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A comparative appraisal of the ecological importance of rice fields for avifaunal species in different regions in the world

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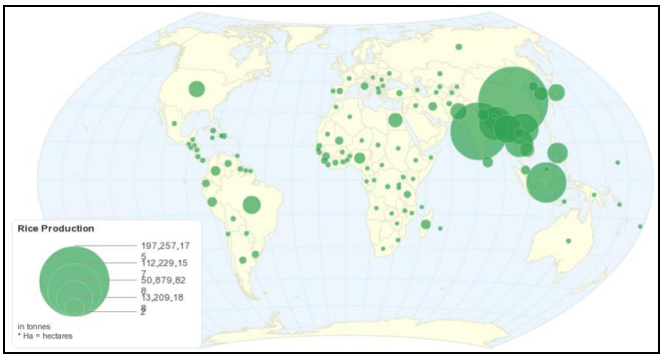
Abstract
Much has been written both in global and local level on paddy culture, rice production and associated problems, the impact of land use changes, biodiversity in rice fields. However, an area that has received little attention in the Sri Lankan context is the value of rice fields for avifaunal species. There are plenty of studies carried out in rice fields located in temperate, arid and Mediterranean climatic zones while only South America, eastern Asia and India are identified among the tropical countries. Being the 'Granary of the east' and one of the biodiversity hotspots, considerable studies carried out to emphasize the importance of rice fields for avifauna are fewer in Sri Lanka. Thus, this is a comparative appraisal to identify the variations of the utilization of rice fields by avifaunal species in the world, prior to applying the study for the Sri Lankan context.

Keywords: Avifauna, conservation status, migration, rice field, water birds

Introduction
Paddy cultivation plays a vital role in rice production. Rice is one of the main staples for human beings, also cultivated in various regions of the world from the wettest climates in the world to the driest deserts (Fig.1), which have been in existence since the beginning of organized agriculture (Edirisinghe and Bambardeniya, 2006) [33]. Most of the rice fields are flooded or submerged by water, naturally or artificially during rice production. Rice fields are usually based on the hydrological and topographical characteristics since they are the most influential conditions. Thus, rice fields in the world classified into four types as; i) irrigated lowland, ii) rain-fed lowland iii) flood prone and iv) upland (Global Rice Science Partnership, 2013) [46]. Edirisinghe and Bambardeniya (2006) [33] have mentioned another type as tidal water rice fields which identified, in particular, West Africa (Wymenga and Zwarts, 2010) [111]. Rice fields are a man-made ecosystem rich in biodiversity. They are ecosystems that sustain not only human beings but also a diverse assemblage of flora and fauna that have made rice fields their niches. These are dynamic and rapidly changing ecosystems. Due to their long existence, the large extent of land occupied in the humid tropics, the array of ecological habitats encompass and the different phases pass through during a cultivation cycle, rice fields have become unique ecosystems. In particular, flooded rice fields serve as ecotones where they provide important foraging habitat for fauna and contribute to enhancing the biodiversity especially in urban and suburban areas (Bambaradeniya *et al.*, 2004) [18].

Rice fields being temporary aquatic habitats with a generally predictable dry phase, can be scientifically defined as an agronomically managed temporary wetland ecosystem (Bambaradeniya, 2000). Halwart (1994) further emphasized rice fields are temporary and seasonal aquatic habitats, managed with a variable degree of intensity. Rice ecosystem consists of two physically and morphologically distinct habitats; the rectangular or similar shaped flooded fields consisting mainly rice plant species and levees; surrounding bunds where weeds or cultivated plants are harboured (Bambaradeniya *et al.*, 2004) [18]. Bird use in rice fields is provided heavily on other parts of the world where rice production is carried out. Such as Europe (Longoni, 2010) [62], India (Sundar and Subramanya, 2010) [99], Japan (Fujioka *et al.*, 2010), Malaysia (Munira *et al.*, 2014) [79], Australia (Taylor and Schultz, 2010), America (Acosta *et al.*, 2010) [32], Africa (Wymenga and Zwarts, 2010) [111] and Korea (Fujioka *et al.*, 2010) [44]. Rice fields are one of the most vulnerable man-made wetlands due to urbanization and cumulative process of land use and land cover changes.

The studies carried out by different researchers have identified rice fields as multi-benefited wetlands for birds (Fasola and Ruiz, 1996; Elphick and Oring, 1998; Richardson and Taylor, 2003; Basavarajappa, 2006; Sundar and Subramanaya, 2010; Fujoka *et al.*, 2010; Longoni, 2010; Stafford *et al.*, 2010; Munira *et al.*, 2014) [62, 99, 83, 19, 41, 86, 37, 91]. Thus, this study attempt to highlight the ecological importance of rice fields for avifaunal species while making a comparison of the species composition in rice growing areas in different climatic zones in the world.



Source: Charts bin statistic collector team, 2011

Fig 1: Worldwide rice production

Avifauna in rice fields

Majority of studies that have been carried out specified 'water birds' in rice fields. A handful of studies have focused the spatiotemporal variations of bird assemblages in rice fields where they have not limited to water birds. However, reviewing literature, clearly, point out that most of the bird assemblages in rice fields are belong to the category of water birds. In terms, the rice fields are home to a variety of waterbird species as well as various terrestrial bird species which occupy the levees of the rice fields. The purpose of visit rice field may vary; for foraging, breeding and roosting. Use of rice fields by breeding water birds can be divided into five categories, however, some species use multiple strategies. They are i) nesting in the standing rice crop, ii) nesting on levees within fields or at a field's perimeter, iii) nesting in associated irrigation canals and ditches, iv) nesting in other wet areas that exist because of rice cultivation and v) foraging in rice fields, while nesting in adjacent habitats (McKay, 1981; Landsown and Rajanathan, 1993; Hohman *et al.*, 1994; Fasola and Ruiz, 1996; Borad *et al.*, 2002; Mukherjee *et al.*, 2002; Durham and Afton, 2006; Pierluissi, 2006; Sundar and Choudhury, 2006) [61, 41, 51, 24]. Among the factors that affect waterbird use of rice fields i) field size ii) the abundance of suitable habitat within a region and iii) the distribution of key habitats are essential (Fasola and Alieri, 1992; Tourenq *et al.*, 2001 and 2004; Pierluissi, 2006; Amano *et al.*, 2008; Elphick, 2008) [39]. The most important fact that the rice field matrix was important for waterbird diversity as it connected wetland fragments (King *et al.*, 2010) [56]. It is relatively unimportant the rice field only as the biodiversity of rice fields emerged through the habitat connectivity, in terms, the spatial configuration of rice and associated habitats (King *et al.*, 2010) [56]. This connectivity of habitats important in migration of birds which was also demonstrated by Farmer and Parent in 1997. The rice cultivation cycle consists of different phases, in which the growing phase is a suitable period for water birds, in particular, as breeding habitats (Sundar and Subramanys, 2010; Pierluissi, 2010) [99, 82]. During the dry periods, birds use adjacent water bodies (Sundar and Choudhury, 2006) [98] as well as forest patches, shrubs and grasslands that form alongside the rice fields for foraging purposes.

Indian subcontinent

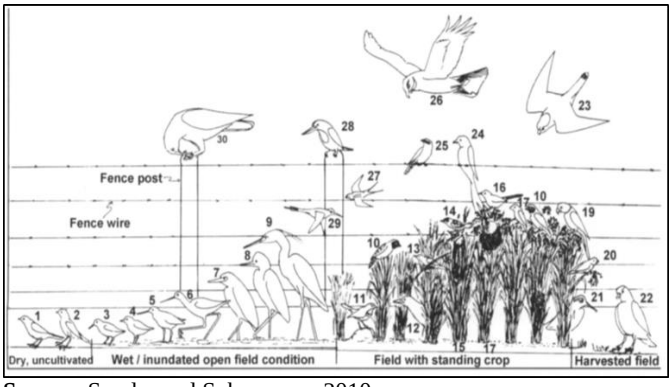
A study carried out by Sundar and Subramanys (2010) [99] observed a total of 351 bird species in Indian sub-continent, constituting 27 per cent of all species in the region and includes 22 of the 127 endemic species of the region. In this study Sundar and Subramanys (2010) [99] mentioned 65 species (19 per cent) of identified bird species are ecotonal, visiting rice fields sporadically. Among them Painted Francolin (*Francolins piceus*), Common Quail (*Coturnix coturnix*), Indian peafowl (*Pavo cristatus*), Red Spurfowl (*Galloperdix spadicea*) and Mandarine Duck (*Aix galericulata*) were included. Among the avifaunal species use rice fields, species of conservation concern also identified. Only in Indian subcontinent 23 species identified are species of conservation concern. Oriental Darter (*Anhinga melanogaster*), Painted Stork (*Mycteria leucocephala*), Lesser Adjutant (*Leptoptilos javanica*) are among them, declining due to loss of wetlands to rice cultivation with different practices.

When considering the cycle of rice cultivation the number of birds using rice fields varies with field wetness and rice growth stage. Fallow fields are mostly used by larks and pipits before planting and after harvest, and by waterbirds; herons, storks, stilts, sandpipers when flooded (Subramanys, 1991; Borad *et al.*, 2000) [24]. Thus, the species richness displayed a bimodal pattern (Sundar and Subramanys, 2010) [22]. Illustrating the bird communities (Fig.2) using various locations for foraging and nesting in rice fields Sundar and Subramanya (2010) [99] have given a clear picture of dominant bird species found in rice fields. The illustration generalizes bird communities found in rice fields.

Subramanya and Veeresh (1998) have studied 24 ha of rice complex in Bangalore, India for three years. Slaty-breasted Rail (*Gallirallus striatus*), Ruddy-breasted Crake (*Porzana fusca*) and White-breasted Waterhen (*Amaurornis phoenicuruc*) were found belong to the family Rallidae nesting in the standing rice crops. Also, they have observed nests of three passerine species in rice fields; Zitting Cisticola (*Cisticola juncidis*), Plain Prinia (*Prinia inornata*) and Red Avadavat (*Amandava Amandava*). Plain Prinias (*P. inornata*) and Zitting Cisticolas (*C. juncidis*) were also identified utilizing standing rice crops in 1991 by Subramanya.

Rice fields are extensively used as breeding habitats by many avifaunal species. Among the prominent species that breed in rice fields is the Sarus Crane (*Grus antigone*) in the Indian subcontinent (Mukherjee, 1999; Sundar and Choudhury, 2006; Sundar and Subramanya, 2010) [99, 98, 75]. Also, Mukherjee (1999) [98] and Sundar and Choudhury (2006) [98, 99] express the suitability of flooded rice fields as breeding habitats which is home to Little Grebes (*Tachybaptus ruficollis*), Purple Swamphens (*Porphyrio porphyrio*) and Pheasant-tailed Jacanas (*Hydrophasianus chirurgus*) while levees for Slaty-breasted Rails (*G. striatus*), Watercocks (*Gallicrex cinerea*) and Greater Painted Snipes (*Rostratula benghalensis*) (Sundar and Subramanya, 2010) [99] and standing paddy crop provide nesting habitat for Ashy Prinias (*P. socialis*) and Red Avadavats (*A. Amandava*) (Subramanya, 1991) [99]. Another study carried out by Basavarajappa in

2006 in rice fields, Karnataka in India has enumerated a total of 27 species of waterbirds belonging to 13 families. Of them, Ardeidae family was reported to dominant.



Source: Sundar and Subramany, 2010

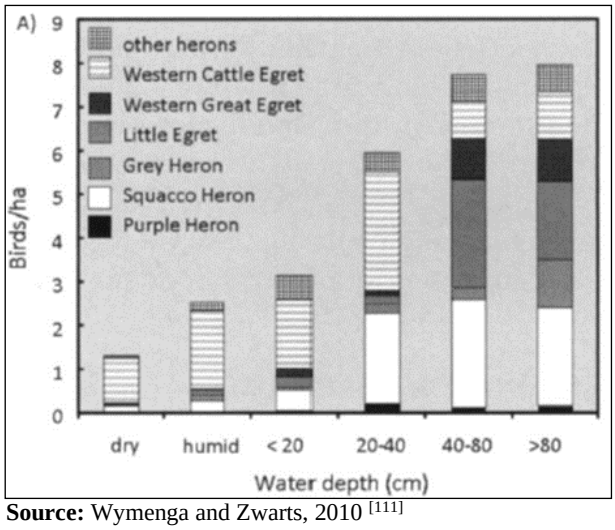
Fig 2: Diagrammatic representation of bird communities using various locations for foraging and nesting in rice fields in Bangalore, South India

Key to bird species (nomenclature follows Gill *et al.*, 2009) [45]: 1. Pipit *Anthus* sp., 2. Skylark *Alauda* sp., 3. Little Ringed Plover *Charladies dubius*, 4. Stint *Calidris* sp., 5. Snipe *Gallinago* sp., 6. Black-winged stilt *Himantopus himantopus*, 7. Indian Pond Heron *Ardeola grayii*, 8. Western Cattle Egret *Bubulcus ibis*, 9. Little Egret *Egretta garzetta*, 10. Baya Weaver *Ploceus phillipinus*, 11. Bluethroat *Luscinia svecica*, 12. Slaty-breasted Rail *Gallirallus striatus*, 13. Paddy field Warbler *Acrocephalus Agricola*, 14. Zitting Cisticola *Cisticola juncidis*, 15. Nest of Zitting Cisticola, 16. Plain Prinia *Prinia inornata*, 17. Nest of Plain Prinia, 18. Munia *Lonchura* sp., 19. Rose-ringed Parakeet *Psittacula krameri*, 20. Red Avadavat *Amandava Amandava*, 21. Greater Painted snipe *Rostratula benghalensis*, 22. Common Pigeon *Columba livia*, 23. Red-necked Falcon *Falco chicquera*, 24. Black Drongo *Dicrurus macro cercus*, 25. Brown Shrike *Lanius cristatus*, 26. Harrier *Circus* sp., 27. Swallow *Cecropis* sp., 28. White-throated Kingfisher *Halcyon smyrnensis*, 29. Green Bee-eater *Merops orientalis*, 30. Brahminy Kite *Haliastur Indus*.

Australia

Taylor and Schultz (2010) have stated that Clamorous Reed Warbler (*Acrocephalus stentorian*) and Little Grassbird (*Mangaluru gramineus*) and Australian Bittern (*Botaurus poiciloptilus*) breed along the vegetative levees in Australian rice fields. The species commute to feed is Little Egret (*Egretta garzetta*), Eastern Great Egret (*Ardea modesta*), Intermediate Egret (*Egretta intermedia*), Eastern Cattle Egret (*Bubulcus coromandus*), and Australian White Ibis (*Threskiornis molucca*) where they breed in the woodland or swampy area adjacent to the rice fields. Glossy Ibis (*Plegadis falcinelus*) and Whiskered Tern (*Chlidonias hybrida*) are the abundant species that not breed locally but roosted in the swamp nearby the rice field which makes easy to commute for food (Taylor and Schultz, 2010).

In the study, Taylor and Schultz (2010) have found a total of 37 waterbird species in rice fields. Further, discussing the temporal variation of wading birds, Intermediate Egret (*E. intermedia*) and Glossy Ibis (*P. falcinelus*) identified as migratory while Eastern Great Egret (*A. modesta*) as partial migrants was their number increase in November. This number reached a peak about late December or early January consisting of Intermediate Egret (*E. intermedia*), White-faced Heron (*Egretta novaehollandiae*) and White-necked Heron (*Ardea Pacifica*). Glossy Ibis (*P. falcinelus*), Royal Spoonbill (*Platalea regia*) and Yellow-billed spoonbill (*Platalea flavipes*) reached its peak numbers earlier, about mid-December (Taylor and Schultz, 2010). The study has signified that the crop management regime as an influential factor for distinguishes densities of egrets and herons in rice fields. Taylor and Schultz (2010) have enumerated 9 shorebird species in rice fields but only 5 occurred regularly; Common Greenshank (*Tringa nebularia*), Marsh Sandpiper (*Tringa stagnatilis*), Sharp-tailed Sandpiper (*Calidris acuminata*), Black-winged stilt (*Himantopus himantopus*) and Masked Lapwing (*Vanellus miles*). Investigating the temporal variation of bird densities Taylor and Schultz (2010) concluded three factors i) decrease prey populations (Richardson *et al.*, 2001) [87], ii) increasing water depths (Wymenga and Zwarts, 2010) [111] and iii) increasing heights and densities of the rice plants (Taylor and Schultz, 2006). Wymenga and Zwarts (2010) [111] explained the effect of water depths on waterbird species (Fig.3) in rice fields. Day and Colwell (1998) [28], Elphic and Oring (1998) [37] and Maeda (2005) [65] stated straw management as another factor effect for rice field use by birds.



Source: Wymenga and Zwarts, 2010 [111]

Fig 3: Average bird densities at different water depths

Sri Lanka

Although literature seems lack for utilization of rice fields of avifauna in Sri Lanka, studying the temporal variations of avifaunal use of rice fields (Fig. 3, 4, 5, 6 and 7) in Awulegama, Kurunegala, Kirinde *et al.* (2017) [17] identified Black-headed Ibis (*Threskiornis melanocephalus*), Intermediate Cattle egret (*Egretta intermedia intermedia*), Red-wattled Lapwing (*Vanellus indicus*), Little Egrets (*E. garzetta*), Mynah (*Acridotheres tristis melanosternus*), Pond-heron (*Ardeola grayii*), Little Swift (*Apus affinis*), Great coucal (*Centropus sinensis*), Yellow-billed Babbler (*Turdoides affinis taprobanus*), Jungle Crow known as Large-billed Crow (*Corvus* [*macrorhynchos*] *culminates*), Kingfisher (*Alcedo arrhis taprobana*), Black drongo (*Dicrurus macro cercus minor*), Woodpecker (*Dinopium psarodes*) and Black-hooded Oriole (*Oriolus xanthornus ceylonensis*). Another study also carried out in Katu gam pola, Kurunegala Gunathilaka and Chandrasekara (2016) [26]

studied the temporal variation of birds' use of rice fields. Accordingly, Green Imperial Pigeon (*Ducula aenea pusilla*) and Rose-ringed Parakeet (*Psittacula krameri manillensis*) have identified abundantly in both vegetative and post-harvesting period. The abundance of seed-eating small birds such as Sparrows also mentioned in this study. According to the study carried out recently in the rice field in suburban areas (Gunathilaka, 2019 unpublished), most of the waterbird species have identified during the first phase of the rice cultivation cycle. Especially during the rainy period, post precipitation has created a pool of foods for various waterbirds while terrestrial avian species prefer to visit the rice fields during the growing, harvesting and post-harvesting periods. Among the species identified, Black-headed Ibis (*Melanocephalus*), Asian Openbill (*Anastomus oscitans*), Grey heron (*Ardea cinerea*), Great white egret(*Ardea alba*), Intermediate Egret (*Ardea intermedia*), Little egret (*E. garzetta*) were salient.

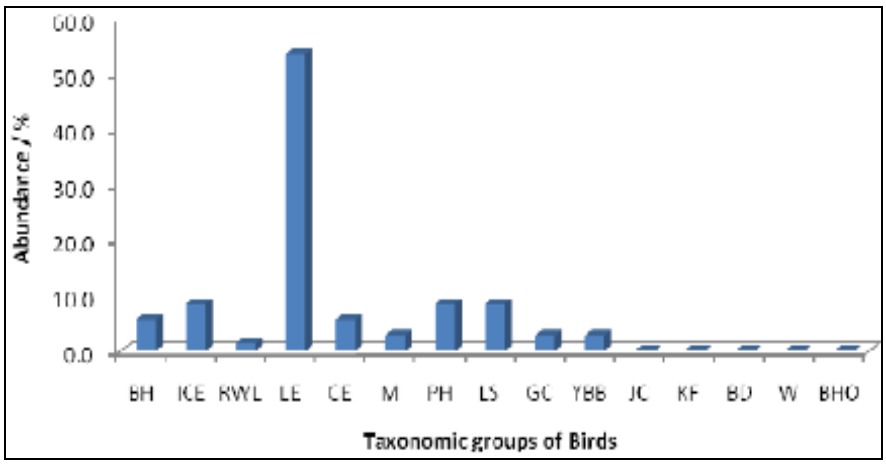


Fig 4: Sowing stage

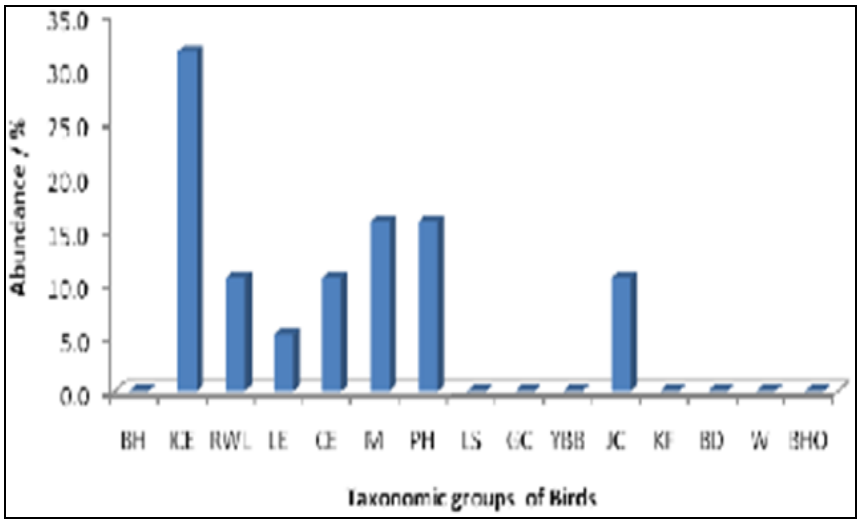


Fig 5: Two weeks after sowing stage

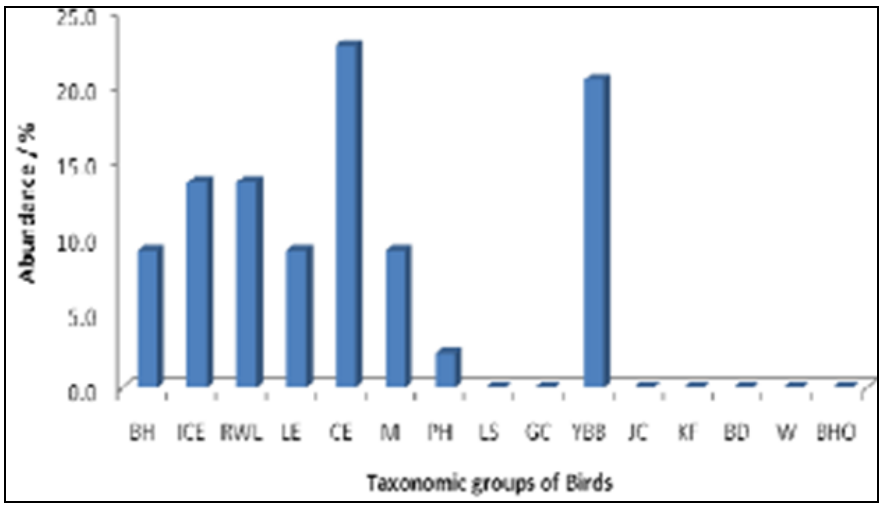


Fig 6: Four weeks after sowing stage

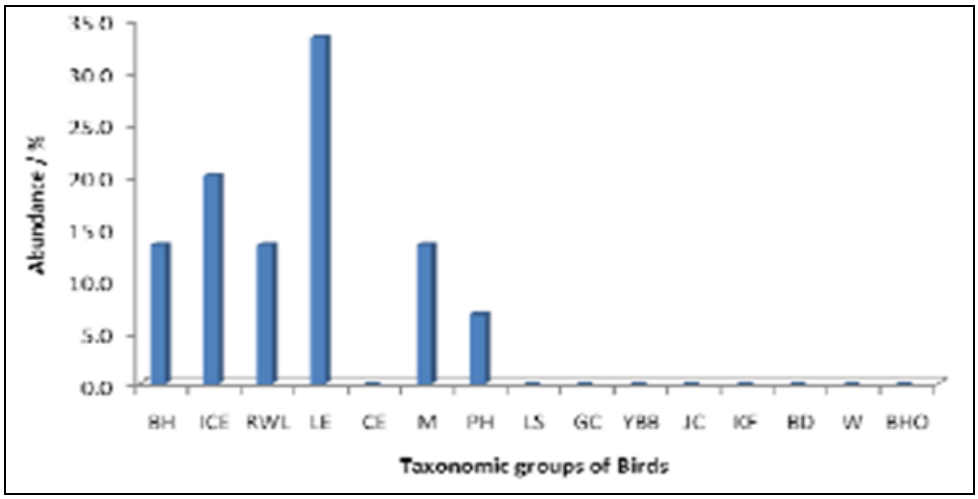
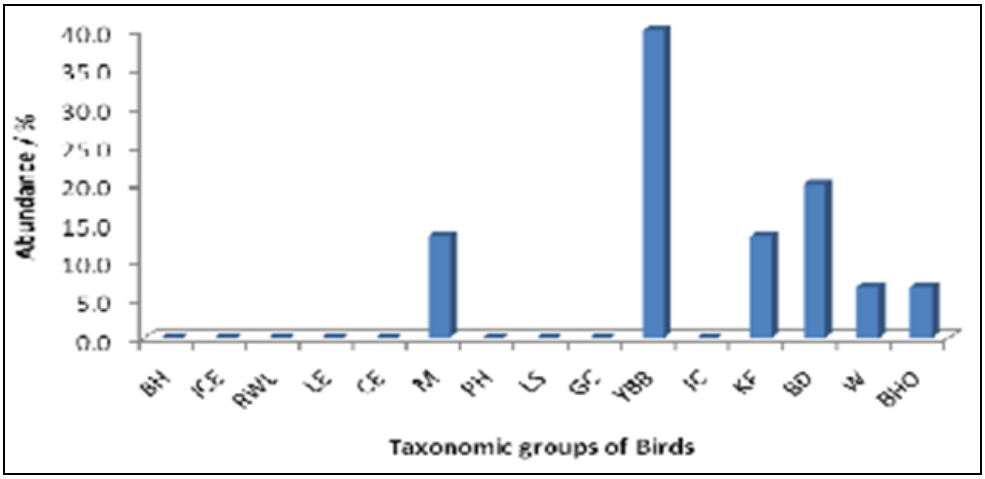


Fig 7: Six weeks after sowing



Source: Kirinde *et al.*, 2017

Fig 8: Ten weeks after sowing

(BHI-Black Headed Ibis, ICE-Intermediate Cattle Egret, RWL-Red Wattled Lapwing, LE-Little Egrets, CE-Cattle Egrets, M-Mynah, PH-Pond Heron, LS-Little Swift, GC-Great Caucal, YBB-Yellow Billed Babbler, JC-Jungle Crow, KF- Kingfisher, BD-Black Drongo, W-Woodpecker, BHO-Black Hooded Oriole)

Malaysia

The study carried out in Malaysia enumerated a total of 5120 individual birds in rice fields (Munira *et al.*, 2014) [18]. A total of 67 bird species belong to 29 families. The highest abundance was Ardeidae (29.09%) followed by Sturnidae (10.15%) and Hirundinidae (7.86%). Purple Heron (*Ardea purpurea*), Little Heron (*Butorides straita*), Great Egret (*Ardea Alba*) and Asian Glossy Starling (*Aplonis panayensis*), Common Myna (*Acridotheres tristis*) belongs to Ardeidae and Sturnidae families respectively. The species belong to family Sturnidae were identified more frequently fruiting trees located along the rice fields. According to Munira *et al.* (2014) [56], five largest bird families were identified in rice fields. They are Ardeidae, Accipitridae, Scolapacidae, Sturnidae and Estrildidae. Among the observed species during the month of March where the rice plots were inundated with water (middle of the first phase growing season) Eastern Cattle Egret (*B. coromandus*) and Little Egret (*E. garzetta*) had the high abundance while Tree-sparrow (*Passer montanus*) and White-rumped Munia (*Lonchura striata*) had recorded 38 and 27 individuals respectively. Just before harvesting (April-May) Great Egret (*A. Alba*) and Little Egret (*E. garzetta*) were the most abundant. Other granivorous avian species such as Eurasian Tree-sparrow (*P. montanus*) and Baya Weaver (*Ploceus philippinus*) were also increased in number during this period. Great Egret (*A. Alba*) could be seen during the harvesting phase as well. Little Egret (*E. garzetta*) was replaced with Eastern Cattle Egret (*B. coromandus*) and Baya Weaver (*P. philippinus*) was common during the harvesting period too.

Burning to remove rice straw created an open field to Jungle Myna (*Acridotheres fiscus*). At the phase of ploughing (Month of August) for the next stage, Eastern Cattle Egret (*B. coromandus*) and Jungle Myna (*A. fiscus*) became dominant. Again Eastern Cattle Egret (*B. coromandus*), Little Egret (*E. garzetta*) and Black-shoulder Kite (*Elanus caeruleus*) were dominated in September, October and November respectively. Apart from them, White-rumped Munia (*L. striata*) and Zitting Cisticola (*C. juncidis*) were also dominant in rice fields. The study has expressed the suitability of rice fields for other avian species such as Greater Coucal (*Centropus sinensis*), Blue-throated Bee-eater (*Merops viridis*) and Brahmine Kite (*Haliastur Indus*) and Black-shouldered Kite (*E. caeruleus*). Pearlstine *et al.* (2006) [27] had reported similar observations of raptors in recently harvested fields. Another

study carried out in Malaysia (Lansdown and Rajanathan, 1993) has pointed out the exclusive utilization of rice fields by Cinnamon Bitterns (*Ixobrychus cinnamomeus*) for nesting purpose, although the high amount of nests depredated when water was drawn down for harvest. And Cinnamon Bitterns (*I. cinnamomeus*) are preferred for mixed rice and grass habitat (Pierlussi, 2010) [30].

Munira *et al.* (2014) [35] have identified September as the highest month of avian abundance with Eastern Cattle Egret (*B. coromandus*) which is a migratory bird to Malaysia (Southward migration). During the harvesting season (phase two-December) migratory species from family Ardeidae except for Cinnamon Bittern (*I. cinnamomeus*). Significantly breeding plumage of Little Egret (*E. garzetta*), Javan Pond Heron (Ardeola speciosa) and Eastern Cattle Egret (*B. coromandus*) had identified in this study. White-rumped Munia (*L. striata*) and Scaly-breasted Munia (*Lonchura punctulata*) attracted to ripened rice fields has also stated in the study. Among the avifauna identified in rice fields in Malaysia Yellow Bittern (*Ixobrychus sinensis*) and Oriental Honey Buzzard (*Pernis ptilorhynchus*) are listed as totally protected wild birds by their Wildlife Act 2010. Munira *et al.* (2014) [68] in their study conclude the abundance of migratory aquatic avian species (King *et al.*, 2010) [56] where Stafford *et al.* (2010) [91] expressed the reason for the abundance of water birds may be due to the considerable count of food availability such as polychaetes, crustaceans and molluscs in rice plots. Munira *et al.* (2014) [68] further emphasize based on personal observation, water birds moved from one plot to another plot by selecting available quality and quantity of habitat taking advantage of exposed prey species. This was further proved by studying rice fields adjacent to the roads. When the rice fields are located at the proximity of roads or alongside roads the waterbird species enumerated are relatively high for Western Cattle Egret (*B. ibis*), Black-necked Stork (*Ephippiorhynchus asiaticus*), Painted stork (*M. leucocephala*), Asian Openbill (*A. ascitans*) and herons (Perennou, 1990; Sundar 2004, 2005) [94, 95] due to the quality of the rice fields.

Korea and Japan

More than 30 per cent of avifauna occurs in the rice fields in Korea and Japan (Fujioka *et al.*, 2010) [44]. Anseriformes, Ciconiiformes and Gruiformes depend heavily on rice fields. Ciconiiformes and smaller Gruiformes (rails) are resident breeders use rice fields in Korea and Japan during the growing phase where fields are flooded. Charadriiformes are spring and autumn migrants in this region using rice fields early in the growing phase (Watanbe, 2001 and 2006) [110, 15]. Anseriformes and larger Gruiformes are winter visitors with few exceptions. Falconiformes and Passeriformes also visit rice fields for foraging (Fujioka *et al.*, 2010) [44]. Sparrow hawk (*Accipiter soloensis*) and the Grey-faced Buzzard (*Butastur indicus*) breed in mosaic landscapes consisting of rice fields and forests. 31 terrestrial and 19 waterbird species (Maeda, 2001) [64] had recorded from rice fields in a rural area in central Japan while 37 waterbird species were recorded in the northeast of Taiwan in winter rice fields. The species richness per 15 ha plot ranged from 5 to 23 (Chan *et al.*, 2007) [12]. Seven species including three geese, two swans and two cranes use rice fields for roosting in winter. These species prefer flooded rice fields as roosts, like in California (Ackerman *et al.*, 2006) [1].

Before rice fields are flooded in the early spring the Grey-headed Lapwing (*Vanellus cinereus*) often nests in rice fields (Takahashi and Ohkawara, 2007) [101]. In this study, Fujioka *et al.* (2010) [44] had enumerated a total of 135 avian species in rice fields where 121 of were used rice fields for feeding only, which indicates the requirement of other habitat elements in the surround particularly for nesting or roosting. Remaining rice grain at the harvesting phase is also an important resource of food for terrestrial birds. Such as Eurasian Collared Doves (*Streptopelia decaocto*), Oriental Turtle Doves (*Streptopelia orientalis*) and Carrion Crows (*Corvus corone*). Some threatened geese (Shimada, 2002) [90] and cranes (Lee *et al.*, 2007b) wintering in Japan and Korea feed on residual rice grain (Fujioka *et al.*, 2010) [44]. During the post-harvest season predatory birds such as the Common Buzzard (*Buteo buteo*), Common Kestrel (*Falco tinnunculus*), Merlin (*Falco columbarius*) and Short-eared Owl (*Asio flammeus*). Most of the carnivorous water birds are summer breeders or passage migrants while Grey Heron (*A. cinerea*), Little Egret (*E. garzetta*) and Greater Painted Snipe (*R. benghalensis*) spend winter in Japan and Korea (Fujioka *et al.*, 2010) [44]. Shimada (2001) [89] has stated the use of rice fields as foraging sites by the Greater White-fronted Geese (*Anser albifrons*) in Japan. The Cattle Egret (*B. ibis*) and Little Egret (*E. garzetta*) were identified as dominant waterbirds that utilize rice fields in Southern China (Wong *et al.*, 1999) [110]. In Hainan province, China, some waterbird species are demonstrated a restricted pattern, such as Eastern Cattle Egret (*B. coromandus*) and Chinese Pond Heron (*Ardeola bacchus*). These species are restricted only to rice fields and pastures, however, southern coastal region possibly also identified as their habitats (Liang *et al.*, 2006) [61].

North Africa and the Middle East

Though coastal rice fields have lower bird densities, bird diversity is high (Wymenga and Zwarts, 2010) [111] in Africa. If for instance, densities of Western Cattle Egrets (*B. ibis*) and Squacco Herons (*Ardeola ralloides*) doubled between November and February. The Western Yellow Wagtail (*Motacilla flava*) identified as the most ubiquitous species (Wymenga and Zwarts, 2010) [111] across all types of rice fields in Western Africa. Herons depend on rice fields thus they are named as pests in Turkey. Rice fields in the Nile Delta of Egypt have become important foraging areas for breeding Squacco Herons (*A. ralloides*) (Czech and Parsons, 2002). Iran and Iraq are the only two rice-growing countries in the Middle East, having 500,000 and 129,000ha of rice fields respectively (Longoni, 2010) [62]. However, the bird's use of rice fields is not well documented.

Europe

Among the other rice-cultivating regions in Europe, northwestern Italy in particular. Small colonies of Black-headed Gull (*Larus ridibundus*), Black-tailed Godwit (*Limosa limosa*), Black Tern (*Chlidonias Niger*) and White-winged Tern (*Chlidonias leucopterus*) nest occasionally within rice fields (Fasola and Ruiz, 1996) [41]. Moorhen (*Gallinula chloropus*) and Mallard often nest along irrigation ditches. Fasola and Alieri (1992) [39] stated the presence of rice fields appears to explain the high amount of wintering Black-crowned Night Herons (*Nycticorax nycticorax*) in northern Italy. The Ruff (*Philomachus pugnax*) and the Spotted Redshank (*Tringa erythropus*) are used rice field in Italy and

Greece (Czech and Parsons, 2002). Eurasian Bitterns (*Botaurus stellaris*) populations (40%) found in Italy completely depend on flooded rice fields (Longoni, 2010) [62]. The Ebro Delta of Spain is also another location popular for rice cultivation. There Red-crested Pochard (*Netta rufina*) (Fasola and Ruiz 1996) [41], Black-winged Stilt (*H. himantopus*) and a smaller number of Pied Avocet (*Recurvirstra avosetta*) nest while Common Moorhen (*G. chloropus*) and Common Coot (*Fulica atra*) build floating nests in fields and Little Bittern (*Ixobrychus minutus*) nests (Kushlan and Hafner 2000) along irrigation ditches (Fasola and Ruiz, 1996) [41]. Apart from them, Dunlin (*Calidris alpine*), Common Snipe (*Gallinago gallinago*), Black-tailed Godwit (*L. limosa*) and Northern Lapwing (*Vanellus vanellus*) also forage in rice fields in the Ebro Delta (Fasola and Ruiz, 1996) [41].

The Delta is used extensively by approximately 20,000 birds comprising 40 species of shorebirds during the winter (Czech and Parsons, 2002). Herons (especially the Little Egret (*E. garzetta*) and Black-crowned Night Heron (*N.nycticorax*), shorebirds and gulls forage in rice fields in the Axios Delta of Greece (Fasola and Ruiz 1996; Fasola *et al.* 1996; Kazantzidis and Goutner 1996) [41, 41]. The other foraging habitats that used to breed by six heron species are the deltas of the Axios, the Ebro in Spain, Po River (Fasola *et al.*, 1996) [41] and the Albufera de Valencia (Prosper and Hafner, 1996). The Squacco Heron (*A. ralloides*), Cattle Egret (*B. ibis*), Little Egret (*E. garzetta*), and Purple Heron (*A. purpurea*) use rice fields extensively during the breeding season. The Redshank (*Tringa totanus*), Common Black-headed Gull (*Chroicocephalus ridibundus*) and Yellow-legged Gull (*Larus cachinnans*) often forage in rice fields, the latter only during the start of flooding. The Gull-billed Tern (*Gelochelidon nilotica*), Common Tern (*Sterna hirundo*), Little Tern (*Sterna albifrons*), Black Tern (*C. Niger*), and White-winged Tern (*C. leucopterus*) forage less commonly in rice fields (Fasola and Ruiz, 1996) [41]. Czech and Parsons (2002) mentioned the Ebro Delta and the Valencia region of Spain as major wintering sites for egrets.

South America

Twelve countries in South America, three in Central America (Mesoamerica), two in North America and four in the Caribbean produce rice (Acosta *et al*., 2010) [25]. Rice fields in the United States of America have identified as one of the important type of ecosystems for birds which evidenced through the well-documented studies (Elphick and Oring, 1998, 2003; Elphic, 2000, 2004; Czech and Parsons, 2002) [37]. Throughout America, rice fields are used by diverse bird communities. In the study carried out by Acosta *et al.* in 2010, 335 avian species had identified. Among them, 169 were aquatic species while the remaining 166 were terrestrial birds. Argentina, USA, Cuba, Uruguay, Trinidad and Tobago and Colombia stand for the largest numbers of terrestrial avian species recorded. The waterbird species were detected in the USA followed by Cuba, Brazil, Argentina, Colombia, Trinidad and Tobago and Costa Rica. Uruguay and Venezuela reported for the least number of water birds. Various researchers have mentioned (Hurtado, 2003; Dias and Burger, 2005; Acosta and Mugica, 2006; Blanco *et al.*, 2006; Taft and Elphick, 2007) [94, 43, 26, 84, 12] the richness of waterbird species by country ranged from 35 to 90 species, and rice fields were used mainly for foraging and resting. Acosta *et al.* (2010) [56] have stated the waterbirds (96%) that used rice fields in America belong to four orders. Charadriiformes (Common in all countries except Venezuela), Pelecaniformes and Gruiformes (Argentina and Uruguay) were prominent among them (Asosta *et al.*, 2010).

The greatest number of avian species had recorded from the family Anatidae followed by Scolopacidae, Rallidae, Ardeidae, Laridae and Threskiornithidae. Western Cattle Egret (*B. ibis*), Western Great Egret (*Ardea Alba*), Snowy Egret (*Egretta thula*), Black-crowned Night-Heron (*N. nycticorax*), Lesser Yellowlegs (T*ringa flavipes*) and Greater Yellowlegs (*Tringa melanoleuca*) were present in rice fields in ten studied countries. This implies the abundance of waterbirds belongs to family Anatidae are a common characteristic in most rice field lands throughout the world. Among the Duck species, Whistling Ducks (*Dendrocygna* spp) had relative abundance while the genus Anas (Anatidae) were common in several American countries, with Blue-winged Teal (*Anas discors*) had reported frequently. Shorebirds also use rice fields particularly species from the genus Calidris. Acosta *et al.* citing Lopez-Lanus *et al.* (2007) [85] stated that Bobolink species (*Dolochonyx oryzivorus*) has a strong association with the rice crops when the rice comes into the milky stage, particularly in, Paraguay, Bolivia, Brazil and Argentina.

North America

Though the climate varies North America also has some extent of rice cultivations in Louisiana and along the Gulf of Mexico. The Least Bittern (*Ixobrychus exilis*), Purple Gallinule (*Porphyrula martinica*), Common Moorhen (*G. chloropus*) and King Rail (*Rallus elegans*) (Meanley and Meanley, 1959) all three species nest in rice fields in Louisiana while Purple Gallinule (*P. martinica*) and Common Moorhen also nest along the Gulf of Mexico (Helm *et al.*, 1987). Apart from them, Fulvous Whistling Ducks are have also reported from Louisiana where they built nests on rice field levees or between levees over water (Meanley and Meanley, 1959; Pierluissi, 2010) [82]. Thus it is clear a wide variety of water birds can be found utilizing Louisiana rice fields (Musumeche, 2000; Huner *et al.*, 2002). In the Central Valley of California, rice fields are highly used by wintering water birds such as the Great Egret (*A. alba*), Killdeer (*Charadrius vociferous*), Black-necked stilt (*Himantopus mexicanus*), Greater Yellowlegs (*T. melanoeuca*), Long-billed Curlew (*Numenius americanus*), Dunlin (*C. alpine*), Long-billed Dowitcher (*Limnodromus scolapaceus*) and Least Sandpiper (*Calidris minutilla*) (Elphick, 2000). Durham and Afton (2003, 2006) have mentioned Mottled Ducks (*Anas fulvigula*) use of rice fields in California while Mallards (*Anas platyrhynchos*) particularly for breeding, where rice is mainly important to Mallards (*A. platyrhynchos*) as brood-rearing ground (McLandress *et al.*, 1996).

In the study carried out by Day and Colwell (1998) [28] over 500,000 individuals comprising 57 species of water birds, geese, ducks, herons, ibises, shorebirds, grebes, rails, Sandhill Crane, American White Pelican (*Pelecanus erythrorhynchos*) and Double-crested Cormorant (*Phalacrocorax auratus*)were observed foraging in harvested rice fields in the Central Valley of California. Among the other avian species the Snow Goose (Chen caerulescens), Greater White-fronted Goose (*A. albifrons*) and Canada goose (*Branta canadensis*) forage on rice in Texas during winter (Flickinger, 1979). Further

expressing Schmutz and Ely in 1999 stated Greater White-fronted Geese (*A. albifrons*) primarily feed on rice in California. Arkansas rice fields are utilized commonly by Soras (Meanley, 1960). Certain areas in South America (e.g. Surinam, Colombia) considers Purple Gallinules (*P. martinica*) as pests as they crush and bend rice plants to make nests while they commonly found in rice fields in South America, however, these species were reportedly more abundant in South Carolina and Georgia during the turn of the 20th century (Meanley, 1963). The Pinnated Bittern (*Botaurus pinnatus*) and Snowy Egret (*E. thula*) used to feed on rice fields in South America (Kushlan and Hafner, 2000). Cuba which is located in Mesoamerica also cultivates a small extent of rice compared to Asia. Among the countries located in the Caribbean region, most studies of birds in rice fields are conducted in Cuba. Rice fields were highlighted as foraging sites (Acosta and Berovides, 1982; Acosta and Mugica, 1990; Acosta *et al.*, 1990, 1994, 1996; Denis *et al.*, 2000; Mugica *et al.*, 2005) [62, 92, 41, 31] as well as breeding habitats (Acosta *et al.*, 1989a; Mugica *et al.*, 1989) [56, 62].

Acosta *et al.* (1989b, 2002a, 2003) [25, 15, 84] have studied the morphometric of birds found in rice fields and the spatiotemporal variation in the bird communities with rice fields (Acosta and Mugica, 1999; Acosta *et al.*, 2002b; Mugica *et al.*, 2001, 2003) [52, 54, 71] and the significance of rice fields for migrant and resident Cuban birds (Blanco *et al.*, 1996; Acosta and Mugica, 2006; Mugica *et al.*, 2006) [64, 56, 82]. The Glossy Ibis (*P. falcinelus*) and White Ibis (*T. molucca*) used to forage In Cuban rice fields (Czech and Parsons, 2002). Vermeer *et al.* in 1974 mentioned a wide variety of herons, ducks and shorebirds utilize rice fields in Surinam. The other Caribbean countries like Costa Rica and Trinidad and Tobago also noted for bird use of rice fields but only in the grey literature (Hurtado, 2003; cited in Acosta *et al.* in 2010) [72]. Waterbird use of rice fields during the first phase; sowing preparation and last phase; post-harvest flooding was significant. Acosta *et al.* (2010) [71] stated dynamics of birds use corresponded with similarities in the rice farming process in Cuba, Surinam and Costa Rica. Rice fields in Costa Rica also supplies a favourable habitat for Jabiru populations (*Jabiru mycteria*) which were adversely affected due to loss of natural wetlands (Hurtado, 2003). Compared to other countries use of rice fields during the sowing phase was higher in Brazil, Argentina and Uruguay (Blanco *et al.*, 2006). The importance of rice fields for avian species of having particular conservation status has evaluated by Acosta (1998) [71] and Mugica (2000). According to Acosta (1998) [71] and Mugica (2000), West Indian Whistling Duck (*Dendrocygna arborea*) found in Cuba is a species considered Vulnerable in the Red Data Book (Bird Life International, 2009), feed on rice at night, thus rice cultivation is critical for the maintenance of their populations. And also, migratory Buff-breasted Sandpiper (*Trinities subruficollis*), a species considered globally Near Threatened (Birdlife International, 2009) utilize the rice fields in farther Brazil and Uruguay.

Among the other avifaunal species documented (Longoni, 2010; Sundar and Subramanya, 2010; Taylor and Schultz, 2010) [62, 99] for their utilization of rice fields are Lesser Whistling Duck (*Dendrocygna javanica*), Common Shelduck (*Tadorna tadorna*), Pacific Balck Duck (*Anas seperciliosa*) and Indian Spot-billed Duck (*Anas poecilorhyncha*).

Conclusion

The value of rice fields as breeding habitat particularly for waterbirds has stressed varying widely based on the species, landscape composition, region and the agricultural practices. Of all the avifaunal species that nest in rice fields, species from the family Rallidae appear to be particularly common and successful in Cuba, USA, India and Brazil. According to Bird Life International (2004) and Tucker and Evans (1997), almost 30 per cent of European waterbird species have unfavourable conservation status. It is a clear size and the distribution of heronries are positively correlated with the surface area under rice cultivation which also stated by Fasola and Alieri in 1992 [39]. Egrets are the generalist thought to benefit greatly from rice fields while herons also highly utilize rice fields. The initial cultivation phase is the high abundance of wading birds reported in most reviewed studies. Rice fields have become a home for various avifaunal species and are a very precious substitute for disappearing natural wetlands for certain species. However, rice fields are not a substitute in marinating waterbird diversity. The Middle East is identified as one of the areas that need further experiments and research to explore the almost entirely unknown status of waterbirds and their occurrence in rice fields.

Most of the reviewed literature indicated the greatest use of rice fields by waterbirds often occurs in regions where rice fields are located along, or at the terminus of, major migration corridors (Remsen *et al.*, 1991; Fasola and Ruiz, 1997; Farmer and Parents, 1997; Elphic and Oring, 1998; Hunter *et al.*, 2002; Blanco *et al.*, 2006; Munira *et al.*, 2014) [42, 37, 79]. Giving examples various researchers (Eadie *et al.*, 2008; Acosta *et al.*, 2010; Fujoka *et al.*, 2010; Longoni, 2010; Sundar and Subramanya, 2010) [62, 99] emphasized the importance of rice fields for migratory birds.

"Rice fields in the southern USA, south-central South America, southern Europe, parts of Asia and elsewhere receive heavy use by migrating waterbirds"

Further Blanco *et al.* stated (2006) nearly 59 species of water birds and 61 non-water birds are profited from the rice fields in South America near the terminus of the Atlantic flyway and the Brazilian central migratory flyway (Antas, 1983). During the migration period number of species are supported from the rice fields of northwestern Italy. Therefore, this appraisal concludes the excessive importance of rice fields for avifaunal species in different climates of the world and why the future research works on avifauna in rice fields, in particular, water birds are highlighted by the appraisal. The extension of this appraisal is to assess the spatiotemporal variations of avifaunal utilization of rice field in suburban areas in the wet climate zone of Sri Lanka and evaluate the diversity, species richness and bird assemblages of avifauna in rice fields in the wet zone.

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