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HARVESTED PADDY FIELDS: AN UNDERSTUDIED ECOSYSTEM FROM THE NORTHERN WESTERN GHATS, INDIA

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Abstract
This study was aimed at assessing the richness and obtaining allied ecological data of harvested rice fields at two sites around the town of Lonavala, northern Western Ghats, India. A total of ten fields were sampled (five at each site) using the quadrate method for the five post-harvest months. A total of 82 species were observed belonging to 74 genera of 31 families with Poaceae being the dominant family. Flora on the bunds and field proper was dissimilar. The natives and dicots species outnumbered the exotics and monocots respectively, and a gradual decline in the richness was observed from December through April. The PAST analysis indicated that some fields in the Tungi area were significantly different floristically from other fields. Presence of forests around the fields probably affects the post-harvest floristic diversity. Given that Indian farmers are experiencing a financial crisis, possible ways of gaining economic benefits out of this post-harvest floral diversity are discussed. Rice fields serve as a surrogate habitat for several species in areas disturbed due to anthropogenic activities and such studies provide baseline data for any future ecological studies.

***Key words*:** exotic, floristics, native, Poaceae, post-harvest floral diversity, rice field.

Introduction

Rice cultivation has been shaping the economy and culture of Asian countries from the beginning of organized agriculture (Edirisinghe & Bambaradeniya, 2006). In the conventional flooding method of rice cultivation, the fields undergo two distinct phases, a temporary wet phase followed by a post-harvest dry phase showing a mosaic of habitats (Heckman, 1974). During the wet phase, paddy fields play a role similar to a natural temporary wetland (Lawler, 2001) and harbor various taxa such as cyanobacteria (Choudhary & Bimal, 2010), fishes (Katano *et al.*, 2003), amphibians (Duré *et al*., 2008), reptiles (Bambaradeniya, 2000), spiders (Sebastian *et al.*, 2005), avifauna (Elphick, 2000) and vascular plants (Bambaradeniya *et al*., 2004) making the fields rich in biological diversity.

Paddy fields are extremely diversified and present various plant groups such as algae (Gupta, 1966), fungi (Min *et al*., 1981), bryophytes (Gaikwad *et al*., 2012), pteridophytes (Bambaradeniya & Gunatilleke, 2002) and angiosperms (Chakravarti, 1963). Globally, rice fields have been well explored for their angiosperm diversity (Barrett & Seaman, 1980; Chandrasena, 1987; 1988). In India, studies like Haq (1955), Prayaga Murty (2011), Bhattacharya *et al*. (2011) deal indirectly with the post-harvest flora of rice fields. Considerable floristic studies in wet as well post-harvest phase of paddy fields have been carried out in different regions of the country such as in eastern India (Maiti *et al*., 1984; Subudhi & Dixit, 1998; Datta & Banerjee, 1978), northern India (Dangwal *et al*., 2012) and southern India (Sukumaran & Jeeva, 2012; Aravindhan *et al*., 2011) .

Western Ghats, being one of the important regions in the production of this major food crop, has considerable area under paddy fields. Mathew *et al*. (2006), Aravindhan *et al*. (2011) and Balu *et al*. (1987) have studied the floristic composition of these rice fields in the southern Western Ghats. On the other hand in northern Western Ghats this unique ecosystem has received meager attention and only a few studies are available regarding these fields (Gaikwad, 2013).

The current study deals with the harvested paddy fields around Lonavala and nearby areas that house tremendous floral diversity which was documented earlier by Santapau (1953) and Venkatareddi (1969). Although these studies were extensive and cover an array of habitats they do not deal with rice fields exclusively as a habitat. Hence, the following study was undertaken to understand this unique ecosystem by assessing the floristic richness of these fields. A thorough documentation of monthly variation in species richness and the compilation of these species in the form of a checklist are presented here. Inter-field comparison based on environmental factors with respect to species richness is also presented.

Materials and methods

***Study area*:** The study was carried out at Lonavala (18°44′50.96″N, 73°24′12.39″E), a town in the Pune District of Maharashtra State, India (Fig. 1). It is located at an altitude of 622 m in the Western Ghats, one of the 35 biodiversity hotspots (Roach, 2005). Its geographical position exposes the area to a rainfall of about 170 inches from June to the end of September. This is followed by winter which lasts from November to January. During summer season the temperature can go up to 35 °C (Singh & Karthikeyan, 2000). The forest type occurring in the study area is classified as Western Subtropical Hill Forest (Type 8A/C2) as per Champion & Seth (1968).

Figure 1: The map of India showing the study location (Lonavala) in northern Western Ghats.

The study was carried out at two different sites namely Tungi and Kusgaon. The Tungi village is situated below the southern edge of the Tungi Fort (Fig. 1). The village has a forest patch adjacent to it followed by a continuous rice cultivation landscape. The residents practice rice agriculture as a major occupation and it is their primary source of livelihood. The cultivation is done by using traditional flooding method. After harvesting the rice crop the fields sometimes are immediately ploughed or are sometimes left unploughed till the next season arrives, while in some cases they are used for cultivation of an intermediate crop. On contrary, the other study site at Dongrewadi near Kusgaon is comparatively more urbanized. The site lies close to the Pune-Mumbai express highway. The people here cultivate rice as a supplementary source of income. The agricultural practices at both places are nearly the same and the post-harvest fields here are almost always left unploughed till the next season arrives.

***Data collection and analysis*:** A total of ten fields were selected with five fields at each site (Tungi area and Kusgaon area). Quadrate method was used as a sampling method (Gotelli & Colwell, 2001). For the determination of the size of the quadrate, species area curve (Connor & McCoy, 1979) was exercised through which a quadrate of 1 m by 1 m was prepared. Similarly a total of five plots in each field were determined using the species number curve (Ugland *et al*., 2003). This quadrate was laid out five times on a diagonal transect selected randomly. The fields were visited in the second week of every month from December to April. During the sampling of each plot details such as name of species and phenology were recorded. Every species was photographed and voucher specimens were collected, pressed, poisoned and mounted on herbarium sheets (deposited at AHMA) following standard protocols (Jain & Rao, 1977). Field identification was carried out using (Cooke, 1901–1908, Singh & Karthikeyan, 2001, Lakshminarasimhan, 1996). Species and family names were standardized following The Plant List (2013). The fields were divided into two sections: bunds (levee) and field proper as explained by Barrett & Seaman (1980). The documentation of plants found on the bunds was done by intensive survey as the standard sampling method could not be used due to their discontinuity. Also, at the Tungi village the bunds were sometimes used for cultivation of pea (*Pisum sativum* L.) and mug (*Vigna radiata* (L.) R. Wilczek)

Separate checklists were made for monthly observations at each field site. All the observed species were then compiled in the form of a checklist. The inter field comparisons of the ten fields (using the checklist data) were made using the PAST Software (Hammer *et al*., 2000). Jacards distance was selected in the PAST software and the bootstrap value was set to 100.

Results

A total of 82 species were observed belonging to 74 genera of 31 families in the harvested paddy fields of the study area (Appendix I). Poaceae was found to be the dominant family with 19 species followed by Asteraceae with nine, Acanthaceae and Amaranthaceae with six each and Fabaceae with five. The remaining 19 species were representatives of a single genus.

Out of the total number of species, the highest number (36) were found only in field proper and an equal number of species was found on the bunds as well as both field proper and bunds. Native species comprised 79 with the remaining three species being exotic. A gradual decline in the species richness was observed from December (57) through April (23). Out of the total species recorded, 58 were dicots and 24 were monocots. Species richness was highest in the months of December and January. Albinism was seen with respect to flowers in *Wahlenbergia marginata*, *Centaurium meyeri*, and *Lindernia oppositifolia*. The PAST analysis revealed that fields no 1 and 2 (Tungi area) were significantly different in terms of species richness from the remaining fields. Fields 3, 4 and 8, 10 were similar in terms of species richness (Fig. 2). Of the total number of species a large number flowered throughout the sampling season. Fruiting was observed in the month of April in almost all species. By the beginning of May the majority of species completed fruiting and started to disappear.

Discussion

Our study presents a great diversity of herbaceous plants which can be attributed to the highly fertile soil of these fields. The fields during monsoon are colonized by nitrogen fixing microphytes which increases the fertility of soil (Singh, 1985). Poaceae are represented by several economic significance species such as *Apluda mutica, Ischaemum indicum, I. rugosum, Cynodon dactylon* and other important fodder grasses (Potdar *et al.*, 2012). In addition, two grass species, *Coix lacryma-jobi* and *Polypogon monspeliensis*, are listed as rare in Maharashtra by Potdar *et al.*, (2012). The PAST analysis suggests that some fields in the Tungi area had markedly different composition which could be the result of better preserved forests in the adjoining area, though a thorough study is necessary to validate this probability.

Some species were observed to have acquired a different niche by inhabiting the bunds. The bunds do not undergo the water logged phase similar to that of the fields proper. Also, bunds are usually used for planting trees and hence receive more shade than the rest of the field. These bunds were the home of some species that were otherwise confined to bunds and are rarely or never observed in the field proper. The vegetation of the bunds is mainly composed of grasses (Appendix I).

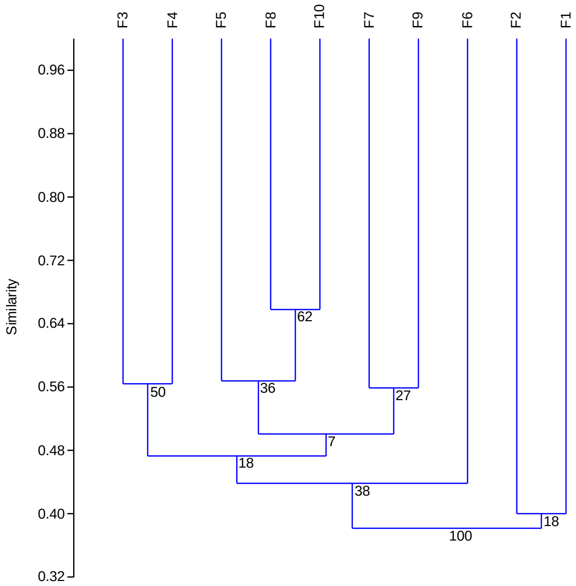

Figure 2: Cladogram showing comparison of ten fields (F1–F10= fields).

Along with nitrogen fixation leguminous plants (the fifth dominant family in the current study) we also observed that some species have the ability of increasing water holding capacity and to prevent denitrification (Roger & Ladha, 1992). Today, the Indian farmers are experiencing a tremendous financial crisis due to the increasing debt (Panchard *et al*., 2007). Re-ploughing these legumes into the soil can be greatly beneficial to the farmers as it can serve as a source of green manure and reduce the cost of external fertilizers. Also, some species like *Oldenlandia corymbosa*, *Ocimum gratissimum*, *Coix lacryma-jobi*, *Cardiospermum halicacabum*, *Amaranthus spinosus* have accepted ethnobotanical and medicinal uses (Agharkar, 1953) from which the farmers could benefit greatly.

In regions where natural wetlands are threatened due to anthropogenic activities, rice fields present a potential surrogate habitat for wetland taxa (Elphick, 2000). Although the flooded rice fields cannot be considered equivalent to natural wetlands conservation of historic natural wetlands should always be given priority.

Classical botanical branches like taxonomy are greatly neglected today (Abrol, 2013) and there is a need of such field studies (Sen, 2013). Such checklists form baseline data for any future ecological studies in the region and should be replicated in other data-deficient areas.

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Literature cited:

Abrol, D. P., 2013. Future of taxonomy in the 21st century – whither or wither? *Current Science*, 104: 1594.

Agharkar, S. P., 1953. *Medicinal plants. Gazeteer of Bombay State. Volume: General-A, Botany (part 1)*. Government Central Press, Bombay, India: 250.

Aravindhan, V., A. Rajendra, B. Thomas, and M. Maharajan, 2011. Weeds and their potential values in Coimbatore , Tamil Nadu. *Journal of Economic & Taxonomic Botany*, 35: 108–113.

Balu, S., K. Santhanam, and C. Lakshminarasimhan, 1987. Observations on weed flora of paddy fields in Thanjavur District (Tamil Nadu). *Journal of Economic & Taxonomic Botany*, 11: 305–309

Bambaradeniya, C. N. B., 2000. Rice field: An important man-made habitat of herpetofauna, *Proceedings of the 4th Asian Herpetological Congress, July 16*–20, 2000. *Chengdu, China*: 24.

Bambaradeniya, C. N. B., J. P. Edirisinghe, D. N. De Silva, C. V. S. Gunatilleke, K. B. Ranawana, and S. Wijekoon, 2004. Biodiversity associated with an irrigated rice agro-ecosystem in Sri Lanka. *Biodiversity & Conservation*, 13: 1715–1753.

Bambaradeniya, C. N. B. and C. V. S. Gunatilleke, 2002. Ecological aspects of weed florainan irrigated rice field ecosystem at Bathalagoda in Sri Lanka. *Journal of the National Science Foundation of Sri Lanka*, 30: 123–147.

Barrett, S. C. and D. E. Seaman, 1980. The weed flora of Californian rice fields. *Aquatic Botany*, 9: 351–376.

Bhattacharya, R. P., D. C. Pal, and B. R. Pati, 2011. Aquatic and wetland monocotyledons of Bihar and Jharkhand states. *Journal of Economic & Taxonomic Botany*, 35: 486–496.

Champion, H. G. and S. K. Seth, 1968. *A Revised Survey of the Forest Types of India*. Government of India publication, Delhi: 404.

Chandrasena, J. P. N. R, 1987. Rice field weeds in the Colombo and Gampaha districts of Sri Lanka. *Journal of the National Science Foundation of Sri Lanka*, 15: 249–265.

Chandrasena, J. P. N. R., 1988. Floristic composition and abundance of rice-field weeds in four low-country wet zone districts of Sri Lanka. *International Journal of Pest Management*, 34: 278–287.

Chakravarti, S. C., 1963. Weed control in India – A review. *Indian Agriculture*, 7: 23–36.

Choudhary, K. K. and R. Bimal, 2010. Distribution of nitrogen-fixing cyanobacteria (Nostocaceae) during rice cultivation in fertilized and unfertilized paddy fields. *Nordic Journal of Botany*, 28: 100–103.

Connor, E. F. and E. D. McCoy, 1979. The statistics and biology of the species-area relationship. *American Naturalist*, 113: 791–833.

Cooke, T. 1901–1908. *The Flora of the Presidency of Bombay*. 2 vols. Taylor and Francis, London.

Dangwal, L. R., A. Singh, T. Singh, and A. Sharma, 2012. Major weeds of paddy fields in district Rajouri (J&K) India. *Journal of Agricultural & Biological Science*, 7: 527–532.

Datta, S. C. and A. K. Banerjee, 1978. Useful weeds of West Bengal rice fields. *Economic Botany*, 32: 297–310.

Duré, M. I., A. I. Kehr, E. F. Schaefer, and F. Marangon, 2008. Diversity of amphibians in rice fields from northeastern Argentina. *Interciencia*, 33: 523–527.

Edirisinghe, J. P. and C. N. Bambaradeniya, 2006. Rice fields: An ecosystem rich in biodiversity. *Journal of the National Science Foundation of Sri Lanka*, 34: 57–59.

Elphick, C. S., 2000. Functional equivalency between rice fields and seminatural wetland habitats. *Conservation Biology*, 14: 181–191.

Gaikwad, S. A., 2013. *Ecological Studies on Weeds from Rice Field from Bhor and Velhe Taluka of Pune District, Maharashtra State*. Unpublished Ph.D. thesis, Savitribai Phule Pune University, Ganeshkhind, Pune, Maharashtra, India.

Gaikwad, S. A., A. S. Upadhye, D. K. Kulkarni, A. Deshpande, and D. R. Shirke, 2012. Survey of bryophyte in rice fields of Bhor and Velhe region. *Science Research Reporter*, 2: 236–238

Gotelli, N. J. and R. K. Colwell, 2001. Quantifying biodiversity: Procedures and pitfalls in the measurement and comparison of species richness. *Ecology Letters*, 4: 379–391.

Gupta, A. B., 1966. Algal flora and its importance in the economy of rice fields. *Hydrobiologia*, 28: 213–222.

Hammer, Ø., D. A. T. Harper, and P. D. Ryan, 2000. PAST: Paleontological Statistics Software Package for Education and Data Analysis. *Palaeontolia Electronica* 4: unpaged.

Haq, A., 1955. Weed flora of paddy fields and its control in eastern Uttar Pradesh. *Science & Culture*, 21: 277–278.

Heckman, C. W., 1974. The seasonal succession of species in a rice paddy in Vientiane, Laos. *Internationale Revue der Gesamten Hydrobiologie und Hydrographie*, 59: 489–507.

Jain, S. K. and R. R. Rao, 1977. A *Handbook of Field and Herbarium Methods*. Today and Tomorrow's Printers and Publishers, New Delhi: 157.

Katano, O., K. Hosoya, K. I. Iguchi, M. Yamaguchi, Y. Aonuma, and S. Kitano, 2003. Species diversity and abundance of freshwater fishes in irrigation ditches around rice fields. *Environmental Biology of Fishes*, 66: 107–121.

Lakshminarasimhan, P., 1996. Monocots. *In*: Sharma B.D., S. Karthikeyan and N. P. Singh (eds.). *Flora of Maharashtra State*. Botanical Survey of India, Calcutta: 794.

Lawler, S. P., 2001. Rice fields as temporary wetlands: A review. *Israel Journal of Zoology*, 47: 513–528.

Maiti, M. M., G. Misra, and R. B. Ghosh, 1984. Studies on weeds in relation to rice crop. *Journal of Economic & Taxonomic Botany*, 5: 17–38.

Mathew, G., J. K. Sharma, and P. S. Easa, 2006. Monitoring biodiversity in selected landscapes in the Kerala part of Western Ghats. *KFRI Researach Report* No. 283: 1–183

Min, K. H., T. Ito, and T. Yokoyama, 1981. Fungus flora of paddy fields in Korea. I. Fungal distribution of paddy fields. *Korean Journal of Microbiology*, 19: 153–162.

Panchard, J., T. V. Prabhakar, J. P. Hubaux, and H. S. Jamadagni, 2007. Commonsense net: A wireless sensor network for resource-poor agriculture in the semiarid areas of developing countries. *Information Technologies & International Development*, 4: 51–67.

Potdar, G. G., C. B. Salunkhe, and S. R. Yadav, 2012. *Grasses of Maharashtra*. Shivaji University, Kolhapur, India: 655.

Prayaga Murty, P., 2011. Positive aspects of the weed species in crop fields of north coastal, Andhra Pradesh, India. *Journal of Economic & Taxonomic Botany*, 35: 249–255.

Roach, J. 2005. Conservationists name nine new “biodiversity hotspots”. *National Geographic News*, 2 February 2005.

Roger, P.-A. and J. K. Ladha, 1992. Biological N_2 fixation in wetland rice fields: Estimation and contribution to nitrogen balance, 41–55. *In*: J. K. Ladha, T. George and B. B. Bohlool (eds.), *Biological Nitrogen Fixation for Sustainable Agriculture*. Springer, Netherlands.

Santapau, H., 1953. The flora of Khandala on the Western Ghats of India. *Records of the Botanical Survey of India*, 16: 1–396.

Sebastian, P. A., M. J. Mathew, S. P. Beevi, J. Joseph, and C. R. Biju, 2005. The spider fauna of the irrigated rice ecosystem in central Kerala, India across different elevational ranges. *Journal of Arachnology*, 33: 247–255.

Sen, D. N., 2013. Field studies in botany are essential. *Current Science*, 104: 158–159.

Singh, P. K., 1985. Nitrogen fixation by the blue-green algae in paddy fields, pp. 344–362. *In*: A. M. Wadhwani (ed.), *Rice Search in India*. Indian Council of Agricultural Research Publication, New Dehli.

Singh, N. P. and S. Karthikeyan (eds.), 2000. *Flora of Maharashtra State*, *Dicotyledons*. *Vol. 1* (*Ranunculaceae to Rhizophoraceae*). Botanical Survey of India, Calcatta: 898.

Singh, N. P., S. Karthikeyan, P. Lakshminarasimhan, and P. V. Prasanna (eds.), 2001. *Flora of Maharashtra State*. *Dicotyledons*. 2 volumes. Botanical Survey of India, Calcutta: 1096.

Subudhi, H. N. and N. Dixit, 1998. Weed flora of rice fields in Orissa. *Journal of Economic & Taxonomic Botany*, 22: 737–739.

Sukumaran, S. and S. Jeeva, 2012. A study on aquatic and wetland flora of Kanyakumari District, Tamilnadu, India. *Journal of Economic & Taxonomic Botany*, 36: 223–243.

The Plant List, 2013. http://www.theplantlist.org/.

Ugland, K. I., J. S. Gray, and K. E. Ellingsen, 2003. The species–accumulation curve and estimation of species richness. *Journal of Animal Ecology*, 72: 888–897.

Venkatareddi, B., 1969–1970. The flora of Sakharpathar and Ambavane region of Poona District. *Bulletin of Botanical Survey of India*, 11 (1–2): 138–149, 12 (1–4): 213–225.

	Pogostemon benghalensis (Burm.f.) Kuntze	B
Fabaceae	*Crotalaria sp.*	B
	Lathyrus sativus L.	BF
	Melilotus alba Ledeb.	F
	Melilotus indicus (L.) All.	F
	Vigna sp.	F
Linderniaceae	*Lindernia oppositifolia* (L.) Mukerjee	F
Lythraceae	*Rotala decussata* DC.	F
Malvaceae	*Triumfetta annua* L.	B
	Urena lobata L.	B
Molluginaceae	*Glinus lotoides* L.	F
Onagraceae	*Ludwigia hyssopifolia* (G.Don) Exell	F
Papaveraceae	*Argemone mexicana* L.	BF
Plantaginaceae	*Bacopa monnieri* (L.) Wettst.	B
	Mecardonia procumbens (Mill.) Small	F
Poaceae	*Apluda mutica* L.	B
	Coix lacryma-jobi L.	F
	Crypsis schoenoides (L.) Lam.	F
	Cynodon dactylon (L.) Pers.	F
	Dichanthium sp.	B
	Digitaria stricta Roth	F
	Echinochloa colona (L.) Link	F
	Eleusine indica (L.) Gaertn.	F
	Eleusine coracana (L.) Gaertn.	F
	Eragrostis japonica (Thunb.) Trin.	F
	Eragrostis unioloides (Retz.) Nees ex Steud.	F
	Ischaemum indicum (Houtt.) Merr.	BF
	Ischaemum rugosum Salisb.	BF
	Polypogon monspeliensis (L.) Desf.	F
	Setaria pumila (Poir.) Roem. & Schult.	B
	Sorghum controversum (Steud.) Snowden	B
	Spodiopogon rhizophorus (Steud.) Pilg.	B
	Themeda quadrivalvis (L.) Kuntze	B
	Triplopogon ramosissimus (Hack.) Bor	F
Polygonaceae	*Polygonum plebeium* R. Br.	BF
Portulacaceae	*Portulaca oleracea* L.	BF
Rubiaceae	*Oldenlandia corymbosa* L.	F
Sapindaceae	*Cardiospermum halicacabum* L.	BF
Scrophulariaceae	*Sutera dissecta* Walp.	BF
Solanaceae	*Physalis minima* L.	F