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**Logo description** : It symbolizes an elephant within an ecological frame of peace and harmony moving towards prosperity and posterity.

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# Indigenous phyto-therapy of Kandha tribe for primary healthcare in Kandhamal district, Odisha

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## ABSTRACT

Kandhamal district (formerly named as Phulbani) in Odisha is home to various tribal and nontribal communities among which the Kandha tribe is predominant. The name of the district is derived from the name of this tribe. The medicinal plants used traditionally by Kandha people for their healthcare was studied during the year 2014-2016. A total of 68 species belonging to 63 genera and 41 botanical families were recorded. The paper enumerates the traditional practices of medicinal species in alphabetic order with notes on their local names, parts used and mode of administration.

**Key words:** Healthcare, Kandha tribe, Kandhamal district, medicinal plants

## INTRODUCTION

Since the time immemorial, the history of plant use as cure for human ailments has been a tradition in the tribal healthcare system. These plants are integral components acting as life support system in the lives of the tribes including the landless, orphaned, aged and infirm. With an ideal combination of rich forest resources, mountainous terrain and a number of tribes living therein and their much dependence on forest for indigenous plants, Kandhamal district in Odisha offers an ample scope for study of medicinal plants. Basically, the tribal and other forest dwelling communities reside in remote areas where communication and life system including healthcare are far from their reach. Through the process of trial and error, these tribes identify and use plant parts such as roots, tubers, rhizomes, leaves, bark, and fruits as medicines for treatment of various diseases and further, several of them have been domesticated in their homesteads. They have experienced and learnt the herbal medicinal knowledge out of their sufferings from diseases through use, continuous observation and experimentation at their level and this practice is

carried forward to the next generation orally or learning from the traditional healers/ medicine men or from the elders. The Kandha medicine man locally called as 'Dishari' possesses a special position in the tribal community and served people with satisfaction against a token support for their livelihood.

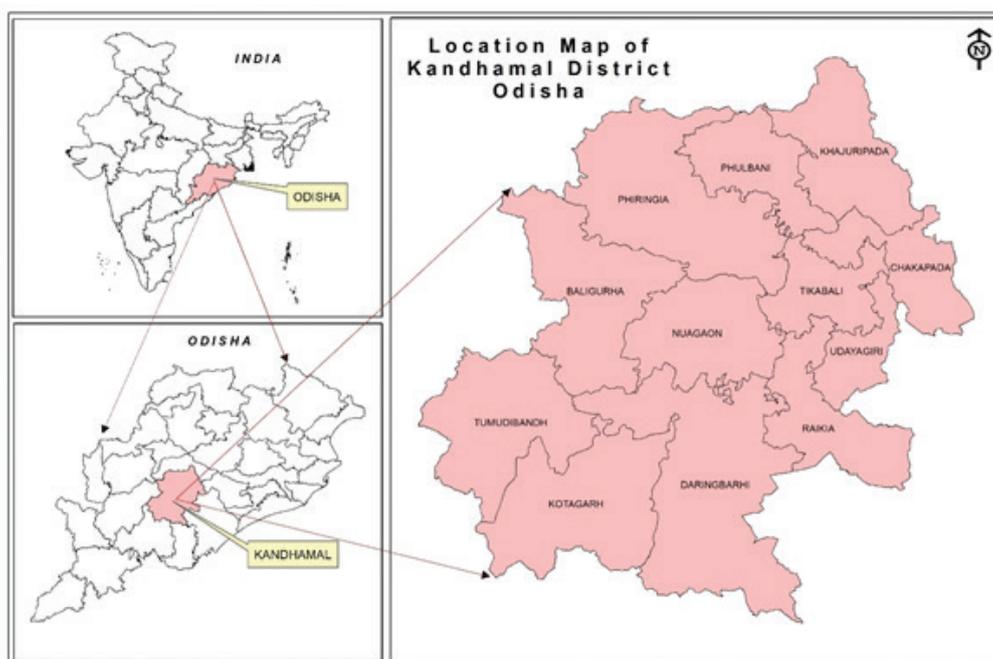
Information on indigenous knowledge of the traditional healthcare system is very poorly reported in this region except very sporadic surveys (Sahoo and Mudgal, 1995; Sahoo, 1995; Mohanty et al., 1996; Panda and Das, 1999; Sahoo and Bahali, 2003). However, scanty information on tribe-wise ethnographic explorations is available in the state (Jain and Banerjee, 1973). This study aims at to record the indigenous medicinal plant resources used by Kandha tribe of Kandhamal district of Odisha and to provide first hand information on vascular plants of 68 species.

## STUDY AREA

Lying between 83° 30' to 84° 35' E longitude and 19° 34' to 20° 34' N latitudes, Kandhamal district is located in the central part of Odisha and

delimited by Boudh district in the north, Gajapati and Rayagada in the south, Ganjam and Nayagarh in the east and Kalahandi and Bolangir in the west (Fig. 1). The topography of the district is irregular and undulating hilly terrain of Eastern Ghats and occupies an area of 5392 sq km forest cover which accounts for 67.22 per cent of total geographical area, estimating district-wise highest area in the state (FSI, 2017). The vegetation is dominantly of mixed moist deciduous and dry deciduous types with patches of bamboo brakes and scrub cover. The district has several remote locations for which access of transport and providing health services

are key challenges. The schedule tribes account for 53.58 per cent of the total district population (Census of India, 2011). Out of 62 notified scheduled tribes in Odisha, as many as 29 tribes are found in Kandhamal and among them Kandha, Saura, Ganda, Kandha-Gouda and Kutia Kandha constitute the major population. The predominant tribe, 'Kandha' or 'Khonds' identify themselves with their dialect as *Kuilaku* or *Kuinga*. Agriculture and horticultural cultivations and collection of forest products are major sources of livelihood in the district.



**Fig. 1.** Location map of Kandhamal district, Odisha, India

## MATERIALS AND METHODS

Intensive explorations were undertaken during 2014 to 2016 in the interior forest areas of different blocks viz. Raikia, K.Nuagaon, Daringbadi, Kotagarh, Tumudibandha, Baliguda, Pheringia, Phulbani, Khajuripada of the district Kandhamal, Odisha. Prior to the field work, a reconnaissance along with literature survey was made to get an idea about the vegetation of Kandhamal and the tribal populations reside within the forested areas. The methodological framework chosen for this study was followed as per the standard techniques

of qualitative and quantitative ethno-biological approaches in the interview technique, elicitation methods, data collection and further authentication (Martin, 1995; Cotton, 1996; Misra et al., 2013). During the field visit, village level medicine men and women were identified and a number of transect walks were made along with them in different landscapes of forest areas. The ethno-botanical information was gathered through interviews and discussions with traditional healers, village heads and elderly people having local knowledge about medicinal use of plants. Data were recorded on local

names, plant parts used and mode of administration as elaborated by Kandha tribe (Fig. 2). Voucher specimens were collected for authentication of information and for future reference. The plant species were identified on the spot and with the help of local floras to ensure correct identification



**Fig. 2.** Kandha tribal man elaborating the medicinal use of *Ceropegia hirsuta* Wt. and Arn.



**Fig. 3.** *Scindapsus officinalis* (Roxb.) Schott, a vulnerable medicinal plant

## RESULTS AND DISCUSSION

The practice of wild and domesticated plants as medicines to treat various diseases is still continuing among the Kandha inhabitants to complement the poor medical facilities in many parts of this district. Information on taxa having indigenous medicinal uses gathered from Kandha tribal inhabitants and practitioners was presented in Table 1. The information was verified by cross-questioning with informants of knowledgeable elderly persons of other villages. During this study, a total of 68 medicinal species were identified

of plants (Haines, 1921-25; Saxena and Brahmam, 1994-96). Plants were enumerated in alphabetic sequence of their botanical names followed by the local name used by Kandha tribe, family and mode of administration.



**Fig. 4.** *Biophytum sensitivum* (L.) DC..



**Fig. 5.** *Curculigo orchiioides* Gaertn.

and enumerated with their scientific names, along with local names, parts used and their mode of administration (Table 1). These species belong to 63 genera and 41 botanical families.

This study provides information on uses of different parts of plants like roots, rhizome, leaves, fruits, seeds, latex and bark for different diseases which include skin diseases, headache, stomach disorders, diarrhoea, dysentery, cold and cough, jaundice, snake bite, high blood pressure, diabetes etc. It is also observed that either a single plant species or a combination of more than one plant

is used to cure a particular disease. This report reveals that a maximum of seven plant species viz. *Scindapsus officinalis* (Fig. 3), *Ricinus communis*, *Hemidesmus indicus*, *Tinospora cordifolia*, *Datura metel*, *Abrus precatorius* and *Vitex negundo* are used against rheumatism. Similarly, the plant species used to cure diarrhoea and dysentery are *Syzygium cumini*, *Holarrhena antidysenterica*, *Celosia argentea*, *Justicia adhatoda*, *Elephantopus scaber*, *Mangifera indica*, *Michelia champaca* and *Phyllanthus fraternus*. The species like *Abutilon indicum*, *Phyllanthus emblica*, *Terminalia chebula*, *Terminalia bellerica*, *Datura metel*, *Biophytum sensitivum* (Fig. 4), *Cyperus rotundus*, *Mentha*

*viridis*, *Murraya koenigii* and *Cymbopogon flexuosus* are used to cure stomach disorders. Kondhs frequently use the plants like *Chromolaena odorata* and *Curculigo orchoides* (Fig. 5) to heal from minor injury and wounds. It was recorded that the traditional healers prescribe the paste of species like *Andrographis paniculata*, *Azadirachta indica* and *Naringi crenulata* to apply on the affected area for curing skin diseases. Further, there are also few plants identified which are administered to treat many ailments such as jaundice, skin infection, gynaecological and dental disorders, snake bites etc.

**Table 1.** Medicinal plants used by Kandha tribe of Kandhamal district

Sl.	Scientific name	Local name	Family	Part used	Mode of administration
1	<i>Abrus precatorius</i> L.	Dhalarunja mala/ Nalirunja mala	Fabaceae	Seed, root	Seed powder of white seeded variety along with 3-5 black peppers is taken to cure rheumatism. Root paste of red seeded variety is locally applied on piles. Root pounded with palm sugar and taken to improve eye sight.
2	<i>Abutilon indicum</i> (L.) Sweet	Pedipedika mara	Malvaceae	Leaf	Juice is administered twice a day for treatment of jaundice.
3	<i>Aegle marmelos</i> (L.) Corr.	Bela mara	Rutaceae	Leaf, fruit	Leaf juice or fruit pulp/ juice are consumed to increase digestion and cures stomach disorders.
4	<i>Aloe vera</i> (L.) Burm.f.	Ghia kuanri	Liliaceae	Leaf	Juice is used to cure headache and skin diseases. A cup of juice can supplement calorific strength of one day diet of an adult.
5	<i>Andrographis paniculata</i> (Burm. f.) Wall. ex Nees	Bhuinnimba	Acanthaceae	Root, leaf	Root paste with cold milk is given to cure acidity and applied for skin diseases. Leaf juice with 5-7 black peppers is taken 3 times daily for 3-5 days to cure malaria.
6	<i>Atylosia scarabaeoides</i> (L.) Benth.	Kartaaka	Fabaceae	Root	Decoction is given to pregnant women to reduce pain during child birth.
7	<i>Azadirachta indica</i> A. Juss.	Nimbamara	Meliaceae	Bark, leaf	Bark paste is applied for skin diseases. Leaves are half-burnt and diffused in a room to repel mosquitoes.
8	<i>Boerhavia diffusa</i> L.	Hatua kusa	Nyctaginaceae	Leaf	Juice is used to cure conjunctivitis. Paste with honey acts as blood purifier. Whole plant with paste of turmeric is applied on infected area of skin in case of children.

9	<i>Biophytum sensitivum</i> (L.) DC.	Hema sagara	Oxalidaceae	Leaf	Juice with 5-7 black peppers is taken 2-3 times a day to reduce pain due to stone in stomach.
10	<i>Calotropis gigantea</i> R. Br.	Jhilerimara/ Ludura	Asclepiadaceae	Root, latex	Root paste or latex applied on the affected parts of insect bites.
11	<i>Cassia fistula</i> L.	Alilknnga	Caesalpineaceae	Seed	Powder with 7 black peppers is taken to cure constipation.
12	<i>Cassia tora</i> L.	Adamemeri	Caesalpineaceae	Seed	Seed powder with cooked coconut oil is smeared on infected parts of skin.
13	<i>Celastrus paniculata</i> Willd.	Prengamala	Celastraceae	Seed	Seed oil is applied to heal skin infected areas.
14	<i>Celosia argentea</i> L.	Penamuksi	Amaranthaceae	Leaf	Juice with little water is prescribed against dysentery.
15	<i>Ceropegia hirsuta</i> Wight and Arn.	Patka plaberi	Asclepiadaceae	Tuber	Tuber is eaten raw in morning to maintain sound health and to enhance vigour.
16	<i>Chromolaena odorata</i> (L.) King and Robins.	Jahajapunga	Asteraceae	Leaf	Crushed leaf with juice is applied on fresh cuts/ wounds to stop bleeding.
17	<i>Cissampelos pareira</i> L.	Dindikidi mala	Menispermaceae	Root	Powder is taken with cold water to cure acidity, indigestion and stomach disorders.
18	<i>Cissus quadrangularis</i> L.	Hadajadi mala	Vitaceae	Whole plant	Crushed branches along with bark pieces of <i>Careya arborea</i> (Kumbha) are heated and tied tightly on affected parts for 3 weeks to join the fractured bones.
19	<i>Clitorea ternatea</i> L.	Aparajita	Fabaceae	Root	Paste is applied on affected parts of snake bite to remove poison.
20	<i>Costus speciosus</i> (Koenig) Sm.	Bambakunanga	Costaceae	Tuber	Tuber paste is smeared on forehead to keep cool and prevents headache.
21	<i>Curculigo orchioides</i> Gaertn.	Taalamuli/ Ghusurikuna	Hypoxidaceae	Root	Paste is applied for healing wounds. Decoction is given to weak patients for strength and vitality.
22	<i>Curcuma longa</i> L.	Singaanga	Zingiberaceae	Rhizome	Paste is taken twice daily to regulate periodic menstrual flow in women.
23	<i>Cymbopogon flexuosus</i> (Nees ex Steud.) Wats	Dhanbantari	Poaceae	Leaf	Decoction along with 4-5 black peppers is taken twice daily to cure flatulence and stomach-ache. Leaf oil also applied on joints to reduce pain.
24	<i>Cyperus rotundus</i> (L.) Pers.	Mutha	Cyperaceae	Root	Paste is taken in empty stomach three times a day to cure hyperacidity and flatulence of stomach.
25	<i>Datura metel</i> L.	Dudura	Solanaceae	Root, leaf, seed	Root powder is administered in empty stomach to cure gastritis. Leaf juice or seed powder mixed with cooked coconut oil is applied on scalp and hair for treatment of baldness, lice and early whitening of hair.
26	<i>Eclipta prostrata</i> (L.)	Kaijati	Asteraceae	Leaf	Leaf juice is applied to cure eye infection.

27	<i>Elephantopus scaber</i> L.	Benga Padai	Asteraceae	Root	Paste along with turmeric and jaggery is prescribed for blood dysentery and gynaecological disorders.
28	<i>Hemidesmus indicus</i> (L.) R. Br.	Sugandhi mala	Periplocaceae	Root	Powder with honey is prescribed to provide strength and vitality for weak persons. It is also useful for rheumatism.
29	<i>Holarrhena pubescens</i> (Buch.-Ham.) Wall. ex G. Don.	Kulchimrahanu	Apocynaceae	Bark, root	Pieces are fermented in water for 3-4 days and added in <i>handia</i> for intoxication. Paste with water is taken to cure dysentery.
30	<i>Indigofera cassioides</i> Rott. ex DC.	Ganjeri punga	Fabaceae	Flower	Flowers eaten as curry to cure piles.
31	<i>Justicia adhatoda</i> L.	Baasadedi	Acanthaceae	Leaf	Half spoon juice is swallowed to cure asthma, cough and rheumatism.
32	<i>Lawsonia inermis</i> L.	Menjuaatimrahanu	Lythraceae	Root	Pieces along with seven black peppers are made into a paste and given to patients suffering from jaundice. Leaves are pounded and made into a paste used as dye ( <i>mehendi</i> ).
33	<i>Litsea glutinosa</i> (Lour.) Robins.	Masnia	Lauraceae	Bark	Crushed bark applied for healing the fractured bone.
34	<i>Madhuca indica</i> Gmel.	Lerpi	Sapotaceae	Twig	Used as tooth brush to cure pyorrhoea.
35	<i>Mangifera indica</i> L.	Maska	Anacardiaceae	Twig	Tender leaves are chewed to cure diarrhoea.
36	<i>Mentha viridis</i> L.	Podina	Lamiaceae	Leaf	Pounded with salt and dry ginger and taken to cure hyperacidity.
37	<i>Michelia champaca</i> L.	Sapadedi	Magnoliaceae	Leaf	Leaf juice is taken three times a day to cure dysentery.
38	<i>Mimosa pudica</i> L.	Lajja	Mimosaceae	Root	Paste is slightly warmed and applied on boils for early healing. Also smeared on the affected parts of snake-bite or scorpion stings.
39	<i>Murraya koenigii</i> (L.) Spreng.	Brusunga	Rutaceae	Leaf	Crushed with 5-7 black peppers and taken to cure stomachache.
40	<i>Naringi crenulate</i> (Roxb.) Nicol.	Narangimrahanu	Rutaceae	Bark	Paste is applied to cure skin infection.
41	<i>Nyctanthes arbortristis</i> L.	Daanimara	Oleaceae	Leaf	Juice with small pieces of ginger is consumed to treat malaria/ intermittent fever.
42	<i>Ocimum sanctum</i> L.	Tulasi	Lamiaceae	Leaf	Juice is given for treating cough and cold and to enhance memory in children.
43	<i>Phoenix acaulis</i> Buch-Ham ex Roxb.	Sitaa	Arecaceae	leaf	Juice is taken with little water for 4-5 times to cure urine infection.
44	<i>Phyllanthus emblica</i> L.	Juruanmara	Euphorbiaceae	Fruit	Dry or roasted fruits are taken to cure stomach-ache and indigestion.

45	<i>Phyllanthus fraternus</i> Webst.	Bhuinjurun	Euphorbiaceae	Root	Paste with black salt is given orally to cure diarrhoea and jaundice.
46	<i>Phyllanthus urinaria</i> L.	Badiaanla	Euphorbiaceae	Root	Paste is prescribed against dysentery and vomiting.
47	<i>Piper longum</i> L.	Pippali	Piperaceae	Fruit	Half-burnt or roasted with honey is given to patients suffering from cough and cold.
48	<i>Piper trioicum</i> Roxb.	Bana pippali	Piperaceae	Root	Powder with dry-ginger is given twice a day for a week to cure rheumatism.
49	<i>Plumbago zeylanica</i> L.	Dhalachita	Plumbaginaceae	Root	Root paste along with black pepper is taken two times for 2-3 days for abortion.
50	<i>Pongamia pinnata</i> (L.) Pierre	Karanja	Fabaceae	Twig, leaf, seed	Twigs are frequently used as tooth brush to strengthen gum. Seed powder taken with water every morning to check diabetes. Seed oil used as message to prevent malaria.
51	<i>Premna latifolia</i> Roxb.	Gandhri	Verbenaceae	Leaf	Decoction is taken to reduce joint pain; paste is also applied on affected areas of pain.
52	<i>Psidium guajava</i> L.	Jam, Pijuli	Myrtaceae	Leaf	Tender leaf juice is taken to prevent blood dysentery.
53	<i>Pueraria tuberosa</i> (Wild.) DC.	Mardimala	Fabaceae	Tuber	Powder mixed with honey is taken orally once daily as health tonic.
54	<i>Quisqualis indica</i> L.	Malati	Combretaceae	Root	Paste is applied to cure eczema, scabies and allied skin diseases.
55	<i>Ricinus communis</i> L.	Kalo	Euphorbiaceae	Leaf	Paste is slightly warmed and applied to sores and boils.
56	<i>Rauwolfia serpentina</i> (L.) Benth. ex Kurz	Usabsul	Apocynaceae	Root	Paste is applied to affected parts of snake-bite and also taken orally with little water to neutralise poisonous effect. Intake of paste in empty stomach helps to check diabetes.
57	<i>Scindapsus officinalis</i> (Roxb.) Sch.	Gajapippali	Araceae	Fruit	Intake of half-burnt fruit and ash with dry ginger and honey cures joint pain and rheumatism.
58	<i>Semecarpus anacardium</i> L. f.	Kala bhalia	Anacardiaceae	Kernel	Half-burnt hot kernels are applied to remove external warts and small swellings/tumours.
59	<i>Shorea robusta</i> Gaertn.f.	Jargi	Dipterocarpaceae	Bark	Bark paste applied on affected parts when bitten by domestic animals. Fruit powder with little water is taken against diarrhoea.
60	<i>Sida acuta</i> Burm. f.	Rupi	Malvaceae	Whole plant	Whole plant is boiled in water and allowed child to take bath after cooling to keep them healthy and free from skin diseases.
61	<i>Smilax zeylanica</i> L.	Muturi	Smilacaceae	Root	Paste of root and turmeric is taken in morning for 5-7 days to regularise menstrual problems of women.

62	<i>Solanum virginianum</i> L.	Bheji	Solanaceae	Root	Root paste along with black pepper is taken to cure cold, cough and fever.
63	<i>Syzygium cuminii</i> (L.) Skeels	Jam	Myrtaceae	Seed	Powder along with leaf powder of Nimbamara ( <i>Azadirachta indica</i> ) is taken once a day for a week to cure diabetes.
64	<i>Terminalia bellerica</i> (Gaertn.) Roxb.	Bahadamrahanu	Combretaceae	Fruit	Intake of powder along with 3-4 black peppers is useful for acidity and stomach disorders.
65	<i>Terminalia chebula</i> Retz.	Haridamrahanu	Combretaceae	Fruit	Tender fruit pulp is applied to dental infection and pain.
66	<i>Tinospora cordifolia</i> (Willd.) Hook. f. and Thoms.	Guluchi	Menispermaceae	Twig	Decoction of dry twig and bark is given for muscular swellings, joint pain and rheumatism and also for fever.
67	<i>Tridax procumbens</i> L.	Bishalyakarani	Asteraceae	Leaf	Crushed leaves and juice is applied to heal fresh wounds and piles.
68	<i>Vitex negundo</i> L.	Nirgundi	Verbenaceae	Root, leaf	Paste of root and leaves is applied on joint pain and rheumatic affections.

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## Response of weed management to grain yield and nutrients uptake in maize (*Zea mays* L.)

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### ABSTRACT

A field experiment was conducted during summer season 2015 at College Farm, Department of Agronomy, N.M. College of Agriculture, Navsari Agricultural University, Navsari in clay soil. There were ten treatments, involving two pre-emergence, three tank mixtures, one post-emergence, one soil mulching, one sugarcane trash mulching, weed free and weedy check. Significantly higher grain and straw yield were registered under weed free treatment (6566 and 8135 kg ha<sup>-1</sup>, respectively), which was statistically at par with atrazine @ 0.75 kg ha<sup>-1</sup> + pendimethalin @ 0.75 kg ha<sup>-1</sup> (6267 and 7921 kg ha<sup>-1</sup>) as PE, alachlor @ 1.5 kg ha<sup>-1</sup> + atrazine @ 0.5 kg ha<sup>-1</sup> (5918 and 7316 kg ha<sup>-1</sup>) as PE, atrazine @ 0.75 kg ha<sup>-1</sup> + 2.4 D @ 0.5 kg ha<sup>-1</sup> (5820 and 7276 kg ha<sup>-1</sup>) as PE, atrazine @ 0.75 kg ha<sup>-1</sup> (5680 and 6856 kg ha<sup>-1</sup>) as PE and atrazine as PoE @ 1.5 kg ha<sup>-1</sup> at 30 DAS (5619 and 6819 kg ha<sup>-1</sup>), while weed control through sugarcane trash mulch @ 5 t ha<sup>-1</sup> and alachlor @ 1.5 kg ha<sup>-1</sup> PE were also at par in case of straw yield. Significantly higher nutrients uptake by grains and straw was observed under weed free condition, which was statistically at par with atrazine @ 0.75 kg ha<sup>-1</sup> + pendimethalin @ 0.75 kg ha<sup>-1</sup> PE, alachlor @ 1.5 kg ha<sup>-1</sup> + atrazine @ 0.5 kg ha<sup>-1</sup> PE, atrazine @ 0.75 kg ha<sup>-1</sup> + 2.4 D 0.5 @ kg ha<sup>-1</sup> PE and only atrazine @ 0.75 kg ha<sup>-1</sup>. Highest uptake by weeds was recorded under weedy check treatment. Itrazine @ 0.75 kg ha<sup>-1</sup> + pendimethalin @ 0.75 kg ha<sup>-1</sup> PE registered significantly lower uptake of nutrients, while significantly higher uptake of nutrients registered under weed control by inter-culturing at 30 and 45 DAS fb HW.

**Key words:** Herbicide, nutrient uptake, soil mulch, tank mixture, yield

### INTRODUCTION

Maize (*Zea mays* L.) is one of the most important cereal crops in the world in agricultural economy both as food and fodder crop and is regarded as queen of cereals. Maize grains are used for human consumption, feed for poultry and livestock, for extraction of edible oil and also for starch and glucose industry. It is called a miracle crop with very high yield potential. In India, maize is grown over an area of 9.34 million ha with an annual production of about 24.35 million tons and an average productivity of about 2583 kg ha<sup>-1</sup>. Gujarat occupies an area of 461 hectares with a production of 692 tons and productivity of 1501 kg

ha<sup>-1</sup> (IIMR, 2014). Weeds emerge fast, grow rapidly and compete with the crop for growth resources viz., nutrients, moisture, sunlight and space during entire vegetative growth and early reproductive stages of maize. They also transpire conserved moisture and absorb large quantities of nutrients from the soil. Further, wide space provided to the maize allows fast growth of variety of weed species causing a considerable reduction in yield by affecting the growth and yield attributing components. Presence of weeds reduces the photosynthetic efficiency, dry matter production and distribution to economical parts, thereby reducing sink capacity of crop resulting in poor grain yield. Thus, the extent of reduction in grain yield of maize has been reported

to be in the range of 33 to 50 per cent depending on type of weed species in standing crop. It is well established that 30 to 60 DAS is the most critical period for crop-weed competition in maize. In recent agricultural activities, the chemical method of weed control is becoming the ultimate weed management strategy. Chemical weed control has been found to offer this efficiency and effectiveness since the weeds could be managed even before they emerge. With the efficient control by herbicides, the plant gets free access to water, nutrients, light and space without competition. The chemicals are more systemic and persistent; thus resulting in an effective, efficient and longer period of weed control (Ali et al., 2003). Mulching is a recent and important non-chemical weed control method. Different organic mulches lower the increase in soil moisture, soil temperature and decrease weed density and increase the crop yield (Sinkeviciene et al., 2009). Keeping all these aspects in view, an attempt was made to find out effective herbicides for weed management in maize under south Gujarat condition.

## MATERIALS AND METHODS

A field experiment was conducted during the summer season of 2015 at College Farm, Department of Agronomy, N. M. College of Agriculture, Navsari Agricultural University, Navsari on clayey soil. There were ten treatments involving two pre-emergence herbicides (alachlor @ 1.5 kg ha<sup>-1</sup> and atrazine @ 0.75 kg ha<sup>-1</sup>), three tank mixture application of herbicide alachlor @ 1.5 + atrazine @ 0.5 kg ha<sup>-1</sup>, atrazine @ 0.75 kg ha<sup>-1</sup> + pendimethalin @ 0.75 kg ha<sup>-1</sup> and atrazine @ 0.75 kg ha<sup>-1</sup> + 2.4 D @ 0.5 kg ha<sup>-1</sup> as PE, one post-emergence herbicide of atrazine @ 1.5 kg ha<sup>-1</sup>, 30 DAS, one soil mulching (Inter-culturing at 30 and 45 DAS fb and weeding), one sugarcane trash mulching @ 5 t ha<sup>-1</sup>, weed free and weedy check. The experiment was laid out in a randomized block design with three replications having net plot size of 4.2 m × 3.0 m. The crop was fertilized with 120 kg N and 60 kg P<sub>2</sub>O<sub>5</sub> per ha through urea and SSP, respectively. Half of N and all of P<sub>2</sub>O<sub>5</sub> was applied at the time of sowing and remaining N was top dressed at 30 DAS. Besides fixed cost of cultivation,

variable cost on spray and cost of herbicides in each treatment was worked out to obtain total cost of production.

The net income was obtained after deducting cost of cultivation from value of produces as samples from grain, straw, central core of cob and weeds were taken separately for the estimation of nutrient content from each treatment from all the three replications. Chemical studies pertaining to nitrogen, phosphorus and potassium content and their uptake by maize and weeds were respectively determined by Kjeldahl's method, Vanadomolybdo Phosphoric acid yellow color method and Flame photometric method. Black (1979) and Jackson (1973) while the estimation of available Nitrogen, Phosphorus and Potassium from soil were carried out by Olsen's method; Alkaline potassium permanganate method and flame photometer suggested by Jackson (1973). The expenses including the cost of input specially fertilizers (NPK) applied to each treatments was calculated on the basis of prevailing local charges. Net returns of each treatment were calculated by deducting the total cost of cultivation from the gross returns.

## RESULTS AND DISCUSSION

### Yield

The grain and straw yield (kg ha<sup>-1</sup>) were significantly influenced by different weed management treatments. Significantly higher grain and straw yield were registered under weed free treatment (6566 and 8135 kg ha<sup>-1</sup>, respectively), which was statistically at par with atrazine @ 0.75 kg ha<sup>-1</sup> + pendimethalin @ 0.75 kg ha<sup>-1</sup> (6267 and 7921 kg ha<sup>-1</sup>) as PE, alachlor @ 1.5 kg ha<sup>-1</sup> + atrazine @ 0.5 kg ha<sup>-1</sup> (5918 and 7316 kg ha<sup>-1</sup>) as PE, atrazine @ 0.75 kg ha<sup>-1</sup> + 2.4 D 0.5 @ kg ha<sup>-1</sup> (5820 and 7276 kg ha<sup>-1</sup>) as PE, atrazine @ 0.75 kg ha<sup>-1</sup> (5680 and 6856 kg ha<sup>-1</sup>) as PE and atrazine as PoE @ 1.5 kg ha<sup>-1</sup> at 30 DAS (5619 and 6819 kg ha<sup>-1</sup>), while weed control through sugarcane trash mulch @ 5 t ha<sup>-1</sup> and alachlor @ 1.5 kg ha<sup>-1</sup> PE were also at par in case of straw yield. Among herbicide treatment, T8 recorded significantly higher with grain yield (6267 kg ha<sup>-1</sup>) followed by T7 and T9. The lowest grain and straw yield (3505 and 5526 kg ha<sup>-1</sup>,

respectively) were recorded under weedy check (T1). The better performance of yield under weed free condition might be due to effective control of weeds and higher weed control efficiency as well as lower weed index observed, which cumulatively facilitated the crop to utilize more nutrients and

water for better growth and development in terms of various yield attributing characters. These findings corroborate the results of Mathukia et al. (2014), Dobariya et al. (2015) and Samant et al. (2015) in maize (Table 1).

**Table 1.** Grain yield, straw yield, nutrients uptake by weeds and maize as influenced by weed management

Treatment	Yield (kg ha <sup>-1</sup> )		Nutrients uptake by weeds (kg ha <sup>-1</sup> )			Nutrients uptake by maize (kg ha <sup>-1</sup> )					
	Grain	Straw	N	P	K	Grain			Straw		
						N	P	K	N	P	K
T1 Weedy check	3505	5526	3.32	1.13	1.02	52.4	15.4	16.1	64.0	11.1	16.4
T2 Weed free	6566	8135	-	-	-	105.6	32.5	32.2	104.4	18.7	26.2
T3 Weed control through soil mulch (Interculturing at 30 and 45 DAS <i>fb</i> HW)	5228	5910	1.37	0.51	0.43	82.8	25.4	25.6	75.9	13.4	18.7
T4 Weed control through trash mulch (Sugarcane trash @ 5 t ha <sup>-1</sup> )	5513	6752	1.07	0.40	0.35	87.9	26.2	26.3	82.6	14.6	20.4
T5 Pre-emergence application of Alachlor @ 1.5 kg ha <sup>-1</sup>	5460	6536	0.95	0.36	0.32	86.6	26.3	26.2	81.9	15.9	19.8
T6 Pre-emergence application of Atrazine @ (0.75 kg ha <sup>-1</sup> )	5680	6856	0.91	0.35	0.31	89.8	27.1	27.2	85.1	14.9	21.4
T7 Pre-emergence application of Alachlor @ 1.5 kg ha <sup>-1</sup> + Atrazine @ 0.5 kg ha <sup>-1</sup>	5918	7316	0.58	0.22	0.19	92.4	26.6	27.7	91.3	15.6	24.3
T8 Pre-emergence application of Atrazine @ 0.75 kg ha <sup>-1</sup> + Pendimethalin @ 0.75 kg ha <sup>-1</sup>	6267	7921	0.52	0.19	0.17	100.2	30.0	29.4	96.8	18.1	24.7
T9 Pre-emergence application of Atrazine @ 0.75 kg ha <sup>-1</sup> + 2.4 D 0.5 @ kg ha <sup>-1</sup>	5820	7276	0.63	0.22	0.19	92.4	26.9	27.8	90.0	16.2	22.4
T10 Post emergence application of Atrazine @ 1.5 kg ha <sup>-1</sup> 30 DAS	5619	7210	1.22	0.46	0.39	87.9	27.0	26.2	83.9	14.2	20.9
S.Em. ±	312.3	505.7	0.093	0.027	0.032	5.36	1.50	1.735	6.50	1.23	1.64
C.D at 5 %	999.1	1617.7	0.30	0.088	0.11	17.14	4.80	5.55	20.79	3.95	5.25
C.V. %	9.73	12.68	13.76	10.94	14.99	10.57	10.16	11.38	13.15	13.98	13.21

### Nutrients uptake

Significantly higher nitrogen uptake by grains and straw was observed under weed free condition (105.6 and 104.4 kg ha<sup>-1</sup>, respectively), which was statistically at par with atrazine @ 0.75 kg ha<sup>-1</sup> + pendimethalin @ 0.75 kg ha<sup>-1</sup> PE, alachlor @ 1.5 kg ha<sup>-1</sup> + atrazine @ 0.5 kg ha<sup>-1</sup> PE, atrazine @ 0.75 kg ha<sup>-1</sup> + 2.4 D 0.5 @ kg ha<sup>-1</sup> PE and only atrazine @ 0.75 kg ha<sup>-1</sup>. Significantly higher phosphorus uptake by grain and straw was recorded by weed free treatment (32.5 and 18.7 kg ha<sup>-1</sup>, respectively), which was at par with pre-emergence application of atrazine @ 0.75 kg ha<sup>-1</sup> + pendimethalin @ 0.75 kg ha<sup>-1</sup> in case of grain, while T8, T9, T5, T7 and T6 (18.1, 16.2, 15.9, 15.6 and 14.9 kg ha<sup>-1</sup>, respectively) in case of straw. Significantly maximum potassium uptake by grains and straw were observed under treatment T2 (32.2 and 26.2 kg ha<sup>-1</sup>), which was statistically at par with T8, T9, T7 and T6 (29.4, 27.8, 27.7 and 27.2 kg ha<sup>-1</sup>) in case of grains, while T8, T7, T9 and T6 (24.7, 24.3, 22.4 and 21.4 kg ha<sup>-1</sup>) in case of straw production. The uptake by weeds was significantly high under weedy check (3.20, 1.15 and 1.02 kg ha<sup>-1</sup> nitrogen, phosphorus and potassium, respectively). Among the different weed management treatments, atrazine @ 0.75 kg ha<sup>-1</sup> + pendimethalin @ 0.75 kg ha<sup>-1</sup> PE registered significantly lower uptake of nutrients (0.52, 0.19 and 0.17 kg ha<sup>-1</sup>, N, P and K, respectively), while significantly higher uptake of nutrients (1.37, 0.51 and 0.43 kg ha<sup>-1</sup>, N, P and K, respectively) registered under weed control by inter-culturing at 30 and 45 DAS fb HW. The nutrient uptake is a function of yield and nutrient concentration in plant. The higher uptake of nutrients might be due to better development of crop resulting lesser crop weed competition. Thus, improvement in uptake of N, P

and K might be attributed to their concentration in grain and straw and associated with higher grain and straw yields. The findings for the nutrients uptake was followed the pattern of those were reported by Kour et al. (2014) and Samant et al. (2015) in maize. To recommend the atrazine @ 0.75 kg ha<sup>-1</sup> + pendimethalin @ 0.75 kg ha<sup>-1</sup> PE is economically better than the rest of the treatments.

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# Selection indices and discriminant function analysis for grain yield in greengram [*Vigna radiata* (L.) Wilczek]

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## ABSTRACT

Ninety mutants of greengram were taken as experiment materials for estimation of selection indices among the yield components and their direct and indirect effects on grain yield based on Smith-Hazel indices. In the case of mutants of *Sujata*, 6.29 % higher genetic gain was observed through SC-II (multiple criteria selection) over genetic gain availed in SC-I (yield *per se*) while, in case of mutants of *OBGG-52*, 5.12 % more genetic gain was availed through SC-II multiple criteria selection ) than the genetic gain availed from SC-I (yield *per se*). The highest genetic advance in grain yield per plant was obtained on a linear combination of traits such as days to 50% flowering, pod length, pods per plant, 100-seed wt; grains per pod and yield per plant suggesting that the above characters could be advantageously exploited in the greengram breeding programs. Using yield *per se* performance and index scores based on multiple character selection criteria, twenty productive mutants of these two varieties were selected which are considered to be significantly superior mutant genotype.

**Key words:** Discriminant function, greengram, mutant, selection indices, seed yield

## INTRODUCTION

Greengram [*Vigna radiata* (L.) Wilczek] is an annual self-pollinated pulse legume. India is the largest producer with more than 50% of world production but the productivity is still very low i.e. 499 kg ha<sup>-1</sup> in India (Anon., 2016) as compared to countries like China where the productivity is 1276 kg ha<sup>-1</sup> (Anon., 2015). The bottlenecks in its improvement have been the lack of variability in different traits and improvement of one trait on its own will affect the performance of other traits because of genotypic correlations between traits. Direct selection based on *per se* yield is often not effective in the identification of productive lines as yield is a polygenic controlled complex trait of moderate to low heritability having non-additive gene action and also dependent on several component traits. Selection indices function like an additional characters which are a result of the

combination of various characteristics from which selection responses are desired (Santos et al., 2007), which allows the improvement of various characters simultaneously, independently of the existence or not of a correlation between them (Smith, 1936; Hazel, 1943; Williams, 1962; Cruz and Regazzi, 2001). Selection indices have been used in numerous studies to determine the most valuable genotypes as well as the most suitable combination of traits with the intention of indirectly improving the yield in different plants (Siahpoosh et al., 2001; Singh and Balyan, 2003; Chandra et al., 2003; Rabiei et al., 2004; Sabouri et al., 2008; Rezaei and Yousefi, 2008; Imani et al., 2009; Fotokian and Agahi, 2014). Therefore, the use of discriminant function of Fisher (1936) for plant selection was proposed by Smith (1936) to construct a selection index i.e. a linear combination of plant characters associated with the yield which can measure the efficiency of various character combinations and better exploit

of genetic correlations with several traits for improvement of the dependent variable i.e. seed yield. The index is a linear weighted function of observations of an individual or its relatives that aim to rank the population for breeding values and thus expected progeny performance (Falconer, 1981). In the present study, yield and multiple character selection index criteria involving direct and indirect components of yield were used for the identification of productive mutant genotype and estimate the expected genetic advance and relative efficiency.

## MATERIALS AND METHODS

Two experiments i.e. first experiment consists forty five mutants of a hybrid variety (*Sujata*) and other experiment consists forty five mutants of a mutant variety (*OBGG-52*) conducted separately to find out the selection indices and the genetic gain in greengram. these mutants are developed by treating the seed samples of two greengram varieties, viz., *Sujata* and *OBGG-52* with different doses per concentrations of one physical mutagen (gamma rays), three chemical mutagens (EMS, NG, MH) and combinations of physical and chemical mutagens with a selection of plants for advancing generations from  $M_1$  to  $M_5$  on yield and yield attributes. The single mutagenic treatments were 20 kR, 40 kR, 60 kR gamma-ray; 0.2 %, 0.4 %, 0.6 % EMS; 0.005 %, 0.010 %, 0.015 % NG and 0.01 %, 0.02 %, 0.03 % MH. The three combined treatments were 40 kR gamma rays combined with 0.4 % EMS, 0.010 % NG and 0.02 % MH.

In  $M_5$  generations, forty five mutants of each variety were grown along with the parent variety in randomized block design with three replications at Orissa University of Agriculture and Technology, Bhubaneswar for the study of selection indices and nine characters i.e. Days to 50% flowering, Days to maturity, Plant height, Clusters per plant, Pods per plant, Pod length, Seeds per pod, 100-seed weight and Yield per plant. Basing on these data selection indices were constructed as follows

## Construction of selection indices

The genotypic and phenotypic variance and co-variances among the characters provide the basis for constructing selection indices. The selection indices are in the form.

$$I = b_1x_1 + b_2x_2 + \dots + b_nx_n$$

where the x's are the phenotypic value of the n-characters included in the index construction, the b's are the relative weights to be assigned to each character for computing the index value and I is the index value of each entry on which selection is to be based. The b values are so estimated as to maximize expected genetic advance in the ultimate economic criterion from selection among the materials.

In the present investigation, seed yield is considered as the ultimate economic criterion and thus, appropriate values of b's would maximize expected genetic advance in yield from index selection obtained by synthesis of the following simultaneous equations as shown by Smith (1963) and Hazel (1943).

$$b_1p_{1.1} + b_2p_{1.2} + \dots + b_n p_{1.n} = G_1.y$$

$$b_1p_{2.1} + b_2p_{2.2} + \dots + b_n p_{2.n} = G_2.y$$

$$\text{-----}$$

$$b_1p_{n.1} + b_2p_{n.2} + \dots + b_n p_{n.n} = G_n.y$$

The P symbols in the above equations represent phenotypic variance co-variance<sup>-1</sup> among characters and the 'G' represents the genotypic co-variance between any particular character and yield.

The selection criteria (SC) applied for the identification of productive mutant cultures were SC-I Direct selection based on yield *per se* (X9) and SC-II Combined direct and indirect selection based on yield (X9) and eight yield influencing traits (X1, X2, X3, X4, X5, X6, X7, and X8). Where, X1-Days to 50% flowering, X2 - Days to maturity, X3 - Plant height, X4 - Clusters per plant, X5 - Pods per plant, X6 - Pod length, X7 - Seeds per pod, X8 - 100-seed weight, X9 - Yield per plant

## RESULTS AND DISCUSSION

The analysis of variance revealed a significant genotype effect for all the traits under study. This provides evidence of the presence of sufficient genetic variability among parents and mutants that can be exploited in a breeding program through selection. The estimates of means for different characters of the mutant cultures of both varieties *Sujata* and *OBGG-52* are presented in Tables 1 and 2, respectively. In both cases, none of the mutants flowered significantly earlier than the parent variety. However, twenty-two mutants of *Sujata* and six mutants of *OBGG-52* flowered significantly late than their respective parents. In *Sujata*, 14 mutants were significantly taller and only one was significantly shorter in height than the parent. In *OBGG-52*, three mutant cultures

were significantly taller and five were significantly shorter in height than the parent. In both cases, none of the mutant cultures showed significantly higher clusters per plant. Seven mutants derived from the variety *Sujata* showed a significant increase in pods per plant. In the case of *OBGG-52*, four mutant cultures exhibited a significant increase in pods per plant. Seven mutant cultures of each showed a significant increase in pod length than their respective parent variety. The mutants of these two varieties differed significantly in seeds per pod. Numbers of mutant cultures showing significantly higher seeds per pod than respective parents were three in the case of *Sujata* and twelve in the case of *OBGG-52*. Nineteen mutant cultures of *Sujata* recorded significantly higher 100-seed weight than its parent while in the case of *OBGG-52*, only one found.

**Table 1.** Means and selection indices for quantitative traits in the mutants of *Sujata* variety

Entry No.	Name of mutants	Days to 50% flowering	Days to maturity	Plant height (cm)	Clusters plant <sup>-1</sup>	Pods plant <sup>-1</sup>	Pod length (cm)	Seeds pod <sup>-1</sup>	100-seed weight (g)	Yield plant <sup>-1</sup> (g)	Selection indices (9 traits)
1	SG1-1	36.0	55.7↓	27.0*	3.47	11.1*	6.50*	9.97	3.03*	3.17*	6.83
2	SG1-2	36.0	55.7↓	27.7*	3.00	10.2	6.33*	9.60	3.05*	2.80*	6.71
3	SG1-3	37.0	56.0	26.9*	3.23	10.7*	6.00	8.87	2.72	2.45	6.50
4	SG2-1	37.7	56.3	26.8*	3.03	8.8	5.97	8.57	3.01*	2.21	6.34
5	SG2-2	37.7	56.7	24.8	2.60	7.3	5.63	9.13	3.19*	2.02	6.19
6	SG2-3	37.3	56.3	27.0*	2.97	8.6	5.83	9.63	3.22*	2.13	6.43
7	SG3-1	38.7*	58.3	26.1	3.17	8.7	6.13	9.53	2.58	2.24	6.28
8	SG3-2	39.3*	58.3	26.8*	3.23	9.1	5.97	9.37	2.68	2.32	6.36
9	SG3-3	38.3	57.3	26.6*	3.17	10.6	6.33*	10.67*	2.75	3.02*	6.85
10	SE1-1	38.0	57.3	27.2*	3.37	9.9	5.90	9.10	2.74	2.54	6.39
11	SE1-2	38.3	57.0	26.3*	3.20	11.2*	6.20*	10.43*	3.19*	3.18*	7.08
12	SE1-3	38.7*	57.3	26.5*	3.03	9.3	5.70	9.63	3.07*	2.46	6.53
13	SE2-1	39.0*	57.0	24.8	2.97	8.8	5.50	9.47	2.70	2.33	6.25
14	SE2-2	39.0*	57.3	24.8	3.30	9.9	6.07	10.03	3.00*	2.83*	6.68
15	SE2-3	38.7*	57.3	27.0*	3.37	9.9	6.30*	10.17	3.22*	2.96*	6.84
16	SE3-1	37.0	57.3	27.1*	3.47	9.4	5.83	8.80	2.95*	2.28	6.24
17	SE3-2	37.3	55.7↓	28.1*	3.43	10.9*	6.43*	10.33*	3.04*	3.27*	6.93

Entry No.	Name of mutants	Days to 50% flowering	Days to maturity	Plant height (cm)	Clusters plant <sup>-1</sup>	Pods plant <sup>-1</sup>	Pod length (cm)	Seeds pod <sup>-1</sup>	100-seed weight (g)	Yield plant <sup>-1</sup> (g)	Selection indices (9 traits)
18	SE3-3	37.3	55.7↓	26.0	3.17	9.2	5.83	9.27	2.99*	2.31	6.37
19	SN1-1	38.3	56.3	22.6	2.93	8.5	5.97	9.03	2.73	2.13	6.25
20	SN1-2	38.7*	57.7	24.0	3.27	11.5*	6.07	10.00	2.95*	3.37*	6.95
21	SN1-3	39.0*	56.3	23.6	3.07	8.0	5.63	8.40	2.49	1.64	5.92
22	SN2-1	38.3	57.7	26.2	3.00	9.1	5.77	9.20	3.05*	2.37	6.44
23	SN2-2	37.7	56.0	27.5*	3.17	9.9	5.23	8.40	2.71	2.43	6.18
24	SN2-3	38.7*	57.3	24.5	3.03	9.4	5.27	8.87	3.08*	2.40	6.36
25	SN3-1	39.3*	57.7	25.1	3.13	10.1	5.53	9.10	2.81	2.67	6.48
26	SN3-2	39.3*	57.7	25.3	3.10	9.7	5.77	9.23	2.80	2.59	6.49
27	SN3-3	39.7*	57.3	25.9	3.13	10.9*	6.20*	9.93	3.22*	3.05*	7.09
28	SM1-1	39.0*	58.0	24.9	3.17	8.9	5.43	8.70	2.70	2.14	6.11
29	SM1-2	39.3*	59.3*	24.9	3.00	9.4	5.93	9.07	2.73	2.45	6.43
30	SM1-3	39.0*	58.0	25.7	3.27	10.8*	5.80	8.50	3.04*	2.91*	6.68
31	SM2-1	38.3	56.3	24.7	2.83	9.7	5.37	8.07	2.80	2.22	6.28
32	SM2-2	38.7*	57.0	23.6	2.80	9.9	5.87	9.53	2.76	2.45	6.59
33	SM2-3	38.7*	58.0	22.9	2.87	8.8	5.43	8.67	2.71	2.07	6.13
34	SM3-1	39.7*	59.3*	22.9	2.53	7.4	5.27	8.37	2.42	1.91	5.83
35	SM3-2	39.7*	58.7	23.9	2.63	8.1	5.43	8.93	2.41	2.31	6.04
36	SM3-3	40.0*	59.0*	23.5	2.73	7.6	5.57	8.63	2.48	1.85	5.97
37	SGE2-1	38.7*	58.7	22.7	2.57	7.3	5.87	9.47	2.33	1.60	5.95
38	SGE2-2	38.7*	59.0*	17.6↓	2.33	7.9	5.97	9.43	2.55	2.26	6.21
39	SGE2-3	38.3	58.3	23.2	2.93	8.1	5.63	9.23	2.79	2.27	6.11
40	SGN2-1	37.0	57.7	21.9	2.63	7.9	5.77	8.60	2.25	1.50	5.80
41	SGN2-2	37.3	58.3	25.9	2.67	7.2	6.00	8.10	2.29	1.91	5.75
42	SGN2-3	37.3	58.0	25.6	2.20	7.2	5.70	9.07	2.60	2.00	6.00
43	SGM2-1	38.0	58.0	20.5	2.53	7.7	5.33	8.27	2.44	1.52	5.77
44	SGM2-2	37.7	58.3	23.3	2.83	8.3	5.70	9.80	3.17*	2.35	6.36
45	SGM2-3	38.3	57.7	21.8	2.97	8.2	5.77	9.50	3.20*	2.38	6.35
46	<i>Sujata</i>	37.0	57.3	23.0	3.13	8.9	5.67	9.30	2.62	2.12	6.06
	C.D. (5%)	1.36	1.46	3.27	0.57	1.79	0.53	1.03	0.31	0.68	-
	GA	1.439	1.505	3.031	0.326	1.758	0.430	0.853	0.478	0.668	

\* Indicates significant increase over control (var. *Sujata*) at 5 % level.

↓ Indicates significant decrease from control (var. *Sujata*) at 5 % level.

Grain yield is a polygenic controlled complex character with low to moderate heritability owing to environmental effects and also greatly influenced by many interrelated component traits, which are also mostly polygenic and the direct selection for yield is often not much effective. Thus the use of multiple criteria selection for identification of superior genotypes has been done in several crops by many workers. The use of different types of multiple selection criteria for the identification of productive micromutant lines in different crops has been reported in pulses crops before by Dasgupta et al. (1984), Patel et al. (2007) and Choudhary et al. (2017). In the present study, instead of selecting M<sub>5</sub> cultures based on yield per plant only, an attempt was made to select high yielding M<sub>5</sub> cultures using multiple character selection indices. The selection was made based on SC-I on basis of yield *per se* and SC II- index based on all nine traits including yield per plant.

Selection indices of each mutant genotype of both varieties for SC-II were calculated using the

respective discriminant function which varies from 5.75 to 7.09 in the case of mutants of *Sujata* (Table 1), whereas 4.59 to 5.74 in the mutants of *OBGG-52* (Table 2). To assess the efficiency of the different selection criteria, the expected genetic gain for those criteria was estimated. In the case of *Sujata* mutant cultures, the expected genetic gain for SC-I (yield *per se*) was 0.668 g per plant while that for the multiple criteria selection through SC-II was 0.710 g plant<sup>-1</sup> indicating 6.29 % superiority over SC-I. In the case of *OBGG-52* cultures, the expected genetic gain for SC-I (yield *per se*) was 0.586 g per plant as against 0.616 g per plant for SC-II indicating 5.12 % superiority over the genetic gain from SC-I. Thus, all the multiple character selection index criteria showed higher expected genetic gain than selection based on yield *per se*. The selection based on the linear combination of yield component characters in the form of selection indices is more advantageous (Fig. 1 and 2) for the improvement of productivity in mungbean which was also earlier reported by Dasgupta and Das (1984), Magnussen (1991) and Lalehzar et al. (2017).

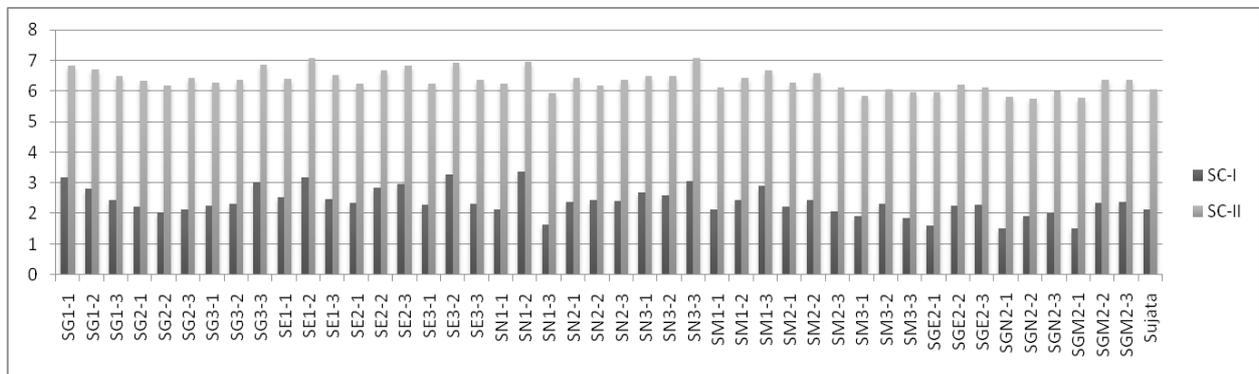


Fig. 1. Selection criteria index for mutants of *Sujata*

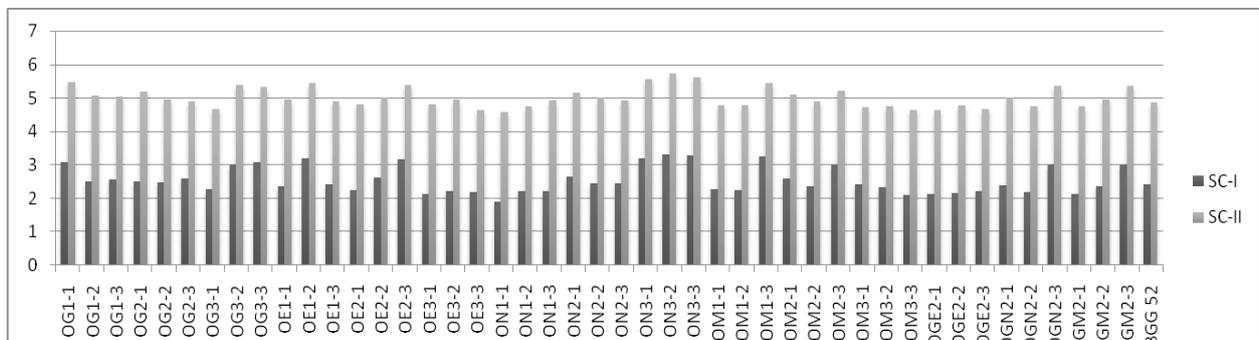


Fig. 2. Selection criteria index for mutants of *OBGG-52*

**Table 2.** Means and selection indices for quantitative traits in the mutants of *OBGG-52*

Entry No.	Name of mutants	Days to 50% flowering	Days to maturity	Plant height (cm)	Clusters plant <sup>-1</sup>	Pods plant <sup>-1</sup>	Pod length (cm)	Seeds pod <sup>-1</sup>	100-seed weight (g)	Yield plant <sup>-1</sup> (g)	Selection indices (9 traits)
1	OG1-1	37.3	57.3	26.3	3.27	10.3*	6.50*	10.40*	3.09	3.09*	5.48
2	OG1-2	38.0	57.7	27.9	3.27	9.5	6.27	9.17	3.10	2.52	5.08
3	OG1-3	37.0	56.7	26.3	3.27	9.5	6.17	9.20	3.12	2.57	5.04
4	OG2-1	40.7*	58.7	27.6	3.03	10.0	5.83	8.60	3.10	2.51	5.18
5	OG2-2	38.7*	59.0*	27.0	3.40	9.5	6.33	8.53	2.96	2.47	4.95
6	OG2-3	37.7	58.7	27.7	3.03	9.1	6.03	8.50	3.17	2.58	4.89
7	OG3-1	36.7	56.7	25.2	2.83	8.4	5.43	8.40	3.25	2.27	4.67
8	OG3-2	37.3	56.7	26.9	3.40	9.3	6.50*	9.83*	3.31	3.00*	5.38
9	OG3-3	37.0	56.7	26.7	3.27	9.4	5.80	9.70*	3.64	3.09*	5.34
10	OE1-1	37.0	56.3↓	27.3	3.07	8.1	6.17	9.33	3.19	2.36	4.97
11	OE1-2	37.3	56.7	28.6*	3.17	10.0	6.33	9.53*	3.44	3.19*	5.44
12	OE1-3	37.7	57.7	26.7	2.87	8.8	5.87	8.63	3.22	2.42	4.89
13	OE2-1	37.3	57.0	25.5	2.90	8.2	6.07	8.67	3.08	2.25	4.80
14	OE2-2	37.0	57.7	26.4	3.23	9.6	6.17	9.17	3.11	2.62	5.01
15	OE2-3	38.3	58.3	26.0	3.00	9.6	6.37	9.60*	3.14	3.18*	5.40
16	OE3-1	37.7	57.3	25.0	2.97	8.5	5.90	8.47	3.40	2.14	4.81
17	OE3-2	37.7	58.0	25.0	3.00	8.8	5.90	9.30	3.45	2.23	4.96
18	OE3-3	36.7	56.7	24.0	2.87	8.7	5.53	7.83	3.46	2.20	4.63
19	ON1-1	37.0	57.0	26.7	2.70	7.0	5.77	8.87	3.06	1.90	4.59
20	ON1-2	37.7	57.7	26.9	3.00	8.6	5.67	8.63	3.08	2.21	4.75
21	ON1-3	37.3	58.3	26.4	2.87	7.3	6.50*	9.50	3.33	2.23	4.93
22	ON2-1	37.3	57.7	28.4	2.93	8.4	6.47*	9.50	3.35	2.66	5.15
23	ON2-2	37.7	57.7	28.5*	3.07	9.0	6.27	9.17	3.07	2.44	5.01
24	ON2-3	37.7	58.0	27.1	2.90	7.9	6.47*	8.67	3.21	2.45	4.93
25	ON3-1	38.3	58.7	30.0*	3.30	10.3*	6.37	9.83*	3.68	3.21*	5.56
26	ON3-2	38.7*	58.7	25.7	3.70	10.4*	6.63*	10.50*	3.43	3.31*	5.74
27	ON3-3	38.3	58.0	24.2	3.37	10.3*	6.57*	10.03*	3.31	3.29*	5.61
28	OM1-1	37.0	57.3	24.0	2.63	7.5	5.83	8.53	3.58	2.28	4.79
29	OM1-2	37.3	58.0	20.9↓	2.93	6.8	5.97	9.00	3.37	2.26	4.78
30	OM1-3	38.7*	58.0	26.5	2.97	9.8	5.93	9.57*	3.31	3.26*	5.45

Entry No.	Name of mutants	Days to 50% flowering	Days to maturity	Plant height (cm)	Clusters plant <sup>-1</sup>	Pods plant <sup>-1</sup>	Pod length (cm)	Seeds pod <sup>-1</sup>	100-seed weight (g)	Yield plant <sup>-1</sup> (g)	Selection indices (9 traits)
31	OM2-1	37.0	56.7	27.5	3.03	8.1	6.00	9.63*	3.36	2.60	5.09
32	OM2-2	36.7	57.0	25.1	2.63	7.7	5.93	9.47	3.30	2.37	4.91
33	OM2-3	39.3*	59.0*	26.8	2.90	7.6	6.07	8.63	3.63	2.99*	5.22
34	OM3-1	36.3	56.3↓	24.7	2.63	8.0	5.77	8.27	3.29	2.42	4.73
35	OM3-2	36.3	56.3↓	23.3	2.87	7.4	6.00	8.40	3.48	2.34	4.76
36	OM3-3	37.0	56.7	23.9	2.67	7.3	5.53	8.17	3.55	2.11	4.64
37	OGE2-1	38.3	58.3	26.2	3.17	8.4	5.60	8.13	2.98	2.14	4.63
38	OGE2-2	38.7*	58.0	24.5	2.77	7.9	5.47	8.27	3.52	2.16	4.79
39	OGE2-3	38.3	58.3	21.5↓	2.70	7.5	5.43	8.50	3.00	2.21	4.66
40	OGN2-1	37.0	57.3	21.0↓	2.43	8.0	6.17	9.20	3.65	2.39	5.02
41	OGN2-2	37.3	57.3	21.3↓	2.43	7.4	5.63	8.67	3.49	2.19	4.76
42	OGN2-3	37.3	57.7	20.3↓	2.67	9.8	6.13	9.67*	3.61	2.99*	5.35
43	OGM2-1	38.3	58.3	23.8	2.57	7.2	5.50	8.67	3.49	2.13	4.76
44	OGM2-2	37.3	57.3	23.5	2.43	7.2	5.87	9.03	3.82*	2.35	4.96
45	OGM2-3	37.3	57.7	25.7	2.90	9.2	6.13	9.83*	3.60	2.99*	5.35
46	OBGG 52	37.3	57.7	25.2	3.27	8.8	5.93	8.47	3.47	2.42	4.87
	C.D. (5 %)	1.34	1.09	3.21	0.44	1.43	0.54	1.04	0.23	0.57	
	GA	1.125	1.139	3.245	0.323	1.608	0.458	0.852	0.384	0.586	

\* Indicates significant increase over control (var. *OBGG-52*) at 5 % level.

↓ Indicates significant decrease from control (var. *OBGG-52*) at 5 % level.

In present experiments, the 10 top-yielding M<sub>5</sub> mutant genotypes of both varieties (SN1-2, SE3-2, SE1-2, SG1-1, SN3-3, SG3-3, SE2-3, SM1-3, SE2-2 and SG1-2 of *Sujata* and ON3-2, ON3-3, OM1-3, ON3-1, OE1-2, OE2-3, OG3-3, OG1-1, OG3-2 and OGN2-3 of *OBGG-52*) were also among top-ranking cultures on the basis of the multiple selection criteria thus appeared to be significantly superior mutants. Here as in the top 10% (top five) yielding M<sub>5</sub> mutant genotype of both varieties, only four are also among top-ranking cultures based on the multiple selection criteria (Table 3). The genotype SG 3-3, which secured 5<sup>th</sup> rank in multiple selection indices due to its weightage for the character seeds per pod which is the highest among all mutants of *Sujata* and useful in breeding

for improvement of that character as well as yield. Similarly, in the case of mutants of *OBGG*, OE1-2 secured 5<sup>th</sup> rank by multiple selection indices due to its weightage for its many significant characters of the seeds per pod which is highest among all the genotypes and useful in breeding for improvement of that character as well as yield. Although there was some rank difference in SC-I and SC-II, almost all top ten got the opportunity indicated that yield *per se* performance based selection i.e. selection of about top 25% of the population might be followed to save time and labor. But when any yield attributing character required for hybridization in a breeding program or required to select only the top 10% then selection must be done as per the multiple character selection criteria (Choudhary et al., 2017).

**Table 3.** Index scores and rank of mutants basing on multiple selection criteria

Mutants of <i>Sujata</i>					Mutants of <i>OBGG-52</i>				
Superior mutants	SC-I (yield)	Rank	SC-II (nine characters)	Rank	Superior mutants	SC-I (yield)	Rank	SC-II (nine characters)	Rank
SN1-2	3.37	1	6.94	3	ON3-2	3.31	1	5.74	1
SE3-2	3.27	2	6.93	4	ON3-3	3.29	2	5.62	2
SE1-2	3.18	3	7.08	2	OM1-3	3.26	3	5.45	5
SG1-1	3.17	4	6.83	7	ON3-1	3.21	4	5.56	3
SN3-3	3.05	5	7.09	1	OE1-2	3.19	5	5.44	6
SG3-3	3.02	6	6.85	5	OE2-3	3.18	6	5.40	7
SE2-3	2.96	7	6.84	6	OG3-3	3.09	7	5.34	10
SM1-3	2.91	8	6.67	10	OG1-1	3.09	8	5.48	4
SE2-2	2.83	9	6.69	9	OG3-2	3.00	9	5.38	8
SG1-2	2.80	10	6.71	8	OGN2-3	2.99	10	5.35	9
Parent ( <i>Sujata</i> )	2.12	33	6.06	37	Parent ( <i>OBGG-52</i> )	2.42	24	4.87	30

## CONCLUSION

It can be concluded that selection via a selection index that gives proper weight to each trait is more efficient than selection for individual traits at a time (Hazel, 1943; Mohammadi et al., 2013). In the case of mutants of *Sujata*, 6.29 % genetic gain expected through SC-II over SC-I whereas, in the case of mutants of *OBGG-52*, it was 5.12 %. The highest genetic advance in grain yield per plant obtained on a linear combination of traits such as days to 50% flowering, pod length, pods per plant, 100-seed wt, grains per pod and yield per plant suggesting that these characters could be advantageously exploited in the greengram breeding programmes. On the basis of yield *per se* and index scores based on multiple character selection criteria including yield in M5 generation, twenty significant higher-yielding mutant lines i.e. SG1-1, SG1-2, SG3-3, SE1-2, SE2-2, SE2-3, SE3-2, SN1-2, SN3-3 and SM1-3 of *Sujata*, and OG1-1, OG3-2, OG3-3, OE1-2, OE2-3, ON3-1, ON3-2, ON3-3, OM1-3 and OGN2-3 of *OBGG-52* were selected which are considered to be productive and desirable mutants.

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# Leaf blotch management of turmeric and concurrent yield assessment

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## ABSTRACT

A field experiment was conducted during June 2018 to February 2019 at High Altitude Research Station, Pottangi, Koraput district under Odisha University of Agriculture and Technology, Bhubaneswar to evaluate various fungicides against leaf blotch of turmeric. Treatments included the fungicides Flusilazole+Carbendazim (0.1%), Hexaconazole (0.1%), Thiophonate Methyl (0.1%), Azoxystrobin+Tabuconazole (0.1%) and Carbendazim+Mancozeb (0.15%) for both rhizome treatment and foliar spray at 60 and 90 days after planting. Among the treatments, rhizome treatment and foliar application with Azoxystrobin+Tabuconazole (0.1%) shown the best result, significantly reduced disease intensity of turmeric leaf blotch (5.62%) and enhanced fresh-rhizome yield 22.33 t ha<sup>-1</sup> followed by Carbendazim+Mancozeb (0.15%) with (6.77%) disease intensity and 21.45 t ha<sup>-1</sup> fresh rhizome yield over control with (21.58%) disease intensity and 16.85 t ha<sup>-1</sup> fresh rhizome yield. High cost-benefit ratio (0.91:1) was achieved with the treatment of Azoxystrobin+Tabuconazole.

**Key words:** Azoxystrobin, carbendazim, leaf blotch, mancozeb, tabuconazole, turmeric

## INTRODUCTION

Turmeric (*Curcuma longa* L.) a rhizomatous perennial belonging to the family Zingiberaceae, is native to tropical South Asia, most probably from India. Commonly known as 'Indian saffron' and is one of the important commercial spice crops. Curcumin and oleoresin are reported to lower the total cholesterol in blood serum (Manjunatha and Srinivasa, 2008). The plant is propagated through rhizomes. The pseudo stems are shorter than leaves. The rhizomes are ready for harvesting in about 7 to 9 months after planting. India is the largest producer, consumer and exporter of turmeric in the world (Anon., 2019). In India, turmeric crop is cultivated in an area of 2.38 lakh ha with a total production of 11.33 lakh ton (Anon., 2018a). The most important foliar diseases of turmeric are leaf spot caused by *Colletotrichum capsici* and leaf blotch caused by *Taphrina maculans* (Vijayakumar, 2017). Leaf blotch disease is commonly occurring in almost all turmeric growing areas of India (Velayudhan et al., 1999). In Odisha, turmeric is an important cash crop grown by tribals for their

livelihood. As per the recent data of Agrivikas from National Institute of Agricultural Marketing under Ministry of Agriculture, Government of India, Odisha contributes about 21% of India's turmeric cultivation in terms of area and Kandhamal makes up for over 50 % of the state's total share (Anon., 2018b). Odisha produces turmeric to the tune of 54500 MT from 27860 ha (Anon., 2018b). Kandhamal district stands first in turmeric crop both in terms of area as well as production in the state and Koraput is the second largest producing district followed by Nayagarh and Keonjhar .

Taphrina leaf blotch appears on the lower leaves and usually late in the crop season during October-November. Symptoms appear as small, oval, rectangular or irregular brown spots on either side of the leaves (Fig. 2) at early stage which soon become dirty yellow or dark brown (Fig. 3) at later stage. This disease infects plant leaves as well as leaf sheath. It reduces total photosynthetic blotch area of the plant leaves under severe infection (Maurya et al., 2011). The leaves also turn yellow. In severe cases the plants exhibit a scorched appearance and

the rhizome yield is reduced. Yield losses were 37.6 to 52.9% due to attack of this fungus (Panja et al., 2000). Very limited effort was made to develop a management strategy with new systemic fungicides. Hence, the present study was conducted for managing leaf blotch disease in turmeric using new systemic fungicides.

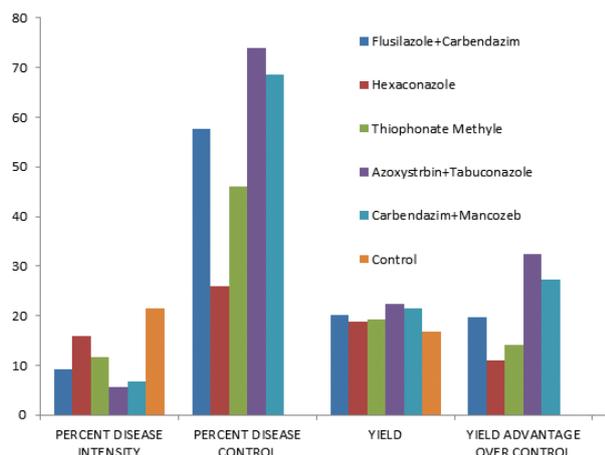


Fig. 1 . Effect of fungicides on leaf blotch of turmeric



Fig. 2. Symptoms of leaf blotch of turmeric (early stage)



Fig. 3. Symptoms of leaf blotch of turmeric (late stage)

## MATERIALS AND METHODS

Field experiment was conducted at High Altitude Research Station (HARS), Pottangi, Koraput under Odisha University of Agriculture and Technology (OUAT), Bhubaneswar (Fig. 4). Field trials were laid out with six treatments and three replications in Randomized Block Design. Forty rhizomes were planted on raised beds of 3 x 1 m size at a spacing of 30 x 25 cm. Nitrogen, phosphorus and potassium (NPK) were applied @ 60 kg ha<sup>-1</sup>, 30 kg ha<sup>-1</sup> and 90 kg ha<sup>-1</sup> respectively in the form of urea, single super phosphate and muriate of potash as basal and top dressing. Fungicides such as Flusilazole + Carbendazim (0.1%), Hexaconazole (0.1%), Thiophonate Methyl (0.1%), Azoxystrobin + Tabuconazole (0.1%) and Carbendazim + Mancozeb (0.15%) were applied separately by dipping rhizomes in the fungicide solution before planting followed by foliar application at 60 and 90 DAP. There were six treatments including control.



Fig. 4. Research plot at HARS, Pottangi

The treatment details of rhizome and foliar application are furnished in Table 1. The first spray was applied at 60 days after planting (DAP) and the second at 90 DAP. Observation on disease intensity was recorded 20 days after the last spray, i.e., 110 DAP.

The percentage of disease intensity was calculated by following formula.

$$\% \text{ Disease Intensity} = \frac{\text{(Number of infected plants)}}{\text{(Total number of plants)}} \times 100$$

The percentage of disease control was calculated by following formula.

$$\% \text{ of Disease Control} = (\text{Per cent disease intensity in control} - \text{Per cent disease intensity in treatment}) / (\text{Per cent disease intensity in control}) \times 100$$

**Table 1.** Effect of fungicides on leaf blotch of turmeric

Sl.	Treatment details	*% disease intensity	% disease control	*Yield (t ha <sup>-1</sup> )	Yield advantage over control (%)
T1	Flusilazole+Carbendazim (0.1%)	9.16	57.6	20.18	19.76
T2	Hexaconazole (0.1%)	15.96	26.04	18.72	11.09
T3	Thiophonate Methyle (0.1%)	11.66	45.96	19.22	14.06
T4	Azoxystrobin+Tabuconazole (0.1%)	5.62	73.95	22.33	32.52
T5	Carbendazim+Mancozeb (0.15%)	6.77	68.62	21.45	27.29
T6	Control	21.58	-	16.85	-
CD(5%)		4.42		0.89	
SEm±		1.47		0.29	

\*Mean of three replications

## RESULTS AND DISCUSSION

Statistical analysis of data revealed that all fungicidal treatments showed significantly superior effect over disease intensity and yield. Disease intensity varied from 5.62 to 21.58%, recorded during the course of the study. Results indicated that rhizome treatment, followed by foliar application of Azoxystrobin + Tabuconazole (0.1%) and Carbendazim + Mancozeb (0.15%) were at par with each other (with corresponding per cent disease intensity of 5.62 and 6.77 respectively). The highest per cent of disease control (73.95%) was recorded in treatment of Azoxystrobin + Tabuconazole (0.1%) followed by Carbendazim+Mancozeb (0.15%) with (68.62%) disease control. These treatments were significantly superior over other fungicidal treatments. Highest fresh rhizome yield 22.33 t ha<sup>-1</sup> was achieved in application of Azoxystrobin+Tabuconazole (0.1%) followed by Carbendazim+Mancozeb (0.15%) with 21.45 t ha<sup>-1</sup> yield. Similarly Azoxystrobin + Tabuconazole (0.1%) gives the highest yield advantage over control 32.52% followed by Carbendazim+Mancozeb (0.15%) with 27.29%. Similar type of experiment

has been carried out by Chopada and Rakholiya (2015) on assessment of yield losses due to leaf blotch of turmeric caused by *Taphrina maculans*.

Economics for each fungicide was calculated based on mean yield analysis (Table 2). All the treatments were economically beneficial over the control. Azoxystrobin + Tabuconazole (0.1%) gave the best economic returns i.e. 1: 1.91 among the fungicides tested followed by Carbendazim+Mancozeb (0.15%) with 1: 1.83. Results of this study on foliar application of Carbendazim+Mancozeb are in agreement with the studies undertaken by Prasadji et al. (2004) and Singh et al. (2003). Azoxystrobin got excellent inhibition capacity on spore germination and mycelial growth of fungus (Petit et al., 2012) which may be a key factor for its superior impact on management of leaf blotch causing fungus. Being both systemic and contact in nature fungicides like Carbendazim + Mancozeb when applied at regular interval got good impact on management of leaf blotch which corroborates the work undertaken by Rao and Kumar (2013).

**Table 2.** Economic analysis of treatments on leaf blotch of turmeric

Sl.	Treatments	Yield (t ha <sup>-1</sup> )	Gross return (Rs.)	Cost of cultivation	Net return (Rs.)	B:C ratio
T1	Flusilazole+Carbendazim (0.1%)	20.18	605400	351785	253615	1: 1.72
T2	Hexaconazole (0.1%)	18.72	561600	350241	211359	1: 1.60
T3	Thiophonate Methyl (0.1%)	19.22	576600	350610	225990	1: 1.64
T4	Azoxystrobin+Tabuconazole (0.1%)	22.33	669900	352185	317715	1:1.90
T5	Carbendazim+Mancozeb (0.15%)	21.45	643500	350385	293115	1:1.83
T6	Control	16.85	505500	349935	155565	1:1.44

\* B C. ratio = Gross Return / Cost of cultivation

## CONCLUSION

Based on the study, it is concluded that rhizome treatment followed by foliar spray with Azoxystrobin+Tabuconazole (0.1%) was the most effective in managing leaf blotch and for increasing yield in turmeric followed by Carbendazim+Mancozeb (0.15%).

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# **Arsenic-mineral interaction and ameliorative effect of vitamin E supplementation in arsenic exposed goats**

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## **ABSTRACT**

This study was aimed at investigating the arsenic-mineral interrelationship and ameliorative efficacy of dietary vitamin E supplementation in arsenic (As) exposed kids. Three treatments, groups (T1, control; T2, 60 mg As kg<sup>-1</sup> diet as sodium arsenite; T3, 60 mg As kg<sup>-1</sup> diet as sodium arsenite + 250 IU vitamin E kg<sup>-1</sup> diet) were formed with seven kids in each group in a randomized block design. Blood samples were collected on day 0, 45, 90, 135 and 180 of the experiment and analyzed for hemato-biochemistry, serum minerals and thyroid hormones. At the end of the experiment, goats were sacrificed to analyze mineral status of different vital organs. Results showed that inclusion of As in the diet adversely affected different kidney and hepatic affliction markers (hemoglobin, total protein, globulin, urea, creatinine, thyroid hormones) as well as serum and tissue mineral (Cu, Zn, Fe, Mn, Se) concentrations. Supplementation of vitamin E (T3) at 250 IU kg<sup>-1</sup> diet could partially ameliorate the adverse effects caused by 60 mg As kg<sup>-1</sup> diet.

**Key words:** Arsenic, kids, mineral retention, serum minerals, thyroxine

## **INTRODUCTION**

Arsenic (As) is one of the most prevalent toxic element around the world (Naujokas et al., 2013). It is now emerging as a serious candidate for causing damage to human and animal health (Naujokas et al., 2013; Mandal, 2017; Zubair et al., 2018a, b). Animals are the silent and worst sufferers of this problem (Keshavarzi et al., 2015; Mandal, 2017; Zubair and Martyniuk, 2018). The health effect is mediated either directly by retention of As in tissues or by interfering with other essential element metabolism (Goyer and Clarkson, 2008; Mohanta et al., 2016; Zubair and Martyniuk, 2018). Arsenic impairs organ functions particularly that of liver and kidney (Mohanta et al., 2014a; Mohanta and Garg, 2018; Zubair and Martyniuk, 2018) through oxidative stress (Mohanta et al., 2015; Ganger et al., 2016).

Moreover, toxic elements are known to interfere with metabolism of essential trace elements leading to disturbances in the homeostasis of essential elements (Goyer and Clarkson, 2008; Mohanta et al., 2014b), which are essential for many physiological functions in the animal's body. Therefore, we were interested in whether As exposure disrupts levels of essential trace elements and other toxic elements in the serum and tissues along with the blood biochemistry.

Vitamin E is well known to act as an anti-oxidant, as it protects body tissues against oxidative damage by reducing free radicals (Zubair et al., 2016; Zubair and Martyniuk, 2018). In view of these facts, present study was conducted to test the efficacy of vitamin E as an ameliorative agent against As toxicity for its effect on blood biochemical parameters, serum thyroid hormones and blood and tissues mineral retention in kids.

## MATERIALS AND METHODS

The experiment was conducted following international guidelines after approval of Institutional Animal Ethics Committee and the Committee for the Purpose of Control and Supervision of Experiments on Animals. Twenty one male goat kids were procured from Sheep and Goat Section of ICAR-Indian Veterinary Research Institute, Izatnagar, India; dewormed for both ecto- and endo-parasites and acclimatized to the shed environment and feeds for one month's duration. The kids of 4-6 months age were then divided randomly into three equal groups on the basis of their body weight ( $6.71 \pm 0.49$  kg). They were maintained under similar managerial conditions in a well-ventilated shed and provided with individual feeding and watering troughs.

Kids were offered a common basal diet comprising of concentrate mixture (27% ground maize grain, 25% soybean meal, 45% wheat bran, 2% mineral mixture and 1% common salt) calculated according to body weight, 100 g wheat straw and about 250-300 g green maize (*Zea mays*) fodder daily to meet their nutrient requirements (NRC, 2007). The analyzed chemical composition of concentrate mixture is presented in Table 1. Experimental feeding was similar in all the groups except that of As, which was added at 60 mg (as aqueous solution of sodium arsenite)  $\text{kg}^{-1}$  in the diet of T<sub>2</sub> and T<sub>3</sub> animals, while kids in group T<sub>3</sub> were additionally supplemented with 250 IU vitamin E per kg diet. Feed was offered daily at 9.30 AM and ors, if any, were recorded for the whole experimental period of 180 days. Clean and fresh drinking water was provided ad libitum.

**Table 1.** Chemical composition (% DM basis) of feeds and fodders offered in the experiment

Attribute	Concentrate mixture	Wheat straw	Green maize
Dry matter	94.49	95.84	26.09
Organic matter	94.38	92.80	93.35
Crude protein	22.44	3.43	5.67
Ether extract	2.05	0.90	2.18
Neutral detergent fibre	33.87	81.82	69.37
Acid detergent fibre	9.34	56.68	38.06
Calcium	1.43	1.43	0.97
Phosphorus	0.67	0.14	0.31
Zinc (ppm)	75.1	28.4	38.7
Copper (ppm)	19.3	19.7	25.8
Iron (ppm)	570	92	504
Manganese (ppm)	82.0	3.9	27.3
Cobalt (ppm)	4.38	4.37	3.87
Selenium (ppb)	279	115	68.1
Arsenic (ppb)	460	771	670

About 10 mL of blood samples were collected on day 0, 45, 90, 135 and 180 of the experiment through jugular vein from each kid. Out of this, 2 mL was collected into heparinized tube and the rest into clean and dry test tube and the other blood was separated by centrifuging at 3000 rpm for 10-15 minutes to get serum and stored in clean vials at  $-20^{\circ}\text{C}$  for further analysis.

Haemoglobin (Hb) was estimated in the whole blood using Drabkin's solution by cyanomethemoglobin method. The serum samples were analyzed for different biochemical constituents (glucose, total protein, albumin, urea, creatinine and total cholesterol) using diagnostic kits (Span Diagnostics Limited, Surat, India). Serum globulin concentration was calculated as the difference between total protein (TP) and albumin.

Tri-iodothyronine ( $T_3$ ) and thyroxin ( $T_4$ ) in serum samples was estimated by radioimmunoassay kits (Immunotech, Radiova, Czech Republic) by competitive immunoanalytical assay. Unknown serum samples and standards were incubated together with  $^{125}I$  triiodotyrosine in monoclonal anti- $T_3$   $T_4$  antibody-coated tubes. After incubation, the contents of the tubes were aspirated and the bound activity was measured in a gamma counter (Packard, USA).

Serum and tissue samples were analyzed for Ca (Talapatra et al., 1940) and P (AOAC, 2012). Trace elements (copper, zinc, iron, cobalt and manganese) were estimated in their mineral extracts [prepared by wet digestion in triple-acid mixture of nitric acid, sulphuric acid and perchloric acid (4:2:1)] using atomic absorption spectrophotometer (AAS, Model 4141, Electronic Corporation of India Limited, Hyderabad, India).

The data generated in the present experiment were analyzed statistically using IBM SPSS 20.0 (2011). Analysis of variance and univariate model of Generalized Linear Model were used for comparing means among groups, and group and period effects, respectively (Snedecor and Cochran, 1994). Duncan test with least significant difference was used for post-hoc comparison.

## RESULTS AND DISCUSSION

### Effect of biochemical profile

The data regarding mean blood Hb concentration, serum TP, albumin, globulin, blood glucose, urea, creatinine and cholesterol are presented in Table 2. Blood Hb level showed a significant ( $P < 0.05$ ) depression in the 60 ppm As ( $T_2$ ) group on 180<sup>th</sup> day of study indicating chronic As toxicity. Similar results were reported in goats fed 50 mg As  $kg^{-1}$  diet (Das et al., 2012). This reduction in Hb levels in As exposed animals might be due to suppression of the granulopoietic activity of bone marrow by residual As (Kaneko et al., 2008). It was further observed that vitamin E supplementation of 250 IU vitamin E  $kg^{-1}$  diet improved the Hb level, suggesting its partial ameliorative effect on blood Hb. In previous reports, supplementation of vitamin

E (50, 100 or 150 IU)  $kg^{-1}$  diet could partially restored Hb level in goats (Das et al., 2012).

Serum albumin concentrations were similar ( $P > 0.05$ ) among three groups, but TP and globulin levels were significantly ( $P < 0.05$ ) reduced in the As exposed kids after 90<sup>th</sup> day of exposure indicating an adverse effect of As on the animals. Reduced TP and globulin values were also observed in goats (Zubair and Martyniuk, 2018). However, no difference was observed in vitamin E supplemented animals and control group, which confirms an ameliorative effect against As toxicity. Similar ameliorative effect of vitamin E against As toxicity was observed in poultry (Kalavathi et al., 2011)

The mean values of serum glucose levels were comparable ( $P > 0.05$ ) among different groups. Contrary to our observations, increased blood glucose level was observed in goats upon As exposure (Pandey et al., 2005) and the authors attributed it to the stress elicited by As exposure that increased cortisol release by adrenal cortex and resulting into gluconeogenesis (Szincicz and Forth, 1988). However, in our previous study, we did not observe any variation in serum cortisol concentration on As exposure (60 mg of As  $kg^{-1}$  diet) in kids (Mohanta et al., 2015). This discrepancy in result might be due to higher concentration of As used i.e. 375 mg vs 30 mg per 15 kg BW ( Biswas et al., 2000).

Serum urea and creatinine are sensitive indicators of glomerular filtration and renal function (Kaneko et al., 2008). Kidney dysfunction results in their decreased clearance and therefore increases their blood levels. Serum urea and creatinine concentrations were increased significantly ( $P < 0.05$ ) in the As exposed kids after 135<sup>th</sup> day of experiment, which approached normal values in the kids supplemented with vitamin E. Similar protective effects were observed by vitamin E supplementation in poultry (Kalavathi et al., 2011). Cholesterol levels in the kids were similar in all the three groups indicating that inclusion of 60 mg As  $kg^{-1}$  feed did not affect cholesterol values of kids.

**Table 2.** Effect of vitamin E supplementation on blood haemato-biochemical parameters of kids in different groups

Group	Period (days)					Mean*	SEM	P value
	0	45	90	135	180			
<b>Haemoglobin (g/ dL)</b>								
Control (T1)	10.0	10.4	10.8	10.6	10.0b	10.5	0.20	G=0.049
As 60 ppm (T2)	10.1	10.5	10.3	9.7	8.6a	9.8	0.20	P=0.005
As 60 ppm+Vit-E (T3)	10.0	10.3	10.6	10.2	9.7b	10.2	0.15	G*P=0.516
<b>Total Protein (g/ dL)</b>								
Control (T1)	6.9	7.02	7.35b	7.22b	7.18b	7.19b	0.16	G=0.022
As 60 ppm (T2)	6.92	7.04	6.88a	6.79a	6.58a	6.82a	0.13	P=0.000
As 60 ppm+Vit-E (T3)	6.89	6.98	7.01ab	6.95ab	7.02ab	6.99ab	0.15	G*P=0.157
<b>Albumin (g/ dL)</b>								
Control (T1)	3.23	3.27	3.25	3.24	3.15	3.23	0.09	G=0.039
As 60 ppm (T2)	3.26	3.25	3.28	3.35	3.26	3.29	0.09	P=0.000
As 60 ppm+Vit-E (T3)	3.27	3.21	3.26	3.31	3.27	3.26	0.08	G*P=0.098
<b>Globulin (g/ dL)</b>								
Control (T1)	3.67	3.75	4.10b	3.98b	4.03b	3.97b	0.12	G=0.020
As 60 ppm (T2)	3.66	3.79	3.60a	3.44a	3.32a	3.54a	0.16	P=0.000
As 60 ppm+Vit-E (T3)	3.62	3.77	3.75a	3.64ab	3.75b	3.73ab	0.17	G*P=0.066
<b>Total cholesterol (mg/ dL)</b>								
Control (T1)	79	90	112	115	110	107	3.03	G=0.697
As 60 ppm (T2)	75	110	115	113	107	111	2.59	P=0.000
As 60 ppm+Vit-E (T3)	81	95	111	114	108	107	3.69	G*P=0.481
<b>Glucose (mg/ dL)</b>								
Control (T1)	53.1	54.8	48.2	49.2	49.8	50.5	1.12	G=0.366
As 60 ppm (T2)	52.3	55.7	55.2	58.2	59.5	57.2	1.43	P=0.001
As 60 ppm+Vit-E (T3)	52.6	54.7	56.2	56.7	59.6	56.8	1.26	G*P=0.896
<b>Urea (mg/ dL)</b>								
Control (T1)	34.4	32.6	35.2	32.7a	32.5a	33.3a	0.60	G=0.038
As 60 ppm (T2)	33.9	35.8	39.0	40.6b	40.0b	38.9b	0.63	P=0.000
As 60 ppm+Vit-E (T3)	35.9	33.6	36.5	40.5b	36.3ab	36.7ab	1.16	G*P=0.910
<b>Creatinine (mg/ dL)</b>								
Control (T1)	1.10	1.29	1.32	1.41a	1.39a	1.25a	0.07	G=0.042
As 60 ppm (T2)	1.05	1.38	1.36	1.67b	1.67b	1.52b	0.05	P=0.000
As 60 ppm+Vit-E (T3)	1.28	1.30	1.44	1.54ab	1.48a	1.44ab	0.04	G*P=0.189

\*Mean of 45, 90, 135 and 180 d values; T1, Goats in the control group; T2, goats additionally added 60 mg arsenic per kg diet; T3, Goats additionally given 60 mg arsenic and 250 IU vitamin E per kg diet; <sup>ab</sup> Means with different superscripts in column differ significantly ( $P<0.05$ )

Thyroid hormones, i.e. tri-iodothyronine ( $T_3$ ) and thyroxine ( $T_4$ ), and  $T_4:T_3$  ratios were adversely affected by exposure to As in kids and vitamin E supplementation could partially reverse the effect of As (Table 3). In our earlier study, we observed similar adverse effect on thyroid hormones in

guinea pigs (Mohanta et al., 2014a). Guo et al. (2018) observed higher arsenic level association with lowered thyroid hormone concentration in pregnant women. Similar effects were seen on the lowering of thyroid hormones on exposure to arsenic (Sun et al., 2016; Ahangarpour et al., 2018).

**Table 3.** Serum hormonal profile indifferent groups of goat kids

Group	Period (days)					Mean*	SEM	P value
	0	45	90	135	180			
T3 (nmol/L)								
Control (T1)	1.81	1.87	1.84 <sup>a</sup>	1.98	1.91 <sup>a</sup>	1.90	0.10	G=0.046
As 60 ppm (T2)	2.09	1.72	1.81 <sup>ab</sup>	1.96	1.40 <sup>b</sup>	1.72	0.07	P=0.002
As 60 ppm+Vit-E (T3)	2.14	1.97	2.23 <sup>b</sup>	1.75	1.53 <sup>b</sup>	1.87	0.10	G*P=0.014
T4 (nmol/L)								
Control (T1)	39.20	33.90	36.80	32.60 <sup>a</sup>	29.90 <sup>a</sup>	33.30 <sup>a</sup>	1.64	G=0.045
As 60 ppm (T2)	43.10	33.90	32.00	25.20 <sup>b</sup>	17.80 <sup>b</sup>	27.30 <sup>b</sup>	1.94	P=0.000
As 60 ppm+Vit-E (T3)	44.40	37.80	29.50	30.50 <sup>ab</sup>	19.30 <sup>b</sup>	26.80 <sup>b</sup>	1.66	G*P=0.115
T4: T3								
Control (T1)	21.66	18.13	20.00 <sup>a</sup>	16.46 <sup>a</sup>	15.65 <sup>a</sup>	17.56 <sup>a</sup>	0.93	G=0.011
As 60 ppm (T2)	20.62	19.71	17.68 <sup>ab</sup>	12.86 <sup>b</sup>	12.71 <sup>b</sup>	15.87 <sup>b</sup>	1.03	P=0.001
As 60 ppm+Vit-E (T3)	20.75	19.19	13.23 <sup>b</sup>	17.43 <sup>a</sup>	12.61 <sup>b</sup>	14.33 <sup>b</sup>	1.05	G*P=0.047

\*Mean of 45, 90, 135 and 180 d values; T1, Goats in the control group; T2, goats additionally added 60 mg arsenic per kg diet; T3, Goats additionally given 60 mg arsenic and 250 IU vitamin E per kg diet; <sup>ab</sup>Means with different superscripts in a column differ significantly (P<0.05)

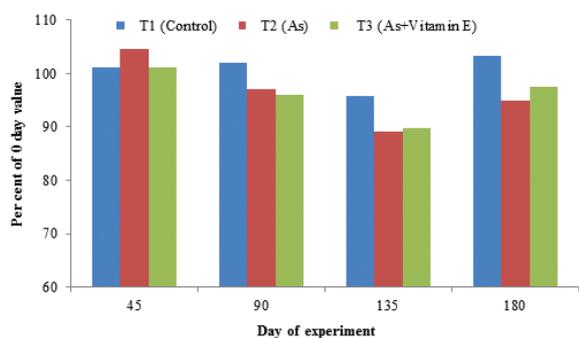
### Effect on serum mineral content

Toxic elements may compete or interfere with essential elements (Molin et al., 2008) and/or create disturbances in the homeostasis of essential elements due to their common chemical properties, common sites or mechanisms of absorption and common functional interest etc (Goyer and Clarkson, 2008). The data pertaining to serum macro and micro-minerals in different groups as well as at different time interval is presented in graphical forms treating 0 day values as 100 (Fig. 1-6).

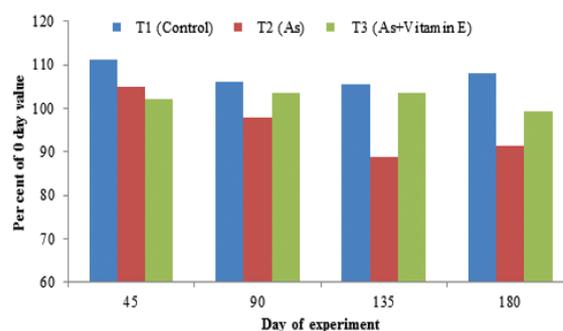
Serum Ca and P levels were marginally depressed, whereas levels of Cu and Mn were reduced significantly (P<0.05) after 90 days of As exposure (Fig. 1-4). A marginal decrease in blood

Cu level was reported in goats when exposed to 2 mg As kg<sup>-1</sup> BW (~38 ppm As) for a period of 6 months (Roy et al., 2009). However, no alterations in serum Cu and plasma ceruloplasmin were observed in pigs fed 30 mg As kg<sup>-1</sup> diet for 78 days (Wang et al., 2006).

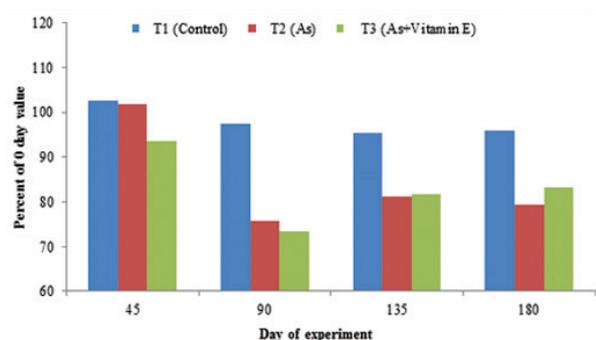
Zinc levels were increased after 45 days of As exposure, which remained elevated upto 90 th day and returned to normal at 135<sup>th</sup> day of observation but at 180<sup>th</sup> day again reduced significantly (P<0.05) (Fig. 5). This may be because of increased uptake of Zn to meet its high demand due to As toxicity (Kumar et al., 2011) as supported by non-significant increase of plasma Zn level in As exposed goats (Roy et al., 2009). In our earlier study also we obtained depressed Zn absorption and retention in goats (Mohanta et al., 2014b). Serum



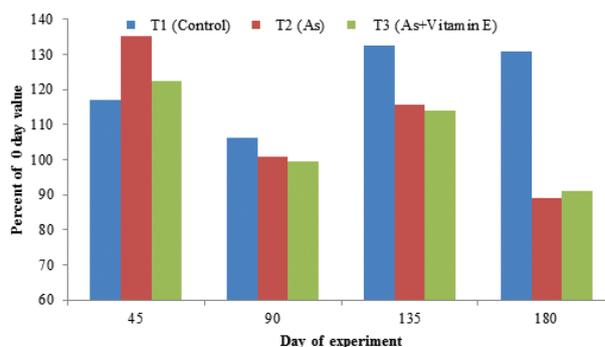
**Fig. 1.** Effect of arsenic exposure ( $60 \text{ mg kg}^{-1}$  diet) and vitamin E supplementation ( $250 \text{ IU kg}^{-1}$  diet) on serum Ca profile of kids



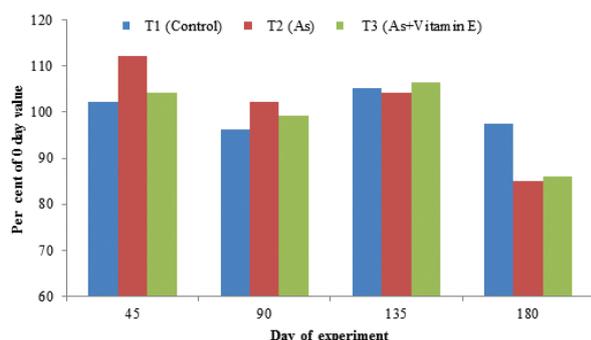
**Fig. 2.** Effect of arsenic exposure ( $60 \text{ mg kg}^{-1}$  diet) and vitamin E supplementation ( $250 \text{ IU kg}^{-1}$  diet) on serum P profile of kids



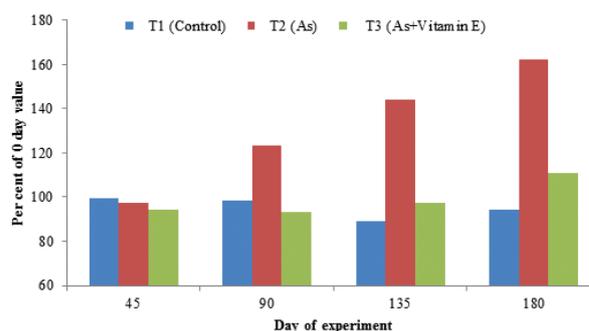
**Fig. 3.** Effect of arsenic exposure ( $60 \text{ mg kg}^{-1}$  diet) and vitamin E supplementation ( $250 \text{ IU kg}^{-1}$  diet) on serum Cu profile of kids



**Fig. 4.** Effect of arsenic exposure ( $60 \text{ mg kg}^{-1}$  diet) and vitamin E supplementation ( $250 \text{ IU kg}^{-1}$  diet) on serum Mn profile of kids



**Fig. 5.** Effect of arsenic exposure ( $60 \text{ mg kg}^{-1}$  diet) and vitamin E supplementation ( $250 \text{ IU kg}^{-1}$  diet) on serum Zn profile of kids



**Fig. 6.** Effect of arsenic exposure ( $60 \text{ mg kg}^{-1}$  diet) and vitamin E supplementation ( $250 \text{ IU kg}^{-1}$  diet) on serum Fe profile of kids

Fe level was increased in As exposed kids from 135 day onwards, but returned to normal in vitamin E supplemented kids showing potential beneficial effect of vitamin E supplementation (Fig. 6). In other studies, a significant alteration in blood Fe levels were observed in pigs fed 20 and 30 mg As kg<sup>-1</sup> diet (Wang et al., 2006).

In our earlier report, we found an increased serum arsenic concentration along with decreased selenium level in serum (Mohanta et al., 2015). Supplementation of vitamin E at present level could not bring back selenium content to normal level and the effect was partially ameliorative.

### Clinical signs

In the present study, no signs of toxicity were observed during 180 days of study. However, a sign of mild dullness and depression was seen along with a relative rough and dull hair coat in As exposed animals. Contrary to our observations,

upon exposure to high dose of As (25 mg As kg<sup>-1</sup> BW), goats exhibited prominent clinical signs of As toxicity (Biswas et al., 2000; Pandey et al., 2005) like dullness and depression, which progressed into partial loss of appetite, reddish coloured urine, rough body coat with erected hairs, and profound muscular weakness. They further reported progressive signs of polyuria, incoordination, inability to get up and salivation along with increased respiration and heart rate (Biswas et al., 2000).

### Effect on organ weight

Weight of liver, kidney, lungs, heart, testes, spleen and rumen was comparable among three groups (Table 4). However, a modest (P>0.05) increase was noticed in lung weight, whereas heart and testes weight was reduced (P>0.05) in As exposed groups, suggesting role of As in causing affection of these organs. Nevertheless, vitamin E supplementation could alleviate these alterations (Table 4).

**Table 4.** Effect of arsenic on weight of vital organs and their ash content in goat kids

Particular	T1 (Control)	T2 (Arsenic)	T3 (Arsenic+ Vitamin E)	SEM	P value
Mean BW (kg)	15.29	16.09	17.05	0.87	0.751
Organ weight (% BW)					
Liver	20.4	19.5	20.4	0.82	0.905
Kidney	3.6	3.4	3.2	0.14	0.510
Lungs	10.7	12.2	11.3	0.45	0.412
Testes	8.6	7.7	8.0	0.35	0.600
Stomach	32.3	32.8	31.5	2.04	0.973
Heart	4.6	4.0	3.9	0.16	0.214
Spleen	1.6	1.5	1.3	0.09	0.441
Ash (% fresh basis)					
Liver	1.34	1.30	1.42	0.03	0.338
Kidney	1.08	1.16	1.37	0.08	0.388
Lungs	1.13	1.07	1.09	0.02	0.510
Testes	1.08	1.03	0.91	0.06	0.479
Stomach	0.78	0.72	0.67	0.04	0.524
Heart	0.93	0.90	0.85	0.05	0.759
Spleen	1.31	1.44	1.40	0.04	0.496

T1, Goats in the control group; T2, goats additionally added 60 mg arsenic per kg diet; T3, Goats additionally given 60 mg arsenic and 250 IU vitamin E per kg diet

### Effect on organ mineral content

The data pertaining to the status of ash, Ca, P, Fe, Cu, Zn and Mn, in different tissues from animals of different groups is presented in Table 5-10. Total ash and calcium content remained similar

( $P > 0.05$ ) in all the analyzed organs of kids among different groups (Table 4, 5) demonstrating that As supplementation did not affect concentration of Ca and total ash in different tissues.

**Table 5.** Tissue calcium content (%) of kids in different groups (on fresh basis)

Particular	T1 (Control)	T2 (Arsenic)	T3 (Arsenic+ Vitamin E)	SEM	P value
Liver	0.044	0.039	0.038	0.001	0.107
Kidney	0.045	0.043	0.042	0.004	0.952
Lungs	0.053	0.089	0.079	0.013	0.543
Testes	0.041	0.057	0.042	0.004	0.248
Stomach	0.157	0.117	0.102	0.014	0.261
Heart	0.058	0.109	0.091	0.018	0.571
Spleen	0.109	0.085	0.123	0.019	0.749
Muscle	0.043	0.041	0.040	0.02	0.774
Lymph node	0.054	0.047	0.058	0.04	0.845
Pancreas	0.084	0.078	0.105	0.01	0.721

T1, Goats in the control group; T2, goats additionally added 60 mg arsenic per kg diet; T3, Goats additionally given 60 mg arsenic and 250 IU vitamin E per kg diet

Phosphorus (P) content was depressed significantly ( $P < 0.05$ ) in lungs and kidney tissues of As exposed kids (Table 6). As and P both belong to the same group, resulting in a competition for their

uptake and utilization (Gonzalez et al., 1995). But, the control and vitamin E supplemented kids showed similar P concentrations in these tissues showing potential ameliorative effect of vitamin E (Table 6).

**Table 6.** Tissue phosphorus content (%) of kids in different groups (on fresh basis)

Particular	T1 (Control)	T2 (Arsenic)	T3 (Arsenic+Vitamin E)	SEM	P value
Liver	0.339	0.336	0.316	0.01	0.511
Kidney	0.232 <sup>b</sup>	0.189 <sup>a</sup>	0.230 <sup>b</sup>	0.008	0.028
Lungs	0.252 <sup>b</sup>	0.226 <sup>a</sup>	0.242 <sup>b</sup>	0.004	0.016
Testes	0.214	0.224	0.221	0.005	0.711
Stomach	0.120	0.129	0.130	0.005	0.668
Heart	0.226	0.195	0.192	0.015	0.623
Spleen	0.279	0.316	0.431	0.059	0.593
Muscle	0.201	0.181	0.186	0.011	0.754
Abomasum	0.161	0.140	0.198	0.019	0.845
Lymph node	0.342	0.281	0.317	0.021	0.683
Skin	0.223	0.143	0.198	0.024	0.652

T1, Goats in the control group; T2, goats additionally added 60 mg arsenic per kg diet; T3, Goats additionally given 60 mg arsenic and 250 IU vitamin E per kg diet, <sup>ab</sup>Means with different superscripts in a column differ significantly ( $P < 0.05$ )

Significant ( $P < 0.05$ ) increase of Fe content was observed in testis and muscle tissues of 60 ppm As exposed kids as compared to the control and vitamin E supplemented groups, indicating that supplementation of 250 IU vitamin E  $\text{kg}^{-1}$  diet could not overcome the adverse effect on tissue Fe level (Table 7). Similar to our findings, high dietary As (30 mg  $\text{kg}^{-1}$  diet) caused marked accumulation of Fe

in the liver, bile, pancreas, spleen and thymus along with a significant reduction in kidney and heart Fe level in pigs (Wang et al., 2006). It showed that As affects Fe status of the vital organs and vitamin E supplementation could not produce any beneficial effect on tissue Fe level in kids. This is further supported by the elevated serum Fe concentration in As exposed kids (Fig. 6), in this study.

**Table 7.** Tissue iron content (mg  $\text{kg}^{-1}$ ) of kids in different groups (on fresh basis).

Particular	T1 (Control)	T2 (Arsenic)	T3 (Arsenic+Vitamin E)	SEM	P value
Liver	60.05	47.92	57.52	5.95	0.874
Kidney	46.89	45.99	39.70	3.97	0.761
Lungs	90.26	99.82	80.87	9.48	0.755
Testes	13.9a	35.81b	31.56b	3.32	0.002
Stomach	75.20	91.42	72.11	6.37	0.455
Heart	37.61	40.55	37.99	1.83	0.807
Spleen	197.7	208.1	212.7	24.01	0.973
Muscle	70.09a	99.31b	111.3b	8.54	0.045
Skin	126.9	113.3	165.8	14.52	0.847
Hair	786.2	682.2	575.7	30.43	0.564
Lymph node	30.25	42.39	29.92	1.02	0.874

T1, Goats in the control group; T2, goats additionally added 60 mg arsenic per kg diet; T3, Goats additionally given 60 mg arsenic and 250 IU vitamin E per kg diet, <sup>ab</sup>Means with different superscripts in a column differ significantly ( $P < 0.05$ )

Significant ( $P < 0.05$ ) reduction in Cu concentration was observed in liver, testes, muscle and lymph node in kids exposed to 60 mg As  $\text{kg}^{-1}$  diet for 180 days, which indicates adverse effects of As on Cu metabolism (Table 8). Similar to our findings, a significant depression in Cu level of liver was observed in As exposed goats (Roy et al., 2009). However, in monogastric animals, dietary As caused marked accumulation of Cu in liver and/or kidney of rats (Cui and Okayasu, 2008) and pigs (Wang et al., 2006); and reduction of Cu concentrations in liver (Uthus, 2001). It is interesting to observe recovery in the Cu level in most of the organs except liver following supplementation of vitamin E (Table 8).

In the present study, Zn concentrations in organs remained similar among three groups, except testis and heart, which was significantly ( $P < 0.05$ ) altered upon As exposure. Increased testicular Zn level may be attributed to its linkage with As for

decreasing its toxicity. In contrast to our findings, significant increase in Zn level was observed in liver and kidney of goats fed 2 mg As  $\text{kg}^{-1}$  BW for 6 months (Roy et al., 2009). In contrast, hepatic Zn concentrations were unaffected and renal Zn level was increased in rats exposed to 10 or 100 mg inorganic As  $\text{L}^{-1}$  water for 16 weeks (Cui and Okayasu, 2008). However, in our earlier study, we obtained significantly lowered Zn absorption and apparent retention in goats (Mohanta et al., 2014b). Arsenic exposure increased uptake of 65 mg Zn in the liver, intestine, and kidney indicating increased requirement of Zn for synthesis of various enzymes or proteins like metallothioneins during As toxicity (Kumar et al., 2011). In vitamin E supplemented kids, tissue Zn level was comparable in all the organs except testis, where Zn concentration was still significantly higher than that of the control values (Table 9) indicating only partial amelioration.

**Table 8.** Copper content (mg kg<sup>-1</sup>) of organs of kids in different groups (on fresh basis).

Particular	T1 (Control)	T2 (Arsenic)	T3 (Arsenic+Vitamin E)	SEM	P value
Liver	6.10b	1.21a	1.30a	0.86	0.010
Kidney	0.525	0.373	0.538	0.041	0.194
Lungs	2.09	1.66	1.84	0.10	0.256
Testes	1.08b	0.656a	1.17b	0.098	0.044
Stomach	0.618	0.950	1.45	0.199	0.250
Heart	1.94	1.62	1.77	0.10	0.498
Spleen	1.01	0.83	0.99	0.058	0.426
Muscle	0.498b	0.200a	0.545b	0.056	0.046
Skin	0.89	0.56	0.99	0.065	0.412
Hair	3.56	2.09	3.51	0.09	0.548
Lymph node	0.786b	0.456a	0.745b	0.049	0.045

T1, Goats in the control group; T2, goats additionally added 60 mg arsenic per kg diet; T2, Goats additionally given 60 mg arsenic and 250 IU vitamin E per kg diet, <sup>ab</sup>Means with different superscripts in a column differ significantly ( $P<0.05$ )

**Table 9.** Tissue zinc content (mg kg<sup>-1</sup>) of kids in different groups (on fresh basis).

Particular	T1 (Control)	T2 (Arsenic)	T3 (Arsenic+Vitamin E)	SEM	P value
Liver	13.50	16.65	16.04	1.16	0.548
Kidney	12.27	11.89	11.01	0.59	0.712
Lungs	13.76	14.03	14.96	0.76	0.824
Testes	8.97a	12.70b	12.57b	1.98	0.031
Stomach	14.87	15.43	14.77	0.80	0.948
Heart	9.15a	1.76b	9.05a	1.17	0.044
Spleen	14.39	17.91	17.90	0.88	0.176
Muscle	16.14	13.52	21.20	0.75	0.584
Skin	9.83	6.89	11.13	0.63	0.756
Hair	62.19	68.44	66.03	9.62	0.845
Lymph node	11.17	15.15	13.39	1.09	0.880

T1, Goats in the control group; T2, goats additionally added 60 mg arsenic per kg diet; T2, Goats additionally given 60 mg arsenic and 250 IU vitamin E per kg diet, <sup>ab</sup>Means with different superscripts in a column differ significantly ( $P<0.05$ )

Manganese (Mn) content was significantly ( $P<0.05$ ) increased in lungs and testes, whereas significantly ( $P<0.05$ ) decreased in kidneys in the 60 ppm As exposed kids (Table 10). Arsenic exposure did not affect the concentration of Mn in kidney and liver in rats received a dose of 1, 10 and 100 mg L<sup>-1</sup> of sodium arsenate in drinking water

daily for 4 and 16-weeks (Cui and Okayasu, 2008). In vitamin E supplemented kids, Mn values were comparable to control, except that of kidney where the value was still significant ( $P<0.05$ ) compared to control (Table 10) indicating partial protective effect of vitamin E at present dose rate.

**Table 10.** Tissue manganese content (mg kg<sup>-1</sup>) of kids in different groups (on fresh basis)

Particular	T1 (Control)	T2 (Arsenic)	T3 (Arsenic+Vitamin E)	SEM	P value
Liver	1.22	1.03	1.10	0.09	0.708
Kidney	0.447b	0.283a	0.305a	0.030	0.033
Lungs	0.248a	0.519b	0.349ab	0.062	0.048
Testes	0.191a	0.512b	0.364ab	0.056	0.042
Stomach	5.23	7.67	5.49	0.78	0.415
Heart	0.238	0.322	0.223	0.034	0.492
Spleen	0.431	0.438	0.446	0.077	0.998
Muscle	4.73	6.70	7.51	0.58	0.085
Skin	8.56	7.65	11.19	0.980	0.657
Hair	53.05	46.03	38.85	6.10	0.654
Lymph node	0.431	0.387	0.383	0.036	0.583

T1, Goats in the control group; T2, goats additionally added 60 mg arsenic per kg diet; T3, Goats additionally given 60 mg arsenic and 250 IU vitamin E per kg diet, <sup>ab</sup>Means with different superscripts in a column differ significantly ( $P<0.05$ )

In our previous published article, we found an increased arsenic concentration in tissues and serum along with decreasing trend in selenium content (Mohanta et al., 2015). This is further proof of toxicity of arsenic and its role in tissue oxidative stress. Supplementation of vitamin E at present level could not bring back tissue selenium concentration to control level and the effect was only partially ameliorative.

Altered retention of essential and toxic elements in some organs indicates their altered metabolism in these tissues, as in kids as ruminants there may be different metabolic process involved for their absorption and retention in the body (Suttle, 2012; Mohanta et al., 2014b) and need further investigation to confirm the results. These alterations could partially be alleviated by addition of vitamin E at present dosage.

### Gross pathology

Gross pathological lesions were not observed in the kids, except mild congestion in cortico-medullary junction of kidneys indicating mild effect of As in ruminants. On higher doses (25 mg kg<sup>-1</sup> BW), kids exposed to As exhibited enlargement of the kidney, abomasum and liver along with haemorrhagic changes in abomasum, intestinal mucosa, kidney and spleen (Biswas et al., 2000).

### CONCLUSION

The findings from the present study reveals that blood haemato-biochemistry, serum mineral concentrations, thyroid hormonal status and retention of mineral elements by different body organs of kids were adversely affected when exposed to 60 ppm of arsenic through their diet. Supplementation of vitamin E at 250 IU kg<sup>-1</sup> diet

could partially reduce these adverse effects in the kids, demonstrating alleviation of oxidative stress through vitamin E alone could not alleviate the adverse effects, which may be due to insufficiency of antioxidant or presence of other dominant mechanisms that address arsenic toxicity.

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# Factors affecting lac crop production and the economy of the tribals living besides Kuldiha Wildlife Sanctuary, Balasore, Odisha

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## ABSTRACT

Lac is one of the most valuable gifts of nature to man. It is the only resin of animal origin, being actually the secretion of a tiny insect *Kerria lacca* (Kerr), which is cultured on shoots of several species of trees, mainly Palash, Kusum and Ber. It basically yields three useful materials: resin, dye and wax. It has a wide range of applications in food, pharmaceuticals, cosmetics, perfumes, varnishes, paints, polishes, adhesives, jewellery and textile industries. Lac production promotes biodiversity and conserves host plants. Lac crop being vulnerable to both biotic and abiotic factors results in lowering of the yield. In the study site, 95.20 per cent respondents pointed out that the one of the major constraints faced in lac cultivation were due to lack of availability of brood lac and other inputs, bad weather, low and fluctuating market, etc.

**Key words:** Biodiversity, biotic and abiotic factors, constraints, host plants, lac

## INTRODUCTION

Worldwide global warming is one of the most confronting challenges for insects. The Inter-governmental Panel on Climate Change has predicted an increase in air temperature of 1.1°C to 6.4°C by 2100 (IPCC, 2007), due to the effects of greenhouse gases, including carbon dioxide (CO<sub>2</sub>) and tropospheric ozone (O<sub>3</sub>). These climate changes affect the biological and ecological characteristics of insect species, through direct effects on their habitat and thereby affect on agriculture (Cannon, 1998). Climate change impacts on pest population include change in phenology, distribution, community composition and ecosystem dynamics that finally leads to extinction of species (Walther et al., 2002). It also affects on the insects' host plants, natural enemies etc. Climate change factors such as rise of ambient temperature, rise in CO<sub>2</sub> concentrations in the atmosphere and precipitation

etc. have strong influence on the development, reproduction and survival of insect pests as a result of which these organism will be affected (Bale et al., 2002). Therefore, it is difficult for lac insects to survive in such extremities of sun light, heat, rains etc. and lac crops are vulnerable to several types of insect predators, parasites. The agricultural production continues to be constrained by a variety of biotic (e.g., pathogens, insects and weeds) and abiotic (e.g., drought, salinity, cold, frost and water logging) factors, that can significantly reduce the quantity and quality of crop production (Wang et al., 2013). Abiotic stress factors such as heat, cold, drought, salinity, and nutrient stress have a huge impact on world agriculture, as they reduce average yields by more than 50 per cent for most major crop plants (Wang et al., 2003). Ninety seven species of such insects have been reported which are either pests of the lac insects and their predators besides several fungal pathogens,

represent a rich diversity of lac ecosystem. Here, 22 species of lac predators, 30 species of primary and 45 species of secondary parasites are affecting the production of lac (Varshney, 1976 and Sharma et al., 2006). Kumar (1996) studied the marketing of Non-Timber Forest Products (NTFPs) in Rohtas district of Bihar. The market price appeared to be 25 times higher than the prices received by tribals indicating the exploitation of tribals in a marketing system, which is predominantly capitalistic. Tejaswi (2008) reported that the main problems faced by the tribals include government restrictions regarding NTFP collection and physical attacks by wild animals, which can be lethal or cause severe lifetime injuries. Limited employment possibilities, inappropriate benefit distribution, misuse of funds and lack of processing activity at the local level affect the production and processing of lac. Patel et al. (2008) studied the marketing of Minor Forest Products (MFPS) in Gujarat. They observed a high variability in the marketing and price of MFPS. Ahenkan and Boon (2010) reported that the NTFPs marketing in rural areas of Ghana are unorganized, dispersed and farmers also lack the necessary marketing skills and information required for optimal performance. Nedanovska (2012) reported that the most important problems that pickers are facing during the collection of NTFPs are identified lack of forest road, too much time spent on collection, low price of NTFPs, lack of buying points and other problems.

## **MATERIALS AND METHODS**

The study area was selected in the surroundings of Kuldiha wildlife sanctuary in Balasore district where lac is cultivated in an extensive scale. We found from the survey that the major lac growers are in sixteen villages of five Gram Panchayats (GPs) namely Kiakata, Chaindar, Balichua, Chekamara (Garudi G.P), Budhiachua, Khadichua, Natapada, Bhaxnal, Ashoknal, Gabapal, Kelamara, Badheipal (Krushna Chandra Pur G.P), Jamuna (Pithahata G.P), Telipal (Telipal G.P) and Tenda (Sajanagada G.P) for the years 2017-18 and 2018-19 to fringe forests (i.e. 5 km ) around Kuldiha reserve forest of Balasore, Odisha. The surrounding

villages are covered with forests having natural lac host trees which provide essential food plant for lac and are largely inhabited by tribal population whose subsidiary occupation is lac cultivation. In all villages, lac is cultured mainly on traditional host trees: palas, ber and kusum. Information and data were collected from eighty number of lac growers for the study.

A detailed questionnaire was designed which covered all the aspects on lac cultivation, special focused on constraints faced by lac growers. Focused group discussion (FGDs) was used to identify key challenges faced by farmers in lac cultivation and their view on possible solutions. Survey method was followed for the detailed enquiry of the farmer to arrive at the exact problems and possible solutions of lac cultivation in this area. Detailed interview with questionnaires and informal interaction were other tools which were used to collect data. Secondary information was conducted by collecting data from government offices of forest department, Integrated Tribal Development Agency (ITDA), Krishi Vigyan Kendra (KVK) and lac co-operative institutions. This helped in building a knowledge base on NTFP specially lac. The important inferences from the survey were compared with data from various sources to assess the validity and reliability. From sixteen selected village, 5 respondents were selected randomly by using simple random sample method. A total of 80 respondents were considered as respondents for the present study. Primary data for the study was collected by personal interview with the respondents with the help of pre-tested structured interview schedule.

## **RESULTS AND DISCUSSION**

The data were collected through the interview schedule on the basis of objectives of the study. The data collected were classified, tabulated, analysed, presented, interpreted and discussed systematically. Based on the enquired data from the respondents sixteen number of constraints and twelve numbers of suggestions were given by the 80 numbers of lac growers (respondents) to overcome the problems faced by them (Table 1 and 2).

**Table 1.** Problems faced by the respondents in the collection and marketing of lac

Sl.	Particular	Frequency*	Percentage
1	Existence of bad weather	120	92.02
2	Low and fluctuated market price	125	90.86
3	Lack of skill oriented training programme related to collection, processing and marketing	58	57.50
4	Unavailability of brood lac and other inputs	119	95.20
5	Obstruction caused by forest rule and regulations in cultivation and collection of from restricted forest areas	110	51.52
6	Deforestation	72	59.12
7	Lack of developed market infrastructure for NTFPs (Lac)	67	47.50
8	Loss of lac quality due to insect, pests, predators and parasite incidences	30	19.18
9	Lack of low cost storage facilities	20	36.92
10	Lack of availability of timely market information	48	39.23
11	Lack of connective roads and transport facilities for marketing of lac	18	23.90
12	Lac of value addition	29	38.89
13	Natural calamities (drought, forest fire, storm etc)	38	40.27
14	Height of the trees	52	45.50
15	Inaccessibility of lac host trees	44	49.45
16	Theft of brood lac, encrusted lac and stick lac by outsiders	39	25.85

\*Data are based on multiple responses. Frequency was studied yearly basis.

The result shows that majority of the respondent pointed out that they were facing the problem of non-availability of brood lac and other inputs (95.20%) followed by existence of bad weather (92.02%), low and fluctuated market price (90.86%), deforestation (59.12%), lack of skill oriented training programme related to collection, processing and marketing of lac (57.50%) i.e. these respondents cultivated lac in traditional manner resulting crop failure. Government machineries should take initiations to provide quality brood lac and also should extend training and demonstration. Brood lacs on an avg wt of 200-250g have been inoculated in standard height Kusum plants of Kishorechandrapur village (Fig. 1). Many of them never used any pest control mechanism, proper pruning techniques and other advance methods for lac cultivation, obstruction caused by forest rule and regulations in production and collection from restricted forest area (51.52%). Problems faced by respondents in other areas are inaccessibility of

lac host plants (49.45%), difficulties due to more height of Kusum tree (45.50%), lack of developed market infrastructures (47.50%), incidence of natural calamities such as drought, forest fire, storm etc (40.27%), lack of availability of timely market information (39.23 %), lack of value addition (38.89%) and lack of low cost storage facilities (36.92%). One cooperative society has been formed in Tartari village of Nilgiri block towards better storage, processing, value addition and marketing of lac products. (Fig. 3 and 4). Theft of brood lac, encrusted lac (Fig. 2) and stick lac being 25.85% happened usually in month of January when most of the farmers do not go to field for work. In Jamuna village, on supervision, large encrustation have been noticed in Ber plants (Fig. 2). The figure for rest shows that lack of transport facilities for marketing (23.90%) and loss of lac quality due to insect, pests, predators and parasite incidences and injuries caused by attack of wild animals (19.18%) (Table 1).

There have been 12 number of suggestions enlisted by the same 80 number of respondents to

overcome the problems faced by them have been presented below in Table 2.

**Table 2.** Suggestions given by the respondents to overcome the problems faced by them in the production and marketing of lac

Sl.	Particular	Frequency*(No of problems identified and studied by respondent)	Percentage
1	Selling prices of lac to be ensured by the government	102	85.56
2	Regular training programme should be organized for skill development in collection, processing and marketing of lac	68	77.52
3	Brood lac and inputs to be provided from govt. agencies	98	85.25
4	Flexibility in forest rule and regulations for lac cultivation and collection	80	59.83
5	Deforestation should be checked	81	75.20
6	Development of existing market infrastructure by the government for marketing of lac	87	37.90
7	Low cost storage facility should be provided	28	46.52
8	Availability of timely market information about lac price	54	59.20
9	Availability of transport facilities for marketing of lac	27	9.80
10	Value addition of lac to be developed through lac co-operative	28	30.19
11	Forest fire to be checked by controlled burning of weeds, leaves before commencement of summer season	48	29.25
12	Checking of thefts by outsiders through expanding lac cultivation areas in the surrounding villages	67	10.85

\* Data are based on multiple responses.

The above suggestions given by the respondents indicate that majority of the respondents (85.56 %) opine that selling prices of lac should be ensured by the government; followed by brood lac and other inputs to be provided from govt. agencies (85.25%). The respondents for regular training programme to be organized for skill development in collection, processing and marketing of lac being 77.52%, 75.20% respondents suggested that deforestation should be checked, 59.83% for flexibility in forest rule and regulations for lac cultivation and collection, 59.20% for availability of timely market information about lac, 46.52%

of respondents suggested for low cost storage, 37.90% respondents for development of existing market infrastructure by the government for marketing of lac, 30.19% respondents for value addition of lac to be developed through lac co-operatives, 29.25% respondents for forest fire to be checked by controlled burning of weeds and leaves before commencement of summer season, 10.85% respondents for checking of thefts by outsiders through expanding lac cultivation areas in the surrounding villages and 9.80% respondents for good road connectivity of villages with market (Table 2) .



Fig. 1. Brood lac inoculation in Kusum Plant



Fig. 4. Lac co-operative in Nilgiri, Balasore, Odisha

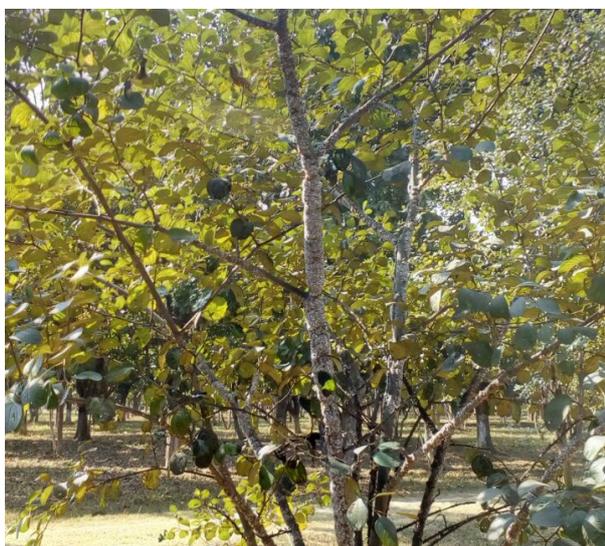


Fig. 2. Lac encrustation in Ber tree in Jamuna village



Fig. 5. Enemy insects of lac



Fig. 3. Value addition of lac

### CONCLUSION

*K. lacca* is a valuable insect of economical and ecological interest. Lac production is an subsidiary activity among rainfed farmers and forest dependants in the surroundings of Kuldiha wildlife sanctuary. Cultivation of lac not only provides livelihood to millions of lac growers but also helps in conserving vast stretches of forests, lac insects and associated biota as most of the lac hosts are in forest areas and farmers resist felling of these trees and protect them for lac cultivation. Thereby, lac culture plays a vital role in the protection of our bioresources. *K. lacca* is prone to biotic and abiotic stress, thus affects the productivity, influencing

the cash inflow of poor and marginal farmers and requires to be managed sustainably. This approach will reduce the cost as well as protect the environment.

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# Successful treatment of abscess in a domestic Asiatic elephant (*Elephas maximus*): A case study at Deogarh district of Odisha, India

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## ABSTRACT

A mahout brought one female domestic elephant from Banaras into Odisha during August 2013 as a routine annual movement. It was suffering from two huge abscesses, one at right foreleg and the other at left foreleg posterior to knee joint having two openings with oozing out of pus and bloody fluid. The animal was anorexic, dull and limping. As reported by the mahout, both the wounds were chronic in nature and about 10 years old. It had been treated 12 times at number of veterinary dispensaries of many different states without much improvement. Rather, in course of time, it was aggravated. Later, the elephant was presented to Veterinary Dispensary, Reamal of Deogarh District on 28.08.2013. First week, magnesium sulphate ( $MgSO_4$ ) powder was introduced into both abscesses and flushed with luke warm potassium permanganate ( $KMnO_4$ ) and followed by dressing. Combination of antibiotics like Penicillin G Sodium and Streptomycin were administered. Injections like meloxicam as analgesic, prednisolone as steroids and hivit and neuroxin-M as supportive therapy were administered intramuscularly including oral vitamin and liver supplementation. There was no improvement because of the presence of hard fibrous mass. Further, copper sulphate ( $CuSO_4$ ) was incorporated into the wound cavities twice which putrefied and degenerated the same that were embedded deep into the cavities. From 02.09.2013 to 05.09.2013, during the usage of  $CuSO_4$  antibiotics and other treatments were dropped. From 06.09.2013 to 08.09.2013, repeat usage of  $CuSO_4$  was undertaken to clear the remaining hard tissues. From 09.07.2013, wound management was taken care of including minor surgical interventions. New generation antibiotics like Intacef-Tazo (combination of Ceftriaxone and Tazobactam) in requisite doses were administered intravenously from 09.07.2013 to 17.07.2013 including supportive therapies as recommended earlier. In addition, fluid therapy, metrogyl and local antibiotics like chloramphenicol were used. During the process, proper debridement of fibrous tissue was done. Cleansing was undertaken with normal saline mixed with 10% povidine iodine. With the extensive treatment protocol maintained from 2<sup>nd</sup> to 3<sup>rd</sup> week of September 2013 with continued dressing, there were fast healing and the wound size was drastically reduced. By 3<sup>rd</sup> week left wound was almost healed and right wound was reduced to 4" size. From 3<sup>rd</sup> to 4<sup>th</sup> week, after necessary cleaning of the wound by normal saline (NaCl) mixed with 10% povidine iodine, chloramphenicol powder was applied 2-3 times daily with spraying of fly repellent all around the wound. By 4<sup>th</sup> week both the wounds were healed up with smaller swellings and circular white scar marks. The elephant restored normal feeding and movement.

**Key words:** Abscess, antibiotics, Asiatic elephant (*Elephas maximus*), putrefy, wound

## INTRODUCTION

The elephant, the largest among living terrestrial animals is classified under the family-Elephantidae and order Proboscidea which has origin from its possession of proboscis or trunk. The only two species of elephants that exist on earth today are Asiatic elephant (*Elephas maximus*) and African elephant (*Loxodonta africana*) [Bennet, 1990]. The former one is common all over the tropical south and south east Asia and are only confined to 13 Asian countries including India (Santiapillai and Jackson, 1990; Rao and Acharjyo, 2006; Hota and Sahu, 2015). The estimated population of the Asian elephants in the wild in these countries ranges between 34,000 and 54,000 (Santiapillai and Jackson, 1990; Rao and Acharjyo, 2006). India holds the largest population of wild Asiatic elephants with nearly 26,000 elephants and 3500 captive elephants found in the country (Rangarajan et al., 2010). Elephants travel long distances as part of their migration activities and they stay within different forest habitats that are enriched with water and fodder (Graham et al., 2010; Hedges et al., 2009; Palei et al., 2016). Elephant is the largest terrestrial animal having large sized compact brain, massive bones, thick skin (probos), long trunk, without gall-bladder, strong olfaction, distinct digestive system with large colon and a good walker (Prater, 2005). Over the years, human have mastered the art of captivating these animals and utilized for their own work in many ways. In different situations, wild or domestic elephants need to have inter-state movement either in search of food abundance or foraging in herd (Palei et al., 2014). Sometimes, these animals get stressed and injured during the process of rearing, travelling, bathing, eco-tourism, temple and festive activities, etc. Samantaray (2007) has emphasized on care and management of captive and wild animals in different parts of the state of Odisha including management and treatment of domestic elephants those are coming from other states in search of food and living. Some of these injuries occur

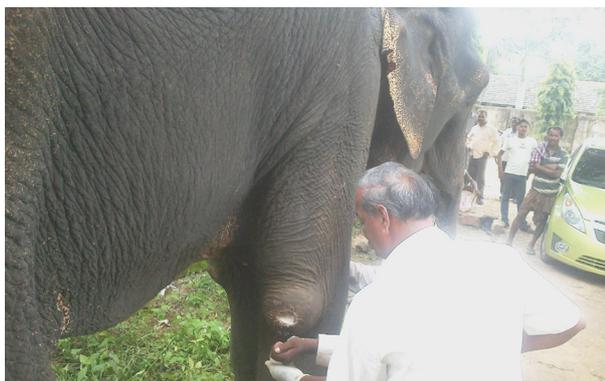
due to non-specific causes though the elephant skin is very thick i.e. 2.5-5.0 cm. (Sukklad et al., 2006). Pachyderms are commonly encountered with traumatic injuries resulting in a variety of superficial and deep wounds. In general, abscesses may occur in all parts of the body in elephants and may become chronic, if not attended in time (Ollivet-Courtois et al., 2003). The elephant's skin lacks sebaceous glands. These anatomical factors may interfere with wound healing (Sukumar, 2003) and even death of elephants in some cases (Sahoo et al., 2017). Latent period of development of abscess varied from weeks to months (Schmidt, 1986).

## CASE HISTORY

The particular elephant named Champabati during a commercial ride came from Benaras to Reamal block of Deogarh district of Odisha along with 3 other elephants during August 2013. It was suffering from huge circular abscesses in both forelegs at knee joint posteriorly. As reported, the right leg incurred injury first during 2003. In due course, left leg got injured during 2004. Initially, there were little swellings in both the knees. Later, they became oedematous. During their movement from state to state, things were aggravated and the wounds became infectious. However, in some of the Veterinary Hospitals, the elephant was extended treatment during the travel. Dressing of wounds, although irregular were undertaken, pus evacuated with some parenteral injections and supportive therapies. Initially, the wounds showed little improvement. Later both were infected and enlarged. During 2007, there were significant openings in both knees with constant ooze out of bloody fluid and pus. Within next 7 years, the elephant was produced to number of Veterinary Hospitals for treatment. Many vets and para vets had attempted their best with different wound management therapies as per some document available with the mahout. Within 2003 to 2013, not much improvement was noticed. Both the wounds were reported to have further aggravated.

## MATERIALS AND METHODS

The female elephant weighing about 3000 kg body weight was produced at Reamal Veterinary Dispensary of Deogarh district, Odisha, India on 28.08.2013 (Fig. 1). Reamal is situated at 21.3519°N and 84.6610° E, some 26 kms from district H.Q. town of Deogarh. Before approaching treatment, the temperature, pulse and respiration of the elephant were recorded and found to be normal.



**Fig. 1.** The elephant produced at Reamal Block Veterinary Hospital;  $MgSO_4$  incorporated into the abscess cavity as initial approach (28.08.2013)

### Wound status

The size of the left wound was measured to be 10" circumference, 3" diameter having opening size of 2" diameter (Fig. 2). The size of right wound was 54" circumference, 18" diameter having opening size of 4" diameter (Fig. 3). Thick pus and bloody fluid were constantly oozing out from these chronic wounds, reported to be 10 years old.



**Fig. 2.** Gauze pack to retain  $MgSO_4$  in the right side abscess

## Strategies

In chronic wounds, surgical interventions have been taken up in different captive and wild animals (Das et al., 2014). Herein, also a definite strategy was made to accomplish the job. The veterinary officer stationed at the dispensary, an expert in Wild animals health care and management attended the case. After visualizing the wound, a long term plan was drawn. The owner was



**Fig. 3.** Left side abscess also fibrosed having a central opening

advised to stay in and around Deogarh district of Odisha so that the expert vet could physically verify the wounds time to time and monitor the treatment regularly. A master plan was drawn in consultation with the Chief District Veterinary Officer of the district. It was decided that the owner will be advised to retain the animal in the district for minimum 1 month. All the vets were advised to extend treatment at their jurisdiction during the course of the animal movement in the district as per the guidance of the expert vet. The mahout was advised to take the elephant in the usual route and halt the animal for continuance of the treatment nearer to a dispensary as demands. The interim surgery and the wound management were taken up under the direct supervision and guidance of the wildlife vet stationed at Reamal block. Treatment was rendered as per the following protocol.

### Medication

On 28.08.2013, the pus from both the cavities were flushed with lukewarm  $KMnO_4$  and cleaned. Then  $MgSO_4$  was introduced liberally

to putrify the hard fibrous mass and reduce the mass size for better manoeuvring (Fig.1). Fowler (1986) established that penicillin has been the drug of choice in different disease conditions and steroids have been recommended in case of traumatic injury and inflammation. Samantaray and Mishra, 2007 successfully treated a wild pigmy elephant at Satkoshia Wildlife Sanctuary Gopalan (1996) used Strepto-penicillin successfully in injured elephant in case of bullet injuries. In line with that, it was decided to go for penicillin at the first go. Dicrystacin LDV (Streptopenicillin

-1 g and Penicillin G sodium-1.5 g) 7 vials, inj. Melonex(Meloxicam) 100 ml, Prednisolone 30 ml and Hivit 30 ml were administered intra-muscularly (I/M) daily. Brotone liquid 200 ml. was given daily orally. Himax ointment applied locally with Topicure spray all around the wounds. For three days,  $MgSO_4$  was kept to act upon the abscess. On 31.08.2013, putrefied tissues were curetted. Treatment extended from 31.08.2013 - 01.09.2013 to see the further development, shown in (Table 1). There was no significant reduction of the size of the abscess.

**Table 1.** Medication from 28.08.13 to 01.09.13

Sl. No.	Name of medicine and Company	Type and presentation	I/M, I/V or Oral	Quantity administered	Schedule	Dosage
1	Dicrystacin LDV (SARABHAI ZYDUS)	Antibiotic Streptopenicillin -1 g Penicillin G sodium-1.5 g	I/M (Intra-muscular)	Large Dose Vial x 6 Vials	Once Daily at morning	50 mg kg <sup>-1</sup>
2	Melonex (INTAS PHARMA)	Analgesic, anti-inflammatory Meloxicam Inj IP 5 mg ml <sup>-1</sup>	I/M	50 ml x 1 Vial	Once daily at morning	1 ml 60 kg <sup>-1</sup> b.wt.
3	Prednisolone (INTERVET)	Steroid Prednisolone Acetate (10 ml x 1 vial)	I/M	10 ml x 3 vials	Alternate day	1 ml 100 kg <sup>-1</sup> b.wt.
4	Hivit(50 ml vial)	Nerve tonic	I/M	50 ml x 1 vial	Once Daily at morning	1 ml 60 kg <sup>-1</sup> b.wt.
5	Brotone Liq (500 ml bottle) (VIRBAC)	Multivits (500 ml bottle)	Oral	500 ml x 1 bottle	Once Daily at morning	1 ml 100 kg <sup>-1</sup> b.wt.
6	Topicure (NATURAL REMEDIES)	Poly herbal Ayurvedic anti-bacterial and anti-inflammatory 250 ml. pack	Outward spray	As per need	Both morning and evening	Local spray
7	Himax ointment (INDIAN HERBS)	Anti-maggot, anti-fungal 50 g cream	Local application	As per need	Both morning and evening	Around the wound

### **Wound status as on 02.09.2013**

From 2<sup>nd</sup> September onwards a change in medication protocol was made as follows. Since, MgSO<sub>4</sub> did not respond much to reduce the hard fibrous mass of the abscess, use of CuSO<sub>4</sub> was planned. Accordingly, on 02.09.13, CuSO<sub>4</sub> (75 gm) was introduced into the right wound in both the pockets proportionately and CuSO<sub>4</sub> (15 gm) into the left wound for 4 days (upto 05.09.13) keeping in view of fast degeneration of the hard masses (Fig. 4). The dressing was suspended upto 05.09.2013 except outward cleaning of the wound. For these days, antibiotics and steroids were dropped and only meloxicam injection and tabs in alternate days including other supportive therapies were continued.



**Fig. 4.** Abscess status in both fore legs posteriorly at Barkote Veterinary Hospital (1<sup>st</sup> time use of CuSO<sub>4</sub> on 02.09.2013).

### **Wound status as on 06.09.2013**

On 06.09.13, the hard mass of the cavities found to be degenerated and seen in form of soft tissue bands and greenish thick fluid. A thick band of 1/2" breadth of greenish tissue half way detached from the base of the wound was noticed. It was cleaned by the artery forcep. Wound was flushed with diluted KMnO<sub>4</sub> and applied with betadine liquid. Since some fibrous mass was still left, it was decided to reuse CuSO<sub>4</sub>. Once again 125 g CuSO<sub>4</sub> (crystals) entered into 3 different cavities in both the wound pockets and allowed to be kept for next 3

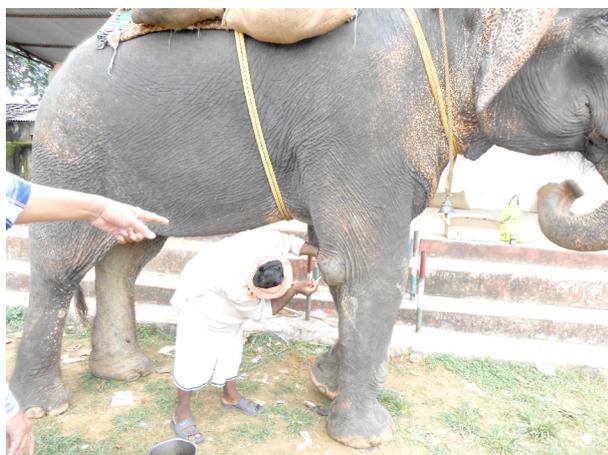
days (from 06.09.13 to 08.09.13) and examined for further dressing from 09.09.2013 onwards (Fig. 5). Medication as earlier was repeated.



**Fig. 5.** Examination of wounds after 2<sup>nd</sup> use of CuSO<sub>4</sub>, at Barkote; planning a thorough dressing (08.09.2013)

### **Wound management from 09.09.13 to 17.09.2013**

On 09.09.2013, it was noticed that greenish pus coming out of the wound, the border of the wound cavity being greenish too. There were significant tissue degeneration and necrosis from the impact of CuSO<sub>4</sub>. The wound pockets were thoroughly washed and cleaned with 1% luke warm KMnO<sub>4</sub> lotion (Fig. 6). Debridement of thick band of greenish dead tissues invaded into three cavities were taken up with help of B.P. blade and artery forceps. Bleeding was controlled by betadine soaked gauze and rubbing of alum into the cavities. The wound was then cleaned with normal saline mixed with 10% povidine iodine solution as per recommendations of Das et al., 2014. Wound gap was packed with sterilized gauze soaked in glycerine and chloramphenicol powder. With the surgical intervention, 60-70% of the enlargement was reduced. Then regular dressing was advocated with proper cleaning and application of Chloromphenicol powder to both the wounds. Ceftriaxone @ 6.75 mg kg<sup>-1</sup> was administered daily intra-veinously including metrozyl @ 1 mg kg<sup>-1</sup>, meloxicam @ 0.6 mg kg<sup>-1</sup> Himax ointment was applied all around the wound with Topicure spray as fly repellent (Table 2).



**Fig. 6.** Curetting of right wound after use of  $\text{CuSo}_4$  (09-09-2013)

By this time, at left side injury there was scab in the middle and having few congestions all around the scab. Alternate dressing was advocated with local application of povidine iodine. The right side wound cavities were flushed with normal saline after cleaning the dead tissues by artery forceps. The wounds size were markedly reduced to 4" and 1" diameter in both right and left wound respectively. After cleaning with gauze cloth, povidine iodine liquid was sprayed into the cavities liberally. Himax ointment was applied all around the wound including topicure spray all over the wound. Meloxicam and vitamins were continued and hot fomentation was recommended.

By 15<sup>th</sup>, the wound size started reducing. Marked improvement of both the wounds were noticed. In the meanwhile, left abscess size was drastically reduced. Regular dressing was undertaken, pus evacuated, betadine soaked gauze introduced into the cavity as a routine protocol. Cavities of right wound were properly curetted and cleaned by artery forceps follows by normal saline (NaCl) spray into the cavities. Then the cavities were cleaned with betadine soaked gauze cloth. From 09.09.13 onwards, new generation antibiotics with combination of Ceftriaxone and Tazobactam was recommended and administered upto 17.09.13. Recommended doses of Neuroxin-M, metrozyl and fluid therapy were also added to the change in protocol which worked better (Fig. 7). It corroborates with the work undertaken by Das et al. (2014).



**Fig. 7.** Administration of antibiotics (Intacef Tazo), supportive and fluid therapy

#### ***Wound status as on 18.09.13***

By 18<sup>th</sup> September, the left wound was healed having circular scar with tender skin cover and right side wound shown significant improvement and tendency of healing. It was then decided to continue the dressing for right side wound only upto 24.09.13. By this time the left side wound had healed with only tender skin cover. By 18<sup>th</sup> the size of the right wound was substantially reduced (5" cir./ 1.5" dia) covered with semi white tender skin formation having marked congestion. Medication including dressing was continued for the next 7 days i.e. from 18.09.13 to 24.09.13 for the right side wound. But it was preferred to drop the anti-biotics, analgesics and antihistaminics after 18th. Rest of the treatment continued upto 24th. On 19<sup>th</sup> morning wound size was reduced to 1" only. From 19<sup>th</sup> onwards chloramphenicol powder (paraxin caps of Nicholas Pharma) sprayed to the wound sites at both left and right wounds respectively 2-3 times daily maintaining all necessary aseptic procedures (Fig. 8).

#### ***Wound status from 21.09.13-23.09.2013***

By this time the pachyderm had entered into Tileibani block. Right wound shown signs of significant improvement and hence from 21<sup>st</sup> only chloramphenicol powder was applied locally 2-3 times daily including supportive therapy upto 23<sup>rd</sup>. By 23.09.2013, right wound was filled up with tender skin cover (Fig. 9).

**Table 2.** Medication from 09.09.13 to 17.09.13

Sl. No.	Name of medicine and Company	Type and presentation	Injection/ Oral administration	Quantity administered	Schedule	Dosage
1	Ceftriaxone + Tazobactam (INTAS PHARMA)	Antibiotic Ceftriaxone- 3 g Tazobactam- 0.375 g	I/V(Intra-venous)	(3.375 g x 6)	Once Daily at morning	6.75 mg kg <sup>-1</sup>
2	Melonex (INTAS PHARMA)	Analgesic Meloxicam Inj IP 5 mg/ ml	I/V	100 ml x 1 Vial	Once Daily at morning	1 ml 30 kg <sup>-1</sup> b.wt.
3	Prednisolone (INTERVET)	Steroid Prednisolone Acetate (10 ml x 1 vial)	I/M	10 ml x 5 vials	Alternate day	1ml 100 kg <sup>-1</sup> b. wt.
4	Neuroxin-M Vet (ZYdUS AH)	Nerve tonic Methyl cobalamine, Cyanocobalamine and B1, B6 and B12 (30 ml vial x 1 vial)	I/M	30 ml x 2 vials	Once Daily at morning	1 ml 50 kg <sup>-1</sup> b. wt.
5	Metrozyl (OMT PHARMA)	Check post-operative anaerobic infection Metronidazole 500 mg (100 ml x 1 bottle)	I/V infusion	100 ml x 6 vial	Once Daily at morning	1 mg kg <sup>-1</sup>
6	Intalyte (INTAS PHARMA)	Dextrose(Glucose) 20 gm+ Na + K + Ca (1L)	I/V	2 L.	Once Daily at morning	Fluid mix as per acceptance
7	Rintose (WOCKHARD Ltd.)	Dextrose 500 ml (500 ml x 1 bottle)	I/V	500 ml x 4 vials(2 lts)	Once Daily at morning	Fluid mix as per acceptance
8	DNS (INFUTECH Health Care Ltd.)	Dextrose + Normal saline solution (500 ml)	I/V	2 L.	Once Daily at morning	Fluid mix as per acceptance
9	D - 10	Dextrose 10 % (500 ml)	I/V	2 L.	Once Daily at morning	Fluid mix as per acceptance
6	D - 5 (PARENTERAL DRUGS India Ltd.)	Dextrose 5 % (500 ml)	I/V	2 L.	Once Daily at morning	Fluid mix as per acceptance
5	Brotone Liq (VIRBAC)	Multivits (500 ml bottle)	Oral	500 ml	Once Daily at morning	1 ml/ 100 kg b.wt.
6	Livol Pfs Liquid (INDIAN HERBS)	Liver Tonic (5 L pack)	Oral	500 ml	Once Daily at morning	1 ml/ 100 kg b.wt.
7	Paraxin cap (NICHOLAS PHARMA)	Antibiotic, antiseptic (Chloramphenicol) 500 mg	Local application	Powder from 5 caps	Once Daily During dressing	Liberal use over wound
8	Topicure Herbal spray (NATURAL REMEDIES)	Poly herbal Ayurvedic anti-bacterial and anti-inflammatory 250 ml. pack	Outward spray	As per need	Both morning and evening	As local spray
9	Himax ointment (INDIAN HERBS)	Anti-maggot, anti-fungal 50 g cream	Local application	As per need	Both morning and evening	All around the wound

### Wound status as on 24.09.13

By 24.09.2013 the right wound had only circular swollen scar mark of 3" cir/1" dia signifying the complete healing. Further, advised to use Volini gel (diclofenac base) to the swollen part with hot fomentation twice daily for couple of week to reduce the swollen parts of both the wounds. As such by 24.09.2013, the elephant was seen to be healthy and both the wounds were completely healed up (Fig. 10).

### RESULTS AND DISCUSSION

Injuries in elephants normally take long time for healing. Sometimes, there are possibility of fractures since bones are very porous in nature. That is why, in the above case, time to time expert opinion was sought considering the intake of medicine, the wastage and other miscellaneous factors like animal's physiological conditions, mood, moment, weather, human presence etc. The process of healing and the reduction of the size of the wound took long time. Hence, the owner was advised not



**Fig. 8.** Right wound shown significant improvement at Barkote (19.09.2013)

to leave the district at least for a month so that treatment can be rendered at different dispensaries. The owner had 3 more elephants in the group and had to change places for funds generation too to meet his livelihood. So, to give so much time to the affected animal was really difficult. Also, huge logistics and exercises were undertaken and that too correct drug dosage was also taken care of.



**Fig. 9.** Treatment at Tileibani block; I/V fluid with support of the platform (21.09.2013)

The abscess status as on 28.08.2013 was very bad with pus oozing out from both the cavities. When flushing was undertaken with lukewarm  $\text{KMnO}_4$ , it seemed to be superficial since the fibrous mass did not allow the antiseptics liquid to get in. It happened to be a chronic wound of about 10 years old and had surgical intervention many a time. It seemed that because of the hard fibrous mass embedded deep into the cavities, the abscess did not respond to usual dressing and wound management. Hence, it was decided to introduce  $\text{MgSO}_4$  liberally into the cavity to putrefy the hard mass for better cleaning and reduction of the mass size. But, it did not work with initial approach. Combination of Streptopenicillin and Penicillin G Sodium was initially approached. It did have least impact on the healing. There was no significant reduction of the size of the abscesses. Hence, it was planned to introduce  $\text{CuSO}_4$  into both cavities to fast degenerate the fibrous hard masses to look forward a complete healing. On 06.09.13, since major fibrous masses were curetted out due to the fast impact of  $\text{CuSO}_4$ , both the wounds were manoeuvred better.

From 9<sup>th</sup> to 17<sup>th</sup> September, combination of Ceftriaxone and Tazobactam was administered intra-veinously. Analgesics, anti-inflammatory and supportive therapy continued apart from regular dressing which started working better towards wound healing. In the process 8-10 litres of fluid were administered intra-veinously daily from 9<sup>th</sup> onwards. A wooden table was used to facilitate

giving fluid therapy to negotiate the height of the elephant. Metrozyl was administered to check further infections. Constant dressing as well as usage of vitamins like Broton liquid facilitated wound healing. Neuroxin-M supported strengthening of nerves. Meloxicam as analgesics and anti-inflammatory property put the animal calm and further reduced and smoothened the wounds. No stomachic pain and indigestion were noticed as such during the course of such a huge treatment regimen (Fig. 10).



**Fig. 10.** Both the wounds healed up; the elephant restored normal feeding and movement (24.09.2013)

## CONCLUSION

A chronic abscess needs regular health care, dressing and necessary surgical intervention in elephants to be healed up. Although special care can heal these wounds within 4 weeks although in many cases. If abscess is very chronic and has got large fibrous mass,  $MgSO_4$  will not work better; instead careful usage of  $CuSO_4$  can fast degenerate the mass to fasten the wound healing. Combination of antibiotics like Streptopenicillin and Penicillin G Sodium did not work. In the present case, combination of antibiotics Ceftriaxone and Tazobactam played pivotal role in wound healing. Cleaning the wound cavities with normal saline mixed with 5% povidine iodine worked better. Chloramphenicol powder spray over both wounds got better effect on wound healing. Vitamin (Brotone liquid) and oral liver supplementation of Livol pfs liquid got better effect on overall health regaining. At the end only circular scar mark of 1" diameter observed signifying the complete healing. It took 28 days and around a month for total healing of both the abscesses.

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# Morphometric characterisation of two species of horseshoe crabs viz. *C. rotundicauda* Latreille and *T. gigas* Muller from Bhitarkanika National Park, Odisha, India

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## ABSTRACT

The morphometric characterisation of two species of horseshoe crabs viz. *Carcinoscorpius rotundicauda* (Latreille) and *Tachypleus gigas* (Muller) was studied from Bhitarkanika National Park, Odisha. Different age groups and sexes from both the species were investigated for morphometric and allometric studies. Various parameters, such as total body length, prosoma length, prosoma width, prosoma-opisthosoma hinge length, opisthosoma length, opisthosoma width, telson length were recorded. The values were found higher in female compared to the male for both the species. Allometry analysis showed significant positive correlation indicating that the different body parts increase proportionately with the gradual increase of body dimension with the advancement of growth.

**Key words:** Allometry, Bhitarkanika, *C. rotundicauda*, *T. gigas*, morphometric

## INTRODUCTION

The horseshoe crabs are the oldest living animals on earth (Khan, 2003). These animals are called living fossils, as they remain unaltered morphologically and genetically through the long evolutionary course of more than 350 million years (Price, 1971). The fossilised records from different parts of the world from different geological time scale (Mikkelsen, 1988) reveals that little structural changes occurred in extant species over the time since the mid-Paleozoic Era (Sekiguchi and Shuster, 2009). There are only four species of horseshoe crabs exist in the present world. These are *Limulus polyphemus* (Linnaeus), *Tachypleus gigas* (Muller), *Tachypleus tridentatus* (Leach) and *Carcinoscorpius rotundicauda* (Latreille). Except for *L. polyphemus* (Linnaeus), the other three species viz. *T. tridentatus*, *T. gigas* and *C. rotundicauda* are Asian species (Sekiguchi and Nakamura, 1979).

*L. polyphemus* occurs in the coastal waters of U.S.A. Among the Asian horseshoe crab species, two species, i.e. the Indian horseshoe crab, *T. gigas* and the mangrove horseshoe crab *C. rotundicauda* occur in the Indian subcontinent.

In Asia, *T. gigas* are distributed from the Bay of Bengal particularly from the coast of Odisha in India to China, North Vietnam, Borneo and South-West of Japan (Chatterji and Abidi, 1993; Pati et al., 2015). *C. rotundicauda* is native to India, Indonesia, Malaysia, Philippines, Singapore and Thailand (Chatterji and Abidi, 1993; IUCN, 1996). Both the two species are confined to north-western coasts of the Bay of Bengal along Orissa and West Bengal. In Odisha, both the horseshoe crabs species are reported by (Chatterji, 1999; Dutta, 2007). Coexistence of both *C. rotundicauda* and *T. gigas* is reported in Odisha, particularly from Bhitarkanika region (Chatterji, 1999). Horseshoe

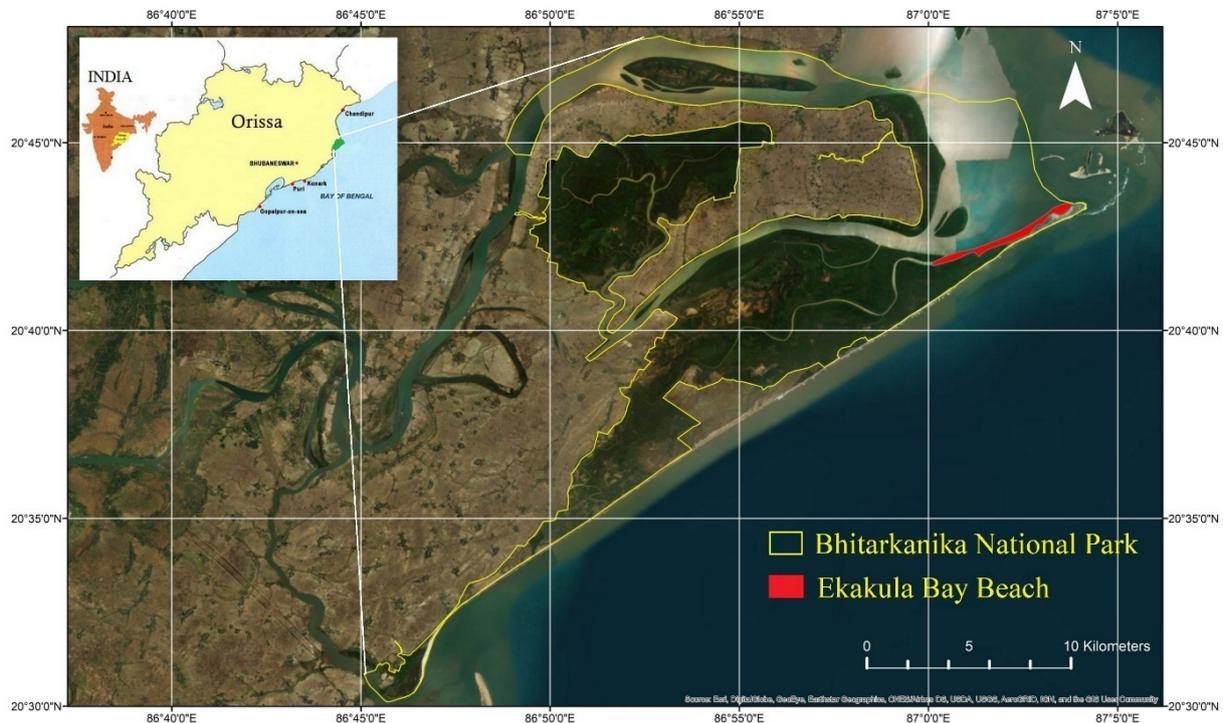
crabs distribution pattern is patchy (Shuster and Botton, 1985) and exhibits site-specificity, especially in areas where eggs and juveniles have thrived (Robert et al., 2014). *T. gigas* prefer relatively clean and sandy beaches in contrast to *C. rotundicauda*, which prefer muddy substratum. *T. gigas* are found on the sandy beach at the mouth of the estuary whereas *C. rotundicauda* are found in the mangroves of the estuary. Both the species occur sympatrically in the mangroves of Odisha. Mature pairs of horseshoe crabs (both the species) in amplexus migrate towards the shore throughout the year for breeding on the mud and sand mixed beaches of Bhitarkanika. These species are also seen to migrate upward, the estuarine river system in Bhitarkanika and Mahanadi delta in mangroves. Both the animals are classified as data deficient in the red list of threatened species.

## MATERIALS AND METHODS

Bhitarkanika estuary lies between the latitude 20°29' and 20°47' N and longitude 86°45' and 87°5'

in the north-western part of the Bay of Bengal on the Odisha coast. The entire area is situated in the mouth region of the Brahmani and the Baitarani river. This area supports diverse mangrove flora in the Indian subcontinent. The whole estuarine ecosystem gets inundated by semi-diurnal tides. Due to its unique and vast flora and faunal diversity with an area of 672 sq. kms, was designated as Bhitarkanika Wildlife Sanctuary, whereas its core region with an area of 145 sq. kms is designated as Bhitarkanika National Park (Fig. 1).

The area comes under the tropical climate. Monsoon chiefly influences the climate and therefore, biological seasons are classified as pre-monsoon (March-June), monsoon (July-Oct.) and post-monsoon (Nov.-Feb.). Average annual rainfall is around 1600 mm. Temperature varies from a minimum of 10°-15°C in December-January to maximum 40°-45°C in May-June. Tropical cyclones also influence the region in monsoon and post-monsoon period. Due to the high productivity



**Fig. 1.** The Google Earth map of Bhitarkanika National Park showing the sampling site of horseshoe crab Ekakula shelter bay beach

of mangroves, Bhitarkanika sustains a diverse group of animals, including horseshoe crabs. Two species of horseshoe crabs, *T. gigas* (Fig. 2) and *C. rotundicauda* (Fig. 3) were studied from Maipura river mouth region on Ekakula shelter bay beach of Bhitarkanika National Park.

The beach comprises of sandy, and muddy substratum, flooded with brackish water that makes the site a suitable habitat for horseshoe crabs. Mangrove species such as *A. alba*, *A. marina*, *S. alba*, *A. rotundifolia*, *R. mucronata* and *R. apiculata* are present on the beach. The horseshoe

crabs usually found to be spawning on the beach throughout the year. Specimens of both the species were collected manually during March 2017. After taking morphometric measurements, the animals were released into their habitat without harming.

The morphometric analysis of horseshoe crabs was carried out following Chatterji et al., 1988. A total of 62 individuals of *C. rotundicauda* horseshoe crabs (31 male and 31 female) and 61 individuals of *T. gigas* horseshoe crabs (30 male and 31 female) were examined for the morphometric study. Specimens were measured with the help of



(a) Dorsal view



b) Ventral view

**Fig. 2.** Morphometric (a) dorsal view and (b) ventral view of species *T. gigas*. It has distinguished feature of circular frontal margin, triangular telson cross section with irregular sized opisthosoma marginal spine compared to *C. rotundicauda*



**Fig. 3.** Morphometric (a) dorsal view and (b) ventral view of species *C. rotundicauda*. It has distinguished feature of circular telson cross section with regular sized opisthosoma marginal spine compared to other three species of horseshoe crabs viz. *L. polyphemus*, *T. gigas* and *T. tridentatus*

Vernier Calliper at a precision level of 0.002 cm for different morphometric parameters such as total body length, prosoma length, prosoma width, prosoma–opisthosoma hinge length, opisthosoma length, opisthosoma width and telson length without harming the animal.

Data obtained for all measurements were pooled according to the species and sex of specimens. The mean and standard deviation of various morphometric parameters were calculated and categorised. Independent samples T-test was applied to test differences between male and female specimen of both the species. The regression analysis was performed by R statistical software in order to discover the dissimilarity of the association degrees within different body parts, prosoma length

vs. total body length, prosoma width vs. total body length, prosoma–opisthosoma hinge length vs. total body length, opisthosoma length vs. total body length, opisthosoma width vs. total body length, and telson length vs. total body length.

## RESULTS AND DISCUSSION

The comparative morphometric analysis assesses the variation in overall morphology between different species. In this study, the morphometric parameters between two species of horseshoe crabs have been investigated. Both the species *C. rotundicauda* and *T. gigas* were found together during the survey at Ekakula beach. This corroborates the findings of Chatterji, 1999 of overlapping habitat and coexistence of these two species in Bhitarkanika. Both the horseshoe

crab species show notable differences in external morphology, based on morphological characteristics following Yamasaki et al. (1988). Most horseshoe crabs of both the species came ashore in amplexus mated pairs. The mating horseshoe crabs are found in tandem where the female was in front of the male.

Sexual dimorphism characteristics of horseshoe crabs are the size differences (Tan et al., 2012). On collation of collected morphometric data, males of both *C. rotundicauda* and *T. gigas* were found to be smaller than females significantly (Table 1 and 2). Independent samples t-test of different body parts between male and female of

each species confirms that the females are larger compare to males. Among the *C. rotundicauda* population of Bhitarkanika, the total body length of females had 12.20% higher value than the males. Similarly, the prosoma length, prosoma width, prosoma-ophiostoma hinge length, ophiostoma length, ophiostoma width and telson length showed 14.23, 8.57, 11.79, 14.56, 8.70 and 8.59 % higher values respectively in females than the males (Table 1). In the *T. gigas* population of Bhitarkanika the prosoma length, prosoma width, prosoma ophiostoma hinge length, ophiostoma length, ophiostoma width, telson length and total

**Table 1.** Measurement of different morphometric parameters of *C. rotundicauda*

	Prosoma length (cm)	Prosoma width (cm)	Prosoma – ophiostoma hinge (cm)	Opisthosoma length (cm)	Opisthosoma width (cm)	Telson length (cm)	Total body length (cm)
(a) Male							
Mean	7.231	13.08	6.294	5.754	9.545	14.58	27.53
SD	0.243	0.494	0.362	0.426	0.425	0.864	1.183
Max	7.615	13.83	7.113	6.452	10.19	16.82	29.97
Min	6.635	11.87	5.618	4.732	8.627	13.27	25.51
(b) Female							
Mean	8.260	14.21	7.035	6.591	10.37	15.84	30.89
SD	0.457	0.857	0.400	1.023	0.396	1.321	1.971
Max	9.006	15.67	7.602	9.952	11.07	17.83	34.97
Min	7.636	12.98	6.344	5.338	9.812	12.41	27.68

**Table 2.** Measurement of different morphometric parameters of *T. gigas*

	Prosoma length (cm)	Prosoma width (cm)	Prosoma – ophiostoma hinge (cm)	Opisthosoma length (cm)	Opisthosoma width (cm)	Telson length (cm)	Total body length (cm)
(a) Male							
Mean	8.383	14.81	6.745	6.088	9.113	15.47	29.71
SD	0.415	1.215	0.315	0.389	0.539	1.369	1.849
Max	9.446	19.99	7.422	7.288	9.980	18.89	34.02
Min	7.654	13.12	6.090	5.408	7.182	13.30	26.42
(b) Female							
Mean	10.82	18.10	8.517	7.766	11.23	17.92	36.06
SD	0.455	0.652	0.384	0.345	0.391	1.798	2.053
Max	11.78	19.78	9.374	8.550	12.52	20.26	39.07
Min	10.11	16.91	7.308	7.102	10.51	12.51	30.11

body length showed 29.15, 22.20, 26.28, 27.56, 23.26, 15.81 and 21.37% higher values respectively in females than the males (Table 2). The females are prominently bigger than the males in horseshoe crabs (Yamasaki et al., 1988; Key et al., 1996; Brockman and Smith 2009; Srijaya et al., 2012).

The allometry study (the relationship between differences in one body parameters to the other) of body parts of the horseshoe crab is utmost important to monitor its growth characteristic in studying the biology of the organism and serve as a functionally predictive tool for the study of animal's ecology (Vijayakumar et al., 2000). The morphometric characters and their allometric relationship are dependent upon age, local environmental conditions and population density of the species. The regression analysis of different morphometric measurements such as prosoma length, prosoma width, prosoma-ophiostoma hinge length, ophiostoma length, ophiostoma width, and telson length with the total body length of male and female individuals of both the species are presented

in Table 3 and 4. The positive correlation between different morphometric parameters and total body length relationship also showed a proportionate increment in these parameters. The increase in the soft body parts could probably be due to increased feeding efficiency and food availability to horseshoe crab (Vijayakumar et al., 2000). The changes in body dimensions of the species, *T. gigas* and *C. rotundicauda* indicate that the relationship could indirectly be influenced by population density, feeding efficiency, food availability and local environmental conditions.

### CONCLUSION

Bhitarkanika National Park is unique of its mangrove ecosystem having a healthy population of two horseshoe crab species on its adobe. The well-protected coast and water body on its bay is an ideal refuge for these two horseshoe crab species. Consequently, this morphometric study aims to provide crucial data that related these two horseshoe crab species in Bhitarkanika waters to support further research.

**Table 3.** Regression relationship between various body parts of *T. gigas* of Bhitarkanika

	Male	Female
Prosoma length vs total body length	$y = 0.158x + 3.695, R^2 = 0.494$	$y = 0.018x + 10.181, R^2 = 0.006$
Prosoma width vs total body length	$y = 0.328x + 5.063, R^2 = 0.249$	$y = 0.051x + 16.282, R^2 = 0.025$
Prosoma – opisthosoma hinge length vs total body length	$y = 0.103x + 3.692, R^2 = 0.362$	$y = 0.010x + 8.165, R^2 = 0.003$
Opisthosoma length vs total body length	$y = 0.115x + 2.677, R^2 = 0.297$	$y = 0.031x + 6.659, R^2 = 0.033$
Opisthosoma width vs total body length	$y = 0.174x + 3.943, R^2 = 0.356$	$y = 0.048x + 9.510, R^2 = 0.063$
Telson length vs total body length	$y = 0.698x - 5.281, R^2 = 0.890$	$y = 0.795x - 10.767, R^2 = 0.825$

**Table 4.** Regression relationship between various body parts of *C. rotundicauda* of Bhitarkanika

	Male	Female
Prosoma length vs total body length	$y = 0.133x + 3.571, R^2 = 0.419$	$y = 0.118x + 4.628, R^2 = 0.257$
Prosoma width vs total body length	$y = 0.251x + 6.164, R^2 = 0.363$	$y = 0.299x + 4.966, R^2 = 0.473$
Prosoma – opisthosoma hinge length vs total body length	$y = 0.218x + 0.293, R^2 = 0.508$	$y = 0.134x + 2.905, R^2 = 0.434$
Opisthosoma length vs total body length	$y = 0.238x - 0.786, R^2 = 0.435$	$y = 0.370x - 4.841, R^2 = 0.508$
Opisthosoma width vs total body length	$y = 0.217x + 3.576, R^2 = 0.364$	$y = 0.144x + 5.933, R^2 = 0.512$
Telson length vs total body length	$y = 0.652x - 3.363, R^2 = 0.797$	$y = 0.512x + 0.012, R^2 = 0.584$

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# Avifauna diversity in YSPUHF campus, Nauni, Solan, Himachal Pradesh, India

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## ABSTRACT

Avifaunal diversity in YS Parmar University of Horticulture and Forestry (YSPUHF) campus was studied by using Point Count method. Points were selected and point counts were carried on early in the morning from 6:30 a.m. to 9:00 a.m. and from 4:00 p.m. to 6:00 p.m. in the evening from October 2018 to May 2019. Total 156 species of birds belonging to 16 orders and 52 families were recorded. Order Passeriformes was found dominant (66.03% occurrence) with 33 family of birds. Order such as Ciconiiformes, Apodiformes, Falconiformes, Caprimulgiformes were found least occurred (0.64 % occurrence each) with only one family of bird each. Steppe eagle (*Aquila nipalensis* H.) and Egyptian vulture (*Neophron percnopterus* L.) which fall under Endangered (EN) category of IUCN were observed. Species like River lapwing (*Vanellus duvaucelii* L.), Himalayan griffon vulture (*Gyps himalayensis* Hume) and Indian alexandrine parakeet (*Psittacula eupatria* L.) which are near threatened are also observed. University campus provides comfortable shelter, suitable grounds for foraging, roosting, site for reproduction and nesting, protection from predation and hostile atmospheric conditions to these birds. But more efforts should be made to protect endangered and near threatened species of birds in the region and the country as a whole.

**Key words:** Avifaunal diversity, endangered, IUCN, point count method

## INTRODUCTION

Birds are related to forests as long as they come in existing, since their origin birds have heterogeneous to occupy a unprecedented array of habitats and hunt ways incomparable with the other terrestrial vertebrates. Birds provide associate huge gift to the forest ecosystem by acting as dispersing agents and as insectivores. Thus birds are revered not just for conserving ecological balance however additionally for merchandise of economic importance (Simeone et al., 2002). Study of avifaunal diversity is an essential ecological tool which acts as an important indicator to evaluate different habitats both qualitatively and quantitatively (Bilgrami, 1995). Currently avifauna are incessantly vulnerable by drivers like environs

loss, forest degradation, hunting, pollution, invasive species and diseases (Sodhi et al., 2011) as population of birds are terribly sensitive to degree of pollution in each terrestrial and aquatic system (Gaston, 1975; Hardy et al., 1987).

Research on avifauna in Asian country has shown that 80 per cent of the birds of the Indian landmass are found within the Indian Himalayan region (Price et al., 2003). Substantial numbers of bird species also are found in lower region of Himachal Pradesh nearer to the university campus. It has been stated that the estimation of native densities of fauna helps to grasp the abundance of assorted species of different organisms (Turner, 2003). Documentation on bird diversity is a pressing need to study the

dynamics and socioeconomic parameters outside the protected areas, especially in urban areas and university campuses. Keeping in view of this facts, investigation had undertaken in UHF, Nauni campus to produce a base-line data on the avifaunal diversity and to gain the ensuing impact of global climate change on avifaunal species diversity.

## MATERIALS AND METHODS

The present study was undertaken in Dr. Yashwant Singh Parmar University of Horticulture and Forestry campus, which is situated in Nauni village of Solan district, Himachal Pradesh, India. It covers an area of 5.5 km<sup>2</sup>. The terrain of the campus is almost hilly and the elevation gradually varies from 1184-1207 m. The campus is predominantly covered with tree species of chir pine, bottle brush, Chinese rain tree, etc. The available climatic data reveals that the annual rainfall varies from 1350-1750 mm. Mean monthly temperature for the study period was 17.4°C. The mean maximum and minimum temperature were recorded 24°C and 04°C, respectively.

Points were selected and point counts were carried on early in the morning from 6:30 a.m. to 9:00 a.m. and from 4:00 p.m. to 6:00 p.m. in the evening from October 2018 to May 2019. Observations not made between these timings were also added to prevent missing of any species from the list. Point counts were avoided in bad climatic conditions. The birds were identified with the help of Nikon 10 X 42 binoculars, their calls and by their photographs. The photographs were shot with Nikon DSLR camera with 300 mm lens. Birdlife International (2016) was used for threat category. Manakadan and Pittie (2001) was followed for nomenclature and taxonomy of bird species. Birds were classified under resident or migratory status as per Ali and Ripley (1987). Frequency of sighting of the birds were categorized according to their occurrence in the study site such as common (C), uncommon (UC), rare (R) and occasional (O).

Occurrence of the order of the bird is obtained by using the following formula:

$$\text{Percentage occurrence} = \frac{\text{No. of spp. of each order}}{\text{Total no. of species of different order}} \times 100$$

## RESULTS AND DISCUSSION

The results obtained from the present study showed that 156 species of birds belonging to 16 orders and 52 families were present in Y S Parmar UHF, Solan. Out of all, order Passeriformes was found dominant (66.03% occurrence) with 103 types of species belonging to 33 families. Order such as Ciconiiformes, Apodiformes, Falconiformes, Caprimulgiformes were found least occurred (0.64 % occurrence each) with only 01 species (Fig. 1 and Table 1).

Under International Union for Conservation of Nature and Natural Resources (IUCN) protection status, species like River lapwing (*Vanellus duvaucelii*), Himalayan griffon vulture (*Gyps himalayensis*) and Indian alexandrine parakeet (*Psittacula eupatria*) were Near Threatened (NT) however species like Steppe eagle (*Aquila nepalensis*) and Egyptian vulture (*Neophron percnopterus*) were under Endangered (EN) category. The other species belong to least concern (LC) category (Table1).

The study revealed that there were two bird species under endangered (EN) and three species under near threatened (NT) category according to IUCN protection status. So it demands immediate action for conserving their population in the study site.

Among the avifauna, 107 were residents (69%), 47 were migrants including 24 winter visitors (15%) and 23 summer visitors (15%), 2 passage visitors (1%) [Fig 2]. Further analysis on frequency of sighting revealed that 90 species were common (57.69%), 5 species were very common (3.21%), 19 species were fairly common (12.18%), 28 species were uncommon (17.95%), 2 species were rare (1.28%) and 12 species were very rare (7.69%) (Table 1).

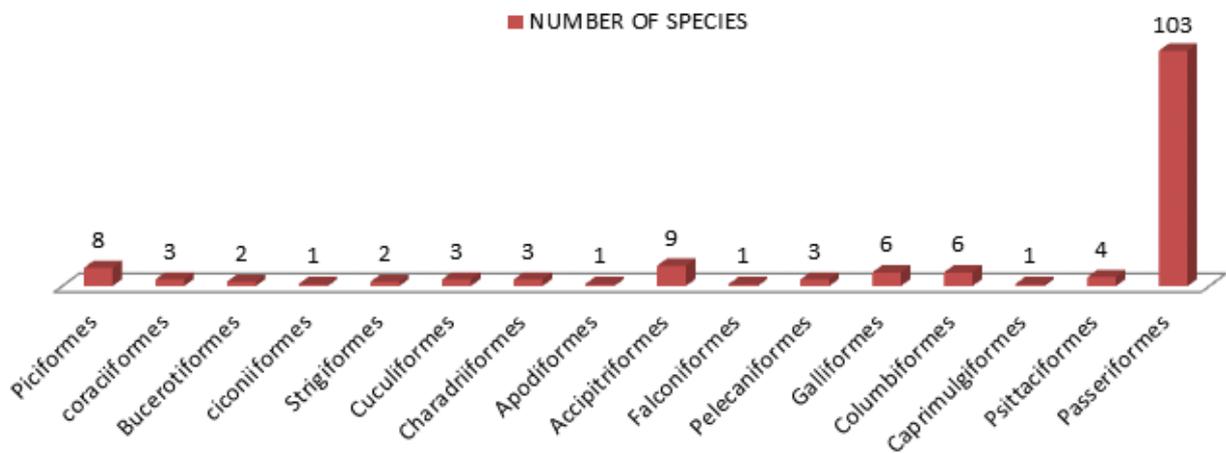


Fig. 1. Occurrence of orders(s) with respect to belonging species of birds

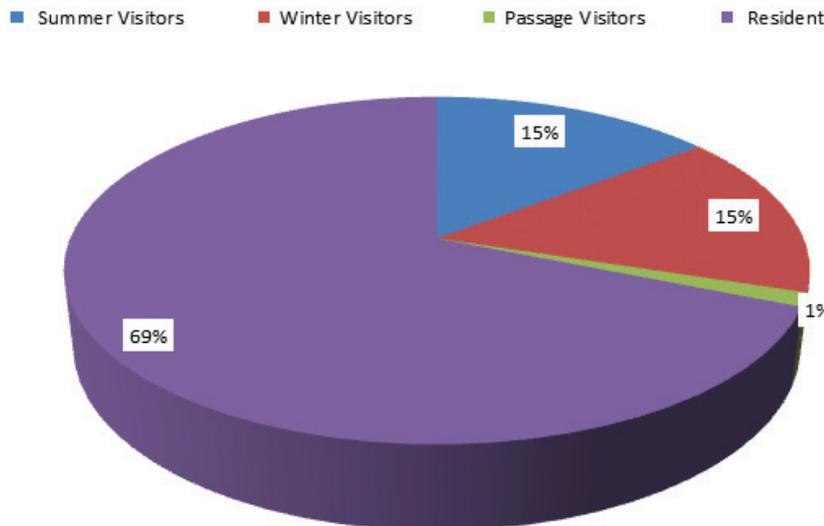


Fig. 2. Representing migratory status of avian species

Birds are used for assessing ecosystem quality (Ridley et al., 1984). To have long term conservational measure it is necessary to have knowledge about species diversity present in an area. The high richness of species diversity in the study site may be attributed to its geographical location, heterogeneity of land characteristics and number of tree and shrub diversity which makes the campus complex structurally. Empirical and theoretical evidence have also proved that species richness is highly influenced by complex landscape. (Lawton, 1999; Gaston, 2000).

There are several other factors which support such number of bird species in the university campus such as availability of food material, suitable sites for nesting, low temperature throughout the year, easy availability of nesting material which have also with (Margules et al., 2000).

From the result of current study, it is inferred that university campus provides comfortable shelter, suitable grounds for foraging, roosting, site for reproduction and nesting, protection from predation and hostile atmospheric conditions to these birds.

**Table 1.** Occurrence and conservation status of bird species in UHF campus

Order	Family	Name of the species	Abundance	IUCN status	Migration status
Piciformes	Megalaimidae	Great Barbet ( <i>Psilopogon virens</i> )	C	LC	R
		Blue Throated Barbet ( <i>Psilopogon asiaticus</i> )	FC	LC	R
	Picidae	Greater flameback Woodpecker ( <i>Chrysocolaptes guttacristatus</i> )	R	LC	R
		Grey Headed Woodpecker ( <i>Picus canus</i> )	FC	LC	R
		Lesser Yellownape woodpecker ( <i>Picus chlorolophus</i> )	FC	LC	R
		Fulvous breasted Woodpecker ( <i>Dendrocopos macei</i> )	C	LC	R
		Grey Capped Pygmy Woodpecker ( <i>Yungipicus canicapillus</i> )	C	LC	R
		Speckled Piculet ( <i>Picumnus innominatus</i> )	FC	LC	R
		Coraciiformes	Alcedinidae	White Breasted Kingfisher ( <i>Halcyon smyrnensis</i> )	C
Crested Kingfisher ( <i>Megaceryle lugubris</i> )	C	LC		R	
	Meropidae	Green Bee Eater ( <i>Merops orientalis</i> )	FC	LC	R
Bucerotiformes	Upupidae	Common Hoopoe ( <i>Upupa epops</i> )	C	LC	R
	Bucerotidae	Indian Grey Hornbill ( <i>Ocyrceros birostris</i> )	R	LC	R
Ciconiiformes	Ciconiidae	Black Stork ( <i>Ciconia nigra</i> )	R	LC	PV
Strigiformes	Strigidae	Brown Fish Owl ( <i>Ketupa zeylonensis</i> )	R	LC	R
		Asian Banded Owl ( <i>Glaucidium cuculoides</i> )	C	LC	R
Cuculiformes	Cuculidae	Asian koel ( <i>Eudynamys scolopaceus</i> )	C	LC	R
		Common Hawk Cuckoo ( <i>Hierococcyx varius</i> )	C	LC	R
		Greater Coucal ( <i>Centropus sinensis</i> )	FC	LC	R
Charadriiformes	Scolopacidae	Eurasian Cuckoo ( <i>Cuculus canorus</i> )	FC	LC	SV
	Charadriidae	Red Wattled Lapwing ( <i>Vanellus indicus</i> )	C	LC	R
		River Lapwing ( <i>Vanellus duvaucelii</i> )	R	NT	R
Apodiformes	Apodidae	House Swift ( <i>Apus nipalensis</i> )	VC	LC	R
Accipitriformes	Accipitridae	Crested Serpent Eagle ( <i>Spilornis cheela</i> )	C	LC	R
		Steppe Eagle ( <i>Aquila nipalensis</i> )	UC	EN	WV
		Bonelli's Eagle ( <i>Aquila fasciata</i> )	VR	LC	R
		Black Kite ( <i>Milvus migrans</i> )	UC	LC	R
		Black Winged Kite ( <i>Elanus caeruleus</i> )	FC	LC	R
		Shikra ( <i>Accipiter badius</i> )	FC	LC	R
		Egyptian Vulture ( <i>Neophron percnopterus</i> )	VR	EN	SV
		Eurasian Griffon Vulture ( <i>Gyps fulvus</i> )	C	LC	WV
	Himalayan Griffon Vulture ( <i>Gyps himalayensis</i> )	C	NT	R	
Falconiformes	Falconidae	Common Kestrel ( <i>Falco tinnunculus</i> )	R	LC	WV
Pelecaniformes	Ardeidae	Indian Pond Heron ( <i>Ardeola grayii</i> )	C	LC	R
		Striated Heron ( <i>Butorides striata</i> )	FC	LC	R
		Cattle Egret ( <i>Bubulcus ibis</i> )	R	LC	R

Galliformes	Phasianidae	Black Francolin ( <i>Francolinus francolinus</i> )	C	LC	R
		Grey Francolin ( <i>Francolinus pondicerianus</i> )	C	LC	R
		Jungle Bush quail ( <i>Perdicula asiatica</i> )	C	LC	R
		Red Jungle Fowl ( <i>Gallus gallus</i> )	C	LC	R
		Indian Peafowl ( <i>Pavo cristatus</i> )	UC	LC	R
		Kalij Pheasant ( <i>Lophura leucomelanos hamiltoni</i> )	C	LC	R
Columbiformes	Columbidae	Rock Dove ( <i>Columba livia</i> )	C	LC	R
		Oriental Turtle Dove ( <i>Streptopelia orientalis</i> )	C	LC	R
		Asian Emerald Dove ( <i>Chalcophaps indica</i> )	UC	LC	R
		Eurasian Collared Dove ( <i>Streptopelia decaocto</i> )	UC	LC	R
		Spotted Dove ( <i>Spilopelia chinensis</i> )	C	LC	R
		Laughing Dove ( <i>Spilopelia senegalensis</i> )	C	LC	R
Caprimulgiformes	Caprimulgidae	Large tailed Nightjar ( <i>Caprimulgus macrurus</i> )	FC	LC	R
Psittaciformes	Psittaculidae	Rose Ringed parakeet ( <i>Psittacula krameri</i> )	C	LC	R
		Plum Headed Parakeet ( <i>Psittacula cyanocephala</i> )	C	LC	R
		Slaty Headed parakeet ( <i>Psittacula himalayana</i> )	C	LC	R
		Indian Alexandrine parakeet ( <i>Psittacula eupatria</i> )	FC	NT	R
Passeriformes	Hirundinidae	Barn Swallow ( <i>Hirundo rustica</i> )	C	LC	SV
		Wire Tailed Swallow ( <i>Hirundo smithii</i> )	FC	LC	SV
		Red Rumped Swallow ( <i>Cecropis daurica</i> )	UC	LC	SV
	Emberizidae	Rock Bunting ( <i>Emberiza cia</i> )	C	LC	WV
		White Capped Bunting ( <i>Emberiza stewarti</i> )	C	LC	WV
		Crested Bunting ( <i>Melophus lathami</i> )	C	LC	SV
		Chestnut Eared Bunting ( <i>Emberiza fucata</i> )	R	LC	R
	Campephagidae	Long Tailed Minivet ( <i>Pericrocotus ethologus</i> )	C	LC	SV
	Passeridae	House Sparrow ( <i>Passer domesticus</i> )	C	LC	R
		Russet Sparrow ( <i>Passer rutilans</i> )	C	LC	R
	Nectariniidae	Purple Sunbird ( <i>Cinnyris asiaticus</i> )	C	LC	SV
		Crimson Sunbird ( <i>Aethopyga siparaja</i> )	C	LC	R
	Dicaeidae	Fire Breasted Flowerpecker ( <i>Dicaeum ignipectus</i> )	UC	LC	R
	Muscicapidae	Himalayan Rubythroat ( <i>Luscinia pectoralis</i> )	UC	LC	SV
		Blue capped Rock Thrush ( <i>Monticola cinclorhynchus</i> )	UC	LC	SV
		Chestnut Bellied Rock Thrush ( <i>Monticola rufiventris</i> )	UC	LC	WV
		Himalayan Bluetail ( <i>Tarsiger rufilatus</i> )	UC	LC	WV
		Indian Robin ( <i>Copsychus fulicatus</i> )	C	LC	R
		Oriental Magpie Robin ( <i>Copsychus saularis</i> )	C	LC	R
		Plumbeous water redstart ( <i>Phoenicurus fuliginosus</i> )	C	LC	R
Spotted Forktail ( <i>Enicurus maculatus</i> )		C	LC	R	
White capped Redstart ( <i>Phoenicurus leucocephalus</i> )		C	LC	R	

	Little Forktail ( <i>Enicurus scouleri</i> )	UC	LC	R
	Common Stonechat ( <i>Saxicola torquatus</i> )	C	LC	WV
	Pied Bushchat ( <i>Saxicola caprata</i> )	C	LC	SV
	Gray Bushchat ( <i>Saxicola ferreus</i> )	C	LC	R
	Brown Rockchat ( <i>Oenanthe fusca</i> )	C	LC	R
	Rufous Gorgeted Flycatcher ( <i>Ficedula strophciata</i> )	UC	LC	R
	Verditer Flycatcher ( <i>Eumyias thalassinus</i> )	C	LC	SV
	Ultramarine Flycatcher ( <i>Ficedula superciliaris</i> )	FC	LC	SV
	Grey Headed Canary Flycatcher ( <i>Culicicapa ceylonensis</i> )	C	LC	SV
	Slaty Blue Flycatcher ( <i>Ficedula tricolor</i> )	UC	LC	WV
	Red Breasted Flycatcher ( <i>Ficedula parva</i> )	UC	LC	WV
	Rufous Bellied Niltava ( <i>Niltava sundara</i> )	UC	LC	WV
	Rusty Tailed Flycatcher ( <i>Ficedula ruficauda</i> )	UC	LC	PV
	Asian Brown Flycatcher ( <i>Muscicapa latirostris</i> )	UC	LC	SV
	Blue Whistling Thrush ( <i>Myophonus caeruleus</i> )	C	LC	R
	Blue Capped Redstart ( <i>Phoenicurus coeruleocephala</i> )	C	LC	R
Estrildidae	Scaly Breasted Munia ( <i>Lonchura punctulata</i> )	C	LC	R
Prunellidae	Black Throated Accentor ( <i>Prunella atrogularis</i> )	UC	LC	WV
	Rufous breasted Accentor ( <i>Prunella strophciata</i> )	R	LC	WV
Fringillidae	Common Rosefinch ( <i>Carpodacus erythrinus</i> )	C	LC	SV
	Pink Browed Rosefinch ( <i>Carpodacus rodochroa</i> )	UC	LC	WV
	Yellow breasted Greenfinch ( <i>Chloris spinoides</i> )	C	LC	WV
	European Goldfinch ( <i>Serinus pusillus</i> )	C	LC	R
	Red Fronted Serin ( <i>Serinus pusillus</i> )	C	LC	WV
Certhiidae	Bar Tailed Treecreeper ( <i>Certhia himalayana</i> )	C	LC	WV
Sittidae	Chestnut Bellied Nuthatch ( <i>Sitta cinnamoventris</i> )	C	LC	R
Tichodromidae	Wallcreeper ( <i>Tichodroma muraria</i> )	C	LC	WV
Sturnidae	Common Myna ( <i>Acridotheres tristis</i> )	C	LC	R
	Jungle Myna ( <i>Acridotheres fuscus</i> )	C	LC	R
	Brahminy Starling ( <i>Sturnia pagodarum</i> )	C	LC	R
	Chestnut Tailed Starling ( <i>Sturnia malabarica</i> )	C	LC	SV
	Spot Winged Starling ( <i>Saroglossa spilopterus</i> )	C	LC	SV
Turdidae	Black Throated Thrush ( <i>Turdus atrogularis</i> )	R	LC	WV
Cisticolididae	Striated Prinia ( <i>Prinia criniger</i> )	C	LC	R
	Plain Prinia ( <i>Prinia inornata</i> )	C	LC	R
	Jungle Prinia ( <i>Prinia sylvatica</i> )	C	LC	R
	Grey Breasted Prinia ( <i>Prinia hodgsonii</i> )	C	LC	R
	Common Tailorbird ( <i>Orthotomus sutorius</i> )	C	LC	R
Pycnonotidae	Black Bulbul ( <i>Hypsipetes leucocephalus</i> )	VC	LC	R
	Red Vented Bulbul ( <i>Pycnonotus cafer</i> )	VC	LC	R

	Himalayan Bulbul ( <i>Pycnonotus leucogenys</i> )	VC	LC	R
Phylloscopidae	Common Chiffchaff ( <i>Phylloscopus collybita</i> )	UC	LC	WV
	Hume's leaf warbler ( <i>Phylloscopus humei</i> )	C	LC	WV
	Western Crowned warbler ( <i>Phylloscopus occipitalis</i> )	UC	LC	SV
	Grey Hooded warbler ( <i>Phylloscopus xanthoschistos</i> )	C	LC	R
Timaliidae	Black Chinned Babbler ( <i>Cyanoderma pyrrhops</i> )	VC	LC	R
	Rusty Cheeked Scimitar Babbler ( <i>Pomatorhinus erythrogenys</i> )	FC	LC	R
	White Browed Scimitar Babbler ( <i>Pomatorhinus schisticeps</i> )	UC	LC	R
Leiothrichidae	White Crested Laughing Thrush ( <i>Garrulax leucolophus</i> )	C	LC	R
	White Throated Laughing Thrush ( <i>Garrulax albogularis</i> )	UC	LC	R
	Streaked Laughing Thrush ( <i>Trochalopteron lineatum</i> )	C	LC	R
	Red Billed Leiothrix ( <i>Leiothrix lutea</i> )	C	LC	R
	Rufous Sibia ( <i>Heterophasia capistrata</i> )	C	LC	R
	Jungle Babbler ( <i>Argya striata</i> )	C	LC	R
Zosteropidae	Oriental White Eye ( <i>Zosterops palpebrosus</i> )	C	LC	R
	Whiskered Yuhina ( <i>Yuhina flavicollis</i> )	C	LC	R
Cinclidae	Brown Dipper ( <i>Cinclus pallasii</i> )	C	LC	R
Motacillidae	White Wagtail ( <i>Motacilla alba</i> )	FC	LC	SV
	Grey Wagtail ( <i>Motacilla cinerea</i> )	C	LC	WV
	White Browed Wagtail ( <i>Motacilla maderaspatensis</i> )	C	LC	R
	Tree Pipit ( <i>Anthus trivialis</i> )	C	LC	WV
Pellorneidae	Puff Throated Babbler ( <i>Pellorneum ruficeps</i> )	UC	LC	R
Corvidae	Red Billed Blue Magpie ( <i>Urocissa erythroryncha</i> )	C	LC	R
	Yellow Billed Blue Magpie ( <i>Urocissa flavirostris</i> )	C	LC	R
	Rufous Treepie ( <i>Dendrocitta vagabunda</i> )	UC	LC	R
	Grey Treepie ( <i>Dendrocitta formosae</i> )	C	LC	R
	Large Billed Crow ( <i>Corvus macrorhynchos</i> )	C	LC	R
Laniidae	Long tailed shrike ( <i>Lanius schach</i> )	UC	LC	R
Dicruridae	Black Drongo ( <i>Dicrurus macrocercus</i> )	C	LC	R
	Hair Crested Drongo ( <i>Dicrurus bracteatus</i> )	C	LC	R
	Ashy Drongo ( <i>Dicrurus leucophaeus</i> )	C	LC	SV
Oriolidae	Indian Golden Oriole ( <i>Oriolus kundoo</i> )	R	LC	SV
Rhipiduridae	White Throated Fantail ( <i>Rhipidura albicollis</i> )	C	LC	R
	Yellow Bellied Fantail ( <i>Chelidorhynch hypoxantha</i> )	C	LC	WV
Monarchidae	Asian Paradise Flycatcher ( <i>Terpsiphone paradisi</i> )	UC	LC	SV
Paridae	Great Tit ( <i>Parus cinereus</i> )	C	LC	R
	Himalayan Black Lored Tit ( <i>Machlolophus xanthogenys</i> )	FC	LC	R

	Black Throated Tit ( <i>Aegithalos concinnus</i> )	C	LC	R
	Green backed Tit ( <i>Parus monticolus</i> )	R	LC	R
Vangidae	Common Woodshrike ( <i>Tephrodornis pondicerianus</i> )	FC	LC	R
Sylviidae	Yellow Eyed Babbler ( <i>Chrysomma sinense</i> )	FC	LC	R

C: Common, R: Rare, FC : Fairly Common, LC: Least concern, NT: Near threatened, EN: Endangered, WV: Winter visitor, SV : summer visitor, R: Resident

## CONCLUSION

The survey being first of its kind in this area which provides a baseline information about bird diversity present at YSPUHF campus. This study creates awareness on documentation of birds in other university campuses of Himalayan region. This type of survey is important to monitor and conserve bird diversity where construction of roads and buildings replace green vegetation damaging their habitat. Further research on bird species behavior, feeding strategy and their role in deciding vegetation of an area by playing significant role in plant pollination and seed dispersal is highly necessary for better conservation and long term monitoring of bird diversity. Although there are natural forest in the campus as shelter of bird, still there is need of awareness campaign and bio-monitoring programmes for maintaining and protecting their numbers in university campus.

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# Population study of tiger (*Panthera tigris tigris*) by trap camera photo capture in Katarniaghat Wildlife Sanctuary, Uttar Pradesh, India

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## ABSTRACT

An intensive habitat survey and deployment of camera trap for photo capture of large cats was conducted for a period of 8 months (February 2007 to October 2007) in Katarniaghat Wildlife Sanctuary, Uttar Pradesh, India. This paper deals with the results obtained from the camera trap photo captures of tiger (*Panthera tigris tigris*). All the six forest ranges of Katarniaghat Wildlife Sanctuary viz. Katarniaghat, Nishangadha, Murtiha, Dharmapur, Kakraha and Motipur were surveyed for carnivore signs, ungulate encounter rate, vegetation types and photo captures of tigers by installation of camera traps. Maximum importance was given to the core areas of the sanctuary i.e. Katarniaghat and Nisangada range. A set of 20 pairs of Camera trap (Make Deercam) units were deployed in 2/ 2 km grid area location for 16 days. And the process continues in buffer area further 1 month. A total of 5 individual tigers confirmed to be resident and signs of movement of additional 3- 4 tigers found in transition zones in Nepal and Kishannagar forest division. Additional data on prey base, co-predators, and other floral composition were recorded during the study. The study also revealed the presence of rare rusty spotted cat, leopard cat and honey badger in the said wildlife sanctuary.

**Key words:** Camera trap, Katarniaghat Wildlife Sanctuary, photo capture, rusty spotted cat, tiger

## INTRODUCTION

The flagship species like tigers, elephants, rhinoceros etc. in the sub-continent draw significant importance. Their exact population, habitat, prey base and vegetation studies are highly required to maintain the ecological balance. Fortunately, a range of new distribution and habitat data are now available for India and elsewhere (Dinerstein et al., 2006). These could be used to focus resources on areas where tigers still struggle to survive. Katarniaghat as far as Uttar Pradesh is concerned, most of the wildlife diversity is confined to the northern region in Terai arc bordering to Uttaranchal and Nepal. Apart from tiger as key species in Kataraniaghat

wildlife sanctuary, many other species like leopard, spotted deer, barking deer, nilgai and sambar live in and play an equally important part in this tiger ecology (Menon, 2003). Elephant and rhinoceros which once migrated from Nepal, have now made Katarniaghat their permanent habitat. Wild boar can be easily seen here even at day time. In addition, porcupine, red jungle fowl and peacock play an important part of tiger prey base in this sanctuary. The sanctuary also has high density of ample spotted deer population which are encountered in hundreds in mass foraging in meadows of Kataraniaghat ranges. Once there are blackbuck herds seen in the sanctuary and locally extinct since 2003. It is among the few places that have retained

their natural character. The people who live within the forest are largely native tribal. They should be provided important ways to secure the financial strength of the people those have conservation will that is essential for conserving the forest and saving wild tigers and other large carnivores within these habitats (Dre `ze and Murthi, 2001). There is the need of enumeration of tigers in different forests of India as a part of ecological and habitat studies.

**STUDY AREA**

Katarniaghat Wildlife Sanctuary lies along the Indo-Nepal border (Fig. 1), in the district of Behraich in Utter Pradesh, India, with a 550 sq. km. of dense Terai jungle comprising of sal and teak forest, lush green grasslands, wetlands and swamps having quite a good number of wildlives (Bajpai et al., 2012). The Katarniaghat WS of West Behraich Forest Division, was declared a Wildlife Sanctuary in May 1975 and today forms a part of the Dudhwa Tiger Reserve along with Dudhwa National Park and Kishanpur Wildlife Sanctuary. There are habitat connectivity and linkages between tiger habitats of Dudhwa National Park and Kishanpur forest division of India and the Bardia National Park in Nepal.



**Fig. 1.** Katarniaghat sanctuary (Motipur range in view) along the Indo-Nepal border

The Katarniaghat wildlife sanctuary has got six forest ranges namely, Katarniaghat, Dharmapur, Nishangadha, Murtiha, Kakraha and Motipur. Dense forest covers the core areas of four ranges such as Katarnia, Nishangadha, Murtiha and Dharmapur, while rest two Kakraha and Motipur are situated in the buffer zone of the Sanctuary (Fig. 2).



**Fig. 2.** Katarniaghat wildlife sanctuary showing beat and ranges with topo sheet (Camera trap area 200 sq km)

The Terai Arc covers an area of 50,911 sq km (Nepal: 24,710 sq km, India: 26,201 sq km) and stretches across 700 km in India and Nepal (Fig. 1). The landscape contains almost 5 important protected areas in the region. These are Rajaji National Park, Corbette National Park and Tiger reserve, Dudhwa National Park and Tiger reserve, Katarniaghat wildlife sanctuary and Valmiki Tiger Reserve (VTR) in the Indian Terai region.

**MATERIALS AND METHODS**

The camera trap was deployed in central position of nearly 2/ 2 km area (4 sq km) in the sanctuary. The shape of the effective camera trap area is almost rectangular or square size imaginary area of about 200 sq km with varied geographic features like stream, meadow, rivers, and dense forest to village fringe areas. The camera trap work was completed in 2 phases of 100 square km area each. The 10/ 10 km area traversed and divided in grids for operation of minimum 20 units (2 cameras

in an unit) for a session of minimum 15 days (including trap nights). Then another 100 sq km is worked as the first sample area.

The Deer cam make heat sensor flash film camera was deployed for the study. No cameras were camouflaged with tree branches and grass straws. All cameras were put in natural and ideal places where the animal could not avoid the trail before captured in cameras. All photos film rolls were coded with markers as local names of the spot and have a serial number in order to avoid intermixing of photo films during washing and developing in local photo labs. There is setting in the camera itself in the form of the date and time. All the cameras were set in one time adjust up to 1 second error from common clock at base camp. There will be fractional error of time 2-3 seconds in two opposite faced cameras. But the timing of capturing photo in one unit of camera trap pair is taken as ideal and no same animal could cover the distance of few meters apart and so the same animal is trapped in different traps in different time of same or different day. It confirms the movement patterns of the animal within the study area. The camera delay was very minimum with lapse of 1 second, i.e. a photo capture can have done after a second gap by the same individual camera (Das et al., 2016). The camera efficiency was so good that it also captures 2-3 photos within 1 second with little change in postures of head region of tiger which observe the camera towards flash light. The photo receiving distance with auto focusing the images is too good and captures photos passing objects like monkey and peacock from a distance of 40 meters in a riverine where animals come for drinking. The camera also takes photo capture with heat sensors from a distance of 10 meters from each camera across wide roads. The flash light can reach and covers almost 5-10 meters at deep dark night. Cameras were set between 40 and 60 cm (more than 1-2 feet) above the ground, and perpendicular to the ground. The cameras were put in convenient locations that suited for our own operation and also placed where the spot satisfies after rigorous sign survey exercises. The actual way of working is illustrated below showing unloaded camera set,

pole position of 20-50 cm high above ground and cleaning of grasses in front of camera in Terai landscape where grassland is a major sampling area. The inspecting vehicle should have stopped before camera tram location in order to avoid the unnecessary photo capture hence consuming camera role films (Fig. 3).



**Fig. 3.** Captured from another active camera before re-collection and putting off during day time

## RESULTS AND DISCUSSION

The operation of camera trap photo records was taken up at 20 different units. All photographs were checked manually and encounters with tiger photo captures in printed mat paper copies were verified in field without computers. Tiger movements from camera trap data over intensive efforts of nearly 800 trap days(nights) covering 180 sq km of tiger habitat in core area showed 5 individual tigers were photographed by camera traps within the sanctuary and there were little movement area crossing the transboundary complexes in Nepal and India. The camera trap survey indicated that at least 11- 13 individual tigers are using the transboundary corridors that connect with Nepal and India's protected areas. While detection of individual tigers in both protected areas and connecting corridors does not confirm dispersal, the supporting evidence based on spatial areas occupied and distances covered suggest these individuals were not resident tigers with territories that overlapped across protected area and corridor boundaries, but were transient, non-resident tigers. The average territory size of female tigers in the

Terai alluvial grassland-savannahs, calculated using MCP analysis, was calculated to be approximately 20 sq km. There were also no recaptures in the same cameras or the units or other functioning adjacent camera units suggesting that these individuals did not move an established territory during short period of trapping time of 2-3 weeks long.

The distances between camera traps in which tiger were photographed in the study also confirmed that it is not necessary that tiger move in a particular trail frequently and in regular interval. The movements seemed to be only for prey base and for defending territory of its own and mating purposes. The distances travelled by individual tigers that trapped in different consecutive camera trap locations also confirms that there is overlapping territories within male and female tigers (Fig. 5, 6, 7 and 8).



**Fig. 4.** Capture of tiger on 10 August 2007 night 23.50hrs



**Fig. 5.** Capture of tiger on 12 August 2007 dawn 6.52hrs



**Fig. 6.** Capture of tiger on 16 August 2007 night 09.53 hrs



**Fig. 7.** Capture of tiger on 19 August 2007 dawn 5.19hrs

The ultimate camera trap resulted in so many gathered data on every ungulate prey base including chinkara and other ungulate species. The night camera trap revealed the presence of civet cat, jackals, jungle cat and bear, those become active and captured in photo. The camera trap also recorded photo capture of herbivores like chital, chinkara, sambar, blackbuck, nilgai, and langur etc. in the sanctuary. It confirmed the prey base diversity in the central zone of India. A tigerkill of sambar surrounded by vultures seen near boat ghat of the sanctuary confirms to support the camera trap (Fig. 8). The carnivorous species reported in trap camera include jackal, bear, leopard, wolf, striped hyaena, jungle cat, etc (Das et al., 2019).



**Fig. 8.** A tiger kill (sambar surrounded by Himalayan griffon vultures) lied in the trail of Katarniaghat wildlife sanctuary near boat Ghat.

### **Tiger conservation strategies**

Conserving large carnivores is important because they are often highly threatened and play key roles in a range of ecosystem processes. The reliable estimates of tiger numbers remain unavailable across most of their ranges in the country. Contrary to official records that indicated stable tiger populations, several protected areas were found to have vastly depleted tiger populations. This provided a sobering reminder not only of the fragility of tiger populations but also of the need for a critical reassessment of the Indian tiger conservation strategy. This particular data carries importance as some of the present Tiger Reserves in India were demarcated over 30 years ago and do not necessarily contain, or have the potential to contain, viable tiger populations today. The science of making replicable estimates of density using camera traps within a capture recapture framework has been well developed for tigers by the Wildlife Conservation Society in India. Tigers are faced with a myriad of threats. Habitat is being converted for both agricultural and commercial needs and rural people hunt tiger prey including deer, pigs, and wild cattle for subsistence or for profit, making food scarce. Without sufficient prey, tigers are unable to survive or breed. Tigers themselves are also targets for poachers seeking to supply the increasing demand for the illegal wildlife trade. Other threats include retaliation

killing due to human-wildlife conflict that results from depredation of livestock, and killing out of fear about their proximity to human settlements. There is particular concern that the clearance of forest for railway track and roadways is having a dramatic impact on tigers and elephant migration in the sanctuary. However, other mitigation strategies may provide important conservation opportunities, as there are conservation issues about crop damages done by nilgai in the southern part of the sanctuary bordering to state government agricultural farms. Tiger also migrated and hide in the farm in sugarcane fields also create another negative ethos to the local farmers and driving away the animals for sugar cane harvesting also creates problems for tiger conservation efforts. There should be discouraging of other money fetching schemes like growth of *Jatropha* as bio fuel plantation in private farms close to sanctuary area.

### **Data availability statement**

Analysis was based on the camera trap data from the deployed cameras and habitat occupancy data from field surveys carried out in the region. The said data have been uploaded in the National tiger individual data base at WII, Dehradun with access to park managers in the country.

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# A comparative study of two different methods for synthesis of copper nanoparticles

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## ABSTRACT

Synthesis of copper nanoparticles was done using green chemistry and green synthesis, using plant leaf extract *Murraya koenigii*. The efficacy of two methods was compared by focussing on some of the parameters like particle size, stability and antibacterial activity. On treatment of aqueous solution of  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$  with *Murraya koenigii* leaf extract, stable copper nanoparticles were formed. UV-vis spectroscopy was used to monitor the quantitative formation of copper nanoparticles. To 1.2% of aqueous starch solution  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$  was added in the presence of ascorbic acid as the capping agent. The synthesized nanoparticles were characterized with UV-Vis Spectroscopy and DLS. By DLS analysis of copper nanoparticles particle size was of 133.4 nm for curry leaf extract and 43.42 nm for green chemistry was observed. Stability of green chemistry synthesized copper nanoparticle was more as compared to biosynthesized nanoparticle. Antibacterial tests showed that biosynthesized copper nanoparticles were more effective as compared to green chemistry synthesized nanoparticle. As a possible green alternative to physical and chemical processes, biogenesis of copper nanoparticle using plant extract may have application in various water purification systems.

**Key words:** Antibacterial activity, biogenesis, copper nanoparticles, green chemistry, plant extract  
*Murraya koenigii*

## INTRODUCTION

In the last decade nanotechnology is widely used in diverse fields like medicine, electronics, biomaterials, food, agriculture and energy production. An imperative area of research in this field is to explore the synthesis of nanoparticles with different chemical compositions, as well as biosynthesis of metal nanoparticles using plant extracts and microbes. Copper nanoparticles have been synthesized by either physical or chemical methods like mechanochemical process (Subhankari and Nayak, 2013), vacuum vapor deposition, (Liu and Bando, 2003) sonochemical reduction (Kumar et al., 2001), reduction processes like thermal, chemical and direct electrochemical (Dang et al., 2011). Nanoparticles produced by

conventional physical or chemical methods, uses many toxic chemicals as capping agent and stabilizing agent, thus restricting its use in clinical and biomedical field. The greener approach of fabrication of nanoparticles using noble and other metals is the more favored one as it is a cleaner, economical and environmental friendly process.

Biological methods for synthesis of copper nanoparticles using plant extracts are simple, inexpensive and eco-friendly. Phytochemicals present in plants like terpenoids, flavonoids, carboxylic acids, quinones, aldehydes, ketones, amides spontaneously reduce metal ions and also control the size and shape of the metal nanoparticle (Prabhu and Poulouse, 2012). Two greener approaches are used for synthesis of nanoparticles

either green chemistry or green synthesis. Green chemistry focuses on the production of nanoparticles by using certain chemicals that are environmentally friendly and can serve as both capping and reducing agent (Xiong et al., 2011). While green synthesis utilizes plant parts such as roots stems and leaves and its aqueous extracts for synthesis of nanoparticles.

Copper nanoparticles due to their unique physical and chemical properties, low cost of preparation compared to noble metals have been of great interest in nanoscience. Copper nanoparticles (Cu-NPs) have special properties, which have made them important for various applications; for example, super strong materials, antibacterial, sensors and catalysts (Javier et al., 2017). Furthermore, they can also interact and react with other nanoparticles due to the high surface area-volume ratio. Synthesis of CuO nanoparticles has been done using various plant extracts of Tea leaf (Vaseeharan et al., 2010) *Magnolia kobus* (Lee et al., 2013), *Piper longum* (Jacob et al., 2012), *Ocimum sanctum* (Kulkarni and Kulkarni 2013), *Syzygium aromaticum* (Subhankari and Nayak, 2013), *Nerium oleander* (Gopinath et al., 2014), *Carica papaya* (Sankar et al., 2014), *Psidium guajava* (Caroling et al., 2015), *Butea monosperma* (Chaturvedi and Verma, 2015), *Calotropis gigantean* (Behera and Giri, 2016), *Murraya koenigii* (Ashtaputrey et al., 2017). Curry leaves has recently been found to be a potent antioxidant due to high concentrations of carbazoles, a water soluble heterocyclic compound (Rai et al., 2008) which is responsible for the reduction and stabilization of metal ions. Green Synthesis of copper nanoparticle was done using curry leaf extracts.

In contrast to plant extracts copper nanoparticles synthesized by green chemistry uses many surfactants as dispersants, capping and reducing agent like ascorbic acid that prevents oxidation and precipitation of copper nanoparticles in colloidal solution. The current study was undertaken to analyze and compare some physical properties like size, stability and antibacterial activity of Copper Nanoparticles

synthesized through green chemistry and green synthesis.

## MATERIALS AND METHODS

### Synthesis of copper nanoparticles using plant extract

For green synthesis of Copper nanoparticles *Murraya koenigii* (curry leaves) were taken. The leaves were collected and shade dried for 2 days. Then 50 g of leaves were crushed in Mixer and boiled in 500 ml of sterile distill water for 15 minutes. A pale brown colour extract was obtained which was allowed to cool at room temperature and then filtered through Whatman filter paper. To 1mM aqueous  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$  solution of 10 ml, 5 ml of aqueous leaf extract was added at room temperature. A gradual change in colour from pale yellow to amber colour was seen after 20 hrs (Fig.1a and b).



Fig. 1(a)



Fig. 1(b)

Fig. 1(a). *Murraya koenigii* (curry leaves) plant extract

Fig. 1(b). Change in colour from yellow to amber colour after addition of plant extract to copper sulphate solution indicating the synthesis of copper nanoparticles

### Synthesis of copper nanoparticles by Green chemistry

Copper nanoparticles were synthesized by dissolving 0.1 M copper (II) sulfate pentahydrate solution into 120 mL of starch (1.2 %) solution with vigorous stirring for 30 min. It was followed by

addition of 50 mL of 0.1 M ascorbic acid solution to synthesis solution under continuous rapid stirring. The pH of the experiment was maintained at 6.5 by adding aqueous NaOH. The mixture was mixed in

a small magnetic stirrer at a constant temperature of 85°C. A gradual change in colour was obtained from white to blue then dark green, orange and dark brown (Fig. 2a,b,c,d and e).



**Fig. 2(a).** Starch solution (1.2%)



**Fig. 2(b).** Addition of copper sulphate pentahydrate to Starch solution



**Fig. 2(c).** Starch copper sulphate and (0.1M) ascorbic acid



**Fig. 2(d).** Addition of sodium hydroxide and continuous stirring at 80°C



**Fig. 2(e).** Colour changes from yellow to ocher indicating the synthesis of copper nanoparticles after 24 hrs

### Characterization techniques

The synthesized copper nanoparticles were characterized by UV-Vis Spectroscopy and DLS. By using phase analysis light scattering technique zeta potential was measured using a Malvern Nano ZS instrument. Copper nanoparticles synthesized, were measured in aqueous state.

### Stability of nanoparticles

Stability of the colloidal solution of copper nanoparticles were checked after 24 hrs of incubation, and then regularly for 15 days.

### Test microorganisms

To 1 ml of local municipality supply water,

9 ml of sterile distilled water was added. Then serial dilution was done and 100 µl from each dilution was plated on Nutrient Agar to get the microbial count. Different colored, shaped colonies, large mucilaginous colonies were picked from Nutrient Agar (NA) plates and Gram Staining was done for initial screening. Black centered colonies with greenish metallic sheen were seen on Eosin Methylene Blue (EMB) plates.

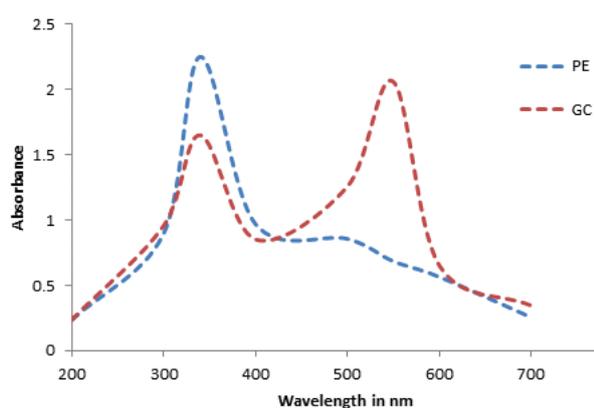
### Antibacterial assay

Nutrient Agar and Eosin Methylene Blue petriplates were prepared as per the manufacturer instructions. Using cork-borer 6mm diameter wells were made on NA and EMB plates. On each NA plate,  $6.8 \times 10^3$  colonies were inoculated and

in each well 50  $\mu$ l of copper nanoparticle using green chemistry and green synthesis were added. The plates were incubated at 37°C for 18hrs. After incubation distinct lawn of microorganisms were seen on NA plates and a clear zone was seen around the wells. On EMB plates 50  $\mu$ l municipality water was spread and in wells 50  $\mu$ l of copper nanoparticle was added. After overnight incubation the EMB plates were filled with *E. coli* colonies and distinct zones were seen around the wells. The diameter of the zones was measured to study the inhibitory effect of copper nanoparticles on microorganisms.

## RESULTS AND DISCUSSION

Recently developed methods for nanoparticles include laser ablation, chemical reduction, polyol synthesis, thermal decomposition and biosynthesis of copper nanoparticles. Among these processes, green chemistry and green synthesis of copper nanoparticles are preferred for their low toxicity and ecofriendliness. In the current study copper nanoparticles particle was synthesized in two different methods; and the effectiveness of CuNPs was compared by investigating various parameters like size and stability. Secondly the antibacterial effect of copper nanoparticles against microbes and Gram negative bacteria was also studied.



**Fig. 3.** The UV Visible absorption spectra of copper nanoparticles in plant extract (PE) and UV Visible absorption spectra of copper nanoparticles stabilized in 0.1M ascorbic acid (GC)

## Characterization of CuNPs

### UV-Vis Spectra

UV- Visible absorbance spectroscopy is the most simple and effective method for studying metal nanoparticles as the peak position and shape depends upon particle size. UV-Visible spectroscopy from a double beam spectrophotometer (U.V. 3000+ LABINDIA, path length 1.0 cm spectral range from 200 nm to 800 nm) was used to study the synthesis of copper nanoparticles.

Curry leaf extract of 5 ml was added to 1mM  $\text{CuSO}_4$  and a gradual change in colour was seen from yellow to amber colour after 48 hrs. Similar results were obtained by Sankar (2014) working on *C. papaya* leaf extract containing 5mM  $\text{CuSO}_4$ , were colour change begins after 24 hrs of incubation and becomes dark brown after 48hrs of incubation. Copper nanoparticles synthesized by green chemistry initially were orange in colour and gradually the colour changed to dark brown after 24 hr of incubation.

The absorption spectrum pattern of CuNP synthesized using green chemistry was different from the CuNP synthesized using curry leaves. While a single, sharp and prominent peak at 340 nm was observed for CuNP synthesized using curry leaves extract, two prominent peaks were seen for CuNP synthesized using green chemistry. Fig. 3 shows the UV-Vis spectrum of CuNP in aqueous medium of curry leaf extract. The absorption peak corresponds to copper nanoparticle synthesis, and its stability (Gopinath, 2014), which has evolved during the reaction time and the change in colour validates it. Two absorption peaks one at 335 nm corresponding to oxidation product of L-ascorbic acid (Xiong et al., 2011) and a broader peak at 560 nm which confirms the formation of CuNPs (Fig. 3). High absorbance is an indication of faster conversion of copper to copper nanoparticles thus leading to higher concentration of copper nanoparticle in the reaction mixture.

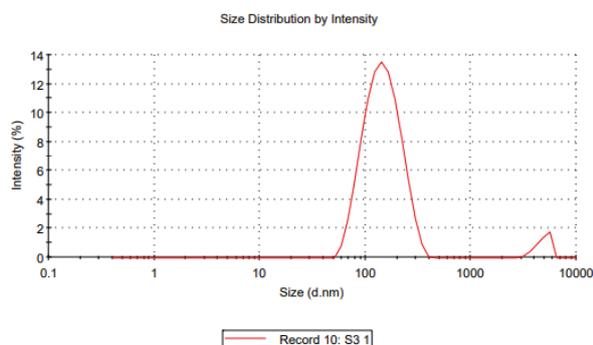
### DLS

Dynamic light scattering (DLS) analysis was used to find out the size and surface charge of

nanoparticles. CuNP synthesized using plant extract (curry leaves) had particle size of 133.4nm (Fig. 4) while CuNP synthesized using green chemistry 43.42 nm (Fig. 5). Dang (2011) used ethylene glycol to synthesize colloidal copper nanoparticles by a chemical reduction method in water. In both media, the particles were rather spherical, and it has been found that the average diameters of the copper nanoparticles were 22 nm and 10 nm in water and EG, respectively, for the most stable solutions. Hoda (2012) reported synthesis of copper nanoparticles (Cu-NPs) in chitosan (Cts) media via a chemical reaction method using ascorbic acid as an antioxidant with particle sizes in the range of 35–75 nm. Behera and Giri (2015) synthesized cuprous oxide ( $\text{Cu}_2\text{O}$ ) nanoparticles (NPs) with an average crystallite size of 8.8 nm in presence of Arka (*Calotropis gigantea*) leaves extract. *Syzygium aromaticum* (Clove) extracts produced Cu nanoparticles with a average particle size of 40 nm and a spherical to granular morphology (Subhankari and Nayak, 2013). Padil (2013) using *Sterculia urens* (Karaya gum) extract was able to synthesize highly stable spherical Copper Oxide nanoparticles with a mean particle size of 4.8 nm.

### Stability of copper nanoparticles

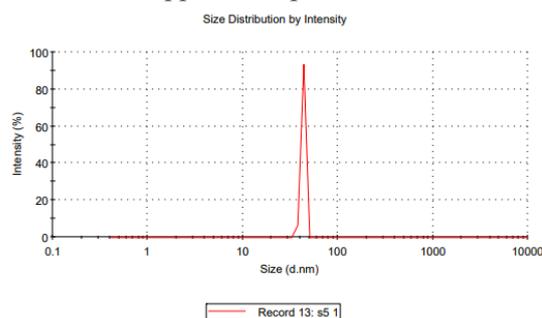
Small metal nanoparticles absorb visible electromagnetic waves by oscillation of conduction electrons at the surface (Dang et al., 2011). This is known as Surface Plasmon effect. Stability of the CuNP was measured by observing the absorption peak at the time of complete colour change and



**Fig. 4.** Average diameter of CuNPs using (PE) is found to be 133.4 nm

then at regular intervals for fifteen days. There was gradual decrease in peak intensity after ten days for copper nanoparticles synthesized using curry leaf extract (Fig. 6). A shift in peak position was also seen for colloidal copper nanoparticles in aqueous medium, with ascorbic acid as capping agent (Fig. 7). The oxidation and precipitation was seen after ten days in case of CuNP synthesized using curry leaf extract while colloidal CuNP synthesized using green chemistry were stable for fifteen days.

Copper nanoparticles synthesized in ambient atmosphere without inert gas intervention have tendency to oxidize to copper oxides as the later are thermodynamically more stable. In the absence of protection, copper nanoparticles tend to aggregate very fast. So in green chemistry method for synthesis of copper nanoparticles, ascorbic acid

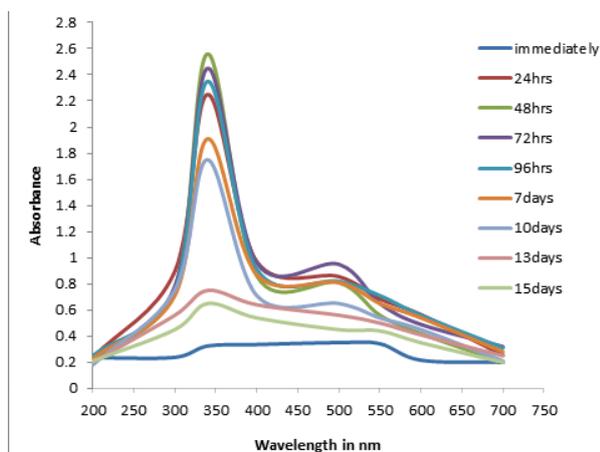


**Fig. 5.** Average diameter of CuNPs (GC) is found to be 43.42 nm

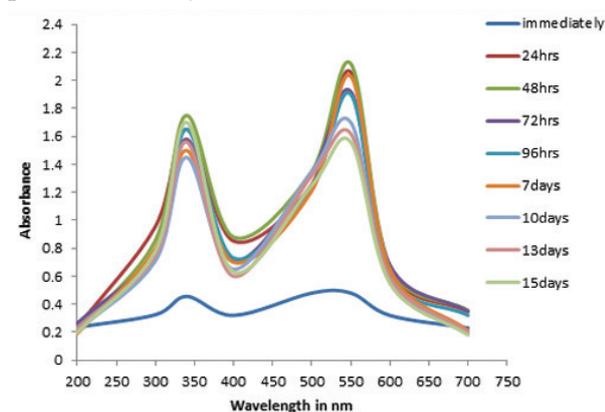
is used as a reducing and capping agent to avoid contamination by other organic compounds. It has been reported earlier that ascorbic acid reduces aggregation of nanoparticles to great extent (Khan et al., 2016). The bioactivity of curry leaves is attributed to the presence of phytochemicals like phenolic acids, essential oils terpenoids, alkaloids, tocopherol,  $\beta$ -carotene, lutein (Patterson and Verghese, 2015). Though it has been reported that high concentration of carbazole in curry leaves is responsible for reduction and stabilization of metal ions (Sajeshkumar et al., 2015) however the exact mechanism for reduction of copper ions in aqueous solutions is yet to be identified.

### Antibacterial activity

Antibacterial activity was tested against *E. coli* and Gram positive bacteria. After overnight



**Fig. 6.** UV visible absorption spectra of copper nanoparticle synthesized using plant extract for a period of 15 days.



**Fig. 7.** UV visible absorption spectra of copper nanoparticle synthesized using green chemistry for a period of 15 days.

incubation distinct zones were seen around the wells containing 50  $\mu$ l of copper nanoparticle. The NA plate containing  $6 \times 10^3$  colonies of bacteria showed a clear zone of 5 mm for CuNP synthesized using Green Chemistry and a bigger zone of 9 mm for CuNP synthesized using plant extract (Fig. 5). In the EMB *E. coli* plate the clear zone size for CuNP synthesized using Green Chemistry was 5.4 mm and 11.2 mm for CuNP synthesized using plant extract.

The biologically synthesized CuNP using plant extract showed higher antibacterial activity compared to CuNP synthesized using ascorbic acid and starch. Similar results were also found by (Lee et al., 2016) working on synthesis of  $\text{CuSO}_4$  using

Magnolia leaf extract and chemically synthesized copper nanoparticles using sodium borohydride and Tween 20. The bactericidal effect of metal nanoparticles is due to their small size and high surface to volume ratio that helps them to interact with the microbial membranes and not due to the release of metal ions into the solution. They have found CuNPs to be effective in controlling growth of *Escherichia coli* cells, a common pathogen. CuNPs synthesized using karaya gum extract showed antimicrobial activity against universal pathogens such as *Escherichia coli* and *Staphylococcus aureus* (Padil et al., 2013)

## CONCLUSION

In this study, CuNPs were successfully synthesized by green chemistry and green synthesis methods. Curry leaves extract was utilized as a natural reducing and capping agent in synthesizing CuNPs. Ascorbic acid was the stabilizing agent for green chemistry. Though the stability of CuNPs synthesized using curry leaf extract was less compared to green synthesized CuNP but antibacterial activity was more pronounced for biosynthesized CuNPs. The identification of CuNPs was done by characterization techniques such as DLS and UV-VIS spectroscopy. CuNP synthesized using green chemistry had particle size of 43.42 nm while CuNP synthesized using plant extract (curry leaves) 133.4 nm. The particle size was larger for biosynthesized CuNP which could be reduced to smaller size by adjusting the concentration of plant extract. Thus in the current study an economical and faster method of biogenesis of copper nanoparticles has been proposed and its effectiveness in controlling growth of bacteria and *E. coli* in water purification systems.

## ACKNOWLEDGEMENT

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# Evaluation of impacts of cyclones on the livelihood status of the people of coastal Odisha and its remedial measures

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## ABSTRACT

The present paper evaluates the impact of cyclones on the livelihood of people in Coastal Odisha (period). Fourteen years after the super cyclone 1999, the severe cyclonic storm Phailin hits the coasts of Odisha on October 12, 2013. The very next year 2014, Odisha was under the threat of another very severe cyclonic storm (VSCS) Hudhud. While the tropical cyclone Daye made the landfall near Gopalpur on September 20, 2018 VSCS Titli made its landfall in Andhra Pradesh coast, adjacent to Gopalpur further south, resulting in severe damage to crops. The storm especially devastated farmers who were preparing to harvest paddy and other crops. Summer crops, orchards, plantations were devastated in a large scale. Although the number of casualties in the recent cyclones had been quite less as compared to the super cyclone 1999, there had been severe economic and ecological losses. Keeping view of the above, the study was conducted in the coastal districts of Puri and Ganjam which are vulnerable to frequent cyclones and its associated disasters. The study findings over agriculture, animal husbandry and fishery sector demonstrated that the cyclones and its related weather vagaries have affected the people, their livelihood and economy in the study area significantly.

**Key words:** Agriculture, cyclone, economic loss, fisheries, livelihood, vulnerable

## INTRODUCTION

Tropical cyclones are known to have significant global impacts on human health, livelihood and economic activity. In many tropical countries, smallholder farmers are highly vulnerable to cyclones and experience significant crop losses, food insecurity affecting income from agriculture and allied sector significantly. Smallholder farmers are vulnerable to climate shocks due to their dependence on rain fed agriculture, limited areas of arable land, high poverty levels, food insecurity, lack of access to information and limited resources to prepare for and to cope with the impacts of cyclone (Mutabazi et al., 2015). Smallholder farms and climate change in Bangladesh with policy options have been studied and recommended by (Rahman et al., 2014). Odisha, the largest livelihood occupation

in agriculture in the coastal zone is frequently affected by climate extremes such as cyclones and floods. (Bahinipati et al., 2015) studied the current adaptation strategies of the farm households and the inputs from the analysis can potentially help the future policies. Odisha is one of the most important states in eastern India which is endowed with plenty of natural resources. However its crop productivity has been found to be quite poor due to water logging and cyclone and/flood problem. Crop damages due to tropical cyclones include many factors, such as salt injury due to blowing tides inland, insufficient oxygen caused by overhead flooding, flash floods wind injury to plant organs and water stress induced by enforced respiration, all of which occur at the same time (Ilizumi et al., 2008; Masutomi et al., 2012). Different farm level

adaptation practices to climate extremes have been recommended by (Bahinipati et al., 2015). Fishing is a high-risk livelihood activity due to the fugitive nature of the resource, the hostile environment of the seas and perishability of the product” (Anon. 2011). The direct impact of climatic shocks can be cyclones, floods, loss of life etc. Cyclones and floods damage boats, nets, fishing gear, and fish landing centres as well as affect education, health, housing and other community infrastructure (Jallow et al., 1999; Westlund et al., 2007). Odisha’s geographic location on the east coast of India and its climatic condition have meant that the state has historically been highly prone to climate change and multiple hazards, such as cyclones, droughts and floods (Bhatta, 1997).

## MATERIALS AND METHODS

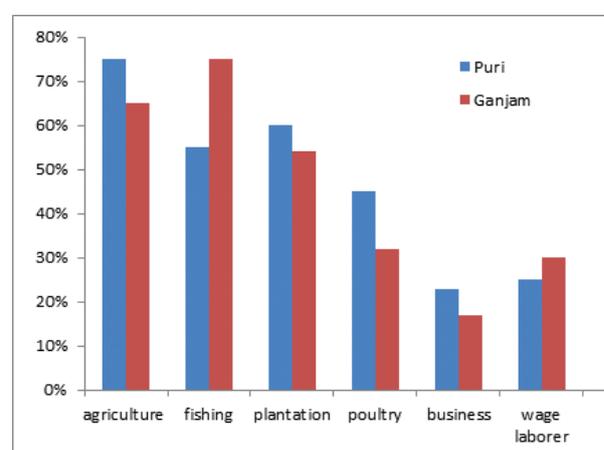
The study was conducted in four villages from district Puri (Udayakani and Bamanal) and Ganjam (Podompeta and Sananalia nuagaon). The area experienced the devastating impact of super cyclone 1999, Phalin 2013 and Titli 2018. The agriculture, animal husbandry and fishing sector in the area faces severe challenges due to natural disasters causing heavy crop loss, poor crop productivity and less fish catch. Several times, these disasters create more havoc as they result in another associated unfavorable event. For example a cyclone disaster is always accompanied with storms, floods and heavy wind and thus cumulates the disaster effect. The study here is concerned with cyclone related risks and hazards that affects the inhabitant’s livelihood of the study area.

Cyclone and livelihood related information were collected from the head of the selected households and local leaders through data sheet, FAQs (Frequent Asked Questions), questionnaires and informal dialogues. For the above study, 660 and 669 respondents were taken up from 240 different households of Puri and Ganjam districts respectively. One focus group discussion (FGD) was also conducted in each study village. Informal discussions and FGDs were carried out to gain additional insights regarding post-cyclone livelihood strategies at household level. Secondary

information was conducted by collecting data from government offices and non-government organizations such as State Disaster Mitigation Authority (OSDMA), Government of Odisha, Bhubaneswar, Nabakrishna Choudhury Centre for Development Studies, Bhubaneswar, Block Disaster Management Plan: Balikuda Block, Jagatsighpur District, Revenue Department etc. which could give an insight into the background, challenges and perspectives over all these cyclones and other natural calamities occurred in yesteryears (Anon, 2002a,b,c,d).

## RESULTS AND DISCUSSION

The livelihoods in the study area were clustered into two groups such as natural resource based (agriculture, fishing, aquaculture, coconut and cashew plantation) and human resource based (boat building, net making, labour). In the present study based on field survey, observation and focus group discussions and analysis of data sheets, major livelihood groups were identified as farmers, fishermen and others (labourers, poultry owners , businessmen) illustrated in Fig. 1.



**Fig. 1.** Major livelihood groups in the study area

The data were collected through the interviews of different livelihood groups to analyze the losses incurred in agriculture and allied sector. The data collected were classified, tabulated and analysed. Based on the enquired data from the respondents, different areas of livelihood affection were categorized and interpreted (Table 1).

**Table 1.** Effect of cyclone on livelihood

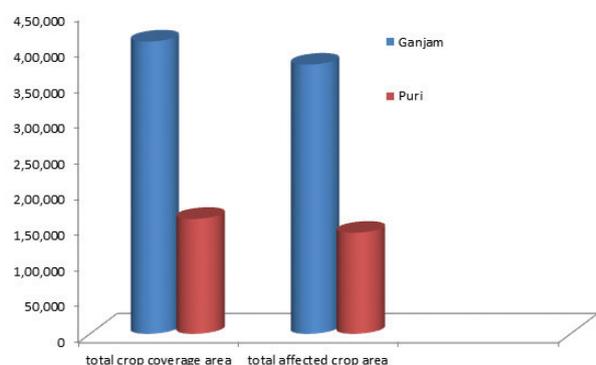
Effect on livelihood	Study villages			
	Puri		Ganjam	
	Number of people interviewed	%	Number of people interviewed	%
Cause frequent flood	43	6.51	44	6.57
Prolonged dry spell	31	4.69	22	3.28
Damage of crops due to water logging	42	6.36	50	7.47
Pest attack	33	5	23	3.43
High incidence of crop failure	64	9.69	40	5.97
Prolonged and repeated illness	33	5	11	1.64
Boat damage	42	6.36	62	9.26
No communication for transportation	33	5	61	9.11
Poor fish catch	45	6.81	73	10.9
Non-availability of fish in shore lines	33	5	81	12.1
Over flowing of ponds and loss of pisci-culture	34	5.15	54	8.07
Shortage of marine fishing due to weather condition	55	8.33	76	11.3
Loss of poultry	31	4.69	13	1.94
Loss of coconut trees	61	9.24	32	4.78
Loss of agricultural crops due to lodging	62	9.39	22	3.28
Loss of livestock	19	2.87	6	0.89
N (Number of People interviewed)	660	100%	669	100%

**Source:** Household Survey (2019)

### Effects of cyclone on Agriculture

The agricultural sector includes field crops, horticultural crops, agro-forestry plants, livestock and fisheries. Cyclones in coastal areas severely affect all these components of agriculture sector through direct damage by high speed wind, torrential rain and extensive flooding. High tide brings in saline water and sand mass making the fields unsuitable for agriculture. The indirect effects include infection and disease of farm animals, fish

and crop plants. Agricultural marketing and trade is adversely affected during and post cyclone. Cyclones in Puri district affected lakhs of coconut trees an important source of secondary income (Fig. 3). Although some farmers are going for replantation programmes initiated by government of Odisha, but new coconut trees will require 5 to 7 years to fully grow and bear fruit. In the process, the agricultural and horticultural land areas have been severely affected (Fig. 2 and Table 2).



**Fig. 2.** Agriculture land (ha) affected due to cyclone (Source: Department of Agriculture, Government of Odisha)

**Table 2.** Horticulture crop area (ha) damaged

Districts	Type of crop	Area affected (ha)	Remarks
Ganjam	perennial fruits	8157	coconut
	vegetables	24,489	
	Kewda	734	
	Floriculture	245	
	Betel Vine	528	
Puri	perennial	1340	coconut, palm
	non-perennial	840	banana, papaya
	vegetables	2990	

Source : Department of Agriculture, Government of Odisha



**Fig. 3.** Coconut plantation affected due to cyclone

### Cyclonic impact on Livestock Resources

As per Odisha rapid damage and need assessment report, the cyclone has caused a significant impact on the livestock in Odisha impacting the food security of the affected households (Anon, 2013). The total number of livestock that are affected in the thirteen districts due to the cyclone and floods are reported as 7.02 million which is about 16.7% of the total livestock population of the state. The reported number of livestock deaths in the three most severely affected districts i.e. Puri, Ganjam and Khordha includes 1,425 large animals (cow/buffalo), 2,906 small animals (goats/sheeps) and about 156,000 poultry.

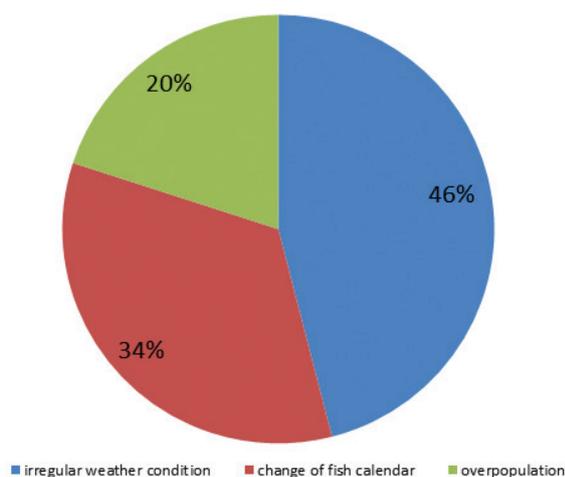
### Effect of cyclone on Fisheries Resources

Fishery based livelihood in the above households have high exposure to climate related shocks and stresses, especially floods and cyclones, because the communities are located in the coastline and livelihoods are dependent upon marine fishing from small vessels. Due to frequent cyclones, storms the fishermen have to abandon their fishing trips and have to return back to the coast. The incomplete trips caused a huge loss to the fishermen (Fig. 4). As per the Odisha rapid damage and need assessment report, the fisheries activities (inland, lagoon and marine) in Ganjam, Puri and Khordha districts have been severely affected (Anon, 2013). As of November 29, 2013, an estimated total of 8,423 boats (including catamarans), 33,398 nets



**Fig. 4.** Fishery affected due to cyclones

and 5,742 ha of inland fish tanks have been fully or partially damaged in the three districts. Due to the disaster, the tanks and the inland fish farms were contaminated and the fish escaped as the water table increased. Hence, there have been severe decline in fish production (Fig. 5). Tropical cyclones and tidal surges damaged house, boat, fish landing jetty, road and other physical assets that make the fishing community workless. Lack of other source of income made them bound for fishing even in rough weather.



**Fig. 5.** Reasons for decline in fish production (Household survey, 2019)

## CONCLUSION

The study finds that agriculture, animal husbandry and fishery sectors, the main sources of livelihood in coastal Odisha were worst affected due to frequent cyclones. Although the number of causality has decreased after the super cyclone of 1999 due to good disaster management practices by the government, more focus need to be given on protection of livelihood source of poor farmers and fishermen.

## Suggestive measures

- The adaptation practices as well as the coastal ecosystem specific opportunities like provision of wind-brake plantation should be adopted.

- Massive plantation in coastal zone helps in reducing the wind speed and simultaneously provides fuel, wood and timber.
- However, in case of post cyclonic phase, advanced crop management interventions and moisture conservation techniques should form the main component and that should be adopted by the farmers on large scale to sustain the cultivated land.
- Creeper vegetables like water melon, pumpkin, ridge gourd, cucumber, and bitter gourd can be planted to provide immediate economic support.
- More investment should be directed into the agriculture, animal husbandry and fishing sector. Options for microcredit loans should be explored to increase the output in agriculture and allied sector, particularly in a cyclone disaster recovery stage when livelihood are likely to be damaged by salt water intrusion and heavy winds.
- Selection of rice varieties, to escape maturity during this peak period of cyclonic disturbances is one option. Rice varieties like Durga and Varsha Dhan maturing after mid December may be adopted in suitable ecosystem.
- Plants such as lemongrass and citronella can be popularized among farmers living in saline areas as these crops are strong and can provide aroma oils.
- Promotion of natural calamity insurance can be one of the best initiatives to enhance cyclone resilient agri and allied communities.
- Alternative livelihood options like fish pickling, making of hand fan with coconut leaf, appropriate training on new innovative fish farming should be provided.
- Moreover, small and cottage industries including design and embroidery clothes, preparing mat, making of bamboo made fishing traps can be other innovative options of livelihood.

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## BRIEF INSTRUCTIONS TO AUTHORS

*e-planet* publishes peer reviewed original research articles and review articles in English on multifarious aspects of ecology, environment, agriculture and allied sciences etc. in the form of full-length papers having a bent towards environmental issues.

- 1. Submission of manuscript.** The manuscript developed in WORD, along with tables and figures in EXCEL and photographs in high resolution .jpg or .png should be sent to the Editor-in-Chief, *e-planet* (OPES) by e-mail – eplanetjournal@gmail.com including Article Certificate (Give details of telephone/ e-mail id of all authors).
- 2. Preparation of manuscript.** Papers should be written in simple and clear language, strictly following the latest *e-planet* journal style. Avoid footnotes in the text. The complete scientific name (genus, species and authority for the binomial) of all the experimental organisms should be given at the first mention both in the Abstract and Materials and Methods. International System of Units in abbreviated form should be used for all the measurements. Spell out the acronyms in the first instance. Manuscript should be typed in double-spacing on one side of Bond Paper (A-4). Tables must not exceed 12 vertical columns. Leave liberal margins on both the sides. Arrange the manuscript in the order of short title, title, author(s), address of each author/ institution of each author, abstract (approx. 300 words), key words (approx.- 5), introduction, materials and methods, results and discussion, acknowledgement and references.
  - 2.1. Short Title/ Title.** A short title of the paper should appear on the top of the article, followed by the long title in small letters. The short title appears on alternate printed pages of each article in capital letters.
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  - 2.3. Abstract.** Maximum 200-300 words convening the objectives, methodology and the most important results.
  - 2.4. Key words.** Maximum of 5-6 key words should be provided for subject indexing.
  - 2.5. Introduction.** It should be concise and include the scope of the work in relation to the state of art in the same field along with specific objectives.
  - 2.6. Materials and Methods.** A full technical description of the methods followed for the experiment(s) should be given, providing enough information. Detailed methodology should be given when the methods are new while for standard methods, only references may be cited.
  - 2.7. Results and Discussion.** In this section, only significant results of the experiment(s) should be reported. Along with the tables and figures, the discussion should deal with interpretation of results and relate the author's findings with the past work on the same subject. The conclusions drawn should be explicitly listed at the end of this section.
- 3. References.** Please refer “Misra, R.C., Pani, D.R., Kumar, P. and Das, P. 2018. Vegetation mapping and management strategy of mangroves of Bhitarkanika wildlife sanctuary, Odisha: A remote sensing approach. *e-planet* 16(2): 89-101. Distinction for the same author and same year be done as 2017a, 2017b etc. Unpublished data, thesis and personal communication are not acceptable as references.
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- 6. Reviews.** Full length review articles are also invited.

