturation. Thyroid hormone T_3 is required for skeletal development during childhood. It regulates bone turnover and mineralisation in adult. Thyroid hormone (T_3) is essential for normal development of endochondral and intra-membranous bone and plays Author's Affiliation: *Professor and Head **Research Scholar, P.G. Department of Zoology, Berhampur University, Bhanja Bihar, Berhampur, Odisha 760007, India. ***Lecturer, G.C. College, Department of Zoology, Bari, Ramachandrapur, Jajpur, Odisha 755003, India.

Reprint's Request: Gitanjali Mishra, Professor and Head, P.G. Department of Zoology, Berhampur University, Bhanja Bihar, Berhampur, Odisha 760007, India.

E-mail: gmishra.bu@gmail.com

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an important role in the linear growth and maintenance of the bone mass. In childhood, retardation of skeletal development and growth are arrested by deficiency of T3 whereas excess T3 accelerates the growth and bone formation. In thyrotoxicosis, there is increase in bone remodelling with imbalance between bone resorption and formation (Bassett and Williams, 2003). T₃ exerts anabolic action during growth to stimulate peak bone mass accrual but has catabolic effects on the adult skeleton that increases the bone turnover. Recent studies suggest that TSH may have direct action in bone cells (Williams, 2009).

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The two elements like calcium and phosphorus are most important macrominerals required for bone growth and body function of animals. Bone tissue serves as reservoir of calcium to maintain the constant concentration in blood, muscle and intracellular fluids. The balance between bone resorption and formation changes with age. The mineral content of bone increases throughout childhood (Lu et al., 1994), peak in adolescence(Bailey, 2000) and remain relatively constant in early or late adulthood (Teegarden et al., 1995) and declined in old age. Calcium ion functions as a signal for many cellular processes like hormonal control of cell function and influences a wide variety of metabolic processes (Martin et al., 1975) play an important role in muscle contraction, working of heart, metabolism, blood clotting, enzyme activity, neuromuscular function, cell adhesion and intracellular signalling (Veum, 2010). Phosphorus plays a major role in multiple biological processes (Berndt et al., 2005) like energy metabolism, cell signalling, acid-base regulation, buffering, regulation of protein synthesis, skeletal development and bone mineralization or bone integrity (Alizaden-Naderi & Reilly, 2010).

Materials and Methods

The common Indian toad, *Bufo melanostictus* of mixed sexes were collected from wild nature during evening time and were transferred to the laboratory within 12 hours. They were maintained in lab condition in wire netted wooden cages ($75 \times 40 \times 35$ cm in size) containing a moist sand bed for about 5 days. They were forced feed with about 1 gm of goat liver (Composition mg/gm wetweight: 110 +41 protein, 84 + 16 lipid, 2.3 +1.1 glycogen) each on every day and water was provided adlibitum.

Treatment

After laboratory acclimation, animals were divided into control and experimental groups. The experimental groups of toad were injected intramuscularly with thyroxine (T_3) Na-salts (flukeAG) at a dose of 0.5 µg / gm (Treated – I) and 2.0 µg /gm (Treated – II) in separate batches, dissolved in 0.65 % of NaCl solution pH = 8.3. The control animals received an equal volume of 0.65 % of NaCl solution pH = 8.3. This injection schedule was continued daily for 7 days so that each animal receives 7 doses. On the eighth day of treatment, the animals were sacrificed for estimation of biochemical parameter after taking their final body weight.

Collection of Tissues Extract

At the end of the treatment, the animals were sacrificed by pithing on the head; blood, muscles & bone were quickly dissected out. Blood was collected from heart of the animal with the help of a hypodermic syringe containing 2ml of 2% sodium citrate solution. The muscles from hind limb were transferred to cold Amphibian Ringer solution and adherent connective tissues, blood vessels, nerve fibres were removed. Then blotted off with whatman filter paper No. 1. Long bones (Humerus) were taken out and cleaned off adherent materials in distilled water. All these 3 tissue extracts were collected by centrifuging at 2000 rpm for 10 minutes; those were used for estimation of biochemical parameters.

Estimation of Calcium

The calcium contents of 3 extracts of Bone, Muscle & Blood were estimated independently by the method of Kramer and Tisdall (1921) as modified by Clark and Collip (1925).

Estimation of Phosphorus

The phosphorus contents of 3 extracts of Bone, Muscles & Blood were estimated by the method of Fiske and Subbarow (1925).

These data were statistically analysed by correlation (correlation coefficient "r").

Results

From our findings it is clear that thyroid hormone action (T_s) is tissue specific.

In long term (7 days) T_3 treatment to these animals caused enhancement of calcium and phosphate concentrations in blood, muscle and bone tissue at both the dose levels except for in bone at higher dose treatment. There is an increased level of calcium and decreased level of phosphorus of bone. The increase in calcium and phosphorus levels at higher dose is much more as compared to that of lower dose level in blood and muscle tissue.

Seven days lower dose $(0.5\mu g/gm)$: The calcium content of blood decreased upto 1 Yr then remained constant in contrast to controls where the calcium content decreased significantly, whereas the calcium content in muscle and bone show biphasic (decreased up to 1 yr, then increased after 1 yr up to 2 yrs, and declined thereafter with the age) and triphasic (decreased up to 1 yr then remained constant after 1 yr up to 3 yrs and further declined with the age) characteristics respectively as compared to control animals (Fig. 1.1, Fig. 1.2, Fig. 1.3).

The Phosphorous content of blood decreased with increasing body weight upto 2 yrs, then remained constant upto 3 yrs and finally declined thereafter. In both muscle and bone tissue the phosphorus content decreased up to 1 yr with increasing body weight. Then increased gradually up to 2+ yrs and subsequently declined with the ageas compared to control animals (Fig. 2.1, Fig. 2.2, Fig. 2.3).

Seven days higher dose $(2\mu g/gm)$: The calcium of blood tissue of treated animals decreased significantly compared to control animals. T₃ treated (P<0.001) animals it exhibited triphasic characteristic. It decreased up to 1 yr, then increased after 1 yr up to 2 yrs with increase in the body weight. Finally it declined after 2 yrs with the age in both muscle and bone (Fig. 1.4, Fig. 1.5, Fig. 1.6).



Fig. 1.1: Correlation of calcium content in blood of control (r = 0.81582; P < 0.001) and T3 (r = 0.80180; P < 0.001) treated toads, *Bufo melanostictus* through different ages. Values are mg/dl of blood. Dose - low dose (0.5μ g/g). Duration - 7 days (multiple treatments).



Fig. 1.2: Correlation of calcium content in muscle of control (r = 0.264938; P, NS) and T3 (r = 0.668155; P < 0.01) treated **toads**, *Bufo melanostictus* through different ages. Values are mg/g tissue wet weight. Dose - low dose (0.5 µg/g). Duration – 7 days (multiple treatments).

The phosphorus content of all the 3 tissues (blood, muscle and bone) exhibited a triphasic characteristic. It primarily decreased up to 1 yr, then increased after 1 yr up to 2+yrs and terminal decrease beyond that with increase in the body weight as compared to control animals. However, enhancement of calcium and phosphate concentrations in blood, muscle and bone tissue at both the dose levels except for in bone at higher dose treatment Fig. 2.4, Fig. 2.5, Fig. 2.6).



Fig. 1.3: Correlation of calcium content in bone of control (r=0.562309; P< 0.02) and T3 (r = 0.798029; P< 0.001) treated toads, *Bufo melanostictus* through different ages. Values are mg / g tissue wet weight. Dose-low dose ($0.5 \mu g/g$). Duration-7 day (multiple treatments)



Fig. 2.1: Correlation of phosphorus content in blood of control (r = 0.50089; P<0.1) and T3 (r=0.537161932; P<0.05) treated toads, *Bufo melanostictus* through different ages. Values are μ g/dl of blood. Dose-low dose (0.5 μ g/g). Duration-7 days (multiple treatments)



Fig. 2.2: Correlation of phosphorus content in muscle of control (r = 0.27763; P, NS) and T3 (r=0.426358; P< 0.2) treated toads, *Bufo* melanostictus through different ages.Values are $\mu g/g$ tissue wet weight. Dose-low dose (0.5 $\mu g/g$). Duration –7days (multiple treatments)

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Fig. 2.3: Correlation of phosphorus content in bone of control (r = 0.020345; P, NS) and T3 (r = 0.426358; P < 0.2) treated toads, *Bufo melanostictus* through different ages. Values are $\mu g/g$ tissue wet weight. Dose - low dose (0.5 $\mu g/g$). Duration - 7 days (multiple treatments)



Fig. 1.4: Correlation of calcium content in blood of control (r = 0.81582; P < 0.001) and T3 (r = 0.944318; P < 0.001) treated toads, *Bufo melanostictus* through different ages. Values are mg/dl of blood. Dose - high dose (2 µg/g). Duration – 7 days (multiple treatments)



Fig. 1.5: Correlation of calcium content in muscle of control (r = 0.264938; P,NS) and T3 (r = 0.76482; P<0.001) treated toads, *Bufo melanostictus* through different ages. Values are mg/g tissue wet weight. Dose - high dose (2 µg/g). Duration-7 days (multiple treatments).



Fig. 1.6: Correlation of calcium content in bone of control (r= 0.562309; P<0.02) and T3 (r=0.634271; P<0.02) treated toads, *Bufo melanostictus* through different ages. Values are mg/g tissue wet weight. Dose-high dose (2 µg/g). Duration-7day (multiple treatments)



Fig. 2.4: Correlation of phosphorus content in blood of control (r =0.625448; P<0.1) and T3 (r=0.480398; P<0.1) treated toads, *Bufo melanostictus* through different ages. Values are μ g/dl of blood. Dose-high dose (2 μ g/g). Duration–7 days (multiple treatments)



Fig. 2.5: Correlation of phosphorus content in muscle of control (r = 0.27763; P, NS) and T3 (r = 0.675486; P < 0.01) treated toads, *Bufo melanostictus* through different ages. Values are $\mu g/g$ tissue wet weight. Dose - high dose (2 $\mu g/g$). Duration – 7 days (multiple treatments)

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Fig. 2.6: Correlation of phosphorus content in bone of control (r = 0.020345; P, NS) and T3 (r = 0.686576; P < 0.01) treated toads, *Bufo melanostictus* through different ages. Values are $\mu g/g$ tissue wet weight. Dose - high dose (2 $\mu g/g$). Duration – 7 days (multiple treatments)

Discussion

In 7 days T₂ treatment to these animals caused enhancement of calcium and phosphate concentrations in blood, muscle and bone tissue at both the dose levels except in bone at higher dose treatment. There is an increased level of calcium and decreased level of phosphorus of bone. The increase in calcium and phosphorus levels at higher dose is much more as compared to that of lower dose level in blood and muscle tissue. It clearly indicates that the thyroid hormone action is both catabolic and anabolic at lower and higher doses respectively. In bone it showed a reciprocal relationship in between calcium and phosphate levels. The increasing trend or the rate of increase at high dose is much high as compared to the lower dose in muscle and blood in subsequent age groups. These observations clearly point to increased retention of these metabolites in tissues of toads by the thyroid hormone making them sufficiently available for incorporation into bones and/or to be utilized by other tissues for different metabolic purposes. Such retentions of both calcium and phosphorus could possibly be mediated through an increase in the somatomedin production or sensitivity (Phillips and Vassilopoulou-Sellin, 1980a, b). Another possibility is that this hormone might be causing calcium and phosphorus retention by way of influencing the rates of their absorption in the digestive tract or the rates of their excretion by the kidney tubules.

Such an observation possibly points to speculation that the hormone influences their levels by regulating their rate of absorption in the digestive tract or rate of excretion at kidney tubules. Calcium and Phosphate homeostasis implies the balance between the calcium & phosphorus minerals among serum and bone while muscle is greatly responsible for utilization of both calcium and phosphorus. In 7 days T₃ treatment, calcium and phosphorus concentration in the blood, muscle and bone at both the dose level decreased showing biphasic and triphasic characteristics. It is clearly indicated that the catabolic effect of thyroid hormone in lower dose and anabolic effect in higher. In our investigation, an age related variations in the response to T_3 is found out. Moreover, in sharp contrast to young and immature animals, the adults and old animals may show certain differential response because of the interplay of other hormones such as gonadal and corticosteroids which appears in adult stage. The action of thyroid hormone is also dependent on the state of thyroidal activity, peripheral deiodination and the level of circulating thyroid stimulating hormone.

The dose of the hormone used, the route of administration, the duration of treatment, environmental temperature, photoperiod, nutritional status, age and seasonal activation appears to be the important factors involved in thyroid hormone action. Moreover, one should not ignore the fact that, a very significant role is played by the thyroid hormones during amphibian metamorphosis when these organisms transform the cartilaginous larval skeleton to calcified and bony skeleton of terrestrial young ones. Therefore, as far as the influence of thyroid hormones on the calcium and phosphorus metabolism is concerned, an extensive study is warranted taking metamorphosing tadpole larvae and the freshly migrated terrestrial young toads as the experimental models before drawing any significant conclusion.

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References

- Reddy, P. A., Harinarayan, C. V., Sachan, A., Suresh, V., Rajagopal, G. "Bone disease in thyrotoxicosis ." Indian J. Med. Res. 2012;135:277-286.
- Bassett, J. H. D., Williams, G. R. The molecular actions of thyroid hormones in bone. Trends Endocrinol. Metab. 2003;14:356-64.
- William, G. R. Action of thyroid hormone in bone. Endokrynol pol. 2009;60(5):380–8.

- Lu, P.W., Briody, J. N., Ogle, G. D., Morley, K., Humphries, I. R., Allen, J., Howman-Giles, R., Sillence, D., Cowell, C.T. Bone mineral density of total body, spine, and femoral neck in children and young adults: A cross-sectional and longitudinal study. J Bone Miner Res. 1994;9:1451–1458.
- Bailey, D. A., Martin, A. D., McKay, H. A., Whiting, S., Mirwald, R. Calcium accretion in girls and boys during puberty: A longitudinal analysis. J. Bone Miner. Res. 2010;15:2245–2250.
- Teegarden, D., Proulx, W. R., Martin, B. R., Zhao, J., McCabe, G. P., Lyle, R. M., Peacock, M., Slemenda, C., Johnston, C. C., Weaver, C. M. Peak bone mass in young women. J Bone Miner Res. 1995;10:711–715.
- Martin, B. R., Clausen. T. And Gliemann, J. Relationships between the Exchange of Calcium and Phosphate in Isolated Fat-Cells, Institute of Physiology, University of Aarhus, 8000 Aarhus C, Denmark, *Biochem. J.* 1975;152:121-129.
- 8. Veum, T. L. Phosphorus and calcium nutrition and metabolism. In: Phosphorus and Calcium Utilization and Requirements in Farm Animals. D. M. S. S. Vitti and E, Kebreab, ed. CAB International, Oxfordshire, UK. 2010.p.94–111.

- 9. Berndt, T.J., Schiavi, S. and Kumar, R. "Phosphatonins" and the regulation of phosphorus homeostasis. *Am. J. Physiol. Renal Physiol.* 2005;289: F1170-F1182. doi: 10.1152/ajprenal.00072.
- 10. Alizadeh, N.A.S. and Reilly, R.F. Hereditary disorders of renal phosphate wasting. Nat. Rev. *Nephrol.* 2010; 6:657–665.
- 11. Kramer and Tisdall. Quoted in Hawk's Physiological Chemistry (Oser, B.L.) 14th edn. (1971) Tata McGraw-Hill publishing Company. New Delhi, 1921.p.113.
- Clark, E. P. and Collip, J. B. Quoted in Hawk's Physiological Chemistry (Oser, B.L.) 14th edn. (1971). Tata McGraw-Hill publishing Company, New Delhi, *J. Biol. Chem.* 1925;63:461.
- 13. Fiske, C. H. and Subbarow, Y. The colorimetric determination of phosphorous. *J. Biol. Chem.* 1925; 66-375.
- 14. Phillips, L. S. and Vassilopoulou Sellin, R. Somatomedins, *N. Engl. J. Med.* 1980a;302:371.
- 15. Phillips, L. S. and Vassilopoulou Sellin, R. Somatomedins, *N. Engl. J. Med.* 1980b;302:438.

Effect of Imbibition on Germination of Vigna Radiata Seed

Jyoti Prasad Saikia*, Barsha Sarma**

Abstract

Vigna radiata (green gram) are staple food in India. The imbibition of the seed is never correlated with germination and vigour of the seeds. In the present experiment we imbibed the seed in 100 ml sterile distilled water for 0 to 24h. The imbibed seeds were allowed to germinate and data were recorded with respect to normal and abnormal germination, fungal infection, non-germinated seed and mean plant length after 7 day of sowing. The 8h period imbibition is found to be best with respect to vigour. The water imbibed after imbibition for a period of 8h was 0.912±0.018 g/g dry weight seed. The normal germination (%), abnormal germination (%), non-germinated (%) and plant length for the same were 61.001.15, 121.15, 23.671.76, 14.30.3 cm respectively.

Keywords: Vigna Radiata; Imbibition; Germination; Vigour; Seed.

Introduction

Seed imbibition is reported to be correlated with even DNA repair and telomere maintenance (Balestrazzi et al., 2015). Water imbibition is one of the first important stages for germination of a seed. Role of imbibition on Vigna radiata germination is reported by Qian et al. (2003). They reported that imbibition also determines the desiccation tolerance of the future plant (Qian et al., 2003). Imbibition is reported to be negatively correlated in hard V. radiata seeds (Promila et al., 2000). They also reported leakage of nutrients during early phase of V. radiata seed imbibition (Promila et al., 2000; Krishnappa et al., 2017). Seed showing fast imbibition are less vigorous compared to slow one (Abdullah et al., 1991). The imbibition period reported by Krishnappa et al. (2017) is 12 h. The time period (12h) is arbitrarily decided by the researcher. Similarly, Castellanos-Barriga et al. (2017) reported that on 6h imbibition V. radiata seed absorbs water equal to its dry weight. Therefore, they might follow the same time period of imbibition in their experiment. Truong et al. (2017) reported that anaerobic imbibition has prominent effect on γ -aminobutyric acid (GABA) accumulation on V. radiata seed. In their research seeds were imbibed inside water for 8h and corresponding GABA

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Author's Affiliation: *Assistant Professor, Department of Molecular Biology and Biotechnology, Tezpur University, P.O.-Napaam-784028, Assam, India. **BSc. Student, Department of Botany, Darrang College, P.O.-Tezpur-784001, Sonitpur, Assam, India.

Reprint's Request: Jyoti Prasad Saikia, Department of Molecular Biology and Biotechnology, Tezpur University, P.O.-Napaam-784028, Assam, India.

E-mail: jyotizone@gmail.com

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accumulation is 27 times of normal imbibitions period. After aerobic imbibitions up to 18h sugar present in the cotyledons are primary energy source for growth (Promila & Kumar, 2000). After 18h the energy source is cotyledon starch (Promila & Kumar, 2000). In the method followed by Promila & Kumar (2000), imbibition starts with sowing on tissue paper with 10ml water. The leached sugar in this type of aerobic imbibitions might accumulate in high concentration due to less volume of water (Krishnappa et al., 2017). These high sugar accumulations might stimulate abscisic acid production leading to delay and drop in germination (Rodríguez-Gacio et al., 2009; Xiong & Zhu, 2003). V. radiata seeds are reported for imbibing 0.222 to 0.078 g water per g seed dry weight on exposure to relative humidity of 30% and 80% respectively (Murthy et al., 2003). With increasing internal water content sugar accumulation increases

in *V. radiata* seeds during storage (Murthy et al., 2003). In the light of the above information it might be concluded that imbibing *V. radiata* seed in large volume of water might help in countering the role of abscisic acid based dormancy induction in embryo. On the other hand, imbibing on tissue paper might not be helpful for the same. Benvenuti & Macchia (1995) reported secondary dormancy due to anaerobic germination. Tian et al. (2016) reported high difference of desiccation tolerance among 6h and 18h imbibed *V. radiata* seeds. The difference of water imbibed on 6h and 18h imbibitions is not significant. Therefore, it might be suggested that prolong anaerobic imbibitions is not suitable for optimum germination of *V. radiata* seed.

In the light of above information to answer the optimum water imbibitions time period for *V. radiata* seed, an experiment has been designed. In the present research hour wise imbibitions of V. radiata seeds were performed and data related to amount of water imbibed, germination (%), average length of germinated plants, abnormal germination and fungal contamination during germination were recorded for analysis.

Materials and Methods

V. radiata seeds were purchased from local market. Seeds were washed and surface sterilized by soaking in 70% ethanol for 5 min. The sterilized seeds were washed three times using sterile distilled water to remove traces of ethanol.

To find out the imbibed water 5.3 g (approximately 100 seeds) of dry *V. radiata* seeds were weighed. The lot is now surface sterilized using method described above. The seeds were imbibed in 100 ml sterile distilled water for 0 to 24 h. The data for 15h is not their as the seeds were lost during experiment. The post imbibition weight of seeds was measured. The weight of water imbibed per gram of seed was calculated and recorded.

Three sets of 100 seeds are used for every imbibed time period (0h to 24h) except for 22h were a set is lost due to accidental falloff. Germination, abnormal germinations, non-germinated seed, fungal contamination percentage were recorded for all three lots. The recorded data were processed to find out mean and standard error. The mean plantlet length was calculated from all normal germinations out of 300 seeds for each imbibition time period. All total of 7,100 seeds were used in the present experiment. The vigour index was calculated by multiplying normal germination (%) and mean plant length (cm). Statistical analysis of the data is performed using one way ANOVA analysis at p=0.05.

Results and Discussions

As presented in Figure 1, the water imbibed (g) per g of dry weight of seed increases with increasing period of imbibition in hours. Compared to earlier report of 6h imbibition for 1g water/g dry weight of *V. radiata* seed, in the present study it is found to be 5h (Castellanos-Barriga et al., 2017). In seeds imbibed for 6, 7 and 8h period there is a drop in imbibed water (Figure1). This might be due to presence of more hard seeds (Promila et al., 2000).

The rate of imbibition from 9h onwards goes down because of saturation of imbibition (Table1). The rate of imbibition for the *V. radiata* seeds imbibed for 8h was found to be slower compared to 5-9h group (Table1). This slow imbibition rate might be responsible for high vigour (Figure4) for seeds imbibed for 8h period (Abdullah et al., 1991). Imbibition for 19h period shown a huge variation in imbibed water (Figure 1) and lower vigour compared to nearby time periods (Figure 4).

The vigour loss of 19h imbibed V. radiata was contributed by drop in case of germination (%) (Figure 2) and not plant length (Figure 3). As presented in Figure 2 the germination (%) increases with increasing imbibition period. The germination (%) was found to be high for V. radiata seeds imbibed for 7, 10, 11 and 13h. The germination (%) before and after these gradually drops (Figure 2). The same trend is found to in non-germinated (%) with 7 and 13h imbibed V. radiata seeds show lowest non-germination (%). It should also noted that germination (%) and nongerminated (%) for every time period of imbibition corresponds to each other (Figure 2). Therefore, it might be suggested that number of abnormal seed did not vary significantly with respect to imbibition time periods (Figure 3). As presented in Figure 3, the plant length was found to be highest in 8h imbibed seeds. Abnormal germination was found highest for 3h imbibed seeds (Figure 3). It should also be noted that more than 5h imbibition did not show any fungal contamination and with increasing h of imbibition fungal contamination decreases (Figure 3).

Abnormal germination (%) is also following a trend of curve with bottom at 12h imbibition and approximately following the desiccation tolerance trend of 6-18h imbibed seed as referred by Tian et al. (2016). The plant length is found to be highest for 8h imbibed *V. radiata* seed. The low standard error of mean plant length suggests synchronized germination



Fig. 1: Water imbibition graph

Table 1: Different parameter of germination with respect to 24 different imbibition time periods

time (H)	Water (G) Per G dry seed		l Germinatono (%)		Abnormal germination		Fungal contamination		Non germinated seed		plan length (cm)		vigour index	Rate of water
	mean	standard error	mean	standard error	mean	standard error	mean	standard error	mean	standard error	mean	standard error		imbibition (g water/g dry wt.h)
0.00	0.000	0.000	2.67	0.67	17.33	4.63	3.67	0.33	76.33	4.19	6.7	0.6	17.97	NA
1.00	0.233	0.014	2.67	0.67	16.33	4.06	4.00	0.58	77.00	4.93	7.9	0.5	20.93	0.233
2.00	0.441	0.011	12.33	2.19	18.33	4.91	3.33	0.67	62.00	9.45	7.1	0.7	87.63	0.220
3.00	0.400	0.041	26.67	3.53	23.67	1.45	0.67	0.67	46.33	2.60	13.6	0.5	362.53	0.133
4.00	0.764	0.037	35.33	4.63	14.67	2.33	0.00	0.00	45.67	0.88	12.8	0.4	453.82	0.191
5.00	0.992	0.039	49.33	9.82	17.33	2.67	0.33	0.33	33.67	7.67	12.1	0.3	598.71	0.198
6.00	0.714	0.031	52.33	3.53	19.00	3.21	0.00	0.33	35.33	6.84	9.3	0.2	484.08	0.119
7.00	0.819	0.005	69.00	5.29	13.00	3.00	0.00	0.00	18.00	2.65	9.5	0.2	652.88	0.117
8.00	0.912	0.018	61.00	1.15	12.00	1.15	0.00	0.00	23.67	1.76	14.3	0.3	873.00	0.114
9.00	1.150	0.015	59.67	2.73	12.33	1.20	0.00	0.00	31.33	6.74	12.4	0.3	741.33	0.128
10.00	1.127	0.007	69.33	7.13	7.33	1.45	0.00	0.00	23.00	8.08	11.2	0.3	776.93	0.113
11.00	1.190	0.023	70.00	2.00	10.67	1.86	0.00	0.00	19.33	0.33	11.7	0.3	818.33	0.108
12.00	1.082	0.063	59.67	2.40	6.33	1.76	0.00	0.00	30.67	5.46	12.1	0.3	723.00	0.090
13.00	1.082	0.017	74.00	7.09	9.33	1.33	0.00	0.00	16.67	6.33	11.2	0.2	827.06	0.083
14.00	1.000	0.015	63.33	6.17	13.00	3.51	0.00	0.00	23.67	8.57	12.9	0.3	815.77	0.071
16.00	1.076	0.047	59.67	0.88	7.00	0.58	0.00	0.00	33.33	1.45	9.4	0.3	560.2	0.067
17.00	1.063	0.026	62.00	0.58	16.00	4.58	0.00	0.00	22.00	4.16	12.1	0.3	748.54	0.063
18.00	1.043	0.009	59.33	2.67	16.33	6.74	0.00	0.00	21.00	6.66	12.2	0.4	725.15	0.058
19.00	1.425	0.335	39.67	1.67	8.67	1.20	0.00	0.00	47.00	7.51	12.2	0.5	483.51	0.075
20.00	1.146	0.045	61.67	3.84	13.00	1.00	0.00	0.00	28.67	3.38	12.5	0.4	770.16	0.057
21.00	1.093	0.023	57.00	3.79	10.00	2.31	0.00	0.00	33.00	6.08	11.6	0.3	661.54	0.052
22.00	1.104	0.029	53.00	1.00	17.50	10.50	0.00	0.00	34.50	14.5	10.9	0.3	5.77.80	0.050
23.00	1.094	0.024	57.33	5.36	15.33	4.70	0.00	0.00	27.33	0.67	11.5	0.3	659.17	0.048
24.00	1.364	0.012	43.00	3.06	19.00	5.20	0.00	0.00	38.00	5.51	12.1	0.4	519.64	0.057







Fig. 3: Abnormgermgraph



Fig. 4: Vigour index

(Figure 3). It is the synchronized germination which helps farmer with respect to pesticide, fertilizer application and harvesting. The vigour of the plant is also found to following a bell shaped curve with 8-16 h as top of the bell with few exceptions.

Conclusion

From the present research it might be concluded that 8h of imbibition is good for germinating *V. radiata* seed.

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References

 Balestrazzi, A., Donà, M., Macovei, A., Sabatini, M. E., Pagano, A., & Carbonera, D. (2015). DNA repair and telomere maintenance during seed imbibition: correlation of transcriptional patterns. Telomere and Telomerase, 2.

- 2. Qian, C., Lei, Y., & Song, S. Effect of pre–imbibition on the desiccation–tolerance of imbibed {\sl Vigna radiata} seeds. Acta Botanica Yunnanica, 2003;26(6):661-667.
- Promila, K., Ram, C., & Dahiya, O.S. Studies on imbibition rate and chlorophyll stability index in relation to hard seeds in green gram (Vigna radiata (L.) Wilczek). International Journal of Tropical Agriculture, 2000;18(1):93-96.
- Abdullah, W.D., Powell, A.A., & Matthews, S. Association of differences in seed vigour in long bean (Vigna sesquipedalis) with testa colour and imbibition damage. The Journal of Agricultural Science, 1991;116(2): 259-264.
- Krishnappa, N.P., Basha, S.A., Negi, P.S., & Prasada Rao, U.J. Phenolic acid composition, antioxidant and antimicrobial activities of green gram (vigna radiata) exudate, husk, and germinated seed of different stages. Journal of Food Processing and Preservation. 2017.
- Castellanos-Barriga, L. G., Santacruz-Ruvalcaba, F., Hernández-Carmona, G., Ramírez-Briones, E., & Hernández-Herrera, R. M. Effect of seaweed liquid extracts from Ulva lactuca on seedling growth of mung bean (Vigna radiata). Journal of Applied Phycology, 2017.p.1-10.

- Truong, T. N., Tuong Danh, N., & Thi Anh Dao, D. Effects of ph soaking solutions and hypoxia/ anaerobic treament on gaba accumulation in germinated mung bean (Vigna radiata L.). Journal of Science and Technology, 2017;55(2):150.
- Promila, K., & Kumar, S. Vigna radiata seed germination under salinity. Biologia Plantarum, 2000;43(3):423-426.
- Rodríguez-Gacio, M.D.C., Matilla-Vázquez, M.A., & Matilla, A.J. Seed dormancy and ABA signaling: the breakthrough goes on. Plant signaling & behavior, 2009;4(11):1035-1048.
- Xiong, L., & Zhu, J.K. Regulation of abscisic acid biosynthesis. Plant physiology, 2003;133(1):29-36.

- Murthy, U.N., Kumar, P.P., & Sun, W.Q. Mechanisms of seed ageing under different storage conditions for Vigna radiata (L.) Wilczek: lipid peroxidation, sugar hydrolysis, Maillard reactions and their relationship to glass state transition. Journal of experimental botany, 2003;54(384):1057-1067.
- Benvenuti, S., & Macchia, M. Effect of hypoxia on buried weed seed germination. Weed Research, 1995;35(5):343-351.
- Tian, X., Li, S., Liu, Y., & Liu, X. Transcriptomic Profiling Reveals Metabolic and Regulatory Pathways in the Desiccation Tolerance of Mungbean (Vigna radiata [L.] R. Wilczek). Frontiers in plant science, 2016.p.7.

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Developement of Yield Predictive Models on the Basis of Thermal Indices for *Brassica Juncea* in Tarai Region of Uttranchal

Ravi Kiran*, Anil Shukla**

Abstract

A field investigation was carried put during *rabi* season of the year 2014 and 2015 at Norman E. Borlaug Crop Research Centre (CRC) of the Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, (Uttarakhand) in split plot design (SPD) taking three dates of sowing *i.e.* Oct 22, Nov 01and Nov 11 in main plots and five planting geometries *viz.*, 30×10 cm, 30×20 cm, 30×30 cm, 45×15 cm and 45×30 cm in sub- plots with three replications on the thermal requirement of Indian mustard var. RGN-73 thermal indices; GDD, PTU, HTU and PTI were calculated at different phenological stages of the Indian mustard The crop sown on 22^{nd} October was found to accumulate more thermal units; and among the planting geometries, the wider geometries (30×30 cm, 45×15 cm and 45×30 cm) accumulated more thermal units.

Keywords: Brassica Juncea; Sowing Dates; Planting Geometries; Thermal Indices; Yield Predictive Models.

Introduction

Indian mustard [*Brassica juncea* (L.) Czern & Coss.] is a crop of tropical as well as temperate zones demanding cool and dry weather for optimum growth and development. High temperature at flowering stage reduces seed yield because of pollen sterility. Mustard is a long day plant requiring 16 h of light period in 24 h cycle, but, flower if it is provided with a cycle of 8 h of light period with 4 h of dark period (short night). It requires to flower in about 50 days under 16/8 h light/dark period.

Growing degree days (GDD), photo-thermal unit (PTU), helios thermal unit (HTU), have frequently been used as a weather based parameters for assessing crop phenology. The GDD is used to quantify effect of temperature and described the timing of different biological process (McMaster and Wilhelm 1997; Qiao-yan et al. 2012). The present investigation was carried out to quantify relationship of GDD, PTU, HTU, with phenological development of crop. The occurance of different phenological events are set within the lifecycle of a plant, but, the duration of a particular stage of growth is directly influenced by temperature within a specified range (Reath and Wittwer, 1952) for a Author's Affiliation: *Assistant Professor, Department of Agrometeorology **Professor, Department of Agronomy, College of Agriculture, G.B.P.U.A &T, Pantnagar-263145, Uttarakhand, India.

Reprint's Request: Dr. Anil Shukla, Professor, Department of Agronomy, College of Agriculture, G.B.P.U.A &T, Pantnagar-263145, Uttarakhand, India. E-mail: dranilshukla8@gmail.com

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particular species, predictable by using the sum of daily air temperatures. The primary focus for estimating phenology has been the approach of growing degree-days (Nuttonson, 1955). assuming a direct and linear relationship between growth of plants and temperature with every plant having its own threshold or base temperature below which the growth does not take place, This approach has widely applied by scientist in past to correlate the phenological development of different crops to predict maturity days.

Growing degree days (GDD), photo-thermal unit (PTU), helios thermal unit (HTU), for assessing crop phenology. therefore the study was carried out to find out the thermal requirement of mustard crop at different phenological events and Development of yield predictive models on the basis of thermal indices for Brassica juncea in tarai region of Uttranchal. 102 Ravi Kiran & Anil Shukla / Development of Yield Predictive Models on the Basis of Thermal Indices for Brassica Juncea in Tarai Region of Uttranchal

Materials and Methods

The investigation was conducted in silty clay loam soil at Norman E. Borlaug Crop Research Centre (CRC) of the Govind Ballabh Pant University of Agriculture and Technology, Pantnagar(29°N latitude and 79.3°E longitude with an elevation of 243.83 m from the mean sea leve), during the *rabi* season of the year 2014-15. This region comes under sub-humid and sub-tropical climate with four distinct seasons Having average rainfall of this area is about 1434.4 mm annually with maximum precipitation during the South-West monsoon. The daily meteorological data used for the study (*i.e.* minimum and maximum temperature, bright sunshine hours) were taken from Agrometeorological observatory at Norman E. Borlaug Crop Research Centre of the University.

The experiment was laid out in Split Plot Design taking the plots of 4.2 m \times 3.6 m with three replications having three planting dates *viz*. 22nd October, 01st November and 11th November, as main plot treatment and five planting geometries *viz*. 30 \times 10 cm, 30 \times 20 cm, 30 \times 30 cm, 45 \times 15 cm and 45 \times 30 cm as sub-plot treatment. Indian mustard (*Brassica juncea*) variety RGN-73 was selected for the experiment which is a medium maturing variety and takes 120-151 days to mature (Yadava and Shekhawat, 2007).

Recommended dose of fertilizers for the mustard crop *i.e.* 120 kg N, 40 kg P_2O_5 and 20 kg K₂O per ha were applied through Urea, Single Super Phosphate and Murate of Potash. Phosphorus and potassium were applied at the time of sowing while the nitrogen was applied in three split doses of 40 kg/ha each at sowing, 30 and 60 DAS for all the treatments. The number of days taken to attain various phenophases of mustard was determined visually by daily field inspection.

All the indices were worked out following Singh *et al.* (2014) as given below:

Growing Degree Days (GDD): A degree day (°C day) or heat unit is the departure from the mean daily

temperature above a minimum threshold temperature.

$$GDD = \sum \frac{(Tmax + Tmin)}{2}$$
 Tb

Where, Tmax and Tmin are daily maximum temperature and daily minimum temperature, respectively. Whereas, Tb represents minimum threshold temperature for the crop growth (base temperature). The base temperature at different phenological stages of mustard was taken as 5°C (Adak *et al.*, 2009; Roy *et al.*, 2005; and Singh *et al.*, 2014).

Photo-Thermal Unit (PTU): Photo-thermal unit (PTU) (°C days hours) was calculated on the basis of GDD and day length.

 $PTU = GDD \times Day length$

Helios Thermal Unit (HTU): Helios thermal unit (HTU) (°C days hours) was calculated on the basis of GDD and sunshine hours (BSSH).

HTU = GDD × Duration of sunshine hours

Results and Discussion

Daily weather dara is presented oin Table1-2.The crop planted on October 22 consumed more number of days to reach all the phonological stages as compared to the crop planted on November 01 and November 11. due to weather conditions being favorableand lateron the crop showed the effect of forced maturity.

Findings of Nanda *et al.* (1996); Prakash *et al.* (2000); Rabiee *et al.* (2004) and Roy *et al.* (2005) have also shown similar results. Widely spaced plants consumed more number of days to accomplish a particular phenophase than the closely spaced plants due to more competition for the resources Days to 50 % flowering, was recorded maximum for 45 × 30 cm geometry.

Growing degree days	Units accumulated up to germination	Units accumulated up to 50% flowering	Units accumulated up to maturity		
Based on sowing dates	Y=0.217X-224.1(R2=0.99)	Y=0.724X-270.7(R2=0.99)	Y=0.165X-12.9(R2=0.769)		
Based on planting geometry	Y=-0.027X-196.5(R2=0.45)	Y=-0.045X-804.5(R2=0.68)	Y=-0.067X-196.5(R2=0.54)		
Photothermal unit					
Based on sowing dates	Y=3.068X-2691(R2=0.99)	Y=7.907X-3439(R2=0.99)	Y=0.992X+14467(R2=0.486)		
Based on planting geometry Heliothermal units	Y=-0.304X+2124(R2=0.45)	Y=-0.473X+8354(R2=0.70)	Y=-0.826X+7204(R2=0.57)		
Based on sowing dates	Y=0.536X+348.3(R2=0.54)	Y=5.360X-2400(R2=0.45)	Y=0.712X+8970(R2=0.48)		
Based on planting geometry	Y=-0.254X+1461(R2=0.55)	Y=-0.154X+5360(R2=0.70)	Y=-0.667X+10911(R2=0.57)		

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Std week	Tmax (°C)	Tmin (ºC)	Relative Humidity Max (%)	Relative Humidity Min (%)	Rainfall (mm)	Sun Shine Hrs	Wind Velocity (Km/hr.)	Evap. (mm)
43	30.9	16.6	85	55	0	1.7	5.3	2.5
44	28.5	13.1	91	46	0	1.8	4.3	2.6
45	29.2	12.8	91	46	0	2.7	8.2	2.5
46	27.9	9.5	94	34	0	2.7	7.7	2.9
47	26.3	8.6	92	38	0	2	8	2.4
48	26.2	8.7	92	41	0	2.3	7.9	2.3
49	24.3	9.9	94	49	0	2	4.9	1.8
50	20.8	8.2	91	57	5.7	5.3	4.3	2.1
51	16.8	7.4	96	78	0	3.9	4.1	1.2
52	18.5	4.9	95	57	0	3.4	5.2	1.1
1	19.1	11.5	93	77	3.1	6	2.8	1.4
2	15.7	8.4	95	75	0	3.5	3	0.8
3	15.8	8.1	95	71	0	3.4	2.5	1.2
4	18.4	8.6	95	75	1.6	4.8	3.6	1.2
5	18.4	8.1	88	62	0	6	4	1.5
6	22.4	7.4	94	54	0	3.9	7	2.1
7	23.2	9.7	88	51	0	3.9	5.7	2
8	27.1	13.4	90	55	0	3.3	5.5	2.1
9	23.3	13	92	61	9.7	6.3	4.4	2.8
10	25.2	10.2	89	45	0	5.8	8.8	2.9
11	26.9	12.7	90	51	0.2	5	6.6	2.9
12	29.3	13.7	88	45	0	4.6	9.5	3.5
13	31.3	17.7	85	46	3.7	5.1	7.7	4.3
14	29.2	15.8	90	48	2.7	5	6.4	3.7

Table 1: Average meteorological data recorded at Pantnagar during mustard growing season from 2014-15

Table 2: Average meteorological data recorded at Pantnagar during mustard growing season from 2015-16

 Std week	Tmax (°C)	Tmin (°C)	Relative Humidity Max (%)	Relative Humidity Min (%)	Rainfall (mm)	Sun Shine Hrs	Wind Velocity (Km/hr.)	Evap. (mm)
43	31.2	13.9	88	48	0	8.7	3	4
44	29	13.7	90	43	5	6.2	2.9	3
45	28	12.1	91	43	2	6.6	3	2.5
46	29	11.9	91	38	0	7.8	2.8	2.7
47	27.7	11.3	92	41	0	7.2	1.6	2.3
48	26.7	12.6	91	46	0	3.7	2.7	2.1
49	24.6	10.2	96	49	0	1.8	2.3	1.6
50	21.1	10.3	94	64	0	2.1	4.3	1.3
51	20.5	4.6	96	50	0	5.3	2.5	1.5
52	21	5	95	46	0	6.1	3	1.5
1	23.6	6.9	92	39	0	6	2.7	1.5
2	22.3	7	94	49	0	4.3	3.3	1.7
3	17.4	6.6	94	64	0	2.3	4.6	1.4
4	17.9	4.1	94	53	0	3.3	3.2	1.3
5	22.2	6.8	96	48	0	4.8	5.3	1.9
6	23.3	8.3	93	46	0	5.4	3.7	2.4
7	26.4	9.4	82	32	0	6.8	5.5	3.1
8	26.4	11.8	87	44	2.5	4.6	6.3	2.9
9	28.8	12.1	88	37	0	7.4	3	3
10	30.4	13.4	86	37	0	8.4	6.1	4.2
11	29.1	13.5	83	37	0.9	7.1	7.7	4.7
12	31.3	14	80	28	0	8.8	6.6	4.7
13	33.7	16	78.4	32.3	0	7	5.1	4.8
14	35.6	20.4	64.9	31.6	0	6.9	6	6.7

Growing Degree Days

The data pertaining to accumulated heat units in different treatments are presented in Figure 2. The GDD accumulation was considerably highest in D_1

(1513.35 day °C) than other sowing dates and in G5 (1500.05 day °C). The minimum GDD was accumulated in D_3 and in G1 treatment. The GDD accumulation was highest in D_1 due to longer

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Fig. 1: Days taken to attain various phenophases of the crop during 2014-15 and 2015-16 (pooled)



Fig. 2: Total heat units (GDD) required to attain various phenophases as influenced by dates of sowing and spacing of the crop during 2014-15 and 2015-16 (pooled)



Fig. 3: Total Photothermal units required to attain various phenophases as influenced by dates of sowing and spacing of the crop during 2014-15 and 2015-16 (pooled)

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Fig. 4: Total heliothermal units required to attain various phenophases as influenced by dates of sowing and spacing of the crop during 2014-15 and 2015-16 (pooled)

duration of crop growing period and lowest in D_3 sowing due to forced maturity caused by increase in temperature. The Decrease in GDD may be due to Decrease in the maturity period of the crop. The decrease in GDD with delayed sowing has also been reported by Kumari *et al.* (2012) and Roy *et al.* (2005).

Photothermal Unit

The photothermal unit (PTU) under various sowing dates is presented in the Figure 3. The highest PTU was obtained by D_1 (16174° day hrs) followed by D_2 And D3 among the sowing dates and in G5 (16203° day hrs) among spacings.

Heliothermal Units

The accumulated heliothermal unit (HTU) under various sowing dates is presented in the Fig-4. Different sowing dates considerably influenced heliothermal unit (HTU). The D2 accumulated maximum heliothermal units (12326°day hrs) to reach maturity stage and in G5(12326°day hrs) among spacings.

Yield predictive models developed based on thermal indices on the pooled data.

Conclusion

The pooled results of 2014-15 and 2015-16 rabi season indicates that the mustard var. RGN-73 requires almost 1510-1580 °C days GDD units and 115-135 days to reach maturity. The crop sown on 22nd October was superior in terms of accumulation of most of the thermal indices over other dates. yield predictive models on the basis of thermal indices for *Brassica juncea* can predict the yield to a considerable accuracy and may be used on the field basis.

References

- McMaster GS, Wilhelm WW. Growing degree days: One equation, two interpretations. Agricultural and Forest Meteorology. 1997;87:291–300.
- 2. Qiao-yan LI, Jun YIN, Wan-dai Liu, Mei Zhou, Lei LI, Ji-shan Niu, Hong-bin Niu, Ying MA. Determination of optimum growing degree days (GDD) range before winter for wheat cultivars with different growth characteristics in North China Plain. Journal of Integrative Agriculture. 2012;11:405–415.
- 3. Kumari, A., Singh, R.P. and Yeshpal, "Productivity, nutrient uptake and economics of mustard hybrid (*Brassica juncea*) under different planting time and row spacing". *Indian J. Agro.*, 2011;57(1):61-67.
- 4. Nuttonson, M.Y., "Wheat climate relationships and the use of phenology in as certaining Thermal and Photo thermal requirement of wheat", American Institute of Crop ecology, Washington DC,USA, 1955.p. 388.
- Rabiee, M., Karimi, M.M. and Safa, F., "Effect of planting dates on grain yield and agronomical characters of rapeseed cultivars as a second crop after rice", *Iranian J. Agric. Sci.*, 2004;35(1):177-187.
- Reath, A. N. and Wittwer, S. H. "The effects of temperature and photoperiod on the development of pea varieties", *Proceedings of American Society of Horticultura1 Science*, 1952;60:301-310.
- 7. Roy, S., Meena, R. L., Sharma, K.C., Kumar, V., Chattopadhyay, C., Khan, S.A. and Chakravarthy,

N.V.K., "Thermal requirement of oilseed *Brassica* cultivalrs at different phencglogieal stages under varying environmental conditions", *Indian J. Agric. Sci.*, 2005;75(14):17-21.

 Yadava, O.K. and Shekhawat, U.S., "Notification of Indian Mustard Variety RGN-73". Notification of crop varieties, 2007;67(4):420-421.

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Biosynthesis and Characterization of Silver Nanoparticles by using Leaf Extract of Thalkudi (*Centella asiatica*) and its Antimicrobial Activity

Gitanjali Mishra*, Diptikanta Acharya**, Sagarika Satapathy**, Manoja Das***

Abstract

Nanoscience and nanotechnology are the study and application of extremely small particles and can be used across all the field of science. Recently, nano particles have been used in catalysis, electronics, optics and a number of industries including pharmaceutical and agriculture. Green synthesis of silver nanoparticles is consider as simple, cost effective, biocompatible, less toxicity to cell and eco friendlytechnique. In the present study, we have adopted a technique of green synthesis of silver nanoparticles using leaf extracts of a common medicinal plant i.e. Tulsi (Ocimum sanctum). Theleaf extract was act as a bio-reducer for synthesis of silver nanoparticles (AgNPs). The synthesized AgNPs were characterized using UV-Vis absorption spectroscopy and the absorption maximum was recorded at 651nm. The capping action of bio molecules on AgNPs was characterized by Fourier Transform Infra-Red Spectroscopy (FTIR). The shape and size of the AgNPs were examined with XRD and scanning electron microscopy (SEM). The XRD analysis indicated the crystalline nature of AgNPs and the SEM photography apparent that the AgNPswerespherical in shapecoated with biomolecules. The anti-bacterial activity of AgNPs was investigated againsta Gram-negative bacterium (E. coli) and a Gram-positive bacterium (Pseudomonas aeruginosa) using agar well diffusion method. The synthesized AgNPs were inhibitory effect on both the experimental bacteria. The present work can be concluded that biomolecules present in Tulsi leaf was a potential bio-reducer for synthesis of AgNPs and the synthesized AgNPshad efficacy as bactericidal activity.

Keywords: Biosynthesis; Silver Nanoparticles (AgNPs); FTIR; SEM; Antimicrobialactivity.

Introduction

Nanoparticles are very similar in size having the size of 1-100nm[1]. Nanomaterials are very important and promising area of investigation not only for their structure and properties but also for their wide use in different areas including catalysis, electronics, optics, industries, medicines and agricultures [2, 3, 4]. Some investigators are also reported that novel metal nanoparticles can be used to regulate the biological systems both *in vitro* and *in vivo*[5]. It is observed that only few metals like gold, silver, copper, platinum are utilized for preparation of nanoparticles though a large number of metals are available at the nature. These nanoforms are used in photography, photonics, catalysis, biolabelling, etc [6,7].

Silver nanoparticles (AgNPs) are very interesting for its shape and properties. These nanoparticles are

Author's Affiliation: *Professor and Head, P.G Department of Zoology. Berhampur University, Bhanja Bihar, Odisha-760001, India. **Assistant Professor ***Associate Professor and Head, Department of Biotechnology, Gandhi Institute of Engineering and Technology, Gunupur-765022, Odisha, India.

Reprint's Request: Diptikanta Acharya, Assistant Professor, Department of Biotechnology, Gandhi Institute of Engineering and Technology, Gunupur-765022, Odisha, India. E-mail: dacharya249@gmail.com

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used in clinic, industries and research fields [8,9,10]. Moreover, they are distinguished for their bactericidal activity with low adverse effect to human cell [11]. In this view, AgNPs may be served as an alternate to the antibiotic especially for against to the multidrug resistance pathogens (MDPs). Silver nanoparticles (AgNPs) are traditionally synthesized by physical and chemical methods [12]. Though the physical method does not utilized chemicals but the demerit of the process is utilization of more space and consumption of more energy. The chemical process of synthesis of AgNPs is rapid and economically viable however the pitfall of the process is utilization of chemicals of environmental hazard. The alternate and ecofriendly method of synthesis of AgNPs is green synthesis. The green synthesis processes utilize microorganisms, enzymes, plants extract, fruit extract, for preparation of the nanoparticles [13].

Tulsi (*Ocimum sanctum*) is worshipped, is offered the gods and is grown in Hindu households as a holly plant. The herb has loaded of benefits. *Tulsi* is extremely beneficial for humans. The most common ailments, strengthening immunity, fighting bacterial & viral infections to combating and treating various hair and skin disorders – just a few leaves of tulsi when used regularly can help resolve a host of health and lifestyle related issues. Tulsi assumes utmost importance when it comes to Ayurveda and naturopathy.

Its essential oils are used to treat number of ailments. Thus, by taking into consideration of great medicinal value of the plant leaf extract, we have utilized it for preparation of silver nanoparticles (AgNPs) in aqueous medium. The stable AgNPs were studied their antimicrobial efficiency against two human pathogens, *Pseudomonas aureus* and *Escherichia coli*.

Materials and Methods

Collection of Plant Material

The leaves of Thalkudi (*Centella asiatica*) with good physical conditionswere collected from GIET garden, Gunupur. The plant was further authenticated at department of Botany, Berhampur University, Berhampur. Then the leaves were collected in a sterilized plastic bag and immediately brought to the laboratory for further research work.

Preparation of Plant Leaf Extract

Centella leaf extract is acting as a reducing agent during the synthesis of Silver nanoparticles (AgNPs). The leaves were washed with tap water initially to remove the dirt and impurity present in surface and then shade dried. The fine powder of leaf was prepared by grinding in a mechanical motor and the size of the particle was maintained homogenously.10 gram of leaf powder wastaken in a round bottom flask with 100 ml of double distilled water and soxhelted it for 5 hrs. The leaf extract was cooled and then filtered through whatman No.1 filter paper. The leaf extract was used for preparation of silver nano particles.

Green Synthesis of Silver Nanoparticles

Silver nitrate (AgNO₃) was used as raw material for preparation of silver nanoparticles. The commercially availableAgNO₃ (Hi media Pvt. Ltd. Mumbai, Purity 99%) was used for the experiment. 1 mmol solution of AgNO₃ was prepared with double distilled water, considered as stock solution and was stored at low temperature for further use [14]. For production of AgNPs, plant extracts from 1 ml was added to 5 ml of 1 mmol of AgNO₃ solution in a screwed test tube and incubated at room temperature (37°C). The initial color was yellowish brown. The color of the solution starts change up after 10 minutes. The solution attained the stabilization color of deep brown after 5 hrs. This can be attributed to the formation of AgNPs.

Characterization of Silver Nanoparticles

The characterization of synthesized nanoparticles was carried out by using different instrumental methods such as UV-Vis spectro photo meter, FTIR and SEM.

UV-Vis spectroscopy is a useful technique for confirmation of presence of AgNPs. The absorption spectrum of a solution depends on the properties of molecules present in that solution. The synthesized AgNPs was analyzed for their absorbency in a range of 300 nm to 700 nm. A material's absorbance of infrared light at different frequencies produces a unique "spectral fingerprint" based upon the frequencies at which the material absorbs infrared light and the intensity. The surface chemical bonding of the particle was studied by Fourier Transform infrared spectroscopy (FT-IR). The confirmation and size of synthesized AgNPs were analyzed under scanning Electron Microscopy (SEM).

Study of Antibacterial Activity

The anti-bacterial activity of synthesized AgNPs was investigated againsta Gram-negative bacterium (*E. coli*) and a Gram-positive bacterium (*Pseudomonas aeruginosa*) using agar well diffusion method [15].1ml of AgNPs was added to the well cut in the Mueller-Hinton agar plate exposed with microorganism by spread plate method. The zone of inhibition of AgNPs wasobserved after 72 h of incubation at 35°C.

Results and Discussion

Synthesis of AgNPs

Tulsi (*Ocimum sanctum*)is an herbal medicinal plant, used for cure of many diseases of human like
cough and cold, bacterial infection and urinary disorder. The leaves of the plant are also used as aliment of domestic animals. The important bioactive compounds present in leaf are identified asoleanolic acid, ursolic acid, rosmarinic acid, eugenol, carvacrol, linalool, β -caryophyllene, β -elemene and germacrene D [16].

The mixture of plant leaf extract and AgNO₃ solution was initially yellow brown in colour Fig. 1. After 10 minutes of mixing of plant extract and AgNO₃ solution, it was begun to change. This indicates of initiation of reduction solution. The stabilization of color of the solution i.e. deep brown color was observed as after 300 minutes of incubation. The AgNO₃ solution and leaf extract are colorless and faint brown color respectively. The mixture solution was at initiation yellowish brown in color. The appearance of color in a solution is due to excitation of surface plasmon vibrations in metal nanoparticles. The change of color of solution is considered as preliminary and significant evidence for synthesis of silver nanoparticles.

UV-Visible Spectrum

The characterization of AgNPs was made further by UV-Vis spectro photometer. The absorption spectra of the synthesized AgNPs are represented in Fig. 2. Absorption maxima were observed at 452 nm. The absorption spectrum clearly indicates that when the concentration of AgNO₃ increases, the absorption spectrum decreased indicating presence of high amount of AgNPs [17].

FTIR Analysis

The silver nanoparticles were further characterized by Fourier Transform infrared (FTIR) to identify the presence of biomolecules attached/capped over it. The spectrum shows three shift peaks at3208.3, 1038.1 and 1011.8 respectively (Fig 3). This is possible due to bind of proteins on the AgNPs through the amine groups. It is also indicated the binding of C=O functional group with the silver nanoparticles. The plant leaf extract contain various constituents like carbohydrates, protein, alkaloids of nitrogen compounds, phenolcompounds etc. The cumulative effect of these compounds helps for of formation and retention of AgNPs in longer period [18].



Fig. 1: The mixture of plant leaf extract and AgNO₃ solution **i.** At the beginning **ii.** After 5 hrs



Fig. 2: The absorption spectra of the synthesized AgNPs



Fig. 3: FTIR analysis of synthesized AgNPs

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Fig. 4: SEM analysis of synthesized AgNPs



Fig. 5: Zone of inhibition developed by synthesized AgNPs in agar plate

Scanning Electron Microscopy

The surface structure and size of the synthesized AgNPs are further analyzed by Scanning electron microscopy (SEM). It was observed that the surface morphology of AgNPs biosynthesized from leaf extract indicated that they are spherical shape (Fig. 4). It has been also observed that some of AgNPs are aggregated and form the cluster. This leads to formation of various sized nanoparticles. The smallest size of AgNPs was 22 nm.

The AgNPs were capped with plant extract bio-

molecules. The molecular composition was determined by EDS detector attached to SEM. This analysis indicated the strong signal in the silver region. Thus, formation of silver nano particles was confirmed. Due to surface Plasmon resonance metallic silver nanoparticles show optical peakand thus confirms the formation of AgNPs.

Antibacterial Activity

The zone of inhibition of AgNPs againsta Gramnegative bacterium (*E. coli*) and a Gram-positive bacterium (*Pseudomonas aeruginosa*) by the synthesized AgNO₃ is represented in Fig 5. It has been observed that the synthesized AgNPs had antimicrobial activity against both the studied pathogens.

Conclusion

The green synthesis of silver nanoparticles has quite advantage over physical and chemical methods. The method is simple, easy, non toxic and environmental friendly. The medicinal plants are used by rural people for aliment of several diseases. Even today the molecular assessments of many plants products are not yet revealed. Tulsi (Ocimum sanctum) is popular for its medicinal and antioxidant properties. The synthesized AgNPs using leaf extract of tulsi are spherical, stabilized and covered with biomolecules. These are also had antibacterial activity against two studied microorganisms, a Gram-negative bacterium (E. coli) and a Gram-positive bacterium (Pseudomonas aeruginosa). Therefore, it can be concluded that the bioactive compound present in tulsi can be exploited for green synthesis of AgNPs.

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References

- Guo J-Z, Cui H, Zhou W, Wang W. Ag nanoparticlecatalyzedchemiluminescent reaction between luminol and hydrogen peroxide.J Photochem Photobiol A Chem. 2008;193:89–96.
- McFarland AD, Van Duyne RP. Single silver nanoparticles asreal-time optical sensors with zeptomole sensitivity. Nano Lett 2009;3:1057–62.
- Sun Y, Yin Y, Mayers BT, Herricks T, Xia Y. Uniform form silvernanowires synthesis by reducing AgNO₃ with ethylene glycol in presence ofseeds and and poly(vinyl pyrrolidone). *Chem Mater.* 2002;14: 4736–4745.
- Naik RR, Stringer SJ, Agarwal G, Jones S, Stone MO. Biomimeticsynthesis and patterning of silver nanoparticles. Nat Mater. 2002;1:169–172.

- Callegari A, Tonti D, Chergui M. Photochemically grown silvernanoparticles with wavelengthcontrolled size and shape. Nano Lett. 2003;3:1565–1568.
- Zhang L, Shen YH, Xie AJ, Li SK, Jin BK, Zhang QF. One-step synthesisof monodisperse silver nanoparticles beneath vitamin E Langmuir monolayers. J Phys Chem B. 2006;110:6615–6620.
- Chandran SP, Chaudhary M, Pasricha R, Ahmad A, Sastry M. Synthesis of gold nanotriangles and silver nanopartides using *Aloevera* plant extract. Biotechnol Prog 2006;22:577–583.
- Gardea-Torresdey JL, Gomez E, Peralta-Videa JR, Parsons JG, Troiani H, Jose-Yacaman M. Alfalfa sprouts: a natural source for the synthesis of silvernanoparticles. Langmuir. 2003;19:1357–1361.
- Kowshik M, Ashtaputre S, Kharrazi S, et al. Extracellularsynthesis of silver nanoparticles by a silver-tolerant yeast strainMKY3. Nanotechnology 2003;14:95–106.
- Bar H, Bhui DK, Sahoo GP, Sarkar P, De SP, Misra A. Green synthesis ofsilver nanoparticles using latex of Jatropha curcas. Colloids Surf A. Physicochem Eng Asp 2009;339:134–139.
- Krishnaraj C, Jagan EG, Rajasekar S, Selvakumar P, Kalaichelvan PT, Mohan N. Synthesis of silver nanoparticles using Acalypha indica leaf extractsand its antibacterial activity against water borne pathogens. Colloids Surf B:Biointerfaces 2010;76:50–56.
- 12. Ghaffari-Moghaddam M, Hadi-Dabanlou R. Plant mediated greensynthesis and antibacterial activity of silver nanoparticles using *Crataegusdoug lasii* fruit extract. J Indus Eng Chem. 2014;20:739–744.
- 13. Gurav AS, Kodas TT, Wang L-M, et al. Generation of nanometer-size fullerene particles via vapor condensation. ChemPhys Lett. 1994;218:304-8.
- Ahmed el HM, Nour BY, Mohammed YG, Khalid HS. Antiplasmodial activity of some medicinal plants used in Sudanese folk medicine. Env Health Inst. 2010;4(4):1-6.
- Bodroth RP, Das M. Phytochemical screening and antimicrobial activity of ethanol and chloroform extract of *Zizyphusnummularis* Wt & Arn. African Biotech 2012;11(21):4929-4933.
- Behera NP, Bodroth RP, Das M. Antibacterial activity of *Aeglemarmelos* L. against selected urinary tract pathogens. Proc AP Akadem Sc. 2008;12(4):355–359.
- 17. Joerger R, Klaus T, Granqvist C. Biologically produced silver-carbon composite materials for optically functional thin film coatings.Adv Mater 2000;12:407-9.
- 18. Leela A, Vivekanandan M. (2008). Tapping the unexploited plantresources for the synthesis of silver nanoparticles. Afr J Biotechnol 7:3162–5.

Effect of Sowing Dates and Planting Geometry on Growth and Yield of Different Parameters of Indian Mustard Var. RGN-73 in Tarai Region

Ravi Kiran*, Anil Shukla**

Abstract

A field experiment was conducted during *rabi* season of the year 2014 and 2015 at Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, (Uttarakhand) to assess the effect of sowing times (22nd October, 1st November and 11th November) and plating geometries on the thermal requirement of Indian mustard var. RGN-73. The crop sown on 22nd October was found superior for accumulation of all the thermal indices; and among the planting geometries, the wider geometries (30 × 30 cm, 45 × 15 cm and 45 × 30 cm) accumulated more thermal units. Seed yield was found highest in case of the 22nd October sown crop (1665.3 kg/ha) followed by 1st and 11th of November while the closer geometries 30 × 10 cm (1635.2 kg/ha) and 30 × 20 cm (1650.3 kg/ha) reported more grain and seed yields. The HUE was in accordance with the seed and biological yields; therefore it could be used as a measure to decide the most favorable time of sowing to get higher yields of Indian mustard. The October 22 sown crop exhibit better vegetative growth and final yield than that of others. Closer plant sapcing resulted into more vertical growth. Closer geometries exhibited maximum yield than on the spacing. Using closer geometries with a delay in sowing would result into better yields.

Keywords: Brassica Juncea; Sowing Dates; Planting Geometries; Vegetative Growth; Seed Yield.

Introduction

Crop yield is influenced by several factors out of these, weather is the only environmental factor which influences the growth of the crop cycle. Sowing time affects various varieties in clear ways. Delay in sowing causes drastic reduction in yield than timely sowing.

Rapeseed- mustard being a cool season crop, is mainly influenced by temperature. In India, mustard is mostly grown in northern and north-western parts of the country as a *rabi* (winter season) crop after harvest of *kharif* (wet rainy season) crop. The crop requires high temperature during vegetative growth stage; and cool weather, clear sky during reproductive phase for better development the tools and techniques are needed to assist in developing strategies that can lead to higher food production, prevent crop production losses, and ensure minimal greenhouse gas emissions.

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Author's Affiliation: *Assistant Professor, Department of Agrometeorology **Professor, Department of Agronomy, College of Agriculture, G.B.P.U.A &T, Pantnagar-263145, Uttarakhand, India.

Reprint's Request: Dr. Anil Shukla, Professor, Department of Agronomy, College of Agriculture, G.B.P.U.A &T, Pantnagar-263145, Uttarakhand, India.

E-mail: dranilshukla8@gmail.com

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Methodology

The investigation was conducted in silty clay loam soil at Norman E. Borlaug Crop Research Centre (CRC) of the Govind Ballabh Pant University of Agriculture and Technology, Pantnagar (29°N latitude and 79.3°E longitude with an elevation of 243.83 m from the mean sea leve), during the *rabi* season of the year 2014-15 l. This region comes under sub-humid and sub-tropical climate with four distinct seasons Having average rainfall of this area is about 1434.4 mm annually with maximum precipitation during the South-West monsoon. The daily meteorological data used for the study (*i.e.* minimum and maximum temperature, bright sunshine hours) were taken from Agrometeorological observatory at Norman E. Borlaug Crop Research Centre of the University. The experiment was laid out in Split Plot Design taking the plots of 4.2 m \times 3.6 m with three replications having three planting dates viz. 22nd October, 01st November and 11th November, as main plot treatment and five planting geometries viz. 30 × 10 cm, 30×20 cm, 30×30 cm, 45×15 cm and 45×30 cm as sub-plot treatment. Indian mustard (Brassica juncea) variety RGN-73 was selected for the experiment which is a medium maturing variety and takes 120-151 days to mature (Yadava and Shekhawat, 2007).

Recommended dose of fertilizers for the mustard **crop** *i.e.* 120 kg N, 40 kg P_2O_5 and 20 kg K_2O per ha were applied through Urea, Single Super Phosphate and Murate of Potash. Phosphorus and potassium were applied at the time of sowing while the nitrogen was applied in three split doses of 40 kg/ha each at sowing, 30 and 60 DAS for all the treatments. The number of days taken to attain various phenophases of mustard was determined visually by daily field inspection.

The height of selected plants was measured in cm with the help of meter scale from the base of plant to the tip of the plant at every 30 days interval from sowing to the maturity.Leaf Area Index (LAI) is a dimensionless quantity that characterizes plant canopies. It is defined as the ratio between leaf area to the ground area. LAI of all the plots was measured at every 30 days interval from sowing to the maturity using by the given formula:

$$LAI = \frac{Total leaf area (m^2)}{Total ground area (m^2)}$$

One plant from each plot were selected at random and uprooted at every 30 days interval, placed inside an electrical oven at 65-75°C for three days. After complete drying of the plant sample, oven dry weight of the sample was taken and recorded in g/plant.After threshing and winnowing of seeds obtained from the net plot area of individual plot were weighed and recorded as seed yield in kg/plot and was converted into kg/ha to get the final yield on hectare basis. Weight of thoroughly sun dried harvested produce of each plot was recorded separately before threshing and expressed as biological yield in kg/plot and was converted into kg/ha.

Results and Discussion

The weather conditions in the experiment years is shown in Figure 1 & 2. Plant height as influenced by different dates of sowing and planting geometry has been shown in Fig 3. In general, plant height increased with advancement of crop age up to its maximum at maturity. The effect of sowing dates was pronounced on plant height at all of the stages . the influence of geometry was also clearly visible for all the crop stages except at 30 days stage. at all the time intervals, Plant height, was found more for the October 22 sown crop as compared to that, of November 01 and November 11 sown crop. similar results has also been reported by Goyal et al. (2006) and Bhuiyan et al. (2008). Plants with 30 × 20 cm were observed taller than that of the other geometries at all the growth stages of crop except at 30 days. At 120 days 30 × 20 cm geometry reported the maximum plant height followed by 30 × 10 cm, 30 × 30 cm and so on.

Effect of sowing dates and planting geometries on LAI at various growth stages of Indian musterd has been presented in Figure 4. The leaf area index attained its maximum value for all the sowing dates at 90 days and decreased thereafter for all the sowing dates. The value of LAI was all the time high for October 22 followed by November 01 and November 11. *Tripathi* (2003) and Pande (2009) have also reported the similar results.Delay in sowing caused considerable decrease in LAI at these stages. The 30 × 20 cm geometry resulted in the maximum value of LAI as compared to the other geometries, its values were at par with that of 30 × 20 cm and 30 × 30 cm, and significantly higher over 45 × 15 cm and 45 × 30 cm at 60 days.

Dry matter accumulation, in general increased gradually with advancement of crop age which is reported in Figure 5. Its peak value was attained at 120 days. Sowing dates had direct bearing upon dry matter accumulation at all the stages from germination to maturity, however, the effect of geometry was not visible at 30 days. The crop sown on October 22 accumulated more dry matter at all the stages as compared to the two later grown crops. November 11 sown crop accumulated least dry matter among all the three dates of sowing. A good amount of dry matter accumulated in timely sown crop thanthat of late sown one. Similar results have been reported by *Dehghani et al. (2008).*

The 30 × 20 cm geometry accumulated the highest dry matter at 120 days which was significantly superior over that of all the other geometries. 45×30 cm accumulateed the least amount of dry matter at all the stages of growth. The seed yield of Indian mustard Ravi Kiran & Anil Shukla / Effect of Sowing Dates and Planting Geometry on Growth and Yield of Different Parameters of Indian Mustard Var. RGN-73 in Tarai Region

as influenced by different dates of sowing and planting geometry has been reported in Fig. 6. The seed yield decreased with delay in sowing date from 22^{nd} of October to the 11^{th} of November, showing the highest yield 1665.3 kg/ha for 22^{nd} October and the lowest yield 1265.8 kg/ha for 11^{th} of November. a decrease in seed yield of Indian mustard with delayed sowing have also been reported by Afroz *et al.* (2011). Among the various planting geometries 30×20 cm produced the highest seed yield being higher thanthat of the two geometries of 45×15 cm and 45×30 cm. the geometries of 30×10 cm and 30×30 cm, however did not differ significantly. Similar findings on planting geometry have been reported by Hassan and Arif (2012). The effect of sowing dates was found clear on the biological yield.Biological yield reduced as the sowing date got delayed from 22^{nd} of October to the 11^{th} of November. The crop sown on 22^{nd} of October produced the highest biological yield being higher than that of 1^{st} and 11^{th} of November. It was found that 30×20 cm produced the highest biological yield followed by 30×30 cm and 30×20 cm planting geometries.





Fig. 3a: Temporal variation of plant height (cm) (pooled)

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Fig. 3b: Temporal variation of plant height (cm) (pooled)







Fig. 4b: Temporal variation of LAI (pooled)



Fig. 5a: Temporal variation of dry matter accumulation (g/plant) (pooled)



Fig. 5b: Temporal variation of dry matter accumulation (g/plant) (pooled)



Fig. 6: Yield components of Indian mustard as influenced by dates of sowing and planting geometry (pooled)

Conclusion

The October 22 sown crop produced taller plants than that of others. Closer plant sapcing resulted into more vertical growth than wider spaced.Date of sowing and planting geometry had direct bearing upon on leaf area index. The peak LAI was recorded with sowing on 22nd October and plants with closer geometries.It increased with advancement of crop age, and attained its maximum at 120 daysand was maximum for the first date of sowing and a closer spacing. The crop sown on 22nd of October resulted into a higher seed yield over the late sowing. Though the magnitude of all the yield attributes was more for wider geometries but their cumulative effect on per hectare basis was lower than that of the closer geometries resulting in a lower grain yield.biological yield reported its maximum for the closer spacing and 22 October sowing, too. Therefore, it may inferred that using closer geometries with a delay in sowing would result into higher seed yields.

References

1. Afroz, M.M., Sarkar, M. A. R., Bhuiya, M. S. U. and Roy, A. K. "Effect of sowing date and seed rate on yield performance of two mustard varieties", J. Bangladesh Agril. Univ., 2011;9(1):5–8.

- 2. Dehghani, H., Omidi, H. and Sabaghnia, N., "Graphic analysis of trait relations of mustard using the biplot method", *Agronomy J.*, 2008;100(1):1443-1449.
- Hassan, F.U. and Arif, M., 2012, "Response of white mustard (*Sinapis Alba L*) to spacing under rainfed conditions", J. Animal & Plant Sci., 2012;22(1):137-141.
- Goyal, K.S., Das, B., Singh, R. and Mohanty, A.K. Influence of the thermal environment on phenology, growth and development of mustard varieties. *J. of Oils and Crops*. 2006;16(2):283-290.
- Bhuiyan, M.S., Mondol, M.R.I., Rahaman, M.A., Alam, M.S. and Faisal, A.H.M.A. Yield and yield attributes of rapeseed as influenced by date of planting. *International J. of Sustainable Crop Production*. 2008;3(3):25-29.
- 6. Tripathi, N. Studies on physiological parameters in relation to heat tolerance in eight wheat varieties. M.Sc. Ag. (Agron.), G.B. Pant Univ. of Agri. and Tech., Pantnagar. 2003.
- 7. Pande, P. Physiological basis of yield differences among wheat varieties under timely and late sown conditions. Thesis, Ph.D. (Agron.), G.B. Pant Univ. of Agri. and Tech., Pantnagar. 2009.

Bionomics and Diversity Pattern of Malaria Mosquito Anopheles minimus in Keonjhar District of Odisha

Prafulla K. Mohanty*, Smrutidhara Dash*, Sarbeswar Nayak*

Abstract

Studies of sibling species, bionomics, distribution, role in malaria transmission, and identification of anopheline vector are significantly important from malaria control point of view. Control of malaria depends on certain aspects such as, response to insecticides, vectorial competence, host preference and resting behaviour. So vector bionomics have been a major area of research over many years. An. minimus was identified as a vector of malaria in east central region of Odisha. Keonjhar district of Odisha State, India is afflicted with high incidence of malaria since many decades. The present study was carried out for bionomics and diversity pattern of malaria mosquito Anopheles minimus in Keonjhar district of Odisha. An. minimus were collected from different ecotopes of Keonjhar district with hand catch method from both indoor and out door resting habitats, identified morphologically and members of the Anopheles minimus species complex was further identified at molecular form by polymer chain reaction assay (PCR). Plasmodium falciparum infection was determined following the dissection of the ovaries. Immatures were also collected from nearest breeding habitat such as perennial stream, well, pond and rice field. Stream is the most preferable breeding habitat of this species followed by pond, well and paddy field. The indoor per man hour density (PMDI) of An. minimus was found to be 6.09. The man hour density was found to increase from summer (March to June) to rainy (July to October). The peak prevalence of this species was noticed during the month of August. The adult specimens prefer to rest inside the room after blood feeding. The species is highly anthropophilic, with an overall human blood index (HBI) of 0.91.

Keywords: Bionomics; Anopheles minimus; Keonjhar; Sibling Species.

Introduction

Malaria is an acute parasitic illness caused by Plasmodium falciparum or Plasmodium vivax in India. It is highly endemic in many parts of India and most of the cases are from the state of Odisha [1]. Having 3.3% of 1,311 million population of the country, Odisha contributes 42.4% of the total malaria cases and 31.8 % of the total malaria deaths of the country during 2016 [2]. Of the total 30 districts of Odisha, Keonjhar is seriously affected by malaria for many decades [3,4,5,6] and malaria control has become a formidable task in this region. Several Anopheles species transmit malaria in India and disease epidemiology is complex due to varied biology of different species [7,8]. So the study of biology of anopheline vector is important in the epidemiology of malaria transmission and vector control operation. Most of the anophelines that are implicated in the

Author's Affiliation: *Postgraduate, Department of Zoology, Utkal University, Vani Vihar, Bhubaneswar-751 004, Odisha, India.

Reprint's Request: Prafulla K. Mohanty, Postgraduate Department of Zoology, Utkal University, Vani Vihar, Bhubaneswar-751 004, Odisha, India.

E-mail: prafulla.mohanty3@gmail.com

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transmission of malaria have been identified as species complex commonly known as sibling species having distinct gene pools and differ in biological characteristics. So far 30 species complexes have been described in different regions of the world ^[2]. Recent developments in vector biology have revealed that the vectorial capacity and competence of each sibling species is different, including their behavioral characteristics, breeding habitats, host specificity and susceptibility to malarial parasites and insecticides [8,9].

Differences in the vectorial capacities and distribution patterns among sibling species are responsible for the wide variation in the endemicity of malaria in an area. Failure to recognize sibling species of anopheline taxa results in failure to distinguish between a vector and a nonvector which may adversely affect vector control efforts, if the vector is not correctly identified [10]. In India, An. minimus is regarded as one of the most predominant malaria vector species which are distributed in eastern to north eastern regions down to Odisha State. During the pre DDT era, this species was widely prevalent in sub-Himalayan foothills of Uttar Pradesh to eastern and northeastern region of India [9,10 11]. But after the introduction of DDT in National Malaria Eradication Programme (NMEP) in 1960s, this species was believed to disappear from Terai of Uttarakhand (formerly Uttar Pradesh), eastern Odisha, northeastern states and Nepal [12,13]. However, after a period of nearly 45 years of disappearance, this species reemerged in Keonjhar distrct of Odisha [14,15, 16]. It has also once again been proven as the major vector species in the foothill valley areas of eastern and northeast India [17,18,19]. Since the malaria epidemiology in Keonjhar district shows high in recent years, a study was undertaken to understand the biology and identification of sibling species of An. minimus in this district.

Materials and Methods

Study Area

The study was conducted during January 2007 to December 2009 in six randomly selected villages of Banspal Community Health Center (CHC) in Keonjhar district of Odisha, India. The study area is traversed by Singhbhum hill range with latitude 20°11" to 20°10"N and longitude 85°11" to 86°22" E and lies 573.4 to 601.2 m above sea level. The average annual rainfall is 132.9 mm with monthly rainfall ranging from 0 to 392.6 mm. The climate is characterised by a hot summer (March to June), a rainy (July to September) and a cool season (October to February). The minimum temperature ranges from 8°C in December to 32°C in May and maximum being 19°C in December to 42°C in May. The average relative humidity ranges from 30.6% in March to 85.45% in October. The villages under study are covered by deep forest and hilly streams. Malaria has been endemic in this district and the majority (>95 per cent) of cases are caused due to P. falciparum. During 2001 to 2008, malaria incidence in the district has shown an increasing trend, with annual parasite incidence (API) ranging from13.9 to 17.07 [2]. Since 1958 to 2000, DDT was used for the indoor residual spraying. From 2001 onwards, synthetic pyrethroids (lambda cylohalothrin or alpha cypermethrin) are being used for indoor residual spraying in place of DDT in 11 of the 13 PHCs of the district under the Enhanced Malaria Control Programme (EMCP) [4].

Immature Collection

The immature survey was carried out in all the available breeding habitats within one km radius of the study villages from January 2008 to December 2008. Habitats representing each type, i.e., streams, rivers, ponds, paddy fields, wells and borrow pits from each village were randomly selected and surveyed fortnightly to monitor the vector breeding and the immature of the vector species were collected. Sampling was undertaken using a standard dipper (10 cm in diameter and 300 ml capacity) in all habitats except wells and borrows pits. One dip was taken at every two meter (m) distance in streams, rivers and ponds along the edges. Two to five dips were taken from each borrow pit depending on the size. An iron bucket (20 cm top diameter, 14 cm bottom diameter and 20 cm height) was used to sample the immature in wells. Three to five samples were taken from each well, two to four from the sides and one from the centre. Successive samples were taken from wells at an interval of three to four minutes so as to allow the larvae to come to the surface and to redistribute themselves following the disturbance caused by the preceeding sampling. As rice is cultivated only during khariff season (June to December) in all the six index villages, larval survey in paddy fields was carried out from June 2008 to December 2008. A total of 18 rice plots, three from each ecotope, covering an area of approximately 4.5 hectares, was selected. A total of 100 dips each from stream and 50 dips each from paddy fields were taken in each village.

Collection of Adult Mosquitoes

Indoor resting collection was carried out with an oral aspirator during morning hours (06.00-08.00 hours) in nine fixed catching stations (six human dwellings and three cattle sheds) randomly selected in each village at monthly intervals. Outdoor resting collection was also done in 12 pit shelters spending five minutes in each village at monthly intervals. Mosquitoes were identified, and grouped according to their abdominal conditions using the keys of Christophers [20]. The ovaries of mosquitoes were dissected out to determine the parity using ovariolar dilatation method [21]. After dissection, the body parts of individual specimen of *An. minimus* were kept in eppendorf tubes, dried for three h at 90°C, and brought to the laboratory for identification of sibling species using the molecular methods [22]. Blood meals of the fully fed *An. minimus* females were analyzed using the agar-gel diffusion method [23] and the source of feeding.

Statistical Analysis

Correlation analysis and its significance by using t-test was carried out to see the relationship between rainfall and density of *An. minimus*.

Results

Immature Survey

A total of 2,341 anopheline immatures were collected during the entire study period out of which 1,808 anopheline mosquitoes emerged. During the entire study period, a total of 782 immatures were collected from the surveys in the streams and a total of 555 anopheline mosquitoes emerged out of which 249 (69.4%) were An. minimus species and 106 (39.6 %) were other anophelines. Similarly, out of 540 collected immatures from the pond, a total of 424 anopheline mosquitoes emerged of which 41 (11.4%) were An. minimus species and 383 (88.6%) were other anophelines. From paddy field, a total of 534 immatures were collected out of which a total of 417 anopheline mosquitoes emerged and among them 65 (18.1%) were An. minimus species and 352 (81.9%) were of other anophelines. A total of 321 immature were collected from the surveys in the river and a total of 224 anopheline mosquitoes emerged out of which 4 (1.1%) were An. minimus species and 220 (98.9%) were of other anophelines. No An. minimus emerged from the immatures collected from the well and borrow pit (Table 1).

Collection of Adults

A total of 2,166 female anophelines belonging to 14 species were collected by hand catches from indoor resting collection in study area (Fig. 1) during January 2007 to December 2009 out of which 27% were *Anopheles minimus*, 20.3% were *An. fluviatilis* and 12.7% were *An. culicifacies*. Among the other collected anopheline species, the most prevalent was *An. vagus* (n = 173, 8%) followed by *An. subpictus* (n = 152, 7.0%), *An. varuna* (n = 120, 5.5%), *An. jeyporiensis* (n = 104, 4.8%), *An. jamesi* (n = 81, 3.7%), *An. annularis* (n = 74, 3.4%), *An. palidus* (n = 31, 1.4%), *An. maculatus* (n = 25, 1.2%), An. splendidus (n = 25, 1.2%) and An. aconitus (n= 14, 0.6%). The PMD of all anopheline species collected from indoor resting collection is enlisted (Table 2). The indoor per man hour density (PMDI) of An. minimus was found to be 6.09. Not a single specimen of An. minimus was collected from cattle sheds. Hence, it may be concluded that An. minimus is endophilic and prefers to rest on human dwelling. The month wise PMD of An. minimus collected from indoor resting collection varied from a low in July (1.33) to a peak in the month of November (13.5) to October (14.5) (Fig. 2). When the relationship between the quantum of rain fall and indoor resting density of An. minimus was compared, a non significant negative correlation (r=-0.962; P>0.05) was found. Though the indoor resting density showed a positive correlation with the average temperature (r=0.554, P>0.05) and humidity (r=0.365, P>0.05), but it was not significant. Analysis of abdominal condition of day time indoor resting females shows that 55.1% were in semigravid condition followed by 38.7% full fed, 4.2% gravid and 2.1% unfed. As the proportion of semigravid was found high, it indicates that An. minimus rest indoors after feeding and when the eggs fully develop, they leave indoor. As many as 335 female An. minimus obtained from various types of collection were dissected out for physiological age grading based on follicular relics. Of the 335 An. minimus dissected females, 64.1 per cent (n=215) were parous (having one or more dilatation). The highest proportion parous (0.68) was recorded during winter season, followed by summer (0.64) and rainy (0.57) seasons.

A total of 200 blood meal samples of An. minimus species were tested and the result showed that 91.7% indicated positive reaction with human anti sera and 8.3 % of the sample did not show any reaction. This result suggests that the population of An. minimus is highly anthropophilic, with an overall human blood index (HBI) of 0.91. A total of 535 An. minimus were dissected out for finding out the plasmodial infection in gut and gland out of which 0.93% (n=5) were found positive for sporozoite. No gut infection was noticed in An. minimus. A total of 100 specimens of An. minimus collected by different methods were identified morphologically and taken up for identification of ITS2 region in PCR assay. Amplification of ITS2 from all the specimens generated a product of equal to 520 base pair (bp) length which is similar to the finding of Garros et al [22] (Fig. 3). When this amplified DNA was mixed with species specific primers [24] and amplification was carried out, the species diagnostic assay produced band nearer on 184 bp region. Comparing the amplified product with previous study [22,24,25,6], the species was identified as An. minimus.

Sl. No	Breeding habitat	No. of Dips Taken	No. of Dips + VE for Anopheline Immature	Per Dip Positve	Total Immature collected	Per Dip Immature Density	No of anopheline mosquito emerged	No of Anopheles minimus emerged	Percentage of Anopheles minimus emerged
1	Stream	1984	424	0.21	782	0.39	555	249	44.9
2	River	1900	386	0.20	321	0.17	224	4	1.8
3	Ponds	2518	497	0.20	540	0.21	424	41	9.7
4	Wells	843	123	0.15	123	0.15	151	0	0.0
5	Paddy fields	1821	412	0.23	534	0.29	417	65	15.6
6	Borrow pits	201	41	0.20	41	0.20	37	0	0.0
7	Total	9267	1883		2341		1808		

Table 1: Number of anopheline immature collected and number of Anopheles minimus emerged from different breeding habitats

 Table 2: Number of anopheline collected and man hour density in indoor and outdoor resting habitats

Sl. No	Species	Indo	or resting habitat		Outdoo	r resting habitat	
	Ĩ	Total Number collected	Total Man hours Spent	PM D	Total Number collected	Total Man hours Spent	PMD
1	An. aconitus	14	96	0.15	0	45	0.00
2	An. annularis	74	96	0.77	0	45	0.00
3	An. culicifaies	276	96	2.88	0	45	0.00
4	An. fluviatilis	439	96	4.57	3	45	0.07
5	An. jamesii	81	96	0.84	0	45	0.00
6	An. jeyporiensis	104	96	1.08	0	45	0.00
7	An. maculatus	25	96	0.26	0	45	0.00
8	An. minimus	585	96	6.09	0	45	0.00
9	An. nigerrimus	67	96	0.70	0	45	0.00
10	An. palidus	31	96	0.32	0	45	0.00
11	An. splendidus	25	96	0.26	0	45	0.00
12	An. subpictus	173	96	1.80	2	45	0.04
13	An. vagus	152	96	1.58	6	45	0.13
14	An. varuna	120	96	1.25	5	45	0.11
15	Total	2166			16		



Fig. 1: Map of study sites

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Fig. 2: Per man hour density (PMD) of An. minimus in different months



Fig. 3: Species specific PCR assay of ITS2 region of *An. minimus;* lane 1 to 7- *An. minimus* A, lane 8-*An. varuna,* lane9 -100bp DNA ladder

Discussion

The study was undertaken in Keonjhar district of Odisha which is hyperendemic for *falciparum* malaria being transmitted by *An. minimus* and *An. fluviatilis* [4].Though during the pre-DDT era this species was incriminated as vectors of malaria all along the foothills of the Himalayas extending from the Terai region of Uttar Pradesh to Assam and the neighboring eastern region, during post-DDT era this species has been considered as a major malaria vector only in the areas of north-eastern region of the country [4]. Though different levels of malaria control were achieved in many parts of India, no appreciable results have been achieved in Keonjhar district and till date malaria continues to be one of the major public health problems. Recently, An. minimus species was rerecorded in Singhbhum hills of east-central India [4] with a sporozoite rate of 1.4% [5]. Knowledge on species composition and human biting habits of anopheline mosquitoes in malarious areas is essential for designing appropriate vector control programs and also in understanding the epidemiology of malaria. Although several studies have been conducted on various aspects of bionomics of An. *minimus* in West Bengal and north eastern states [27, 28, 29, 30], no adequate and systematic information is available on this aspect for the reappearance of An. minimus in Keonjhar for which the study was undertaken.

According to Rao, An. minimus generally rests in houses and cattle shed during day time [15]. During the present study, An. minimus was collected only from human dwellings and not from cattle sheds, indicating its preference to rest in human dwellings. In Assam also, An. minimus was reported to rest predominately in human dwellings [19]. Contrary to this finding, a study conducted in Darrang district of Assam [31] showed that the ratio of An. minimus resting in human dwellings to cattle sheds was 5.9: 15.4 [31]. The reason for the absence of An. minimus in the present study was because of the open type of cattle sheds without walls. The abdominal condition of day time resting females provide an additional evidence of their resting behavior [32]. In the present study, it was observed that among the indoor resting females of An. minimus, the proportion of semi gravid was markedly lesser than fully feds and the proportion of gravid was lower than semi gravid, which indicates that a large proportion leave indoors before completion of their gonotrophic cycle. This leads to believe that the population of *An. minimus* in the study area tends to be more exophilic for resting.

However, during the entire study period, not a single An. minimus was collected from outdoors. In the present study, since the villages are surrounded by forest, the potential resting shelters outdoors are vast. Probably, this could be the reason for not collecting a good number of An. minimus outdoors. However, it is necessary to focus intensively on outdoor collection especially by digging more ideal pit shelters and by fixing light-traps so as to confirm the exophilic behaviour of this vector species. Recently, endophily of An. minimus has been reported in Assam by some researchers [33, 15]. In Sonpur [19] and Tamulpur Primary Health Centre (PHC) [34] of Assam, most of the An. minimus collected from houses were either fully fed, semi gravid or gravid in almost equal proportion indicating its endophilic behaviour. Therefore, it was suggested that An. minimus population in Tamulpur PHC, though endophilic, exhibited some degree of exophily and these findings need further confirmation. Outside India, endophily of An. minimus was reported in China [35] and Burma [36]. An important finding of this study was that the vector species rest mainly on walls of the houses and a small number was collected from roofs, hanging clothes and other articles and under beds. Dev (1996) observed in Assam that An. minimus prefer to rest on walls, hanging clothes and other articles and under beds [19]. In the present study, the reason for less finding these vector species on roofs, eaves and hanging objects inside human dwellings could be attributed to the structure of the huts in the studied area. There was a gap of two to three feet between the two side walls and roof which makes the house more lighted immediately after day breaks. Because of this, mosquitoes avoid resting on light exposed portions such as roof, eaves and hanging objects in houses and preferred to rest on walls at a height of three to four feet which is relatively darker. The density of this vector species does not correlate with rainfall in the study area and their abundance throughout the year might be due to the presence of perennial streams, and the preferential breeding habitat of this vector species [15]. The increase in density during post rainy months could be due to enhanced breeding in paddy fields [15]. In Assam, peak abundance of An. minimus was noticed during rainy season [19]. The results of breeding habitat analysis showed that stream and pond were the perennial breeding habitats and paddy field was the seasonal breeding habitat. The intensity of breeding of An. minimus was higher in streams followed by paddy fields and ponds. In Assam, it is also reported that *An. minimus* predominantly breed in streams [9, 31].

A study in Kanchanaburi village, Thailand showed that forest cleared for sugar cane cultivation, created widespread breeding ground for breeding An. minimus and the species preferred to breed in sunshine [37]. An. minimus was found to be the predominant human sucking mosquito with a high parous rate and exhibiting endophagy throughout the year of the present study. The sporozoite rate of An. minimus was found to be high and no gut infection was noticed in any of the An. minimus species dissected in the present study. In most of the P. faciparum predominant district of Assam, this species An. minimus also show high rate of sporozoite infection [38]. In spite of the undisputed vectorial importance of An. minimus in malaria transmission in east central India, there is a paucity of information on their species identification. From the 100 samples tested in the present study, no intraspecific variation was detected in the sequence of the ITS2 region in mosquitoes of An. minimus and all were of species A. This sibling species has been incriminated as a malaria vector in Assam [39] and also in the study area earlier [4,5,40].

Conclusion

Surveys conducted in the present study area in 1980s and 1990s did not record the presence of *An. minimus*. However, 45 years after the lunching of malaria eradication programme, recently this species has been reported to in the present study area [4]. As malaria is the major public health problem and the trend of malaria cases is in increasing order for the last five years. Information generated in the study, particularly the indoor resting pattern, breeding behavior and feeding behaviour would be useful for following aspects.

- 1. Integration of vector control measures and improvement of preventative assess before transmission season.
- 2. Specific designing of Information, Education and Communication (IEC) and behaviour change communication (BCC) activities to changing behaviour of local tribal people for accepting Indoor Residual Spray (IRS) and insecticide Treated Mosquito Net (ITMN) to control the man vector contact and alerting them how malaria causes a serious problem to incur huge expenditure towards treatment without preferring to vector control measures.

- 3. To dispel various misconceptions and myths regarding malaria transmission and disseminate information that mosquitoes are the sole agent of transmitting malaria causing parasites.
- 4. Regarding ecotopes, top hill and foot hill villages have to be considered with top priority for controlling the malaria as the density of *An*. *minimus* was higher in this ecotope.

Further investigation on the impact of deforestation, ecological parameters such as soil type, altitude, rainfall and temperature on the breeding and resting habitats of *An. minimus* in this study area and a control area is suggested.

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References

- Kumar A, Valecha N, Jain T, Dash A. Burden of malaria in India: retrospective and prospective view. Am J Trop Med Hyg. 2007;77:69-78.
- Anonymous, 2007. National vector borne disease control programme: Malaria Situation in India. Government of India, Ministry of Health and Family Welfare;[http://www.nvbdcp.gov.in/Doc/malariasituation-March17.pdf], Accessed on 29 Mayl 2017.
- Dash AP, Behura DK, Roy JR. On the distribution of Anopheline mosquitoes in Orissa, India. J Zool Soc India. 1984;36:1-14.
- 4. Jambulingam P, Sahu SS, Manonmoni A. Reappearance of *Anopheles minimus* in Singhbhum hills at east-central India, Acta Trop. 2005;96:31-35.
- Sahu SS, Gunasekaran K, Jambulingam P, Krishnamoorthy N. Identification of *Anoepheles* fauna in a hyperendemic falciparum area of Orissa State, India. Indian J Med Res. 2008;127:178-182.
- Watts RC. Report No. II. Malaria survey of the mining settlement of Singhbhum, Orissa. Superintendent. Govt. Printing, Bihar and Orissa, Patna; 1924.
- 7. Das A, Anvikar AR, Cator LJ, Dhiman RC, Eapen A, Mishra N, et al. Malaria in India: The Center for the

Study of Complex Malaria in India. Acta Trop. 2012; 121(3):267–273.

- Singh V, Mishra N, Awasthi G, Dash AP, Das A. Why is it important to study malaria epidemiology in India? *Trends Parasitol*. 2009;25(10):452–457.
- Anonymous, 2010.World Health Organization: Malaria disease burden in SEA region.[http:// www.searo.who.int/EN/Section10/Section21/ Section340_4018.htm], Accessed on 23 April 2010.
- Barik TK, Sahu B, Swain V. A Review on *Anopheles culicifacies*: from bionomics to control with special reference to Indian subcontinent. Acta Trop. 2009; 109:87-97.
- 11. Ghosh SK, Tiwari SN, Raghavendra K, Sathyanarayan TS, Dash AP. Observations on sporozoite detection in naturally infected sibling species of the *Anopheles culicifacies* complex and variant of *Anopheles stephensi* in India. J Biosci. 2011; 33:333-336.
- 12. Gunathilaka N, Fernando T, Hapugoda MD, Wijeyerathne P, Wickramasinghe AR, Abeyewickreme W. Increasing trend of *Anopheles culicifacies* (Giles) and other potential malaria vector mosquitoes in Trincomalee District, Sri Lanka. Proceedings of the Annual Session of Sri Lanka Association of Advancement Sciences, Colombo, Sri Lanka. 2013;69:17.
- 13. Muirhead Thomson RC. Studies on the behaviour of *Anopheles minimus*. The behaviours of adult in relation to feeding and resting in houses. J Mal Inst Ind. 1941;4:217-245.
- 14. Senior White RA, Ghosh AR, Rao JV. On the adult bionomics of some Indian Anophelines with special reference to malaria control by pyrethrum spraying. J Mal Inst Ind. 1945;6:129-215.
- 15. Rao TR. The Anophelines of India. Malaria Research Centre, ICMR, Delhi; 1984.
- Gunasekaran K, Sahu SS, Jambulingam P. Estimation of vectorial capacity of *Anopheles minimus* Theobald and *An. fluviatilis* James (Diptera: Culicidae) in a malaria endemic area of Odisha State, India. Indian J Med Res. 2014;140(5):653-659.
- 17. Chakrabarti AK, Singh NN. The probable cause of disappearance of *Anopheles minimus* from the Terai area of Nainital district of UP. Bull Nat Soc Ind Mal Mosq Dis. 1957;5:82-85.
- Parajuli MB, Shreshta SL, Vaidya RG, White GB. National wide disappearance of *Anopheles minimus* Theobald 1901, previously the principal malaria vector in Nepal. Trans R Soc Trop Med Hyg. 1981; 75: 603.
- 19. Dev V. *Anopheles minimus*: its bionomics and role in the transmission of malaria in Assam, India. Bull World Health Organ. 1996;74(1):61-66.
- 20. Christophers SR. The Fauna of British Indiaincluding Ceylon and Burma, Diptera. Vol.4 Family

Culicidae, Tribe Anopheline. Taylor and Francis, London. 1933;271.

- 21. Polovodova VP. Determination of the physiological age of female *Anopheles*. Medical Parasitol. 1949;18: 352-355.
- Garros C, Koekemoer LL, Coetzee M, Coosemans M, Manguin S. A single multiplex assay to identify major malaria vectors within the African Anoipheles funestus and the oriental An. minimus Groups. Am J Trop Med Hyg. 2004;70: 583-590.
- 23. Crans WJ. An agar-gel diffusion method for the identification of mosquito blood meal. Mosq News. 1969;29:563–566.
- 24. Phuc HK, Ball AJ, Son L, Hanh NV, Tu ND, Lien NG, et al. Multiplex PCR assay for malaria vector *Anopheles minimus* and four related species in the Myzomyia Series from Southeast Asia. Med Vet Entomol. 2003;17:423-428.
- Van Bortel W, Trung HD, Roelants P, Harbach RE, Backeljau T, Cooseman M. Molecular identification of *Anopheles minimus* s.l. beyond distinguishing the members of the species complex. Insect Mol Biol. 2000;9:335-340.
- Prakash A, Walton C, Bhattacharyya DR, Loughlin SO', Mohapatra PK, Mahanta J. Molecular characterization and species identification of the *Anopheles dirus* and *An. minimus* complexes in northeast India using r-DNA ITS-2. Acta Trop. 2006;100: 156-161.
- 27. Wajihullah B, Jana B, Sharma VP. *Anopheles minimus* in Assam. Curr Sci. 1992;63:7-9.
- 28. Nandi J, Misra SP. Present prospectives of malaria transmission in Boko area of Assam. J Commun Dis. 1993;26:18-26.
- 29. Nandi J, Kaul SM, Sharma SN, Lal S. Anthropophily of anophelines in Duars of West Bengal and other regions of India. J Commun Dis. 2000;32:95-99.
- Dev V, Ansari MA, Hira CR, Barman K. An outbreak of *Plasmodium falciparum* malaria due to *Anopheles minimus* in Central Asam, India. Indian J Malariol 2001;38:32-38.

- 31. Kamal S, Mahanta HC. Anopheline fauna of parts of Darrang district, Assam with reference to malaria transmission. J Commun Dis. 2007;39(4):251-254.
- Das PK, Gunasekarana K, Sahu SS, Sadanandane C, Jambulingam P. Seasonal prevalence and resting behaviour of malaria vectors in Koraput district, Orissa. Indian J Malariol.1990;27:173-181.
- Service MW. Mosquito Ecology: Field Sampling Methods. Applied Science Publishers Ltd., London. 1976;583.
- Prakash A, Bhattacharyya DR, Mohapatra PK, Mahanta J. Current insecticide susceptibility status of *Anopheles minimus* Theobald in Assam. J Commun Dis. 1996;28:143-145.
- 35. Chow CY. The bionomics of two important malaria vectors in China. Proceedings of International Congress on Tropical, Medicine and Washington, 1948;1:861-865.
- Weeks EB. Experience in the control of malaria a carried by *Anopheles minimus* in Burma. World Health Organization Malaria Conference for Western Pacific and South East Asia Regions, Taipei, WH0 /MAL/ 1954;112:1-10.
- Yasuoka J, Levins R. Impact of deforestation and agricultural development on anopheline ecology and malaria epidemiology. Am Trop Med Hyg. 2007; 76(3):450-460.
- Dev V, Phookan S, Sharma VP, Anand SP. Physiographic and entomologic risk factors of malaria in Assam, India. Am Trop Med Hyg. 2004; 71(4):451-456.
- Subbarao SK. Anopheline Species complex in South East Asia Technical Publication of WHO, SEARO No. 18, New Delhi 82;1998.
- 40. Sahu SS, Gunasekaran K, Jambulingam P. Bionomics of An. minimus and An. fluviatilis (Diptera: Culicidae) in East-Central India, Endemic for falciparum malaria: human landing rates, Host feeding and parity. J Med Entomol. 2009;46(5):1045-1051.

Response of House Sparrow (*Passer Domesticus*) Towards Artificial Nest Boxes in Rural Areas

Gitanjali Mishra*, Umakanta Behera**, Subhasmita Pattnaik**

Abstract

Sharp decline of house sparrow population has been observed over the globein recent years. In Odisha this trend has accelerated after super cyclone and Philin. In rural areas the natural habitat of house sparrow are rapidly replaced by concrete houses due to implementation of concrete housing schemes by the Government. Pertaining to this ongoing phenomenon, the present study evaluates the response of house sparrow towards the scientifically designed artificial nest boxes. This short term study has got high and positive response by the house sparrows towards the artificial nest boxes with respect to nesting and roosting behavior. This quick and significant response indicatesthat sparrows are in a need of nesting site. The individual and community efforts towards the installation of artificial nest boxes in the newly made concrete houses may be a pioneer method in conservative point of view.

Keywords: Artificial Nest Box; Concrete House; Thatched House; Nesting Site.

Introduction

The house sparrow has an extremely large range of population and is not seriously affected by the human activities, so it is assessed as least concerned for conservation on the IUCN red list [1]. However, population have been declining in many parts of the world [2].

The declines were first noticed in the North America where they were initially attributed to spread of house finches, but have been most severe in Western Europe [3].

Decline has not been universal as no serious decline has been reported from Eastern Europe, but has been occurred in Australia where the house sparrow was introduced recently. In Great Britain population peaked in the early 1970s [4], but have since declined by 68% overall [5], and about 90% in some regions [6]. In London the house sparrow almost disappeared from the central city [6].

In 2010 Britain's Royal society of protection of bird has enlisted the house sparrow in the red list on the basis of the finding of the research in the different parts of the world including India. The number of house sparrow in Netherland have dropped half

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Author's Affiliation: *Professor and Head **Research Scholar, P.G. Department of Zoology, Berhampur University, Bhanja Bihar, Berhampur, Odisha 760007, India.

Reprint's Request: Umakanta Behera, Research Scholar, P.G. Department of Zoology, Berhampur university, Bhanja Bihar, Berhampur-760007 Orissa, India.

Email: umakantazoology@gmail.com

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since 1980, so the house sparrow even considered as endangered species (BBC news 2008). In Edenberg, Dublin, Glasgow, Humburg and Berlin are other European cities that have reported a sparrow decline. In recent years there has been significant drop in house sparrow population across Bangalore, Mumbai, Hyderabad and other cities in India [7].

Ornithologist survey conducted by Indian Council of Agriculture Research (ICAR) has reported that the sparrow population in Andhra Pradesh alone has dropped by 80% and in other states like Kerala, Gujurat and Rajasthan it has dropped by 20%, while the decline in coastal area was sharp as 70% to 80%. So far hose sparrow population status in the state of Odisha is concerned its pathetic condition is not so far behind the ongoing trend in different parts of the country. A sharp decline in their population has been observed since after the super cyclone hit Odisha in 1999. The status is in the alarming stage especially in the coastal belt of the state.

Probable Causes of Decline of House Sparrow Population

A single reason cannot be ascertained for cause of decline of house sparrow because a combination of several factors is responsible for the urban declines of the sparrow [8].

Many reasons have been suggested including the wide spread use of garden pesticides resulting in the absence of insects needed by the new born sparrows. Joshi (2009) reported change in the agricultural practices, in particular the shift to the monoculture crop planting as the main cause of decline [9].

Joris Everaert and Dark Bauwens (2007) showed that fewer house sparrow males were seen at locations with relatively high electric field strength value of GSM base stations and there for support the notion that long term exposer to the high level of radiation negatively affect the abundance or behavior of the house sparrow in the wild [10].

The electromagnetic radiation is proved to effect reproduction, circulatory and central nervous system and may cause micro wave syndrome which lead to decline general health [11].

The lack of nesting sites in the modern concrete houses and decrease in the number of thatched houses are found to be the main causes of decline [13].

According to the findings of Kate Vincent [12] the lower rate of productive in house sparrow in suburban areas is due to starvation of the chicks because in the areas the food accessible to them lacks the animal product such as aphides. The lower average body mass of the fledglings would result in the lower post fledgling survival.

Crick *et al.* [13] reported that sub urban sparrow were found to experience higher nest failure rate and Peach et al. [14] explained that it is mostly due to reduced nest survival as compared to their rural counterpart in Britain. Thus decreased reproductive success has been suggested to account for the decline of urbanized population. Several reasons have been proposed for the reproductive failure of the urban sparrow.

First, nestlings require an arthropod diet, and parents may unable to find nestling foods of sufficient quality and/or quality due to the scarcity of the native vegetation [15,16].

Second, according to Summer-Smith [3] arthropod density may be reduced in the cities due to the

introduction of unleaded petrol. The unleaded petrol releases harmful byproduct which kills small insects. The insecticidal nature of the byproduct makes the food for those birds feeding on the insects scarce. Though the adult sparrow can survive without insects in their diet, they need them to feed their young. The lacking of spine shrubs and trees less than 7ft height most preferred by house sparrows as roosting sites is also one of the causes of decline [8].

Aim of the present study is to find out the response of the house sparrow towards the artificial nest boxes installed in the rural area where the natural nesting site are rapidly replaced by the building of concrete houses.

Material and Methods

Study Area

The present study was carried out in different villages of Ganjam district. Geographically Ganjam district is located on 19.4 to 20.17 degree North Latitude and 84.7 to 85.12 degree East Longitude. The villages included in the present study were Dhunkapada, Pandiripada and Bhamasyali. This was a preliminary study carried out in the north east mansoon season (September to November).

Design of Artificial Nest Box

The artificial nest box was prepared by ply wood. Artificial nest boxes are designed on the basis of different parameters of the nest studied under natural condition. The nest box is designed in such a way that the sparrow can able to enter in to the nest box and freely accommodate.

After study of 50 nests from different study area the average diameter of the nest mouth was found to be 6.4 cm. accordingly the nest box mouth was made. Through this circular mouth only the house sparrow could able to enter in to the nest. Other predator birds are prevented from entering in to the nest. The height and breadth of the nest box was kept as 21cm and 17 cm respectively. The height of the nest mouth from the base was kept 7.5 cm. The pedestal of the artificial nest kept 2cm so that only the house sparrow can able to land on the nest while other birds like crow and pigeon are prevented due to large size of their claw.

These dimensional measurements are kept in accordance with the different morphometric parameters of the house sparrow such as length and height of the body. During the study of different nest characteristics under natural condition it was found that house sparrow preferred to build nest in particular range of height from the ground. The average nest height from the ground was calculated as 7 meters. Keeping this in view the artificial nest boxes were installed above 7 meters from the ground.

In addition to this suspended earthen pots from the roof of the concrete house act as artificial nest. These settings are made more effective by suspending a bunch of rice grain twigs near to them. This food material would attract the bird towards the artificial nest. With a hope to extend the population over a large range from a particular habitat to a new habitat the nest box are installed in relay which is called as relay installation. 50 nest boxes were installed in different streets of the study area

The installed nest was observed in a regular interval of 4 days for 3 months. The nest observation was carried out in morning from 6 AM to 8 AM. During this time the birds were found to be more active. The entry and exit of the birds are visually observed and different activities at the nest site are photographed by camera.

Analysis of Data

The significance of response of house sparrow towards the nest box was analyzed by using student's t-test.

Result

The response of the house sparrow towards the installed nest boxes in different streets of study area categorized in three different categories such as attempted, unattempted and nesting. Attempted category refers to the nests those were found frequently visited by the sparrow and fed the food grains that were coupled with the installed nest box. On the other hand the nesting category refers to the nests those were made permanent nesting sites by the sparrow.

In these categories of nest boxes varieties of nesting materials such as straw, dry grass, feather, fine polythene fibers and the bird excreta were found. Out of 50 nest boxes installed in 5 different streets of the study area 48 nests were attempted by the house sparrow except 2 nest box were left un attempted each one in two different streets

This high response was statistically significant. Similarly out of 50 installed nest boxes 32 nest boxes were found under nesting category in three month of our study. This category of positive response was found statistically significant. Similar results were observed by Balaji*et al.* [17] and Bhatacharya *et. al.* [18].

Discussion

The present study indicated the high response of house sparrow towards the installed artificial nest boxes in rural areas within a short duration. This could be explained as the house sparrows were in high need of nesting sites. The natural nesting sites of the house sparrow in rural areas are mostly roofs of thatched houses. After super cyclone hits Odisha and Philin in 2013, most of the thatched houses were replaced by the concrete houses and the natural habitat of house sparrow is destroyed.

This replacement phenomenon has become accelerated after the implementation of different concrete housing schemes by the Government. In our study area, most of the thatched houses were replaced by concrete buildings. Artificial nest boxes were installed in safest height of above 3 meters from the ground and in a predator-free site were most significantly preferred by the house sparrows in place of natural nest sites. While installing nest boxes the height from the ground plays an important role because the sparrow always avoids predator's approachable height.

Table 1: Response of house sparrow towards the artificial nest box

Name of the study site	No. of nest box installed	Attempted	Un attempted	Nesting
Bada Sahi	10	10	0	7
Tala Sahi	10	10	0	6
Main road	10	09	01	6
Nua Sahi	10	10	0	7
Telanga Sahi	10	09	01	6
Total	50	48	02	32

(Number of attempted boxes was significantly different(calculated t value=18.77, df= 4, t=2.77) (Number of nested boxes was significantly different (calculated t value=14.69, df= 4, t=2.77)



Fig. 1: Graph showing response of house sparrow towards artificial nest box





Fig. 2: Artificial nest box

Fig. 4: House sparrow collecting nest materials for nesting



Fig. 3: Nest box installed in concrete house coupled with bunch of rice grain twigs



Fig. 5: Pigeon a common competitor of house sparrow

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The range of height which is mostly preferred by the sparrow is 3 meters to 8 meters. These birds are opportunistic pertaining to the nest materials. They collect the nest materials according to the availability of these materials in the surrounding [19].

In rural areas the nest materials mostly consist of light twigs dry straws, grasses, leaves, feathers, and polythene fibers. It was found that most of the nest boxes were responded by a pair of male and female bird and both the partners were observed collecting nest materials for the same. The crow and pigeon were seen competing and attempting to occupy the installed nest box, but couldn't get into the boxdue to small size of the entrance hole.

So, the appropriate diameter of entrance hole is important in making it accessible to the house sparrows only. The nest boxes those were coupled with the rice grain twigs were responded earlier than others without food grain. This infers that food accessibility is also an important factor in determining the nesting sites of the house sparrow. Nest boxes in the concrete houses should be installed in dry surrounding and away from the direct fall of sunlight and rain as natural nests are found in these conditions.

Conclusion

For conservational point of view every individual should take a noble step towards installing an artificial nest box in their concrete houses. At the same time Government should frame a strict guide line to install an artificial nest box in their newly made concrete houses for those who are the beneficiaries of different housing schemes of government such as Indira AvasYojana and Mo kudiaYojana.Man is the superior of all the creatures on the earth. By virtue of his superiority it is his moral duty to save and conserve the living world. At last by creating sympathy and awareness for this human friendly cultural bird among the people we can able to save it from the verge of extinction.

References

- Bird life international. Passer domesticus, IUCN Red List of Threatened Species, Version 2013. 2., International Union for conservation of nature, retrieved 12 March 2014.
- 2. Even sparrows don't want to live in cities anymore, Times of India, 13 June 2005.

- Summer-Smith, J.D. Changes of house sparrow population in Britain, International Studies on sparrows, 2005;30:23-37.
- Summer- Smith, J.D. The sparrow S.T. and A.D. Poyser, Calton, Staffordshire, UK, 1988.p. 157-158, 296.
- 5. Sparrow numbers' plummet by 68%, BBC News. 20 November 2008.
- McCarthy, Michael: It was once a common or garden bird. Now it's not common or in your garden. Why? The Independent. 16 May 2000.
- Dandapat, A., Banarjee, D and Chakrabaty, D. A Review, The Case of Disappearing House Sparrow (*Passerdomesticusindicus*), Veterinary world, 2010;3 (2):97-100.
- Singh, R., Kour, D.P., Ahmed, F. and Sahi, D.N. The cause of Decline of House Sparrow (*passer domesticus*, Linnaeus 1758) in urban and sub-urban areas of Jammu Region, J and K, Maun, Ent. Zool., 2013;8(2): 803-810.
- 9. Joshi, D.K. House Sparrow (*passer domestics*): The Endangered Bird, Orissa Review. 2009.
- 10. Everaert, J. and Bauwens, D. A possible effect of electromagnetic radiation from mobile phone base station on the number of Breeding House Sparrow (*passer domesticus*), electromagnetic Biology and medicine, 2007;26:63-72.
- 11. Mohan Kumar, Vanishing Sparrows, The Green OSAI, 2010. retrieved from http://www.greenosai. org/environment/diversity/73-vanishing-sparrows.html.
- 12. Vincent, K.E. Investigating the cause of the decline of the urban House Sparrow *passer domesticus* population in Britain Ph.D. thesis, DE Montfort University 2005.p.303.
- Crick, H.Q.P., Robinson, R.A., Appleton, G.F., Clark, N.A. and Rickard, A.D. Investigation into the causes of the decline of starlings and house sparrows in Great Britain, British Trust for Ornithology. 2002.
- Peach, W.J., Vincent, K.E., Fowler, J.A. and Grice, P.V. Reproductive success of house sparrows along an urban gradient. Anim. Conserv., 2008;11:493-503.
- 15. Shaw, L.M., Chamberlain, D. and Evans, M. The house sparrow *passer domesticus* in urban area: reviewing a possible link between post-decline distribution and human socio-economic status. J. Ornithol., 2008;149:293-299.
- South Wood, T.R.E. The number of species of insect associated with various trees. J. Apple. Ecol., 1961;30:1-8.
- Balaji, S., Baskaran, S., Rajan, M.K. and Pavaraj, M. Investigating the causes for the decline and strategies to conserve house sparrow, *passer domesticus* in SivakasiTalek, Virudhunagar district, Tamil Nadu, India, World Journal of Zoology, 2013;8(3):278-284.

- Bhattacharya, R., R. Roy and C. Goswami, Studies on the response of House sparrow to artificial nest, International Journal of Environmental Sciences, 2011;1(7):1574-1580.18.
- 19. Chetan S., J. Improved design of the nest box for Indian house sparrow, passer domesticusindicus, Bioscience Discovery, 2012;3(1):97-100.



Effect of Different Visible Light Wavelengths on Seed Germination and Photosynthetic Pigment Contents in Vigna unguiculata (L.) Walp

Nand Lal*, Priti Sachan**

Abstract

Among the various naturally occurring abiotic factors regulating plant development, light (radiations) plays an important role in photosynthesis, photoperiodism and photomorphogenesis. The present investigations aimed to study the effects of different colour of light on seed germination, hypocotyl growth, mobilization efficiency (ME), vigor index (VI), biomass production and content of photosynthetic pigments (Chl a, Chl b and Carotenoids) in Vigna unguiculata (L.) Walp. cv. Kanchan, an important annual herbaceous food legume crop. Germination rate was found comparatively high in natural light with 95% germination at 84 hours. Individually, red light showed maximum % germination (98) at 84 hours while, green light showed almost no germination even after 96 hours. Blue light and yellow light caused significant reduction in % germination to 71 and 56, respectively, at 84 hours. The seedlings grown under different lights showed variation in biomass production (fresh weight of root and shoot). Root and shoot growth were highest in red light and the order of biomass production was red > yellow > natural > blue > green. ME and VI of cowpea seedlings revealed maximum (610.41 and 4.41, respectively) in red and minimum in yellow light (163.38 and 1.49, respectively). Both, ME and VI could not be determined under green light due to absence of well-marked hypocotyl. The data on photosynthetic pigments indicates synthesis of photosynthetic pigments highly dependent on light quality. Highest content of chlorophyll a, chlorophyll b and carotenoids were observed in red, yellow and natural light, respectively. The findings indicate possibility for using light quality for manipulation of germination and seedling health of crop plants in general and V. unguiculata in particular.

Keywords: Visible Light Wavelengths; Germination; Photosynthetic Pigments; Seedling Vigour; *Vigna Unguiculata*.

Introduction

Among the various naturally occurring abiotic factors regulating plant development, light (radiations) plays an important role in photosynthesis, photoperiodism and photomorphogenesis. Solar light consists of electromagnetic radiation with wavelengths ranging 400 to 700 nm (violet, blue, green, yellow, orange and red). Nature has produced a number of light absorbing molecules that enable organisms to respond to changes in the natural light environment. The changes in the light signal/quality (wavelength) influences various physiological processes (i.e. intra- and inter-cellular differentiation, seed germination and seedling growth, photosynthesis, flowering etc.), depending on the species and developmental stage or studied organ Author's Affiliation: *Professor and Head **Research Scholar, Department of Life Sciences, C.S.J.M. University, Kanpur (U.P.) – 208024, India.

Reprint's Request: Nand Lal, Head, Department of Life Sciences, Dean, Faculty of Life Sciences, Member, Executive Council & Former Pro-Vice Chancellor, C.S.J.M. University, Kanpur-208024, India.

E-mail: nl_pr@yahoo.co.in, nl_pr@rediffmail.com

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(He *et al.*, 2017). Green light, in the process of seed germination of *Arabidopsis*, stimulates the early elongation of the stems, antagonizing the growth inhibition by light whereas the white and red light, in ferns can delay the chlorophyll loss due to senescence (Burescu *et al.*, 2015). It has been reported earlier that light is absolute factor regulating the seed germination in numerous plant species (Jala, 2011). Over a study period of 27 days, Jala (2011) found that

the seeds of Nepenthes mirabilis under white and red light germinated first and those under green light were the last once to germinate and the highest average speed of emergence was also recorded highest for seedlings under red light. Pigments are molecules that absorb light usually in the range of 320 to 760 nm and their biosynthesis in germinating seeds is highly dependent on light quality they perceive. Burescu et al. (2015) studied the effect of different wavelengths LED lights on the growth of Spruce (*Picea abies* L.) plantlets and observed increased biosynthesis of chl a, chl b under blue and yellow light, respectively. Carotenoid synthesis was also significantly enhanced in yellow light treated plantlets. However, all pigments tested were found lower in plants grown under green light than in other treatments. Considering this, the present study was conducted to study the effect of different colours of light (natural, red, blue, yellow, and green) on seed germination, hypocotyl growth, biomass production, mobilization efficiency (ME), vigor index (VI) and photosynthetic pigments in Cowpea/ Lobia (Vigna unguiculata (L.) Walp., an important pulse crops cultivated in the semi-arid and sub-humid tropics for its grain and fodder purposes.

Materials and Methods

Cowpea/Lobia (*Vigna unguiculata* L.) Walp. *cv*. Kanchan was used as experimental material for germination using Knop's solution as nutrient medium. Knop's solution (10X) was prepared by mixing 0.8 mg of Ca(NO₃)₂.4H₂O, 0.2 mg of KNO₃, 0.2 mg of K₂HPO₄, 0.2 mg of MgSO₄.7H₂O and traces of FeSO₄ in 50 ml of distilled water (DW). This stock solution was further diluted with DW for the preparation of 250 ml nutrient solution for germination of seeds.

Hundred surface sterilized seeds of *V. unguiculata* were grown in a series of 5 petri dishes, each containing equal amount of sand and moistened with 30 ml of nutrient solution. These petri dishes were exposed to light of different wavelength (i.e. natural, red, yellow, green and blue light) provided using polypropylene film light filters for the duration of 96 hours.

Mobilization efficiency (ME) in germinating seedlings of each light treatment was estimated by the method of Mohan *et al.* (1996) with the following formula:

ME = Dry weight of seedlings/ Dry weight of cotyledon X100

Vigor index (VI) of germinating seedlings in each light treatment was estimated by the method of Abdul-Baki and Anderson (1973) with the following formula:

VI = % germination X average hypocotyl length

The content of chlorophyll a, chlorophyll b, total chlorophyll and carotenoid were estimated in mg/ gm fresh weight according to method of Arnon (1949) with slight modification (Bansal *et al.*, 1976). On 5th day 80% (v/V) acetone homogenate of plants was incubated at 4°C for 24 hours, and then the homogenate was centrifuged at 3000 revolution per minute for 15 minutes. The supernatant was used to determine OD of each sample/treatment at 480, 510, 630, 645, 652, 663 and 665 nm using Spectronic 20 Bousch and Lomb spectrophotometer. The pigment values were calculated as:

Total Chlorophyll = $O.D_{652} \times 1000/34.5$

Chlorophyll a = 15.6 X (O.D₆₆₅) – 2 X (O.D₆₄₅) – 0.8 X (O.D₆₃₀)

Chlorophyll b = Total Chl – Chl a

Carotenoids = 7.6 ($O.D_{480}$ - 1.4 X $O.D_{510}$)

The actual pigment content (mg/g FW) was computed as pigment value X V/1000 X 1/W

Where V - volume of acetone extract (in ml) and W - weight of the leaf tissue used (in g).

Results and Discussion

The effects of different light treatments on germination of cowpea (Vigna unguiculata L.) seeds are summarized in figure 1. The extent/rate of germination has been found to depend on light quality (wavelength) and exposure period. The germination was recorded maximum (98%) in red light at 84 hours duration and its wavelength was found more suitable for germination than other lights tested. Similarly, in the study of Abdullateef and Osman (2011), red light (660 nm) had better influence on germination in Stevia rebaudiana Bertoni seeds than white light (400-700 nm). Thereafter, in natural light the rate of germination was much faster than other light treatments with maximum germination of 95% at 84 hours. Sharma and Sen (1975) also recorded highest percentage of germination in Merremia species with red light treatment. Blue and yellow light showed moderate germination (71 and 56%, respectively) at 84 hours. Almost no germination was seen under green light even after 96 hours. It has been reported earlier in case of Nepenthes mirabilis that seeds under white and red light germinated first and those under Nand Lal & Priti Sachan / Effect of Different Visible Light Wavelengths on Seed Germination and Photosynthetic Pigment Contents in *Vigna unguiculata* (L.) Walp

green light were the last ones to germinate (Jala, 2011). However, upon completion of germination, Jala (2011) recorded highest % germination in yellow light followed by red and natural light. The present results on germination show deviation from Jala (2011) but conform to observations of Colbach *et al.* (2002) on *Alopecurus myosuroides* and Ambika (2007) on *Chromolaena odorata* seeds.

The effect of different lights on biomass production in cowpea/ lobia is summarized in Table 1 in terms of root fresh weight (FW), shoot fresh weight (FW), seedling dry weight, cotyledon weight and hypocotyl length. Seedlings under red light gave highest biomass yield in terms of root, shoot and cotyledon fresh weight. The order of biomass production under different light qualities was red > yellow > natural > blue > green. Irradiation with blue was not suitable for biomass growth (particularly root) in V. unguiculata. It resulted in smaller cotyledons and leaves with relatively low FW and Seedling dry weight and caused significant reduction in hypocotyls length. Horizontal and vertical expansion of shoot, particularly leaves is genetically controlled developmental process (Tsukaya, 1998) and irradiation with blue light seems to cause imbalance in expression of concerned genes leading to inhibition of leaf expansion. For the lettuce crop, the fresh and dry weight accumulations were higher under the RB (red-blue) treatment (Mickens, 2012). Snowden (2015) also observed significant reduction in dry biomass in radish in the presence of green light at the high level among the comparable treatments. In contrast to present findings, green light stimulates the spruce (Picea abies L.) seed germination and plant growth whereas the blue light inhibits hypocotyl elongation (Burescu et al., 2015).



Fig. 1: Germination (%) in V. unguiculata in the presence of different light treatments

Table 1: Biomass production of root, shoot and hypocotyls of germinating seeds in V. unguiculata under different light treatments

S. N.	Treatments	Root FW (g)	Shoot FW (g)	Seedling DW (g)	Cotyledon DW (g)	Hypocotyl length (cm)
1	Natural Light	0.012±0.005	0.155±0.019	0.015±0.008	0.016±0.007	1.580±0.245
2	Red Light	0.014 ± 0.008	0.186±0.017	0.018±0.007	0.020 ± 0.009	1.900±0.236
3	Blue Light	0.005±0.002	0.106±0.013	0.009 ± 0.004	0.009 ± 0.004	1.000±0.190
4	Yellow Light	0.013±0.006	0.178±0.015	0.016±0.005	0.019 ± 0.008	1.768±0.215
5	Green Light	*	*	*	*	*

FW-Fresh Weight, DW- Dry Weight, each value is shown as mean ± standard deviation

Table 2: Changes in Mobilization efficiency and vigor index of seedlings of *V. unguiculata* under different light treatments

Treatments	Mobilization Efficiency (ME)	Vigor Index (VI)
Natural Light	224.29±4.786	3.49
Red Light	610.41±8.324	4.41
Blue Light	172.09±3.509	3.56
Yellow Light	163.38±2.575	1.49
Green Light	*	*

Each ME value is shown as mean ± standard deviation



Fig. 2. Changes in the photosynthetic pigments of Cowpea seedling leaves grown under different light treatments

Variation was recorded in mobilization efficiency (ME) and vigor index (VI) in seedlings of cowpea (*Vigna unguiculata* L.) obtained in different light treatments and both ME and VI were highest under red light followed by yellow light (Table 2). Under green light, both ME and VI could not be determined due to absence of well differentiated hypocotyl. Contrary to these findings, Jala (2011) reported that seedling vigor index and germination index were highest under yellow light, followed by red light.

The seedlings formed under different lights showed differences in the quantity of photosynthetic pigments (Figure 2). Total chlorophyll and chlorophyll b were recorded highest in natural light whereas chlorophyll a was highest in red light in comparison to other treatments. Natural light also recorded maximum synthesis of carotenoids followed by red, blue and yellow light, respectively. Green light had no measurable pigments because of insufficient growth and development of seedlings. In some instances, green light may function by informing the plant of photosynthetically unfavorable conditions, allowing plants to adjust their compositions and physiology to the available light quality. The chlorophyll a:b ratio also varied in different light treatments. In red light, chlorophyll a:b ratio was maximum (2.12 mg/g) whereas total chlorophyll : carotenoid ratio was highest (3.78 mg/g) in yellow light in comparison to other lights. Saebo et al. (1995) reported that red light is important for the development of the photosynthetic apparatus (plastid differentiation) of plants and a combination of red and blue light is important in the formation of chlorophyll. The use of red-LED light to drive photosynthesis has been widely accepted due to fact that red wavelengths (600–700 nm) are efficiently absorbed by photosynthetic pigments (Sager and McFarlane, 1997) and the same is evident from the present results. Similarly, it has been found the highest inhibition of all the assimilating pigments in **spruce** (*Picea abies* L.) plantlets when exposed to green LEDs (Burescu, 2015). In a recent study, He *et al.* (2017) suggested that the appropriate combination of redand blue-LED light enhances plant growth and photosynthetic capacities of *Mesembryanthemum crystallinum* compared to red- or blue-LED alone.

References

- 1. Abdul-Baki AA, Anderson JD. Vigor determination in soybean seeds by multiple criteria. *Crop Science* 1973;13:630-633.
- 2. Abdullateef RA, Osman M. Effects of Visible Light Wavelengths on seed germinability in *Stevia Rebaudiana* Bertoni. *International Journal of Biology* 2011; 3:83-91.
- 3. Ambika SR. Effect of light quality and intensity on emergence, growth and reproduction in *Chromolaena* odorata. In: Lai PO, Reddy GVP, Muniappan R, editors. Proc Seventh International Workshop on Biological Control of *Chromolaena odorata* and *Mikania micrantha*, NPUST, Pingtung, Taiwan, 2007.p.14-27.
- Arnon DI. Copper enzyme in isolated Chloroplasts. Polyphenoloxidase in *Beta vulgaris*. *Plant Physiology* 1949;24:1-15.
- 5. Bansal RP, Bohra RN, Sen DN. Effect of coumarin and IAA on the pigment system in some arid zone plants. *Geobios* 1976;3:62-63.
- Burescu L, Cachita D, Craciun C. The Effect of Different Wavelengths LED Lighting on the growth of Spruce (*Picea abies* L) plantlets. *Romanian Biotechnological Letters* 2015;20:11025-11034.
- Colbach N, Chauvel B, Dürr C, Richard G. Effect of environmental conditions on *Alopecurus myosuroides* germination. I. Effect of temperature and light. *Weed Research* 2002;42:210-221.
- 8. He J, Qin L, Chong ELC, Choong T, Lee SK. Plant Growth and Photosynthetic characteristics of

Mesembryanthemum crystallinum grown aeroponically under different Blue- and Red-LEDs. Frontiers in Plant Science 2017;8:Article no. 361.

- 9. Jala A. Effects of different light treatments on the germination of Nepenthes mirabilis. International Transaction Journal of Engineering, Management, & Applied Sciences & Technologies 2011;2:83-91.
- 10. Mickens MA. Comparative Study of Lettuce and Radish Grown under Red and Blue Light-Emitting Diodes (LEDs) and White Fluorescent Lamps. Final Report, 2012; JPFP CBRE, Orlando.
- Mohan R, Singh R, Singh PR, Saran B. Effect of GA₃ against Cd toxicity during germination in black gram. *Journal of Neo Botanica Convention* 1996;4:87-90.
- 12. Saebo A, Krekling T, Appelgren M. Light quality affects photosynthesis and leaf anatomy of birch

plantlets *in vitro*. *Plant Cell*, *Tissue and Organ Culture* 1995;41:177-185.

- Sager JC, McFarlane JC. Radiation. In Plant Growth Chamber Handbook (eds. Langhans RW, Tibbitts TW), Ames, IA: Iowa State University Press,1977. p.1–29.
- 14. Sharma SS, Sen DN. Effect of light on seed germination and seedling growth of *Merremia* species. *Folia Geobotanica and Phytotaxonomia* 1975;10: 265-269.
- 15. Snowden MC. Effects of Blue and Green Light on Plant Growth and Development at Low and High Photosynthetic Photon Flux. *All Graduate Theses and Dissertations* 2015; Paper no. 4613.
- 16. Tsukaya H. Genetic evidence for polarities that regulate leaf morphogenesis. *Journal of Plant Research*, 1998;111:113–119.

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Season Wise Haematological Parameters of Flightless Bird Emu, Dromaius novaehollandiae (Latham, 1790)

Prafulla K. Mohanty*, Sujata Puspamitra**, Ipsita Dash**, Smita R. Kullu**, Ananya Bhattacherjee**, Sarbeswar Nayak**

Abstract

The objective of the present study is to find out the haematological parameters of adult captive emus (*Dromaius novaehollandiae*) in three different seasons, i.e., winter, summer and rainy. Hematological parameters like RBC, TLC, Hb, PCV, and erythrocyte indices like, MCV, MCH, and MCHC have been recorded. The mean and significant difference are determined for each hematological parameter. The findings from our study contribute to the database for baseline values of hematological parameters of emu with respect to different seasons. The Hb percentage, RBC counts, and PCV percentage were higher (P<0.01) during the winter season than other two seasons. The average reading of TLC is recorded highest during rainy season and lowest during the winter season (P< 0.05).

Keywords: Season; Haematology; Flightless Bird; Emu; Dromaius novaehollandiae.

Introduction

Emu is the second biggest (first being Ostrich) living bird of the world belonging to order Ratite which is native of Australia [1]. It stands 5-6ft high, 2-3ft less than the Ostrich and dwarfed by the giant moas of New Zealand that became extinct few centuries ago. Emus are related to cassowaries and share with them the coarse, drooping plumage and small wings hidden by the feathers (Fig. 1).

Emus like ostriches, rheas and kiwis as flightless birds are known as ratites. The sexual dimorphism is indistinct excepting the nature of voice of males and females. The male makes a guttural cries, whereas the female has a resonant booming call made by a large air sac connected to the wind pipe. Females are heavier than males just opposite of the normal chicken. Before Europeans settled in Australia there were several species of emu, but all except one have been wiped out.

At one time Tasmania, Kangaroo, Flinders and other islands, had their own emus, but they were killed so rapidly that hardly any specimens reached museum [2]. The eggs of emus are large and dark emerald green.

As flightless birds, they are strong runner and belong to the super-order Palacognathae or Ratitae

Author's Affiliation: *Professor **Post Graduate, Department of Zoology, Utkal University, VaniVihar, Bhubaneswar, Odisha- 751 004, India.

Reprint's Request: Sujata Puspamitra, Post Graduate Department of Zoology, Utkal University, Vani Vihar, Bhubaneswar, Odisha- 751 004, India.

Email: puspamitrapm@gmail.com

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(flightless bird with a flat breast bone), order Casuariiformes under the family Dromaiidae.

The chemistry, nature and structure of the cells of blood can determine the condition of the heart as well as entire circulatory system. Physiological equilibrium is maintained mainly by the blood [3] but this equilibrium is altered in various physiological conditions. Haematological parameters are related to the blood and blood-forming organs [4]. In veterinary medicine, haematological examination provides an effective tool in monitoring the nutritional and health status of animals [5]. A complete blood count is a good indicator of general health, as seasonal illness and stress can modify hematological parameters, especially with regard to lymphocyte and erythrocyte count [6]. The health of various species of poultry is monitored by haematological parameters and for their physiological changes various stress factors are responsible [7,8]. Haematological and serum biochemical analyses provide beneficial data

on the immunological status of animals [9]. Many aspects like age, sex, different breeds, physiological status, blood collection procedure, reproductive status, exercise, circadian rhythm [10], and season [11] are the important factors responsible in haematological variation. Other factors also play significant role in the effect of different treatments on metabolic, nutritional, and animal welfare conditions [12]. Level of haemoglobin might be reduced due to nutritional deficiency or exposure to parasites [13]. It is well known that clinical haematology and biochemistry can be useful aids for diagnosis in birds [14]. Since information on the effect of seasons on hematological parameters in emu is inadequate, the present investigation is an effort to analyse the seasonal changes on haematological parameters of adult captive emus (Dromaius novaehollandiae).

Materials and Methods

In the present study, blood samples were collected from 10 individuals of emu of different seasons, i.e., winter, summer and rainy in ethylene diamine tetra acetic acid (EDTA) vials from the local poultry farm located at northern Bhubaneswar (20.3360°N, 85.8114°E), Odisha. For each sample, two ml blood was taken from jugular vein of the neck from live bird without harming in different seasons like winter, summer and rainy with average temperature 22.75°C, 34.25°C, 27.75°C and relative humidity 72%, 72.25%, 89% respectively. According to the international ethical committee, adequate measures were taken to minimize the discomfort and pain to the bird. Then smears were prepared on microscopic slides (BLUE STAR, PIC 2, Polar Industrial Corporation, Mumbai, Maharashtra, India). Smears were stained with Giemsa's stain prepared from Giemsa's powder (Qualigens CAS NO. 51811-82-6 Product No. 39382, Thermo Fisher Scientific India Pvt.Ltd. Mumbai, Maharashtra, India) for further studies. The recorded data were analysed using Microsoft Office Excel 2007 software and interpreted.

Estimation of haemoglobin was carried out by Sahli's acid hematin method [15] with Sahli's haemometer (HiMedia GW 191-1NO, Plane haemometer (Square Type), HiMedia Laboratories Pvt. Ltd., Mumbai, Maharashtra, India). PCV was found out by centrifugation (REMI Centrifuge, Catalogue No.C8527/94, Serial NO. GCLC-1632, REMI Motors, Bombay, Maharashtra, India) of blood at 3,000 rpm for 15 minutes [16]. Total erythrocyte count (TEC) and total leukocyte count (TLC) were calculated by using the Neubauer's counting chamber. Erythrocyte indices like, mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), and mean corpuscular haemoglobin concentration (MCHC) were determined from the values obtained from the haemoglobin concentration, packed cell volume (PCV) and red blood cells (RBC) count [17].

MCV expresses the average volume of the individual RBC.

MCV (fl) =PCV/ Erythrocytes count ×10

MCH expresses the average weight of haemoglobin in the erythrocyte.

MCH (Pg) = Haemoglobin/ Erythrocytes count ×10

MCHC indicates the percentage of the MCV which the haemoglobin occupies.

MCHC (%) = Haemoglobin / PCV ×100

For each parameter, Mean±SE were calculated by using Microsoft Office Excel 2007. For comparison of mean, statistical analyses were undertaken by Paleontological Statistics (PAST) version 2.17 [Natural History Museum, University of Oslo] for One-Way Analysis of variance (ANOVA) followed by Turkey's pair wise comparison tests. Differences were classified as significant at P<0.05 and highly significant at P<0.01.

Results and Discussion

The value of erythrocyte and leukocyte parameters with respect to seasons is found out (Table 1). Among three seasons, the highest and the lowest mean hemoglobin concentration are recorded in winter and summer season respectively. The highest average total erythrocyte count and PCV have been observed in winter and summer season respectively while the lowest values are recorded in rainy and winter season respectively. The average MCV is recorded to be the highest during summer season when the weather is hot and dry. It is moderately high during the humid rainy season and lowest during the winter season. However, the average MCH is calculated to be the highest in rainy and lowest in winter season. The highest and the lowest MCHC are recorded in winter and summer season respectively. For concentration of hemoglobin (g/dl), no significant differences were observed among the three seasons (Table 1). For total RBCs count, highly significant difference (p<0.01) exists between winter and rainy season and highly significant difference (p<0.01) between winter and summer season are recorded. For PCV no significant difference was there among the three seasons. The mean \pm SE (range) of the packed cell volume 40.62 \pm 1.89 to 45.71 \pm 2.96 of emu, which is congruent to the findings of Dunan et al [17] comparing to all the seasons. For MCV, winter season has significant difference (p<0.05) with summer season and no significant difference was observed in rainy season.

Figures in parentheses are number of observations. Mean \pm SE with same superscript in the same row differ significantly (p<0.01)**, (p<0.05)*, Not significant (NS)

For MCH, winter season has significant difference (p<0.01) with rainy season. For MCHC, highly significant difference (p<0.01) is there between winter and summer season. The highest and lowest total leukocyte counts are recorded in rainy and winter seasons. The value of haematology and blood chemistry amongst species of free-ranging tropical pelagic sea birds varies with age, sex, season, and inland of collection [18].

In juvenile ostriches, the total RBC count and haemoglobin percentage is lower than adults. In raptors, the packed cell volumes are constant [19]. The RBC vaues are significantly higher in the winter and PCV values are significantly higher in rainy season. It seems the lower ambient temperature but higher environmental humidity in the rainy seasons favored higher food intake with the consequent higher haematological values in the rainy seasons than the summer season [20]. WBC count is significantly lower in winter than summer, and rainy respectively. In case of Mallard duck and the Canvasback duck, the higher leucocyte counts during the summer than during the winter matches with the study of [21]. The WBC value in the summer season is observed in the study are similar with the work of Shave and Howard [22]. Increasing value of PCV and MCV depends on temperature and storage duration [23]. In flightless bird like ostrich, the high value for total erythrocyte count, packed cell volume, and haemoglobin concentration might indicate that a high oxygen capacity enables these birds to run at speed as compared to other fast animals [24]. An increase in PCV value is probably due to its higher growth rate, metabolic activities and production of gonadotropins, sex and metabolic hormones [25]. Males have high EI than females and these differences are higher in rainy season. No significant difference is found in temperature, body weight, and all haematological parameters which are measured in two sexes of emu [26]. The significant higher MCV values (Fig. 2) during the summer and rainy season in the present study may be due to the higher ambient temperature and lower relative humidity during the summer season compared to the higher relative humidity and lower ambient temperature during the rainy season. This might have resulted in changes in water content of the blood and blood viscosity due to the decrease in evaporative cooling. This might have caused haemoconcentration, which results in the relative higher MCH and MCHC [27]. Stress leads to reduction in number of erythrocyte, content of haemoglobin, and haematocrit value [28,29].



Fig. 1: Emu (Dromaius novaehollandiae)

Table 1: Influence of haematological parameters among three different season

Sl. No	Blood Parameters	Winter (n=10)	Summer (n=10)	rainy (n=10)	F Value
1	Hb (%)	15.36±0.68 ª	12.66±0.76 ab	14.72±0.72 ^b	6.39**
2	RBC(millions/mm ³)	2.28±0.12 ^a	1.59±0.12 ª	1.52±0.12 ª	11.02**
3	PCV (%)	45.71±2.96	44.02±3.04	40.62±1.89	1.34NS
4	WBC(thousands/mm ³)	14.07±1.21 ª	16.21±1.39	19.95±2.26 ª	3.21*
5	MCV (fl)	203.42±13.83 ª	305.264±28.55 ª	284.69±30.40	4.53*
6	MCH (pg)	68.43±3.51 ª	83.80±8.36	101.42±8.74 ª	5.14**
7	MCHC (%)	34.14±1.28	28.48±2.21 ª	36.63±2.03 ª	4.87**

Figures in parentheses are number of observations. Mean \pm SE with same superscript in the same row differ significantly (p<0.01)**, (p<0.05)*, Not significant (NS)



Fig. 2: Comparision of haematological parameters in three different seasons

Future Perspective

Blood profile plays an important role in mainlining the health status of the birds and it is significantly influenced by seasons, so it is suggested that a complete haematological profile with respect to age, sex, egg-laying, feed, environmental condition along with morphology, blood cell morphometry, and biochemical parameters may be analysed and interpreted in detail.

Conclusion

The haematological data obtained in the study can be considered as preliminary reference value which will be helpful for poultry production. Further, blood profiling is helpful in detecting health issues, parasitism, subclinical metabolic conditions, erroneous feeding practices, and welfare of emus, thereby enabling changing conditions to be diagnosed early. The findings from this study show that seasons show significant differences on most of the haematological parameters. The present study can provide a basic haematological profile for further study.

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Compliance with Ethical Standards

Conflict of Interest

The authors declare that we have no conflict of interest.

References

- 1. Shendare RC, Gongale MA, Rajput AB, Mandlekar SM. Vet World 2007;5(9):303-304.
- 2. Burton M and Burton R. Funk and Wagnalls Wildlife, Inc., New York,1990;6:703-704.
- 3. Geneser F. Textbook of histology. Denmark: Munksgaard, Copenhagen, 1986.p.335-352.
- Bamishaiye EI, Muhammad NO, Bamishaiye OM. Haematological parameters of albino rats fed on tiger nuts (Cyperus esculentus) tuber oil meal-based diet. Int J Nutr Wellness 2009;10(1):97-98.
- Klinkon M, Zadnik T. Dynamics of red and white blood picture in dairy cows during periparturient period. Comp Haematol Intern 1999;9:156-161.
- 6. Hinton M, Jones DRE, Festing MFW. Haematological findings in healthy and diseased rabbits, a multivariate analysis. Lab Animal 1982;16:123-129.
- Fairbroather A, Craig MA, Walker K, Louglin DO. Changes in mallard (*Anas platyrhynchos*) serum chemistry due to age, sex and reproductive condition. J Wildl Dis 1990;26:67-76.
- Maxwell MH. Avian blood leucocyte responses to stress. World's Poul Sci J 1993;49:34-43.

- 9. Campbell TW. Hematology, Avian medicine Principles and Application. Ritchie LR, Harrison BW and Harrison GJ Ed. Wingers Publishing Inc. Lake Worth, FL 1994.p.176-198.
- 10. Kral I, Suchy P. Haematological studies in adolescent breeding cocks. Acta Vet Brno 2000;69:189-194.
- Moniella G, Bovera K, Sonilas IL, Piccolo G, Pinna W, Nizza A. Effect of age and blood collection site on the metabolic profile of ostrich. S Afr J Anim Sci 2005;35:267-171.
- Bertoni G, Piccioli CF, Baldi F, Borghese A, Duranti E, Falaschini A, Formigoni A, Grasso F, Lacetera N, Lupi P, Meluzzi A, Pinna W, Rosi F, Stanon B, Zicarelli L, Bernabucci U, Campanile G, Moniello G, Trombtta MF Guidaalla inter pretazionedei profile metabolici in zootecnia. Prog Nutr 2000;2:51-76.
- Coles EH. Avian hematology and blood chemistry. In: E. H. Coles (Ed.) Veterinary Clinical Pathology. 4th edn., WB Saunders Company, Philadelphia 1986; 291-300.
- 14. Sahil H. Lehrbuch d.klin. Untersuchungen Methode, 5th edn. Leipsic 1909.p.846.
- Mcinroy RA. A micro-haematocrit for determining the packed cell volume and haemoglobin concentration on capillary blood. J Clin Pathol 1953;7:32-36.
- Duncan JR, Prasse KW, Mahaffey EA. Erythrocytes. In: Duncan JR, Prasse KW, Mahaffey EA (eds). Veterinary laboratory medicine. Clinical pathology.3rd Ed. Iowa State University Press, Ames, 1994.p.3-36.
- 17. Kumar BK, Swapna E, Lakashman M, Reddy VR, Reddy. A Haemato-biochemical observations in emu (*Dromaius novaehollandiae*). Indian J Vet Pathol 2009;33:238-239.
- 18. Work TM. Weights, haematology and serum chemistry of seven species of free ranging tropical pelagic sea-birds. J Wildl Dis 1996;32(4):643-657.

- Smith EE, Bush M. Haematological parameters on various species of Strigiformes and Falconiformes. J Wildl Dis 1978;14:447-449.
- Abelenda M, Nava MP, Fernandez A, Alonso JA, Alonso JC, Muniz-Pulido R., Bautista LM, Puerta ML. Blood values of common crane (*Grus grus*) by age and season. Comp Biochem Physiol 1973;104:575-578.
- 21. Shave HJ and Howard V. A hematologic survey of captive waterfowl. J Wildl. Dis 1976;12:195-201.
- 22. Olayemi FO, Ojo EO, Fagbohun OA. Comparative study of the haematological and plasma biochemical parameters in the Nigerian duck (*Anas platyrhynchos*) and the Nigerian laughing dove (*Streptopelia senegalensis*). Vet. Archive 2006;76:145-151.
- 23. Hadzimusic N, Katica M, Muharemovic Z, Musanovic I. Effect of temperature storage on haematological parameters of avian turkey blood. Int J Col Res Intern Med Pub Health 2010;2(5):158-166.
- 24. Palomeque J, Pinto D, Viscor G. Haematologic and blood chemistry values of the Masai ostrich (Struthio camelus). J Wildl Dis 1991;27:34-40.
- 25. Atwal OS, McFarland LZ, Wilson WO. Hematology of *Coturnix* from birth to maturity. Poult Sci 1964; 43:1392–1401.
- Menon DG, Bennett DC, Schaefer AM, Cheng KM. Haematological and serum biochemical profile of farm emu (*Dromaious novaehollandiae*) at the onset of their breeding season. Brit. Poultry Sci 2013;92:935-944.
- 27. Olayemi FO, Arowolo ROA. Seasonal Variations in the Haematological Values of the Nigerian Duck (*Anas platyrhynchos*). Int J Poult Sci 2009;8(8):813-815.
- 28. Yadav S, Hurwitz S. Induction of thermotolerance in male broiler chickens by temperature conditioning at an early age. Poult Sci 1996;75:402-406.
- 29. Yadav S. The effect of constant and diurnal cyclic temperatures on performance and blood system of young turkeys. J Therm Biol 1999;24:71-78.

Preliminary Survey on the Primary Fishermen Co-Operative Societies (PFCS) of Murshidabad District of West Bengal

Bhaskar Mahanayak*, Subhasree Chakraborty**, Ashis Kumar Panigrahi***

Abstract

Fishery sector has high potentiality in our country. The fishery resources are very rich in West Bengal which is one of the leading fish producing states in India. Fishery cooperatives are developed in this state in the line of Indian cooperative movement. West Bengal occupies 4th rank as per the number of PFCS in India. Among the Districts of West Bengal, Murshidabad has the highest number of PFCS. A primary survey has been done in this district on the functioning of PFCS. The survey finds very grim picture about the performance of the co-operatives in the district. The suggestive measures for the improvement of PFCS in Murshidabad District have been proposed in this paper.

Keywords: Fishery; PFCS; Murshidabad.

Introduction

Our country stood second in fish production in the world after China. Fishery sector is very important in Indian economy and this sector contributed 0.92 % share to Indian GDP during the 2013-14 financial year. This sector can generate large scale employment, particularly in rural areas and may help in poverty alleviation.

The potentialities of Indian fishery is huge both in freshwater and marine sector, a major part of which is still remain in untapped condition. Fish is a good source of protein which has significant role in ensuring food security in 21st century. As the global population is increasing rapidly, there is an urgent need to increase the production of fish and other aquatic eatable animals for feeding the large number of people throughout the world.

Materials and Methods

The basic approach of the study is to collect data from primary sources by field surveys and secondary data from reports of Govt. of West Bengal and India and also from published articles in scientific journals. The data has been analyzed using statistical tools. Author's Affiliation: *Assistant Professor, Dept. of Zoology **Assistant Professor, Dept. of Economics, Berhampore Girls' College, Berhampore, Murshidabad, West Bengal 742101 India. ***Professor, Dept. of Zoology, University of Kalyani, Kalyani, Nadia 741235, India.

Reprint's Request: Bhaskar Mahanayak, Assistant Professor, Dept. of Zoology, Berhampore Girls' College, Berhampore, Murshidabad, West Bengal 742101, India. E-mail: bmahanayak@gmail.com.

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Meaning and Concepts of Fishermen Cooperatives

A co-operative is an autonomous association of persons united voluntarily to meet their common economic, social and cultural needs and aspirations through a jointly owned and democratically controlled enterprise.

As the fishermen generally comes from weaker sections of the society, they lack necessary monetary resources, knowledge of technological advancements and organizational capacity required for better fish production, storage, processing and marketing. Due to low income, they usually borrow money from fish merchants at high rates of interest. Thus, there is a vicious circle of indebtedness fostering exploitation. Formation of fishermen co-operative society can solve all these problems and fishermen in different countries have adopted the co-operative system of working to improve their fisheries all round as well as develop their socio-economic condition.

History of formation of fishermen co-operative societies

- a. The modern co-operative society has its roots in England, when it started in 1844.
- b. The fishery co-operative movement in India began in 1913 when the first fishermen society was organized under the name of "Karla Machimar (Fishermen) Co-operative Society" in Maharashtra.
- c. The State of West Bengal was the next to organize cooperative societies in fishery sector in 1918.

Functions of fishermen Co-operative Societies

- a. Providing financial loan to fishermen as and when needed.
- b. Making available banking facilities for receiving financial deposits.
- c. Transport, processing, storage, and sale of fish catches.
- d. Propagation and conservation of fisheries resources on scientific lines.
- e. Establishment of facilities and supply of goods necessary for the fisheries.

- f. Activities for the prevention of disasters, disaster relief and boat insurance.
- g. Activities for education and dissemination of information related to fisheries.

Organizational structure of fishermen Cooperative Societies

In West Bengal the fishermen Co-operative societies are arranged in three tier system as follows:

- a. An Apex Federation at State Level called Benfish.
- b. Central Fishermen cooperative societies at District level
- c. Primary Fishermen cooperative societies at village level.

Fishermen co-operatives in west Bengal

West Bengal is the 2nd state in India, which formed fishermen cooperatives in 1918. Since then, a large number of fishermen co-operatives are formed in West Bengal involving about one lakh fishers who are mostly belong to socially, economically and educationally backward community.

*The following table shows the number of fishermen co-operative societies (Inland and Ornamental) in West Bengal as on 31.03.2016**

Sl. No.	District	District CFCS PFCS Category		,	Total	Effective water area	Total number of members	
			Α	В	С		(in ha)	
1	Darjeeling	0	1	0	2	3	3	400
2	Jalpaiguri	1	0	15	0	15	431	4000
3	Cooch Bihar	1	37	12	15	64	3414	14073
4	Uttar Dinajpur	1	0	0	22	22	134	5000
5	DakshinDinajpur	1	12	0	0	12	156	5796
6	Malda	1	75	13	5	93	3188	14671
7	Murshidabad	1	24	13	76	113	21425	19312
8	Nadia	1	39	31	27	97	7760	13056
9	Birbhum	1	11	3	24	38	619	814
10	Bardwan	1	22	8	28	58	222	4611
11	North 24 Parganas	1	44	14	14	72	1727	8526
12	South 24 Parganas	1	36	28	38	102	966	3512
13	Hooghly	1	15	7	14	36	202	2115
14	Howrah	1	13	0	0	13	121	738
15	Purulia	1	0	0	49	49	6527	5919
16	Bankura	2	4	6	11	21	43	2630
17	PurbaMedinipur	1	32	26	11	69	2070	2477
18	PaschimMedinipur	1	19	6	4	29	93	4997
	Total	18	384	182	340	906	49101	112647

*Source: Hand Book of Fisheries Statistics 2015-16, Govt. of WB.

In Marine Sector Fishermen co-operative societies in West Bengal as on 31.03.2016 are as follows*

Sl. No.	District	CFCS	PFCS Category		Total	Effective water area	Total number of members	
			Α	B	С		(in ha)	
1	South 24 Parganas	1	16	0	0	16	5730	
2	PurbaMedinipur	1	7	6	52	66	4135	
	Total	2	23	6	52	82	9865	

*Source: Hand Book of Fisheries Statistics 2015-16, Govt. of WB.

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Comparative account of fishermen Co-operatives in West Bengal and other states of India

In India, there are over 18 thousand of functional primary fisheries co-operative societies having a membership of around 3 lakh fishers in the country. The data which found in the website of Natioal level federation of fishermen co-operatives (FISHCOPFED) is somewhat different from the data found in Hand Book of Fisheries Statistics 2015-16, Govt. of WB. As per FISHCOPFED survey data, Telengana has highest number of fishermen cooperatives followed by Maharashtra. West Bengal occupies 4th rank as per the number of fishermen cooperatives in India, but the total number of members under the PFCS is very low in West Bengal in comparison to other states of the country. The graphical representation of Fishermen co-operatives of five leading states of India as per FISHCOPFED data, is given below-



Fishermen Cooperatives in Murshidabad District

Among the district wise impounded fresh water area, Murshidabad with 28,348ha, is the 3rd highest in West Bengal, after South 24 Parganas, with 49,237 ha &Burdwan with 31,180 ha. Number of rivers in the district is 14 covering total length of 912 km & number of canals -914 covering 2138 km.No. of water bodies in the district is (05 acre & above)-122 with the area of 7,751 ha. Total fish cultivable area in the district is 20,599 ha. In Murshidabad, number of fishing village is 109 where 21,673 families live. The total fisher folk population of the district is 3,53,174; most of whom belong to socially and economically backward scheduled caste category. This district has the highest number of fisher folk population in SC category in West Bengal

Murshidabad has highest number of primary fishermen co-operative societies (113) in west Bengal involving 19,312 members who are engaged in fish production covering an area of 21,425 ha. The number of water bodies with an area of 5 acre or above, under the control of PFCS in Murshidabad is 118 having the total water area of 7316.73 ha. The primary survey of the PFCS in the district reveals the following facts

- 1. Most of the co-operatives in the district are found in moribund condition with very low production.
- 2. All (12 No.)Ornamental fishery PFCS in the district are non-functional at present condition.
- 3. Three Co-operative Societies of the district namely, Bhakuri Matshyajibi Samaboy Samity, Agragami Beel Bishnupur F.C.S, Katiganga-Manindranagar F.C.S. are found in proper functioning condition out of the 113 PFCS in the district.
- 4. The system adopted by the PFCS for production of fish is mostly traditional catch of fish with old type fishing crafts and gear.
- 5. No PFCS is successful in production of fish seed by induced breeding process.
- 6. There is no system of cold storage run by the PFCS and total catch is daily sold in the local markets.
- 7. Most of the fishermen members are compelled to adopt other profession including daily wage labour or rickshaw puller as full mandays are not created in the PFCS throughout the year.
- 8. Effects of Anthropogenic pressure and Pollution, particularly due to untreated sewage have been observed in the water bodies managed by the PFCS.
- 9. Some fishers also complained of undesirable political intervention as the cause of malfunctioning of PFCS.
- 10. Lack of knowledge of modern aquaculture has been observed among the members.
- 11. One unit of cage culture has been constructed but no production has been made due to lack of appropriate knowledge.
- 12. It has also been found that PFCS are unable to participate in the auction of large water bodies due to lack of funds.

Conclusion

In West Bengal, fishery is a sunrise sector and many scopes are there for its improvement. Nearly one thousand primary fishermen cooperative societies with over one lakh fishermen as member can play vital role in production of fish and other economically important aquatic organisms. The facts revealed by the primary survey in Murshidabad district of West Bengal where highest number of fishermen Cooperatives exist, are highly frustrating in nature. So, there is a need to change the management policy of the PFCS to make the cooperatives more dynamic in culture and production of fish with advanced knowledge in this field. Education and training are also required to test the water and soil quality parameters, prevention of fish diseases and control of pollution. Undesirable political intervention need to be stopped in the functioning of PFCS. Increase in the access to credit facility is also required. There is a need to change the existing co-operative law to make the cooperatives most conducive to market driven economy. Participation of women in large number in the regular functioning of cooperatives may improve the gender inequality and quality of management of PFCS

References

 Chandrashekar, B.S. Fishery Co-Operative Societies in India: Problems and Prospects. Global Journal for Research Analysis, 2014;3:92-94.

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- 2. Das R.C. & Behera D.K. Environmental Science, Principles & practice. PHI Pvt. Ltd., New delhi
- FAO. Increasing the contribution of small scale fisheries to poverty alleviation and food security. FAO technical guidelines for responsible fisheries No-10 Rome. 2005.p.79. www.fao.org/docrop/005/ y7300e.htm
- FAO. Report of the Global Conference on small scale fisheries: Bringing together responsible fisheries and social development fisheries & aquaculture report No-911 Rome. 2009.p.189. www.fao.org/docrop/012/ i1227t.pdf
- FAO ad IFAD. Cooperatives in small scale fisheries: enabling success through Community empowerment. 2012. http://social.un.org/ coopsyear/2012.
- 6. Gupta S.K & Gupta P.C. General and Applied Ichthyology, S chand& co Ltd. New Delhi. 2016.
- 7. Handbook of Fisheries statistics 2015-16 published by dept. of fisheries, Govt. of West Bengal.
- Jhingran V.G. Fish and fisheries of India, Hindustan Publishing corporation, New Delhi. 1982.
- Mishra B.K. Fisheries Co-operatives in India, international Cooperative information Centre, 1997 May -Aug;7(2).
- 10. NCUI. Indian cooperative movement- a statistical profile, New Delhi. 2012.
- 11. State agriculture plan 2015 published by dept. of agriculture in association with NABARD, Govt. of West Bengal.
- 12. Zade S.B. Principles of Aquaculture, Himalaya Publishing House, Mumbai. 2011.

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A Comprehensive Review on the Socio Economic and Technological Profile of River Side Fishermen Community in India

A. Bakshi*, A.K. Panigrahi**

Abstract

Pollution is, undoubtedly, the most frightening issue of concern among all recent environmental hazards. It has been established that aquatic ecosystem is mostly harmedby the impacts of pollution among all the types of ecosystems in India. Loss of aquatic diversity, to be more precise, loss of fish diversity is one of the commonest consequences of pollutionin aquatic environment. It casts serious threatto the human society mostly to those whose occupations are directlyrelated to rivers, pond or other waterbodies eg., fishers, fish dealers etc. It has been reported several authors that more or less all the riversof this planet are being threatened y gradual degrading ecological conditions. Since, the productivity, especially fish yield, has decreased alarmingly, fishers, dependenton this riverfor long, are on the verge of altering their occupationin most cases affecting the total socio-economic structure of the riverside society. To develop the fishing industry a comprehensive knowledge on presents ocio economic condition of the fishermen community and their knowledge dispersal strategies should be reviewed. In orderto this, attempts have been done to preparea comprehensive review on the aforesaid topic.

Keywords: Socio Economic Structure; Fishermen Community; Knowledge Dispersal; Pollution; Diversity.

Introduction

Riverhas been casting a deep impressionon the livelihood of the riversided wellers since years. Naturally, disturbances of the riverimpose adverse impact on the societies dwelling the riverine area. For this, studies on socio-economic structure of the riverside villages seem to be inevitable to find the complete impact of pollution riverand the effect that inflicts on the society. According to Bhaumikand Pandit (1994), various parameters for determining socio-economic status of any society such as age, caste, education, occupation, social participation, income, experience, farm size of fishers, are said to be positive and significantly correlated with attitude towards fish farming.

Here, age and experience, income, caste distribution, education, alternateoccupation options and knowledgedispersalof fishers have been investigated to drawa clear idea about impact of river on the socio-economic structure of any river sidearea.

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Author's Affiliation: *Ex- Research Scholar, Ecotoxicology, Fisheries and Aquatic Extension Laboratory **Professor, Department of Zoology, University of Kalyani, Kalyani, West Bengal 741235, India.

Reprint's Request: A.K. Panigrahi, Professor, Department of Zoology, University of Kalyani, Kalyani, West Bengal 741235, India.

E-mail: panigrahi.ashis@gmail.com

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Age of the Fishermen

According to Librero (1985), most of the fishermenuse to spend about half of their life in fishing in Philipines. They also reported that fishermen spend an average of 211 days per year. It reflects the fact that fishermen usually rely only on the productivity of adjacent aquatic system throughout their life. Bhaumik and Pandit (1994) studied on the age of fishermen at some beels of West Bengal. According to them, most of the fishermen are engaged in fishing varied through a range of 18-62 years of age. Dutta Roy (2012) and Panigrahi and Bakshi (2014) have reported the same pattern of age distribution of the

fishermen from different harvesting sites *i.e.*, artificial (Ornamental fish farm) and natural Churni (river).

Caste of the Fishermen

In India, a number of micro level studies have been led by different Governmental agencies, Government personnel and researchers to describe the socioeconomic condition of the fishermen family and the fact has been reported that all the families in riverside areas are not found to be associated with fisheries activities. Only 62.1% from fishermen communityand 29.9% from other communities being found involved in fishing duringa study on river Churniside areas (Bakshi, 2016). These have been reported as Government articles in various journals. Halder *et al.*, (1988) reported that the fishermen majority belongs to "Scheduledcaste" community villages of West Bengal.

Central Inland Capture Fisheries research Institute'CICFRI' (1990) has done a commendable work related to sociological survey of the fishing families of the Narmada river. It was reported that fishing families beside Narmada river comprise of 31.0% "Schedule caste" families, 1.5% "scheduletribe" families, 63.6% families of the "other communities" whereas, 3.9% fishers have been reported as non-respondents. Bhaumik and Pandit. (1994) conducted similar investigation son some beels of West Bengal and found that majority of the fishermen belongs to "schedule caste" community.

Educational Qualification of the Fishermen

All rounddevelopmentof any society is achievedbasicallyby the invasionof knowledge and education. Likewise, proper knowledge on fishing and gears ensures better economic growth of any fishermen society. However, most of the fishermen are basicallyfoundto be illiterateor merelyhave primaryeducation.

Valiakandathil(1970) has studied on socioeconomic condition of the fishermenof Keralaand reported that literacyrate recorded for Poonthuria, a fishing villageof Keralawas only 22.7% that was dominatedby primaryeducated fishermenand 14.7% for Balusutippa, a fishing village of Andhra Pradesh.

According to a report by Mammen(1984), in Keralaamong all the fishermen, only 1.94% have been found to be SSLC qualified, 0.2% graduates, 0.2% postgraduates. During the study, Panigrahiand Bakshi (2014) have also reported the fact that illiteracy is the basic problem of the under survey area.

Income of the Fishermen Family

Bhaumikand Saha (1994) studied on the income and its sources for the fishermenat Sundarban. They reported that main source of income of fishers is fishing. Siddiqui (1996) specified that income of fishermenis usually depending upon the catches of the fishes obtained from voyage to voyage and theirmarketing.In a separate study, it has been foundthat fishermencommunityis mainly distressed, mostly lackingin education withlow income level (Akhtar, 1995). The fishermenhave been found to be involvedin collection of seed and repairing of boats as well as weavingnets duringtheirleisure time. Duringfishing season they have been found to be fullyengaged in fishery activities but duringoff season they have to exploreal ternative occupation opportunitieslike honey collection, fire wood collection and agriculturalactivities for their livelihood. Fishers of our study area have also been found to battle against poverty due to ecological degradation of the riverPanigrahi(and Bakshi, 2014).

Fishermen and Alternate Occupational Options

The fish diversity of the aforesaid river has been facing the threat of declination since years (Das and Chakrabarty, 2007). Fishing and fish marketing cannot be the only option for the fishers of river Churnias the productivity of the river is said to be declining (Das et. al., 2007). In some beels of West Bengal, Panigrahiet al., (2015) have reported that ecological condition of any river system cast direct impact on fishers' economic condition.Panigrahiand Bakshi (2014) have found that ecological degradation and less productivity of any river system pose adverse impact on riverside economy stressing fishers to alter their soul occupation, fishing. Bhaumikand Pandit (1994) found that the fishermen cannot undertake fishing round the year owing to observation of conservation measure for which they engage themselves for alternative job for their livelihood. They observed that most of them earn between 401- 500 per month followed by Rs. 301-400. It was reported that the income of fishermen during off-season varies between Rs. 201-300. Basavakumar et al. (2011) described fishermen groups as full time, part time and occasional during a survey in Karnataka. Thus, it is not very astonishing fact that fishers usually have to opt for other occupations during unproductive or less productive period to sustain their normal livelihood. The same division among the fishermen community has been reported by Bakshi and Panigrahi (2012) with no exception in case of River Churni, West Bengal based fishing community.

Knowledge Dispersal Strategy of Fishermen Society

The attitude of inland fisherman community towards cultural and social activities can be understood by determining their level of interest in reading newspapers, listening to radio, watching television programmes and attending other socio cultural programmes.

A study has been conducted in a village of Dharwad district, Karnataka to construct the sociological status of fishermen by Basavakumar et al. (2011). The study has revealed that 69.18 percent of the fishers' population listened to radio programmes regularly and 26.16 percent occasionally. Onlya small portion of the population(4.65%) never listened to radio. With regard to specific krishi programmes like "krishiranga", it was found that 44.44 percent of fishermen are regular listeners. Since all the families are located in a single colony, there is very good interaction among them about agricultural and fishery programmes broad casted by the All India Radio (AIR) and the recently launched Krishi Community Radio (KCR) FM 90.4. In Dharwad district this Radio Channel is exclusively known for broadcasting programmes in regional language on agriculture and allied sciences. Pattanshetti (2010) has reported that the programmes broadcast by krishi community radio (KCR) are increasingly becoming popular. Beegum (2006) has reported in a separate study that 16.02 percent of the fisherman population listened to radio, while 7.97 percent watch TV programmes related to fishing knowledge in Kerala. Panigrahi and Bakshi (2014), during the survey of some fishers' villages in Nadia district have reported about one third of total respondents (36.25%) as regular listener to TV or radio programmes whereas majority of the respondents have been found to be occasional in this manner. In case of newspaper reading, maximum numbers of respondents (45%) have been found hardly interested. Though, active participation in socio-cultural gatherings has been found to be rare in case of major respondents (42.08%), they often attend the gatherings.

Fishermen and their Living Habits

Study has been revealed that most of the fishermen in Narmada Basin live in very poor housing conditions. Majority of the fishermen there live in huts made of mud; few of them also have houses made of cement and bricks (Sharma *et al.*, 2010). An investigation has revealed that smoking, betel-nut chewing and use of liquor were the common habits among all adult fishermen and fisherwomen in Dharwad district, Karnataka. This has also been found that though economic and social restrictions have been imposed there on the use of liquor, 84.21 percent of family heads take liquor regularly and remaining population take liquor occasionally along with smoking habit. The pan chewing habit is found to be regular among adult fisherman Basavakumar (*et al.*, 2011).

Fishermen and Fishing Crafts and Gears

Deficiency of proper equipment or instruments related to fish cultures has been found to hamper the socio-economic growth of fishermen (Sharma et al., 2010). House, fishing gears, agricultural and, household articles, cattle, sheep, poultry etc. are consideredas assets of fishermen family (Basavakumar et al. 2011). In a survey in Kerala, Basavakumar et al. (2011) estimated that the type and number of gears ownedby the families have direct impact on the income earned by each individual. The Number of gears owned by the family has been found to differ with the number of fishermen attending fishing works. In Dharwad district nearly 43.85% of families own 1-2 gears and 29.82 per cent of families own 3-4 gears. Remaining families own more than fourgears. Most commonly used gears by all fishermen are cast nets and gill nets of varying mesh sizes. Most of them make their own nets. As these two nets are not specific for any individual species, all varieties of fish get caught in these. Sharma et al. (2010) found that most used nets in Narmada Basin by fishermen are Scoop nets, Cast nets, Hook-lines net, Drag-nets, Gill-nets among which gill nets are most common and abundant. Bakshi (2016) have reported that economic condition of the fishermen beside River Churni, West Bengal has not found to be so good that they can afford modern technical gadgets for the fishing and other purposes. Cast nets, handnets and gill nets are usually used to catch the fishes in these areas. Large nets are also used to construct traps with the help of bamboo which are also used for the catchment purposes. Most of them make their own nets.

Conclusion

Socio economic parameters such as age, caste, education, occupation, social participation, income, experience etc., of present India have been discussed in this article. The study has revealed that the fishers are mostly of middle-agedor old. Major part of the fishermen of India has been found to belong among the Scheduled cast , Scheduled tribe among OBC (Other backward community)-A& B. Several authors like Mammen (1984), Bhaumikand Pandit (1994), Bakshi (2016), Panigrahiand Bakshi (2014) have established the aforesaid statistics. The fishers are mostly illiterateor school drop outs in India. The similar statistics has been reported that fishermen community is mainly distressed, mostly lacking in education with low income level (Akhtar, 1995). Alteration of occupation opportunity is very common phenomena in Southern part of the country. It has been also reported that fishermen could not go for fishing round the year owing to observation of conservation measures and during that period they engaged themselves for alternate jobs for their livelihood (Bhaumikand Pandit, 1994). Review has been revealed that the income level of fishers is verylow aroundRs 5000-7000 possessing BPL (Below proverty level) rationcards. The investigations have revealed that smoking, betel-nut chewing, chewing of tobacco products and uses of liquor are most common habits among all adult fishermen and in some young also. Females of the familyare also addicted with betel-nut chewing or others. Chewing of Betel Leaves along with betel-nut has also been found to be very common to both men and women. It has been established that sociological and economical constrains have imposed on the use of liquor. A reporthas been shown that 65.41 percent of the fishermen beside river Churni take liquor regularly and most of the remaining population takes it occasionally along with smoking and other habits (Panigrahiand Bakshi, 2014). The attitude of the fishermen community towards the social and cultural activities have also been investigated with the help of some pre-tested parameters viz., reading of newspaper, listening to radio, watching television programmes, participating and attending socio-cultural gatherings etc. A very few percentage of fishers are found to be very much attached to the socio-cultural activities. A further development in present condition can only be brought about by introducing new culture practices of fish in natural water bodies. Bakshi et al. (2016) have recommended the practice of ornamental fishery in the lower stretch of the river Churni for further development of socio economy of fishermen community. The review will help to outline the possible strategies for the development offishers.

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Reference

- Akhtar N. Socio-economic setting and technological aspects of inland fisherman of Punjab. Proceedings of the second "Aquaculture" sponsored symposium held in Budapest, Hungary, 1995 Sept 6-9;123(1-4):478.
- Bakshi, A. Analysis of anthropogenic disturbances and impact of pollution on fish fauna of River Churni with special reference to Chromium pollution. (Doctoral Dissertation). Kalyani University, Kalyani, India. 2016.p.188.
- Bakshi., A., Panigrahi, A.K., Dutta (Roy), S., Mondal, A. Study To Identify The Potentiality of Ornamental Fish Farming Opportunities in the River Churni With Special Reference To Socio-Economic Growth of The Fishers. IJSR 2016 May;5(5). ISSN No-2277-8179.
- Bakshi. A, Panigrahi A.K. Studies on pollution load and its effects on the diversity of fish and fish food organisms in Churni River, West Bengal- A Survey. Environ. Life Sci. 2012.p.101-109. ISBN-81-85543-11-9.
- Basavakumar, K. V., Devendrappa, S., Srenivas, S. T. A study on profile of fishing community of a village in Karnataka J. Agric. Sci., 2011;24(5):684-687.
- 6. Beegum, S. Socio-economic condition of inland fisherman– A case study of Kerala, Ph.D Thesis, Mahatma Gandhi University, Kerala. 2006.
- Bhaumik U. and Pandit S.K. Socio-economic Status of fishermen in some beels of West Bengal. Environment and Ecology, 1994;9(3):600-603.
- Bhaumik, U. and Saha, S.K. Prospective on socioeconomic status of fishermen engaged in fishing in the estuarines of Sunderban. Environmentand Ecology 1994;12(1):181-185.
- Das S. K, Chakrabarty, D. The use of fish community structure as a measure of ecological degradation: A case study in two tropical rivers of India, Science direct BioSystems, 2007;90:188–196.
- Das S.K, Biswas D., Roy, S. Use of biotic community structureas measure of ecological degradation.2007. Chin J Appl EnvironBiol. ISSN- 1006-687X. 2007;13(5):662-667.
- 11. Dutta Roy. S. Studies on the present status indigenous ornamental fishes of West Bengal with special reference to protozoan diseases and it's control, PhD thesis, Kalyani University, 2012.p.30.
- 12. Halder, D.P., Bhaumik, V. and Pandit, P.K. (1988). In the villageof West Bengal fish mix with food.J. Indian farming. 1988;38(8):29.
- 13. Librero, A.R. Socio-economic condition of small scale fishermen and Fish farmer in Philipenes. International Research Development Centre, Philipenespp. 1985.p.229.
- 15. Mammen, T. Fishermen andfisherwomen in KeralaFishing. Chimes, 1984;4(5):19-25.

- 150
- A. Bakshi & A.K. Panigrahi / A Comprehensive Review on the Socio Economic and Technological Profile of River Side Fishermen Community in India
- 16. PanigrahiA K, Bakshi A. A study on profile of fishing community of the riverside villages of river Churni, Nadia, West Bengal with special reference to socioeconomic and technological appraisal of fishermen.

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Use of Earthworms for Sustainable Agriculture

Bhaskar Mahanayak*, Subhasree Chakraborty**, Ashis Kumar Panigrahi***

Abstract

Land degradation due to application of chemical fertilizers and pesticides is major impediment for sustainable agriculture. This can be prevented by the use of earthworm involving a technology called vermitechnology. Vermiculture, vermicompost, vermicast, vermibeds and vermiwash are the related terms of this technology. There is a long tradition of the awareness related to the beneficial effects of earthworms by the ancient naturalists. Earthworms have important roles in improving soil health and maintaining balance in soil ecosystem. The limitations of traditional chemical based agriculture can be overcome by the use of earthworm as a biotechnological tool. There are different ecotypes of earthworms and some are suitable for vermiculture. Method of vermicompost preparation involving vermitechnology has been described in brief and some precautionary measures needed in this case have also been mentioned. There are many experimental evidences which showed that vemicompost is highly beneficial for the soil health and growth of plants. The Problems and Prospects of vermitechnology in our country have also been discussed briefly.

Keywords: Earthworm; Vermitechnology; Vermicompost; Soil; Organic Fertilizer; Plant.

Introduction

Indiscriminate use of chemical fertilizers contributes largely to the deterioration of the environment through depletion of fossil fuels, generation of Carbon dioxide and contamination of water, air and land. Imbalanced use of chemical fertilizers leads to loss of soil fertility and produces adverse impact on agricultural productivity. In recent years, it has been realized that application of ecological and sustainable farming practices can only reverse the environmental degradation caused due to extensive use of chemical fertilizers (Aveyard 1998, Wani and Lee 1992, Wani et al. 1995). In normal condition, soil contains a number of micro and macro organisms that can convert organic waste into valuable resources containing plant nutrients which are critical for maintaining soil productivity. Earthworms present in the soil are very important biological organisms that maintain nutrient re-cycling in the soil and improve soil fertility. For this reason, Charles Darwin has rightly called earthworms as the "friend of farmers".

Author's Affiliation: *Assistant Professor, Dept. of Zoology **Assistant Professor, Dept. of Economics, Berhampore Girls' College, Berhampore, Murshidabad-742101, India. ***Professor, Dept. of Zoology, University of Kalyani, Kalyani, Nadia 741235, India.

Reprint's Request: Bhaskar Mahanayak, Assistant Professor, Dept. of Zoology, Berhampore Girls' College, Berhampore, Murshidabad Berhampore, West Bengal 742101 India.

E-mail: bmahanayak@gmail.com.

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Currently, a technology has been materialized using earthworm to increase soil fertility and to promote sustainable plant growth under Biotechnology Programme. This technology, involving earthworm for sustainable agriculture, is called vermitechnology.

What is Vermitechnology?

Vermitechnology is a biotechnological process in which certain species of earthworms are used to enhance the process of composting of organic wastes to produce a highly fertile, nutrient reach end product. This process is faster than the normal composting process. The organic waste passes through the digestive canal of earthworm. During this passage, transformation of wastes into organic manures takes place. The organic manures are released in the form of earthworm castings. These are rich in microbes, plant growth regulators and also have paste repellence attributes.

What is Vermiculture?

Collection, breeding and successful rearing of earthworm for generations in an artificial media or laboratory is known as vermiculture.

What is Vermicomposting?

Composting is the process of bioconversion of organic matter by heterotrophic microorganisms (bacteria, fungi, actinomycetes, protozoa etc.) into humus like material. The process of composting using earthworms to create a heterogeneous mixture of decomposing vegetables or food wastes, bedding materials, and vermicast is called vermicomposting.

What is Vermicast?

It is the end product of the breakdown of organic matter by an earthworm in its digestive canal and is released through the anus as ball of mud. It is also known as worm castings, worm humus or worm manure. These castings have been shown to contain reduced levels of contaminants and a higher saturation of nutrients than what organic materials do contain before vermicomposting. It contains water soluble nutrients, nutrient rich organic fertilizer and soil conditioner. This vermicast is an excellent bioorganic manure.

What is Vermibed?

It is the actual layer of good moist loamy soil placed at the bottom, about 150 to 200 mm thick above and a thin layer (50mm) of broken bricks and coarse sand below. Earthworms are introduced into the loamy soil, which the worms will inhabit as their home. About 100 earthworms are introduced into a compost pit with a vermibed. The vermibed should always be kept moist, but should never be flooded.

What is Vermiwash?

The seepage drained from the worm bed is especially valued, and is used in diluted form as foliar spray. This is called vermiwash. A decoction is made of one part vermicompost to ten or twenty parts water. This concentrated liquid fertilizer contains valuable amino acids and silicic acids. This strengthens the epidermis of the leaves and reduces damage by aphids and penetrating fungal spores. It can also be used in drip irrigation.

Historical Perspectives

Although vermitechnology has developed recently, but the beneficial activities of earthworm was observed by ancient naturalists. Aristotle called the earthworms the "Intestines of the Earth". Besides its role as soil health indicator, it also helps to improve and enrich the soil as earthworm move through it. Earthworms make tunnels in the soil causing air and water to pass through. As they form tunnels, they bring up nutrients from below and carry organic matter from the surface, mixing it into the soil.

Earthworm can consume organic matter equal to their own weight in each day. Charles Darwin in his 39 years of studying earthworms, found that in a healthy environment, earthworms can create as much as 36000 pounds of nitrogen rich castings per acre. Darwin first pointed out in his book "Formation of Vegetable Moulds through the Action of Worms" that earthworm castings bring to the surface 7-18 tons of soil per acre annually.

Limitations of Traditional Agricultural System

The remarkable limitations of traditional agricultural practices are given below:

- 1. Nowadays, agriculture has become chemical manure based.
- 2. Soil is losing its microbial nutrient potentials.
- 3. Water level of soil is going down.
- 4. Rabi crop production is seen to be reduced.
- 5. Agricultural programme has become pesticide dependent.
- 6. Soil chemistry is being changed day by day by losing its organic fertility.

To check the above mentioned adversities, vermitechnology has been introduced which not only adds natural manuring potentialities to the soil, it also serves other beneficial attributes.

Role of Earthworm in Improving Soil Health

In Agro Eco System

Earthworms are natural burrowers. They move from upper surface to deep in the soil making burrows

there. They devour soil with organic materials and liberate faeces or castings with decomposed manure. The castings are distinct, small, rounded pallets or balls leading to the porosity in the soil which helps water holding capacity, aeration and microbial growth in the soil. Again, the movement and feeding behaviour of earthworm provide soil formation and mixing of soil with mineral nutrients. It has been observed that in natural tillage system, the soil is digged upto 30cm. while earthworm performs tillage upto 3meters depth. Hence, earthworms are called natural tillers. Earthworm burrows present macro pores that provide low resistance channels for plant root growth, water filtration and gas exchange.

In Humification

Humus is a type of soil vermicomposting with organic matters like humic acid, humin, cellulose and hemi cellulose. The posture soil with earthworms is provided with casts which contains 73 percent nitrogen found in the ingested litter. The organic wastes whenever pass through the elementary canal of earthworm, the decomposition of the said matter takes place yielding the nitrogenous manure.

In Rapid Biofertilizer Formation

It has been found that earthworms convert organic matter into a compost or vermicompost within a short period. In natural process one ton organic decompost manure is produced in six months while the same amount of compost manure may be obtained by employing thousand earthworms within a month. Thus earthworms appear as unique biofertilizer agent and referred to as mini fertilizer plant.

In Eradication of Fungus Outgrowth

In apple orchards scrab fungus grows on litters accumulated near the plant over the soil surface. The scrab fungus grows up along with the spreading of pores on the plant twigs and leaves leading to the ill health of the plant. Litter feeding earthworm, by consuming the said litter prevent the growth of harmful fungus and enabling good health of plants.

Pollution Indicator

Earthworms are being recognized as indicators of agro ecosystem health and as important tools for ensuring soil improvement and efficient nutrient cycling. They are linked with the accumulation of organic matter in the soil leading to soil fertility. The existence of less number of earthworms in any agro ecosystem denotes the incorporation of pollutants in the soil. It is evident that a good number of herbicides, pesticides and inorganic fertilizers transform soil chemistry and reduce the growth and viability of the earthworms. Thus, earthworm count indirectly helps to access the stress condition of the soil.

Vermibreeds used in Vermitechnology

In vermitechnology, earthworms are employed to produce manure. Not all earthworm species are used for this technology. There are suitable breeds and nonsuitable breeds of earthworms found in nature.

Suitable Breeds for Vermiculture

Among the earthworms which live on the soil surface and thrive on organic wastes are called suitable breeds for vermiculture. Such worms possess the following features-

- i. They have wide range tolerance to environmental factors.
- ii. They are very much efficient to consume a greater biomass and convert them to an organic decompost matter.
- iii. They have rapid population growth.
- iv. They need less duration to complete life cycle.
- v. They are disease resistant.

Names of suitable vermibreeds are given below:

Sl. No.	Common name	Scientific Name
1.	Red wiggler	Eisenia foetida
2.	European Crawler	Eisenia hortensis
3.	Red earthworm	Lumbricus rubellus
4.	Blue worm	Perionyx excavator
5.	African night craw	Eudrilus engeniae

Non-Suitable Breeds for Vermiculture

The earthworm species which are deep soil dwellers are not recommended for vermiculture and are called non-suitable breeds for vermiculture. It includes the following species

Sl. No.	Common Name	Scientific Name
1.	Night crawler	Lumbricus terrestris
2.	White earthworm	Enchytraeus albidus

Ecotypes of Earthworms

Earthworms are divided into three groups called ecotypes. These three groups are Epigeic, Endogeic

and Anecic. Comparative accounts of these three groups are given below.

S1. No.	Epigeic	Endogeic	Anecic
1. 2.	Surface dweller Ingests large non-decompost litter.	Soil dweller(10 to 50 cm deep) Ingests large quantities of organic	Deep soil burrower (down to 2 meters) Ingests partially decomposed litter, manure and
	(Litter feeder	rich soil. (Soil feeder)	other organic matter. (Litter and soil feeder)
3.	Pigmented body.	Non pigmented body.	Dorsally pigmented body.
4.	Structurally small. (Adult 1 to 7 cm	Structurally optimum in length.	Structurally large.
	long)	(Adult 2 to 12 cm long)	(Adult 8 to 15 cm long)
5.	They do not make burrows	They make horizontal burrows	They make extensive vertical burrows
6.	Tolerant to resistance	Less tolerant	Less tolerant.
7.	Reproductive rate high.	Optimum.	Less
8.	Used in vermicomposting	Used in soil formation and aeration	Used in decomposition and nutrient cycling
9.	Colour red brown	Gray, blue and pink	Reddish-brown
10.	Major species take part in composting.	Do not take part in composting.	Limited species take part in composting.
11.	Example: Eisenia foetida.	Example: Allolobophora chlorotica.	Example: Lumbricus terrestris.

Methods of Vermicompost Preparation Involving Vermitechnology

A thatched roof shed preferably open from all sides with unpaved floor can be erected in east-west direction to protect the side from direct sunlight. A shed area of 12'x12' is sufficient to accommodate three vermibeds of 10'x3'each having 1' space in between for treatment of 9 to 12 quintals of waste in a cycle of 40 to 45 days. The length of the shed can be increased or decreased depending upon the quantity of waste to be treated and availability of space. The height of thatched roof is kept at 8' from the centre and 6' from the sides. The base of the site is raised atleast 6" above ground to protect it from flooding during the rains. The vermibeds are laid over the raised ground as per the procedure given below. The site marked for vermibeds on the raised ground is watered and a 4" to 6" layer of any slowly biodegradable agricultural residue such as dried leaves, straw, sugar cane trash etc. may be laid over it after soaking with water. This is followed by 1" layer of vermicompostor farm yard manure.

Earthworms are released on each vermibed at the rate of 1.5 kg per vermibed for treatment of cowdung or agriwaste or household garbage. The loaded waste is finally covered with a jute mat or banana leaves to protect earthworms from birds and insects. Water is sprinkled on the vermibeds daily according to requirement and season to keep them moist. They waste is turned upside down fortnightly without disturbing the basal layer. The appearance of black granular crumbly powder on the top of vermibeds indicates harvest stage of the compost. Watering is stopped for at least five days at this stage. The earthworms go down and the compost is collected from the top without disturbing the lower layers. The first lot of vermicompost is ready for harvesting after two months and the subsequent lots can be harvested after every six weeks of loading. The vermibed is loaded for the next treatment cycle.

Compost is harvested from the vermiculture operation when scraps of uneaten food are no longer visible. The harvesting process should ensure that adult worms are not lost in the process of harvesting the compost. The small lemon shaped cocoons of earthworm should also be returned to the system. One process for harvesting involves stopping the addition of food items on one side of the worm bin while continuing to add them to the other side of the bin. The worms will naturally migrate to the side of the bin where food is being added and allow the easy harvesting of the other side of the bin.

Precautionary Measures for Compost Making

- Temperature of the vermibed should be within the range of 20 to 30°C.
- Moisture level in the bed should not exceed 40to 50 percent. Water logging hampers normal activities of worms leading to weight loss and decline in worm biomass.
- 3. Earthworms should not be injured during handling.

- Vermibed should be protected from predators like
 red ants, white ants, centipedes and others like
- todes, rats, cats, poultry birds etc.5. Frequent observation of culture bed is essential as accumulated casts may cause retardation of
- 6. Space is the criterion for growth and establishment of culture.
- 7. Minimum space required is 2 m² per 2000 worms with 30 to 45 cm thick bed.
- 8. Mixture of cattle, sheep and horse dung with vegetable wastes forms ideal feed for worms. Addition of neem cake in small quantity enhances growth of worms.

Benefits of Vermicompost

growth of the worms.

Soil Quality

- Improves soil physical structure
- Enriches soil by addition of enzymes such as phosphatase and cellulose.
- Microbial activity in worm castings is 10 to 20 times higher.
- Attracts deep burrowing earthworms already present in the soil.
- Improves water holding capacity of the soil.

Plant Growth

- Enhances germination, plant growth and crop yield.
- Improves root growth and structure.
- Enriches soil with microorganisms and adds plant hormones such as auxins and gibberellic acid.

Economic Benefit

- Low capital investment and relatively simple technologies make vermicompost useful in less developed countries.
- Creates low-skilled jobs at local level.
- Bio-waste conversion reduces waste flow to landfills.

Environmental Benefit

• Elimination of bio-wastes from the waste stream reduces contamination of other recyclables collected in a single bin.

 Vermicompost production reduces greenhouse gas emissions such as Methane and Nitric oxide produced in landfills or incinerators.

Use as Fertilizers

- Vermicompost is an eco-friendly natural fertilizer prepared from biodegradable organic wastes and is free from chemical inputs.
- This fertilizer does not have any adverse effect on soil or plants.
- It promotes better root growth and nutrient absorption.

Some Experimental Observations about the Importance of Vermicompost

- 1. Sreenivas et al. (2000) studied the integrated effect of application of fertilizer and vermicompost on soil available nitrogen (N) and uptake of Ridge Gourd (*Luffa acutangula*) at Rajendranagar, Andhra Pradesh , India. Soil available nitrogen increased significantly with increasing levels of vermicompost and highest N uptake was obtained at 50% of the recommended fertilizer rate plus 10 ton/hectare vermicompost. Similarly the uptake of N, P,K and Mg by rice (*Oryza sativa*) plant was highest when fertilizer was applied in combination with vermicompost (Jadhav et al. 1997).
- 2. Growth promoting activity of vermicompost was tested using a plant bioassay method. The Plumule length of maize (*Zea mays*) seedling was measured 48 hours after soaking in vermicompost water and in normal water. The marked difference in plumule length of maize seedlings indicated that plant growth promoting hormones are present in vermicompost (Nagavallemma K. P. et al. ,2004)
- 3. The application of vermicompost gave higher germination (92%) of mung bean (*Vigna radiata*) compared to the control (84%). Further, the growth and yield of mung bean was also significantly higher with vermicompost application. In another experiment, it has been found that the fresh and dry matter yields of cowpea (*Vigna unguiculata*), were higher when soil was amended with vermicompost than with biodigested slurry (Karmegam et al. 1999, Karmegam and Daniel, 2000).
- 4. The efficiency of vermicompost was evaluated in a field study by Desai et al. (1999). They started that the application of vermicompost along with fertilizer N gave higher dry matter (16.2 g/plant)

and grain yield (.6 ton/hectare) of Wheat (*Triticum aestivum*) and higher dry matter yield (0.66g/ Plant) of the following Coriander (*Coriandrum sativum*) crop in sequential cropping system. Similarly, a positive response was obtained with the application of vermicompost to other field crops such as sorghum (*Sorghum bicolor*) (Patil and Sheelavantar, 2000) and Sunflower (*Helianthus annuus*) (Devi and Agarwal 1998, Devi et al. 1998).

- 5. Application of vermicompost at 5 ton/hectare significantly increased the yield of tomato (*Lycopersicon esculentum*) at the rate of 5.8 ton/hectare compared to control of 3.5 ton/hectare as observed in farmers' field in Adarsha watershed, Kothapally, Andhra Pradesh.
- 6. The fresh weight of flowers such as *Chrysanthemum chinensis* increased with the application of different levels of vermicompost. Also, the number of flowers per plant (26), flower diameter (6 cm) and yield (0.5 ton/hectare) were maximum with the application of 10 ton/hectare of vermicompost along with 50% of recommended dose of NPK fertilizer (Nethra et al. 1999).
- 7. Studies on vermicompost indicate that it increases macropore space ranging from 50 to 500µm in the soil, resulting in improved air-water relationship in the soil which favourably affects plant growth (Marinari et al. 2000). The application of organic matter including vermicompost favourably affects soil pH, microbial population and soil enzyme activities (Maheswarappa et al. 1999). It also reduces the proportion of water soluble chemical species which cause possible environmental contamination (Mitchell and Edwards, 1997).

Problems Associated with Vermitechnology

Maintenance of Moisture

Vermicompost always necessitates high moisture content in the vermibed which becomes a problematic task during summer season for the farmers associated with vermiculture.

Transport of Earthworms for Inoculation

For vermiculture seed earthworms should be carried to the site of culture. In winter season, it can be done safely. But in other seasons, transport of earthworms needs air-conditioned cars. If weather temperature is more than 15°C, the worms come out of the pack and on exposure to high temperature they die.

Escaping Tendency of Earthworms

Earthworms usually stay in the vermipit. During inoculation, the worms try to come out of the pit and to check such problem light is put over the pit so that they are further inserted in the pit. Such inconvenience may also develop during rainy season when external humidity is higher than the pit.

Prevalence of Bad Odour

Vermicompost site may lead to bad smell due to decomposition of excess feed stock of vermibed. The bad smell is due to release of ammonia gas.

Increased Fly and Rodent Population

As the vermibed is associated with kitchen wastes, several flies and rodents are attracted to the site. Such pest population is seen to be increased with vermiculture attached to domestic sites.

Prospects of Vermitechnology in India

In the late 1980s and 1990s agricultural scientists in the world realized the limitations of the chemical fertilizer used in agriculture. While on one hand research was initiated to improve the use and efficiency of chemical fertilizers, on the other hand alternative input were also considered.

Organic matter recycling has been in use in India for centuries. In 19th and 20th century, scientific methods for converting low valued organic matter into high valued organic compost were developed. The activities of earthworms for recycling of organic matter became the focus of attention of scientific community during 1990s. Initially vermiculture i.e., use of surface living earthworms was carried out at a very small scale mainly for management of kitchen wastes. In 1995 Morarka Foundation began with 100 earthworms of Eiseniafoetida to develop a commercial process of vermiculture. This pioneering effort enabled Morarka Foundation to become the single largest producer of vermicompost in 1998, a position which it is still enjoying.

From 1997-98 onwards, many government agencies in India such as Directorate of Agriculture, Watershed department, DPIP, Department of Biotechnology financially supported vermiculture programme. Subsequently, beginning in the year 2000, entrepreneurs came forward to set up large scale commercial units for the production of vermicompost. During these periods many cattle relief organizations, Gaushalas had also started vermiculture. In the last few years, vermiculture production units have also been set up as "Common Facility Centres" by group of farmers in villages. Vermiculture production units have now become a major component of agri-business models across the country.

References

- 1. Banerjee, T. K. *Applied Zoology*. Kolkata.: New Central Book Agency Ltd, 2016.
- Bhatnagar, R.K. Earthworm: vermiculture and vermicomposting. New Delhi.: Kalyani Publishers. 1996.
- Buchanan, M.R. Earthworms in environmental waste management. Netherlands: SPB Academic Publishers. 1988.
- 4. Chattopadhyay, D. *Elementary Applied Zoology.* . Kolkata.: Book Syndicate Pvt. Ltd,. 2012.
- 5. Chaudhuri, P.S. *Kechor jiban baichitra o kecho prajukti.* Kolkata: Gyan Bichitra Prakashani. 2006.
- 6. Dash, M.C., & Dash, S.P. Fundamentals of Ecology. New Delhi: Tata McGraw-Hill Education Private Ltd. 2009.
- Desai, V.R., & et. al. Integrated nitrogen management in wheat coriander cropping system. *Journal of Maharasthra Agricultural Universities*. 1999;24(4) :274-275.
- Devi, D., & Agarwal, S.K. Performance of sunflower hybrids as influenced by organic manure and fertilizer. *Journal of Oilseeds Research* 1998;15(2):272-279.
- Jadhav, A.D. Influence of the conjunctive use of FYM, vermicompost and urea on growth and nutrient uptake in rice. *Journal of Maharashtra Agricultural Universities* 1997;22(2):249-250.
- Jim, A. Land degradation: hanging attitudes-Why? Journal of Soil Conservation, New South Wales 1998; 44:46-51.
- 11. Karmegam, N., & Daniel, T. Effect of biodigested slurry and vermicompost on the growth and yield

of cowpea (Vigna unguiculata). *Environment and Ecology* 2000;18(2):67-70.

- Maheswarappa, H.P. Influence of organic manures on yield of arrowroot, soil physico-chemical and biological properties when grown as intercrop in coconut garden. *Annals of Agricultural Research* 1999;20(4):218-224.
- Marinari, S. et., al. Influence of organic and mineral fertilizers on soil biological and physical properties. *Bioresource technology* 2000;72(1):9-17.
- Mitchell, A., & Edwards, C.A. The production of vermicompost using Eisenia foetida from cattle manure. *Soil Biology and Biochemistry* 1997;29: 3-4.
- Nagavallemm, K.P. et. al. Vermicomposting: Recycling Wastes into Valuable Organic Fertilizer. Andhra Pradesh: International Crop Research Institute for the Semi-Arid Tropics. 2004.
- Nethra, N.N. et. al. China aster (Callistephus chinensis) cultivation using vermicompost as organic amendment. *Crop Research, Hisar* 1999;17(2): 209-215.
- Patil, S.L., & Sheelavantar, M.N. Effect of moisture conservation practices, organic sources and nitrogen levels on yield, water use and root development of water sorghum (Sorghum bicolor) in the vertisols of semi-arid tropics. *Annals of Agricultural Research* 2000;21(21):42-46.
- Sarkar, S.K. Introduction to Economic Zoology. Kolkata: New Central Book Agency Ltd. 2014.
- 19. Sreenivas, C. et. al. Vermicompost a viable component of IPNSS in nitrogen nutrition of ridge gourd. *Annals of Agricultural Research* 2000;21(1): 108-113.
- 20. Wani, S.P. et. al. Sustainable agriculture in the semiarid tropics through biological nitrogen fixation in grain legumes. *Plant and Soil* 1995;174:29-49.
- Wani, S.P., & Lee, K.K. Biofertilizers role in upland crops production. In H. L. Tandon, *Fertilizers, organic manures, recyclable wastes and biofertilizers* 1992.p.91-112. New Delhi, India: Fertilizer Development and Consultation Organization.

Necessity of Ecological Balance for Widespread Biodiversity

Ashok Kumar Verma

Abstract

The ecological balance is a stable state between all plants and animals in an ecosystem and destabilization of this stable state is ecological imbalance that in turn exerts serious threats to widespread nature of biodiversity. The ecological balance is sustained by the cyclic flow of materials from abiotic environment to the biosphere and then back to the abiotic environment and upholding the equilibrium of interaction inside food webs. Both these processes must be maintained in the ecosystem and any interference with these cycles disrupts and affects the ecological balance. The ecological balance is currently a necessity to maintain the rich and varied diversity of animals, plants and microbial life, which is essential for mutual survival and existence of all living beings including human.

Keywords: Ecological Balance; Flora; Fauna; Biological Diversity; Ecosystem; Eco-Friendly; Survival.

Introduction

Ecological balance is 'a state of dynamic equilibrium within a community of organisms' and the environment is everything that is around us. Indeed, environment is 'nature' that consists of matter and energy. The interaction of matter and energy forms a system of abiotic (non-living) and biotic (living) components. The biotic components include plants (flora), animals (fauna) and microbes.

The system of abiotic and biotic components together constitutes an ecosystem. In order to maintain this system, an ecosystem needs three kinds of diversity *namely* biological, genetic and functional. Biological diversity refers to the richness of species in a particular area; genetic diversity refers a way for a particular species to adapt itself to changing environments while functional diversity equates to the biophysical processes that happen within the area.

Biodiversity or biological diversity refers to the variety of life on Earth comprising millions of plants, animals, microorganisms and the genes they contain. It simply means the existence of a wide variety of plant and animal species in their natural environments. Author's Affiliation: Zoologist, Department of Zoology, Government Post Graduate College, Saidabad Allahabad-221508 (U.P.), India.

Reprint's Request: Ashok Kumar Verma, Zoologist, Department of Zoology, Government Post Graduate College, Saidabad Allahabad-221508 (U.P.), India.

E-mail: akv.gdcz@gmail.com

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The Convention on Biological Diversity (Glowka *et al*, 1994) defines biodiversity as the variability among living organisms from all sources including, among other things, terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are a part; this includes diversity within species, between species and of ecosystems.

The biodiversity has already been detailed and described at several angles from time to time by a number of scientists such as Kaushik *et al*, (2008), Odum (1971), Wilson (1988), Nair (1992), Subba Rao (2001), Verma *et al*, (2015, 2016a, 2016b, 2017a, 2017b and 2017c), Prakash *et al*, (2015, 2016a, 2016b, 2016d, 2017a, 2017b, 2017c and 2017d) etc. but there is a gap in describing the biodiversity with ecological balance. In present discussion, author is trying to fill this gap by discussing the necessity of ecological balance for widespread biodiversity.

Basic Types of Biodiversity

The biodiversity is usually described at three levels *namely* genetic, species and ecosystem and all these three work together to create the unique path for life on the Earth. The genetic diversity is the diversity of the basic units of hereditary information (genes) within a species, which are passed from one generation to next. The genetic diversity results in variations hence the basic source of biodiversity and the amount of genetic variation is therefore the basis of speciation.

The species diversity refers to the variety of species within a region. It is the variability found within the population of a species or between different species of a community. The species is the real basic unit used to classify the organisms and its diversity is the most commonly used level for describing the biodiversity.

The ecosystem diversity is the diversity of habitats, which include the different life forms within. Diversity at the level of community and ecosystem exists along 3 levels. First is alpha diversity (within community diversity), second is beta diversity (between communities diversity) and the third is gamma diversity (diversity of the habitats over the total landscape or geographical area).

Richard (2015) told that genetic diversity plays an important role in the survival and adaptability of a species. Thus, different levels of biodiversity: ecosystem, species and genetic, all have huge potential and a decline in biodiversity will lead to serious economic, ecological and socio-cultural losses. If we want our human race to survive then we must protect all biodiversity because biodiversity has existence value.

Importance of Biodiversity

The living organisms on earth are of great diversity, having diverse qualities and are vital to human existence providing food, shelter, cloths, medicines etc. The importance of widespread biodiversity include productive value, consumptive value, social value, aesthetic value, legal value, ethical value, economic value, ecosystem service value and so on.

Moreover, biodiversity has scientific and evolutionary value also, in which each species provides some clues to scientists as to how life evolved and will continue to evolve on earth. The biodiversity helps scientists to understand how life functions and the role of each species in sustaining ecosystems. The ethical value of biodiversity is based on the concept of '*Live and Let Live*'.

Benefits of Ecological Balance

Ecological balance is 'a state of dynamic equilibrium within a community of organisms in which genetic, species and ecosystem diversity remains relatively stable'. When a natural or humancaused disturbance disrupts the natural balance of an ecosystem then ecological imbalance is caused. In fact, the ecological balance actualizes the survival of all organisms.

The ecological balance maintains the entire biota which in turn establishes the healthy environment on the earth necessary for survival. On the other hand, the ecological imbalance causes an irreparable loss and deterioration of natural habitats, unprecedented climatic change, global warming, pollution etc. that in turn deplete the biodiversity. The greenhouse effect, depletion of ozone layer and acid rain are the major effects caused due to disturbance in ecological balance.

Conclusion

Today, the world has assumed the form of a 'global village' due to the metaphoric shrinkage of the geopolitical boundaries of nation-states through the use of Information and Communications Technology. But increased and indiscriminate exploitation of natural resources by human beings in an irresponsible manner is creating an imbalance in the nature from ecological point of view.

Human being plays a key role to maintain ecological balance because they have the highest thinking capacity as compared to other living organisms. Humans should understand that sufficient food availability to all living organisms and their stability reflects the existence of ecological balance. Since, this balance is vital as it ensures survival, existence and stability of the environment hence it should be maintained at any cost.

Since human beings are deriving all the benefits from ecological balance and biodiversity and their anthropogenic activities are largely responsible for ecological imbalance and loss of biodiversity hence they should take proper care for the maintenance of ecological balance and preservation of biodiversity in all its forms. The eco-friendly and sustainable positive efforts will definitely provide good health, inclusive and sustainable development as well as safety to the future generation. Harmonious relationships among organisms and environment will reflect healthy and desirable ecological balance. The ecological balance does mean the proper management of the biosphere by human beings in such a way that it gives maximum benefits to the present generation and also develop its potential so as to meet the needs of the future generations. Humans must develop an eco-friendly approach in order to maintain the ecological balance in a state of dynamic equilibrium.

References

- 1. Glowka L. *et al.*, *A Guide to the Convention on Biological Diversity Environmental* Policy and Law Paper No. 30 IUCN Gland and Cambridge. 1994;12;161.
- Kaushik A. and Kaushik C.P. Environmental Studies: New Age International Publishers, New Delhi. (2008).
- 3. Nair S.M. Endangered Animals of India and Their Conservation. National Book Trust, New Delhi. (1992).
- 4. Odum E.P. Fundamentals of Ecology. W.B. Saunders Company, Japan, 3rd edition. (1971).
- Prakash S. and Verma A.K. Studies on different fish genera in Alwara lake of Kaushambi. *Bioherald: An International Journal of Biodiversity & Environment*. 2015;5(1-2):60-62.
- Prakash S. and Verma A.K. Impact of awareness programme on growth and conservation of vulnerable avian species *Grus antigone antigone* in and around Alwara lake of District Kaushambi (Uttar Pradesh), India. *The Journal of Zoology Studies* 2016a;3(2):1-5.
- Prakash S. and Verma A.K. Conservation Status of fresh water fishes reported in Alwara lake of District Kaushambi (U.P.). *International Journal of Zoology Studies* 2016b;1(5):32-35.
- Prakash S. and Verma A.K. IUCN Conservation Status of Fishes of Khanwari Pond of District Kaushambi (U.P.); Proceedings of The Zoological Society of India. 2017;16(1):81-84.
- 9. Richard F. "Genetics and Extinction". *Biological Conservation*. 2005;126(2):1-140.
- 10. Subba Rao S. Ethics of Ecology and Environment. Rajat Publications, New Delhi. 2001.
- Verma A.K., Prakash S. and Kumar Sunil. Status and Ecology of Sarus Crane, *Grus antigone antigone* in and around the Alwara Lake of District Kaushambi (U.P.). *International Journal on Environmental Sciences*. 2015;6(2):331-335.

- Verma A.K. and Prakash S. Fish biodiversity of Alwara lake of District Kaushambi, Uttar Pradesh, India. *Research Journal of Animal, Veterinary and Fishery Sciences* 2016a;4(4):5-9.
- Verma A.K. and Prakash S. Population dynamics of Indian Sarus Crane, *Grus antigone antigone* (Linnaeus, 1758) in and around Alwara lake of Kaushambi district (Uttar Pradesh), India. *International Journal of Biological Research*. 4(2): http://www.science pubco. com/index.php/IJBR/article/view. 2016b.p.206-210.
- 14. Verma A.K. and Prakash S. Fish Biodiversity of Khanwari Pond of District Kaushambi (U. P.), India; *The Journal of Zoology Studies*. 2017a;4(1):37-40.
- Verma A.K. and Prakash S. Sarus Crane: An Eternal Symbol of Marital Fidelity; *International Journal of Zoological Investigations*. 2017b;3(1):11-14.
- Verma A.K. and Prakash S. Dominancy of cat fishes in Khanwari pond of district Kaushambi (U.P.). *Life Science Bulletin*. 2017c;14(1):85-87.
- Verma A.K. Dominancy of Cypriniformes fishes in Alwara lake of District Kaushambi (U.P.). *International Journal on Agricultural Sciences*. 2016a;7(1):89-91.
- Verma A.K. Distribution and Conservation Status of Cat Fishes in Alwara Lake of District Kaushambi (U.P.). International Journal on Environmental Sciences. 2016b;7(1):72-75.
- Verma A.K. Biodiversity: Its Different Levels and Values. International Journal on Environmental Sciences. 2016c;7(2):142-144.
- Verma A.K. A Preliminary Survey of Fresh Water Fishes in Muntjibpur Pond of Allahabad (U.P.). *Indian Journal of Biology*. DOI: http://dx.doi.org/10.21088/ ijb. 2394.1391.3216.2. 2016d;3(2):99-101.
- Verma A.K. Distribution and Conservation Status of Fishes reported from Muntjibpur Pond of Allahabad (U.P.). *International Journal of Scientific World*, doi: 10.14419/ijsw.v5i1.7162. 2017a;5(1):50-53.
- 22. Verma A.K. Environmental Ethics: Need to Rethink. International Journal on Environmental Sciences; 2017b;8(1):7-9.
- Verma A.K. Genetic Diversity as Buffer in Biodiversity. *Indian Journal of Biology*. DOI: http:// dx.doi.org/10.21088/ijb.2394.1391.4117.9.2017c;4(1): 61-63.
- 24. Verma A.K. Multiple effects of Unsustainable Agriculture. *International Journal on Agricultural Sciences*; 2017d;8(1):24-26..
- 25. Wilson E.O. Biodiversity. National Academic Press, Washington, D.C. (1988).

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