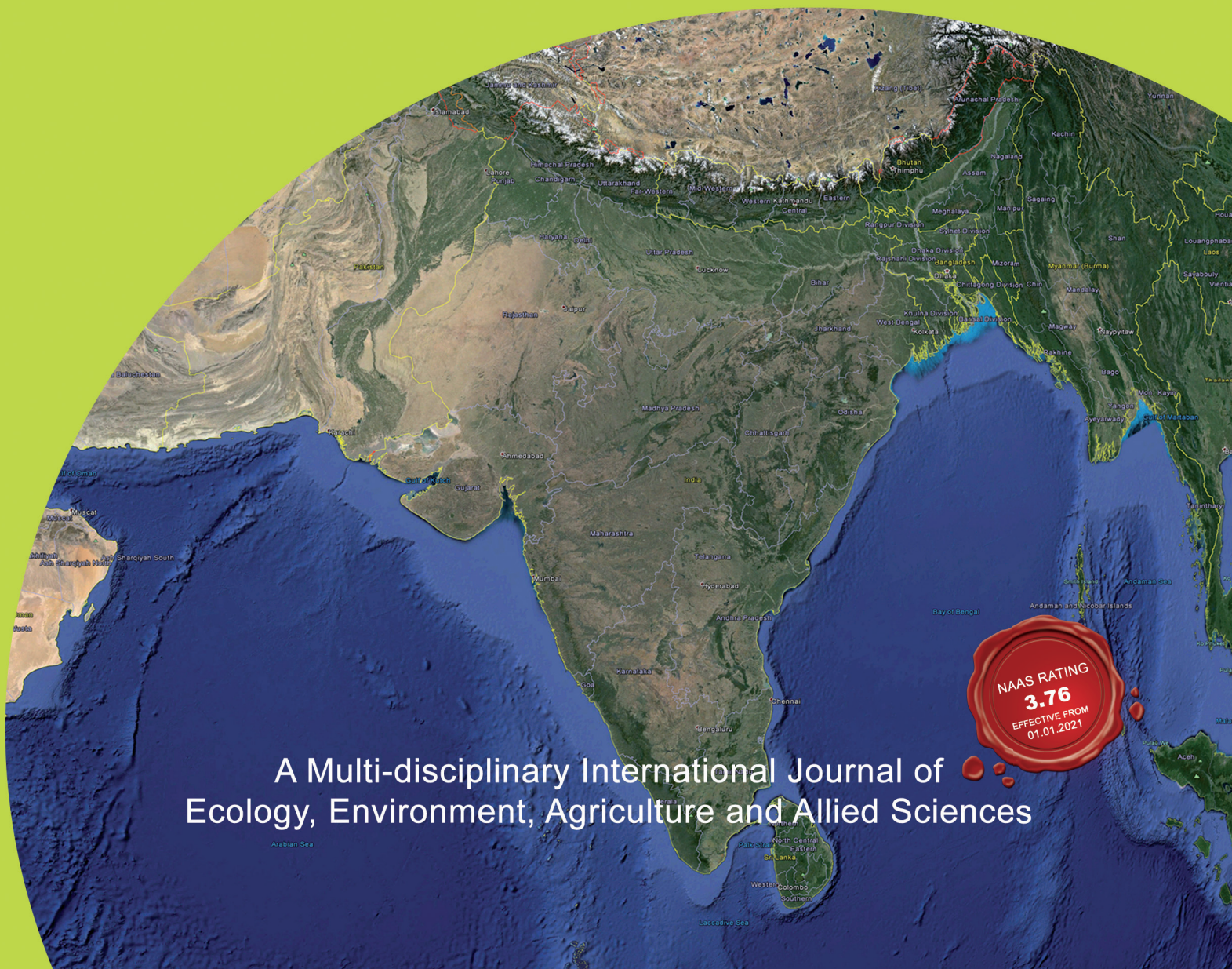
RNI No. ORI ENG / 2003 / 15643 / 22.11.2005

ISSN No. 0974 - 4398 / 2008

ORGANISATION FOR PROTECTION OF ECOSYSTEM ENVIRONMENT AND ENDANGERED SPECIES

e-planet

Volume- 20 JUNE-2022 Issue No. - 1



A Multi-disciplinary International Journal of
Ecology, Environment, Agriculture and Allied Sciences

Editorial Board

Printed, published & edited by Dr. R.K. Samantarai, 1(A), Nandankanan Zoo, P.O. Barang, Dist- Khurda, Odisha, India, Pin - 754005. Owned by the Organisation for Protection of Ecosystem, Environment and Endangered Species (OPES), Plot No. - A-47, Rameswarpatna, Maushima Square, Old Town, Bhubaneswar-751002, Odisha, India. Published and printed at Print-Tech Offset Pvt. Ltd., Bhubaneswar - 751024

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

SUBSCRIPTION

Life Member (Individual) 15 yrs	– Rs. 5000/-
Life Member (Overseas)15 yrs	– USD 100/-
Life Member (Institutional) 15 yrs	– Rs. 30000/-
Patron (Individual) 15 yrs	– Rs. 20000/-
Patron (Institutional) 15 yrs	– Rs. 50000/-

* Please send payment to : **OPES, Bhubaneswar** in shape of D.D. payable at Bhubaneswar

ADDRESS FOR CORRESPONDENCE
Dr. R.K. Samantarai
Editor-in-Chief
A - 47, Rameswarpatna, Maushima Square
Bhubaneswar - 751 002, Odisha
e-mail - eplanetjournal@gmail.com
Mob. : +91 7008370017 / 9437090017

Please visit us at : *www.e-planet.co.in*

e-planet

Volume - 20 JUNE-2022 Issue No. - 1

A Multi-disciplinary International Journal

of

Ecology, Environment, Agriculture and Allied Sciences

CONTENTS

e-planet **20** (1): 1-7 (June 2022)

Mutagenic effects of gamma-rays and EMS on chromosomes and pollen sterility in greengram

T.R. DAS[1*] AND B. BAISAKH[2]

[1]*ICAR-IARI Regional Station, Pusa, Samastipur-848125, Bihar, India*

[2]*Department of Plant Breeding and Genetics, OUAT, Bhubaneswar-751 003,Odisha, India*

[*]*trdas.iari@gmail.com*

Date of receipt: 25.03.2022 Date of acceptance: 29.05.2022

ABSTRACT

To determine the potency of different doses of physical and chemical mutagens and deduce an optimum dose, cytological analysis for induced chromosomal variation is considered an accurate index in mutation breeding. Therefore, the present investigation was carried out to estimate the relative frequency and spectrum of meiotic chromosomal abnormalities at various stages of cell division using gamma-rays, Ethyl methanesulfonate (EMS), and their combination treatments in the M_1 generation of greengram (*Vigna radiata* L. Wilczek) varieties Sujata and OBGG-52. The analysis revealed a wide range of induced meiotic chromosomal abnormalities like univalents, multivalents, chromosome stickiness, laggards, bridges, and micronuclei by different mutagen doses. In general, the meiotic chromosomal abnormalities increased along with the increase in concentration in mutagens in both varieties. However, the induction of meiotic aberrations was observed to be higher in gamma rays treatments, suggesting that gamma rays could be more effective in inducing additional variability than EMS, in greengram. It was observed that the combined treatments induced meiotic abnormalities at a higher frequency as compared to individual treatments of gamma rays and EMS. Comparative estimation of induced chromosomal abnormalities suggested higher mutagenic sensitivity of var. Sujata than the var. OBGG-52 towards the single mutagenic treatments used whereas in combined treatment of moderate doses OBGG-52 expressed higher mutagenic sensitivity than Sujata. The pollen sterility observed in mutagenic treatments may be due to the induced mutation in chromosomes. A positive and significant correlation between induced chromosomal abnormality and pollen sterility was observed in both varieties.

Key words: Chromosomes, EMS, gamma-rays, greengram, induced mutation, pollen sterility

INTRODUCTION

Greengram [*Vigna radiata* (L.) Wilczek] known as mungbean, is an important short-duration grain legume having wider adaptability and low input requirements. It is widely grown in the sub-tropical countries of the South and South-east Asia, Australia, West Indies, South and North America, and Tropical and Subtropical Africa. The conventional approaches of plant breeding have exploited the available genetic variability which has in turn led to a narrow genetic base in this crop. Induced mutations provide a powerful means of creating new and useful variability in crop plants both in qualitative and quantitative traits (Das and Misra, 2005). Physical and chemical mutagens induce genes to mutate at rates above spontaneous baselines, thus producing a range of novel traits and broadening of genetic diversity of plants (Das and Baisakh, 2013). Physical or chemical mutagen-induced quantitative variation not only serves as an alternative source of germplasms for natural variation but is also useful in generating appropriately linked gene complexes that are responsible for the improvement in yield and

other characteristics of economic interest (Das and Prusti, 2020).

Gamma rays, one of the most commonly used physical mutagen in mutation breeding are known to influence plant growth and development by inducing cytological, genetic, biochemical, physiological, and morphological changes in cells and tissues (Das and Prusti, 2020). Gamma rays are the highly energetic ionizing radiations with a higher penetration power and thus can induce various changes at the chromosomal and molecular level and proved to be an effective physical mutagen in creating variation and effective mutation. Chemical mutagens also play important role in inducing chromosomal aberrations and mutations that are useful for crop improvement. Among the chemical mutagens used for induction of mutations in various crops, Ethyl methanesulfonate (EMS) an alkylating carcinogenic organic compound is one of the most effective, efficient, and frequently used mutagens that generate random mutations in genetic content through nucleotide substitution (Minocha and Arnason, 1962; Das and Baisakh, 2020). It is a popular mutagenic agent, that donates alkyl group i.e., ethyl group (CH_3-CH_2) to the guanine producing O_6-ethyl guanine which pair with thymine to eventually produce point mutations and induces mispairing and base changes due to chemical modification of nucleotides (Okagaki et al., 1991; Greene et al., 2003). Tarar and Dnyansagar (1980) and Zeerak (1991) found physical mutagens more effective than chemical mutagens while many other researchers reported chemical mutagens are more effective than physical mutagens (Dhanayanth and Reddy, 2000; Bhat et al., 2005; Baisakh et al., 2011).

Chromosomal rearrangements are one of the most frequently produced cases of mutation that result from the action of both physical and chemical mutagenic agents. Mutation of any of the genes disrupts meiosis, gametes sterility, and other abnormalities. Analysis of chromosomal behavior at various meiotic stages is one of the most dependable indices for estimation of the potency of any mutagen. Thus, the investigation of meiotic aberrations and their genetic consequences forms an integral part of most mutation studies. They also provide a considerable clue to assessing the sensitivity of plants to different mutagens (Zeerak, 1992). To induce genetic variability and utilize useful mutants in plant breeding programs, the identification of appropriate mutagen and its appropriate dose/ concentration is essential (Das and Baisakh, 2011). Hence a study was undertaken to assess the effect of different doses of gamma-rays and EMS on pollen sterility and meiotic behavior in the M_1 generation of greengram.

MATERIALS AND METHODS

Dry and well-filled seeds of two greengram varieties, namely Sujata and OBGG-52 were administered mutagenic treatments with three doses each of gamma rays (20, 40 and 60 kR), ethyl methane sulphonate (0.2, 0.4 and 0.6%), and combine mutagens of 40 kR gamma rays with 0.4% EMS and were coded as G1, G2, G3, E1, E2, E3 and GE2, respectively. Dry seeds were irradiated with gamma ray treatment at Bhaba Atomic Research Centre, Trombay. For treatment with EMS, the seeds were pre-soaked in distilled water for six hours, blotted dry and then treated with a freshly prepared aqueous solution of above chemical mutagen for 6 hours, with intermittent shaking. For combination treatment, seeds were first irradiated with 40 kR gamma rays and then treated with 0.4% EMS solution in the same manner as described above. After treatment, the seeds were thoroughly washed with running water to bleach out the residual chemicals and then dried on blotting paper after treatment. To grow the M_1 generation, the treated seeds were sown in RBD in two replications with spacing of 25 × 10 cm^2. Young flower buds from 50 randomly selected plants from each treatment were fixed in Carnoy's fluid (1 part glacial acetic acid: 3 parts chloroform: 6 parts ethyl alcohol), separately for 24 hours. Then these flower buds were transferred to vials containing 70% alcohol and preserved at 5° C. Chromosomal abnormalities were scored by Sqush Technique. Mean pollen sterility was determined based on acetocarmine stainability.

RESULTS AND DISCUSSION

In the present study, a broad spectrum of chromosomal aberrations was induced at various

stages of meiotic division in M_1 generation using gamma-rays, EMS alone as well as in combination in both varieties of greengram (Table 1 and 2). The spectrum of meiotic chromosomal abnormalities observed in various mutagenic treatments in both varieties included univalents, multivalents, chromosome stickiness, laggards, bridges, and micronuclei.

Table 1. Frequency and spectrum of chromosomal abnormalities induced by gamma rays, EMS and their combination in greengram var. Sujata

Treatments	Univalent (%)	Multivalent (%)	Stickiness (%)	Bridge (%)	Laggard (%)	Micro-nucleic (%)	Total chromosomal abnormality (%)	Pollen sterility (%)
G1	0.37	1.12	0.75	0.37	-	-	2.61	2.11
G2	1.22	0.81	1.63	1.22	1.63	0.81	7.32	4.56
G3	1.81	0.90	3.17	1.81	2.71	1.81	12.21	7.81
E1	-	0.72	1.44	0.72	-	0.36	3.24	2.46
E2	0.77	1.16	1.93	-	1.54	0.77	6.17	4.79
E3	2.04	1.63	2.86	1.22	2.04	1.63	11.42	7.43
G2E2	1.19	1.19	2.38	1.59	1.59	-	7.94	3.41
Sujata (C)	-	-	-	-	-	-	-	

Table 2. Frequency and spectrum of chromosomal abnormalities induced by gamma rays, EMS and their combination in greengram var. OBGG-52

Treatments	Univalent (%)	Multivalent (%)	Stickiness (%)	Bridge (%)	Laggard (%)	Micro-nucleic (%)	Total chromosomal abnormality (%)	Pollen sterility (%)
G1	-	0.72	0.72	1.08	-	-	2.52	2.14
G2	1.14	0.76	1.52	1.14	1.52	0.76	6.84	3.78
G3	1.15	0.77	2.69	1.54	1.92	1.15	9.22	5.47
E1	0.33	-	0.99	-	0.33	-	1.65	1.43
E2	1.07	0.71	1.07	0.71	0.36	-	3.92	1.77
E3	1.81	1.08	1.08	0.72	1.81	0.72	7.22	3.69
G2E2	1.50	1.13	2.26	0.75	1.50	0.75	7.89	4.23
OBGG-52 (C)	-	-	-	-	-	-	-	-

The univalents were found in all most all treated populations (except E1 in Sujata and G1 in OBGG-52) and their frequency was maximum at the higher dose of mutagen (Table 1 and 2). The occurrence of univalents indicates non-homology between certain chromosomes in the compliment. The mutagenic treatments induce structural changes in chromosomes and induced gene mutations might be responsible for the failure of pairing among homologous chromosomes and hence the presence of univalents. According to Kumar and Tripathi (2004) the chemical mutagens induce univalent formation through cryptic structural changes in chromosomes, which restrict the pairing and in turn reduce the chiasma frequency. The multivalent were observed in all treated populations (except E1 in OBGG-52) and followed dose dependency in EMS treatments. The moderate dose combination treatment G2E2 produced higher multivalent in comparison to single moderate dose mutagenic treatments

(G2 or E2). Multivalents can be attributed to irregular pairing and breakage followed by translocation and inversions. (Dixit and Dubey, 1986). The occurrence of multivalent association is a common feature in the treated plants with the presence of more than two homologous chromosomes.

All the mutagenic treatments in both varieties induced stickiness of chromosomes and their frequencies were increased with increasing the dose of the mutagens in both varieties (Table 1 and 2). It was also observed that the moderate dose combination treatment (G2E2) produced higher stickiness of chromosomes in comparison to single moderate dose mutagenic treatments (G2 or E2). This stickiness of chromosomes resulted due to depolymerization of DNA (Darlington, 1942; Tarar and Dnyansagar, 1980), partial dissolution of nucleoprotein (Kaufmann, 1956), and alteration in the pattern of organization of chromosomes by Evans (1962). McGill et al. (1974) and Klasterska et al. (1976) suggested that stickiness arises due to improper folding of chromosome fibers, while Rao and Laxmi (1980) attributed it to be due to the disturbances of cytochemical balanced reactions by the mutagens. In addition, Gaulden (1987) postulated that stickiness may result from defective functioning of one or two types of specific non-histone proteins involved in chromosome organization which is necessary for chromatid separation and segregation. The altered functioning of these proteins leading to stickiness is caused by mutations in the structural genes coding for them (hereditary stickiness) or by the action of mutagens (induced stickiness). It may also be possible that the mutagen itself reacts with the histone proteins and brings about a change in the surface property of chromosomes due to improper folding of DNA, thereby causing them to clump or stick. The stickiness of chromosomes at metaphase-I adversely affected the normal disjunctions of chromosomes at anaphase-I, which resulted in the formation of laggards and unequal separation of chromosomes at the anaphase stage.

In this study, the chromosomal bridges were observed in almost all the mutagenic treatments in both varieties (Except E2 in Sujata and E1 in OBGG-52) and their frequencies were increased with increasing the dose of the mutagens in both varieties of greengram. The chromosomal bridge formation may be attributed to the general stickiness of chromosomes at the metaphase stage or breakage and reunion of chromosomes. The chromosome bridge was useful for obtaining information on clastogenic activity. The Chromosomal bridges occur due to sister chromatid exchange followed by delayed or failure of their separation during later stages of anaphase and telophase chromosome. According to Saylor and Smith (1966), the bridge formation could be due to the failure of chiasmata in a bivalent to terminalize, and the chromosomes get stretched between the poles. Sinha and Godward (1972) suggested that paracentric-inversion may lead to the formation of chromatin bridges at anaphase I/II and telophase I/II. The bridges may be due to the stickiness of chromosomes. This stickiness interfered in the normal arrangement of chromosomes at metaphase and further led to their inability to separate, thus leading to sticky bridges. When the spindle fibers pulled the chromosomes towards the poles these bridges were broken into fragments, which either moved towards the poles or formed the laggards and micronuclei (Rees, 1955). The presence of single and multiple bridges may be due to the occurrence of dicentric chromosomes formed as a result of breakage fusion bridge cycles (McClintock, 1941; Kumar and Singh, 2002).

The laggards observed, in the present study, have also been reported earlier and maybe the result of delayed terminalization, the stickiness of chromosomes, or the failure of chromosomal movement due to abnormal spindle formation, and as a result spindle fibers failed to carry the respective chromosomes to the polar region and resultantly lagging chromosome appeared (Tarar and Dnyansagar, 1980; Jayabalan and Rao, 1987). The formation of laggards may also be due to chromosomal breakage by binding to DNA in GC-rich regions (Bhat et al., 2007). In the present study, Lower doses are rarely induced laggards and the frequencies of laggards were increased with increasing the dose of gamma-rays and EMS in both the varieties. During telophase, a high frequency of micronuclei was observed at high dose treatments

of gamma-rays as well EMS in both varieties. Micronuclei might have arisen from the fragments and lagging chromosomes which failed to reach the poles and get included in the daughter nuclei (Kumar and Dubey, 1998).

The cytological study of the control plants was having normal meiosis activities in comparison to mutagen-treated populations. Cytological studies of mutagen treatment revealed that here was an increase in the frequency of meiotic chromosomal abnormality as increased the mutagen dose of gamma-rays and EMS confirmed the observations of earlier workers (Dhamayanthi and Reddy, 2000; Bhat et al., 2007). Although the types of chromosomal abnormalities were more or less common in both the varieties, the frequency of such aberrations was comparatively more in var. Sujata than the OBGG-52 indicates that it is more sensitive towards the mutagens (Table 1 and 2). Among the different doses/concentrations of mutagens, gamma-rays show more chromosomal abnormalities than the EMS except for the case of the lower dose of gamma-ray in the var. Sujata. These results support the general hypothesis that physical mutagens produce more cytological abnormalities than chemical ones (Kozgar, 2014). However, EMS was earlier found to be more effective in inducing meiotic irregularities than Gamma rays individually as well as in combination with Gamma-rays treatments (Dhamayanthi and Reddy, 2000). A dose-dependent increase in meiotic abnormalities has also been reported by Ignacimuthu and Babu (1989) in urdbean (*V. mungo*) and mung beans (*V. radiata*). Such chromosomal abnormalities may lead to the formation of nonfunctional spores.

The pollen sterility was increased with the increases in the dose/concentration of gamma rays and EMS treatments. A very high per cent of sterility was observed at high dose treatments of gamma rays and EMS in both varieties (Table 1 and 2). Gamma-ray treatments recorded the maximum pollen sterility (7.81% in Sujata and 5.47% in OBGG-52) at higher dose (60kR) whereas the minimum pollen sterility (2.11% in Sujata and 2.14% in OBGG-52) at a lower dose (20kR). In the case of EMS treatments, the maximum pollen sterility (7.43% in Sujata and 3.69% in OBGG-52) was observed at 0.6%, and the minimum (2.46% in Sujata and 1.43% in OBGG-52) at 0.2%. In Combination treatment, the pollen sterility was observed at 3.41% in Sujata and 4.23% in OBGG-52. The negative effect of mutagens on pollen fertility may be due to the cumulative effects of various meiotic aberrations that occurred due to the induction of mutations. The increased pollen sterility with increasing doses of mutagens was also reported by several investigators in greengram (Das et al., 2006; Tah, 2006; Das and Baisakh, 2020). The probable reason for increased pollen sterility might be due to more meiotic irregularities such as translocations (Das and Baisakh, 2020). Ramanna (1974) reported that any deviation in karyokinesis or cytokinesis could produce non-viable microspores. It may therefore be assumed that cytological disturbances caused as a result of

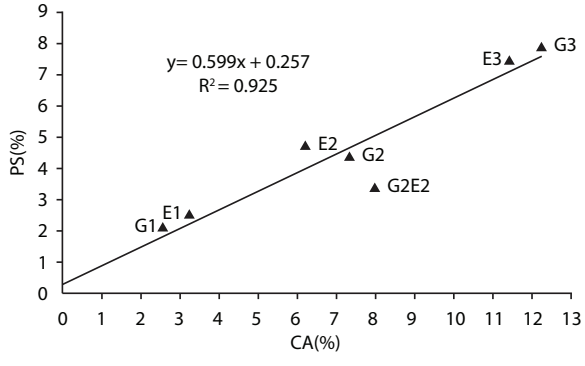


Fig. 1. Relationship between chromosomal aberrations and pollen sterility in different mutagenic treatments in greengram var. Sujata

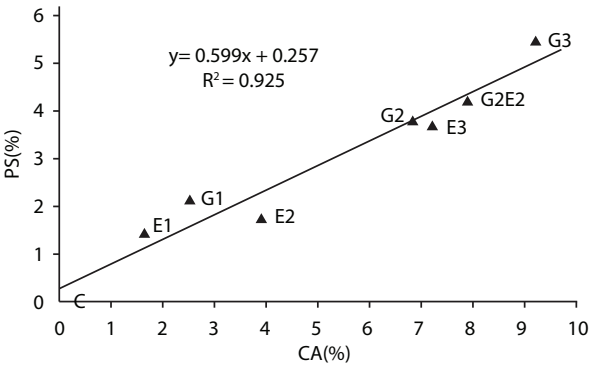


Fig. 2. Relationship between chromosomal aberrations and pollen sterility in different mutagenic treatments in greengram var. OBGG-52

physical or chemical mutagenesis were responsible for pollen sterility. Moreover, due to the mutations caused by gamma rays and EMS, the changed protein product as a result of changes in amino acid sequences might have affected the fertility of pollens. The relationship between chromosomal aberration and pollen sterility in different mutagenic treatments of both varieties are presented in Fig. 1 and 2 which suggested that induced pollen sterility may be the result of chromosomal aberrations and increases with increasing the frequency of chromosomal aberrations in both varieties of greengram. Correlation coefficient values between chromosomal abnormality and pollen sterility due to mutagenic treatments (0.962 in Sujata and 0.975 in OBGG-52) were positive and highly significant.

CONCLUSION

In the present investigation, various meiotic chromosomal variations were noticed in the mutagen treated populations of both varieties of greengram whereas, in the control population of both varieties, meiosis was normal. The percentage of chromosomal abnormalities as well as pollen sterility percentage increased with an increase in dose/concentration of gamma rays and EMS. Among the different doses/concentrations of mutagens, gamma rays show more chromosomal abnormalities than the EMS. A positive and significant correlation between chromosomal abnormality and pollen sterility was observed in this study. The relationship between chromosomal variation and pollen sterility suggested that induced pollen sterility may be due to the induced mutation in chromosomes and chromosomal aberrations. Moreover, due to such induced mutations, the changed protein product as a result of changes in amino acid sequences might have affected the morphology and fertility of pollen grains. It is concluded that both the mutagen are effective in inducing genetic variability for the improvement of greengram. Even though all mutations are not beneficial thus it is the skill of geneticist and plant breeder to select the appropriate dose, mutagen, plant characters, purposes, and methods for the betterment of crop improvement.

ACKNOWLEDGEMENT

The authors are thankful to the Vice-Chancellor, OUAT, Bhubaneswar (Odisha) and Director, IARI, New Delhi for their support and encouragement along with providing all necessary facilities during this research.

REFERENCES

Baisakh, B., Das, T.R. and Nayak, B.K. 2011. Efficacy of physical and chemical mutagenic treatments for micro-mutants in urdbean. *J. Food Legum.* **24**(2): 106-109.

Bhat, T.A., Khan, A.H. and Parveen, S. 2005. Comparative analysis of meiotic abnormalities induced by gamma rays, EMS and MMS in *Vicia faba* L. *J. Indian Bot. Soc.* **84**: 45-48.

Bhat, T.A., Sharma, M. and Anis, M. 2007. Comparative analysis of meiotic aberrations induced by diethylsulphonate and sodium azide in broad bean (*Vicia faba* L.). *Asian J. Plant Sci*. **6**: 1051–1057.

Darlington, C.D. 1942. Chromosome chemistry and gene action. *Nature* **149**: 66-69.

Das, T.R. and Baisakh, B. 2011. Effect of mutagenic treatments on chlorophyll mutation in greengram (*Vigna radiata* L. Wilczek). *e-planet* **9**(2): 17- 20.

Das, T.R. and Baisakh, B. 2020. Effectiveness and efficiency of physical and chemical mutagens in greengram [*Vigna radiata* (L.) Wilczek]. *e-planet* **18** (1): 6-12.

Das, T.R. and Prusti, A.M. 2020. Mutagenic effectiveness and efficiency of gamma rays, EMS and NG in Greengram (*Vigna radiata* L. Wilczek). *Int. J. Curr. Microbiol. Appl. Sci*. **9**: 2336-2344.

Das, T.R. and Baisakh, B. 2013. Efficacy of physical and chemical mutagenic treatments for developing superior mutants in greengram (*Vigna radiata*). *Indian J. Agric. Sci*. **83**: 595-598.

Das, T.R. and Misra, R.C. 2005. Genetic analysis of mutagen induced variability in yield traits in greengrams (*Vigna radiata*). *Env. Ecol*. **23**: 381-384.

Das, T.R. and Prusti, A.M. 2020. Mutagenic effectiveness and efficiency of gamma-rays, EMS and NG in Greengram (*Vigna radiata* L. Wilczek). *Int. J. Curr. Microbiol. Appl. Sci.* **9**: 2336-2344.

Das, T.R., Misra, R.C. and Sahu, P.K. 2006. Efficiency of mutagenic treatments in expression of macro and micro-mutations in M_2 generation in greengram and its early predictability on basis of M_1 parameters. *Environ. Ecol*. **24** (2): 283-288.

Dhamayanthi, K.P.M. and Reddy, V.R.K. 2000. Cytogenetic effects of gamma rays and EMS in chilli pepper (*Capsicum annum*). *Cytologia* **65**: 129-133.

Dixit, P. and Dubey, D.K. 1986. Alkylating agent induced chromosomal aberrations in lentil (*Lens culinaris*. Med.) var. 1-36. *Cytologia* **51**: 325-331.

Evans, H.J. 1962. Chromosome aberrations induced by ionizing radiations. *Int. Rev. Cytol.* **13**: 221-321.

Gaulden, M.E. 1987. Hypothesis: some mutagens directly alter specific chromosomal proteins (DNA topoisomerase II and peripheral proteins) to produce chromosome stickiness, which causes chromosome aberrations. *Mutagenesis* **2**(5): 357–365.

Greene, E.A., Codomo, C.A., Taylor, N.E., Henikoff, J.G., Till, B.J., Reynolds, S.H., Enns, L.C., Burtner, C., Johnson, J.E., Odden, A.R., Comai, L. and Steven, H. 2003. Spectrum of chemically induced mutations from a large scale reverse genetic screen in *Arabidopsis*. *Genetics* **164**: 731–740.

Ignacimuthu, S. and Babu, C.R. 1989. Induced chromosomal abnormality and pollen sterility in wild and cultivated urd and mungbean. *Cytologia* **54**: 159-167.

Jayabalan, N. and Rao, G.R. 1987. Gamma radiation induced cytological abnormalities in *Lycopersicon esculentum* Mull. var. Pusa Ruby. *Cytologia* **52**: 1–4.

Kaufmann, B.P. 1956. Cytochemical studies of changes induced in cellular materials by ionizing radiations. *Ann. N. Y. Acad. Sci*. **59**: 553.

Klasterska, I., Natrajan, A.T. and Ramel, C. 1976. An interpretation of the origin of subchromatid aberrations and chromosome stickiness as a category of chromatid aberrations. *Hereditas* **83**: 153–162.

Kozgar, M.I., Hussain, S., Wani, M.R. and Khan, S. 2014. The role of cytological aberrations in crop improvement through induced mutagenesis. In: P. Ahmad, M. Wani, M. Azooz, L.S. Phan Tran (eds). *Improvement of crops in the era of climatic changes*, Springer, New York, pp. 283-296

Kumar, G. and Singh V. 2002. EMS induced chromosomal stickiness in *Hordeum vulgare*. *Nucleus* **45**: 139-142.

Kumar, G. and Tripathi, A. 2004. Mutagenic response of caffeine in *Capsicum annum* L. *J. Indian Bot. Soc.* **83**: 136-140.

Kumar, S. and Dubey, D.K. 1998. Effect of gamma rays EMS and DES on meiosis in *Lathyrus sativus*. *J. Cytol. Genet.* **33**: 139-147.

McGill, M.S., Pathak, S. and Hsu, T.C. 1974. Effects of ethedium bromide on mitosis and chromosomes: A possible material basis for chromosome stickiness. *Chromosoma* **47**: 157-167.

McClintock, B. 1941. The stability of broken ends of chromosomes in *Zea mays. Genetics* **26**: 234-282.

Minocha, J.L. and Arnason, T.J. 1962. Mutagenic effectiveness of ethylmethane sulfonate in barley. *Nature* **196**: 499-499.

Okagaki, R.J., Neffer, M.G. and Wessler, S.R. 1991. A deletion common to two independently derived waxy mutations of maize. *Genetics* **127**: 425-431.

Ramanna, M.S. 1974. The origin of unreduced microspores due to aberrant cytokinesis in meiocytes of potato and its genetic significance. *Euphytica* **23**: 20-30.

Rao, N.B. and Laxmi, N. 1980. Gamma ray induced meiotic abnormalities in *Capsicum annuum* L. *Caryologia* **33**: 509-518

Rees, H. 1955. Genotypic control of chromosomal behaviour in rye inbred lines. *Heredity* **9**: 93-116.

Saylor, L.G. and Smith, B.N. 1996. Meiotic irregularities in species of interspecific hybrids in *Pinus. Am. J. Bot.* **5**: 453-468.

Sinha, S.S.N. and Godward, M.B.E. 1972. Radiation studies in Lens culinaris. *Indian J. Genet.* **32**: 331-339.

Tah, P. 2006. Induced macromutations in mungbean [*Vigna radiata* (L.) Wilczek]. *Int. J. Bot.* **2**(3): 219-228.

Tarar, J.L. and Dnyansagar, V.R. 1980. Comparison of ethyl methane sulphonate and radiation induced meiotic abnormalities in *Turnera ulmifolia* Linn. var. *angustifolia* wild. *Cytologia* **45**: 221–231.

Zeerak, N.A. 1991. Cytological effect of gamma rays and ethyl methane sulphonate in brinjal (*Solanum melongena* L.). *Cytologia* **56**: 639-643.

Zeerak, N.A. 1992. Mutagenic effectiveness and efficiency of gamma rays and ethyl methane sulphonate in brinjal (*Solanum melongena* L.). *J. Nucl. Agric. Biol*. **21**: 84–87.

e-planet **20** (1): 8-13 (June 2022)

Evaluation of bio-efficacy of pyroxsulam for weed control in wheat

Y.K. ZIAR*, M.S. BHULLAR AND T. KAUR

Department of Agronomy, Punjab Agricultural University, Ludhiana, Punjab-141 004, India

yousafziar@gmail.com

Date of receipt: 02.01.2022 Date of acceptance: 03.05.2022

ABSTRACT

A field study was conducted to investigate the bio-efficacy of pyroxsulam 4.5% OD against weeds in wheat. The experiment was laid out in randomized block design with three replications. The treatments were pyroxsulam 4.5% OD at 12, 15 and 18 g a.i. ha^{-1} was applied with and without polyglycol, sulfosulfuron at 25 g a.i. ha^{-1}, metsulfuron at 4 g a.i. ha^{-1}, pyroxsulam 4.5% OD at 36 g a.i. ha^{-1} with and without polyglycol was evaluated for residue studies, and pyroxsulam 4.5% OD at 18 g a.i. ha^{-1} with polyglycol was evaluated for compatibility with chlorpyriphos, carbendazim and urea. Among these treatments, pyroxsulam 4.5% OD with polyglycol at 15 or 18 g a.i. ha^{-1} (both differ significantly) recorded effective control of grasses and broadleaf weeds and recorded the highest wheat grain yield during both the years. It was safe for use in wheat and for succeeding rice crop.

Key words: Metsulfuron, polyglycol, pyroxsulam, sulfosulfuron, weeds, wheat

INTRODUCTION

Wheat (*Triticum aestivum* L.) is an important cereal crop of Punjab, which is a highly productive zone in the Indo-Gangetic Plains and contributes about 84% wheat and 54% rice in the country. Wheat is the major crop of Punjab covering 3.5 million ha area with 16.1 million tonnes production and 4.58 t ha^{-1} productivity (Anonymous, 2017). Several yield reduction factors in wheat have been studied and reported by many researchers. The wheat yield losses due to weeds is verified to be 30-50% based on weed infestation (Pandey and Singh, 1997). For weed control in wheat, herbicides are found to be most effective and widely used due to cost and time effectiveness and also increase yield (Nalewaja, 1974; Chhokar et al., 2012; Mohammed and Addisu, 2016; Ehsas et al., 2019; Prasad et al., 2019).

In weed control, long term use of herbicide results in weeds resistance to herbicide apart from weed flora shift. Herbicide residue hazards in the environment and preponderance of perennial weeds are seen in the crops grown agro-ecosystem (Das, 2008). In the whole world, first report of weed resistance to herbicide was reported by Ryan (1970) that *Senecio vulgaris* L. (Common groundsel) was detected bio-type resistance to triazines in USA in 1968. In India too, *Phalaris minor* (Little seed canary grass) developed resistance to isoproturon during 1992-93, the report was made by Malik and Singh (1993, 1995). Number of herbicides introduced after isoproturon such as clodinafop, fenoxaprop, sulfosulfuron with fairly well performance, but unfortunately the farmers forgot the golden rule of herbicide rotation (Kaur et al., 2019).

Continuous use of herbicides reduces its bio-efficacy and leads to resistant weed population. So, this calls for the evaluation of some new herbicide molecules against the weeds in wheat. Pyroxsulam, a new sulphonamide herbicide that controlling many broad-leaved and grassy weeds effectively in wheat (DeBoer et al., 2011; Kebede et al., 2017).

Pyroxsulam is providing growers with a high performance, low dose herbicide with a desirable environmental profile (Jabusch and Tjeardema, 2008). It inhibits the plant enzyme acetolactasynthese (ALS) which is essential for the synthesis of branched-chain amino acids valine leucin and isoleucine (Gonzalez et al., 2008). Inhibition of amino acid production subsequently inhibits cell division and causes death in susceptible plants. Therefore, the present study was conducted to evaluate the bio-efficacy of Pyroxsulam 4.5% OD against weed flora in wheat.

MATERIALS AND METHODS

Bio-efficacy evaluation

The experiment was laid out on the experimental farm of the Department of Agronomy, Punjab Agricultural University (PAU), Ludhiana (30^0 56' N, 75^0 52' E, 247 m above sea level), Punjab, India. The climate of the region is hot dry summer (March-Jun), wet monsoon season (late June-mid September) and cool, dry winter (October-February). Fourteen treatments were assigned in Randomized Block Design. The treatments were pyroxsulam 4.5% OD at 12, 15 and 18 g a.i. ha^{-1} was applied with and without polyglycol, sulfosulfuron at 25 g a.i. ha^{-1}, metsulfuron at 4 g a.i. ha^{-1}, pyroxsulam 4.5% OD at 36 g a.i. ha^{-1} with and without polyglycol was evaluated for residue studies, and pyroxsulam 4.5% OD at 18 g a.i. ha^{-1} with polyglycol was evaluated for compatibility with chlorpyriphos, carbendazim and urea. Wheat variety HD 2967 was sown on 16.11.2012 and 14.11.2013, respectively, by using seed rate of 112.5 kg ha^{-1}. Recommended dose of fertilizers was applied at the time of sowing. The herbicides were applied on 18.12.2012 and 20.12.2013 with knap sack sprayer fitted with flat fan nozzle using 375 liters per hectare of spray volume per hectare. The data on weed count and dry matter accumulation were recorded from four spots at 60 days after sowing (DAS) using 50 × 50 cm quadrat. The phytotoxicity of herbicide on crop was observed 7, 15 and 30 days after application in all the treatments using 0 – 10 scale (0 = no phytotoxicity and 10 = complete kill of crop). The data of emergence on residual crop rice was taken.

RESULTS AND DISCUSSION

Weed flora

Grass weed like *Phalaris minor* and broadleaf weeds like *Chenopodium album, Medicago denticulata, Rumex dentatus, Coronopus didymus* and *Anagallis arvensis* were the main weeds in the experimental plots (Table 1).

Efficacy

During 2012-13, pyroxsulam 4.5% OD with polyglycol at 18 g a.i. ha^{-1} significantly reduced population of narrow and few broad leaf weeds (*C didymus* and *M denticulata*) as compared to pyroxsulam 4.5% OD at 12 g a.i. ha^{-1} and sulfosulfuron and unweeded control. With the increase in dose of the herbicide pyroxsulam 4.5% OD, the weed population decreased (Table 1). The herbicide at higher dose was more effective in controlling grass and broadleaf weeds as compared to its lower doses. However, both doses of pyroxsulam 4.5% OD with polyglycol at 15 and 18 g a.i. ha^{-1} were at par in controlling broad leaf weed population. There was significant difference in control of *P minor* w.r.t all doses of pyroxsulam 4.5% OD with polyglycol. Population and dry matter of *P minor* and broadleaf weeds were at par where pyroxsulam 4.5% OD with polyglycol was applied at 12 g a.i. ha^{-1} with sulfosulfuron. Pyroxsulam 4.5% OD with polyglycol was more effective in controlling population of both *P. minor* and broadleaf weeds as compared to pyroxsulam 4.5% OD applied without polyglycol. Metsulfuron significantly reduced the broadleaf weed population and dry matter than lower dose of pyroxsulam 4.5% OD with polyglycol i.e., 12 g a.i. ha^{-1}. Significantly less broadleaf weeds were recorded in pyroxsulam 4.5% OD with polyglycol at 18 g a.i. ha^{-1} as compared to metsulfuron.

Pyroxsulam 4.5% OD with and without polyglycol at 36 g a.i. ha^{-1} reduced the population and dry matter of narrow and broadleaf weeds significantly during both the years. Compatibility of pyroxsulam 4.5% OD with polyglycol at 18 g a.i. ha^{-1} with chlorpyriphos was not effective. There was suppression or toxicity in wheat though reduced the weeds. Pyroxsulam 4.5% OD with polyglycol with

urea and carbendazim was effective in controlling weed population during both the years.

During 2013-14, the populations of narrow and broadleaf weeds recorded at 60 DAS were significantly less in pyroxsulam 4.5% OD with polyglycol i.e., 15 g a.i. ha^{-1} than 12 g a.i. ha^{-1}. Similar trend was recorded in case of weeds dry matter which also showed decreasing trend with the increase in the dose of pyroxsulam 4.5% OD with polyglycol. Population and dry matter of *P minor* was significantly less in pyroxsulam 4.5% OD with polyglycol i.e., 18 g a.i. ha^{-1} than 15 g a.i. ha^{-1}. Population and dry matter of *P. minor* were at par where pyroxsulam 4.5% OD with polyglycol was applied at 12 g a.i. ha^{-1} with sulfosulfuron and dry matter of broad leaf weeds was also at par. Metsulfuron significantly reduced the broadleaf weed population and dry matter than lower dose of pyroxsulam 4.5% OD with polyglycol, i.e., 12 and 15 g a.i. ha^{-1} but significantly more dry matter as compared to 18 g a.i. ha^{-1} (Table 1). This result resembles with Chhokar et al. (2019) who reported that pyroxsulam at 18 g a.i. ha^{-1} was effective control the diverse weed flora (*Avena ludoviciana*, *Phalaris minor*, *Medicago denticulata* and *Lathyrus aphaca*) under field and pot studies. Zobiole et al. (2016) found that the applied rate of 15, 18 g a.i. ha^{-1} pyroxsulam provided excellent control (>85) of *Lolium multiflorum*. Muhammad et al. (2013) observed that pyroxsulam was more effective on controlling of broadleaved weeds which reduced the weed population as compared to other herbicides and also can control serious grassy weeds on wheat.

Grain yield

During both the years (Table 2) all the herbicidal treatments recorded significantly higher wheat grain yield than the unsprayed control. Pyroxsulam 4.5% OD with polyglycol i.e 18 g a.i. ha^{-1} recorded the highest wheat grain yield during both the years. Grain yield differed significantly where pyroxsulam 4.5% OD with polyglycol i.e 18 g a.i. ha^{-1} and 15 g a.i. ha^{-1} was applied and significantly less in 12 g a.i. ha^{-1}. Significantly less grain yield was recorded at all doses of pyroxsulam 4.5% OD applied without polyglycol as compared to respective dose with polyglycol. Significantly less grain yield was obtained in sulfosulfuron as compared to pyroxsulam 4.5% OD with polyglycol i.e 12,15 and 18 g a.i. ha^{-1}. Metsulfuron, being only broad leaf killer recorded significantly less grain yield than all doses of pyroxsulam.

Pyroxsulam 4.5% OD with and without polyglycol at 36 g a.i. ha^{-1} recorded grain yield at par with 18 g a.i. ha^{-1} and significantly less without polyglycol during both the years. Pyroxsulam 4.5% OD with polyglycol at 18 g a.i. ha^{-1} with chlorpyriphos recorded significantly less grain yield as compared to its application with urea and carbendazim (Table 2). The findings are in agreement with the work of Zobiole et al. (2016) who reported that the application of pyroxsulam at the rate of 15 or 18 g a.i. ha^{-1} without adverse effect increase grain yield of wheat. El-Metwally and Gad (2019) also recorded that Isoproturon + diflufenican followed by pyroxsulam and mesosulfuron-methyl treatments gave the largest grain yield in wheat.

Phyto-toxicity

Visual observation of phyto-toxicity symptoms, such as leaf injury, stunting, crop wilting, necrosis, epinasty and hyponasty on wheat plants were recorded at 15, 30 and 45 days after spray as per the phytotoxicity rating scale (using 0-10 rating scale, where 0= no phytotoxicity, 1= 1-10 % phytotoxicity, 2= 11-20 % phytotoxicity, 3= 21-30 % phytotoxicity, 4= 31-40 % phytotoxicity, 5= 41-50 % phytotoxicity, 6= 51-60 % phytotoxicity, 7= 61-70 % phytotoxicity, 8= 71-80 % phytotoxicity, 9= 81-90 % phytotoxicity and 10= 91-100 % phytotoxicity or complete death of plants). Pyroxsulam 4.5% OD did not show any visual symptoms of phytotoxicity on wheat plants at 36 g a.i. ha^{-1} during both the years (Table 1). Tanj et al. (2017) founded that herbicide treatments containing pyroxsulam or mesosulfuron-methyl + iodosulfuron-methyl-sodium caused weeds injured, but wheat plants were recovered and grain was also not affected. Zobiole et al. (2018) reported that the proposed commercial rate of 15 and 18 g a.i. ha^{-1} pyroxsulam did not cause visual injury in wheat above 10% in wheat. Pyroxsulam caused >10% injury in wheat at location of Cascavel, when applied at the rate of 21, 30, 36 and 42 g a.i. ha^{-1};

Table 1. Efficacy of pyroxsulam 4.5% OD with and without polyglycol on weed count and dry matter during rabi 2012-13 and 2013-14

Treatments	Dose (g a.i. ha^{-1})	NLW (No. m^{-2})		BLW (No m^{-2})								Dry wt P minor (g m^{-2})		Dry wt BLW (g m^{-2})	
		P minor		C Album		R dentatus		C didymus		M denticulate					
		2012-13	2013-14	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14	2012-13	2013-14
Pyroxsulam +Poly glycol	12	4.1 (16)	4.2 (17)	1.7 (2)	1.7 (2)	2.3 (5)	3.0 (8)	3.4 (11)	2.6 (6)	3.9 (14)	3.5 (11)	4.2 (17)	5.0 (23)	5.4 (29)	8.2 (67)
Pyroxsulam +Poly glycol	15	3.3 (10)	3.2 (9)	1.4 (1)	1.2 (0.5)	1.7 (2)	2.2 (4)	1.6 (2)	1.3 (1)	2.0 (3)	2.3 (4)	2.5 (6)	4.2 (16)	4.9 (23)	7.1 (50)
Pyroxsulam +Poly glycol	18	2.7 (6)	2.6 (6)	1.2 (0.6)	1.1 (0.2)	1.6 (2)	1.6 (2)	1.3 (1)	1.3 (0.7)	2.0 (4)	1.8 (3)	2.2 (5)	3.5 (11)	3.8 (14)	5.3 (27)
Pyroxsulam	12	5.4 (28)	4.5 (19)	1.9 (3)	2.6 (6)	2.4 (6)	3.7 (13)	2.4 (6)	3.2 (9)	3.5 (11)	2.3 (5)	4.6(21)	6.3 (39)	8.5 (71)	8.7 (74)
Pyroxsulam	15	4.0 (15)	4.0 (15)	1.5 (2)	2.2 (4)	2.1 (4)	3.2 (9)	1.8 (3)	3.0 (7)	4.1 (16)	1.6 (2)	3.7(13)	4.8 (22)	7.6 (57)	7.6 (57)
Pyroxsulam	18	3.4 (11)	4.0 (15)	1.2 (0.7)	1.4 (1)	1.8 (3)	2.6 (6)	1. 5(2)	2.6 (6)	3.4 (11)	1.4 (1)	2.9 (7)	4.4 (19)	4.8 (22)	5.8 (34)
Sulfosulfuron+ surfactant	25	4.3 (17)	4.0 (15)	2.1 (3)	2.4 (5)	2.9 (8)	4.0 (15)	2.8 (7)	3.2 (9)	3.6 (12)	3.1 (9)	4.6 (20)	5.3 (27)	5.5 (30)	7.3 (52)
Metsulfuron+ surfactant	4	7.3 (53)	5.8 (33)	1.0 (0)	1.0 (0)	1.0 (0)	1.2 (0.7)	1.5 (2)	3.0 (8)	1.9 (3)	3.0 (8)	8.8 (77)	8.6 (73)	4.2 (17)	4.9 (23)
Pyroxsulam+Poly glycol	36	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)
Pyroxsulam	36	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)	1.0 (0)
Pyroxsulam+Poly glycol +chlorpyriphos	18	2.8 (7)	3.0 (8)	1.3 (0.7)	1.4 (0.8)	1.6 (2)	1.6 (2)	1.4 (1)	1.3 (0.6)	2.1 (4)	1.9 (3)	2.4 (5)	3.6 (12)	4.1 (16)	5.2 (27)
Pyroxsulam+Poly glycol +carbendazim	18	2.5 (5)	2.8 (7)	1.3 (0.8)	1.2 (0.7)	1.6 (2)	1.6 (2)	1.4 (1)	1.3 (0.7)	2.0 (3)	1.8 (2)	2.3 (4)	3.6 (12)	3.7(12)	5.2 (26)
Pyroxsulam+Poly glycol + urea	18	2.4 (5)	2.7 (6)	1.4 (0.8)	1.1 (0.2)	1.7 (2)	1.5 (1)	1.4 (1)	1.3 (0.6)	2.1 (4)	1.8 (2)	2.4 (5)	3.5 (11)	4.0 (15)	5.3 (27)
Control		7.4 (54)	5.8 (33)	2.6 (6)	4.3 (17)	5.3 (27)	5.4 (28)	4.1 (16)	5.1 (25)	4.7 (21)	5.0 (25)	8.4 (70)	8.6 (73)	10 (100)	10.2 (103)
CD at 5%		0.5	0.4	0.6	0.4	0.8	0.4	1.0	0.4	0.7	0.9	0.9	0.7	0.7	1.1

*Figures in parenthesis are original and data is subjected to square root transformation

Table 2. Efficacy of pyroxsulam 4.5% OD with and without polyglycol on yield of wheat during *rabi* (2012-13 and 2013-14)

Treatments	Dose (g a.i. ha^{-1})	E tillers per m^2		Grain yield (q ha^{-1})	
		2012-2013	2013-2014	2012-2013	2013-2014
Pyroxsulam +Poly glycol	12	329.0	332.0	57.6	51.3
Pyroxsulam +Poly glycol	15	330.5	334.9	60.2	53.1
Pyroxsulam +Poly glycol	18	335.6	337.4	62.2	56.3
Pyroxsulam	12	327.4	328.4	52.8	44.1
Pyroxsulam	15	328.3	331.5	55.8	45.5
Pyroxsulam	18	330.6	332.0	59.8	46.1
Sulfosulfuron+surfactant	25	329.1	338.4	57.6	49.7
Metsulfuron+surfactant	4	327.1	330.3	55.2	47.8
Pyroxsulam+Poly glycol	36	334.8	325.4	62.8	43.5
Pyroxsulam	36	324.7	320.0	57.0	39.8
Pyroxsulam+Poly glycol +chlorpyriphos	18	330.4	334.9	59.8	52.1
Pyroxsulam+Poly glycol +carbendazim	18	334.0	337.7	62.8	56.3
Pyroxsulam+Poly glycol + urea	18	334.2	337.4	62.0	55.8
Control		278.5	284.4	43.0	34.1
CD at 5%		1.3	2.1	1.4	1.1

however, the crop fully recovered from the injury by 28 days after application and did not have an adverse effect on wheat grain yield, regardless of the rate applied. Abdulkareem et al. (2017) reported that pyroxsulam could be consider as a good herbicide of low toxic and no residual effects on wheat and soil when used it in the recommended dose in optimum condition in Iraq.

Effect on succeeding crop

The residual effect of pyroxsulam 4.5% OD was recorded on succeeding rice crop. The herbicide did not influence germination of rice. Rice plants did not show any visual symptoms of herbicide phytotoxicity when the herbicide was applied to wheat at 36 g a.i. ha^{-1}.

CONCLUSION

One post-emergence application of pyroxsulam 4.5% OD with polyglycol at 15 or 18 g a.i. ha^{-1} (both differ significantly) recorded effective control of grasses and broadleaf weeds and recorded the highest wheat grain yield during both the years. These applications may be recommended for field for effectively controlling grasses and broadleaf weeds.

REFERENCES

Abdulkareem, J.A., Sadeem, S.A. and Hanan, A.K. 2017. Residual determination of pyroxsulam 4.5% OD in Iraqi wheat and field soil using QuEChERS/ HPLC. *Int. J. Res.* **6**(10): 571-574.

Anonymous. 2017. Package of Practices for *Rabi Crops.* Punjab Agricultural University, Ludhiana.

Chhokar, R.S., Sharma, R.K. and Sharma, I. 2012. Weed management strategies in wheat: A review. *J. Wheat Res.* **4**(2): 1-21.

Chhokar, R.S., Sharma, R.K., Gill, S.C. and Singh, R.K. 2019. Broad spectrum weed control in wheat with pyroxsulam and its tank mix combination with sulfosulfuron. *J. Res.* **11**(1): 23-36.

Das, T.K. 2008. *Weed Science: Basics and Applications.* 1st edn. Jain Brothers Publishers, New Delhi, India, pp. 582-583.

DeBoer, G.J., Thornburgh, S., Gilbert, J. and Gast, R.E. 2011. The impact of uptake, translocation and metabolism on the differential selectivity between black-grass and wheat for the herbicide pyroxsulam. *Pest Manage. Sci.* **67**: 279-286.

Ehsas, J.A., Salihy, A.R., Jalali, M.N., Ghafari, S.R., Samim, M.M. and Ebrahimi, N. 2019. Response of weed management to grain yield and nutrients uptake in maize (*Zea mays* L.). *e-planet* **17**(1): 9-12.

El-Metwally, I.M. and Gad, N. 2019. Wheat productivity and water use efficiency responses to irrigation, cobalt and weed management. *Italian J. Agrometeorol.* **(1)**: 13-24.

Ghafari, S.R., Mangal, M.Q., Jalali, M.N., Ali, J. and Dass, A. 2018. Yield, efficiency indices and economics of wheat (*Triticum aestivum* L.) varieties as influenced by variable row spacings. *e-planet* **16**(1): 1-8.

Gonzalez, M.A., Gorman, D.B., Hamilton, C.T. and Roth, G.A. 2008. Process development for the sulfonamide herbicide pyroxsulam. *Org. Process Res. Dev.* **12**: 301-303.

Jabusch, T.W. and Tjeardema, R.S. 2008. Chemistry and fate of triazolopyrimidine sulfonamide herbicide. *Rev. Env. Contamin. Toxicol.* **193**: 31-52.

Kaur, T., Bhullar, M.S. and Kaur, S. 2019. Control of herbicide resistant Phalaris minor by pyroxasulfone in wheat. *Indian J. Weed Sci.* **51**(2): 123-128.

Kebede, M., Gerama, G., Bidira, T. and Birhana, C. 2017. Influence of post-emergence herbicides on major grass weeds and wheat (*Triticum aestivum* L.) at Gedo and Shambo, western Oromia, Ethiopia. *Common Plant Sci.* **6**(2): 55-61.

Malik, R.K. and Singh, S. 1993. Evolving strategies for herbicide use in wheat: Resistance and integrated weed management. In: *Procedings International Symposium of the Indian Society of Weed Science,* 18-20 Nov., Hisar, India, **1**: 225-238.

Malik, R.K. and Singh, S. 1995. Littleseed canary grass (*Phalaris minor Retz*.) resistant to isoproturon in India. *Weed Technol.* **9**: 419-425.

Mohammed, Z. and Addisu, S. 2016. Evaluation of sequential application of herbicides for broad and grass weed management in durum wheat, Ethiopia. *Am. J. Environ. Resour. Econ.* **1**(1): 32-36.

Muhammad, F.K. Gul, H., Gulzar, A. and Sajjad, K. 2013. Comparative efficacy of herbicides on yield and yield components of wheat (*Triticum aestivum* L.). *ARPN J. Agric. Biol. Sci.* **8**(1): 12-20.

Nalewaja, J.D. 1974. Energy requirements for various weed control practices. *Proc. North Central Weed Control Conf.* **29**: 19-23.

Pandey, J. and Singh, R. 1997. Weed control in wheat is key to higher production. *Indian Farming* **47** (8): 4-7.

Prasad, S.M., Saha, S., Chourasia, M., Sarangi, D.R., Sahoo, T.R., Sethy, S. and Mohanta, R.K. 2019. Effect of integrated weed management in rainfed upland rice of Odisha. *e-planet* **17**(2): 106-110.

Ryan, G.F. 1970. Resistance of common groundsel to simazine and atrazine. *Weed Sci*. **18**: 614-616.

Tanji, A., Baye, Y. and Boutfirass, M. 2017. Evaluating post emergence herbicides for broadleaf weed control in irrigated bread wheat (*Triticum aestivum* L.). *J. Exp. Biol. Agric. Sci.* **6**(5): 614-622.

Zobiole, L.H.S., Gast, R., Masters, R.A., Pereira, G.R. and Rubin, R. 2018. Pyroxsulam: Sulfonamide herbicide for weed control in wheat in Brazil. *Planta Daninha,* USA **36**: 1-6.

e-planet **20** (1): 14-19 (June 2022)

Impact of farmers' field school on fertilizers and pesticide usage in paddy cultivation

A. MANOJ

Division of Agricultural Extension, Indian Agricultural Research Institute, Pusa, New Delhi-110 012, India

alajangimanoj@gmail.com

Date of receipt: 13.04.2022 Date of acceptance: 14.05.2022

ABSTRACT

The present study was conducted in united Andhra Pradesh with the objective to find out the impact of integrated crop management Farmers' Field School (FFS) on fertilizers and pesticide usage. A total of three districts were selected purposively from three regions of united Andhra Pradesh. Respondents were selected through simple random sampling procedure. The total sample size was 240 comprising 120 FFS farmers and 120 non-FFS farmers. The Double Difference method was used by comparing change in performance to before and after the programme for FFS farmers to the change in performance over the same period for non-FFS farmers unaffected by the programme. The study revealed that a high level of over-dose of chemical fertilizers and pesticides which was reduced to the recommended level through the intervention of FFS methodology among FFS farmers. None of the famers were found to apply recommended dose of nitrogen, phosphorus and potassium fertilizers, during pre -FFS period. Whereas, as a result of farmers field schools during post-FFS period, majority of FFS farmers had applied recommended dose of nitrogen, phosphorus and potassium fertilizers along with the increase in application of farm yard manure (FYM). Similar results were found in number of pesticide spray applications. During pre-FFS period the rate of application was almost equal among FFS farmers (8.62 sprays) and non-FFS farmers (8.48 sprays). Whereas, during post-FFS period, the number of sprays were reduced to 5.81 among FFS farmers as against 8.25 sprays in case of non-FFS farmers. The results in turn helped the FFS farmers to reduce the expenditure incurred on fertilizers and pesticides (Rs.17610 ha^{-1}) as compared to non-FFS farmers (Rs.21473 ha^{-1}).

Key words: Farmers' field school, fertilizer, impact, integrated crop management, pesticide

INTRODUCTION

Over the years, chemicals play a major role in agriculture. From the last three decades, fertilizer and pesticide sales have soared globally. Many older, non-patented, more toxic, environmentally harmful chemicals are used intensively in developing nations (Ecobichon, 2001; Schreinemachers and Prasnee, 2012). India is one of the countries encountering the indiscriminate use of chemical inputs coupled with ineffective extension services on sustainable farm management (Aktar et al., 2009; Peshin, 2021). In recent years, farmers' field school is an innovative extension approach is being extensively used for field-based training courses that aim to reduce indiscriminate use of fertilizers and pesticides in order to conserve natural resources, reduce cultivation cost and sustain small-scale agriculture profitability through Integrated Crop Management (ICM) practices (Kenmore, 1996; van den Berg, 2004). The FFS focus not only on pests but also provide farmers an opportunity to learn and get greater control over the field conditions that they encounter every day in their fields. Farmers are thus empowered by field schools (Pontius et al., 2002). Keeping the above facts in view, the present study

was undertaken to find out impacts of FFS on fertilizer and pesticide usage among farmers in the areas where the paddy is the major crop where there are high chances for application of fertilizers and pesticides.

MATERIALS AND METHODS

The study followed the *ex-post facto* research design. A total of three districts were selected purposively from these three regions of united Andhra Pradesh based on the area under paddy during the year 2012-13. The selected districts were West Godavari from coastal Andhra region, Warangal from Telangana region and Kurnool from Rayalaseema region. A total of six *mandals,* two *mandals* from each district and two villages from each *mandal* (one FFS village and one non-FFS village) were selected based on random sampling. From each FFS and non-FFS village, 20 farmers were selected through random sampling method. Thus, the total sample of the study had 240 respondents consisting of 120 FFS farmers and 120 non-FFS farmers.

The data on FFs impacts were collected from FFS and non-FFS farmers during two periods namely pre-FFS period and post-FFS period. Thus, the double difference method was used which compared change in performance before and after the programme for FFS farmers to the change in performance over the same period for non-FFS farmers unaffected by the programme. The farmers were interviewed by using a structured interview schedule. The data for pre-FFS period were collected through recall method. The impacts of FFS on fertilizers and pesticide usage were studied with respect to the manures and fertilizer use; frequency of pesticide application. Data were subjected to descriptive statistics such as frequency, percentage and chi-square. Data were analyzed using SPSS- 16 statistical package.

RESULTS AND DISCUSSION

Change in use of manures and fertilizers by the farmers

The results of the study (Table 1) have shown astonishing level of over-dose of nitrogen fertilizers during pre-FFS period. About 90.83 per cent of FFS farmers had applied it at over-dose level and only 9.17 per cent of them at recommended level. In case of non-FFS farmers a similar situation existed. The results clearly showed that a high level of change happened in application of nitrogenous fertilizers among FFS farmers after the training under FFS. About 59.17 per cent of FFS farmers followed recommended dose of nitrogenous fertilizers during post-FFS period. The farmer who had used over-dose of fertilizers during pre-FFS period came down to 40.83 per cent level from 90.83 per cent. Similar changes happened among FFS farmers even in application of phosphorus and potassium fertilizes.

Impacts of the FFS programme was measured in terms of percentage of change over pre-FFS period. The overall impact due to FFS was 545.45 per cent (4.6 fold) increase in use of recommended dose of nitrogenous fertilizers. This means that FFS has helped farmers to apply recommended dose of nitrogenous fertilizers. The results shown similar changes in adoption of phosphorous and potassium fertilizers among FFS farmers. About 115.63 per cent of change was found with respect to use of recommended dose of phosphorous and 106.06 per cent with respect to recommended dose of potassium fertilizers among FFS farmers. Whereas, there were no measurable changes happened in case of non-FFS farmers during the same period except with nitrogen fertilizers which is almost 6 times lesser than the change happened among FFS farmer.

Study revealed that farmers who were trained by FFS methodology not only reduce the over dose of chemical fertilizers but also increase (66.67 %) in application of recommended dose of FYM compared to farmers who were not affected by the FFS programme. This means, FFS methodology encouraged the farmers to believe that application of FYM in sufficient dose is essential to enhance the soil carbon content as well as for promotion of the growth of beneficial soil microorganisms for retaining profitable yields (Behera et al., 2015).

Table 1. Change in use of manures and fertilizers by the farmers

Farmers category	Level of fertilizers application	Nitrogen			Phosphorus			Potassium			Farm Yard Manure		
		% of farmers		% change	% of farmers		% change	% of farmers		% change	% of farmers		% of change
		Pre-FFS period	Post-FFS period		Pre FFS period	Post FFS period		Pre FFS period	Post FFS period		Pre FFS period	Post FFS period	
FFS Farmers (n=120)	Recommended	9.17	59.17	545.45	26.67	57.50	115.63	27.50	56.67	106.06	20.00	33.33	66.67
	Over dose	90.83	40.83	-55.05	73.33	35.00	-52.27	72.50	39.17	-45.98	24.17	12.50	-48.28
	Under dose	0.00	0.00	0.00	0.00	7.50	100.00	0.00	4.17	100.00	55.83	54.17	-2.99
Non-FFS (n=120)	Recommended	10.83	20.00	84.62	29.17	30.00	2.86	40.83	30.83	-24.49	17.50	12.50	-28.57
	Over dose	89.17	80.00	-10.28	61.11	51.67	-27.06	59.17	57.50	-2.82	21.67	5.83	-73.08
	Under dose	0.00	0.00	0.00	0.00	18.33	100.00	0.00	11.67	100.00	60.83	81.67	34.25

The results in the Table 1 revealed an alarming status of application of nitrogen, phosphorus and potassium among both the farmers during pre-FFS period. The reason for this situation was lack of knowledge and moreover the framers believed that more application of fertilizers would lead to more yields (Sabur and Molla, 2001). However, they were not aware of the fact that any increased application of fertilizers at higher pace would result in increased pest attack.

Frequency of pesticide application by FFS and non-FFS farmers

The major problems faced by the farmers in paddy cultivation were high incidence of pests (brown plant hopper, stem borer, gall midge and leaf folder), diseases (rice blast, sheath blight and false smut) and weeds (*Echinochloa colona* and *E. crus-galli*) from the early stage of the crop. In general farmers use high amount of pesticides to control these pests. The data in Table 2 and Fig. 1 reveal that during pre-FFS period, total number of sprays for control of these insect pests, diseases and weeds ranged from 4 to 11 with an average of 8.62 sprays among FFS and 8.48 among non-FFS farmers. More than 90.00 per cent of the FFS farmers had over dose of pesticide sprays that were 8 (34.17 %), 9 (43.33 %), 10 (9.17 %) and 11 (5.00%) sprays for one crop season. The average number of pesticide sprays during pre-FFS period was less or more similar among both the farmers. However, after training under FFS methodology, there was a significant reduction in the total number of pesticide sprays given by FFS farmers during post-FFS period when compared to pre-FFS period.

The average number of pesticides sprays during post FFS period was reduced to 5.81 from 8.62 sprays among FFS farmers. In case of non-FFS farmers, the number of pesticides sprays (8.25) was almost similar to pre-FFS period without any considerable difference. Thus, there was a significant level of reduction in application of pesticides in case of FFS farmers during post-FFS period when compared to the level of pesticide application during pre-FFS period. However, in case of non-FFS famers there was no significant difference appeared as revealed by C2 values (2.81).

Table 2. Frequency of pesticide spray by FFS and Non-FFS farmers

Number of sprays	Per cent of FFS Farmers (n=120)		Level of significance	per cent of Non-FFS Farmers (n=120)		Level of significance
	Pre	Post	χ^2	Pre	Post	χ^2
4 and below	0.00	6.67	41.62**	0.00	0.00	2.81 NS
5	1.67	35.00		5.00	6.67	
6	3.33	31.67		2.50	4.17	
7	3.33	24.17		5.83	8.33	
8	34.17	2.50		30.83	30.00	
9	43.33	0.00		40.83	42.50	
10	9.17	0.00		11.67	5.83	
11	5.00	0.00		3.33	2.50	
>11	0.00	0.00		0.00	0.00	
Average	8.62	5.81		8.48	8.25	

**= Highly Significant; NS= non-Significant

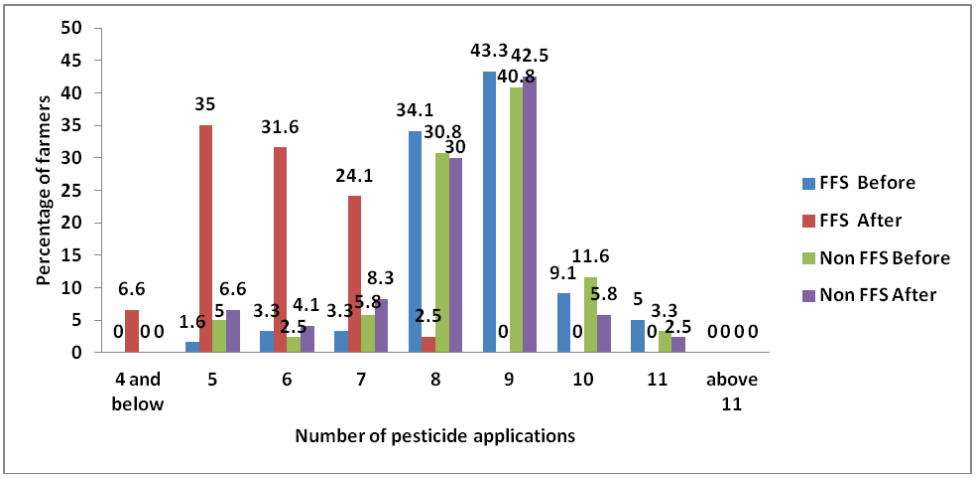


Fig. 1. Frequency of pesticide spray by FFS and Non-FFS farmers

This indicates participation of farmers in FFS has enabled them to apply appropriate pesticides.

The investigation has shown that participation of the farmers in FFS had helped them to apply right amount of pesticides by understanding the ratio of pests and beneficial insects in the field, predict the insect population dynamics based on climate, economic threshold levels which has resulted in significant reduction of overuse of pesticides during post-FFS period (Mancini et al., 2007). Further, they had discussion with the other participants of the programme. These all helped them to take appropriate decision concerning in use of right quantity of pesticides.

In case of non- FFS farmers, due to the lack of knowledge on use of pesticide and its consequences and survival of beneficial insects lead them towards rigorous application of pesticides irrespective of the stage of the pest or condition of the crop. The reduction of pesticide usage due to participation in FFS has been reported by several studies (Rola et al., 2002). Before enrolling in the FFS, according to Resosudarmo and Yamazaki (2011), farmers thought that most of the insects in the field

including beneficial as pests that therefore should be killed. After training under the FFS, farmers realised that there were some harmless insects and some were beneficial insects prevailed in the field. They knew that some of the beneficial insects act as predators for harmful insects that they should be conserved. Damalas and Koutroubas (2017) had found in their study that majority of the trained farmers had expressed higher levels of knowledge of pesticide application than non-trained farmers. Further, farmers understood that there is an economic threshold of pest population, below which the pests would not have any significant impact on the crop yields where the application of pesticides are not needed to control the pest.

Impact of FFS on input use and cost savings in paddy

The data in Table 3 show that FFS farmers reduced inorganic fertilizers and pesticides while scaling up the organic manures. Conversely, in the case of non-FFS farmers, reduction was high in organic fertilizers and low in inorganic fertilizers. Further, the data show that FFS farmers had incurred 19.5 per cent increase of cost over previous but this is due to the increase of prices on chemicals as years gone by. Whereas, non-FFS farmers incurred an increase of 50.29 per cent. This indicates that non-FFS farmers had incurred more cost the than FFS participant in case of fertilizers and pesticides.

Saving of cost was experienced among FFS farmers than non-FFS farmers mainly due to reduction in indiscriminate use of fertilizers and pesticides which intern increase the yield and income of the farmers (Debbarma and Ram Singh, 2012). After FFS, higher number of FFS farmers applied recommended quantity of fertilizers. The application of N, P and K per hectare in case of non-FFS farmers was much higher than that of FFS farmers. Several studies have shown the increased use of balanced fertilizers and proper nitrogen application due to FFS. The changed behaviour among FFS farmers was mainly due to experiential, participatory learning experienced including the

Table 3. Impact of FFS on Input use and cost savings in paddy: A comprehensive analysis between FFS and Non-FFS farmers

Fertilizers	Physical Units (ha^{-1})	Standard dose (ha^{-1})	FFS (n=120)						non-FFS (n=120)					
			Pre-FFS period		Post-FFS period		% of increase		Pre-FFS period		Post -FFS period		% of increase	
			Qty	Cost (Rs)	Qty	Cost (Rs)	Qty	Cost (Rs)	Qty	Cost (Rs)	Qty	Cost (Rs)	Qty	Cost (Rs)
N	kg	90	254	1129	143.2	1115	-43.67	-1.23	251.2	1133	185.3	1366	-26.25	20.59
P	kg	60	113	4511	57.36	6597	-49.13	46.24	108.9	4355	81.21	9339	-25.41	114.44
K	kg	60	79.9	599	42.17	1406	-47.2	134.7	79.83	599	67.42	2247	-15.54	275.37
Zn	kg	50	80.7	613	58.99	707.9	-26.94	15.44	76.61	592	80.73	968.7	5.378	63.63
Granules	kg	Varies based on pest incidence	3.81	114	3.63	217.6	-4.79	90.43	4.14	124	5.33	319.9	28.71	157.42
Chemical pesticide	l	Varies based on pest incidence	5.49	4956	3.52	4054	-35.97	-18.2	5.22	4720	4.75	5373	-8.89	13.83
Total cost				14737		17610		19.5		14288		21473		50.29
Organic Fertilisers. FYM	't'	3	3.13	2815	3.35	3513	6.97	24.8	3.07	2765	1.77	1859	-42.37	-32.76

effect of demonstration plots, which enabled farmers to observe benefits (Pontius et al., 2002). The FFS methodology uplifted the farmers with skills and confidence to take up different growing techniques (recommended fertilization) and change the mix of inputs used on their farms.

Thus, involvement of the farmer in FFS helped them to have deeper understanding of agro-ecological system which enhance their confidence to adopt the ICM practices in terms of proper use of fertilizers, pesticides and organic manures. Proper application of fertilizers and pesticides saves farmers' money, conserves natural enemies, reduces the potential causes for environmental problems and reduces pesticide resistant over the insects (Samantaray and Mohapatra, 2008). Hence, the study clearly shown that FFS as an effective methodology to teach complex practices such as Integrated Pest Management practices. Since its adoption, the concept of Farmers Field Schools is being taken up in all the districts of Andhra Pradesh at large scale even today for the benefit of the farming community.

CONCLUSION

The results of the investigation show that the FFS has helped the participating farmers in adopting recommended dose of inorganic fertilizers and organic manures. There was a significant reduction among FFS famers in the use of pesticides spray applications in controlling insect pests, diseases and weeds. Over use or misuse of both fertilizers and pesticides can foul land and water when they are caused to run off fields as an undesirable impact on environment. By opting FFS methodology, farmers can able to get sustainable income at longer periods as most of the expenditure, the farmers spend on applying chemical fertilizers and pesticides.

REFERENCES

Aktar, M.W., Sengupta, D. and Chowdhury, A. 2009. Impact of pesticides use in agriculture: their benefits and hazards. *Interdiscip. Toxicol*. **2**(1):1-12.

Behera, M.P., Sahoo, J., Behera, B. and Mishra, G.C. 2015. Effect of S, Zn, B, FYM on yield and economics of rice (*Oryza sativa*) under rainfed ecosystem of coastal Odisha. *e-planet* **6** (2): 45-50.

Damalas, C.A. and Koutroubas, S.D. 2017. Farmers' training on pesticide use is associated with elevated safety behavior. *Toxics*. **5**(3): 19.

Debbarma, B. and Ram Singh. 2012. A case study of resource conserving method of system of rice intensification (SRI) in Tripura: an economic analysis. *e-planet* **10** (2): 43 – 47

Ecobichon, D.J. 2001. Pesticide use in developing countries. *Toxicology* **160** (1):27-33

Kenmore, P.E. 1996. Integrated Pest Management in rice. In: G.J. Persley (Ed.), *Biotechnology and Integrated Pest Management*. Wallingford, UK: CAB International. pp 76-77.

Mancini, F., Bruggen, A.V., and Jiggins, L. 2007. Evaluating cotton integrated pest management (IPM) farmer field school outcomes using the sustainable livelihoods approach in India. *Exp. Agric.* **43** (1): 97-112

Peshin, R. 2021. Impact of integrated pest management programmes on pesticide use in indian agriculture. *Indian J. Entomol*. **83**(1) 141-148.

Pontius, J., Dilts, R. and Bartlett, A. 2002. *From Farmers' Field Schools to community IPM. Ten years of IPM training in Asia*. FAO, Regional Office for Asia and the Pacific, Bangkok.

Resosudarmo, B. and Yamazaki, S. 2011. *Training and Visit (T&V) extension vs. Farmers' Field School: the Indonesian experience*. Crawford School Research Paper.

Rola, A.C., Jamias, S.B. and Quizon, J.B. 2002. Do Farmers' Field School graduates retain and share what they learn? An investigation in Iloilo, Philippines. In: *International learning workshop on Farmers' Field Schools: Emerging issues and challenges*, Yogyakarta, Indonesia.

Sabur, S.A. and Molla, A.R. 2001. Pesticide use, its impact on crop production and evaluation of IPM technologies in Bangladesh. *Bangladesh J. Agric. Econ.* **20** (1,2): 21-38.

Samantaray, B.R. and Mohapatra, S.C. 2008. Role of Krishi Vigyan Kendra in changing the profile of rural folks of Subarnapur district, Orissa. *e-planet* **6**: 42-44.

Schreinemachers, P. and Prasnee, T. 2012. Agricultural pesticides and land use intensification in high, middle and low income countries. *Food Policy* **37**: 616-626

Van den Berg, H., Ooi, P.A., Hakim, A.L., Ariawan, H. and Cahyana, W. 2004. *Farmer field research: An analysis of experiences in Indonesia*. FAO Regional Office for Asia and the Pacific.

e-planet **20** (1): 20-23 (June 2022)

Effect of herbicides on weed control and grain yield of wheat in Kabul, Afghanistan

N.M. INQILAABI[1*] AND A.Y. AHMADI[2]

[1*]*Department of Agronomy, Faculty of Agriculture, Paktia University, Paktia, Afghanistan*

[2]*Department of Agronomy, Faculty of Agriculture Shaikh Zayed University, Khost, Afghanistan*

[*]*niazmohammad5194@gmail.com*

Date of receipt: 25.11.2021 Date of acceptance: 03.05.2022

ABSTRACT

The field experiment was conducted at the Research Farm, Agronomy Department of Kabul University, Kabul, Afghanistan, to study the efficacy of two different herbicides 2, 4-D and MCPA for weed control and grain yield of wheat during 2019-20. The experiment was laid out in randomized block design with four treatments such as weed free, weedy check, 2,4-D @1 kg ha^{-1} and MCPA@ 1 kg ha^{-1}, replicated five times. The soil of the experimental field was sandy loam with low organic matter and available nitrogen, medium in available potassium, but low in available phosphorus. Soil pH and EC were 8.2 and 0.16 dSm^{-1}, respectively. 2, 4-D herbicide was applied at tillering (3-5 leaves) stage, whereas, the MCPA herbicide was also applied at tillering (3-5 leaves) stage. Urea granules (46% N) and DAP (18% N, 46% P_2O_5) were used for supplying 120 kg N and 60 kg P_2O_5 ha^{-1}. One third N and full dose of P_2O_5 were applied as plough sole placement before sowing. The urea granules (46% N) were applied as 1/3 at the jointing stage and remaining 1/3 at the anthesis stage. The seeds of wheat cultivar Kabul 013 were sown in furrows spaced at 25 cm with the help of had seed drill at the rate of 110 kg seed ha^{-1} on 12th November in the year 2019. Five irrigations were given, the first irrigation was performed after sowing, second irrigation was conducted 20 days after the first irrigation, in order to prevent crust establishment, third at booting stage, fourth at flowering stage, and final irrigation at the soft dough stage, with the help of tube well, coinciding with the critical stages of the growth of wheat crop. Results revealed that 2, 4-D was effective to control weed population and produced a higher number of effective tillers, 1000 grain weight and enhanced the yield up to 43.1% over weedy check.

Key words: Grain yield, herbicides, weed control efficiency, weed density and biomass

INTRODUCTION

Wheat (*Triticum aestivum* L.) is one of the most important cereals and is grown extensively throughout the world. It is the main staple food and largest grain crop of Afghanistan. The area of wheat cultivation in Afghanistan is more than 2.00 million hectares with an average yield of 3.60 million tons (Ahmadi et al., 2021). Regardless of all the other ways of crop yield enhancement, weed control is one of the important key factors in crop yield improvement particularly in Kabul Province to cope with the annual weed population blast. Weeds compete with crops for available moisture, nutrients, space, and light and provide shelter for harmful insect-pests which result in yield reduction (Prasad et al., 2019). Weeds cause yield reduction up to 15-50 per cent depending upon the weed density and weed flora (Jat et al., 2003). Jan and How (2013) reported that weeds reduced wheat production more than 30% in Northern provinces of Afghanistan. Weeds not only

reduce yield but also lower the quality of the produce and increase the cost of harvesting, threshing and cleaning. Apart from improved agronomic practices and plant protection measures, chemical weed control is one of the important key factors to enhance wheat production and productivity. Most of the small, medium and large farmers in Afghanistan are well aware about integrated weed control strategies, even though chemical weed control measures have a prominent place. Therefore, proper selection of herbicide and time of application remains the only resort to check weed population and to improve crop yield. Herbicidal treatments increased grain yield as compared with un-weeded and hand weeding treatments (Amin et al., 2008). But as a part of rat-race among each other, the farmers use excessive chemicals which not only pollute the environment but hazardous human health too. That's why choice of best herbicide and time of application are the important considerations for lucrative returns (Prasad et al., 2019). Keeping in view the importance of the weeds problem in wheat, this study was undertaken to investigate the effectiveness of different herbicides for controlling the weeds in wheat crops.

MATERIALS AND METHODS

The experiment was conducted at Research Farm, Agronomy Department of Kabul University Kabul, Afghanistan during rabi season of 2019-20. Kabul is located at 34° 54' 44.1" N latitude and 70° 10' 9.2" longitudes and altitude 1791 m (5876 Ft) above sea level. The climate of the experimental site in Kabul is cold in winter, with an average temperature in January of -1°C, usually freezing nights and with possible peaks of -20 to -25°C. Snowfalls are fairly frequent and sometimes heavy. Summer is hot during the day but nights remain usually cool. Precipitation in Kabul is 300 mm per year. The rainiest season is spring. In the summer it rarely rains. The soil of the experimental site was sandy loam having pH 8.2, low in organic carbon (0.91%), low available N (150.5 kg ha^{-1}), low available P (150 kg ha^{-1}) and high available K (273 kg ha^{-1}). The seeds of wheat cultivar Kabul 013 was sown in furrows spaced at 25 cm with the help of hand seed drill at the rate of 110 kg seed per hectare on 12th November in the year 2019. The experiment was laid out in randomized block design with four treatments such as weed free, weedy check, 2,4-D 1 kg ha^{-1}, MCPA 1 kg ha^{-1} and replicated thrice. Herbicides were applied with a knapsack sprayer. 2, 4-D and MCPA were applied as post- emergence at tillering (3-5 Leaves) stage. The weed density and dry weight of broad-leaf weeds were analyzed using transformation of square root i.e., ($\sqrt{x+1}$), before carrying out analysis of variance and comparison were made on transformed values.

RESULTS AND DISCUSSION

The data recorded on weed density (number m^{-2}), weed dry matter (g m^{-2}), weed control efficiency (%), effective tillers (number m^{-2}), test weight (g), straw yield (t ha^{-1}) and grain yield (t ha^{-1}) were significantly affected by different herbicides treatments.

Effect on weeds

The density and dry matter of broad-leaved weeds decreased significantly as compared to weedy check. The decline in weed density and weed dry matter was owed to withering of weeds (Table 1). Removing the weeds whenever they appear under the weed free treatment resulted in complete elimination of weed competition as it resulted in lowest total weed dry weight. Among post-emergence herbicide treated plots, the maximum reduction of broad weeds was observed with the application of 2, 4-D followed by MCPA.

The highest weed population and dry matter was observed in weedy check. The results are in line with those of Walia et al. (2012). The weed control efficiency among the weed control management practices ranged from 72.8 to 100%. The highest weed control efficiency was found in weed free plots followed by 2, 4-D (76.9%). The lowest weed control efficiency (72.8%) was recorded in MCPA plots (Table 2).

Effect on crop

Grain and straw yield differed significantly due to different weed control treatments (Table 4). Weed control treatments registered significantly higher grain and straw yield than weedy check.

Table 1. Effect of different weed control treatments on population (number m^{-2}) and dry matter of broad- leaved weeds (g m^{-2}) in wheat

Treatments	Broad leaved weeds			Dry weight of broad-leaved weeds		
	120 DAS	150 DAS	At harvest	120 DAS	150 DAS	At harvest
Weed free	1(0)	1(0)	1(0)	1(0)	1(0)	1(0)
Weedy check	8.7(79.7)	8.7(75.6)	8.3(68.4)	4.4(18.4)	7.8(60.3)	16.5(273.1)
2,4-D	8.7(75.2)	2.5(4.31)	2.5(5.73)	4.1(16.4)	4.7(21.1)	9.9(98.7)
MCPA	8.8(77.2)	2.5(5.26)	2.5(5.11)	4.3(17.5)	4.6(20.8)	10.1(101.1)
LSD(p=0.05)	1.63	0.46	0.44	2.3	1.9	1.3

Original data given in parenthesis was subjected to square root (+1) transformation before analysis.

Table 2. Effect of different weed control treatments on weed control efficiency (%) in wheat

Treatments	Weed control efficiency (%)
Weed free	100
Weedy check	-
2,4-D	76.9
MCPA	72.8

Table 3. Effect of different weed control treatments on effective tillers (number m^{-2}) and test weight (g), grain yield (t ha^{-1}) and straw yield (t ha^{-1}) of wheat

Treatments	Effective tillers per m^2	Test weight (g)	Grain Yield (t ha^{-1})	Straw Yield (t ha^{-1})
Weed free	406.4	38.7	5.88	9.19
Weedy check	347.2	34.4	3.63	6.77
MCPA	365.9	36.9	4.40	7.50
2,4-D	383.7	37.4	5.07	8.23
LSD (p=0.05)	16.02	2.80	0.35	0.42

The higher grain and straw yield were recorded with application of 2, 4-D (5.07 and 8.23 t ha^{-1}), respectively compared to MCPA (4.40 and 7.50 t ha^{-1}, respectively). The higher grain and straw yield in these treatments is mainly due to better control of weeds and higher weed control efficiency during early stage of crop growth which resulted in effective utilization of resources such as nutrients, moisture, space and light resulted in better expression of yield components i.e., number of effective tillers per m^2 (383.7 and 365.9, respectively) and the test weight (37.4 g and 36.9 g, respectively. Whereas, lower grain and straw yield was recorded with weedy check (3.63 and 6.77 t ha^{-1}, respectively) owing to severe crop weed competition which resulted in reduction in the expression of yield components such as effective tillers per m^2 (347.2). It was further observed that the lowest test weight (36.9 g) was obtained from MCPA followed by 2,4-D (37.4 g) treated plots, which was statistically equal to the weedy check plots which in turn was statistically lower with the remaining herbicidal treatments. These results are in conformity with the findings of Ali et al. (2004), Chemma et al. (2006), Hussain et al. (2013), and Khalil et al. (2013).

CONCLUSION

On the basis of these results, it can be concluded that application of 2, 4-D as post-emergence is the best weed management practice

in wheat under Kabul agro climate to obtain higher yield and its components. Additional studies should be conducted on 2, 4 –D and MCPA applications to study the duration of its effects on environment and economic benefits for soils fertility and crops.

REFERENCES

Ahiya, K.N. and Yaduraju, N.T. 1991. Optimizing isoproturon application in relation to first irrigation in wheat (*Triticum aestivum*). *Indian J. Agron.* **36** (4): 492-495.

Ahmadi, A.Y., Salari, M.W., Arian, M.J. and Mosawer, A. 2021. Effects of seed density on grain yield and agronomic traits of wheat (*Triticum aestivum* L.) under Kabul and Khost Agro-Ecological conditions, Afghanistan. *Int. J. Sci. Res. Biol. Sci.* **8**(2): 24-30.

Ali, M., Sabir, S., Mohy-ud-Din, Q. and Ali, M.A. 2004. Efficacy and economics of different herbicides against narrow leaved weeds in wheat. *Int. J. Agric. Biol*. **6**(4): 647-651.

Amin, A., Khan, M.A., Hassan, G., Marwat, K.B., Rashid, H. and Nawab, K. 2008. Weed control efficacy and economics of pre-emergence herbicides in maize (*Zea mays* L.). *Asian Australas. J. Plant Sci. Biotechnol.* **2**(2): 72-75.

Baghestani, M.A., Zand, E., Soufizadeh, S., Mir-vakili, M. and Jaafarzadeh, N. 2007. Response of winter wheat (*Triticum aestivum* L.) and weeds to tank mixtures of 2, 4-D plus MCPA with clo-dinafop propargyl. *Weed Biol. Manage.* **7**: 209–218.

Cabrera, A., Cox, L., Spokas, K.A., Celis, R., Hermosı ´n, M.C., Cornejo, J. and Koskinen, W.C. 2011. Comparative sorption and leaching study of the herbicides fluometuron and 4-chloro-2-methylphenoxyacetic acid (MCPA) in a soil amended with biochars and other sorbents. *J. Agric. Food Chem.* **59**: 12550–12560.

Cheema, M.S., Akhtar, S. and Iqbal, M.S. 2006. Performance of different herbicides in wheat under irrigated conditions of southern Punjab, *Pakistan. Pakistan J. Weed Sci. Res.* **12**(1-2): 53-59.

Curdy, E.V. and Molberg, E.S. 1974. Effect of the continuous use of 2,4-D and MCPA on spring wheat production and weed population. *Can. J. Plant Sci.* **54**: 241-245.

Deshi, J.S. 1970. Control of weeds in wheat with 2, 4-D. *Indian J. Agron.* **15**: 408-409.

Dixit, A. and Bhan, V.M. 1997. Weed control efficacy of isoproturon applied at different concentration and its combination with 2, 4-D in wheat. *Indian J. Weed Sci.* **29** (142): 11-14.

Hu, J., Yang, T., Yin, S. and Cao, D. 2012. Dissipation and residue of MCPA (4-chloro-2-ethylphenoxy-acetate) in wheat and soil. *Environ. Monit. Assess.* **184**: 5017–5024.

Hussain, Z., Marwat, K.H., Munsif, F., Samad, A. and Ali, K. 2013. Evaluation of various herbicides and their combinations for weed control in wheat crop. *Pakistan J. Bot.* **45**(1): 55-59.

Jan, A. and How, P. 2013. Weed control trainings for agricultural stakeholders is increasing wheat productivity in Northern Afghanistan. https://www.jdainternational.org

Jat, R.S., Nepalia, V. and Chaudhary, P.D. 2003. Influence of herbicide and methods of sowing on weed dynamics in wheat (*Triticum aestivum*). *Indian J. Weed Sci.* **35**: 18-20.

Khalil, M.F., Hussan, G., Ahmad, G., Anwar, S. and Khan, S. 2013. Comparative efficacy of herbicides on yield and yield components of wheat (*Triticum aestivum*). *APRN J. Agric. Biol. Sci.* **8**(1): 76-80.

Miteva, L., Ivanov, S. and Alexieva, V. 2003. Comparative effect of 2,4-D on the glutathione levels, glutathione-s-transferase and glutathione reductase activity in pea (*Pisum sativum* L.) and wheat (*Triticum aestivum* L.). *C. R. Acad. Bulg. Sci.* **56**: 53-58.

Prasad, S.M., Saha, S., Chourasia, M., Sarangi, D.R., Sahoo, T.R., Sethy, S. and Mohanta, R.K. 2019. Effect of integrated weed management in rainfed upland rice of Odisha. *e-planet* **17** (2): 106-110.

Shaktawat, M.S. 1986. Efficacy of herbicides for weed control in wheat. *Indian J. Weed Sci.* **17** (3): 46-49.

Sohail, N.1993. *Efficacy of weedicides to control broadleaf weeds in wheat.* M. Sc. Hons. Agric. Thesis, Dept. of Agronomy, University of Agriculture, Faisalabad, Pakistan.

Walia, U.S., Walia, S.S., Sidhu, A.S. and Nayyar, S. 2012. Bioefficacy of pre-and post-emergence herbicides in direct-seeded rice in Central Punjab. *Indian J. Weed Sci.* **44**(1): 30-33.

e-planet **20** (1): 24-32 (June 2022)

Effect of plant density and drip emitters on yield parameters in banana cv. Grand Naine

A.W. AMIRI*, M.Y. AMINI, A.S. ALUR, M. HEGDE, G.S.K. SWAMY AND H. KULAPATI

Department of Fruit Science, University of Horticultural Sciences, Bagalkote, Udyanagiri - 587 104, Karnataka, India

**wasiamiri_08@yahoo.com*

Date of receipt: 04.12.2021 Date of acceptance: 03.05.2022

ABSTRACT

An experiment was conducted during 2018-19 and 2019-20 at Horticultural Research Station, University of Agricultural Sciences, Bengaluru to study the effect of varied plant densities and different placement of drip emitters on yield, post-harvest and quality parameters in banana cv. Grand Naine. The experiment was laid out in factorial RCBD design with three varied plant densities S1 (1.5 × 1.5 m), S2 (1.8 × 1.8 m) and S3 (2 × 2 m) and four different placement of emitters E1 (placement of emitters at plain), E2 (placement of emitters at 40 cm), E3 (placement of emitters at 50 cm) and E4 (placement of emitters at 60 cm) with three replications. The results of the experiment clearly indicated that the highest yield (79.37, 86.48 tons ha^{-1}) was registered in treatment (S1, E2 respectively) and the lowest yield (51.35, 54.33 tons ha^{-1}) was observed in treatment (S3, E1 respectively) in main crop. Postharvest parameters like pulp weight (82.15 g, 104.53 g), pulp to peel ratio (1.83, 2.50) and shelf life (8.19, 8.52 days) was registered highest and peel weight was found lowest (46.00 g, 42.04 g) in treatment (S3, E2 respectively) in main crop. The highest quality parameters viz., total sugar (19.56, 19.54 %), reducing sugar (16.96, 16.59 %), non-reducing sugar (2.70, 2.75 %) and total soluble solid (23.11, 23.37 ^{o}Brix) was recorded highest in treatment (S3, E2 respectively) in main crop. The similar trend of post-harvest and quality parameters was found in ratoon crop also. However, the lowest postharvest and quality parameter was observed in treatment (S1, E1) in plant and ratoon crop respectively.

Key words: cv. Grand Naine, emitters, plant density, post-harvest

INTRODUCTION

Banana has emerged as the major cash subsistence crop across the world and it is grown in almost all parts of the world especially in the tropical regions. In the world of fruits, banana is a complete food fruit packed with all the necessary energy and health-giving elements (Anon, 1969). On account of these properties combined with delicious taste and flavor, it is in great demand in fresh as well as processed form all over the world and has gained commercial popularity in the international fruit trade (Thomas et al., 1968). Banana is botanically a herb, where training and pruning response is not applicable. Hence, alternative technologies to improve the productivity of banana are main concerns of present researchers. High density planting (HDP) as an intensive system of cultivation in banana not only provides high production and net returns but also facilitates efficient utilization of solar energy, nutrients and water (Apshara and Sathiamoorthy, 2003). A closer spacing can be adopted under good management conditions using micro irrigation and fertigation techniques. Drip irrigation in banana plantations has helped in saving water and offers a great promise, owing to precise and direct application of water in the root zone of plants (Shashidhara et al., 2007). In addition, due to higher frequency of irrigation, ensuring availability

of moisture at critical crop growth stages saves the plants from moisture stress throughout the growing period (Dahiwalkar et al., 2004). The other issue related to drip irrigation is its economic viability and the farmers are often reluctant to adopt this method due to their weak resource base.

MATERIALS AND METHODS

The present study was conducted during 2018-19 and 2019-20 at Horticultural Research Station, University of Agricultural Sciences (UAS), Bengaluru. The main objective of the study was to identify the optimum yield, post-harvest and quality parameters under varied plant densities and different placement of emitters in banana *cv.* Grand Naine. The investigation was carried out by planting tissue cultured banana plants at 3 varied plant densities *viz.,* S_1 (1.5 × 1.5 m), S_2 (1.8 × 1.8 m) and S_3 (2.0 × 2.0 m) and 4 different placement of emitters E_1 (Placement of emitters at plain), E_2 (Placement of emitters at 40 cm), E_3 (Placement of emitters at 50 cm) and E_4 (Placement of emitters at 60 cm) with 3 replications. The treatments were imposed in the month of September 2018. Fertilizer application schedule followed with a dose of 200:100:300 g NPK (Urea, P_2O_5 and K_2O) per plant as per the package of practice of UAS, Bengaluru recommended for tissue cultured banana (Anon, 2017). A drip irrigation system was installed at the experimental site with different placement of emitters. The emitters' water discharge rate was 4 liters per hour.

Geographical location of the experiment site

The research was carried at Horticulture Research Station, UAS, GKVK, Bengaluru. The research station is situated at 12°58′ North latitude and 77°35′ East longitude, at an altitude of 930 m above mean sea level.

Climate and weather condition

Bengaluru has a tropical savanna climate with distinct wet and dry seasons. Due to its high elevation, Bangalore usually enjoys a more moderate climate throughout the year. The UAS, GKVK Bengaluru annual rainfall ranges from 528 mm to 1374.4 mm with the mean of 915.8 mm. The mean maximum temperature during the period of experimentation was 29.5°C while the mean minimum temperature during the same period was 18.2°C with relative humidity ranging from 48-89 per cent. The average rainfall during the period of experimentation was 867.9 mm. The weather data recorded during the crop growth period from September 2018 to November 2020 were collected from meteorological station of ZARS, UAS, GKVK, Bengaluru.

Soil characteristics of the experimental site

Soil of the experimental area is medium red sandy loam with acidic pH ranging from 5.33 to 6.20 and poor in organic content. Before the imposition of the treatments, a composite soil sample from the experimental site was collected at 0-30 cm depth. The soil sample was air dried, powdered, passed through 2 mm sieve and analyzed for chemical properties. The soil of experimental plot was acidic in nature with pH 6.10, Electric Conductivity (EC) 239 dSm^{-1} and available nitrogen 137.98 kg per hectare, available phosphorus (P_2O_5) 13.96 kg per hectare, available potassium (K_2O) 130.32 kg per hectare.

The treatment details are furnished as below.

T_1 (S_1E_1) 1.5 × 1.5 m + Emitters Placement at 0 cm (plain)
T_2 (S_1E_2) 1.5 × 1.5 m + Emitters Placement at 40 cm
T_3 (S_1E_3) 1.5 × 1.5 m + Emitters Placement at 50 cm
T_4 (S_1E_4) 1.5 × 1.5 m + Emitters Placement at 60 cm
T_5 (S_2E_1) 1.8 × 1.8 m + Emitters Placement at 0 cm (plain)
T_6 (S_2E_2) 1.8 × 1.8 m + Emitters Placement at 40 cm
T_7 (S_2E_3) 1.8 × 1.8 m + Emitters Placement at 50 cm
T_8 (S_2E_4) 1.8 × 1.8 m + Emitters Placement at 60 cm
T_9 (S_3E_1) 2 × 2 m + Emitters Placement at 0 cm (plain)
T_{10} (S_3E_2) 2 × 2 m + Emitters Placement at 40 cm
T_{11} (S_3E_3) 2 × 2 m + Emitters Placement at 50 cm
T_{12} (S_3E_4) 2 × 2 m + Emitters Placement at 60 cm

*Plain: Beside the plant

Observations recorded

The pits or hills were selected randomly from each treatment for observation. Six uniformly growing plants were selected randomly in each treatment. The observations recording and mean values were computed. The following biometrical observations were made at different stages of crop

growth viz., 3rd MAP (Month After Planting), 5th MAP and 7th MAP and at shooting stage. Whereas yield, post-harvest and quality parameters were recorded after harvest of the bunch. The following observations were recorded.

Yield per hectare (t ha^{-1})

The plant yield was calculated by multiplying the yield per plant with the total number of plants per hectare and expressed in tonnes per hectare.

Post-harvest attributes

Fruit characters were recorded after harvest at ripe stage for parameters like final fruit pulp weight, peel weight, pulp to peel ratio.

Pulp weight at ripe stage (g)

Pulp weight of ripened fruit weighed after removing the peel by digital electronic weighing balance and mean weight was recorded and expressed in grams.

Peel weight at ripe stage

Peel weight of representative ripened fruit was weighed by using digital electronic weighing balance and mean weight was recorded and expressed in grams.

Pulp to peel ratio at ripe stage

The fruit weight, pulp weight and peel weight were recorded from two ripened fruits and pulp to peel ratio was worked out by dividing the pulp weight of the fruit by the peel weight of the fruit and was expressed in number.

Shelf life (days)

Shelf life of fruits was decided based on the appearance and marketability of the fruits. When the fruits attained beyond edible ripe stage (without spoilage), then those fruits were considered to have reached the end of their shelf life. It was expressed in number of days.

Fruit quality analysis

The quality parameters such as total soluble solids, total sugars, reducing and non-reducing were recorded after harvest from two randomly selected fruits from all the treatments. These fruits were assessed for determining the various biochemical parameters.

Total soluble solids (°Brix)

The total soluble solids were recorded at ripe stage. The fruit juice was extracted from pulp of selected fruits through muslin cloth and TSS was determined by using Atago and Hanna (HI 96801) digital hand refractometer (0-32 °Brix) replicated two times and mean was expressed in °Brix.

Reducing sugar (%)

Reducing sugar of juice selected fingers was estimated by Fehling's solution method. Five gram of pulp was homogenized with 25 – 50 ml distilled water in a 50 ml test tube and volume made up to 100 ml with distilled water. The solution was then filtered through Whatman No. 1 filter paper and the filtrate was used for analysis. The values obtained were expressed in percentage.

Calculation

$$\text{Reducing sugar} = \frac{\text{Factor} \times \text{volume made up}}{\text{Titre value} \times \text{Weight of sample}} \times 100$$

Total sugars (%)

The total sugar of juice was estimated by following the procedure used for reducing sugar. 25 ml of the filtrate (prepared for reducing sugar estimation) was hydrolyzed with 10 ml of 1:1 HCL at room temperature for 24 hours. All the sugars present in the sample were now converted to reducing sugar. The hydrolyzed sample was neutralized with 20 per cent NaOH and the volume was make up to 100 ml with distilled water. The prepared volume was used for analysis and values obtained were expressed in percentage.

Calculation

$$\text{Total sugar (\%)} = \frac{4 \times \text{Factor} \times \text{volume made up}}{\text{Titre value} \times \text{Weight of sample}} \times 100$$

Non-reducing sugars (%)

The percentage of non-reducing sugars was obtained by subtracting the percentage of reducing sugars from the total sugar and expressed in percentage.

Non-reducing sugar (%) = Total sugars – Reducing sugar

RESULTS AND DISCUSSION

Significant difference was registered among the treatments with varied plant densities and different placement of emitters on yield per hectare in both plant and ratoon crop (Table 1). The highest yield per hectare was obtained in the main crop (79.37 t ha^{-1}), ratoon crop (77.75 ha^{-1}) and cumulative yield (78.56 t ha^{-1}) in high plant density S1 (1.5 x 1.5 m^2). However, the lowest yield in main crop (51.35 t ha^{-1}), ratoon crop (46.42 t ha^{-1}) and cumulative yield (48.89 t ha^{-1}) was registered in low plant density S3 (2 × 2 m^2). With regard to placement of emitters the yield was found significantly highest in main crop (86.48 t ha^{-1}), ratoon crop (73.72 t ha^{-1}) and cumulative yield (80.10 t ha^{-1}) with E2 (Placement of emitters at 40 cm) and lowest yield per hectare was obtained in main crop (54.33 t ha^{-1}), ratoon crop (51.43 t ha^{-1}) and cumulative yield (52.88 t ha^{-1}) in E1 (placement of emitters at plain).

The highest post-harvest parameters viz., pulp weight (82.15 g, 80.45 g), pulp to peel ratio (1.83, 1.89), shelf life (8.19 days, 7.71 days) and lowest peel weight (46.00 g, 43.86 g) were registered in low plant density S3 (2 × 2 m) in main and ratoon crop respectively. However, the lowest post-harvest parameters like pulp weight (70.78 g, 68.02 g), pulp to peel ratio (1.45, 1.45), shelf life (6.87 days, 6.74 days) and highest peel weight (49.73 g, 47.96 g) were observed in S1 (1.5 × 1.5 m) in main and ratoon crop respectively. Among the placement of emitters, E2 (Emitters' placement at 40 cm) registered the highest pulp weight (104.53 g, 101.57 g), pulp to peel ratio (2.50, 2.54), shelf life (8.52 days, 7.63 days) and lowest peel weight (42.04 g, 40.05 g). Whereas the lowest pulp weight (59.16 g, 58.07 g), pulp to peel ratio (1.15, 1.12), shelf life (6.71 days, 6.70 days) and the highest peel weight (53.33 g, 51.51 g) were found in E1 (placement of emitters at plain) (Table 2).

The significant results were observed in different plant densities regarding quality parameters. The highest quality parameters viz., total sugars (19.56 %, 19.00 %), reducing sugars (16.96 %, 16.46 %), non-reducing sugars (2.70 %, 2.54 %) and total soluble solids (23.11 °Brix, 22.25 °Brix) were registered in low plant density S3 (2 × 2 m) in main and ratoon crop respectively and the least total sugars (17.19 %, 15.94 %), reducing sugars (15.10 %, 14.57 %), non-reducing sugars (2.05 %, 1.37 %) and total soluble solids (20.92 °Brix, 20.25 °Brix) were found in high plant density S1 (1.5 × 1.5 m) in main and ratoon crop respectively. Regarding placement of emitters, the highest total sugars (19.54 %, 18.40 %), reducing sugars (16.59 %, 16.04 %), non-reducing sugars (2.75 %, 2.35 %) and total soluble solids (23.37 °Brix, 22.57 °Brix) were recorded with E2 (placement of emitters at 40 cm). However, the lowest total sugars (17.86 %, 17.25 %), reducing sugars (16.14 %, 15.45 %), non-reducing sugars (1.86 %, 1.79 %) and total soluble solids (21.56 °Brix, 20.81 °Brix) were registered with E1 (placement of emitters at plain) in main and ratoon crop, respectively (Table 3).

The highest yield in ratoon crop (77.75 t ha^{-1}) and cumulative yield (78.56 t ha^{-1}) in high plant density S1 (1.5 × 1.5 m) and ratoon crop (73.72 t ha^{-1}) and cumulative yield (80.10 t ha^{-1}) with E2 (Placement of emitters at 40 cm) can be attributed to increase in plant population per unit urea (Ahmad and Manan, 1970). It also might be due to high light intensity and plants were more exposed to sun light and indirectly got greater amount of assimilates accumulated in the various organ in the wider planted plants led to good bunch size. And also, excellent growth parameters gave the highest bunch in particular period. Moreover, precisely uniform quantity of water applied through drip irrigation with emitters' placement at closer distances could have positively affected on enhancing the yield. Similar results were also obtained in Red Banana (Suganthi, 2002). Reduction in yield under high density planting is

normally expected due to competition for light, water and nutrients, which causes poor translocation of photosynthates. However, the total yield per hectare was more under HDP because the yield in banana is a function of bunch weight and bunch numbers per hectare (Hannah and Pandian, 2004). But the highest morphological and physiological characters was registered in low plant density S3 (2 × 2 m), therefore it was recorded the highest yield in individual levels of plant, but number of plants occupied per hectare area was low. With respect to placement of emitters, increase in fruit yield was due to the improvement in bunch weight of banana under drip irrigation, possibly due to enhanced water utilization through drip, better nutrients uptake and excellent soil-water-air environment in the root zone.

Increase in the pulp weight (82.15 g and 80.45 g) was observed with decrease in plant density (S3) and (104.53 g and 101.57 g) in closer placement of emitters (E2) in main and ratoon crop respectively may be due to high photosynthetic assimilates, better flow of assimilates in to growing fingers and beneficial optimum amount of water and also efficiency of nutrients. The results are in agreement with (Badway et al., 2010; Pawar and Dingre, 2013) in banana cv. Grand Naine.

Decrease in the mean peel weight (46.00 g and 43.86 g) was observed with lowest plant density (S3) and (42.04 g, and 40.05 g) with closer placement of emitters'(E2) in both main and ratoon crop respectively might be due to high photosynthetic assimilates, better flow of assimilates for developing fingers particularly pulp weight. The results are in conformity by Basavaraj (2014) and Puttana (2016) in banana cv. Grand Naine

The highest values obtained in plant and ratoon crop with respect to pulp to peel ratio (1.83 and 1.89) was observed with lower plant density (S3) and (2.50 and 2.54) with placement of emitters at closer distance (E2) might be due to the finger development phase; growing fruits act as heavy sink and better assimilates resulted in highest physiological efficiency. The results are in agreements with Ney Poovan (Murugan, 2003) and Grand Naine (Badway et al., 2010). Plant and ratoon crop extended of highest shelf life (8.19 days and 7.71 days) in lowest plant density (S3) and (8.52 days, 7.63 days) with closer placement of emitters (E2) could be due to antisense properties inhibited ethylene biosynthesis. and reduced metabolic activity which will help to extended shelf life. These results are well supported by the previous findings of banana viz., Cavendish banana (Kurien et al., 2000) and Nendran (Manivannan, 1994).

The highest total sugar content (19.56 % and 19.00 %) was registered in lowest plant density (S3) and (19.54 % and 18.40 %) with closer placement of emitters (E2) in main and ratoon crop could be due to the fact that, low plant density might have caused increase in light efficiency led to greater photosynthetic activity in the banana plant. With respect to closer placement of emitters, it can provide more precise and uniform amount of the water. These findings are in corroboration with Ney Poovan (Murugan, 2003) and Rajapuri (Athani and Hulamani, 2000).

Both the plant and ratoon crop had the highest reducing sugar content (16.96 % and 16.46 %) in lower plant density (S3) and (16.59 %, 16.04 %) with closer placement of emitters (E2). It might me due to allowing proper light distribution in the plants which is a key function in increasing the quality of fruits. Further, the optimum amount of water through more number of emitters improved the nutrient uptake and nutrient mobilization towards growing fruits led to good sugar content as reported by from the work of Ney Poovan (Murugan, 2003) and Robusta (Nalina et al., 2003). In the present study the highest total soluble solids (23.11 °Brix and 22.25 °Brix) was registered in lower plant density (S3) and (23.37 °Brix and 22.57 °Brix) with closer placement of emitters (E2) in both main and ratoon crop. This might be due to light interception of the plant canopy regulation during vegetative growing period and better utilization and efficiency of water. This is in line with the work of Poovan (Sanjay, 2011) and Grand Naine (Gaonkar, 2018).

CONCLUSION

Application of three varied plant densities and four different placements of emitters influenced on yield, post-harvest and quality parameters of banana cv. Grand Naine. The yield per hectare was found highest in high plant density (S1) and closer placement of emitters (E2) which is due to more plant population per unit area. The

Table 1. Effect of different plant density and placement of emitters on yield (tons ha^{-1}) in Banana cv. Grand Naine

Treatments	Yield (tons ha^{-1})		
Factor-01	Main crop	Ratoon crop	Cumulative yield
	Spacing		
S1	79.37	77.75	78.56
S2	68.25	60.00	64.13
S3	51.35	46.42	48.893
S.Em ±	1.45	1.53	1.05
C.D.at 5%	4.29	4.53	3.1
Factor-02	Placement of Emitters		
E1	54.33	51.43	52.88
E2	86.48	73.72	80.10
E3	65.86	62.64	64.25
E4	58.63	57.77	58.20
S.Em ±	1.68	1.77	1.213
C.D.at 5%	4.96	5.23	3.58
Interaction effect (S × F)			
S1E1	69.68	66.65	68.16
S1E2	94.21	90.60	92.40
S1E3	78.15	77.40	77.78
S1E4	75.44	76.35	75.89
S2E1	52.00	47.82	49.91
S2E2	93.59	77.70	85.64
S2E3	70.60	62.80	66.70
S2E4	56.81	51.69	54.25
S3E1	41.33	39.84	40.58
S3E2	74.64	52.88	62.26
S3E3	48.82	47.72	48.27
S3E4	43.63	45.27	44.45
S.Em ±	2.91	3.07	2.1
C.D.at 5%	NS	NS	6.2

NS: Non-Significant

highest post-harvest and quality parameters were registered highest in low plant density (S3) and closer placement of emitters (E2); whereas the lowest was observed in higher plant density (S1) and wider placement of emitters (E1). However, long-term studies are needed to determine the effect of different plant densities and placement of emitters as well as their interaction effect with other factors such as fertilizer, desuckering and management practices.

Table 2. Post-harvest parameters as influenced by different plant density and placement of emitters in Banana cv. Grand Naine

Treatments	Pulp weight (g)		Peel weight (g)		Pulp to peel ratio		Shelf life (Days)	
	Main crop	Ratoon crop	Main crop	Ratoon crop	Main crop	Ratoon crop	Main crop	Ratoon crop
Factor-01	Spacing							
S1	70.78	68.02	49.73	47.96	1.45	1.45	6.87	6.74
S2	79.30	77.67	47.25	45.42	1.75	1.75	7.48	7.38
S3	82.15	80.45	46.00	43.86	1.83	1.89	8.19	7.71
S.Em ±	0.28	0.52	0.66	0.58	0.03	0.02	0.32	0.15
C.D.at 5%	0.83	1.55	1.95	1.713	0.11	0.08	0.94	0.45
Factor-02	Placement of Emitters							
E1	59.16	58.07	53.33	51.51	1.15	1.12	6.71	6.7
E2	104.53	101.57	42.04	40.05	2.50	2.54	8.52	7.63
E3	77.50	75.71	46.31	44.71	1.67	1.70	7.69	7.49
E4	68.45	66.17	48.96	46.73	1.39	1.41	7.14	7.21
S.Em ±	0.32	0.60	0.76	0.67	0.04	0.03	0.37	0.17
C.D.at 5%	0.96	1.79	2.25	1.97	0.13	0.09	1.09	0.52
Interaction effect (S × F)								
S1E1	56.54	55.07	56.00	53.57	1.08	1.02	5.71	6.62
S1E2	92.76	88.25	44.00	41.66	2.11	2.11	8.08	6.84
S1E3	69.28	67.32	48.93	48.41	1.41	1.38	7.03	6.84
S1E4	64.55	61.46	50.03	48.22	1.28	1.27	6.67	6.67
S2E1	59.68	58.56	53.00	51.19	1.25	1.14	6.68	6.90
S2E2	109.06	107.53	42.04	40.46	2.60	2.66	8.11	7.85
S2E3	80.20	78.24	46.04	44.25	1.74	1.77	7.74	7.72
S2E4	68.26	66.35	48.07	45.79	1.42	1.44	7.38	7.06
S3E1	61.26	60.59	51.07	49.77	1.19	1.21	7.71	6.84
S3E2	111.78	108.92	40.12	38.02	2.79	2.86	9.38	8.20
S3E3	83.03	81.58	44.00	41.47	1.88	1.96	8.31	7.91
S3E4	72.54	70.72	48.88	46.19	1.48	1.52	7.38	7.95
S.Em ±	0.56	1.05	1.32	1.16	0.07	0.05	0.64	0.30
C.D.at 5%	1.66	3.11	NS	NS	NS	0.17	NS	NS

NS: Non-Significant

Table 3. Quality parameters as influenced by different plant density and placement of emitters in Banana cv. Grand Naine

Treatments	Total sugars (%)		Reducing sugars (%)		Non-reducing sugars (%)		TSS (°Brix)	
	Main crop	Ratoon crop	Main crop	Ratoon crop	Main crop	Ratoon crop	Main crop	Ratoon crop
Factor-01	Spacing							
S1	17.19	15.94	15.10	14.57	2.05	1.37	20.92	20.25
S2	19.33	18.41	16.91	16.17	2.26	2.21	22.98	22.48
S3	19.56	19.00	16.96	16.46	2.70	2.54	23.11	22.25
S.Em ±	0.11	0.07	0.14	0.05	0.12	0.03	0.04	0.08
C.D.at 5%	0.33	0.21	0.13	0.14	0.37	0.11	0.14	0.24
Factor-02	Placement of Emitters							
E1	17.86	17.25	16.14	15.45	1.86	1.79	21.56	20.81
E2	19.54	18.40	16.59	16.04	2.75	2.35	23.37	22.57
E3	18.87	17.93	16.33	15.86	2.54	2.06	22.46	21.80
E4	18.51	17.57	16.22	15.57	2.20	1.95	21.96	21.42
S.Em ±	0.13	0.08	0.05	0.05	0.14	0.04	0.05	0.09
C.D.at 5%	0.38	0.25	0.15	0.17	0.42	0.12	0.16	0.28
Interaction effect (S × F)								
S1E1	16.60	15.56	14.95	14.15	1.65	1.41	20.24	19.90
S1E2	17.70	16.47	15.42	14.99	2.36	1.47	21.28	20.08
S1E3	17.32	16.07	15.06	14.75	2.26	1.32	21.23	20.65
S1E4	17.16	15.67	14.96	14.37	1.94	1.29	20.95	20.37
S2E1	18.46	18.07	16.73	16.07	1.73	1.94	22.28	21.89
S2E2	20.22	19.09	17.15	16.32	2.42	2.77	24.31	23.69
S2E3	19.52	18.35	16.90	16.19	2.62	2.16	23.03	22.21
S2E4	19.14	18.20	16.86	16.11	2.27	1.97	22.31	22.11
S3E1	18.52	18.17	16.76	16.14	2.19	2.03	22.16	20.63
S3E2	20.70	19.64	17.21	16.82	3.48	2.82	24.51	23.94
S3E3	19.77	19.37	17.02	16.65	2.75	2.72	23.15	22.53
S3E4	19.24	18.83	16.85	16.24	2.39	2.59	22.62	21.77
S.Em ±	0.22	0.14	0.09	0.10	0.25	0.07	0.09	0.16
C.D.at 5%	NS	NS	NS	NS	NS	0.22	0.29	0.49

NS: Non-Significant

REFERENCES

Ahmed, K. and Mannan, A. 1970. Effect of size of plant and spacing on the performance of Amritsagar banana. *Punjab Fruit J.* **32**: 7-13.

Anonymous, 2017. Package of practices for horticulture crops. UAS, Bengaluru.

Anonymous,1969. *Medicinal secrets of Yarn Food.* 1st Ed. Pub. Sec., Indo America Hospital. N.R. Mahulla. Mysore, pp. 183-191.

Apshara, E.S. and Sathiamoorthy, S. 2003. Effect of planting more than one sucker per pit on growth and yield of Banana cv. Nendran (AAB). *Indian J. Hort.* **60** (4):339-342.

Athani, S.I., Hulamani, N.C. and Shiroi, A.M. 2000. Effect of vermicompost on fruit yield and quality of banana cv. Rajpuri (Musa AAB). *Karnataka J. Agril. Sci.* **13** (4): 942-946.

Badway, M.A., Roshdy, K.A. and El-Shenawi, M.R. 2010. Effect of plant density on growth, flowering, fruiting and yield of Grand Naine banana in Sandy Soil. *Alexandria Sci. Exchange J.* **31**(4): 380-384.

Basavaraj, A.K. 2014. *Effect of NPK levels and high-density plants on growth, yield and quality of ratoon crop of tissue culture banana cv. Grand Naine under hill zone.* M.Sc. (Hort.) Thesis submitted to University of Agricultural and Horticultural Sciences, Shivamogga, India.

Dahiwalkar, S.D., Divekar, B.K. and Sonawane, D.A. 2004. Relative performance of fertigation on growth, yield and quality of banana. *J. Maharashtra Agric. Univ.* **29** (2):235- 237.

Gaonkar, Y.A. 2018. *Studies on plant density and nutrient requirement in banana cv. Grand Naine.* Ph.D. (Hort.) thesis, Vasantrao Naik Marathwada Krishi Vidyapeeth Parbhani. India.

Hannah, K.A. and Pandian, B.J. 2004. Effect of high density planting, fertigation and panchagavya spray on banana cv. Rasthali. *South Indian Hort.* **54** (1-6): 229-233.

Kurien, S., Anil, B.K., Rajeevan, P.K., Bharathan, V. and Krishnan, S. 2000. Phosphorus mobilization to uneconomic tissues and effects of bunch trimming regimes in banana. *Sci. Hort.* **83**: 25-32.

Manivannan, M. 1994. *Effect of planting density on growth and development of banana cv. Poovan (AAB).* M. Sc. (Hort.) Thesis. Tamil Nadu Agricultural University, Coimbatore.

Murugan, V. 2003. *Influence of fertigation on growth and productivity of banana cv. Ney Poovan under different planting densities.* M. Sc. Thesis. Tamil Nadu Agricultural University, Coimbatore.

Nalina, L., Kumar, N. and Sathiamoorthy, S. 2003. Studies on high density planting in banana cv. Robusta (AAA). *Indian J. Hort*. **60** (4): 307-311.

Pawar, D.D. and Dingre. S.K. 2013. Influence of fertigation scheduling though drip on growth and yield of banana in western Maharashtra. *Indian J. Hort.* **70** (2): 200-205.

Puttana, C. 2016. *Effect of high-density planting and nutrition on growth, yield and quality of tissue culture banana cv. Grand Naine under transitional zone of Karnataka.* M.Sc. (Hort.) Thesis. University of Agricultural and Horticultural Sciences, Shivamogga India.

Sanjay, M.A. 2011. *Standardization of nutrient requirements for high density planting in banana cv. Poovan ('Mysore' AAB).* M.Sc. Thesis. Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India.

Shashidhara, K.K., Bheemappa, A., Hirevekanagoudar, L.V. and Shashidhar, K.C. 2007. Benefits and constraints in adoption of drip irrigation among the plantation crop growers. *Karnataka J. Agri. Sci.* **20** (1): 82-84.

Suganthi, L. 2002. *Fertigation management studies in banana cv. Red Banana (AAA) under different planting densities*. M.Sc. (Hort.) Thesis, Tamil Nadu Agricultural University, Coimbatore.

Thomas, P., Dulal, W.B., Pushpa, M.C. and Amla, B.L. 1968. Harvesting, handling and transportation of bananas for export from India. *Indian Food Packer* **22**: 16-21.

e-planet **20** (1): 33-39 (June 2022)

Note on *Ocimum africanum* Lour.: New distributional record of wild basil for Odisha and central India

R.C. MISRA[1*], A.P. RAINA[2] AND S.P. AHLAWAT[3]

[1*]*ICAR – National Bureau of Plant Genetic Resources, Regional Station, Cuttack-753006, Odisha, India*
[2, 3]*ICAR – National Bureau of Plant Genetic Resources, Pusa Campus, New Delhi-110012, India*

[*]*rcmisranbpgr@gmail.com*

Date of receipt: 27.03.2022 Date of acceptance: 31.05.2022

ABSTRACT

Ocimum Linn. (Lamiaceae) is a large and diversified genus of economically useful and medicinal and aromatic importance and associated with Indian cultural traditions. It is highly valued for its therapeutic properties in indigenous as well as modern pharmacological system. During the exploration mission for germplasm collection in parts of Odisha and Northeast India, the natural occurrence of *Ocimum africanum* (syn. *O. citriodorum* Vis.), a natural hybrid and alien to the Indian flora, was explored from parts of Odisha, Tripura and Manipur. After critical assessment of published literature on distribution, its natural occurrence is found to be a new species record for the flora of Odisha extending to central India. The present report deals with its taxonomic description, ecology, ethno-botany and information on bio-chemical analysis of essential oil for easy identification and further economic utilization.

Key words: Basil, central India, germplasm collection, new species record, *Ocimum africanum,* Odisha

INTRODUCTION

The genus *Ocimum* of family Lamiaceae, collectively called as basil, is a large and diversified plant group of high medicinal and aromatic importance and associated with manifold Indian cultural traditions. Most of the members are annual, biannual or perennial herbs or shrubs and distributed in the tropics and subtropics of the old and new worlds, with few species cultivated in temperate areas (Paton, 1992). The main centre of diversity of *Ocimum* appears to be Africa (Hedge, 1992; Paton, 1992) with secondary centre in South America: Brazil and Asia: India (Sobti and Pushpagandan, 1982; Vieira and Simon, 2000). A high degree of polymorphism along with inter-specific hybridization and polyploidy (Harley and Heywood, 1992) has created taxonomic confusion in the genus which designates a large number of subspecies and varieties. Hence the nomenclature of *Ocimum* species and varieties is still complicated and various workers have reported the content of species not in exact numbers but approximately ranging from 30 to 160 (Mabberly, 1997; Charles and Simon, 1990; Pushpagandan and Bradu, 1995; Gill et al., 2012; Bhasin, 2012). However, *Ocimum* has 66 accepted species names and the rest were placed as synonyms and unassessed (Anonymous, 2014). India is represented by 9 species of *Ocimum* (including 3 exotics) mainly confined to tropical and peninsular region (Anonymous, 1966). It is highly valued for its therapeutic properties in traditional as well as modern pharmacological system. The species are good source of essential oils and aromatic compounds, culinary herbs, food preservatives and attractive fragrant/ perfumery ornamentals, aromatherapy and to inhibit growth of microorganism (Simon et al., 1984; 1990). Extracts of plant are used in traditional medicines and have been shown to contain biological active constituents of insecticidal, nematicidal, fungistatic and antimicrobial importance.

Ocimum africanum Lour. (syn. *Ocimum citriodorum* Vis.); commonly known as lemon

basil, hoary basil or Lao basil, is a hybrid between *Ocimum basilicum* (sweet basil) and *Ocimum americanum* (American basil). It is a native of northeastern Africa and South Asia and further recorded as an invasive species in many countries including India and Ecuador. It was recorded earlier in the country in southern peninsula and Northeast India. However, the wild occurrence of *Ocimum africanum* as natural hybrid in different phyto-geographical zones of Odisha forms a new distributional record for the flora of Odisha and Central India.

MATERIALS AND METHODS

During the exploration mission for germplasm collection of medicinal and aromatic plants and other crops in parts of Odisha and Northeast India during the period 2011 to 2021, the first author observed the natural occurrence of one uncommon wild relative of *Ocimum* species in Odisha and Northeast India (Fig. 1-3). A total number of 14 germplasm accessions of this species were collected from different phyto-geographical zones of Odisha, Tripura and Manipur (Table 1). The seed germplasm bearing respective accession number were collected from the field and conserved in the National Gene Bank, NBPGR, New Delhi for long term storage. Further, the seeds were multiplied and live plants were characterized in experimental plots of NBPGR, Base Center, Cuttack for morphological and biochemical traits. The plant specimens bearing both vegetative and flowering parts were deposited in the herbarium of NBPGR base center, Cuttack, Odisha along with one set at the National Herbarium of Cultivated plants (NHCP), NBPGR New Delhi. The live plants and the herbarium specimens were critically studied and the morphological features of the plant were examined using the trinocular lens and dissection microscope and the distinctive characters were recorded. The collected specimens were also compared with the images of the authentic herbarium type specimens (K000911679, K000011682) deposited at the Royal Botanical Garden, Kew, London to confirm the identity of the plant. The photographs of the vegetative, flowering/ fruiting stage and seeds along with the associated species in the natural habitat were taken for reference and future use. Besides, information on biochemical analysis of essential oil of leaves and fatty acid composition of seed oil of this species was incorporated from the investigations made at the Division of Germplasm Evaluation, ICAR-NBPGR, New Delhi (Raina and Misra, 2018; Raina and Misra, 2020).

Fig. 1. *O. africanum* in wild habitat in Dhenkanal district, Odisha

Fig. 2. Natural occurrence of *O. africanum* in Bishnupur district, Manipur

Fig. 3. Natural occurrence of *O. africanum* in Gomati district, Tripura

Table 1. Specimen examined and seed germplasm of *Ocimum africanum (syn.O. citriodorum)* collected and conserved

Site	Collection No.	IC No.	Date of collection	Source	Site of collection					
					Village	Block	District	State	Latitude	Longitude
1	RCM/GD/02	589183	28.03.2011	Disturbed wild	Gabapadar	Khallikote	Ganjam	Odisha	19° 44’	85° 12’
2	RCM/PM-MS/07	624514	30.11.2012	Disturbed wild	Nityabazar	Killa	Gomati	Tripura	23° 34’	91° 34’
3	RCM/GD/98	599313	14.03.2013	Disturbed wild	Kukuprasad	Dasapalla	Nayagarh	Odisha	20° 20’	84° 49’
4	RCM/GD/107	599322	15.03.2013	Natural wild	Sidhamula	Gania	Nayagarh	Odisha	20° 23’	85° 06’
5	RCM/GD/109	599324	5.03.2013	Natural wild	Ekdal	Gania	Nayagarh	Odisha	20° 25’	85° 07’
6	RCM/GD/125	599338	17.03.2013	Wasteland	Ghantapada	Narsinghpur	Cuttack	Odisha	20° 29’	85° 03’
7	RCM/GD/127	599340	7.03.2013	Wasteland	Champeswar	Narsinghpur	Cuttack	Odisha	20° 26’	85° 09’
8	RCM/GD/139	599352	20.03.2013	Disturbed wild	Dandimal	Odopada	Dhenkanal	Odisha	20° 42’	85° 31’
9	RCM/GD/141	599354	20.03.2013	Disturbed wild	Balaram prasad	Odopada	Dhenkanal	Odisha	20° 46’	85° 24’
10	RCM/GD/144	599357	20.03.2013	Wasteland	Gaudakateni	Hindol	Dhenkanal	Odisha	20° 47’	85° 22’
11	RCM/GD/147	599360	20.03.2013	Disturbed wild	Gahama	Kaniha	Angul	Odisha	21° 07’	85° 09’
12	RCM/GD/159	599372	22.03.2013	Disturbed wild	Bariapur	Parjang	Dhenkanal	Odisha	20° 56’	85° 21’
13	RCM/PM/MS/31	626384	14.11.2013	Wasteland	Maibam Chingning	Nambol	Bishnupur	Manipur	24° 42’	93° 49’
14	RCM/PK/19/83	635064	26.12.2019	Disturbed wild	Chakratirtha	Anandpur	Keonjhar	Odisha	21° 16’	86° 15’

RESULTS AND DISCUSSION

On critical examination of the vegetative and floral characters of live plants grown at the experimental plots of the center coupled with study on herbarium specimens and perusal of literature, the species was identified as *Ocimum africanum* Lour. The plants grow gregariously in disturbed areas such as waste lands, fallow, open scrub lands etc. in natural habitat and its occurrence was recorded at different locations of Odisha, Tripura and Manipur (Fig. 1- 3). However, some records were available in which it was reported to be cultivated or run wild in India in few states of southern peninsula and Assam without mentioning the specific locality of occurrence (Drury, 1866; Gamble, 1925; Matthew, 1982; Henry et al., 1987; Pullaiah et al., 2011; Sasidharan, 2011; Suddee et al., 2005; Kumar, 2019). On verification of major published Indian literature, it was found that it has not been reported till date in wild condition from Central India including Odisha (Haines, 1922; Saxena and Brahman, 1995; Mudgal et al., 1997; Singh et al., 2001; Singh and Karthikeyan, 2000). Therefore, the present collection counts an addition of species to the flora of Odisha and forms a new distributional record for Central India. A detailed taxonomic description on morphology of different parts, field photographs and ethno-botanical uses were provided for easy identification and sustainable utilization (Fig. 4 - 8).

Fig. 4. *O. africanum* maintained in experimental plot, NBPGR Regional Station, Cuttack

Fig. 5. Flowering twig of *O. africanum*

Fig. 6. Leaves of *O. africanum*

Fig. 7. Flowers of *O. africanum*

Fig. 8. Seeds of *O. africanum*

Taxonomic account

Ocimum africanum Lour., Fl. Cochinch. 370. 1790. *O. americanum* var. *pilosum* (Willd.) A.J.Paton, Kew Bull. 47:426. 1992; *Ocimum basilicum* var. *anisatum* Benth. Labiat. Gen. Spec.: 4. 1832; *Ocimum citriodorum* Vis. Index Seminum (PAD, Patavium) 1840: 9. (1840); *Ocimum graveolens* A.Br. Flora 24: 265. 1841; *Ocimum petitianum* A.Rich. Tent. Fl. Abyss. 2:176. 1850; *Ocimum pilosum* Willd. Enum. Pl.: 629. 1809.

Perennial aromatic herb or under shrub up to 90 cm high; stem and branches erect, 4-angled, hairy, woody at base, sometimes grooved, primary branches 12-22; young shoot densely hairy, apical nodes and petioles pilose with long spreading and sometimes retrorse hairs. Leaves simple, opposite decussate, ovate or elliptic-lanceolate, 3.5 to 6.0 cm including petiole; lamina 2.5 to 5.0 × 1.5-3.0 cm; petiole 0.8 - 1.5 cm long, hairy; leaf base acute to decurrent, margin entire or distantly sparingly serrate, apex acute; lower surface glandular- punctate, hairy on nerves beneath with long spreading hairs on midrib and lateral veins, upper surface glabrous or puberulous; strongly lemon-scented. Inflorescence lax, verticels 5 - 15 mm apart, distance reduces towards apex, axis densely pubescent with sometimes retrorse hairs; bracts ovate to obovate, sessile, 3-5 mm long; apex acute to acuminate, base attenuate, margin pilose, glandular punctate; pedicels recurved, 1- 2.5 mm long, shorter than calyx, finely patent- pubescent; spikes 10 - 25 cm long, flower whorls 10-18 per spike. Flowers small, verticellate, 6 in a whorl, in terminal, elongated 3- chotomous racemes. Calyx campanulate, 2-lipped, 1.5 - 3.0 mm long at anthesis, 4.0 - 6.0 mm long in fruit; anterior lip 4- toothed with two median teeth lanceolate, acuminate, move upwards slightly longer than posterior and laterals; lateral teeth more or less deltoid, acute, almost equal to posterior; posterior lip reflexed, broad, rounded, decurrent on calyx tube, apparently accrescent, sometimes apiculate at apex; calyx tube densely hairy, with a ring of dense villous hairs on throat; throat open, with or without sessile glands outside. Corolla campanulate, white, 2- lipped, 5- 8 mm long including corolla tube, truncate, upper lip truncate, 5-6 mm long, 4- lobed; lobes not equal, ovate- obovate; lower lip boat- shaped, elliptic-oblong, up to 8 mm long; tube straight, glabrous on both sides. Stamens -4, declinate, in two pairs, exserted, posterior pair with a glabrous transverse process near base; anther cells confluent, filaments free; style thinly 2- fid. Nutlets ovoid - oblong, minutely tuberculate, black, 1 - 1.5 mm long, produce mucilage when wet. Essential oil is light yellow with strong odour of lemon. Flowering and fruiting: December-January.

Distribution

It is primarily a native to tropical and subtropical old world, northeastern Africa and southern Asia such as Malaysia, Philippines, Indonesia, Papua New Guinea, Laos, Thailand, Vietnam, Madagascar, Ethiopia, Angola etc. and further spread as an invasive species in many countries including India and Ecuador. In India, it was recorded earlier in southern peninsula and Northeast India.

Habitat and ecology

The species was naturally growing in disturbed habitats on different landscapes among the weeds in wastelands, fallow and open scrublands interspersed with herbs, shrubs and grasses. A total of 14 acc were recorded from different locations of phyto-geographical zones of Odisha, Tripura and Manipur. The species is comparatively hardy, prefers direct sunlight and propagated through seeds and even from stem cuttings.

Specimens examined and germplasm collected and conserved

Fourteen germplasm accessions of *Ocimum africanum* were explored from different landscapes of Odisha, Tripura and Manipur and information on the sites of specimen collection and germplasm conservation were provided in Table 1.

Ethno-botanical uses

The local inhabitants of Kandha, Bhuyan and Gond tribes of Dasapalla and Gania blocks of Nayagarh district named this species as "*Lembu Tulasi*" and use the juice of fresh leaves along with honey in empty stomach for curing cold, cough and bronchial asthma, especially in children. The half-burnt leaves and the leaf-smoke is diffused in the huts/ cowsheds to ward-off insects and mosquitoes particularly during rainy season, as reported by tribes such as Shabar and Gonda of Parjang, Odopada and Kaniha blocks of Dhenkanal and Anugul districts. The Saura tribe of Ganjam and Kolha and Bathudi tribe of Anandpur, Keonjhar district use the leaf powder on hairs of body surface to remove the lice of dogs and cocks. Besides, the local inhabitants of Tripura and Manipur consume raw leaves with vegetable/ fruit salad and also in curry and fresh chili pickles. The leaves are also steeped in boiled water to make herbal lemon tea.

In Laos, the lemon basil is the key-ingredient in curries, stews and stir-fried dishes. In Indonesia, it is often eaten raw with salad or *lalap* (raw vegetables) and also to season certain dishes, such as curries, soup, stew and steamed dishes. In Cambodia and Thailand, the nutlets, which produce mucilage when wet, are used for making soup or sweet desserts. The fresh leaves are the main side dish for the traditional Thai rice noodle dish called 'Khanom Chean'.

Biochemical analysis of essential oil

The essential oil profiling of leaves of *Ocimum africanum* exhibited a total of forty-four compounds constituting 95.2–99.9% of total oil (Raina and Misra, 2018). Among these, oxygenated monoterpenes (33.5–86.8%) were most predominant, followed by phenylpropanoids (1.1–56.2%), sesquiterpene hydrocarbons (3.7–14.6%), oxygenated sesquiterpenes (0.8–2.3%) and monoterpene hydrocarbons (0.1–0.3%). Based on essential oil composition, this species showed two prominent chemotypes represented by geranial/ neral and methyl chavicol-rich types. Geranial/ neral-rich chemotype (IC-599354) showed substantially high content of geranial (42.2%) and neral (28.8%), which was detected only in *O. africanum*. Methyl chavicol-rich chemotypes were represented by IC-599325 with methyl chavicol content of 55.5%, followed by IC599357 (33.0%). Other common aroma compounds identified in both chemotypes were linalool (5.5–12.2%), nerol (1.8–3.5%), geraniol (1.6–2.0%), (Z)-α-bisabolene (1.7–8.2%), *trans*-α-bergamotene (0.7–2.0%) and caryophyllene oxide (0.3–1.6%). Earlier studies have also reported citral and methyl chavicol-rich chemotypes in *O. africanum* germplasm (Vieira and Simon, 2006). In addition, analysis of fatty acid composition of seed oil exhibits high linolenic acid content (66.82 - 72.95%) and chemotypes with highest content in *O. africanum* (Raina and Misra, 2020).

ACKNOWLEDGEMENT

The authors are grateful to the Director, ICAR, National Bureau of Plant Genetic Resources, New Delhi for providing research facilities during the course of investigation.

REFERENCES

Anonymous. 1966. *The Wealth of India - A dictionary of Indian raw materials and industrial products (Raw materials),* vol. 7. Council of Scientific and Industrial Research, New Delhi, pp. 79-89.

Anonymous. 2014. *The Plant List- A working list of all plant species*. Online database: www.theplantlist.org/browse/A/Lamiaceae/Ocimum/

Bhasin, M. 2012. *Ocimum*- Taxonomy, medicinal potentialities and economic value of essential oil. *J. Biosphere* **1**: 48-50.

Charles, D.J. and Simon, J.E. 1990. Comparison of extraction methods for the rapid determination of essential oil content and composition of basil (*Ocimum* spp). *J. Am. Soc. Hort. Sci.* **115**: 458–462.

Drury, H. 1866. *The Handbook of the Indian Flora*, Mount Road, Madras. vol. II, p. 516.

Gamble, J.S. 1925. *Flora of the Presidency of Madras*, vol. II. Adlard and Son Limited, 21 Hort Street. W.C. London.

Gill, D., Soni, N., Sagar, B.P.S., Raheja, S. and Agarwal, S. 2012. *Ocimum kilimandscharicum*: A systematic review. *J. Drug Deliv. Ther.* **2** (3): 45-52.

Haines, H.H. 1922. *The Botany of Bihar and Orissa*, part III-IV. Adlard and Son and West Newman Ltd, London.

Harley, R.M. and Heywood, C.A. 1992. Chromosome numbers in tropical American Labiatae.In: *Advances in Labiatae science* (Eds. Harley, R.M. and Reynolds, T.). Royal Bot. Garden, London, pp. 211-246.

Hedge, I.C. 1992. A global survey of the biogeography of the Labiatae. In: *Advances in Labiatae Science* (Eds. Harley, R.M. and Reynolds, T.). Royal Bot. Garden, London, pp. 7-17.

Henry, A.N., Kumari, G.R. and Chithra, V. 1987. *Flora of Tamilnadu, India: Series I: Analysis*, Botanical Survey of India, Southern Circle, Coimbatore **2:** 179-180.

Kumar, A. 2019. Chemical composition and uses of lemon-scented basil (*O. africanum* Lour.). *Agriculture Food: e-Newsletter* **1**(6): 95-96.

Mabberley, D.J. 1997. *The Plant Book: a Portable Dictionary of the Vascular Plants*, 2nd edn. Cambridge University Press, Cambridge.

Matthew, K.M. 1982. *The Flora of the Tamilnadu Carnatic*, part 2. The Rapinath Herbarium, Tiruchirapalli.

Mudgal, V., Khanna, K.K. and Hajra, P.K. 1997. *Flora of Madhya Pradesh*, vol. 2., Flora of India, Series 2. Botanical Survey of India, Calcutta.

Paton, A. 1992. A synopsis of *Ocimum* L. (Labiatae) in Africa. *Kew Bull.* **47**: 403-435.

Pullaiah, T., Sandhya Rani, S. and Karuppusamy, S. 2011. *Flora of Eastern Ghats: Hill ranges of Southeast India*, volume 4. Regency Publications, New Delhi.

Pushpagandan, P. and Bradu, L. 1995. Basil. In: Chadha KL, Gupta R (eds) *Medicinal and Aromatic Plants, India*, Malhotra Publishing House, India, pp. 627-658.

Raina, A.P. and Misra, R.C. 2018. Chemo-divergence in essential oil composition among germplasm collection of five *Ocimum* species from eastern coastal plains of India. *J. Essent. Oil Res.* **30**: 47-55.

Raina, A.P. and Misra, R.C. 2020. Characterization of fatty acid composition of seed oil of Ocimum species/ chemotypes. *Med. Plant* **12** (4): 615-622.

Sasidharan, N. 2011. *Flowering plants of Kerala.* Ver. 2.0 (DVD). Kerala Forest Research Institute, Peechi.

Saxena, H.O. and Brahmam, M. 1995. *The Flora of Orissa*, vol 3. Odisha Forest Development Corporation Ltd, Bhubaneswar.

Simon, J.E., Chadwick, A.F. and Craker, L.E. 1984. *Herbs: An indexed bibliography* 1971–1980. Archon Books, Hamden. pp. 7-9.

Simon, J.E., Quinn, J and Murray, R.G. 1990. Basil: a source of essential oils. In: J. Janick and J.E. Simon (eds.), *Advances in New Crops*. Timber Press, Portland, OR, pp. 484-489.

Singh, N.P. and Karthikeyan, S. 2000. *Flora of Maharastra State: Dicotyledons*, vol 2. Botanical Survey of India, Calcutta.

Singh, N.P., Mudgal, V., Khanna, K.K., Srivastava, S.C., Sahoo, A.K., Bandopadhyay, S., Aziz, N., Das, M., Bhattacharya, R.P., Hajra, P.K. 2001. *Flora of Bihar: Analysis*. Botanical Survey of India, Calcutta.

Sobti, S.N. and Pushpangadan, P. 1982. Studies in the genus *Ocimum*: Cytogenetics, breeding and production of new strains of economic importance. In: C.K. Atal and B. M. Kapur (eds.), *Cultivation and utilization of aromatic plants.* Regional Laboratory Council of Scientific and Industrial Research, Jammu-Tawi, India, pp. 457–472.

Suddee, S., Paton, A.J. and Parnell, J.A.N. 2005. Taxonomic revision of Tribe Ocimeae Dumort. (Lamiaceae). *Kew Bull.* **60** (1): 3-75.

Vieira, R.F. and Simon, J.E. 2006. Chemical characterization of basil (Ocimum spp.) based on volatile oils. *Flavour Fragr. J.* **21**: 214–221.

Vieiria, R.F. and Simon, J.E. 2000. Chemical characterization of basil (Ocimum spp.) founding the markers and used in traditional medicine in Brazil. *Econ. Bot.* **54**: 207–216.

e-planet **20** (1): 40-46 (June 2022)

Anti-oxidative effect of polyphenols of *Litsea glutinosa* leaf: An *in-vitro* assay

P.C. BEHERA[1], M.R. SENAPATI[2*] AND D.R. PARIDA[3]

[1]*Dept. of Veterinary Biochemistry, CVSc&AH, OUAT, Bhubaneswar, Odisha-753001, India*

[2*]*Agro-Polytechnic Centre (Animal Science), OUAT, Chiplima, Sambalpur, Odisha-768025, India*

[3]*Fisheries & Animal Resources Development Department, Bhubaneswar, Odisha-751001, India*

[*]*mitu56v@gmail.com*

Date of receipt: 17.05.2022 Date of acceptance: 29.05.2022

ABSTRACT

The study aims at extracting total phenolic content from leaf of *Litsea glutinosa* in different solvent medium under the microwave-assisted extraction system and assessment of its antioxidative activity. Solvents of extraction were classified into 7 groups such as Gr-A (100% methanol), Gr-B (100% de-ionized water), Gr-C (methanol: water: acetic acid in 70:25:05 v/v), Gr-D (ethyl acetate: methanol: water in 60:30:10 v/v), Gr-E (100% acetone), Gr-F (acetone: water: acetic acid in 90: 9.5: 0.5 v/v) and Gr-G (100% ethanol).Total polyphenols were quantitatively estimated following standard protocol. Organic and aqueous solvent mixture groups of Gr-C, D, and F exhibited significantly ($p<0.01$) higher concentrations of total polyphenols. Total and individual anti-oxidative activities were analyzed in the solvent group having the highest amount of total phenolics. The polyphenols extracted in Gr-D exhibited significantly higher antioxidant activities ($p<0.01$) in phospho- molybdenum and reducing power method than the solvents at Gr-C and F. The polyphenols extracted in the Gr-C solvent depicted significantly higher antioxidative activities ($p<0.01$) in the FRAP method followed by Gr-D and F. Also leaf extract in Gr-D solvent exhibited significantly higher superoxide (Ferric Reducing Antioxidant Power) and nitric oxide radical scavenging activities ($p<0.01$) followed by Gr-C and F. On the other hand, polyphenols extracted in Gr-F exhibited significantly ($p<0.01$) higher hydroxy radical scavenging activity and lipid peroxidation inhibition assay followed by Gr-C and D. The present study reflects that the plant derived phyto-chemicals can be better extracted through organic and aqueous mixture solvents than individual one with potent anti-oxidative activity.

Key words: Antioxidant, FRAP, free radical scavenging activity, microwave-assisted extraction, total phenolics

INTRODUCTION

Natural antioxidants have been associated with reduced risks of cancer, cardiovascular disease, diabetes, inflammation, bacterial disease and diseases associated with ageing (Kumar and Surh, 2008; Thatoi et al., 2008) owing to their free radical scavenging activities (Veerapur et al., 2009) by blocking the initiation or propagation step of oxidizing chain reactions or by scavenging various types of reactive species or chelating transition metal ions (Halliwell, 2007). Traditional knowledge of rural tribes of Indian natives plays a pivotal role in the discovery of new and safer lead molecules of plant origin with potential biological activities. Since, these are cheaper, locally available, easily consumable (raw) and simple, it serves as alternative medicine (Surveswaran et al., 2007) in most of the regions of India and the world also. Even though the scientific world has studied the efficacy of these plant-derived chemical constituents,

the mechanisms of their action have not yet been investigated systematically (Alasalvar et al., 2006). These components vary in chemical characteristics, polarities, and distribution in the plant matrix (Sultana et al., 2009). Therefore, suitable environment/ conditions to harvest the bio-active components of plants determine their efficacy/ potency for which extraction conditions viz nature of solvent and technique are the major concern to enhance the efficiency (Boateng et al., 2008).

The claims with regard to medicinal plants posing anti-oxidant, anti-inflammatory, anti-tumor, anti-mutagenic, anti-carcinogenic, anti-bacterial, hepato-protective or anti-viral activities are mainly attributed to polyphenols. Polyphenols are the secondary plant metabolites with one/ more phenolic hydroxyl groups attached to carbon-based aromatic phenyl-ring. There are over 8,000 structural variants of polyphenols distributed variedly in the plant kingdom.

Litsea glutinosa belonging to Family Lauraceae is a medium-sized branched moist deciduous plant indigenous to India (Bhuniya et al., 2010). Pharmacological studies have confirmed that this plant exhibits a broad range of potential biological effects. However, the crude extract of the plant has been used as a traditional medicine for the treatment of various diseases that may pave pathway for future indigenous drug development. The study reveals the potentiality of various solvent extracts of different parts of this plant, particularly as an analgesic and wound healing (Devi and Meera, 2010), antidiarrhoeal (Bulbul et al., 2021), hepato-protective (Ghosh et al., 2016), anti-hyperglycemic and antihyperlipidemic (Zhang et al., 2018), anti-nociceptive (Rumzhum et al., 2012), anti-diabetic (Palanuvej et al., 2009), anti-inflammatory (Bhowmick et al., 2014) anti-bacterial and antioxidant (Arunodaya et al., 2016). Moreover, every part of this plant has great medicinal value and is being used internally as well as externally. It is applied externally on wounds to reduce inflammation, and also loss of appetite, abdominal pain in liver disorders, worm infestation, fever, and in general weakness. The seeds contain aromatic oils which have been used to make candles and soaps. The roots yield fibres used in Thailand for rope manufacture and paper pulp preparation. The young leaves are consumed by livestock as fodder. The pounded seeds are also applied medicinally against boils. The leaves and the mucilage in the gum from the bark have been used for poultices (Wang et al., 2010). The bark also acts as a demulcent and mild astringent in case of diarrhoea and dysentery (Devi and Meera, 2010). Indian tribes of Odisha province use aqueous paste and decoction of various parts of this plant along with ghee and honey traditionally for the treatment of rheumatoid arthritis, hepatic disorders, splenomegaly, fever, anorexia, obesity, diabetes, body ache, itches, wounds, stomach-ache, flatulent dyspepsia, helminthiasis, diarrhea, dysentery, urinary calculi, dysuria, and cystitis.

Oxidative stress of endogenous/exogenous origin can be overcome by chain-breaking antioxidants (CBAs) as 1st line of defense like tocopherol, ascorbic acid, glutathione (GSH), uric acid, carotenoids, ubiquinone, and polyphenols. The ongoing reaction can be terminated/ interrupted by autocatalytic reactions of antioxidant enzymes viz superoxide dismutase (SOD), catalase (CAT), and GPxs as 2nd line of defense. With the advancement of age and the decline of anti-oxidative defense natural and synthetic antioxidants are essential. Constraints of producing adverse effects on the liver restrict the use of synthetic antioxidants butylated hydroxyanisole (BHA) and butylated hydroxytoluene (BHT). Plant extracted polyphenols being safe in this regard are free to be used to overcome any such oxidative stress. Therefore, the present study aims to extract the polyphenols from *Litsea glutinosa* leaves in different solvent system and to assay the *in vitro* anti-oxidative effect by various chemical tests for advocating its efficacy through validation and development of potent lead molecules.

MATERIALS AND METHODS

Plant material

Litsea glutinosa, locally known as Jaysandha was collected from forest areas of Keonjhar district of Odisha, identified in the Department of Botany, O.U.A.T. following the description of Saxena and Brahman (1995). The plant leaves collected at pre-flowering stage were cleaned, dried under shade, and ground into fine structures for preparation of extracts.

Solvent and groupings

Solvents of extraction were classified into 7 groups such as Gr-A (100% methanol), Gr-B (100% de-ionized water), Gr-C (methanol: water: acetic acid in 70:25:05 v/v), Gr-D (ethyl acetate: methanol: water in 60:30:10 v/v), Gr-E (100% acetone), Gr-F (acetone: water: acetic acid in 90: 9.5: 0.5 v/v) and Gr-G (100% ethanol)

Extraction process

Extraction of phyto-constituents was done in Microwave-Assisted Extraction (MAE) method by Multiwave 3000-801V (Anton Paar) digestion system following the method of Senapati et al. (2013) where 2 g of ground mass in 20 ml of solvent was heated at 80°C for 25 minutes followed by 15 minutes cooling and filtration through what man No-1 filter paper to harvest the extract.

Removal of chlorophyll

Equal volumes of filtered crude extract and hexane were mixed and kept for 2 minutes. The supernatant was aspirated carefully to obtain chlorophyll free extract.

Estimation of total polyphenols and antioxidant activity assay

Total polyphenol content of different solvent extract was determined by the method of Singh et al. (2002). The anti-oxidant activities were assayed with use of the concerned extract obtained from 1 g of leaf powder. The total antioxidant activity of extracts under different solvents was evaluated by phospho-molybdenum (Prieto et al., 1999), FRAP (Benzie and Strain, 1996) and the reducing power method (Oyaizu, 1986). Individual antioxidant capacities of these extracts were estimated by scavenging of Superoxide, (SO) (Hyland et al., 1983), Nitric oxide, (NO) (Sreejayan Rao, 1997) and Hydroxyl radical, (OH^-) (Halliwell et al., 1997) whereas lipid per-oxidation inhibition assay (LPOIA) was estimated by the method of Ohkawa et al. (1979).

Statistical analysis : The data were subjected to analysis of variance to test the significance of difference of mean values between different groups according to Snedecor and Cochran (1994).

RESULTS AND DISCUSSION

The total polyphenol content of chlorophyll free extract of 1 g of powdered *L. glutinosa* leaf in different solvents was exhibited in Table 1. Significantly higher proportion of ($p<0.01$) total polyphenols were extracted in solvent mixtures of methanol with other solvents at Gr-D and C and in acetone at Gr-F as compared to other individual solvents at Gr-A, B, E and G. The values of total phenolics were in descending order from Gr-D > C > F > E > A > G > B.

Table 1. Total polyphenol content of *Litsea glutinosa* leaf extracts in different solvents (Mean ± SE) expressed as mg of Gallic acid equivalent per g of plant material (mg GAE / g of plant)

Gr-A	Gr-B	Gr-C	Gr-D	Gr-E	Gr-F	Gr-G
1.41^{a} ±0.05	1.27^{a} ±0.06	1.84^{c}±0.06	1.88^{c} ±0.05	1.48^{b}±0.06	1.63^{c} ±0.05	1.32^{a} ±0.05

Means with different superscripts within rows showed significant difference ($p<0.01$) between the groups.

Total antioxidant activities of the solvent extracts showing significantly higher contents of polyhenols were estimated for Gr-C, D and F by three different methods (Table-2). The polyphenols extracted in Gr-D exhibited significantly higher anti-oxidant activities ($p<0.01$) in phosphomolybdenum and reducing power method than the solvents at Gr-C and F. The polyphenols at Gr-C solvent depicted significantly higher activities ($p<0.01$) in FRAP method followed by Gr-D and F.

Table 2. Total antioxidant activity of *Litsea glutinosa* leaf extracts (Mean ± SE)

	Gr-C	Gr-D	Gr-F
Phosphomolybdenum (µM of AAE / g of plant)	349.51^{a}±4.29	484.57^{b}±4.34	298.10^{c}±2.96
FRAP (10^3 XµM of AAE / g of plant)	7.13^{a} ±0.12	5.46^{b} ±0.10	2.42^{c} ±0.06
Reducing power (µM of AAE / g of plant)	743.05^{a}±3.11	1059.29^{b}±3.29	379.01^{c} ±2.09

Means with different superscripts within the rows differ significantly ($p<0.01$).

Individual antioxidant activities of the extracts showing significantly higher contents of polyhenols were estimated for Gr-C, D and F by four different methods (Table 3). The polyphenols extracted in Gr-D exhibited significantly higher superoxide and nitric oxide radical scavenging activities ($p<0.01$) followed by Gr-C and F. On the other hand polyphenols extracted in Gr-F exhibited significantly ($p<0.01$) higher hydroxy radical scavenging activity and lipid peroxidation inhibition assay followed by Gr-C and D.

Table 3. Individual antioxidant (Radical Scavenging %) activity of *Litsea glutinosa* leaf extracts (Mean ± SE)

Parameters	Gr-C	Gr-D	Gr-F
Superoxide (SO)	29.76^{a} ±0.98	36.28^{a}±1.17	8.49^{b} ±0.22
Nitricoxide (NO)	19.24^{a}±0.88	27.21^{b}±1.11	16.96^{a}±0.77
Hydroxyl (OH)	24.96^{b}±0.96	20.55^{a}±0.92	26.64^{b}±0.92
Lipid Per-oxidation Inhibition (LPOI)	15.96^{a}±0.83	15.21^{a}±0.94	20.38^{b}±0.84

Means with different superscripts within the rows differ significantly ($p<0.01$).

Polyphenols are groups of compounds containing more than one hydroxyl groups directly attached to carbon-based aromatic phenyl-ring. Dietary polyphenols with over 8,000 structural variants are predominantly secondary metabolites of fruits, vegetables, wine, tea, leaf, chocolate and other cocoa products. These are mostly derivatives and/or isomers of flavones, isoflavones, flavonols, catechins and phenolic acids and possess similar biological properties of anti-oxidants. Total phenolic content, in the study, varied among the different solvents within the same plant. The concentration of total phenolic content was significantly lower ($p<0.01$) in individual water, methanol and ethanol extracts than combined Methanol + Water + Acetic acid mixture, Ethyl acetate + Methanol + Water mixture and Acetone + Water + Acetic acid mixture. It depicted that maximum components of poly phenols were more soluble in the mixtures of organic solvents than in aqueous and individual solvents. Due to the phytochemical diversity in polyphenol contents this variation between the experimental groups was recorded and it was corroborated with the reports of Siddhuraju et al. (2002).

Three different chemical methods were used to estimate the total anti-oxidant activity of the plant derived polyphenol extracts to study the comparative and absolute effects. The total anti-oxidant activity by phospho-molybdenum assay is based on the reduction of Mo^{VI} to Mo^{V} and the formation of a green Mo^{V} complex with a maximal absorption at 695 nm. It was observed that antioxidant activity was higher in polyphenol extracted from solvent consisting of Ethyl acetate + Methanol + Water mixture and than those extracted in Acetone + Water + Acetic acid mixture. The result was in accordance with the findings of Rumzhum et al. (2012). The reducing property of bioactive phenolic compounds was associated with antioxidant activity (Siddhuraju et al., 2002). The study of reducing power of different solvent extract of leaf samples revealed increased anti-oxidative activity of the extracts with increase concentration of polyphenol content. It was concluded that the amount of phenolic constituents were more in extracts with solvent components Ethyl acetate + Methanol + Water, Methanol + Water + Acetic acid and Acetone + Water + Acetic acid. Because phenolics present in these leaf extracts are good electron donors and could terminate the radical chain reaction by converting free radicals to more stable products. Our findings were in good agreement with earlier reports where it was stated that the antioxidant properties were concomitant with the development of reducing power (Hu et al., 2003). The relevant chemical reaction of the

FRAP method involves a single electron reaction between Fe $(TPTZ)_2$ (III) and a single electron donor ArOH. The polyphenols like caffeic acid, tannic acid, ferulic acid, ascorbic acid, and quercetin, etc. react with Fe $(TPTZ)_2$ (III) slowly. So the reducing power cannot be correctly measured and there is possible interference due to the UV-Vis absorption at 593 nm by compounds other than Fe $(TPTZ)_2$ (II). Therefore, the FRAP assay cannot be used in biological samples as many vegetable extracts being colored may have similar interference. The result corroborates with the reports of Sharma et al. (2019) on ethanol extract only.

The topography of soil, climatic condition, season and stage of leaf collection might be the reason for variable contents of polyphenols in different plants. Besides, the organic solvents/ their mixtures and method of extraction also added to the aforesaid attributed reason. But the variation of total antioxidant properties of the plants might be due to difference in the constituents of plants responsible for extending protection against oxidative stress and ROS generation. In our study it might be due to different concentrations of polyphenols in various plants which showed variable antioxidant properties.

Individual Antioxidant Activity was determined by superoxide, nitric oxide and hydroxyl radical scavenging activity along with lipid peroxidation inhibition assay. The superoxide radicals were generated by illuminating the solution. The relative scavenging effect of total phenolics of different solvent extracts showed that the scavenging activity on superoxide radicals with the highest by the phenolics from Ethyl acetate + Methanol + Water and Methanol + Water + Acetic acid mixture extracts. Sodium nitroprusside in standard phosphate buffer produces nitric oxide and the plant extracts scavenge it to show their protective effects. The relative scavenging effect nitric oxide radicals of total phenolics of different solvent extracts showed that the scavenging activity on superoxide radicals with the highest by the phenolics from Ethyl acetate + Methanol + Water and Methanol + Water + Acetic acid mixture extracts. The variations in per cent of scavenging nitric oxide between different solvents and their mixtures were significant owing to their significant different concentrations of total polyphenols (Gil et al., 2000). The leaf extracts also exhibited a potent scavenging activity for hydroxyl radical. Deoxyribose is degraded into malonaldehyde on exposure to hydroxyl radicals generated by Fenton systems. On heating the mixture under acid conditions, malonaldehyde was detected spectrophotometrically by reaction with thiobarbituric acid to form a pink chromogen (Smith et al., 1992). The relative scavenging effect of total phenolics of different solvent extracts of leaf sample showed that the highest scavenging was exhibited by the phenolics extracted from Acetone + Water + Acetic acid and Methanol + Water + Acetic acid mixture. Thiobarbituric acid reactive substances are produced as by-products of lipid peroxidation when induced by the ferrous sulfate in poultry brain homogenate. The plant extracts in different organic solvents were exposed to inhibit the production of MDA to assay their antioxidant activities. The relative scavenging effect of total phenolics of different solvent extracts of leaf sample showed that the highest scavenging was exhibited by the phenolics extracted from Acetone + Water + Acetic acid and Methanol + Water + Acetic acid mixture.

CONCLUSION

The scavenging of superoxide, nitric oxide, hydroxyl radical and inhibition of MDA production were the avenues of chemical methods origin to measure the anti-oxidative effects of plant extracts. The plant extracts in different solvents showed different scavenging activities based on the solvent used for extraction. The solvents as well as methods of extraction played a significant role in contributing different polyphenolic components derived from plant leaves. The wide diversity in these components in the plant extracts was responsible to exhibit difference in antioxidant activity through scavenging various ROS radicals. It might be the reason of obtaining a variable per cent of scavenging different ROS radicals in various methods by the plant extracts of different solvent origin.

REFERENCES

Alasalvar, C., Karamac, M., Amarowicz, R. and Shahidi, F. 2006. Antioxidant and antiradical activities in extracts of hazelnut kernel (*Corylus avellana* L.) and hazelnut green leafy cover. *J. Agric. Food Chem*. **54**: 4826-4832.

Arunodaya, H.S., Krishna, V., Shashikumar, R. and Girish Kumar, K. 2016. Antibacterial and antioxidant activities of stem bark essential oil constituents of *Litsea glutinosa* C. B. Rob. *Int. J. Pharm. Pharm. Sci.* **8**(12): 258-264.

Benzie, I.E.F. and Strain, J.J. 1996. The ferric reducing ability of plasma (FRAP) as a measure of "antioxidant power": The FRAP assay. *Anal. Biochem*. **239**: 70-76.

Bhowmick, R., Sarwar, M.S., Dewan, S.M.R., Das, A., Das, B., Uddin, M.M.N., Islam, M.S. and Islam, M.S. 2014. In vivo analgesic, antipyretic and anti-inflammatory potential in Swiss albino mice and in vitro thrombolytic activity of hydroalcoholic extract from *Litsea glutinosa* leaves. *Biol. Res*. **47**(1): 1-8.

Bhuniya, T., Singh, P. and Mukherjee, S.K. 2010. An account of the species of *Litsea* LAM. (Lauraceae) Endemic to India. *Bangl. J. Plant Taxon*. **17**: 183-191.

Boateng, J., Verghese, M., Walker, L. and Ogutu, S. 2008. Effect of processing on antioxidant contents in selected dry beans (*Phaseolus* spp. L.). *LWT Food Sci. Technol*. **41**: 1541-1547.

Bulbul, I.J., Uddin, M.E., Nahar, N., Kuddus, M.R., Haque, Md. and Rashid, M.A. 2021. Antidiarrheal activity of four different species of *Litsea* available in Bangladesh. *Biomed. Pharmacol. J*. **14**(3): 1259-1266.

Devi, P. and Meera, R. 2010. Study of antioxidant, anti inflammatory and wound healing activity of extracts of *Litsea glutinosa*. *J. Pharm. Sci. Res*. **2**(2): 155-163.

Ghosh, N., Chaki, R., Pal, M. and Mandal, S.C. 2016. Hepatoprotective activity of methanol extract of *Litsea glutinosa* against hepatotoxin induced toxicity. *Orient. Pharm. Exp. Med.* **16**(2): 139-146.

Gil, M.I., Tomas-Barberan, F.A., Hess-Pierce. B., Holcroft, D.M. and Kader, A.A. 2000. Antioxidant activity of pomegranate juice and its relationship with phenolic composition and processing. *J. Agric. Food Chem*. **48**: 4581-4589.

Halliwell, B. 2007. Dietary polyphenols: Good, bad, or indifferent for your health? *Cardiovasc. Res*. **73**: 341-347.

Halliwell, B., Gutteridge, M.C. and Aruoma, O.I. 1997. The deoxyribose method: a simple test tube assay for determination of rate constants for reactions of hydroxyl radicals. *Anal. Biochem*. **165**: 215-219.

Hu, C., Zawistowski, J., Ling, W. and Kitts, D.D. 2003. Black rice (*Oryza sativa* L. indica) pigmented fraction suppresses both reactive oxygen species and nitric oxide in chemical and biological model systems. *J. Agric. Food Chem*. **48**(10): 5271-5277.

Hyland, K., Voisin, E., Banoun, H. and Auclair, C. 1983. Superoxide dismutase assay using alkaline dimethylsulfoxide as superoxide anion generating system. *Anal. Biochem.* **135**(2): 280-287.

Kumar, J. and Surh, Y. 2008. Cancer chemopreventive and therapeutic potential of resveratrol: Mechanistic perspectives. *Cancer Lett.* **269**: 243-246.

Ohkawa, H., Oshishim, N. and Yagi, K. 1979. Assay for lipid peroxide in animal tissue by thiobarbituric acid reaction. *Anal. Biochem.* **95**: 351-358.

Oyaizu, M. 1986. Studies on product on browning reaction prepared from glucose amine. *Jpn. J. Nutr.* **44**: 307-315.

Palanuvej, C., Hokputsa, S., Tunsaringkarn, T. and Ruangrungsi, N. 2009. In vitro glucose entrapment and alpha-glucosidase inhibition of mucilaginous substances from selected Thai medicinal plants. *Sci. Pharm*. **77**(4): 837-850.

Prieto, P., Pineda, M. and Miguel, A. 1999. Spectrophotometric quantitation of antioxidant capacity through the formation of Phosphomolybdenum Complex. *Anal. Biochem.* **269**: 337-341.

Rumzhum, N.N., Rahman, M.M., Sharukh, A.A., Chowdhury, S. A. and Parvin, M.N. 2012. In vitro antioxidant and antinociceptive potentialities of methanolic extract of *Litsea glutinosa*. *Bangladesh J. Sci. Ind. Res*. **47**(4): 401-406.

Saxena, H.O. and Brahmam, M. 1995. Rosaceae to Martyniaceae. *The flora of Orissa*.Vol-II., Regional Research Laboratory, Bhubaneswar and Orissa Forest Development Corporation Ltd., Bhubaneswar.

Senapati, M.R., Behera, P.C., Bisoi, P.C. Maity, A. and Parija, S.C. 2013. HPTLC finger print analysis of phytophenols of *Paederia foetida* under different extraction regimen. *Bioscan* **8**: 603-609.

Sharma, B.K., Loksh, K.R. and Jain, A.P. 2019. Screening of phytochemicals and antioxidant potential of leaves extract of *Litsea glutinosa*. *J. Drug Deliv. Ther*. **9**(4-s): 1214-1217.

Siddhuraju, P., Mohan, P.S. and Becker, K. 2002. Studies on the antioxidant activity of Indian Laburnum (*Cassia fistula* L.): a preliminary assessment of crude extracts from stem bark, leaves, flowers and fruit pulp. *Food Chem*. **79**: 61-67.

Singh, R.P., Jayaprakasha, G. K and Murthy, K.N.C. 2002. Studies on antioxidant activity of pomegranate (*Punica granatum*) peel and seed extracts using in vitro models. *J. Agric. Food Chem.* **50**: 81-86.

Smith, C.A., Mitchinson, M.J., Aruoma, O.I. and Halliwell, B. 1992. Stimulation of lipid peroxidation and hydroxyl-radical generation by the contents of human atherosclerotic lesions. *Biochem. J.* **286**: 901-905.

Snedecor, G.W. and Cochran, W.G. 1994. *Statistical Methods*, 8th edn, Iowa State University Press, Ames, USA.

Sreejayan Rao, M.N.A. 1997. Nitric oxide scavenging by curcuminoids, *J. Pharm*. **49**: 105-107.

Sultana, B., Anwar, F. and Ashraf, M. 2009. Effect of extraction solvent/ technique on the antioxidant activity of selected medicinal plant extracts. *Molecules* **14**: 2167-2180.

Surveswaran, S., Cai, Y.Z., Corke, H. and Sun, M. 2007. Systematic evaluation of natural phenolic antioxidants from 133 Indian medicinal plants. *J. Food Chem*. **102**: 938-953.

Thatoi, H.N., Panda, S.K., Rath, S.K. and Dutta, S.K. 2008. Antimicrobial activity and ethnomedicinal uses of some medicinal plants from Similipal Biosphere Reserve, Odisha. *Asian J. Plant Sci.* **7**: 260-267.

Veerapur, V.P., Prabhakar, K.R., Parihar, V.P., Kandadi, M.R., Ramakrishana, S., Mishra, B., Satish Rao, B.S., Srinivasan, K.K., Priyadarsini, K.I. and Unnikrishnan, M.K. 2009. *Ficus racemosa* stem bark extract, a potent antioxidant and a probable natural radioprotector. *Evid Based Complement Alternat. Med*. **6**(3): 317-324.

Wang, Y.S., Huang, R., Lu, H., Li, F.Y. and Yang, J.H. 2010. A New 2' Oxygenated Flavone Glycoside from *Litsea glutinosa* (Lour.) C B. Rob. *Biosci. Biotechnol. Biochem*. **74** (3): 652-654.

Zhang, X., Jin, Y., Wu, Y., Zhang, C., Jin, D., Zheng, Q. and Li, Y. 2018. Anti-hyperglycemic and antihyperlipidemia effects of the alkaloid-rich extract from barks of *Litsea glutinosa* in ob/ob mice. *Sci. Rep.* **8**:12646.

e-planet **20** (1): 47-49 (June 2022)

Symbiotic relationship between sea pen and porcelain crab: Art of living in marine ecosystem

S.N. SETHI[1*], N.R. MURTHY[1], A.P. NAYAK[2], S.K. PATRA[3] AND M.K. TRIPATHY[3]

[1*]*Madras Research Centre, ICAR-Central Marine Fisheries Research Institute, Chennai, India*

[2]*Krishi Vigyan Kendra, Puri, OUAT, Odisha, India*

[3]*College of Fisheries, OUAT, Rangailunda, Berhampur, Odisha, India*

[*]*sethisatyanarayana@yahoo.co.in*

Date of receipt: 02.05.2022 Date of acceptance: 14.05.2022

ABSTRACT

Mutualistic symbiosis is a common phenomenon in nature. In this relationship, the porcelain crab is benefitting from the sea pen by being protected from potentially harmful predators (tiger shark, white tip reef shark, hammerhead shark, blacktip reef shark, green hump head parrotfish, napoleon wrasse and the cuttlefish) and it has a place to live. On the other hand, the sea pen is benefitting by getting nutrients from the Porcelain crab that it would not normally get by itself. Nutrients such as ammonia, sulphur and phosphorus are excreted by the porcelain crab are used by sea pen. The symbiotic relationship between Porcelain crabs and sea pens is a well-known example of mutualism in the sea. Among marine organisms, marine sessile invertebrates are rich sources for obtaining bioactive natural molecules. A majority of the last decade studies about sessile invertebrate *Pennatulacea* (Class- *Anthozoa*) focused on the potential of *Pennatulacea* derived bioactive molecules in treating neoplasm. Terpenoids are organic compounds extracted from *Octocoralina,* a subclass of *Anthozoa*, which demonstrate anti-cancer effects. Terpenoids are further classified to Hemiterpenes, Monoterpenes, Sesquiterpenoids, Diterpenoids, Sesterterpenes, Triterpenoids, Tetraterpenoids, and Polyterpenoid; Sarcophine ($C_{20}H_{28}O_3$), as a Diterpene with high anti-tumour activity.

Key words: Bioactive compounds, mutualistic symbiosis, porcelain crab, sea pen

INTRODUCTION

Mutualistic symbiosis (the interaction between species, where both partners derive benefits) is a common phenomenon in nature (Mebs, 2009). In this particular relationship, the Porcelain crab is benefitting from the sea pen by being protected from potentially harmful predators (tiger shark, white tip reef shark, hammerhead shark, blacktip reef shark, green hump head parrotfish, napoleon wrasse, and the cuttlefish) and porcelain has got a permanent shelter to live. On the other hand, the sea pen is benefitting by getting nutrients such as ammonia, sulphur and phosphorus from the excreta of porcelain crab (Mebs, 2009). The porcelain crab also assists in keeping the sea pens free from debris (Shedd Aquarium, 2001).

MATERIALS AND METHODS

During sampling, a living specimen of the sea pen, *Pteroeides esperi* Herklots 1858, Anthozoa: Octocorallia), was brought to the shore by shore seine gear at Jegadapattinum fishing harbour, Tehsil/Taluk: Arantangi near Pudukkottai district

of Tamil Nadu during August, 2013. Sea pens are colonial marine cnidarians belonging to the order Pennatulacea. There are 16 families within the order; they are thought to have a cosmopolitan distribution in tropical and temperate waters worldwide. Sea pens are grouped with the octocorals (soft corals), together with sea whips or gorgonians. Although named after their feather-like appearance reminiscent of antique quill pens, only sea pen species belonging to the sub-order Subselliflorae live up to the comparison. This species has been duly submitted to Zoological Survey of India, ZSI, MBRC, Museum, Chennai and got accession number: M-236 **(**File.No.4-49/2015) in 2015.

RESULTS AND DISCUSSION

A porcelain crab (*Porcellanella triloba*), the colour pattern of which resembled that of the host to a remarkable degree, was found sheltering between the pinnules of a sea pen. The camouflage was so perfect that it was difficult at a casual glance to spot the crab, the general colour of which was whitish as that often sea pen while the carapace and chelipeds had dark more or less symmetrically arranged spots, simulating to some extent the dark spots on the distal part and margin of the pinnules (Fig. 1). Attempts to dislodge the crab automatically disturbed the sea pen which reacted immediately by shrinking. This reduced further the interspace between the pinnacles, thereby affording greater protection to the porcelain crab.

Fig. 1. Sea pens, *Pteroeides esperi* collected from fish landing centre of Jegadapattinum, Pudupettai district of Tamil Nadu

Fig. 2. Sea pens, *P. esperi* showing the one pair of Porcelain crab, *P. triloba* from fish landing centre of Jegadapattinum, Pudupettai district of Tamil Nadu

The crab in turn clasped firmly on to the body of the sea pen and only with considerable difficulty could it be separated without inflicting any damage. The porcelain crab belongs to the genus *Porcellanella* White (Family Porcellanidae: Section Anomura) and does not come under the category of true crabs. There are three species of the above have hitherto been recorded from Indian waters, *P. quadrilobata* Miers and *P. gakwari* Hornell from Alcyonarians and *P. triloba* White from Pennatula. (Fig. 2). A number of sea pens were collected subsequently, each with one to four crabs, two being the general rule as a pair. The crabs are characterized by long antennae which are constantly kept in motion and quite often the chelipeds are waved to and fro movement. The association of mutual benefits of both animals as the row of setaceous hair present in the form of a comb on the inner margin of each cheliped may help to brush off and thus keep clean the body of the sea pen from organic matter and dirt that might get entangled in its body.

The symbiosis refers to the biological interaction between two organisms living in close association. It is a widespread phenomenon in tropical marine communities and the association between sea pens and porcelain crabs belongs to the most common cases. It is a familiar example of mutualism. The symbiotic relationship between porcelain crab and sea pen is a classic example of mutualism relationship in the sea. Among marine organisms, marine sessile invertebrates are a rich source for obtaining bioactive natural molecules. A majority of the last decade studies about sessile invertebrate *Pennatulacea* (Class *Anthozoa*) focused on the potential of *Pennatulacea* derived bioactive molecules in treating neoplasm (Rocha et al., 2011). The order of *Pennatulacea* contains sea pens, which are colonial marine invertebrates including 300 species. The sea pens have feather-like appearance available at intertidal zones (15 meter) up to 600 meters depths (Sharifi and Safaeian, 2015). Terpenoids are organic compounds extracted from *Octocoralina* (a subclass of *Anthozoa*) which demonstrate anti-cancer effects (Rocha et al., 2011).

Terpenoids are classified to Hemiterpenes, Monoterpenes, Sesquiterpenoids, Diterpenoids, Sesterterpenes, Triterpenoids, Tetraterpenoids, and Polyterpenoid (Abandansari et al., 2013), Sarcophine ($C_{20}H_{28}O_3$), as a Diterpene with high anti-tumour activity (Sharifi and Safaeian, 2015), has the capability to induce apoptosis in cancer cells both *in-vitro* and *in-vivo*, as well as showing anti-inflammatory effects (Zhang et al., 2009). This species is available as bycatch by gillnet, shore seine, no body uses specifically, but it is used as trash fish as fish meal in poultry and fish feed industry.

ACKNOWLEDGEMENT

The authors are thankful to SIC, Madras Research Centre of CMFRI, Chennai and Director, CMFRI, Cochin for providing research facilities to conduct the above research programs smoothly.

REFERENCES

Abandansari, H.S., Aghaghafari, E., Nabid, M.R. and Niknejad, H. 2013. Preparation of injectable and thermoresponsive hydrogel based on penta-block copolymer with improved sol stability and mechanical properties. *Polymer* **54**: 1329–1340

Dutta, P.K., Roy, A.K., Barua, A.K., Chaudhuri, S.K. and Patra, A. 1990. Isolation of a Bioactive sterol from a sea pen, *Pteroides esperi. J. Nat. Prod.* **53**: 1347.

Jones, S. 1959. Notes on animal associations S 1. A porcellanid crab on the sea pen, *Pteroeides esperi* Mrklots. *J. Mar. Biol. Ass. India* **1** (2): 178-179.

Mebs, D. 2009. Chemical biology of the mutualistic relationship of sea anemones with fish and crustaceans. *Toxicon* **54**: 1071-1074.

Rocha, J., Peixe, L., Gomes, N.C. and Calado, R. 2011. Cnidarians as a source of new marine bioactive compounds-an overview of the last decade and future steps for bioprospecting. *Mar. Drugs* **9**: 1860–1886.

Sharifi, S. and Safaeian, S. 2015. Anti-inflammatory effect of lipid extract of sea pen (*Virgularia gustaviana*) in mice. *Asian J. Pharm. Clin. Res.* **8**: 332–334.

Shedd. Aquarium, 2001: http://sea.sheddaquarium.org/sea/fact_sheets.asp. Accessed 14 April 2014.

Zhang, X., Bommareddy, A., Chen, W., Khalifa, S., Kaushik, R.S., Fahmy, H. and Dwivedi, C. 2009. Sarcophine-diol, a chemo preventive agent of skin cancer, inhibits cell growth and induces apoptosis through extrinsic pathway in human epidermoid carcinoma A431 cells. *Transl. Oncol.* **2**: 21–30.

e-planet **20** (1): 50-67 (June 2022)

Avifaunal diversity of Badrama Wildlife Sanctuary, Bamra, Odisha, India

N.C. PALEI[1*], B.P. RATH[2] AND P.S. MALLIK[3]

[1&2]O/o Principal Chief Conservator of Forests (Wildlife) and Chief Wildlife Warden, Odisha, India*

[3]Divisional Forest Officer, Bamra (Wildlife) Division, Bamra, Bhubaneswar, Odisha, India

[*]wildpalei@gmail.com

Date of receipt: 28.04.2022 Date of acceptance: 14.05.2022

ABSTRACT

The study on bird diversity of Badrama Wildlife Sanctuary of Bamra, Odisha was carried out between August 2021 to March 2022. During the study period, a total of 171 species of birds belonging to 56 families were recorded. Out of 171 species a total 85.38% (n=146) species resident birds, 12.28% (n=21) species winter migrants, 2.34% (n=4) species summer migrants were recorded in the study area. According to the frequency of sighting of birds recorded in the study area, 81 species (47.37%) were common, 52 species (30.41%) were uncommon, 25 species (14.62%) were rare and 13 species (7.6%) were occasional were reported in Badrama Wildlife Sanctuary.

Key words: Abundance, Badrama Wildlife Sanctuary, birds, checklist, migratory bird, Odisha

INTRODUCTION

The avifaunal diversity of Odisha has been documented by various authors, i.e., Acharya and Kar (1996), Acharya et al. (1997, 1999), Sahu and Kar (2000), Gopi and Pandav (2007a, b), Sahu and Rout (2005). Ball (1877, 1878), Mukherjee (1952), Singh (1993), Kar and Sahu (1993, 1999). Almost all previous information on the birds of Odisha is based on the studies and surveys from its costal region and most of the studies were focused on waterbirds, i.e., Kar and Sahu (1993, 1999), Acharya and Kar (1996), Acharya et al. (1997, 1999), Sahu and Kar (2000), Gopi et al. (2005, 2006) and Gopi and Pandav (2007a, b). Few studies have done in other parts of Odisha (Ball, 1877,1878; Mukherjee, 1952; Singh, 1993; Sahu and Rout, 2005). Despite those and other recent works dealing with bird species richness in different areas of Odisha by Palei et al. (2011a, b), Palei et al. (2012a, b), Pradhan et al. (2012), Sahu et al. (2012), Palei et al. (2013), Palei et al (2014a, b, c), Pradhan et al. (2014), Palei et al. (2015), Bal et al. (2017), Palei et al. (2017), Rajguru (2017), Palei et al. (2018), Payra et al. (2019a, b) and Palei et al. (2020). No specific complete checklist of birds of Badrama Wildlife Sanctuary was prepared by any agency or any research institute except, the reference of some common birds of the Sanctuary in the Sanctuary Management Plans.

MATERIALS AND METHODS

Study Area

The name of the Badrama Wild Life Sanctuary is as per name of the Badrama Reserve Forest extending over an area of 304.03 sq km from 21°20’ to 21°40’ N latitude and 84°10’ to 84°30’ E longitudes; (Fig. 1) situated in Sambalpur district of Odisha State. The mean daily temperatures of winter range from 5°C to 20°C and that of summers range from 30°C to 45°C. There are three distinct seasons that is Summer- March to June, Rainy-July to October and winter-November to February. The rainfall of the sanctuary and the nearby areas varies from 1000 mm to 1800 mm. Due to good rainfall in the sanctuary area, moist peninsular high level sal and moist mixed deciduous forests are noticed,

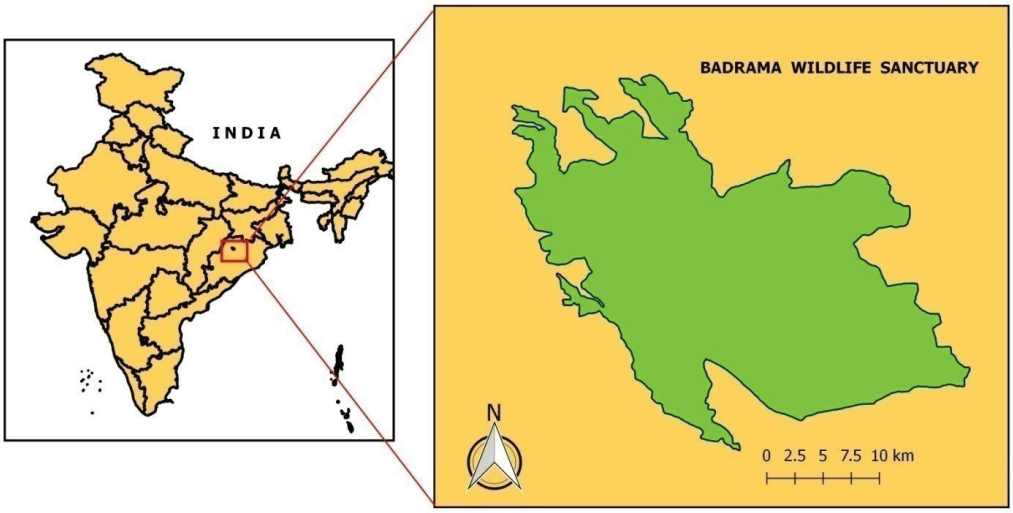


Fig. 1. Location map of Badrama Wildlife Sanctuary, Sambalpur, Odisha

along with extensive bamboo forests. Most villagers inside in the sanctuary and some people are tribal, and their activities inside forest are grazing livestock and collection of forest products (e.g., fodder for livestock, non-timber). The sanctuary is dominated by Northern Tropical Dry Deciduous Forest, Dry Peninsular Sal Forests and Northern Dry Mixed Deciduous Forests (Champion and Seth, 1968). The Sanctuary contain forest of good quality having associates like *Terminalia tomentosa, Anogeissus latifolia, Pterocarpus marsupium, Diospyros melanoxylon, Adina cordifolia, Terminalia chebula, Terminalia bellirica, Lagerstroemia parviflora, Buchanania lanzan, Lannea coromandelica and Dalbergia latifolia* etc. The common plants are *Emblica officinalis, Cassia fistula, Morinda tinctoria, Antidesma* sp., *Randia* sp., *Symplocos racemosus* and *Cleistanthus collinus.* The under growths in these forests are *Flemingia chappar*, *Indigofera cassioides*, *Woodfordia fruticosa, Desmodium* sp., *Strobilanthes* sp. The common climbers in these forests are *Bauhinia vahlii* and *Smilax* sp. while *Combretum roxburghii* occurs in valleys and ravines.

In addition to birds, important mammals found in sanctuary are elephant (*Elephas maximus*), sambar (*Rusa unicolor)*, barking deer (*Muntiacus muntjak)*, wild pig (*Sus scrofa)*, gaur (*Bos gaurus)*, four-horned antelope (*Tertracerus quadricornis)*, leopard (*Panthera pardus)*, rusty spotted cat (*Prionailurus rubiginosus),* jungle cat *(Felis chaus)*, striped hyena (*Hyaena hyaena)*, Indian grey wolf (C*anis lupus papillaries*), golden jackal (*Canis aureus),* Indian fox (*Vulpes bengalensis)*, sloth bear (*Melursus ursinus*), giant squirrel (*Ratufa indica)* and hanuman langur (*Semnopithecus entellus*) were reported in Badrama Wildlife Sanctuary (Kumar, 2018).

Methodology

Survey in Badrama Wildlife Sanctuary of Bamra, Odisha was carried out between August 2021 to March 2022. Regular surveys were done by walking on fixed routs throughout the study area. Observations were made in the morning and evening hour, depending on the light condition. Recordings were not made at the time of heavy rains. Surveys were conducted on foot in different type of habitat, where sighting chances are more. The study was carried out on day time to encounter the maximum numbers of birds. All species identifications were done following the works of Ali and Ripley (1995), Grimmet et al. (2006), Balachandran et al. (2009) and Naik and Mishra (2017). Surveys were conducted twice a week. Birds were observed using 7 X 50 and 7 X 42 Bushnell binoculars. Photographs were taken by Canon EOS 7D Mark II digital SLR and refined APS-C sized 20.2 megapixel CMOS sensor with dual DIGIC 6 image and Mark II 100-400 mm

lens with Canon EF100-400 mm f/4.5-5.6l IS II USM Telephoto Zoom Lens. At each site, birds were counted using a binocular before moving to the next point as rapidly as possible without disturbing the birds. We observed details on habitat type, season and status (resident/ migrant). In case of doubtful identification, photographs were taken and the species were identified later by consulting experts.

The counting methodology was followed in line with the methods and trends undertaken by Urfi et al. (2005). The status of the birds as Common (C), Uncommon (UC), Occasional (O) and Rare (R) is based on the frequency of spotting. The birds were divided into following categories in accordance with the classification suggested by Ali (2012): R-resident bird migratory birds are further subcategorized as WM -winter migratory and SM - summer migratory.

RESULTS AND DISCUSSION

A total of 171 species of birds (Table 1) belonging to 56 families were recorded from Badrama Wildlife Sanctuary (Table 1). The present study revealed that Muscicapidae and Accipitridae family (9 sp. each) dominated the avian species in this area, followed by Ardeidae and Strigidae (8 sp.), Columbidae (7 sp. each), Passerinae, Turdinae and Motacillidae (each 6 sp.), Alaudidae, Cuculidae, Anatidae, Picidae, Sylviinae and Timaliinae (5 sp. each), Rallidae, Sturnidae, Estrildidae and Campephagidae (4 sp. each), Phalacrocoracidae, Phasianidae, Psittacidae, Charadriidae, Corvidae, Scolopacidae, Alcedinidae, Caprimulgidae, Dicruridae, Meropidae and Laniidae (3 sp. each), Podicipedidae, Apodida, Pycnonotidae, Muscicapinae, Oriolidae and Capitonidae (2 sp. each) (Table 1). Moreover, 21 families Anhingidae, Ciconiidae, Falconidae, Turnicidae, Jacanidae, Threskiornithidae, Recurvirostridae, Laridae, Tytonidae, Coraciidae, Upupidae, Bucerotidae, Hirundinidae, Irenidae, Monarchinae, Rhipidurinae, Dicaeidae, Nectariniidae, Fringillidae, Ploceinae, Zosteropidae and Paridae were poorly represented in the study area with a single species each were record in the study area (Table 1).

Based on the feeding behaviour from the present data it is apparent that the avifauna of the campus is dominated by insectivores (46.2%) followed by omnivores (16.96%), piscivores (11.7%), granivores (8.19%), carnivores (9.94%), frugivores (7.01%), respectively. According to the frequency of sighting of birds recorded in study area, 81 spp. (47.37%) were common, 52 spp. (30.41%) uncommon, 25 spp. (14.62%) rare and 13 spp. (7.6%) occasional as reported in Badrama Wildlife Sanctuary. Among the total bird species observed in the sanctuary, 146 (85.38%) as resident, 21 (12.28%) as winter migrant and 4 (2.34%) as summer migrants were recorded in the study area.

Badrama Wildlife Sanctuary was here with established to be a suitable habitat for avifauna (Fig.2). Nocturnal birds recorded in the study area were barn owl *(Tyto alba),* Indian scops owl *(Otus bakkamoena),* spotted owlet *(Athene brama),* mottled wood owl *(Strix ocellata),* brown fish owl *(Bubo zeylonensis),* dusky eagle owl *(Bubo coromandus),* brown hawk owl *(Ninox scutulata)* and jungle owlet *(Glaucidium radiatum)* were recorded Kutab and Argen area of the sanctuary (Fig. 3). Birds of prey species were recorded i.e., Oriental honey-buzzard *(Pernis ptilorhynchus),* black-shouldered kite (*Elanus caeruleus),* black kite *(Milvus migrans),* brahminy kite *(Haliastur Indus),* crested serpent-eagle *(Spilornis cheela),* osprey *(Pandion haliaetus),* shikra *(Accipiter badius),* booted eagle *(Hieraaetus pennatus)* and Jerdon's baza *(Aviceda jerdoni),* recorded in Kutab, Gayalmundi and Gantab area of the sanctuary May be start of a new sentence. Some terrestrial birds were also recorded, i.e., common hoopoe *(Upupa epops)*, emerald dove *(Chalcophaps indica),* red vented bulbul *(Pycnonotus cafer), little green bee-eater* (*Merops orientalis),* grey wagtail *(Motacilla cinerea),* pied bushchat *(Saxicola caprata),* brahminy starling (*Sturnus pagodarum)* coppersmith barbet *(Psilopogon haemacephalus),* white throated kingfisher *(Halcyon smyrnensis),* Indian roller *(Coracias benghalensis),* oriental pied hornbill *(Anthracoceros albirostris)* and Indian grey hornbill *(Ocyceros birostris)* with multiple coloured photographs (Fig. 4) in Badrama Wildlife Sanctuary.

However, a long-term study would bring out robust ornithological information on the sanctuary. This study generated a baseline data on bird species of Badrama Wildlife Sanctuary which will be helpful in developing future conservation

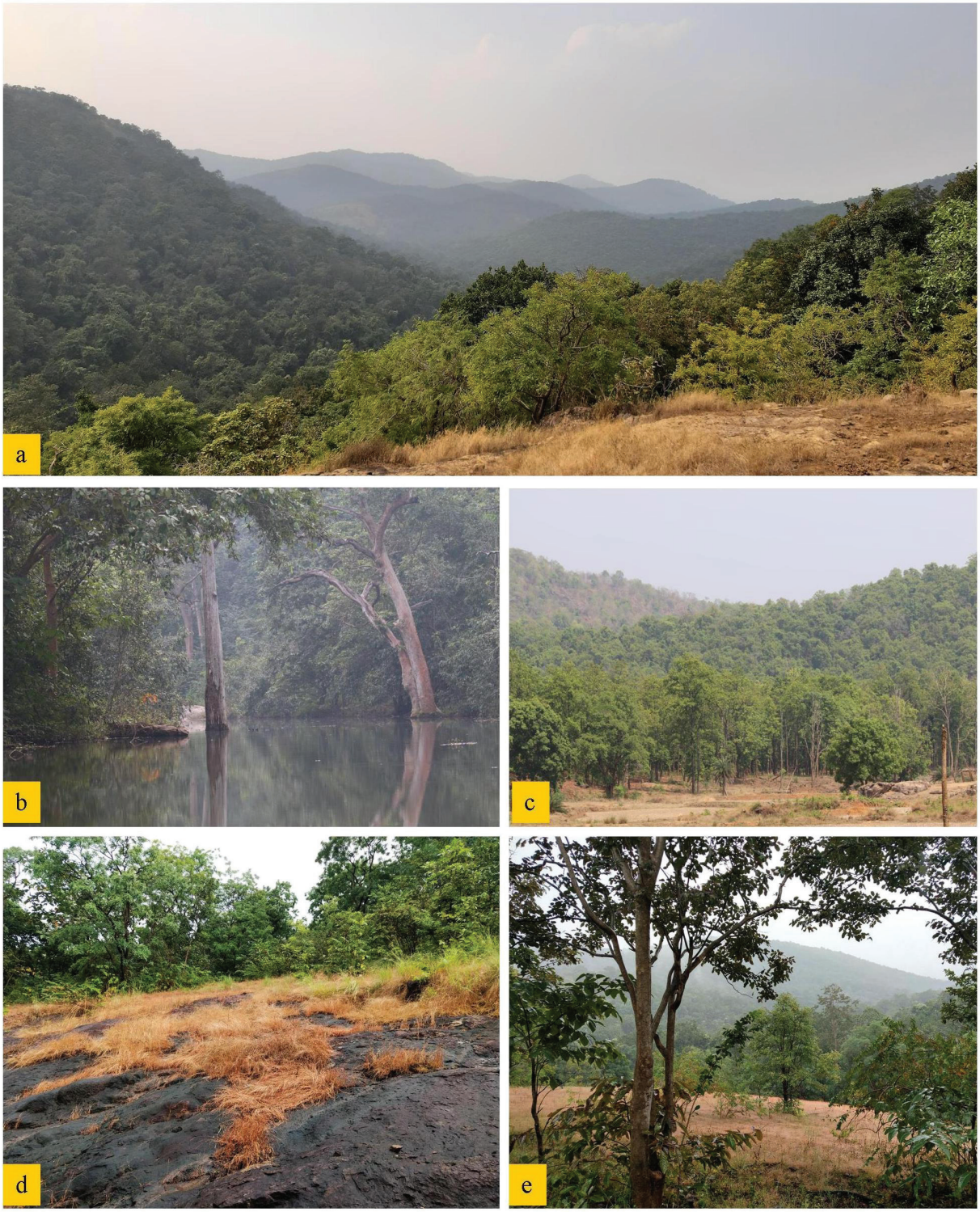


Fig. 2. (a-e) Forest habitats in Badrama Wildlife Sanctuary

Fig. 3. Some nocturnal and common birds of Badrama Wildlife Sanctuary (a. Indian eagle-owl, b. Brown fish-owl, c. Indian scops owl, d. Indian spotted owl, e. Jungle owlet, f. Indian roller, g. Eurasian golden oriole, h. Brahminy starling, i. Pied hornbill, j. Long tailed shrike, k. Crested serpent eagle, l. Brown shrike, m. Paddy field pipit, n. Yellow wattled lapwing, o. Indian night jar)

Fig. 4. Some terrestrial and wetland dependant birds of Badrama Wildlife Sanctuary (a. Common Hoopoe, b. Emerald Dove, c. Red-vented bulbul, d. Small blue-eater, e. Grey wagtail, f. Pied bushchat, g. Black drongo, h. Purple rumped sunbird, i. Coppersmith barbet, j. Bronze-winged jacana, k. White throated kingfisher, l. Large egret, m. Purple heron, n. Indian pond heron, o. Asian open-bill stork)

and management programs.

Table 1. Checklist of birds and its resident or migratory status, feeding habit and abundance of Badrama Wildlife Sanctuary, Odisha

Sl. No	Common Name/ Families	Scientific Name	Authority	IUCN Status	Schedule	Resident/ Migratory	Feeding Habit	Abundance
	1. Podicipedidae							
1	Little Grebe	*Tachybaptus ruficollis*	Pallas, 1764	LC	SCH.IV	R	P	UC
2	Great Crested Grebe	*Podiceps cristatus*	Linnaeus, 1758	LC	SCH.IV	M, W	P	UC
	2. Phalacrocoracidae							
3	Little Cormorant	*Phalacrocorax niger*	Vieillot, 1817	LC	SCH.IV	R	P	UC
4	Indian Shag	*Phalacrocorax fuscicollis*	Stephens, 1826	LC	SCH.IV	R	P	UC
5	Great Cormorant	*Phalacrocorax carbo*	Linnaeus, 1758	LC	SCH.IV	R	P	UC
	3. Anhingidae							
6	Darter	*Anhinga melanogaster*	Pennant, 1769	LC	SCH.IV	R	P	O
	4. Ardeidae							
7	Little Egret	*Egretta garzetta*	Linnaeus, 1766	LC	SCH.IV	R	P	C
8	Large Egret	*Casmerodius albus*	Linnaeus, 1758	LC	SCH.IV	R	P	UC
9	Median Egret	*Mesophoyx intermedia*	Wagler, 1829	LC	SCH.IV	R	P	C
10	Cattle Egret	*Bubulcus ibis*	Linnaeus, 1758	LC	SCH.IV	R	P	C
11	Indian Pond-Heron	*Ardeola grayii*	Sykes, 1832	LC	SCH.IV	R	P	C
12	Black-crowned Night-Heron	*Nycticorax nycticorax*	Linnaeus, 1758	LC	SCH.IV	R	P	R
13	Little Green Heron	*Butorides striatus*	Linnaeus, 1758	LC	SCH.IV	R	P	UC
14	Purple Heron	*Ardea purpurea*	Linnaeus, 1766	LC	SCH.IV	R	P	UC
	5. Ciconiidae			LC				
15	Asian Openbill-Stork	*Anastomus oscitans*	Boddaert, 1783	LC	SCH.IV	R	P	UC
	6. Threskiornithidae			LC				
16	Black Ibis	*Pseudibis papillosa*	Temminck, 1824	LC	SCH.IV	R	P	UC
	7. Anatidae							

Sl. No	Common Name/ Families	Scientific Name	Authority	IUCN Status	Schedule	Resident/ Migratory	Feeding Habit	Abundance
17	Lesser Whistling-Duck	*Dendrocygna javanica*	Horsfield, 1821	LC	SCH.IV	R	OM	C
18	Spot-billed Duck	*Anas poecilorhyncha*	J.R. Forester, 1781	LC	SCH.IV	R	OM	UC
19	Red-crested Pochard	*Rhodonessa rufina*	Pallas, 1773	LC	SCH.IV	M, W	OM	UC
20	Common Pochard	*Aythya ferina*	Linnaeus, 1758	LC	SCH.IV	M, W	OM	UC
21	Tufted Pochard	*Aythya fuligula*	Linnaeus, 1758	LC	SCH.IV	M, W	OM	UC
	8. Accipitridae							
22	Oriental Honey-Buzzard	*Pernis ptilorhynchus*	Temminck, 1821	LC	SCH.IV	R	CV	R
23	Black-shouldered Kite	*Elanus caeruleus*	Desfontaines, 1789	LC	SCH.IV	R	CV	C
24	Black Kite	*Milvus migrans*	Boddaert, 1783	LC	SCH.IV	R	CV	C
25	Brahminy Kite	*Haliastur indus*	Boddaert, 1783	LC	SCH.IV	R	CV	UC
26	Crested Serpent-Eagle	*Spilornis cheela*	Latham, 1790	LC	SCH.IV	R	CV	C
27	Osprey	*Pandion haliaetus*	Linnaeus, 1758	LC	SCH.IV	R	CV	R
28	Shikra	*Accipiter badius*	Gmelin, 1788	LC	SCH.IV	R	CV	C
29	Booted eagle	*Hieraaetus pennatus*	Gmelin, 1788	LC	SCH.IV	M, W	CV	R
30	Jerdon's Baza	*Aviceda jerdoni*	Blyth, 1845	LC	SCH.IV	R	CV	R
	9. Falconidae							
31	Peregrine Falcon	*Falco peregrinus*	Tunstall, 1771	LC	SCH.IV	R	CV	R
	10. Phasianidae							
32	Jungle Bush-Quail	*Perdicula asiatica*	Latham, 1790	LC	SCH.IV	R	OM	UC
33	Red Junglefowl	*Gallus gallus*	Linnaeus, 1758	LC	SCH.IV	R	OM	UC
34	Indian Peafowl	*Pavo cristatus*	Linnaeus, 1758	LC	SCH.IV	R	OM	UC
	11. Turnicidae							
35	Small Buttonquail	*Turnix sylvatica*	Desfontaines, 1789	LC	SCH.IV	R	OM	UC
	12. Rallidae							

Sl. No	Common Name/ Families	Scientific Name	Authority	IUCN Status	Schedule	Resident/ Migratory	Feeding Habit	Abundance
36	White-breasted Waterhen	*Amaurornis phoenicurus*	Pennant, 1769	LC	SCH.IV	R	OM	C
37	Common Moorhen	*Gallinula chloropus*	Linnaeus, 1758	LC	SCH.IV	R	OM	C
38	Common Coot	*Fulica atra*	Linnaeus, 1758	LC	SCH.IV	R	OM	C
39	Brown Crake	*Amaurornis akool*	Sykes, 1832	LC	SCH.IV	R	IN	C
	13. Jacanidae							
40	Bronze-winged Jacana	*Metopidius indicus*	Latham, 1790	LC	SCH.IV	R	OM	C
	14. Charadriidae							
41	Little Ringed Plover	*Charadrius dubius*	Scopoli, 1786	LC	SCH.IV	R	IN	C
42	Yellow-wattled Lapwing	*Vanellus malabaricus*	Boddaert, 1783	LC	SCH.IV	R	IN	C
43	Red-wattled Lapwing	*Vanellus indicus*	Boddaert, 1783	LC	SCH.IV	R	IN	C
	15. Scolopacidae							
44	Common Snipe	*Gallinago gallinago*	Linnaeus, 1758	LC	SCH.IV	M, W	IN	UC
45	Common Sandpiper	*Actitis hypoleucos*	Linnaeus, 1758	LC	SCH.IV	M, W	IN	C
46	Little Stint	*Calidris minuta*	Leisler, 1812	LC	SCH.IV	M, W	IN	UC
	16. Recurvirostridae							
47	Black-winged Stilt	*Himantopus himantopus*	Linnaeus, 1758	LC	SCH.IV	R	IN	UC
	17. Laridae							
48	River Tern	*Sterna aurantia*	J.E. Gray, 1831	LC	SCH.IV	R	P	C
	18. Columbidae							
49	Blue Rock Pigeon	*Columba livia*	Gmelin, 1789	LC	SCH.IV	R	GR	C
50	Oriental Turtle-Dove	*Streptopelia orientalis*	Latham, 1790	LC	SCH.IV	R	GR	UC
51	Spotted Dove	*Streptopelia chinensis*	Scopoli, 1786	LC	SCH.IV	R	GR	C
52	Eurasian Collared-Dove	*Streptopelia decaocto*	Frivaldszky, 1838	LC	SCH.IV	R	GR	UC

Sl. No	Common Name/ Families	Scientific Name	Authority	IUCN Status	Schedule	Resident/ Migratory	Feeding Habit	Abundance
53	Little Brown Dove	*Streptopelia senegalensis*	Linnaeus, 1766	LC	SCH.IV	R	GR	C
54	Emerald Dove	*Chalcophaps indica*	Linnaeus, 1758	LC	SCH.IV	R	GR	R
55	Yellow-legged Green-Pigeon	*Treron phoenicoptera*	Latham, 1790	LC	SCH.IV	R	GR	UC
	19. Psittacidae							
56	Rose-ringed Parakeet	*Psittacula krameri*	Scopoli, 1769	LC	SCH.IV	R	FR	C
57	Alexandrine Parakeet	*Psittacula eupatria*	Linnaeus, 1766	LC	SCH.IV	R	FR	UC
58	Plum-headed Parakeet	*Psittacula cyanocephala*	Linnaeus, 1766	LC	SCH.IV	R	FR	C
	20. Cuculidae							
59	Brainfever Bird	*Hierococcyx varius*	Vahl, 1797	LC	SCH.IV	R	OM	UC
60	Indian Cuckoo	*Cuculus micropterus*	Gould, 1838	LC	SCH.IV	R	OM	C
61	Asian Koel	*Eudynamys scolopacea*	Linnaeus, 1758	LC	SCH.IV	R	OM	C
62	Large Green-billed Malkoha	*Phaenicophaeus tristis*	Lesson, 1830	LC	SCH.IV	R	OM	C
63	Greater Coucal	*Centropus sinensis*	Stephens, 1815	LC	SCH.IV	R	IN	C
	21. Tytonidae							
64	Barn Owl	*Tyto alba*	Scopoli, 1769	LC	SCH.I	R	CV	R
	22. Strigidae							
65	Brown Fish-Owl	*Ketupa zeylonensis*	Gmelin, 1788	LC	SCH.I	R	CV	UC
66	Mottled Wood-Owl	*Strix ocellata*	Lesson, 1839	LC	SCH.I	R	CV	UC
67	Jungle Owlet	*Glaucidium radiatum*	Tickell, 1833	LC	SCH.I	R	CV	C
68	Spotted Owlet	*Athene brama*	Temminck, 1821	LC	SCH.I	R	CV	C
69	Indian Scops Owl	*Otus bakkamoena*	Pennant, 1769	LC	SCH.I	R	OM	C
70	Dusky eagle Owl	*Bubo coromandus*	Latham, 1790	LC	SCH.I	R	OM	C
71	Brown hawk owl	*Ninox scutulata*	Raffles, 1822	LC	SCH.I	R	CV	UC

Sl. No	Common Name/ Families	Scientific Name	Authority	IUCN Status	Schedule	Resident/ Migratory	Feeding Habit	Abundance
72	Indian eagle owl	*Bubo bengalensis*	Franklin 1831	LC		R	CV	UC
	23. Caprimulgidae							
73	Indian Jungle Nightjar	*Caprimulgus indicus*	Latham, 1790	LC	SCH.IV	R	IN	C
74	Large-tailed Nightjar	*Caprimulgus macrurus*	Horsfield, 1821	LC	SCH.IV	R	IN	C
75	Common Indian Nightjar	*Caprimulgus asiaticus*	Latham, 1790	LC	SCH.IV	R	IN	C
	24. Apodidae							
76	Asian Palm-Swift	*Cypsiurus balasiensis*	J.E. Gray, 1829	LC	SCH.IV	R	IN	UC
77	House Swift	*Apus affinis*	J.E. Gray, 1830	LC	SCH.IV	R	IN	C
	25. Alcedinidae							
78	Small Blue Kingfisher	*Alcedo atthis*	Linnaeus, 1758	LC	SCH.IV	R	P	C
79	White-throated Kingfisher	*Halcyon smyrnensis*	Linnaeus, 1758	LC	SCH.IV	R	P	C
80	Lesser Pied Kingfisher	*Ceryle rudis*	Linnaeus, 1758	LC	SCH.IV	R	P	UC
	26. Meropidae							
81	Small green bee-eater	*Merops orientalis*	Latham, 1801	LC	SCH.IV	R	IN	C
82	Blue-tailed Bee-eater	*Merops philippinus*	Linnaeus, 1766	LC	SCH.IV	M, W	IN	O
83	Chestnut-headed Bee-eater	*Merops leschenaulti*	Vieillot, 1817	LC	SCH.IV	R	IN	UC
	27. Coraciidae							
84	Indian Roller	*Coracias benghalensis*	Linnaeus, 1758	LC	SCH.IV	R	IN	C
	28. Upupidae			LC				
85	Common Hoopoe	*Upupa epops*	Linnaeus, 1758	LC	SCH.IV	R	IN	C
	29. Bucerotidae				SCH.IV			
86	Indian grey hornbill	*Ocyceros birostris*	Scopoli, 1786	LC	SCH.IV	R	FR	R
87	Oriental pied hornbill	*Anthracoceros albirostris*	Shaw and Nodder 1807	LC	SCH.IV	R	FR	R
	30. Capitonidae							
88	Coppersmith Barbet	*Psilopogon haemacephalus*	P.L.S. Müller, 1776	LC	SCH.IV	R	FR	C

Sl. No	Common Name/ Families	Scientific Name	Authority	IUCN Status	Schedule	Resident/ Migratory	Feeding Habit	Abundance
89	Brown-headed Barbet	*Psilopogon zeylanicus*	Gmelin, 1788	LC	SCH.IV	R	FR	C
	31. Picidae							
90	Brown-capped Pygmy Woodpecker	*Dendrocopos nanus*	Vigors, 1832	LC	SCH.IV	R	IN	R
91	Yellow-fronted Pied Woodpecker	*Dendrocopos mahrattensis*	Latham, 1801	LC	SCH.IV	R	IN	UC
92	Lesser Golden-backed Woodpecker	*Dinopium benghalense*	Linnaeus, 1758	LC	SCH.IV	R	IN	UC
93	Greater Golden-backed Woodpecker	*Chrysocolaptes lucidus*	Scopoli, 1786	LC	SCH.IV	R	IN	R
94	Black-shouldered Woodpecker	*Chrysocolaptes festivus*	Boddaert, 1783	LC	SCH.IV	R	IN	UC
	32. Alaudidae							
95	Red-winged Bush-Lark	*Mirafra erythroptera*	Blyth, 1845	LC	SCH.IV	R	IN	R
96	Bengal Bush-Lark	*Mirafra assamica*	Horsfield, 1840	LC	SCH.IV	R	IN	R
97	Rufous-tailed Finch-Lark	*Ammomanes phoenicurus*	Franklin, 1831	LC	SCH.IV	R	IN	R
98	Eastern Skylark	*Alauda gulgula*	Franklin, 1831	LC	SCH.IV	R	IN	UC
99	Black-crowned Sparrow-Lark	*Eremopterix nigriceps*	Gould, 1839	LC	SCH.IV	R	IN	UC
	33. Hirundinidae							
100	Barn Swallow	*Hirundo rustica*	Linnaeus, 1758	LC	SCH.IV	M, W	IN	C
101	Red-rumped Swallow	*Cecropis daurica*	Linnaeus, 1771	LC	SCH.IV	R	IN	C
	34. Motacillidae							
102	White Wagtail	*Motacilla alba*	Linnaeus, 1758	LC	SCH.IV	M, W	IN	C
103	Large Pied Wagtail	*Motacilla maderaspatensis*	Gmelin, 1789	LC	SCH.IV	R	IN	C
104	Citrine Wagtail	*Motacilla citreola*	Pallas, 1776	LC	SCH.IV	M, W	IN	C
105	Yellow Wagtail	*Motacilla flava*	Linnaeus, 1758	LC	SCH.IV	M, W	IN	UC
106	Grey Wagtail	*Motacilla cinerea*	Tunstall, 1771	LC	SCH.IV	M, W	IN	UC

Sl. No	Common Name/ Families	Scientific Name	Authority	IUCN Status	Schedule	Resident/ Migratory	Feeding Habit	Abundance
107	Paddyfield Pipit	*Anthus rufulus*	Vieillot, 1818	LC	SCH.IV	R	IN	C
	35. Campephagidae							
108	Large Cuckoo-Shrike	*Coracina macei*	Lesson, 1830	LC	SCH.IV	R	IN	O
109	Small Minivet	*Pericrocotus cinnamomeus*	Linnaeus, 1766	LC	SCH.IV	R	IN	C
110	Scarlet Minivet	*Pericrocotus flammeus*	Forster, 1781	LC	SCH.IV	R	IN	C
111	Common Woodshrike	*Tephrodornis pondicerianus*	Gmelin, 1789	LC	SCH.IV	R	IN	O
	36. Pycnonotidae							
112	Red-whiskered Bulbul	*Pycnonotus jocosus*	Linnaeus, 1758	LC	SCH.IV	R	FR	C
113	Red-vented Bulbul	*Pycnonotus cafer*	Linnaeus, 1766	LC	SCH.IV	R	FR	C
	37. Irenidae							
114	Common Iora	*Aegithina tiphia*	Linnaeus, 1758	LC	SCH.IV	R	IN	C
	38. Laniidae							
115	Brown Shrike	*Lanius cristatus*	Linnaeus, 1758	LC	SCH.IV	M, W	IN	UC
116	Bay-backed Shrike	*Lanius vittatus*	Valenciennes, 1826	LC	SCH.IV	R	IN	UC
117	Rufous-backed Shrike	*Lanius schach*	Linnaeus, 1758	LC	SCH.IV	M, W	IN	R
	39. Turdinae							
118	Indian Chat	*Cercomela fusca*	Blyth, 1851	LC	SCH.IV	R	IN	O
119	Indian Robin	*Saxicoloides fulicata*	Linnaeus, 1776	LC	SCH.IV	R	IN	C
120	Blue-headed Rock-Thrush	*Monticola cinclorhynchus*	Vigors, 1832	LC	SCH.IV	M, W	IN	O
121	Oriental Magpie-Robin	*Copsychus saularis*	Linnaeus, 1758	LC	SCH.IV	R	IN	C
122	White-rumped Shama	*Copsychus malabaricus*	Scopoli, 1786	LC	SCH.IV	R	IN	C
123	Black Redstart	*Phoenicurus ochruros*	Gmelin, 1774	LC	SCH.IV	M, W	IN	O
	40. Timaliinae							
124	Spotted Babbler	*Pellorneum ruficeps*	Swainson, 1832	LC	SCH.IV	R	IN	R

Sl. No	Common Name/ Families	Scientific Name	Authority	IUCN Status	Schedule	Resident/ Migratory	Feeding Habit	Abundance
125	Indian Scimitar-Babbler	*Pomatorhinus horsfieldii*	Sykes, 1832	LC	SCH.IV	R	IN	R
126	Yellow-eyed Babbler	*Chrysomma sinense*	Gmelin, 1789	LC	SCH.IV	R	IN	C
127	Jungle Babbler	*Turdoides striatus*	Dumont, 1823	LC	SCH.IV	R	IN	C
128	Common Babbler	*Turdoides caudatus*	Dumont, 1823	LC	SCH.IV	R	IN	C
	41. Sylviinae							
129	Jungle Prinia	*Prinia sylvatica*	Jerdon, 1840	LC	SCH.IV	R	IN	R
130	Ashy Prinia	*Prinia socialis*	Sykes, 1832	LC	SCH.IV	R	IN	R
131	Plain Prinia	*Prinia inornata*	Sykes, 1832	LC	SCH.IV	R	IN	R
132	Common Tailorbird	*Orthotomus sutorius*	Pennant, 1769	LC	SCH.IV	R	IN	C
133	Common Chiffchaff	*Phylloscopus collybita*	Vieillot, 1817	LC	SCH.IV	M, W	IN	C
	42. Muscicapinae							
134	Red-throated Flycatcher	*Ficedula parva*	Bechstein, 1792	LC	SCH.IV	M, W	IN	O
135	Tickell's Blue-Flycatcher	*Cyornis tickelliae*	Blyth, 1843	LC	SCH.IV	R	IN	O
	43. Monarchinae							
136	Asian Paradise-Flycatcher	*Terpsiphone paradisi*	Linnaeus, 1758	LC	SCH.IV	M, S	IN	R
137	Black-naped Monarch	*Hypothymis azurea*	Boddaert, 1783	LC	SCH.IV	R	IN	UC
	44. Rhipidurinae			LC				
138	White-browed Fantail	*Rhipidura aureola*	Lesson, 1831	LC	SCH.IV	R	IN	R
	45. Dicaeidae			LC	SCH.IV			
139	Thick-billed Flowerpecker	*Dicaeum agile*	Tickell, 1833	LC	SCH.IV	R	FR	C
	46. Nectariniidae							
140	Purple Sunbird	*Nectarinia asiatica*	Latham, 1790	LC	SCH.IV	R	OM	C
	47. Zosteropidae							
141	Oriental White-eye	*Zosterops palpebrosus*	Temminck, 1824	LC	SCH.IV	R	FR	C
	48. Fringillidae							

Sl. No	Common Name/ Families	Scientific Name	Authority	IUCN Status	Schedule	Resident/ Migratory	Feeding Habit	Abundance
142	Common Rosefinch	*Carpodacus erythrinus*	Pallas, 1770	LC	SCH.IV	M, W	FR	O
	49. Estrildidae							
143	Red Munia	*Amandava amandava*	Linnaeus, 1758	LC	SCH.IV	R	GR	R
144	White-throated Munia	*Lonchura malabarica*	Linnaeus, 1758	LC	SCH.IV	R	GR	C
145	White-rumped Munia	*Lonchura striata*	Linnaeus, 1766	LC	SCH.IV	R	GR	UC
146	Spotted Munia	*Lonchura punctulata*	Linnaeus, 1758	LC	SCH.IV	R	GR	C
	50. Passerinae							
147	House sparrow	*Passer domesticus*	Linnaeus, 1758	LC	SCH.IV	R	GR	C
148	Black breasted weaver	*Ploceus benghalensis*	Linnaeus, 1758	LC	SCH.IV	R	GR	C
149	Baya Weaver	*Ploceus philippinus*	Linnaeus, 1766	LC	SCH.IV	R	GR	C
	51. Sturnidae							
150	Brahminy Starling	*Sturnus pagodarum*	Gmelin, 1789	LC	SCH.IV	R	OM	UC
151	Asian Pied Starling	*Sturnus contra*	Linnaeus, 1758	LC	SCH.IV	R	OM	C
152	Rosy Starling	*Sturnus roseus*	Linnaeus, 1758	LC	SCH.IV	R	OM	UC
153	Common Myna	*Acridotheres tristis*	Linnaeus, 1766	LC	SCH.IV	R	OM	C
	52. Oriolidae							
154	Eurasian Golden Oriole	*Oriolus oriolus*	Linnaeus, 1758	LC	SCH.IV	R	OM	R
155	Black-headed Oriole	*Oriolus xanthornus*	Linnaeus, 1758	LC	SCH.IV	R	OM	UC
	53. Dicruridae							
156	Black Drongo	*Dicrurus macrocercus*	Vieillot, 1817	LC	SCH.IV	R	IN	C
157	Ashy Drongo	*Dicrurus leucophaeus*	Vieillot, 1817	LC	SCH.IV	R	IN	R
158	White-bellied Drongo	*Dicrurus caerulescens*	Linnaeus, 1758	LC	SCH.IV	R	IN	UC
	54. Corvidae							

Sl. No	Common Name/ Families	Scientific Name	Authority	IUCN Status	Schedule	Resident/ Migratory	Feeding Habit	Abundance
159	Indian Treepie	*Dendrocitta vagabunda*	Latham, 1790	LC	SCH.IV	R	OM	C
160	House Crow	*Corvus splendens*	Vieillot, 1817	LC	SCH.IV	R	OM	C
161	Jungle Crow	*Corvus macrorhynchos*	Wagler, 1827	LC	SCH.IV	R	OM	C
	55. Paridae							
162	Great Tit	*Parus major*	Linnaeus, 1758	LC	SCH.IV	R	IN	UC
	56. Muscicapidae							
163	Orange headed Thrush	*Zoothera citrina*	Latham, 1790	LC	SCH.IV	R	IN	UC
164	Oriental Magpie Robin	*Copsychus saularis*	Linnaeus, 1758	LC	SCH.IV	R	IN	C
165	Indian Robin	*Saxicoloides fulicata*	Linnaeus, 1766	LC	SCH.IV	R	IN	C
166	Pied bushchat	*Saxicola caprata*	Linnaeus, 1766	LC	SCH.IV	R	IN	C
167	Blue rock Thrush	*Montocola solitarius*	Linnaeus, 1758	LC	SCH.IV	R	IN	UC
168	Blue capped rock thrush	*Munticola cinclorhyncha*	Vigors, 1832	LC	SCH.IV	R	IN	UC
169	Asian brown flycatcher	*Muscicapa dauurica*	Pallas, 1811	LC	SCH.IV	M, S	IN	O
170	Blue throated blue flycatcher	*Cyornis rubeculoides*	Vigors, 1831	LC	SCH.IV	M, S	IN	O
171	Tickell's blue flycatcher	*Cyornis tickelliae*	Blyth, 1843	LC	SCH.IV	M, S	IN	O

(Resident/ Migratory: R=resident, M=Migratory, W= Winter, S=Summer, Feeding habit: IN=Insectivores, P= Piscivores, CV= Carnivores, GR=Grainivores, FR=Frugivores, OM=Omnivores, Abundance: C=Common, UC=Uncommon, R=Rare, O=Occasional)

ACKNOWLEDGEMENT

The authors express their sincere thanks to PCCF (Wildlife) and Chief Wildlife Warden, Government of Odisha for extending necessary permission to undertake the research work in Badrama Wildlife Sanctuary. The authors are also thankful to Divisional Forest Officers, Bamra Wildlife Division, for timely guidance and support. Also, thanks are due to the Forest Range Officer, Foresters and Forest Guards and other staffs of Badrama Wildlife Range for extending necessary logistics and providing valuable field information.

REFERENCES

Acharya, S. and Kar, S.K. 1996. Checklist of waders (Charadriiformes) in Chilika lake, Odisha. *Newsletter for Birdwatchers* **36**: 89-90.

Acharya, S., Kar, S.K., and Bohidar, K. 1997. Threats to waterfowl and its conservation measures in Chilika lake, *Pranikee* **17** and **18**: 21-27.

Acharya, S., Kar, S.K. and Bohidar, K. 1999. Habitat utilisation by shorebirds. (Charaadriiformes) wintering in Chilika lake. Odisha. *Pranikee* **13** and **14**: 39-46.

Ali, S. and Ripley, S.D. 1995. *A Pictorial Guide to the Indian Birds of the Indian Subcontinent*, Bombay Natural History Society, pp. 1-275.

Bal, A.K., Palei N.C., Rath B.P., Palei H.S. and Mishra A.K. 2018. Birds' diversity of Mundali area (Mahanadi River) under Cuttack Forest Division, Odisha, India *e-planet* **16** (2): 165-176.

Balachandran S., Sathiyaselvam P. and Panda S. 2009. *Bird Atlas of Chilika*. Bombay Natural History Society, Mumbai, Chilika Development Authority, Bhubaneswar, pp. 1-226.

Ball, V. 1877. Notes on birds observed in the region between the Mahanadi and Godavari rivers. *Stray Feathers* **5**: 410-420.

Ball, V. 1878. From the Ganges to the Godaveri. On the distribution of Birds, so far as it is at present know, throughout the hill region which extends from the Rajmehal Hills to the Godaveri valley. *Stray Feathers* **7**: 191-235.

Champion, H.G. and Seth, S.K. 1968. *A Revised Study of the Forest Types of India*. Government of India, New Delhi, India. p. 404.

Gopi, G.V. and Pandava, B. 2007a. Observation on breeding biology of three stork species in Bhitarkanika mangroves, India. *Indian Birds* **3** (2): 45-50.

Gopi, G.V., and Pandava, B. 2007b. Avifauna of Bhitarkanika Mangroves, India, *Zoo's Print J.* **22**: 2839-2847.

Kar, S.K. and Sahu, H.K. 1993. Preliminary study on ecology of aquatic birds in Chilika lake, Odisha. In: *Proc. First National seminar on Changing Scenario of Bird Ecology and Conservation,* Bangalore, pp. 62-64.

Kar, S.K. and Sahu, H.K. 1999. Study on feeding pattern of Anatids in Nalaban sanctuary of Chilika lake, Odisha. In: *Proc. 42nd Annual Conference-Zoological Society of Odisha and First Zoological Congress,* Odisha, Khurda. p. 5.

Kumar, S.N. 2018. *Management Plan of Badrama Wildlife Sanctuary*, Forest and Environment Department, Government of Odisha, pp 1-423

Mukherjee, A.K. 1952. On a collection of birds from the Similipal hills, Mayurbhanj district, Odisha. *Rec. Indian Mus*. **50**: 157-71.

Naik, S. and Mishra, A. 2017. Photographic Field Guide to Birds of Sundargarh Forest Division, pp. 1-194.

Palei, N.C., Bal, A.K., Rath B.P. and Udgata, H. 2020. Birds' of Balukhanda-Konark Wildlife Sanctuary Puri, Odisha, India. *e-planet* **18**: 61-78.

Palei, H.S., Debata, S., Mohapatra, P.P. and Mishra, A.K. 2017. Diversity and status of birds in Bonai Forest Division, Odisha, India. *e-planet* **15**(2): 166-177.

Palei, H.S., Mishra, A.K., Dash, P.K. and Mohapatra, P.P. 2013. Biodiversity of sacred groves of Koliposh range in Bonai Forest Division, Odisha, India. *e-planet* **10**(1): 20-30.

Palei, H.S., Mohapatra, P.P., and Sahu, H.K. 2012a. Birds of Hadagarh Wildlife Sanctuary, Odisha, Eastern India. *World J. Zool.* **7** (3): 221-225.

Palei, H.S., Mohapatra, P.P., Dutta, S.K., Singh, L.A.K., Sahu, H.K. and Rout, S.D. 2011a. Avifauna of Karlapat Wildlife Sanctuary, Southern Odisha, India. *Indian Forester* **137**: 1197-1203.

Palei, N.C., Mishra, S.R. and Sahu, H.K. 2014c. White-bellied sea eagle (*Haliaeetus leucogaster*) in Bhitarkanika National Park, Odisha, India. *Cheetal* **51**: 28-37.

Palei, N.C., Mishra, S.R., Sahu, H.K. and Rout, S.D. 2011b. Birds of Sunabeda Wildlife Sanctuary, Odisha. *J. Newsletter for Birdwatcher.* **51** (4): 49-53.

Palei, N.C., Palei, H.S. Rath, B.P. and Sahoo, P.K. 2015. Avifauna of Kapilash Wildlife Sanctuary, Odisha, India. *J. Newsletter for Birdwatcher.* **55** (3): 27-31.

Palei, N.C., Palei, H.S., Ratha, B.P. and Mishra, A.K. 2018. Spot-bellied eagle-owl: Range extension of the spot-bellied eagle owl (*Bubo nipalensis)* Hodgson, 1836 (Strigiformes: Strigidae) in Odisha, eastern India. *Zoos' Print J.* **33**(6): 6-8.

Palei, N.C., Rath, B.P. and Sahu, H.K. 2012b. Birds of Lakhari Valley Wildlife Sanctuary, Odisha. *J. Newsletter for Birdwatcher* **52** (4): 201.

Palei, N.C., Rath, B.P., Pradhan, S.R., Swain, K.K. and Pati, M. 2014b. The Water Birds of Paradeep Phosphate Limited (PPL) Campus of Jagatsinghpur District in Odisha, India. *World J. Zool.* **9**: 208-213.

Palei, N.C., Rath, B.P., Sajan, S.K. and Mishra, A.K. 2014a. Avifauna of Athgarh Forest Division, Odisha, India. *J. Entomol. Zool. Stud.* **2** (5): 329-334

Payra, A., Dash, S.K., Palei, H.S. and Mishra, A.K. 2019a. Additions to the avifauna of Athgarh Forest Division, Cuttack, Odisha, eastern India. *Bionotes* **21**(4): 112-115.

Payra, A., Dash, S.K., Palei, H.S., Mishra, A.K., Mishra, R.K. and Rout, S.D. 2019b. Updated avifaunal list of Ansupa lake and its adjoining areas, Cuttack, Odisha, India, with notes on the record of Grey-necked Bunting (*Emberiza buchanani*). *J. Fores. Wildlife* **8**: 558-568.

Pradhan, R.N., Palei, H.S. and Sahu, H.K. 2012. Checklist of waterbirds in Angul district, Odisha, India. *Tiger Paper* **39**: 31-32.

Pradhan, S.R., Palei, N.C., Rath, B.P. and Swain, K.K. 2014. Assessment of floristic diversity of mangrove vegetation in Bagagahan Heronry of the Bhitarkanika National Park, Odisha, India. *Am.-Eurasian J. Agric. Environ. Sci*. **15**: 237-242.

Rajguru, S.K. 2017. Breeding biology of Indian Skimmer *Rynchops albicollis* at Mahanadi River, Odisha, India. *Indian Birds* **13** (1): 1–7.

Sahu, H.K. and Kar, S.K. 2000. Habitat utilisation of Anatids (Family: Anatidae) in Nalaban sanctuary of Chilika lake, Odisha, India. In: *Proc. Ninth All India Cong. Zool. and National Symposium on Zoological Research in 21st century*, pp. 127-128.

Sahu, H.K. and Rout, S.D. 2005. Checklist of Water birds in Mayurbhanja District, Odisha. *Zoo's Print J.* **20**: 1992-1993.

Sahu, H.K., Das, K. Sunit, and Palei, N.C. 2012. Some observations on white-bellied sea eagle (*Haliaeetus leucogaster*) in Bhitarkanika National Park, eastern India. *Tiger Paper* **39** (1): 6-9.

Singh, L.A.K. 1993. Survey of raptors seen in Similipal Tiger Reserve, Odisha. *Bihang Newsletter* **1** (2): 5-6.

Urfi, A.J., Sen, M., Kalam, A. and Meganathan, T. 2005. Counting birds in India: Methodologies and trends. *Curr. Sci*. **89**: 1997-2003.

e-planet **20** (1): 68-73 (June 2022)

A preliminary study of avifaunal diversity in and around Govt. (Auto.) College, Angul, Odisha, India

M. BAGHA[1*] AND S. SAHOO[2]

[1]*School of Life Sciences, Sambalpur University, Jyoti Vihar, Burla, Odisha, India*
[2]*Deapartment of Zoology, Govt. Autonomous College, Angul, Odisha, India*

**monsoontigerone@gmail.com*

Date of receipt: 07.11.2021 Date of acceptance: 03.05.2022

ABSTRACT

The present study was carried out between mid-December 2019 to November 2020 in and around Government Autonomous College, Angul, Odisha. Regular field survey was carried out by fixed route and direct observation method, which revealed a total of 46 bird species belonging to 40 genera, 13 orders and 26 families. Out of all the species, 28 species (60.87%) were common, 6 species (13.04%) were locally common, 8 species (17.39%) were uncommon and 4 species (8.70%) were rare. According to the residential status of bird community found in this area, 34 bird species (73.91%) were resident, 10 species (21.74%) were residential local migrants and only 2 species (4.35%) were residential winter migrants. Direct human intervention is one of the major factors affecting the campus avifaunal diversity which can be controlled by maintaining the campus environment and creating constant awareness among students and staffs.

Key words: Avifauna, campus biodiversity, direct observation method, habitat, species diversity

INTRODUCTION

Birds are the most liked animals because of their fabulous colours, melodious calls and easily identifying characters. They play a vital role in keeping balance of nature. Richness, abundance and community composition of birds are often used by ecologists to understand the diversity of species in natural occurrence (Singh et al., 2018; Khan et al., 2021). Avifauna are continuously threatened by drivers such as habitat loss and degradation, hunting, pollution, invasive species and disease (Palei et al., 2017). As the world is growing, urbanisation and concretisation are touching the sky. Due to this rapid expansion of urban development, it is important to understand the relationship between natural flora and fauna and urban habitats. Urban biodiversity has received very little attention from conservation biologists as compared to natural and protected ecosystems. Many cities in India contain vast biodiversity of flora and fauna but due to rapid urbanization there has been an alarming reduction in biodiversity (Dapke et al., 2015). Thus, bird community evaluation has become an important tool in biodiversity conservation and for identifying conservation actions in areas of high human pressure (Sethy et al., 2015).

About 1408 bird species are found in Indian subcontinent and 524 species of bird species found in Odisha (Lenka and Singh, 2020). Odisha is endowed with rich biodiversity due to its strategic location in the east coast of India (Mishra, 2007). Angul district is situated in the very centre of Odisha and lies between 20.50°N to 85.00°E. The total geographical area of the district is 6,375 sq. km with a human population of ~1 million in number (Angul district official site, 2021). The climatic condition of the district is much varied. Though having an average annual rainfall of 1421 mm, there is a remarkable variation of rainfall from year to year. The district is rich with forests having

371.01 sq. km of very dense forest, 1380 sq. km of moderately dense forest and 1031.62 sq. km of open forest (Indian State Forest Report, 2019). However, very few ornithological works has been done in the district to date. Pradhan et al. (2012) has done a status survey of the water birds of Angul district and recorded a maximum of 18 numbers of species, each at Mahanadi river and Sisupathar dam and 6 species in Athmallik water body. In a recent work, Panda et al. (2021) has reported 17 bird species in a wetland of Talcher, Angul. In their study, they found minimum number of species in Talcher site among all other sites studied. The present work is an attempt to study the birds found in and around Govt. Autonomous College, Angul and to prepare a preliminary checklist of birds found inside and vicinity of the college campus. Furthermore, this will be helpful for future studies of avian diversity of the district, urban areas and campus biodiversity.

MATERIALS AND METHODS

Study area

Govt. Autonomous College, Angul was established in the year 1957 by the then chief minister Dr. Hare Krishna Mahatab and Sri Kumuda Chandra Singh, the then Member of the Legislative Assembly of Hindol (Government Autonomous College Angul official site, 2021). It lies between 20. 82° N, 85.10° E and is located in the heart of Angul town, nearly 1 km away from NH - 55 (Fig.1). The college campus encompasses an area of land with varied habitat. The main college campus has buildings with very little vegetation; mostly large trees like *Mangifera indica* (mango), *Azadirachta indica* (neem) and *Albizzia lebbeck* (siris) as compared to the sports field area. The botanical garden of the department of botany is the only place inside the campus where the vegetation is richer and more diverse as compared to other parts of the college campus. However, it is mostly interfered with human disturbances. The college campus has a big sports field which is surrounded by green vegetation, which is dominated by large trees like neem (*Azadirachta indica*), teak (*Tectona grandis*) , kendu (*Diospyros melanoxylon*), honey hocust (*Senna siamea*), nadia (*Cocos nucifera*) and siris (*Albizzia lebbeck*). The college campus is surrounded by human habitations which include a busy market, a pond and households of the locals.

Methodology

The study was carried out from mid-December 2019 to early November 2020 in Govt. Autonomous College Angul and the adjoining area. The study area can be divided into 3 parts, the main building, sports field and the pond. Bird survey was done following a fixed route and direct observation methods. Observations were made twice a day *i.e.,* 6.30 am- 9.00 am and 4.30 pm- 6.00 pm in the evening every day by walking on the fixed route and directly observing the birds without disturbing them.

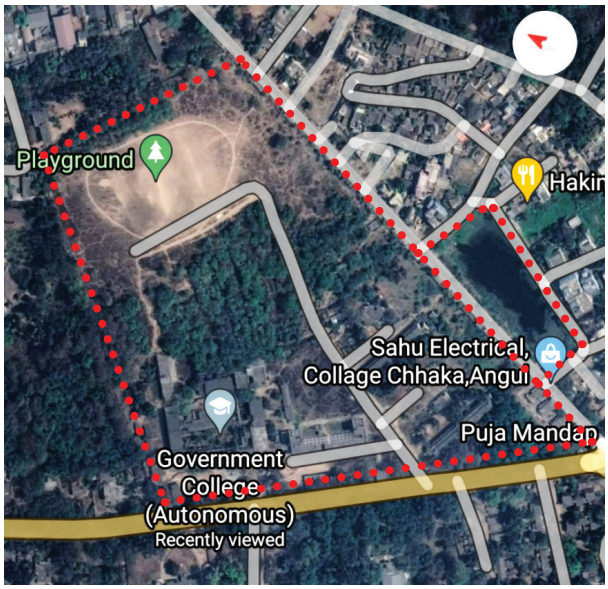


Fig. 1. Satellite image of Govt. College (Autonomous), Angul, Odisha. Lines demarcated with red colour, represent the studied area.

Birds were sighted using Super Zenith (10 × 50 mm), Tasco (8 × 25 mm) binoculars and were identified with the help of the standard field guides of Indian birds (Ali, 2002; Kumar et al., 2005). In case of confusion, photographs were captured by Nikon digital SLR D3500 with the 70-300 mm telephoto zoom lens and identified with help of more bird identification guides and websites (Mohapatra et al., 2019 a,b; ebird.org). The threat category of each bird species was also determined by the threatened list of IUCN (IUCN, 2022).

The birds were categorised based upon their sighting frequency such as (1) common (C): if the bird was sighted for more than 30 times or found regularly during every field visit in the study area and its vicinity; (2) locally common (LC): if a common bird species was found only in the study area and not anywhere else; (3) uncommon (U): if the bird was sighted for 5 to 30 times and lastly (4) rare (R): if the bird was sighted for less than 5 times during the entire study period. The residential status of birds were categorised as (1) resident (R): if the bird species is resident to the study area; (2) local migrant (LM): if the bird was not found to breed inside the study area; (3) winter migrant (WM): if the bird species was found only during the winter season.

RESULTS AND DISCUSSION

In the present study, a total of 46 bird species belonging to 40 genera and 26 families under 13 orders were recorded (Table 1). IUCN status revealed that all species were under the least concern category (IUCN, 2022). Among all the bird species, 28 species (60.87%) were common, 6 species (13.04%) were locally common, 8 species (17.39%) were uncommon and 4 species (8.70%) were rare. Out of all the species, 34 species (73.91%) were residential birds, 10 species (21.74%) were residential local migrants and 2 species (4.35%) were residential winter migrants.

Table 1. Annotated checklist of bird species recorded in the study area

Sl.	Order	Family	Common name	Scientific name	Abundance	Status
1	Passeriformes	Passeridae	House sparrow	*Passer domesticus*	C	R
2		Motacillidae	White-browed wagtail	*Motacilla maderaspatensis*	R	R
3			Grey wagtail	*Motacilla cinerea*	U	R/WM
4		Oriolidae	Indian golden oriole	*Oriolus kundoo*	U	R/LM
5		Dicruridae	Black drongo	*Dicrurus macrocercus*	C	R
6			Ashy drongo	*Dicrurus leucophaeus*	U	R
7		Sturnidae	Common myna	*Acridotheres tristis*	C	R
8			Jungle myna	*Acridotheres fuscus*	C	R
9			Asian pied starling	*Gracupica contra*	C	R
10		Corvidae	Common crow	*Corvus splendens*	C	R
11			Indian jungle crow	*Corvus macrorhynchos*	U	R
12		Pycnonotidae	Red-vented bulbul	*Pycnonotus cafer*	C	R
13			Red-whiskered bulbul	*Pycnonotus jocosus*	C	R
14		Phylloscopidae	Greenish warbler	*Pylloscopus trochiloides*	C	R
15		Paradoxornithidae	Yellow-eyed babbler	*Chrysomma sinense*	C	R
16		Muscicapidae	Asian brown flycatcher	*Muscicapa dauurica*	U	R
17			Indian robin	*Saxicoloides fulicatus*	R	R
18		Nectariniidae	Purple sunbird	*Cinnyris asiaticus*	C	R
19		Dicaeidae	Pale-billed flowerpecker	*Dicaeum erythrorhynchos*	U	R
20		Estrildidae	Scaly-breasted munia	*Lonchura punctulata*	C	R
21		Muscicapidae	Oriental magpie-robin	*Copsychus saularis*	C	R

Sl.	Order	Family	Common name	Scientific name	Abundance	Status
22	Cuculiformes	Cuculidae	Greater coucal	*Centropus sinensis*	C	R
23			Asian koel	*Eudynamys scolopaceus*	C	R
24			Common hawk-cuckoo	*Hierococcyx varius*	C	R
25			Grey-bellied cuckoo	*Cacomantis passerinus*	R	R/LM
26	Pelecaniformes	Ardeidae	Indian pond heron	*Ardeola grayii*	C	R/LM
27			Little egret	*Egretta garzetta*	C	R/LM
28			Intermediate egret	*Mesophyox intermedia*	R	R/LM
29			Cattle egret	*Bubulcus ibis*	C	R
30	Gruiformes	Rallidae	Purple moorhen	*Porphyrio porphyrio*	LC	R/LM
31			Eurasian moorhen	*Gallinula chloropus*	C	R/WM
32			White-breasted waterhen	*Amaurornis phoenicurus*	LC	R
33	Columbiformes	Columbidae	Blue rock pigeon	*Columba livia*	C	R
34			Spotted dove	*Streptopelia chinensis*	C	R
35			Release dove	*Columba livia domestica*	C	R
36	Accipitriformes	Accipitridae	Shikra	*Accipiter badius*	C	R
37			Black kite	*Milvus migrans*	C	R
38	Strigiformes	Strigidae	Spotted owl	*Athene brama*	U	R
39			Jungle owlet	*Glaucidium radiatum*	U	RS
40	Coraciiformes	Alcedinidae	White-throated kingfisher	*Halcyon smyrnensis*	C	R/LM
41		Meropidae	Green bee-eater	*Merops orientalis*	C	R
42	Bucerotiformes	Bucerotidae	Indian grey hornbill	*Ocyceros birostris*	C	R
43	Charadriiformes	Jacanidae	Bronze-winged jacana	*Metopidius indicus*	LC	R
44	Podicipediformes	Podicipedidae	Little grebe	*Tachybaptus ruficollis*	LC	R/LM
45	Anseriformes	Anatidae	Cotton pygmy-goose	*Nettapus coromandelianus*	LC	R/LM
46	Suliformes	Phalacrocoracidae	Little cormorant	*Phalacrocorax niger*	LC	R/LM

Abundance: C- Common, LC- Locally Common, U-Uncommon, R-Rare; Status: R- Resident, LM- Local Migrant, and WM- Winter Migrant

The highest number of bird species was recorded from order Passeriformes i.e., 21 species (45.65%), followed by 4 species each (8.70%) from order Cuculiformes and Pelecaniformes; 3 species each (6.52%) from order Gruiformes and Columbiformes; 2 species each (4.35%) from order Accipitriformes, Strigiformes and Coraciiformes; and only 1 species each (2.17%) from four orders such as Bucerotiformes, Charadriiformes, Podicipediformes, Anseriformes and Suliformes.

The maximum number of species were recorded from family Ardeidae and Cuculidae with 4 species each (8.69%), followed by Rallidae, Columbidae, Sturnidae, and Muscicapidae with 3 species each (6.52%), Accipitridae, Strigidae,

Motacillidae, Pycnonotidae, Dicruridae, Corvidae with 2 species each (4.34%). Only 1 species each (2.17%) was recorded from 14 families such as Podicipedidae, Phalacrocoracidae, Anatidae, Jacanidae, Bucerotidae, Alcedinidae, Meropidae, Nectariniidae, Dicaeidae, Estrildidae, Passeridae, Phylloscopidae, Paradoxornithidae, Muscicapidae.

Among all the study sites, the highest species richness was found in the sports field (31 spp. = 67.39% of total bird species), followed by the pond (27 spp. = 58.70%) and lastly the least species richness was observed around the main building (15 spp. = 32.61%). There are several factors which support such number of bird species in the campus such as availability of food material, suitable sites for nesting, low temperature throughout the year and easy availability of nesting material (Mohapatra et al., 2019 a,b).

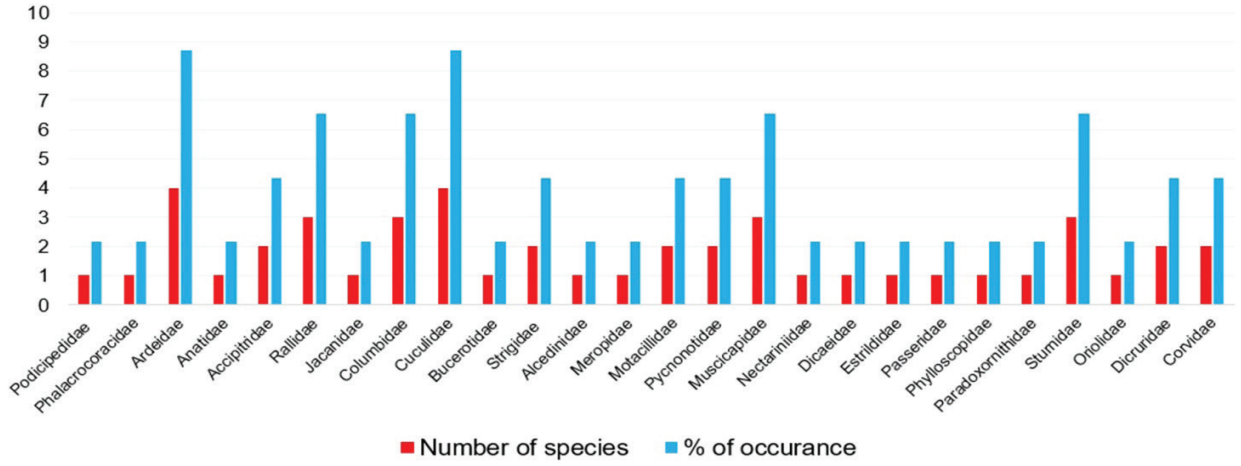


Fig. 2. Graph representing number of species and percentage of occurrence of various families

Bird species found around the main building area are few in number and mostly inhabit large trees present inside the campus whereas the sports field area has a diverse number of bird species and dominated by large and long trees as mentioned under study area heading. One part of the field is covered with honey locust (*Senna siamea*) plants and opposite to this an area was covered with teak trees and *Eucalyptus* trees. In both of the areas, black drongo (*Dicrurus macrocercus*) was recorded in the maximum numbers. Species like Indian golden oriole (*Oriolus kundoo*) was sighted rarely in this area. The house sparrows (*Passer domesticus*) were only found in the field among the three sites surveyed. It is may be due to less human interference and presence of heavy vegetation in comparison to other sites. One part of the field is filled with middle length trees which are mostly inhabited by passerines like warblers, robins. They are quick in action and escape the viewer eyes quickly. The field is devoid of grass in the middle as it is widely used not only by the students but also by the local people for different activities. But the surrounding area of the field has enough grass. wagtails and house sparrows are mostly seen in those places. Opposite to the large trees, the field contains shrubs and creepers which are sudden associated with more big trees on the side and lined with mud houses and markets by the wall. Those areas are mostly used by the pigs domesticated by the local people. Spotted owlet (*Athene brama*) were seen very rarely, because this bird species was sighted for only 3-4 times during the whole study time. Indian grey hornbill (*Ocyceros birostris*) was very common in the field area and they mostly sighted on the *Eucalyptus* trees.

The pond is located just adjoining the campus. This site was taken into account to check and compare the urban wetland avifaunal diversity as it is present in the middle of the market and houses. One side of the pond is attached to the campus road and all the other three sides are surrounded by houses. However, the numbers of species found in

the area are quite good despite of being a disturbed area with high level of human interference. The pond is dominated by Eurasian moorhen (*Gallinula chloropus*) (in water) and bulbuls (inland). Both the Red-whiskered Bulbul (*Pycnonotus jocosus*) and red vented bulbul (*Pycnonotus cafer*) was widely present in the area. The pond site has several palash (*Butea monosperma*), where the Sunbirds and Flower Peckers were sighted. Occasionally, spotted munia (*Lonchura punctulata*) and Starlings were also recorded near the pond areas which are not commonly seen. The diversity of bird distribution concerning available habitat types represents the importance of the college campus as a suitable bird habitat.

CONCLUSION

The major influencing factors on the composition and distribution of bird species in the study area is the environmental pressure due to direct human intervention. Campuses are mostly set in the urban areas due to the easy mode of communication, where the human interventions remain high. This high anthropogenic pressure affects the birds in a negative manner. But the study area can be turned into to a better place for bird study and conservation if the campus environment is maintained well and the awareness is created among the students and staffs. The present study showed that the bird species diversity of the Govt. Autonomous College, Angul is due to the habitat heterogeneity and varied vegetation despite the urban location and human intervention in the study area.

REFERENCES

Ali, S. 2002. *The Book of Indian Birds*. 13th Ed. Bombay Natural History Society, Oxford University Press, Mumbai; pp: 1-466.

Angul district official site. 2021. https://angul.nic.in/about-district/. Accessed on 21st August 2021.

Dapke, S., Didolkar, S. and Koushik, S. 2015. Studies on diversity and abundance of avifauna in and around Laxminarayan Institute of Technology, Nagpur. *J. Entomol. Zool. Stud.* **3**(5):141-146.

Govt. Autonomous College Angul official site. 2021. http://www.gaca.nic.in/. Accessed on 21st August 2021.

Ebird. 2022. Ebird website. https://ebird.org/. Accessed on 15 March 2022.

Indian State Forest Report. 2019 (Volume II). Odisha. 11.21. Forest Survey of India *(Ministry of Environment Forest and Climate Change)*, Uttarakhand. pp. 202-211.

IUCN. 2022. The IUCN Red List of Threatened species. Version 2021-3. https://www.iucnredlist.org/. Accessed on 15 March 2022.

Khan, P., Kumar, M. and Pandey, R. 2021. Avifaunal diversity of National Zoological Park, Delhi. *e-planet* **19** (1): 79-87.

Kumar, A., Sati, J.P., Tak, P.C. and Alfred, J.R.B. 2005. *Handbook on Indian Wetland Birds and their Conservation*. Zoological Survey of India. M-Block, New Alipore, Kolkata; pp. 1-468.

Lenka, R. and Singh, C. 2020. A preliminary study on the birds of Berhampur University (Bhanja Bihar) campus, Ganjam, Odisha, India. *Rec. Zool. Surv. India* **120**(4): 387–399.

Mishra, A.K. 2007. An overview of wild floral and faunal bio-diversity status of Odisha. *e-planet* **5** (1): 64-75.

Mohapatra, R.K., Bhatia, G., Das, J.K. and Paul, S. 2019a. *Birds of Nandankanan Wildlife Sanctuary-a pocket guide to 168 familiar birds.* Nandankanan Biological Park, Forest and Environment Department, Govt. of Odisha.

Mohapatra, S.R., Kumari, A., Chowdury, H. and Mahajan, A. 2019b. Avifauna diversity of YSPUHF campus, Nauni, Solan, Himachal Pradesh, India. *e-planet* **17** (1): 62-69.

Palei, H.S., Debata, S., Mohapatra, P.P. and Mishra, A.K. 2017. Diversity and status of birds in Bonai Forest Division, Odisha, India. *e-planet* **15** (2): 166-177.

Panda, B.P., Das, A.K., Jena, S.K., Mahapatra, B., Dash, A.K., Pradhan A. and Parida, S.P. 2021. Habitat heterogeneity and seasonal variations influencing avian community structure in wetlands. *J. Asia-Pacific Biodivers.* **14**(1): 23-32.

Pradhan, R.N., Palei, H.S. and Sahu, H.K. 2012. Checklist of waterbirds in Angul, Orissa, India. *Tiger Paper* **39**(2): 31-32.

Sethy, J., Samal, D., Sethi, S., Baral, B., Jena, S., Payra, A., Das, G.N, Boruah, B. and Sahu, H.K. 2015. Species diversity and abundance of birds in and around North Orissa University, Takatpur, Baripada, Mayurbhanj, Odisha. *Int. J. Innov. Res. Sci. Eng. Technol.* **4**(2): 300-311.

Singh, R., Jaiswal, A., Singh, J., Singh, N., Bhaskar, S.K., Kumar, N., Singh, V.K. and Singh, D.K. 2018. Study of bird diversity in Gorakhpur University campus. *J. Biodivers. Endanger. Sp.* **6**(2): 01-03.

e-planet **20** (1): 74-78 (June 2022)

Surgical treatment of baculum fracture in sloth bear *(Melursus ursinus)*: A case report

A. SHA. ARUN*, A. S.VIRK, AND S.P. PATIL

Wildlife SOS, Bannerghatta Bear Rescue Centre, Bannerghatta, Tamilnadu, India

**arun@wildlifesos.org*

Date of receipt: 16.11.2021 Date of acceptance: 03.05.2022

ABSTRACT

A rescued dancing male sloth bear (*Melursus ursinus)* neutered according to CZA norms at Wildlife SOS, Bannerghatta bear rescue center, aged around 24 years was noticed to exhibit frequent behavior of licking and biting of penile region. With the aid of radiographic examination, it was confirmed as a novel case of baculum fracture in the sloth bear. Radiographic examination revealed complete fracture of baculum at its anterior one third. Under general anesthesia with ketamine and xylazine in combination at a dose rate of 5 mg kg^{-1} and 2 mg kg^{-1}, respectively, a surgical procedure was performed which involved removal of the anterior fractured portion of the bone without causing any damage to urethra. Utmost post-operative care was provided. After the completion of the surgical intervention, the bear was recovered and stopped exhibiting the abnormal behaviour of licking and biting.

Key words: Baculum fracture, sloth bear, surgical correction

INTRODUCTION

Sloth bear comes under the family Ursidae along with 7 species of bears which include brown bears, polar bears, American black bear, Asian black bears, sun bears, spectacled bears and the giant panda. Baculum also referred to, as heterotopic or extra-skeletal bone is found in the penis of certain placental mammals and primates but absent in humans (Sharir et al., 2011). Anatomically it is in the glans tissues at the distal end of penis and dorsally to the urethra. Generally distal end of corpus cavernosum touches the proximal end of the baculum. The baculum has variations in its shape, size and length in different species. Multiple theories are associated with the significance of baculum but the function of baculum is still not ruled out (Baryshnikov et al., 2003). A study suggests that variation in the length is associated with the taxonomic and behavioral variations, length of baculum varies according to the intromission time in some species (Dixson, 1987). Baculum fracture is amongst the uncommonly observed clinical case with the most probable etiological cause, i.e., aggressive behavior within the species while mating and also snapping associated with the sudden removal of penis during copulation (Bartosiewicz, 2000). One of the male sloth bears, aged around 24 years, was observed with an injury on his penile region (Fig. 1) and the same bear was subjected for a close examination (Fig. 2) after immobilization.

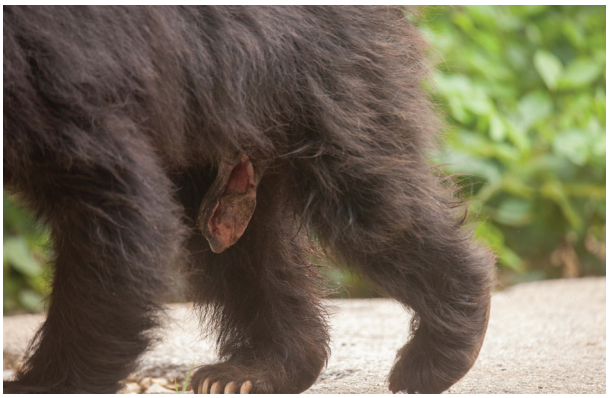


Fig. 1. The sloth bear showing the visible damage of the penile region

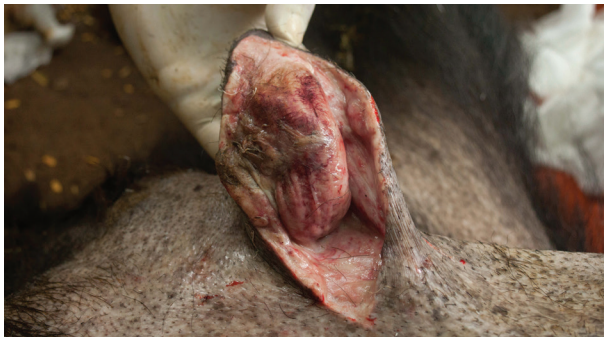


Fig. 2. Close examination of injury after immobilisation

MATERIALS AND METHODS

This procedure was conducted at Wildlife SOS; Bannerghatta bear rescue center on a rescued dancing sloth bear aged 24 with the symptoms of frequent licking and biting of penile region. For restraining and in-depth examination of animal chemical immobilization was preferred. Sedative and anesthetic agent was selected considering the safety of the animal. Xylazine and Ketamine were selected considering their safety and smooth recoveries from the previous observations. Based on the body weight the required dose was calculated, i.e., for 90 kg body weight Ketamine (100 mg ml^{-1}) @ 5 mg kg^{-1} the calculated dose was 450 mg and Xylazine (100 mg ml^{-1}) @ 2 mg kg^{-1} the calculated dose was 180 mg. Hind quarter muscles were the preferred site for the administration of the anesthetic drugs. The drugs were combined and loaded in dart with a capacity of 5 ml with partial dose of Ketamine, i.e., 320 mg and complete dose of Xylazine; the remaining dose of ketamine was administered after animal achieved sternal recumbence for complete induction of anesthesia. Darts were delivered with the aid of blow pipe.

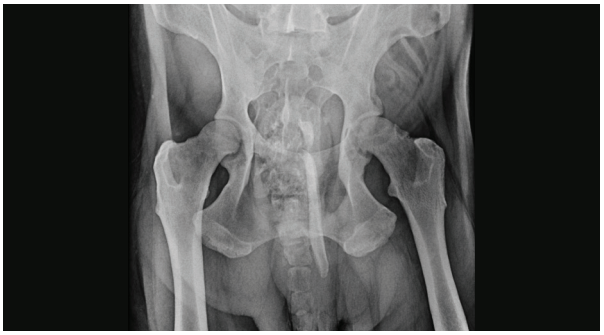


Fig. 3A. Radiographic image of hip region showing the fracture at one third of the baculum.

After the confirmation of complete induction of anesthesia, the animal was blind folded and under continuous monitoring of its vital signs, was shifted to the Wildlife SOS, Wildlife Veterinary Hospital at Bannerghatta Bear Rescue Center. Palpation of the suspected penile region emphasized the need for a radiographic confirmation to rule out the facture of the baculum at its anterior one third (Fig. 3A, 3B, 3C).

For surgical procedure, the sloth bear was intubated with 18 mm endotracheal tube (Fig. 4) and gaseous anesthesia was maintained with 4 liters of oxygen and 2% to 4% isoflurane gas. Intravenous line was started in the saphenous vein.

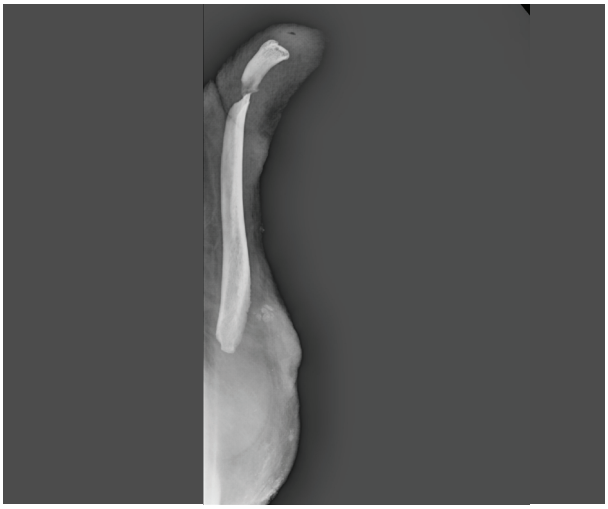


Fig. 3B. Radiographic image of the baculum fracture

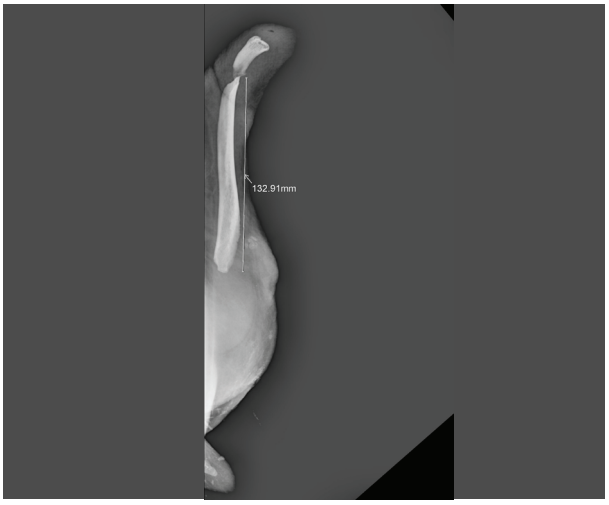


Fig. 3C. Radiographic image of the baculum fracture with measurement

Fig. 4. Endotracheal intubation for gaseous anesthesia.

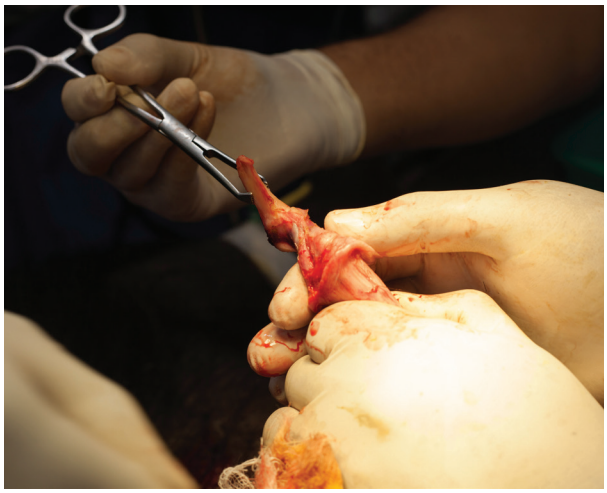


Fig. 5. Removal of broken piece of baculum

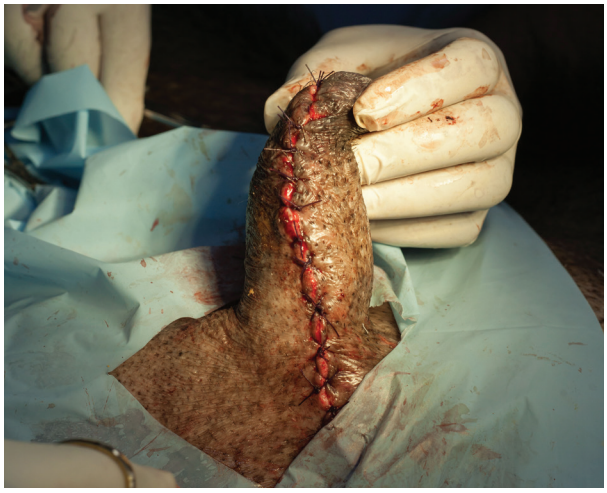


Fig. 6. Post surgical intervention and sutured wound

The pelvic area was trimmed and cleaned with spirit and wounds inflicted by biting were cleaned by hydrogen peroxide and 5% povidone iodine and further wound debridement was done. A longitudinal incision of 3-4 cm was made at the site of fracture from the lateral side of the penis by using a No. 3 bp blade. During incision minimal damage to the underlying structures were ensured by displacing the tissues and muscles. The broken proximal part of the penis was removed using forceps (Fig. 5) and, the surrounding tissues were disinfected by using hydrogen peroxide and 5% povidone iodine, followed by the removal of the excessive fibrous tissues. The blunt edges of exposed bone were smoothened by filer to avoid injuries to the tissues and urethra as well. Blood vessels were thermo cauterized to avoid excessive bleeding. The edges were cleaned and sutured by using 2-0 absorbable sutures (Fig. 6) and antibiotic powder was adequately applied.

The post-operative medication regimen was adhered to

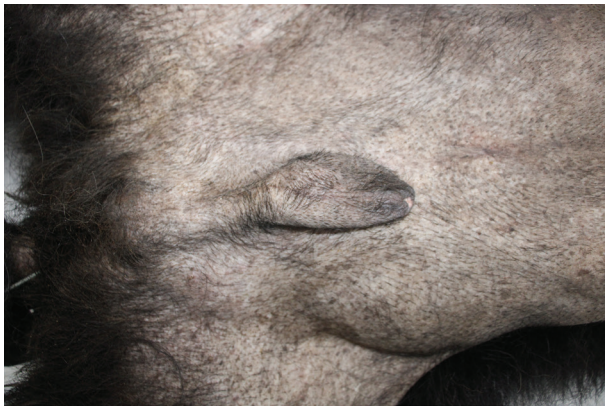


Fig. 7A. Post healing of the soft tissue

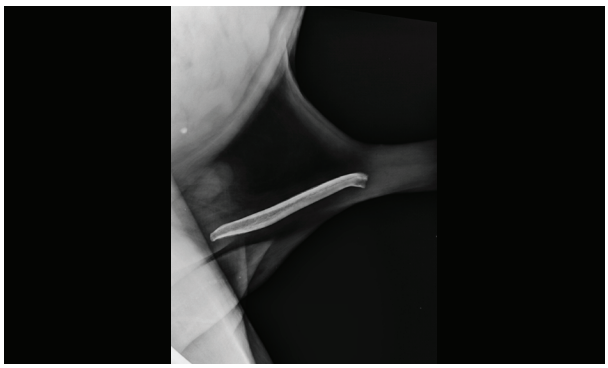


Fig. 7B. Radiographic image of baculum.

- Antibiotic tablet Cephalexin (Hatvet Pharma Private Limited, Meerut, Uttar Pradesh) @ 15 mg kg^{-1} body weight twice daily – to avoid the secondary infections
- Cap. Tramadol (Intas Pharmacueticals Limited, Thaltej, Ahmedabad) 50 mg and combination of enzymatic anti-inflammatory, i.e., Trypsin, Bromelain, Rutoside twice daily – to alleviate pain and inflammation.

RESULTS AND DISCUSSION

After the surgical correction of the deformity the bear recovered from anesthesia smoothly and was observed to be alert and active exhibiting normal feeding behaviour and was noticed to refrain itself from exhibiting the previous abnormal behaviour of sucking and licking of penile region leading to a healthy recovery of the sloth bear (Fig. 7A) and its radiographic healing was confirmed (Fig. 7B).

Behavioral changes of the animals are the important factors while considering the health status of individual. Behavioral changes in the wild animals are very less known so far and can be assessed rarely to resolve a cause unlike the domestic animals. Assessing the condition or abnormality amongst wild animals needs broader perspective and requires understanding of normal behavior. A specific term called "Zoocosis" is associated with stereotypic behavior in captive wild animals where there is substantial alteration of behavior which includes array of signs including sucking, over grooming or excessive licking and self-mutilation, biting, rocking, head bobbing, vomiting, and regurgitating, coprophilia, coprophagia and circling movements.

In captivity, the life of animals has a remarkable difference between what they exhibit in the wild. Factors like space, human presence, climate, social interactions and diet have a peculiar impact on the animal behavior (Vickery and Mansion, 2005). Thus, while accessing the health issues of the captive animals, the stereotypic behaviors and natural behavior must be considered along with the alterations in behavior associated with illness. There should be a clear understanding of stereotypic, normal and illness associated behavior to get the complete and accurate diagnosis of the illness (Sha et al., 2020). While dealing with health issues and abnormal behavior in the wild animal's implementation of conventional knowledge and modern diagnostic aids can act as liaison to achieve confirmatory diagnosis. However, there must be proper considerations or assumptions to act accordingly, which can minimize the time duration and ensure quick healthy recovery of the distressed animal.

In this study, the observed behavior of sucking was due to baculum fracture resulting in pain and discomfort of the animal. Such pain and discomfort can lead to aggression in the animals. Injuries in the penile region may cause ascending urinary tract infections where the bacteria first invade the urethral mucosa, towards urinary bladder further to kidneys and finally into the circulatory system (Belyayeva and Jeong, 2021). The authors documented that the average length (Fig. 8) of an adult sloth bear baculum falls around 162 mm to 167 mm (n=18).

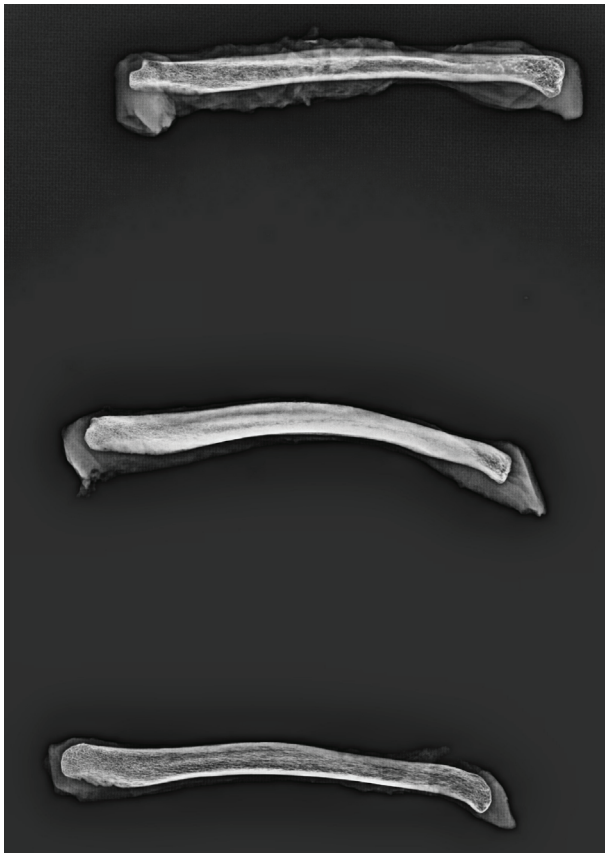


Fig. 8. Radiographic image of intact baculum of sloth bears

ACKNOWLEDGEMENT

The authors are thankful to Executive Director, Bannerghatta Biological Park and Mr. Kartick Satyanarayan and Ms Geeta Seshamani, Co-Founders, Wildlife SOS, for extending their support during the study. The authors would also like to thank and acknowledge the support of staff at Bannerghatta Bear Rescue Centre for their valuable field assistance during the upkeep of the rescued sloth bears.

REFERENCES

Bartosiewicz, L. 2000. Baculum fracture in carnivores: Osteological, behavioural and cultural implications. *Int. J. Osteoarchaeol.* **10**(6): 447-450.

Baryshnikov, G.F., Bininda-Emonds, O.R. and Abramov, A.V. 2003. Morphological variability and evolution of the baculum (Os Penis) in Mustelidae (Carnivora). *J. Mammal.* **84**(2): 673–690.

Belyayeva, M. and Jeong, J.M. 2021. Acute Pyelonephritis. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing.

Dixson, A.F. 1987. Baculum length and copulatory behavior in primates. *Am. J. Primatol.* **13**(1): 51-60.

https://www.worldatlas.com/articles/what-is-zoochosis.

Sha, A.A., Bakde, R. and Adhithyan, N.K. 2020. Successful rescue and rehabilitation of an injured wild sloth bear trapped in a poacher's snare. *e-planet* **18** (2): 158-163.

Sharir, A., Israeli, D., Milgram, J., Currey, J.D., Monsonego-Ornan, E. and Shahar, R. 2011. The canine baculum: the structure and mechanical properties of an unusual bone. *J. Struct. Biol.* **175**(3): 451-456.

Vickery, S.S. and Mason, G.J. 2005. Stereotypy and perseverative responding in caged bears: further data and analyses. *Appl. Anim. Behav. Sci.* **91**(3-4): 247-260.

e-planet **20** (1): 79-82 (June 2022)

Distribution of leopard cats in Similipal Tiger Reserve, Mayurbhanj, Odisha

S.R. MISHRA* AND M. MOHAN

O/o Regional Chief Conservator of Forest & Field Director

Similipal Tiger Reserve, Odisha Forest Department, Baripada, Odisha, India

**sandeep.mishra579@gmail.com*

Date of receipt: 13.03.2022 Date of acceptance: 14.05.2022

ABSTRACT

In this study, the distribution patterns of leopard cats in Similipal Tiger Reserve using camera trap methods were studied. The leopard cat, *Prionailurus bengalensis,* is a common spread small cat in Asia which is mainly nocturnal and solitary in nature. A rapid camera trapping survey was conducted to study the distribution during 2016 in Similipal Tiger Reserve. During the survey, 156 nos of Leopard cats were captured covering both core and buffer division of Similipal Tiger Reserve. Maximum leopard cats were captured form Similipal core division (103) followed by Baripada division (36), Karanjia division(10) and Rairanagpur division(07). Similarly range wise maximum Leopard cats captured from Upper Barakamuda range(56%) followed by Jenabil range(17%), Pithabata range(10%), Chahala range(5%), Nawana South range(5%), National park range(4%) and Nawana north range(3%).

Key words: Camera trap, distribution, leopard cat, Similipal Tiger Reserve

INTRODUCTION

There is existing 28 species of lesser wild cats in the world among them 10 species are thriving in India (Nowell and Jackson, 1996). The increase in human population, spread of settlement and exploitation of natural resources of wild lands, together with persecution are threatening some species with extinction. For other cat species worldwide population decline was observed. Conservation initiatives were taken in every part of the world to ensure survival of threatened species. For effective species conservation and management, an understanding of species ecology with population trend constituent is vital, particularly if the species forms an important constituent of the lesser mammalian guild and that regulates small mammal populations. Only a few studies on their ecology including distribution and abundance were carried out in India (Das et al., 2019; Palei et al., 2021). Apart from the four big cats the small ones do not feature in any major research or conservation planning.

The estimation of abundance and density for cryptic and secretive species is extremely difficult in the field (Trolle and Kerry, 2003). Recently, camera trapping associated with capture recapture studies has proved effective for elusive and nocturnal species (Karanth, 1995; Trolle and Kerry, 2003; Palei et al., 2021). It has successfully been used for individual identifiable large carnivores such as tigers, leopards and hyenas, but there are comparatively few studies that have been carried out on smaller carnivores (Palei et al., 2021). The leopard cat is a wide spread common small cat in Asia, across the range of habitats from tropical rain forest to temperate broadleaf and marginally coniferous forest as well as shrub forest and successional grasslands (Sanderson et al., 2008). This species is considered as least concern (LC) by IUCN

and CITES listed in appendix 1. A radio collared study in Thailand revealed that the home range size of the leopard cat was 12.4 km^2 with daily movement of 1298 m (Grassman et al., 2005). The small Asian felids are poorly represented in felid studies (Grassman et al., 2005) and information on leopard cats was surprisingly scanty in Odisha. The general ecology of leopard cats (Grassman, 2000; Austin, 2002) and their diet and movement pattern was studied in Thailand (Grassman et al., 2005).

Lesser wild cat populations are threatened throughout their extant range in India by habitat loss, conflict and wildlife trade. The distribution pattern of the leopard cats is unknown in Similipal Tiger Reserve. Therefore, it is essential to study the distribution pattern of leopard cat through camera trap. This was the first kind of study through camera trap in Similipal Tiger Reserve (Mayurbhanj, Odisha, India) which is very important for conservation, management and scientific purpose.

Study area

Similipal Tiger Reserve located in the Mayurbhanj District of Odisha (Fig. 1) spreads over 2750 km^2 of the Chotanagpur plateau. The park is surrounded by high plateaus and hills, the highest peak being the twin peaks of Khairiburu and Meghashani (1515 m above mean sea level). At least twelve rivers cut across the plain area, all of which drain into the Bay of Bengal. The prominent among them are Budhabalanga, Palpal, Bandan, Salandi, Khairi, Khadkei, Budhabalanga, West Deo, East Deo. Earlier studies record 1254 species of vascular plants including 94 species of orchids in Biosphere Reserve (Sahoo et al., 2016). It hosts 55 species of mammals, 304 species of birds, 60 species of reptiles, 21 species of frogs, 60 species of fishes and 164 species of butterflies that have been recorded from the park (Mishra and Mohan, 2019). The core area comprises of ranges with an area of 1194.75 km^2.

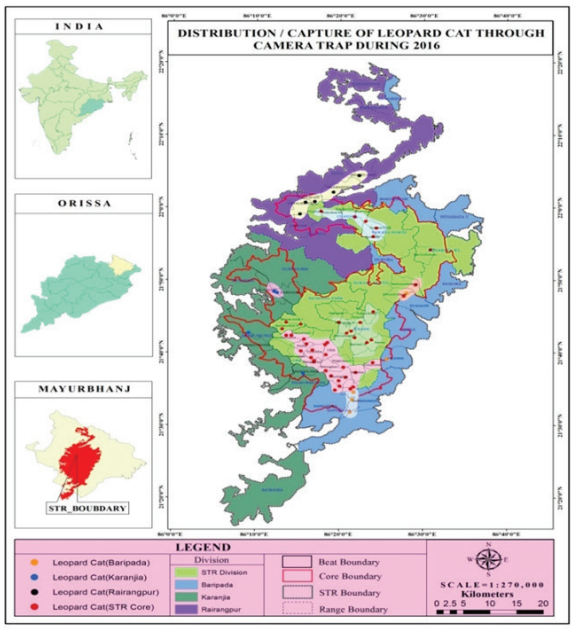


Fig. 1. Showing the study area and distribution of leopard cat in Similipal Tiger Reserve

Camera trapping

Camera-trapping has long been used to survey for and monitor the occurrence of wildlife species around the world (Karanth, 1995). Much attention has been focused on using camera-trapping to detect otherwise elusive species. Over the time, these efforts have been replaced by more systematic sampling approaches, often centered on identifying individual animals in a mark-recapture framework. Karanth (1995) used to estimate their population abundance from photographs and indices are often used to make inference about differences in abundance across time, space and species. The camera trap survey was carried out from February 2016 to May 2016 for the purpose of Tiger estimation survey inside Similipal Tiger Reserve.

MATERIALS AND METHODS

The success of camera-trapping depends on the selection of ideal locations to deploy the camera traps so as to maximize the number of captures. Prior to camera placement, survey is done along the forest paths, animal trails, dirt-trackers, dried stream bed to record carnivore

presence through indirect signs (pug marks, tracks, scat, scraps, rake marks, scent deposits and kills). Potential location of camera trap stations was then mapped using ArcGIS 9.3. During the exercise camera were deployed a sampling grid of 4.0 km^2 (2.0 × 2.0 km) in the core area and buffer area of Similipal Tiger Reserve. A pair of (Cuddy back 1) camera traps was placed opposite to each other so as to photograph of both flanks of animal can captured.

Camera trapping exercise was conducted from February-May 2016 for 119 days. The cameras were active 24 h period that accounted for one sampling occasion. 623 sites were selected for deployment of camera traps in the core area and buffer area of Similipal Tiger Reserve. Each camera was assigned a unique identification number. Date, time, and camera ID was recorded for every capture. The locations of each photo-capture of Leopard cat were recorded and mapped over Similipal Tiger reserve to understand their geographic distribution in the study area.

RESULTS AND DISCUSSION

Conservation of large felids is a major focus of many wildlife programmes. However, lesser cats have received limited academic as well as conservation attention. The current study establishes base line information on leopard cat in the region. Similipal is the richest watershed in Odisha giving rise to many perennial rivers. Four types of forest habitat such as semi evergreen, tropical moist deciduous, dry deciduous hill forests and high level sal forests found in Similipal Tiger Reserve. The major plant species include *Shorea robusta, Dillenia pentagyna, Syzygium cumini, Terminalia tomentosa, Syzygium cerasoides, Michelia champaca, Bombax ceiba, Schleichera oleosa*. Perennial river streams crosses all over the forest. Leopard cat photographs captured in main forest track as well as fitted in interior animal trails (foot path) and both areas covered with moist deciduous and semi evergreen forest and inhabited with perennial river stream (Fig. 2A/2B).

During the camera trap survey, total leopard cats (N=156) were captured at both the core and buffer division of Similipal Tiger Reserve. Maximum leopard cats were captured in Similipal core division (N=103) followed by Baripada division (N=36), Karanjia division (N=10) and Rairangpur division (N=07). Similarly in Similipal core division, maximum leopard cats were captured in upper Barakamuda range (N=58) followed by Jenabil (N=18), Pithabata (N=10), Chahala(N=05), Nawana-South(N=05), National Park (N=04) and Nawana-North(N=03) (Fig. 3A/3B).

Fig. 2A. Leopard cat captured through camera trap in Similipal Tiger Reserve

Fig. 2B. Leopard cat captured through camera trap in Similipal Tiger Reserve

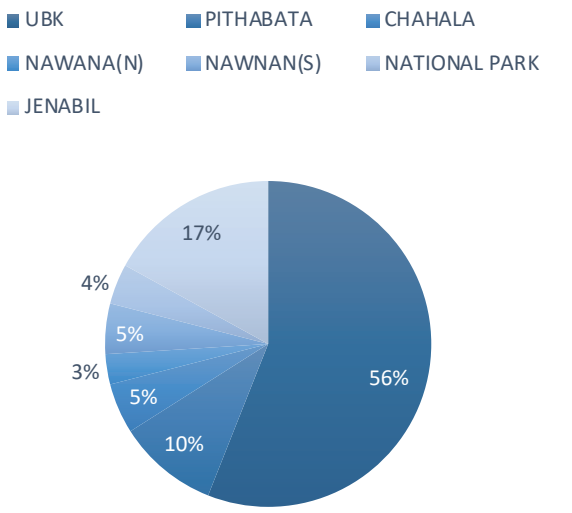


Fig. 3A. Range wise Leopard cat captured during the exercise in Similipal Tiger Reserve

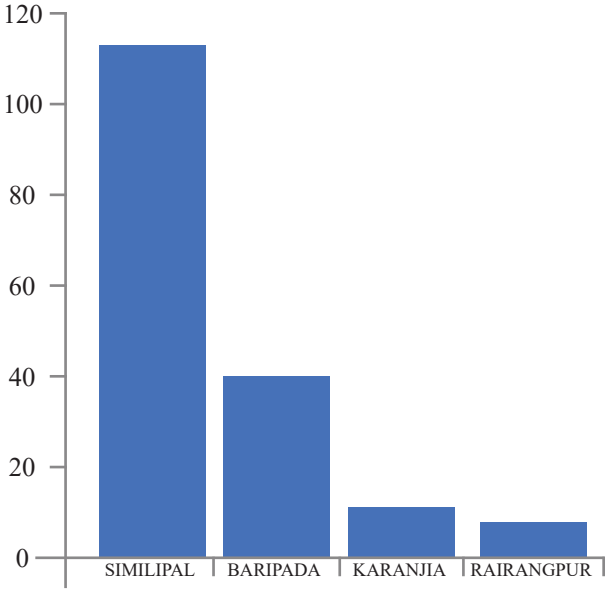


Fig. 3B. Range wise Leopard cat captured during the exercise in Similipal Tiger Reserve

CONCLUSION

The ecology and population status of the leopard cats are poorly known in India. In Similipal Tiger Reserve studies using methodology like camera trapping will be beneficial for the purpose to develop improved species conservation and management plan for leopard cat as well as lesser-known animals.

ACKNOWLEDGEMENT

The authors express their gratitude to all the field staff of Similipal Tiger Reserve for their cooperation and valuable information during the field survey and data collection.

REFERENCES

Austin, S.C. 2002. *Ecology of Sympatric Carnivorous in Khao Yai National Park, Thailand*, PhD dissertation, Texas A&M university-kingsville and Texas A&M university, college station, USA.

Das, U.K., Setty, J. and Srivastava, V. 2019. Population study of tiger (*Panthera tigris tigris*) by trap camera photo capture in Katarniaghat Wildlife Sanctuary, Uttar Pradesh, India. *e-planet* **17** (1): 70-75.

Grassman, L.I., Jr. 2000. Movement and prey selection of the leopard cat (*Prionailurus bengalensis)* in dry evergreen forest in Thailand, *Acta Theriol.* **45**: 421-426.

Grassman, L.I., Tewes, M.E., Silvy, N.J. and Kreetiyutanont, K. 2005. Spatial organization and diet of the leopard cat (*Prionailurus bengalensis*) in north-central Thailand. *J. Zool*. **266**: 45-54.

Karanth, K.U. 1995. Estimating tiger (*Panthera tigris)* populations from camera trap data using capture-recapture models. *Biol. Conserv*. **71**: 333-338.

Nowell, K. and Jackson, P. (Eds). 1996. *Wildcats, Status Survey and Conservation Action Plan*, International Union for Conservation of Nature, Gland, Switzerlnand. p. 382.

Palei, N.C., Rath, B.P., Satpathy, A.K., Acharya, S.N. and Mohalik, R.K. 2021. Ecological studies on wild carnivores and herbivores through camera trap in Hadgarh Wildlife Sanctuary, Odisha, India. *e-planet* **19**(2): 187-195

Sahoo, H.K., Misra, R.C. and Mukherjee, A.K. 2016. Wild edible fruits traditionally used by tribes of Similipal Biosphere Reserve. Odisha. India. *e-planet* **14**(2): 45-56

Trolle, M. and Kerry, M. 2003. Estimation of Ocelot density in the Pantanal using capture-recapture analysis of camera trapping data. *J. Mammal.* **84**: 607-614.

e-planet **20** (1): 83-89 (June 2022)

Poultry farming in India : An overview

A. PATHAK[1*], A.M. TRIPATHI[2], V. SINGH[3] AND T. JAHAN[1]

[1*]*College of Veterinary and Animal Sciences, GBPUAT, Pantnagar, Uttarakhand,India*

[2]*R.M.L Avadh University, Faizabad, Uttarpradesh, India*

[3]*DUVASU, Mathura, Uttarpradesh, India.*

[*]*drpathak1704@gmail.com*

Date of receipt: 24.12.2021 Date of acceptance: 21.05.2022

ABSTRACT

Poultry farming has traditionally been an important part of India's livestock production system. In the previous four decades, India's poultry production has evolved from an utterly unstructured and unscientific agricultural practice to a commercial production system with cutting-edge technology innovations. The Indian poultry business has evolved significantly as a result of the industry's scientific approach and the government's creation of an enabling environment. In terms of structural and management changes, poultry production is quite dynamic. In today's corporate world, the sooner you can react to changing system requirements, the faster you can expand. However, long-term viability frequently necessitates reliance on other sectors, such as feed/ingredient inputs and processing facilities. Many reasons, including growing earnings and a fast expanding middle class, have contributed to the rise of the poultry business in India, as well as the advent of vertically integrated poultry farmers who have decreased consumer prices by decreasing production and marketing expenses. Integrated production, the move from live birds to chilled and frozen goods, and regulations that maintain supplies of competitively priced maize and soyabean are all important factors in India's future poultry sector growth. Furthermore, disease surveillance, monitoring, and management will determine the sector's fate.

Key words: Broiler farming, egg production, poultry farming

INTRODUCTION

India has a population of 1.38 billion people, with the population growth rate at 1.2%. In India all communities accept eggs and poultry and they are available at very low costs (Landes, 2004). Poultry generally refers to all bird species that may be domesticated by humans for the purposes of producing eggs, meat, pleasure, and excrement on a regular basis, as well as feathers, bones, blood, oil, and other industrial products. Poultry includes chicken (bird), duck, guinea fowl, turkey, quail, geese, ostrich, and other animals that are raised across the country and around the world. Over the course of four decades, India's chicken business has evolved from a simple backyard occupation to a large commercial agri-based enterprise. High-yielding layer (310-340 eggs) and broiler (2.4-2.6 kg at 6 weeks) varieties, combined with a standardized package of nutrition, housing, management, and disease control practices, have helped India achieve spectacular growth rates in egg (4-6 % per year) and broiler production (8-10 % per year). In line with improved output, annual per capita availability climbed to 60 eggs and 2.5 kg. of meat. Poultry sector along with livestock provide a major contribution to India's economy (Nath et al., 2012)

In India, chickens account for almost 95% of total egg production, with ducks and other poultry species contributing the rest. Based on the size of the operation and level of biosecurity, the FAO divided chicken production systems into four categories: village or backyard production, commercial production with low biosecurity, large scale commercial with high biosecurity, and industrial and integrated production systems. Feed contributes for 65-70 % of the cost of broiler production and 75-80 % of the cost of layer production. India now ranks third in the world in egg production and fifth in chicken meat output (DADF, 2018). Total poultry in the country is 851.81 million in 2019, increased by 16.8% over previous year whereas total backyard poultry in the country is 317.07 million in 2019, increased by 45.8% over previous census. The total commercial poultry in the country is 534.74 million in 2019, increased by 4.5 % over previous census (Fig. 1). In India, 260 million layers generate 3.4 million tonnes (74 billion) of eggs per year, while 3000 million broilers create 3.8 million tonnes of chicken meat (Singh, 2019). The poultry industry contributes over Rs.70,000 crores to the national GDP and employs over 4 million people directly and indirectly. As a byproduct, around 2-2.5 million tonnes of chicken litter, a valuable organic fertilizer, are generated each year. (Mehta et al., 2002). According to the 2019 census, India has 852 million birds, with 20 recognized chicken varieties and two duck species. India is the world's third-largest egg producer (after China and the United States) and fourth-largest broiler producer (Srikanth et al., 2018). Tamil Nadu, Andhra Pradesh, Telangana, Maharashtra, Karnataka, and West Bengal are the top five states in terms of poultry population, with Assam (71.63 %) and West Bengal (46.34 %) having the highest growth rates from 2012 to 2019 (Table 1).

Table 1. Poultry population of major states of India during 2012 and 2019

Sl. No.	States	Population (In million) 2012	Population (In million) 2019	% Change
1.	Tamil Nadu	117.3	120.8	2.92
2.	Andhra Pradesh	80.6	107.9	33.85
3.	Telangana	80.8	80.0	-0.93
4.	West Bengal	52.8	77.3	46.34
5.	Maharashtra	77.8	74.3	-4.49
6.	Karnataka	53.4	59.5	11.33
7.	Assam	27.2	46.7	71.63
8.	Haryana	42.8	46.3	8.11
9.	Kerala	24.3	29.8	22.61
10.	Odisha	19.9	27.4	37.95

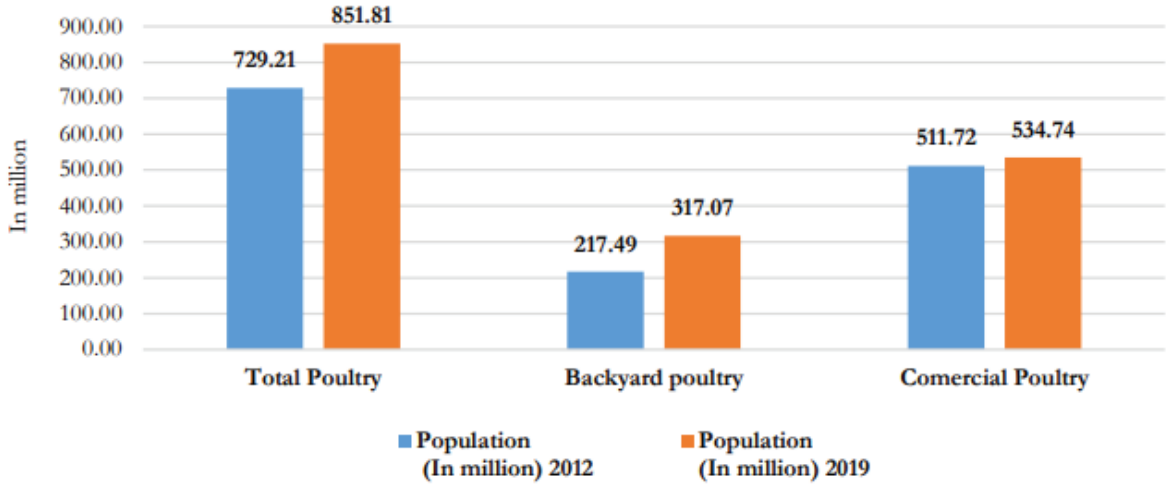


Fig. 1. Poultry population 2012 and 2019 (DADF, 2019)

IMPORTANCE OF POULTRY PRODUCTION

Poultry provides direct and indirect employment to nearly 6 million people in the country. The poultry industry has evolved from subsistence farming to an organized, scientifically oriented, and technologically driven industry over the last four decades, and this growth can be attributed to a number of factors, including government support, R&D efforts, high per-capita income growth, and international collaborations. Among all animal industries, the Indian poultry sector has shown the fastest yearly increase of roughly 6% in egg production, 10% in meat output, and 8.35 % in broiler production during the previous decade. In the livestock sector, the poultry industry accounts for around 1% of national GDP and 14% of animal GDP. Meat products account for about two-thirds of livestock GDP, while dairy products account for 22.5% and poultry goods for 12.5 %. (DADF, 2018).

- Given to its traditional form of monetary operation, it has the best market shock absorption ability of any agricultural farm;
- It has huge potential to bring about quick economic growth, notably helping the poor, due to its cheap investment need and short gestation period.
- Among other livestock sectors, it has the greatest employability/unit of investment.
- Adding poultry farming to agricultural diversification adds to the necessity of resolving the agrarian problem.
- It satisfies all requirements for quick R&D, allowing the generation of genetically better birds capable of high output in a shorter time frame.

Table 2. List of poultry population

Poultry population (%)		Share of layer population (%)		Contribution to egg production (%)	
Backyard Poultry	29.8	Desi fowl	28	Backyard Poultry	21
Layers	29.4				
Broilers	38.7	Improved fowl	72	Commercial farms	79
Ducks	0.68				
Others	1.43				

The Indian poultry business, worth over Rs. 80,000 crore in 2015-16, is divided into two sub-sectors: one with a highly organized commercial sector and the other with an unorganized commercial sector, accounting for around 80% and 20% of the total market share, respectively (Mohanty and Rajendran, 2003). The unorganized sector, often known as backyard poultry, is critical for the poorest of the poor in terms of additional revenue creation and family nutrition. Small and medium farmers are largely engaged in contract farming systems under bigger integrators, and there are >30 million farmers engaged in backyard poultry, with a chicken population of 729 million (30 % layers and 40 % broilers (Chakrabarti et al., 2014) Organized and unorganized sectors have quite distinct demands. The commercial poultry business is thriving in areas with a favorable environment and backward and forward connections, but the unorganized sector is dispersed and micro-fragmented.

The unorganized sub-sector creates additional revenue and helps the poorest of the poor improve their nutritional status. However, until today, this sector has received little assistance. However, help is being given for beneficiaries from BPL households under one of the components of the Centrally Sponsored Scheme, 'Rural Backyard Poultry Development.' However, this is little in comparison to the need. The transitional Small and Marginal sub-sector of the unorganized sector is where small/ marginal entities are currently emerging as a result of government measures for entrepreneurship development. These, on the other hand, can only be sustained if they work in a clustered

fashion. Omonona and Oni (2004) described that poultry was one of the fastest ways for increase the high-quality protein supply in short interval of time. Bujarbaruah and Gupta (2005) observed that rural poultry farming has been responsible to produce 40% of meat and 44% of egg requirement in India. For disease surveillance, drug residue and drug/vaccine quality control, standardization and quality control of poultry feed, eggs, and meat, application of Hazard Analysis and Critical Control Point (HACCP) and Good Manufacturing Practices for compliance with WTO and CODEX norms and gradation, value addition, brand promotion, and export boosting, among other things, the organized sub-sector requires policy support and intervention. The country's egg output climbed by around 6% from around 83 billion in 2015-16 to over 88 billion in 2016-17. Egg availability per capita has risen from 58 in 2012-13 to 79 in 2018-19.

Table 3. Egg production-growth rate

Year	Egg production (in billion no.)	% Annual egg production growth rate	Per capita egg availability
2011-12	66.45	5.40	…
2012-13	69.73	4.94	58
2013-14	74.75	7.20	61
2014-15	78.48	4.99	63
2015-16	82.93	5.66	66
2016-17	88.13	6.28	69
2017-18	95.20	8.03	74
2018-19	103.30	8.51	79

China, the United States of America, India, Mexico, and Japan are the major egg producers in the world.

PRODUCTION OF BROILERS

Broiler production is centered in the states of Tennessee, Arkansas, Mississippi, Oklahoma, and Telangana, with the Cobb breed accounting for 65-70 % of the market. Ross, Marshall, Hubbard, Hybro Avian, and Anak are other prominent breeds. Poultry farms range in size from 200 to over 50,000 birds. Only a few big poultry integrators have controlled-environment housing with automatic feeding and drinking systems, whereas the majority of the farms are basic open sheds (Mehta et al., 2002). The controlled environment poultry barn idea is not widely used due to high capital costs and unpredictable power supply. Broilers are typically raised for 35-40 days to reach a market weight of 1.8 to 2.2 kg and an FCR of 2.2. Broiler prices are subject to considerable seasonal fluctuations due to supply-demand imbalances, which may climb in the summer due to lower output but fall during Hindu holidays. Because of customers' appetite for chicken, rising income levels, and changing eating habits, broiler growth is likely to stay high. Broiler meat sales at the live market still account for >90-95 % of overall sales, whereas processed chicken meat accounts for just around 5% of total output (Singh, 2019). Organized commercial farms produce more than 80% of India's chicken production. Vertically integrated operations account for 60-70 % of total chicken production at major poultry corporations. Major corporations/ integrators operate hatcheries, feed mills, and main processing facilities, and they frequently offer loans, extension services, and veterinary treatment to contractual farmers. Integrators work with a number of smaller farmers who raise the chicks until they are ready to be slaughtered. Integrators acquire live birds for slaughter and processing, while wholesalers distribute them through live marketplaces (Desai, 2004).

MARKETING

In the broiler category, 65-70 million chickens are placed every week on average. 60 % of the broiler meat business is dominated by five

large players: Suguna in Coimbatore, Venky's in Pune, CP, Sneha, and Shalimar in Kolkata. In India, broiler meat output has increased by 7-8%. Individual farmers produce one-third of the crop, while contract farmers (integration farmers) produce the other two-thirds, with an average farm size of 7000-8000 birds (Islam, 2002). The placement of birds is determined by feed prices, the condition of disease outbreaks, the financial situation of farmers, and the profitability of the current demand and price of the final product on the market. Feed price accounts for around 80% of production costs and is thus a critical factor in shifting production and marketing scenarios.

GROWTH OF BROILER POULTRY

Poultry meat output in the country has risen from roughly 2.48 million tonnes in 2011-12 to 4.14 million tonnes in 2018-19, an increase of more than 6%. The United States, China, Brazil, the Russian Federation, Mexico, and India are all major broiler poultry producers in the world.

Table 4. Growth of Broiler Poultry

Year	Poultry production (million tons)	% Annual poultry production growth rate	Per capita broiler meat availability	Consumption volume in metric ton ('000)
2011-12	2.48	13.22	2.1	…
2012-13	2.68	8.01	2.2	2872.85
2013-14	1.92	-28.50	2.2	3064.96
2014-15	3.05	59.16	2.8	3283.7
2015-16	3.26	6.75	2.9	3428.04
2016-17	3.46	6.13	3.0	3540.6
2017-18	3.96	7.0	3.1	3700.3
2018-19	4.14	8.0	3.8	3737.3

POULTRY FARMING SYSTEMS

In a nation like India, where farmers' access to resources varies greatly, poultry production techniques vary as well, ranging from traditional small-scale production (with dual-purpose indigenous breeds) to intense commercial production systems (with hybrid birds specially bred for meat or egg). The FAO divided poultry production systems into four groups, or 'sectors,' depending on their amount of operation and level of biosecurity. Within each of these, there is a lot of variety between different types of production systems and value chains.

PRODUCTION IN THE VILLAGE OR IN THE BACKYARD

Rural India is home to about 70% of the country's population. These types of manufacturing methods may be found in both rural and urban locations. It is believed that "backyard" poultry farming accounts for around 15% of overall chicken output in India today (Landes et al., 2004). Traditional local, native breeds are used to produce both eggs and meat birds. Improved backyard types such as Vanaraja, Gramapriya, Srinidhi, Giriraja, Kroiler, Rainbow rooster, and others are now being kept to help resource deprived households increase their dietary protein consumption and revenue (Chakrabarti, 2014).

LOW BIOSECURITY COMMERCIAL POULTRY PRODUCTION

Although this sector is centered on commercial production, it preserves certain aspects of traditional backyard systems, notably in the sale of live birds. The scale of production units is typically moderate, ranging from 200 to 10,000 to 50,000 birds. Birds are frequently not permanently housed, mixed flocks of chickens and ducks are common, birds are typically marketed live, and a variety of marketplaces, unmonitored for health hazards, are utilized for produce (eggs and broiler) sales and input supplies. (BAHS, 2017, 2019).

COMMERCIAL ON A LARGE SCALE WITH A HIGH LEVEL OF BIOSECURITY

Commercial flocks of broilers, layers, or breeding birds on a bigger scale (50,000 to 1,00,000 birds) make up this industry. For these larger-scale ventures, only relatively rich people or commercial joint-stock corporations have the requisite investment money or can obtain adequate financing. Birds are continually kept, rigorously prohibiting interaction with other flocks or wildlife, using automation as seen in four southern states, which together generate 57 % of the nation's egg output. In India, native chicken varieties reared in backyard conditions contribute about 11 % of total egg production in India (Kumaresan et al., 2008).

INDUSTRIAL AND INTEGRATIVE PRODUCTION

This sector includes the poultry industry's largest and most industrialized farms (>1.00 lakh birds), where multiple stages of the value chain are vertically and horizontally integrated into a single industrial organization. The broiler and layer components are either completely integrated or distinct production units, while feed grinding, with or without a feed unit, remains a separate economic entity. The introduction of better, exotic genetic material is a critical initial step in the commercial poultry sector's growth and development (Ravisankar et al., 2012). New strains are often less resilient and resistant to endemic illnesses than native birds. Complementary inputs of specifically formulated concentrate feeds, as well as enhanced housing, management, and veterinary care, are required to achieve the higher productive potential. Nonetheless, the addition of new genetic material serves as the foundation for further technical advancements.

The majority of commercial poultry production is currently centred in urban and peri-urban regions. Only roughly a quarter of the population in metropolitan areas consumes 75-80 % of eggs and chicken meat.

THE POULTRY INDUSTRY'S CHALLENGES

- In comparison to the suggested levels, per capita availability is still low, with roughly 73 vs. 180 eggs and 3.4 vs. 11 kg of chicken meat per year. (The National Institute of Nutrition) .This reflects a wide disparity between availability and ever-increasing demand for poultry goods.
- To be sustainable and progressive, the sector must be internationally competitive.
- Disease outbreaks (bird flu, etc.), a lack of processing/storage facilities, and increased feed component prices all have a negative impact on the export of poultry and poultry products.
- Financial institutions' reluctance to assist in the establishment of small/medium chicken production units.
- Birds are exposed to climatic stress, illnesses, and epidemics due to inadequate facilities.
- Due to a lack of comprehensive governing power, poultry farm production, processing, and transportation requirements do not meet international standards.
- Farm licenses are granted at the municipal level, which sometimes lacks professional experience to properly enforce quality requirements.
- A lack of infrastructure between producers, markets, and consumers, which frequently causes the system to become paralyzed in order to fulfil seasonal demand.

INTERVENTIONS BY THE GOVERNMENT

NABARD provides financial infrastructure to support poultry production.

- National Coop. Dev. Cooperation (NCDC) to finance small and marginal farmers, IRDP for poultry insurance, FSSAI for meat processing license, and National Livestock Mission for the livestock and poultry sector's long-term growth and development
- A web-based Farmer Portal and a mobile-based M-Farmers SMS Portal for delivering digital data and informing farmers.

CONCLUSION

The dearth of fundamental infrastructure, such as storage and transportation, as well as the cold chain, is a key impediment to the chicken industry's expansion in India. As a result, the

prices of chicken goods, such as eggs and broilers, fluctuate dramatically. Another stumbling block to expansion is a sluggish marketing infrastructure. Both the producer and the customer are harmed by the existence of so many market middlemen. The price availability of feed supplies is a third issue. Corn, often known as maize, plays a significant role in broiler production, accounting for 50 to 55 % of broiler feed. Because the broiler sector is expanding at a 15 % annual pace, maize demand is expected to rise. India now grows just 11 million tons of maize and has only 5 million tons available for poultry, which is insufficient to continue the industry's present growth pace. Despite a number of setbacks over the years, India's poultry output has continued to increase at a phenomenal rate. With rising demand for chicken eggs and meat, India's poultry industry is expected to expand and industrialize. The adoption of small-scale chicken farming in rural families' backyards would improve the nutritional and economic condition of rural residents. Future obstacles will not be a deterrent with the advancement of knowledge and new discoveries in many disciplines of poultry, and thus envisions a bright future for poultry production in this nation.

REFERENCES

BAHS. 2017. *Basic Animal Husbandry Statistics.* Department of animal husbandry, dairying and fisheries. Ministry of Agriculture, Government of India. New Delhi.

BAHS. 2019. *Basic Animal Husbandry Statistics.* Government of India, Department of Animal Husbandry and Dairying, Ministry of Agriculture, Krishi Bhawan, New Delhi.

Bujarbaruah, K.M. and Gupta, J.J. 2005. *Family poultry for the development of NEH region* ICAR Research Complex Umiam, Barapani, Meghalaya. In: IPSACON-2005.

Chakrabarti, A., Dey, A. and Barari, S.K. 2014. Backyard poultry farming- a source of better livelihood for rural farmers. Krishisewa. https://www.krishisewa.com/articles/livestock/410-backyard-poultry-farming.html

DADF. 2018. Department of Animal Husbandry Dairying and Fisheries (DADF), ministry of agriculture. Government of India, New Delhi.

Desai, A. 2004. *An overview of the Indian poultry and future scenario*. All India Poultry Year Book, Special Millennium Issue. Delhi.

Islam, R., Mahanta, J.D., Barua, N. and Zaman, G. 2002. Duck farming in North-Eastern India (Assam). *World Poult. Sci. J.* **58**: 567-572.

Kumaresan, A., Bujarbaruah, K.M., Pathak, K.A., Chettri, B., Ahmed, S.K. and Haunshi., S. 2008. Analysis of a village chicken production system and performance of improved dual-purpose chickens under a subtropical hill agro- ecosystem in India. *Trop. Anim. Health Prod*. **40**: 395–402.

Landes, M., Persaud, S. and Dyck, J. 2004. India's poultry sector: development and prospects. Economics Research Service: Agricultural and Trade Report WRS-04-03. United States Department of Agriculture, Washington DC.

Mehta, R., Nambiar, R.G., Singh, S.K., Subrahmanyam, S. and Ravi, C. 2002. *Livestock industrialization, trade and social-health-environment issues for the Indian poultry sector*. IFPRI/FAO Livestock Industrialization Project, Phase II Project. Washington DC, International Food Policy Research Institute.

Mohanty, S. and Rajendran, K. 2003. 2020 vision for Indian poultry. *Int. J. Poult. Sci.* **2**(2): 139–143.

Nath, B.G., Pathak, P.K. and Mohanty, A.K. 2012. Constraints analysis of poultry production at Dzongu area of North Sikkim in India. *Iran J. Appl. Anim. Sci.* **2**: 397–401.

Omonona, B.T. and Oni, O.A. 2004. Economics of table egg production in Ibadan Metropolis, Oyo state, Nigeria. *Trop. Anim. Health Prod.* **7**: 67–73.

Ravisankar, N., Ganeshkumar, B., Chaudhuri, S.G., Raja, R. and Srivastava, R.C. 2012. Development of Integrated Farming System (IFS) Models under different resource conditions in humid tropics of Bay islands. In: *IV World Waterfowl Conference* Thrissur, India, pp. 267- 268.

Singh, R. 2019. Broiler Integrator Marathon and Small Farmer. *Pashudhan Praharee*. https://www.pashudhanpraharee.com/broiler-integrator-marathon-small-farmer.

Srikanth, D., Brahmanandam, V. and Ravi Teja, M. 2018. Emerging trends in duck farming in India. *Int. J. Sci. Manage. Stud.* **01** (01): 7-13.

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.
    - **2.2. Author(s).** Author(s) name(s) should be typed in bold letters, first initials and then surname. Corresponding author's name should be specified by an asterisk mark . Serial numbers of authors to be superscripted on top right e.g. 1,2,3 representing the group of authors from the particular institution. Corresponding name of the of the institutions / place of work be given serially below the authors name. E-mail id be indicated below the detailed address.
    - **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.
4. **Table.** Number the tables consecutively in Arabic numerals. Tables should have comprehensible legends. Conditions specific to a particular experiment should be stated. Zero results must be represented by 0 and not determined by n.d. The dash sign is ambiguous. For values <1, insert a zero before the decimal point.
5. **Illustrations.** All graphs, diagrams and half-tones should be referred to as Figure and should be numbered consecutively in Arabic numerals. The figures should either match with the column width (8.5 cm) or the printing area (17.8 x 22 cm). The legends should be brief and self-explanatory. All graphs, figures should be drawn by EXCEL and submitted in editable format. Define in the footnote or legend any non-standard abbreviations or symbols used in a table or figure.
6. **Reviews.** Full length review articles are also invited.

RNI - Regd. No. ORI ENG/2003/15643 Dated -22.11.2005

Waldenwoods ECO Village

WALDENWOODS ECO VILLAGE (WEV)

(1st of it's kind 2nd home / farm house venture of eastern india)

चलो चले

जंगल की और ...

Kantamalia, Dhenkanal, Land Mark – Kapilash (Hills), Wildlife Sanctuary (On North East Edge)
City Office - 2nd Floor, 550, Saheed Nagar, Bhubaneswar, Odisha.
Call-9776088888 I Mail : wevindia@gmail.com