ECOLOGY OF HOUSE CROW *(Corvus splendens)* AND JUNGLE CROW *(Corvus macrorhynchos)* IN AGRICULTURAL LANDSCAPE

A

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IN

AGRICULTURAL ENTOMOLOGY

BY

JADAV PRAVINKUMAR CHHOTABHAI

B. Sc. (Agri.)

DEPARTMENT OF AGRICULTURAL ENTOMOLOGY
B. A. COLLEGE OF AGRICULTURE
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ANAND - 388 110

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This is to certify that the thesis entitled **"ECOLOGY OF HOUSE CROW (*Corvus splendens*) AND JUNGLE CROW (*Corvus macrorhynchos*) IN AGRICULTURAL LANDSCAPE"** submitted by **Mr. JADAV PRAVINKUMAR CHHOTABHAI** in partial fulfillment of the requirement for the award of the degree of **Master of Science (Agriculture)** in **Agricultural Entomology** of the Anand Agricultural University, Anand is a record of bonafide research work carried out by him under my personal guidance and supervision and the thesis has not previously formed the basis for the award of any degree, diploma or other similar title.

Place : Anand **(B. M. Parasharya)**

Date : / /2012 **Major Advisor**

DECLARATION

This is to certify that the research work reported in the thesis in partial fulfillment of the requirements for the award of the degree of **Master of Science (Agriculture)** in the subject of **Agricultural Entomology** is the result of investigation done by undersigned under the direct guidance and supervision of **Dr. B. M. Parasharya**, Research Scientist (Ornithology), AINP on Agricultural Ornithology, Anand Agricultural University, Anand and no part of research work has been submitted for any other degree so far.

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Place : ANAND **(Pravinkumar C. Jadav)**
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ABSTRACT

Study on "Ecology of House Crow (*Corvus splendens*) and Jungle Crow (*Corvus macrorhynchos*) in Agricultural Landscape" was carried out from January 2011 to July 2012 at Anand Agricultural University campus, Anand city and adjoining villages in central Gujarat, India.

Food of crows was classified into two major categories *viz*., animal & plant matter. Jungle Crow mainly consumed animal matter (56.43 % F & 60.47 % R. A.) whereas House Crow was chiefly feeding on plant matter (65.04 % F and 55.48 % R. A.). Both the species in residential area largely relied upon kitchen waste and flesh of road-killed vertebrates. Jungle Crow depredation on fruits (10.50 %) and predation on invertebrates (6.55 %) and vertebrates (2.73 %) was higher compared to House Crow in the study area. It indicates that Jungle Crow act as predator of insect pest of important food crops as well as act as pest on fruit crops to some extent.

Study area was divided into two major habitats *viz*., agricultural habitat and human habitation, and these major habitats were further classified into habitat components. Frequency and relative abundance of House Crow was higher in area of human habitation (72.39 % F & 62.63 % R. A.) compared to agricultural habitat

(27.61 F % & 37.37 % R. A.) while Jungle Crow distribution in agricultural habitat (71.25 % F & 78.27 % R. A.) was higher compared to area of human habitation (28.75 % F & 21.73 % R. A.). House Crow distribution was recorded in the area close to human residency whereas Jungle Crow distribution was observed highest in agricultural habitat, away from human residency.

Avian community attending different farm operations *viz*., land preparation, green manuring, sowing, irrigation, interculturing and harvesting were recorded during the study. Amongst all farm operations, interculturing (20 % F) and green manuring (12.5 % F) operations showed higher relative frequency of Jungle Crow compared to other farm operations even though Jungle crow did not play any significant role in reducing insect-pest population from fields. Very few House Crow were observed during various farm operations during the study because the farm operations were done only in agricultural habitat and House Crow distribution was very low in this habitat.

The Jungle Crow showed tendency to nest in agricultural habitat (61.11 % nests) whereas House Crow showed tendency to nest exclusively in residential habitat (98.67 %). Jungle Crow largely used trees (97.22 %) as substrate for nesting and occasionally utilized artificial structure (2.78 %) while House Crow utilized artificial structures (13.33 %) in higher frequency compared to Jungle Crow (2.78 %). Jungle Crow occupied 17 different tree species from 30 tree species available in the study area. Availability (20.90 %) and utilization (28.57 %) of mango by the Jungle Crow was the highest in the study. The House Crow occupied 16 different tree species for nesting from 25 tree species available in the study area. Tree height (14.27 ± 3.79 m) and canopy cover (14.63 ± 6.71 m) of Jungle Crow nesting trees were significantly higher compared to tree height (11.45 ± 4.71 m) and canopy cover (11.43 ± 5.20 m) of trees occupied by House Crow. Average Jungle Crow nest height (12.57 ± 3.92 m) from the ground level was higher compared to House Crow nest height (8.85 ± 3.82 m). Tree characters of *viz*., tree height, circumference at breast height, canopy diameter and crown height of trees occupied by both species of crows were significantly higher compared to surrounding trees.

For determining the predation risks around the nests, detactibility rank was given to each nest based on its visibility from the ground level, ranging between 0 – 1. When a nest could not be detected, it's ranked zero and when detected with little efforts, it was ranked one. As the rank given to the nests increased, the predation risk increased. Detectibility of 66.67 % nests had zero rank indicating that they were almost safe against ground predators. On the other hand in House Crow, only 6.67 % nests had zero rank detectibility while remaining 93.33 % nests had predation risk from the ground. Jungle Crow possess larger territorial area than House Crow, to avoid competition with conspecifics.

During breeding season of 2012 clutch initiation of Jungle Crow started from third week of March and continued till last week of May, whereas, House Crow initiated clutches from last week of May showing slightly overlapping breeding season. It indicated that Jungle Crow and House Crow had distinct breeding season i. e., during summer and monsoon respectively. Jungle Crow laid maximum clutches in first week of April while House Crow laid maximum clutches in the first week of June. Clutch size of Jungle Crow ranged from 2 - 5 and most common clutch size was three and four (36.84 %) whereas clutch size of House Crow ranged from 3 - 6 and most common clutch size was three, four and five (31.58 % of each). Average length, width and weight of eggs of Jungle Crow was 40.12 ± 2.25 mm, 28.25 ± 1.78 mm and 17.01 ± 1.45 g, respectively and for House Crow it was 37.96 ± 1.27 mm, 26.87 ±

1.04 mm and 14.90 ± 1.51 g, respectively. The mean incubation period of Jungle Crow (18.42 days) eggs was higher compared to House Crow (17.53 days). Nestling period (34.54 days) and nesting period (49.33 days) of Jungle Crow was higher compared to House Crow (28.23 days and 44.23 days, respectively). Though hatching success of House Crow (44 %) was lower compared to Jungle Crow (56.45 %), its fledgling success (63.64 %) was higher compared to Jungle crow (48.57 %). Overall breeding success of House Crow (28 %) and Jungle Crow (27.42 %) was nearly similar during year 2012. Loss of eggs due to unknown reason was also similar in both crow species. Loss of chicks, probably due to predation was higher in Jungle Crow (51.43 %) compared to House Crow (36.36 %). Twelve per cent eggs of House Crow failed to hatch whereas no hatching failure was recorded in Jungle Crow eggs during 2012. Brood parasitism of Asian Koel was higher in the nests of Jungle Crow (73.68 %) compared to House Crow (33.33 %). Though lower parasitism was recorded in the nests of House Crow, survival of Asian Koel chicks was greater in the nests of House Crow (52.63 %) compared to Jungle Crow (35.71 %). Host survival per cent in Koel parasitised nests was similar in both crow species (House Crow 20.83 % and Jungle Crow 20.93 %) with very low rate compared to un-parasitised nests.

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Place:Anand **(Jadav Pravin C.)**
Date :   /   / 2012

I. INTRODUCTION

Crows, Jays and Treepies belong to class Aves, order Passeriformes, family Corvidae. Amongst corvidae family, Crows and Ravens are most numerous and distributed world-wide as commensal of mankind. Crows are known for their intelligence and have found place in the stories of Panchtantra. Crows were found very familiar, social, clever, and active omnivore bird living in close association with human beings (Ali and Ripley, 1983). Amongst birds, crows have very important place in folklores. In Indian subcontinent, two species of crows namely House Crow (*Corvus splendens*) and Jungle Crow (*Corvus macrorhynchos*) are most numerous and widely distributed species.

Four subspecies of House Crow namely *Corvus splendens splendens*, *Corvus splendens protegatus*, *Corvus splendens maledivicus* and *Corvus splendens zugmayeri* are recorded from Indian sub-continent. House Crow has a black crown, face and throat contrasting with dusky grey nape, neck and breast. The nominate subspecies are distinguished by slight variation in paleness or darkness of the grey collar, *C. splendens splendens* is found throughout India, except Kerala and northwest. It is also present in Bangladesh, Nepal, Sikkim, Bhutan and Assam (Ali and Ripley, 1983) (Plate 1).

House Crow has a native range which stretches throughout the Indian sub-continent, including southern Iran, Myanmar, Nepal and Sri Lanka. Over last century, it has spread, intentionally or unintentionally, throughout much of the Indian Ocean rim including Arabian Peninsula, eastern and southern Africa, some Indian Islands as well as east and south East Asia (Feare and Mungroo, 1989; Jennings, 1992; Ryall, 1994; Yap, 2003).

Amongst Corvids, House Crow is very well adapted to urban areas where ample food resources and suitable nesting and roosting sites are available (Ali and Ripley, 1983).

House Crow generally feeds on grain, groundnut, fruits, flower nectar, eggs and young birds, lizards, small rodents, fish, insects, land crabs, kitchen scraps, garbage, offal and carrion (Ali and Ripley, 1983; Long, 1981; Alexander, 1985; Ryall, 1986). The House Crow is kleptoparasitic on various avian species (Baglione and Canestrari, 2009).

House Crow is a serious pest on agricultural crops and causes significant economic losses (Dilshan *et al.,* 1982; Gourami, 1985). Crows invade freshly sown maize, barley, and fields (Verghese and Chakravorthy, 1978; Toor and Sandhu, 1979; Ash, 1984; Dhindsa *et al.,* 1982).

Four subspecies of Jungle Crow namely *Corvus macrorhynchos culminatus, Corvus macrorhynchos leaillantii, Corvus macrorhynchos tibetosinensis* and *Corvus macrorhynchos intermedins are* recognized worldwide (Ali and Ripley, 1983).

Of these, subspecies *macrorhynchos culminatus* is found in Gangetic Plains, peninsular India south to Kanykumari, and from the sea coast up to 2000 m in Ceylon. It is virtually absent in desert and semi-desert areas west of Delhi. Jungle Crow has uniformly glossy jet-black color with a heavy black bill and deep guttural voice. Sexes are alike. It is less gregarious and sociable than House Crow, usually keeping singly or in pairs and small scattered parties. Occasionally large gatherings are seen where food is abundant (Ali and Ripley, 1983) (Plate 1).

Jungle Crow feeds on animals as well as vegetation. Items recorded include carrion, garbage, bird's eggs, young and sickly birds, rats, mice, squirrels; lizards and frogs; land and sand crabs; centipedes; insects, wild and orchard fruits; cereal grains, groundnuts dug up from fields; flower-nectar and petals (Ali and Ripley, 1983).

Jungle Crow is known to cause severe damage to guava fruits (Chakravarthy, 1998), seedlings of the paddy (Chandrappa and Krishnappa, 1993) and cashew in agricultural land (Shyama, 1998).

Both the species of crows are important component of avian community foraging in the agricultural landscape during various farm operations like ploughing, sowing, transplanting, irrigation, harvesting and at various crop growth stages. Hence, the crows are always prone to the agricultural practices including negative impact of pesticides within the agricultural landscape.

Nuisance is currently the main impact caused by House Crow to humans. Besides noise and dropping litter, there are also possibilities that these birds may transmit pathogens. Reports from Hong Kong suggested that dead House Crows were confirmed to be H5N1 virus positive after tests (AFCD, 2008). House Crows have been shown to carry organisms detrimental to human health, including *Salmonella* and *Escherichia coli* (Jennings, 1992) and that of livestock, including Newcastle Disease (Roy *et al*., 1998). The species is also a potential reservoir for West Nile Virus and avian influenza (Nyari *et al*., 2006).

Ecology of both House Crow and Jungle Crow have been sparsely studied except preliminary studies on their breeding ecology by Lamba (1963) and feeding impact on agriculture by Yahya and Ahmed (1999). In fact, the quantitative ecological studies on crows in agricultural landscape of India are seriously missing.

Besides being omnivorous, these species are also scavengers and important depredators of some crops; and a common bird in the agricultural landscape, a detailed study of its ecology is warranted. The study will provide insight in to their management in the agricultural landscape and ultimately help in conservation of these avian species.

Therefore, present study is planned out with following objectives.

Objectives:

1) Study the food and foraging behaviour of crows
2) Study distribution of crows within agricultural landscape
3) Study significance of crows in avian assemblages during farm operations
4) Study nesting ecology

II. REVIEW OF LITERATURE

2.1 FOOD AND FORAGING BEHAVIOR OF CROWS

2.1.1 House Crow

House Crow generally feeds on grains, groundnuts, fruits, flower nectars, eggs and young birds, lizards, small rodents, fish, insects, land crabs, kitchen scraps, garbage, offal and carrion (Ali and Ripley, 1983).

According to Dharmakumarsinhji (1955), House Crow feeds on all kind of refuse and omnivorous in its diet, great stealer of food, feed upon many injurious insects, even have courage to attempt to drink milk from the jars off the heads of milkmaids and snatching bread from the hands of children.

Crows are scavenging birds found in cities feeding on human food remains and drinking freshwater from swimming pools and artificial ponds. In fact, House Crows are closely tied to human habitation and human refuse seems to form an important part of their diet (Goodwin, 1976; Feare and Mungroo, 1989).

In Pakistan, House Crow is very well adapted in the areas where ample food resources and suitable nesting and roosting sites are available. It feeds on man's rubbish, scraps, offal, garbage and sewage. It consumes anything edible; insects, termites, grains, nectar, fruits, carrion, groundnut, kitchen scrap, road kills and small animals including lizards, fish, land crabs, fiddler crabs and locusts. As herbivore, crow eats seeds, grains, fruits and berries as well as sucks nectar from the trees such as *Erythrina sp., Salmalia sp., Butea sp., Sesbania sp., Spathodea sp.* (Roberts, 1992).

House Crow out-competes many species for food and nesting sites and directly feed on chicks and eggs of other bird species (Bijlsma and Meininger, 1984).

Mason and Lefroy (1912) studied gut content of 42 birds and identified 226 insects of which one was beneficial, 153 injurious and 72 neutral. Gut content analysis of ten birds revealed only injurious insects and of eight birds showed presence of neutral insects while one bird showed presence of only beneficial insects. One contained insects only. All except one bird contained vegetable matter; while oat, wheat, maize, linseed, peas, *Bombax spp*. flower and *Ficus spp*. fruit were evident in 13, 6, 11, 1, 1, 2 and 6 birds respectively. Gut content of 4 birds' revealed frogs in diet while centipedes, lizard and worm were evident in 3, 1 and 1 bird, respectively.

Hussain and Bhalla (1937) classified food items of House Crow as 44.13 per cent crop seeds, 2.68 per cent weed seeds, 7.33 per cent vegetable matter, 6.46 per cent cultivated fruits, 5.39 per cent wild fruits, 8.34 per cent animal flesh, 16.15 per cent insects and 9.47 per cent miscellaneous items in the diet. Murthy *et al*., (1988) observed two House Crows eating dead dog-faced water snakes at Lake Rambha. Balasubramanian (1990) found Indian House Crow preying upon Pied Ground Thrush, *Zoothera wardane* at Point Calimere, Tamil Nadu.

Occurrence and relative abundance of House Crow consuming fruits of mulberry was recorded as 4 per cent and 0.39 per cent, respectively at AAU, Anand (Anno., 2000).

House Crow was recorded damaging freshly sown maize, mature maize cobs, harvested wheat, sunflower, and barley at alarming rate (Khan, 2002).

House Crows were estimated to damage 65.1 per cent of sprouting sunflower seedlings at Ludhiana, Punjab (Dhindsa *et. al*., 1991).

Kishore and Gupta (1993) found that House Crows causes much damage to standing crops and fruits such as mango, guava, fig and mulberry in the field.

House Crow remains active throughout the day, emerging from their roosts at about sunrise to perform various diurnal activities *viz*., foraging, searching suitable roosting sites and appropriate nesting sites for breeding (Gupta *et al*., 1998).

2.1.2 Jungle Crow

Amongst insects, Jungle Crow feeds especially on soil dwelling larvae that are a permanent source of nutriment to the crow (Mason and Lefroy, 1912). Jungle Crow is known to feed on some important insect pests like grubs of *Holotrichia consanguinea* (Parasharya *et al*., 1994) and *H. armigera* larvae in tomato crop (Mehta *et al*., 2010).

Food of Jungle Crow consists of refuse of all kind, small animals and carrion; it chiefly preys upon young birds and eggs of useful species and it is very destructive bird. Jungle Crows were also recorded feeding on coleopteran beeteles, locusts and other insect life and their larvae (Dharmakumarsinhji, 1955).

Jungle Crow and House Crow were most voracious feeder of *S. litura* larvae, consuming on an average 3.00 and 3.01 larvae per minute respectively. Among the different bird species preying on *S. litura*, Jungle Crow appeared in greater number (27) than House Crow (5), Common Myna (7) and Bank Myna (6) (Patel, 1988).

Jungle Crows eat food, frequently tearing it into small pieces and they feed their young in their nests directly from the gular pouch, making it hard to identify the food items by video recording. They gather at communal roosts every evening and regurgitate indigestible portions of food as pellets regularly (Yamagishi, 1982). Jungle Crow feeds on animal as well as vegetative matter. Items recorded include carrion, garbage, bird's eggs, young and sick birds, rats, mice, squirrels, lizards and frogs, land

and sand crabs, centipedes, insects, wild and orchard fruits; cereal grains, groundnuts dug up from fields, flower-nectar and petals (Ali and Ripley, 1983).

Harishkumar (1989) observed Jungle Crow preying upon a House Sparrow and winged termites at Bangalore. Borad and Mukherjee (1999) recorded Jungle Crow feeding on young ones of Rose-ringed Parakeet at Anand. Mason and Lefroy (1912) recorded 65 insect species from 33 birds including Jungle Crow of which none were beneficial while 40 were injurious and 25 were neutral.

Jungle Crow damages standing bajra crop and occasionally wrenches off the entire earhead and carries it to a nearby tree to deal with (Ali, 1954). Both species of crows have been known as depredators of freshly sown groundnut seeds. It becomes serious pests of groundnut pods at the time of harvest at Coimbatore (Bhanumathi and Thirumurthi, 1991). Both the species of crows were observed feeding on seeds of wild plants like *Acacia melanoxylon* and *Albizia lebbeck* in Tamil Nadu (Natarajan *et al*., 1992).

Small quantity of grit in the gut of all the species of crows is well known (Mason and Lefroy, 1912). Chhangani (2002) observed sand eating by House Crow *(Corvus splendens),* Large-billed Crow *(Corvus macrorhynchos)* and Common Raven *(Corvus corax)* at Municipal Corporation Dumping Ground (MCDG) at Jodhpur.

2.2 DISTRIBUTION OF CROWS WITHIN AGRICULTURAL LANDSCAPE

Geographically, Indian House Crows (*C. splendens Vieillot*) as its name indicates is indigenous to the Indian subcontinent; found in cities, towns and villages, even far inland. House Crow presents great ecological flexibility, as well as an obligate association with human presence, to the extent that no populations are known to live independent of man (Nyari *et al*., 2006). Associated with human settlements, disturbed areas, especially coastal settlements (Rasmussen and Anderton, 2005). Invaded areas are mainly urban or semi urban, where house crows benefit from human food refuse disposed. Commercial areas, public housing areas and urban parks are associated with higher abundance (Lim *et al*., 2003). Human association clearly broadens the ecological potential of the species into areas that might not otherwise be habitable (Nyari *et al*., 2006). Crows tend to visit and revisit interchangeably those sites which are characterized by rubbish dumps, dry weather watering points, coastal fish market places; animal farms especially poultry and duck farms, cow keeping sites as well as agricultural plots and which become informal territorial sites for crows colonies (Ali and Tamrini, 2009).

House Crow and Jungle Crow both roost communally throughout the year, often close to human habitation (Gadgil and Ali, 1975). Crows congregate in huge communal roosts at dusk producing loud calls and leave the same roost at about dawn in varying directions for foraging, feeding and other social activities (Dvir, 1985; Redpath, 1997). The birds roost communally and can involve thousands of individuals (Cramp, 1994). Such large roosts in urban areas create high levels of noise pollution and faecal contamination (Jennings 1992, Brook *et al*., 2003). Basic information on communal roost of House Crow in Gujarat was given by Tere (2005).

Scarce information is available on use of agricultural landscape and its components in India by crows. However, such information is available on other members of the family. Spring corn, meadows and pastureland were of the greatest significance in the Rook's (*Corvus frugilegus*) foraging area (Kasprzykowski, 2003).

Mean population of House Crow in cashew (37.6), banana (16.4), vegetable (58.6) and orchard (27.4) cropping systems was recorded at KAU, Thrissur (Anno., 2009).

Occurrence of House Crow in agricultural habitat (36 %) was recorded higher followed by villages (23 %), urban area (20 %), wetland (14 %) and in forest (7 %) (Anno., 2009).

2.3 SIGNIFICANCE OF CROWS IN AVIAN ASSEMBLAGES DURING FARM OPERATIONS

Crows are observed following a plough or tractor and are efficient predators of root grubs, crickets and other insects which inhabit the soil (Prasad, 1987).

Relative occurrence and abundance of House Crow (50 and 8.99 % respectively) attending tractor ploughing was higher compared to Jungle Crow (31.25 and 4.83 % respectively) (Anno., 1998).

Relative occurrence and abundance of House Crow was 25 per cent and 2.07 per cent respectively in the community structure of birds attending irrigation operation at AAU (Anno., 1998).

House Crows formed 3 - 46 per cent of the avian community feeding on white grub during ploughing operation in Kapadvanj tahsil of Kheda ditrict, Gujarat while Jungle Crow formed only 19 per cent of the avian community in the same experiment (Parasharya *et al*., 1994).

Kler (2008) found that House Crow was the most dominant bird species recorded during sowing stage of maize agro-ecosystem amongst whole bird community associated with it at selected villages in Ludhiana, Punjab.

Relative abundance of House Crow during sowing of paddy and wheat was 18.50 per cent and 18.71 per cent respectively, and during harvesting of paddy and wheat it was similar (15 % each) at Punjab Agricultural University, Ludhiana (Anno., 2009).

2.4 NESTING ECOLOGY

2.4.1 House Crow

2.4.1.1 Breeding Season

Breeding season of House Crow initiates in March-April and extends up to July-August with mainly from April to June but peak periods varying locally in the Northern India (Ali and Ripley, 1983).

Ali (1954) did not mention about breeding season of the species in Gujarat, however he recorded its breeding in Kutch during May-June to October end. Dharamakumarsinhji (1955) recorded breeding season to be May to August (with peak activity during monsoon) in Saurashtra peninsula of Gujarat state.

Female House Crow ovaries mature for egg laying in the month of June or sometimes in 1st or 2nd week of July. In majority of the cases after the first showers of rain at Vadodara, Gujarat (Ambadkar and Chauhan, 1977). Courtship and nest building starts from late May to early June and most clutches are completed by the end of July in Pakistan (Roberts, 1992). Ali (2008) recorded the breeding season of House Crow from late May to early September with peak period during end of the July at Islamabad, Pakistan.

2.4.1.2 Nest Site Character

House Crow is a tree nester although found in association with human habitations (Goodwin, 1976; Lamba, 1963, 1976).

The location of nesting sites of Indian House Crows is related with food availability within an area. Nesting sites are located close to food sources especially areas with poor sanitation (Chongomwa, 2011).

Nests are located at least 3 m or more from the ground in Pakistan (Brooks and Ahmed, 1990).

According to Lamba (1976), House Crow builds a nest platform on a thin vertical fork near the top of the tree, or on one of the outer most branches of any of the larger trees like *Dalbergia sissoo*, *Acacia arabica*, *Tamarindus indicus*, *Meilia azadirachta*, or *Ficus spp*. as favorite sites. But it does not hesitate to avail itself of other sites provided by smaller trees, edges and nooks of buildings in the localities where large trees are wanting or have already been occupied by others of its own species (Hume, 1873; Baker, 1934), telephone and telegraph poles and wires (Dharmakumarsinhji, 1955).

Lamba (1963) described that nests built in farming areas were mainly composed of twigs. In Mauritius, nests were mainly located in *Ficus bengalensis*, however, a few nests were found on other trees like *Terminalia mantali*, *Tebeuia pentaphylla*, *Callistemum sp*. and *Mangifera indica* (Feare and Mungroo, 1989).

The nest is a bulky platform of sticks and twigs frequently intermixed with metal wires, with a cup-like depression lined with soft materials such as grasses, vegetable fibres, feathers, tow, coir wool, animal hairs, rags, materials include pieces of disposed wires, and bits of discarded that wires netting to hold twig firmly together (Anvery, 2002).

2.4.1.3 Clutch Size, Egg Size, Weight and Incubation Period

Four to five eggs are normally laid but often three and rarely six eggs are also found. Larger clutches were laid more frequently in the first half of the breeding season. Average eggs measured 38.5 × 26.1 mm (length × width) (Lamba, 1963).

Eggs laid in 4-5 in number which are pale blue-green, speckled and streaked with brown. Average size of eggs is 37.2 × 27 mm (length × width) (Baker, 1934).

Ambadkar and Chauhan (1977) observed that 4-5 eggs were laid by House Crow normally. Incubation period was 15-17(average 16, n=6) days.

In Pakistan, usual clutch is 4 eggs but 3-6 eggs are often recorded varying in shades of bluish green in ground color, blotched, speckled with red and sepia browns and grey under marking (Roberts, 1992).

Rad (2010) recorded clutch size of 3 – 5 eggs (mean 3.8 eggs) and 75 per cent nests contained 4 eggs at Kharag Island, Persian Gulf.

According to Whistler (1986) normal clutch size of House Crow is 4-5 eggs. Incubation period is of 15-17 days (Lamba, 1963; Brooks and Ahmed, 1990). House Crow suffers brood parasitism at places where Asian Koel *(Eudynamys scolopacea)* is common (Whistler, 1986). Asian Koel lays eggs before incubation of the crow's eggs in well-advanced (Dharmakumarsinhji and Lavkumar, 1972). Frequency of brood parasitism was maximum in cropland nests (24 %) followed by suburban (20 %) and urban nests (6 %) of House Crow in Pothwar region of Pakistan (Ali *et. al*., 2007)

2.4.2 Jungle Crow

2.4.2.1 Breeding Season

Breeding season of Jungle Crow is February to June, varying locally; chiefly March-April in northern India (Ali and Ripley, 1983). Breeding season of Jungle Crow spans from February to June in North-West region (Lamba, 1965).

Hume (1873) considered March to May as the normal breeding season in India. Breeding season of the Jungle Crow commences in February and ends in May or June with peaks during April at Saurashtra, Gujarat (Dharmakumarsinhji, 1955).

2.4.2.2 Nest Site Character

The choice of nest sites by many species of birds is known to be affected by topographic or climatic variables (Weltey, 1975). Amongst corvids, nest site varies widely and may be chosen considering protection from predators or weather (Goodwin, 1976). Eurasian Crows (*Corvus corone cornix*), for instance, prefer to nest in conifers, where predation is lower than in deciduous trees (Loman, 1979). Unlike House Crow, Jungle Crow seems to be rather selective about the site of the nest. Normally a fork high up in a tall tree is selected on the outskirts of, or near, human habitation, in well wooded, open, cultivation, or waste land (Lamba, 1976).

Lamba (1965) observed nest of Jungle Crow which was placed in a loop made of two insulated electric mains.

Platform of sticks and twigs with a neat central cup, the nest has a diameter of 15-18 cm and is 10-14 cm deep lined with coir, tow, hair or wool, placed 7-10 meters up on a forking branch or crouch on a mango, casuarina, sheesham or other large trees like coconut or palmyra palm (Ali and Ripley, 1983).

2.4.2.3 Clutch Size, Egg Size, Weight and Incubation Period

Three to five eggs are generally laid by Jungle Crow, at an interval of twenty-four to forty-eight hours. Eggs measure 42.0 × 28.6 mm on an average and mean egg weight is 18.39 grams, the maximum being 20.5 and the minimum 16.5 grams, with incubation period of an average 18 days (Lamba, 1976).

Three to five eggs are laid, similar to those of House Crow but larger in size. Average size of 60 eggs was 38 × 28.1 mm (Baker, 1934). Incubation period is normally 18 days; young fledge and leave the nest in 3-4 weeks (Ali and Ripley, 1983).

Asian Koel parasites the species but with less frequently compared to House Crow (Grimmett *et al*., 1998; Ali and Ripley, 1983). Lamba (1976) did not record brood parasitism by the Asian Koel in Jungle Crow nests in Pune.

III. MATERIAL AND METHODS

3.1 STUDY AREA

Anand district is situated in the central part of the Gujarat state. The total area of the district is 2, 94,751 hectares which is 1.52 per cent area of Gujarat state.

The area of the district comprises of plain land. The region has typical fertile soil popularly known as "*Goradu* soil" with loamy sand of alluvial origin. Goradu soil is known for its productivity. Hence, intensive cropping is practiced throughout the year. Agriculture and dairying are the priorities of the rural area. About three fourth of the population depend on agriculture. Entire district lies between two major rivers, Mahisagar on the eastern side and Sabarmati on the western side. The northern part of the district has a common boundary with Kheda district. Ahmedabad district is on its western side and Vadodara district on the eastern side. The southern side is attached to the Gulf of Khambhat.

Major area of the district has canal irrigation facility and therefore, irrigated farming is practiced. The net cropped area of the district is 2, 04,905 hectares with 1, 97,226 hectare area having irrigation facility. Important crops of the district are tobacco (*Nicotiana tabacum* L.), pearlmillet (*Pennisetum typhoides* L.), rice (*Oryza sativa* L.), wheat (*Triticum aestivum* L.), mustard (*Brassica spp*.), sugarcane (*Sachharum officinarum* L.) and chickpea (*Cicer arientinum* L.). In some patches vegetables and fruits *viz*., banana (*Musa paradisica* L.), papaya (*Carica papaya*) lemon (*Citrus limon* L.), mango (*Mangifera indica* L.) etc. are grown. Recently, the farmers have started growing cash crops like transgenic (Bt) cotton in some parts of the district. Sorghum (*Sorghum vulgare* Pers.), cluster bean (*Cyamopsis tetragonoloba*) and lucerne (*Medicago sativa*) are grown as fodder crops. There is no real forest in the district, but has a great diversity of flora. Babul (*Acacia nilotica*), manila tamarind (*Pithecellobium dulce*), peltophorum (*Peltophorum ferrunginium*), neem (*Azadirachta indica*) and *Eucalyptus spp*. are the most common trees amongst many others growing on the farm borders and road sides. The density of trees is very high in most parts of the district.

The district comprises of eight tahsilsas as per the revenue record. Total area of Anand tahsil is 40,109 hectares of which 32,072 hectares is cultivable land and 91.5 per cent of the cultivable land has irrigation facility. The land is plain and its soil, at most of the places is sandy loam to clay loam.

The investigation on ecology of House Crow and Jungle Crow in agricultural landscape was carried out from January 2011 to July 2012 at the campus of Anand Agricultural University, Anand and its surrounding areas such as Jahangirpura, Hadgud, Ismilenagar, Vallabh Vidhyanagar, Lambvel, Navli, Vadod, Mogri, Napa, Karamsad, Bakrol etc (Figure 1). Anand Agricultural University is located in Anand at a latitude of 22^0 32’ N and longitude of 73^0 00’ E and situated at 45.1 m above mean sea level. The study area has broadly two habitats, *viz*., agricultural habitat (the residential area characterized by the presence of orchards, cropped area, road-side plantations and dumping sites of agricultural habitat) and human habitation characterized by residential area, road side plantations of residential habitat.

Anand Agricultural University campus has old and large trees only on the road sides, while the majority of the area has kitchen gardens consisting of small trees which are replaced after some years. Majority of the old trees present on the road sides are peltophorum, neem, mango, etc. Major crops grown in the campus are cotton, maize, bajra, wheat, tobacco, pigeon pea, mustard, green gram, vegetables, etc. Mango, guava, sapota and aonla are grown in the horticultural farm. The campus also has animal shed and poultry farm. Anand city area and surrounding villages have less tree cover than university campus. This urban area of Anand city is having tree cover only at road sides and personal residence on very few places. Surrounding villages are economically sound and possess sub urban type of habitat whereas Anand city area is typical urban habitat.

3.2 CLIMATE

The region is roughly 70 – 120 km away from Arabian Sea and hence the climate is semi-arid and tropical monsoon type. South-western currents in summer bring monsoon rain from the third week of June to September end. Average annual rainfall is 840 mm. Climate of the area is influenced by its surrounding regions through which the cold wind blows from the northern side of India. Winter is mild, cool and dry, while summer is hot and dry. October to May is sunny months generally receiving an average of bright sunshine for ten hours a day. Temperature during hot weather starts increasing from the end of February to the end of June. Winter sets in the mid of October and continues till the end of February. Average temperature of winter and summer season was 23.47 ºC and 28.2 ºC, respectively, in the year 2011.

Weekly average data of various weather parameters during the study during 2011 are presented in Table 1. There was no rainfall up to May. The wind speed was higher in the first week of June (9.4 km / h) while lowest wind speed was observed in the third week of January and second week of February (2.2 km / h). Maximum temperature ranged from 42.1^0 C (1^{st} week of May) to 25.7^0 C (1^{st} week of January). Minimum temperature of the area ranged from 28.4^0 C (1^{st} week of July) to 8.3^0 C (2^{nd} week of January). Mean weekly temperature of the area ranged from 33.8^0 C to 17.1^0 C. Relative humidity ranged from 40.4 per cent to 88.9 per cent in the study area. The Southwest monsoon set in 3^{rd} week of July. Total 64 mm rainfall was recorded in the month of July.

Weekly average data of various weather parameters during the study in 2012 are presented in Table 2. There was no rainfall up to third week of June. The wind speed was higher in the first week of July (10.1 km / h) while lowest wind speed was observed in the second week of February (2.2 km / h). Maximum temperature ranged from 40.1^0 C (2^{nd} week of April) to 25.3^0 C (second week of January). Minimum temperature of the area ranged from 27.8^0 C (3^{rd} week of June) to 8.6^0 C (2^{nd} week of January). Mean weekly temperature of the area ranged from 32.9^0 C to 17.0^0 C. Relative humidity ranged from 39.9 per cent to 84.4 per cent in the study area. The Southwest monsoon sets in 3^{rd} week of June.

Table 1: Weekly average of maximum and minimum temperature (ºC), rainfall (mm) and relative humidity (%) during in 2011

Month	Week No.	Rainfall (mm)	Wind Speed (km/hr)	Temperature (ºC)			Relative humidity (%)		
				Max.	Min.	Mean	RH_1	RH_2	Mean
January	1	0.0	3.4	25.7	8.4	17.1	74.7	34.4	54.6
	2	0.0	2.3	27.8	8.3	18.0	80.7	38.3	59.5
	3	0.0	2.3	27.3	9.2	18.2	83.4	29.9	56.6
	4	0.0	2.6	29.5	11.3	20.4	85.6	39.4	62.5
February	5	0.0	2.5	29.6	11.6	20.6	85.9	37.6	61.7
	6	0.0	2.2	31.3	13.2	22.3	89.9	37.9	63.9
	7	0.0	2.9	31.0	14.7	22.9	82.3	39.3	60.8
	8	0.0	3.5	31.2	13.1	22.1	75.7	27.9	51.8
March	9	0.0	3.2	33.4	14.1	23.8	77.4	30.4	53.9
	10	0.0	3.5	34.3	15.3	24.8	68.6	20.4	44.5
	11	0.0	3.3	37.6	16.4	27.0	64.3	16.4	40.4
	12	0.0	3.8	36.9	17.3	27.1	78.3	23.0	50.6
April	13	0.0	3.6	39.0	18.9	28.9	65.6	19.1	42.4
	14	0.0	3.7	37.8	19.0	28.4	72.1	21.3	46.7
	15	0.0	4.3	39.7	23.7	31.7	66.4	20.4	43.4
	16	0.0	3.4	40.0	21.3	30.7	67.1	21.9	44.5
May	17	0.0	5.5	42.1	23.3	32.7	68.1	18.3	43.2
	18	0.0	6.5	39.6	24.8	32.2	68.3	31.0	49.6
	19	0.0	6.0	39.1	24.6	31.9	78.7	36.7	57.7
	20	0.0	6.2	40.2	25.8	33.0	76.9	37.0	56.9
June	21	0.0	9.4	37.7	27.3	32.5	75.1	43.7	59.4
	22	0.0	8.7	40.1	27.1	33.6	73.4	39.1	56.3
	23	0.0	6.9	39.5	28.1	33.8	78.1	43.6	60.9
	24	0.0	8.9	37.9	27.6	32.7	80.7	47.0	63.9
July	25	0.0	10.5	37.1	28.4	32.7	77.9	49.1	63.5
	26	0.0	10.3	36.6	27.8	32.2	75.4	47.3	61.4
	27	64.0	8.2	36.2	26.0	31.1	85.9	59.9	72.9
	28	44.7	6.4	30.1	25.0	27.5	95.9	82.0	88.9

Source: Meteorological Observatory, Anand Agricultural University, Anand campus, Anand.

Table 2: Weather data (Anand – 2012)

Month	Week No.	Rainfall (mm)	Wind Speed (km/hr)	Temperature (^oC)			Relative humidity (%)		
				Max.	Min.	Mean	RH_1	RH_2	Mean
January	1	0.0	3.0	26.3	11.1	18.7	91.6	47.0	69.3
	2	0.0	2.7	25.3	8.6	17.0	80.7	33.3	57.0
	3	0.0	2.5	26.7	9.4	18.0	86.6	32.1	59.4
	4	0.0	2.8	27.8	10.7	19.3	80.7	35.3	58.0
February	5	0.0	3.7	27.8	10.7	19.3	71.4	38.1	54.8
	6	0.0	4.6	26.2	9.9	18.0	64.9	30.7	47.8
	7	0.0	3.0	29.4	12.2	20.8	78.7	32.4	55.6
	8	0.0	2.7	32.4	12.2	22.3	84.9	26.4	55.6
March	9	0.0	3.5	32.1	13.4	22.8	73.4	28.7	51.1
	10	0.0	3.2	32.0	12.9	22.5	76.9	21.9	49.4
	11	0.0	3.5	33.9	14.4	24.1	59.9	19.1	39.5
	12	0.0	3.2	36.9	15.6	26.2	65.7	17.6	41.6
April	13	0.0	3.3	39.8	18.8	29.3	61.3	18.4	39.9
	14	0.0	3.8	40.1	21.0	30.5	78.3	23.1	50.7
	15	0.0	4.5	39.4	21.8	30.6	87.1	25.9	56.5
	16	0.0	5.6	35.7	25.6	30.6	62.4	33.4	47.9
May	17	0.0	5.8	38.2	24.6	31.4	62.9	29.7	46.3
	18	0.0	6.1	39.6	23.3	31.5	81.4	30.1	55.8
	19	0.0	6.0	38.9	25.9	32.4	76.1	38.7	57.4
	20	0.0	6.1	39.0	25.3	32.2	74.4	37.7	56.1
June	21	0.0	6.6	39.9	25.7	32.8	77.1	32.0	54.6
	22	0.0	7.8	39.6	26.3	32.9	76.0	36.6	56.3
	23	0.0	8.6	37.7	27.8	32.8	80.4	42.9	61.6
	24	4.1	6.8	37.5	27.6	32.6	84.1	55.6	69.9
July	25	0.0	10.1	37.9	27.8	32.9	83.9	44.1	64.0
	26	2.6	9.3	37.5	27.6	32.6	83.1	44.9	64.0
	27	76.8	8.6	34.6	27.0	30.8	88.9	66.7	77.8
	28	131.4	6.5	32.8	25.8	29.3	93.9	75.0	84.4

Source: Meteorological Observatory, Anand Agricultural University, Anand campus, Anand.

METHODS:

3.3 FOOD AND FORAGING BEHAVIOR

Food consumed by the crows was recorded visually using 10 × 12 binoculars. Food items (plant or animal) were identified to the nearest taxa level. Seasonal variations and the frequency of various food items were also worked out. Food items were further classified as follows: food grains, kitchen waste, agricultural Market waste, depredated fruits, road kill (vertebrate), live invertebrate, live vertebrate, non-vegetarian food waste and carcasses etc. Occurrence of agricultural products and insect / rodent pests in the diet was worked out to determine the role of crows in agricultural landscape.

3.3.1 Observation Schedule

Minimum 5 hours per week observations were recorded over 5 km transect on the fixed route of given area. Food types were recorded as food grains, kitchen waste, agricultural market waste, depredated fruits, road kill vertebrate, predated live invertebrates and vertebrates and non-vegetarian food waste and carcasses and water. This recorded food types were categorised into major food categories *viz.,* animal matter and plant matter. Frequencies of both species of crows feeding on various food items were worked out. Food preference was decided by comparing frequencies and abundance of crows feeding on various food items. Presence and number of other species were also recorded.

Frequency of a particular crow species feeding on particular food type was calculated using following parameters.

1). Relative frequency (% F) of each crow species feeding on particular food type was calculated using following formula:

$$F = \frac{fi}{S} \times 100$$

Where,

fi = frequency of i^{th} time crows feeding on particular food type (item)

S = Sum of frequencies of all food type

2). Relative abundance (% RA) of each crow species feeding on particular food type

$$RA = \frac{Ai}{S} \times 100$$

Where,

Ai = it is abundance of i^{th} crows encountered feeding on particular food type

S = Sum of crows encountered feeding on all food types

3.4 DISTRIBUTION OF CROWS WITHIN AGRICULTURAL LANDSCAPE

Road transect method was used for determining distribution of crows within given area by minimum 5 hours observations over 5 km transect on the fixed route of the given area. Time: 07:00-10:00 hrs. A total of 7 fixed routes (given below) were decided in such a way that whole study area could be covered.

Seven routes utilized for recording observations on ecology of crows were as follow.

Route 1: Starting from Mogri village – Anand juna rasta – Amin auto – Townhall – 100 ft road – Overbridge, Ismilenagar – Samarkha chwokdi – Bone meal waste dump area – Samarkha village road – Vasad road – return.

Route 2: Starting from Mogri village - Anand juna rasta – Borsad chowkdi – Agriculture college *via* Veterinary campus, MVRS farm, RRS farm, Forage farm, LRS farm, Horticulture farm – B. A. C. A. and surrounding farms.

Route 3: Starting from B. A. C. A. and surrounding farms – Hadgud road (Hadgud village and surrounding area) – Vadod village and surrounding area – return to AAU campus.

Route 4: Starting from Mogri village – Andhariya road – Andhariya chowkdi – Navli – Navli – Jitodiya back side raod – RRS farm – LRS farm – Horticultural orchards – MVRS farm – BTRS farm – B. A. C. A. building.

Route 5: Starting from Mogri village– Gana road – Gana village (village and surrounding) – Napa village – return.

Route 6: Starting from Mogri village – Janta chowkdi – V. V. Nagar and surrounding – Bakrol village – upto Vadtal village – return.

Route 7: Starting from Mogri village– Anand Sojitra road – Karamsad village – Valasan village – Bandhni chowkdi – return.

Observations on the distribution of crows were carried out from July 2011 to June 2012. Crow numbers were counted from a given area by direct observation through binocular (10 × 12) and food consumed was also recorded at the same time if observed. All the areas covered under seven routes were broadly classified into two major habitats *viz.,* agricultural habitat (A) and human habitation (H). Observations were recorded from following components of the landscape for classifying of crow distribution.

3.4.1 Components of landscape:

Sr. No.	Habitat	Description
Agricultural Habitat		
1	Cropped area	Area utilized for crop production
2	Commercial building (A)	Building area not utilized by human for residency in agricultural habitat
3	Livestock farm	Large and small animal shed of area
4	Orchard	Horticultural fruit crop orchards
5	Poultry farm	Poultry fowl domestication area
6	Roadside plantations (A)	Tree plantations along roadside in agricultural habitat
7	Waste dump area (*Agricultural market waste*)	Agriculture produce market committee waste dumping site
8	Waste dump area (*Vegetarian food waste*)	Restaurant's vegetarian food waste dumping site
9	Waste dump area (*non- vegetarian food waste and carcasses*)	Killed animals, bone meal waste, and non- vegetarian food waste dumping site
Human habitation		
10	Commercial building (H)	Building area not utilized by human for residency
11	Residential	Area which are utilized by human for residency, both urban and rural
12	Roadside plantations (H)	Tree plantations along roadside in human habitation
13	Waste dump area (*non- vegetarian food waste -H)*	Non-vegetarian food waste dumping site within human habitation

Distribution pattern (component utilization) of crows in different habitat components was worked out using frequency distribution.

Frequency of a particular crow recorded in a particular habitat component was worked out by following parameters.

1). Relative frequency (% F) of each habitat component was calculated using following formula:

$$F = \frac{fi}{S} \times 100$$

Where,

fi = frequency of i^{th} time crows encountered at particular habitat component

S = Sum of frequencies all habitat components

2). Relative abundance (% RA) of each crow in a particular habitat component was calculated using following formula:

$$RA = \frac{Ai}{S} \times 100$$

Where,

Ai = Number of crows encountered at i^{th} habitat component

S = total number of crows encountered from all habitat components

3.5 SIGNIFICANCE OF CROWS IN AVIAN ASSEMBLAGES DURING FARM OPERATIONS

Crows play dual role in agriculture; they cause damage to the crops and fruits and also act as beneficial bird by feeding on insect pests. The crows attend several farm operations and pick up insects and other organisms exposed. Observations on significance of crows in avian assemblages during farm operations were carried out from September 2011 to June 2012 in the study area. Observations were made as numbers of crows recorded in the avian community gathered during farming operations, *viz.,* given below.

a. Land preparation (ploughing by cultivator, mouldboard plough and disc plough)
b. Green manuring
c. Sowing
d. Irrigation
e. Inter-culturing

f. Harvesting

Above farm operations were examined to record presence of crows and other species of birds at the time of particular farm operation. Observations were recorded whenever an opportunity aroused during other field studies. Number of crows and their activities were recorded. Value of index of importance was used for determining significance of crows and other bird species during farm operations. Calculations of Relative frequency (% F) and Relative Abundance (R.A. %) were calculated as per earlier section i. e. 3.4.

Index of Importance (I) was calculated by using following formula

$$I = \frac{F + \%RA}{2}$$

(Obrtel and Holisova, 1974)

Where,

% F = Relative frequency of crows observed during particular farm operation

% RA = Relative abundance during particular farm operation

3.6 NESTING ECOLOGY

3.6.1 Study Area and Period: Breeding ecology was studied during January 2011 to July 2012 in the area of Anand city, AAU campus and surrounded villages.

3.6.2 Nest Searching: Jungle Crow normally prefer tall tree on the outskirts of, or near human habitation, in well wooded land or cultivation, (Lamba, 1976) and House Crow prefer to construct nest on smaller trees near to human habitation and dumped area; such sites in the study area were checked for presence of nest.

3.6.3 Searching Clues: Visits and revisits of crows in a particular area with nesting material or food items in beak gave clue to find nest in study area. Inquiry with local people was carried out for presence of nest at AAU campus and surrounding villages. On identifying a nest, it was pinned at fixed point on Google map of the study area. Using Google map, distribution pattern of crow nests was worked out. Measurements *viz.,* inter-nest distance, distance of crow nest from human habitation, water source, dumping sites and slaughter houses were calculated by using pinned locations of crow nests on Google maps.

3.6.4 Substrate Selection

1) Nesting substrate: Substrate on which the nest was constructed were identified (tree/ pole etc.) and measurements of below mentioned substrate characteristics were taken.
2) Available nesting substrate (trees): five substrates (tree) near nesting tree were identified and measurements of nesting substrate. Characters were taken.

Selectivity Index: It was calculated to test the hypothesis and find out the selectivity. Selectivity is the utilization of tree species in relatively greater proportion than its occurrence in environment (Ivlev, 1961). It is the preference of a bird for a tree spp. for nesting. Selectivity index S was calculated using Ivlev's (1961) formula.

$$S = (Ci - Ai)/ (Ci + Ai)$$

Where,

S = Selectivity

Ci = Proportion of utilized tree species

Ai = Proportion of available tree species in environment

The selectivity index ranges from +1 to -1. Tree species with near +1 are utilized in much greater proportion than they are offered. Tree species with an index near zero are utilized just in proportion to their availability. Species with an index -1 are utilized well below the proportion offered.

3.6.5 Substrate Characteristics

1) Type of substrate: Nesting tree species / pole were identified.
2) Height: Height of substrate was measured from top to ground using digital rangefinder.
3) Canopy diameter: Measured as diameter of canopy shadow at 1200 h, average of two measurements was considered.
4) Circumference at Breast Height (CBH): Circumference at breast height was measured, using measuring tap.
5) Crown height: The height from which the first branches start to the top of the tree was measured, using digital range finder.
6) Bole height: The height from ground to the first side branches that develop from the tree was measured.
7) Number of unoccupied platforms on substrate was recorded.

3.6.6 Nesting Habitat

1) Habitat type was identified for each nesting substrate.
2) Association with other habitat components: Distances of other habitats components from the nesting substrate were measured to assess association, if any.
    a) Human habitation
    b) Wetland/water source
    c) Garbage/dump/waste site

d) Slaughter house

e) Animal shade

3.6.7 Breeding Ecology

3.6.7.1 Nest Characters

1) Nest location: Location of the nest on nesting substrate was identified as primary, secondary or tertiary branch etc.
2) Nest height: Height of the nest from the ground was measured.
3) Direction of nest: Location of nest on tree canopy with reference to directions as N/S/E/W was recorded.
4) Detectability rank: Detectability rank was given to the nest platform on 0-1 scales. 0 scale was given to the nest not visible from the ground. 1 scale was given when nest was visible from any corner of the ground.
5) Circumference of nest branch: Circumference of the branch on which nest is present was measured.
6) Distance to next crow nest: Distance between two nests of crows was recorded (Using google map nest locations measurement technology)
7) Nest Diametric: External and internal diameter of nest was measured with the help of measuring tape from top edges of nest and of internal clean cup respectively. Depth of nest from top to internal bottom of cup was measured.

3.6.8 Breeding Performance

The nesting season of crows starts from early February to August. On identifying an active nest, it was checked at 3 day interval for presence of nest content (eggs or chicks). The eggs were brought down to the ground level in cloth bags for further observations. The eggs were numbered with the help of permanent marker in the sequence of laying (Plate 1). This helped to keep tract of in determining incubation period.

Eggs were measured for their width, length and weight with the help of verenier callipers and spring balance, respectively (Plate 1). Eggs of brood parasite (AsianKoel) were identified and measured if present in the nest.

After taking the above measurements the eggs were placed back in the nest for growth and development.

Observations were also be made for the hatching percentage (number of eggs hatched out from the total number of eggs laid), fledging success (the percentage of nestlings hatched that fledged), nesting success (the percentage of nests that fledged at least one chick). Factors causing mortality of eggs/ nestling were recorded.

3.6.9 Statistical Analysis

Nesting ecology: Mean and standard deviation of each parameter (substrate selection, substrate characteristics and nesting habitat) was worked out on the basis of rank or making a comparison using t or F test or Chi square test.

Breeding ecology: Egg measurement and mean clutch size and standard deviation were worked for comparison: Paired T test was applied to test significance in measurments. The egg shape index (ESI), volume etc. were calculated with the help of a standard formula:

ESI = Maximum breadth / maximum length × 100

$$\text{Volume} = K \times \text{Length} \times \text{Breadth}^2 \quad \text{where } K = 0.0506 \text{(Hoyt, 1979)}$$

Other calculations on breeding ecology

a) Hatching success: Number of eggs hatched / number of eggs laid.

b) Nesting success : Percentage of nests that fledged at least one chick

c) Fledgling success: Percentage of nestling hatched that fledged.

d) Overall breeding success: Percentage of eggs which could ultimately fledge.

IV. RESULTS AND DISCUSSION

The results of investigations on ecology of House Crow and Jungle Crow in agricultural landscape carried out from January 2011 to July 2012 are categorised under following titles.

(1) Food and foraging behaviour of crows

(2) Distribution of crows within agricultural landscape

(3) Significance of crows in avian assemblages during farm operations and

(4) Nesting ecology

4.1 FOOD AND FORAGING BEHAVIOUR OF CROWS

Food consumed by the crows was recorded visually with the help of binoculars (10 × 12) and food items were identified to the nearest taxa level. A total of 249 observations were made in study area during the course of this study (Jan 2011 – May 2012) to assess food habit of crows.

Observations on food consumed by crows were classified into two major categories; Plant matter and animal matter, further these broad categories were divided into respective food type consumed by crows. Overall frequency and relative abundance of both crow species feeding on major food categories are presented in Table 3. Out of 216 observations, House Crow was recorded in 123 observations and Jungle Crow was recorded in 140 Observation. Both species were found feeding together in 47 observations. Frequency and relative abundance of House Crow feeding on plant matter (65.04 %F and 55.48 % R. A.) was higher compared to animal matter (34.96 % F and 44.52 % R. A.). In case of Jungle Crow, Animal matter (56.43 % F and 60.47 % R. A.) was higher compared to plant mater (43.57 % F and 39.53 % R. A.). Overall dependence of House Crow on plant matter was higher compared to Jungle Crow. On the other hand, Jungle Crow relied more on animal matter compared to House Crow. This was further evident from the frequency of occurrence of both the species on animal and plant matter.

Table 3. Frequency and relative abundance of crows feeding on major food types

Sr. No.	Major food category	N	House Crow				Jungle Crow			
			F	%F	Count	%RA	F	%F	Count	%RA
1	Animal matter	95	43	34.96	280	44.52	79	56.43	410	60.47
2	Plant matter	121	80	65.04	349	55.48	61	43.57	268	39.53
	Total	**216**	**123**	**100**	**629**	**100**	**140**	**100**	**678**	**100**

Note: N = Total number of observations, F = Frequency of observation, RA = Relative Abundance, Count = Total number of species individual counted

Table 4. Classification of major food category into various food types

Sr. No.	Food types	Term
Plant matter		
1	Food grains	Bajra, jowar, maize, groundnut, etc.
2	Kitchen waste	Vegetarian food waste from restaurant and kitchen
3	Agricultural market waste	Agricultural produce market committee vegetable food waste
4	Fruits (depredated)	Mango, guava, sapota, papaya, etc. from orchards
Animal matter		
5	Road kill (vertebrate)	Dogs, cats, squirrel, etc. dead animal killed on road by accident
6	Invertebrate (predated)	Insects exposed in agricultural operations, insect parasite on cattle body
7	Vertebrate (predated)	Pigeons, parrot, chicks of other birds species
8	non-vegetarian food waste and Carcasses	Waste product of bone meal and poultry, dead animal dump, non-veg. food waste,
Water		

4.1.1 Food Habit of Crows in Agricultural Habitat

Frequency and relative abundance of crows feeding on various food types in agricultural habitat is given in Table 5.

Various food types *viz.,* agricultural market waste, food grains, fruits, kitchen waste, live vertebrates, live invertebrates, road killed vertebrates, non-vegetarian food waste and carcasses were consumed by crows from agricultural habitat.

The House Crow procured most of its food from food waste (82.4 %) of human being. Frequency and relative abundance of House Crow feeding on non-vegetarian food waste and carcasses (30.23 % F and 41.36 % R. A.) was highest followed by kitchen waste (23.26 % F and 35.80 % R. A.) and agricultural market waste (6.98 % F and 5.25 % R. A.). Road killed vertebrates (13.95 % F and 7.41 % R. A.) in an agricultural habitat were consumed in low proportion. No House Crow was recorded feeding on fruits and feeding on live vertebrates. Agricultural market waste (6.98 % F and 5.25 % R. A.), food grains (6.98 % F and 3.09 % R. A.) and invertebrate (9.30 % F and 4.01 % R. A.) consumption was recorded with very low frequency and relative abundance respectively. Jungle Crows are known to have a wide range of food preferences. They feed on insects, bird eggs and chicks, and scavenge on dead animals. They eat various fruits and seeds of trees as well, and thus their role as seed disperser has been pointed out (Ueda and Fukui, 1992). In present study, Jungle Crow procured only fifty percent of its food from food waste of human being. Jungle Crow feeding on non-vegetarian food waste and carcasses (15.84 % F and 36.55 % R. A.) was higher followed by depredation on fruits (14.85 % F and 15.46 % R.A.) and kitchen waste (16.83 % F and 13.86 % R. A.) in an agricultural habitat. No Jungle Crow was recorded feeding on agricultural market waste. Invertebrate (17.82 % F and 9.64 % R. A.), road killed vertebrates (9.90 % F and 10.44 % R. A.), live vertebrates (9.90 % F and 3.82 %R. A.) and food grains (4.95 % F and 2.21 % R. A.) were recorded with very low frequency and abundance respectively compared to other food type.

Table 5 show that House crow did not show tendency to prey on live vertebrates or cause any damage to ripening fruits.

Frequency of House Crow (9.30 %) and Jungle Crow (9.90 %) drinking water was similar with relative abundance of 3.09 per cent and 8.03 per cent respectively.

Table 5. Frequency and relative abundance of crows feeding on various food types in agricultural habitat

Sr. No.	Food Type	N	House Crow				Jungle Crow			
			F	%F	Count	% RA	F	%F	Count	% RA
1	Food grains	8	3	6.98	10	3.09	5	4.95	11	2.21
2	Kitchen Waste	18	10	23.26	116	35.80	17	16.83	69	13.86
3	Agri market waste	3	3	6.98	17	5.25	0	0.00	0	0.00
4	Fruits (Depredated)	15	0	0.00	0	0.00	15	14.85	77	15.46
5	Road Kill (Vertebrate)	12	6	13.95	24	7.41	10	9.90	52	10.44
6	Invertebrate (Predated)	22	4	9.30	13	4.01	18	17.82	48	9.64
7	Vertebrate (Predated)	10	0	0.00	0	0.00	10	9.90	19	3.82
8	Non-vegetarian food waste and Carcasses	16	13	30.23	134	41.36	16	15.84	182	36.55
9	Water	10	4	9.30	10	3.09	10	9.90	40	8.03
	Total	**114**	**43**	**100**	**324**	**100**	**101**	**100**	**498**	**100**

Note: N = Total number of observations, F = Frequency of observation, RA = Relative Abundance, Count = Total number of species individual counted

4.1.2 Food Habit of Crows in Human Habitation

Frequency and relative abundance of crows feeding on various food types in the human residential habitat is given in Table 6.

Various food types *viz.,* food grains, kitchen waste, vertebrates, road killed vertebrate and carcasses and non-veg. food waste were consumed by crows from the area of human habitation. When both the species were feeding together at non-vegetarian food waste and carcasses dumping site, the Jungle Crow (58 %) out numbered the House Crow (42 %). On the other hand, at kitchen waste dumping site, the House Crow (63 %) out numbered the Jungle Crow (37 %).

Frequency and relative abundance of House Crow feeding on kitchen waste (62.50 % F and 58.46 % R. A.) was higher followed by road killed vertebrates (17.71 F %

and 20.47 % R. A.) and non-vegetarian food waste and carcasses (3.13 % and 11.87 % respectively) in the human residential area. No House Crow was recorded feeding on vertebrates. Food grains (4.17 % F and 2.67 % R. A.) consumption by House Crow was recorded with very low frequency and abundance respectively.

Frequency and relative abundance of Jungle Crow feeding on kitchen waste (48.98 % F and 47.23 % R. A.) was higher followed by road killed vertebrates (42.86 % and 35.74 % respectively) and non-vegetarian food waste and carcasses (6.12 % and 10.21 % respectively) from human residential area. No Jungle Crow was recorded feeding on food grains from this area. Predation on vertebrates (2.04 % and 0.43 %) by Jungle Crow was recorded with very low frequency and relative abundance respectively.

Relative abundance of House Crow (58.46 %) feeding on kitchen waste was higher compared to Jungle Crow (47.23 %) whereas frequency of Jungle Crow (42.86 %) feeding on road killed vertebrates was higher compared to House Crow (17.71 %) in the human habitation.

Frequency of House Crow and Jungle Crow recorded as drinking water was similar with relative abundance 6.53 % and 6.38 % respectively.

Both the species in residential area largely relied upon kitchen waste and flesh of road-killed vertebrates.

Table 6. Frequency and relative abundance of crows feeding on various food types in human habitation

Sr. No.	Food Type	N	House Crow				Jungle Crow			
			F	%F	Count	% RA	F	%F	Count	% RA
1	Food grains	4	4	4.17	9	2.67	0	0.00	0	0.00
2	Kitchen waste	73	60	62.50	197	58.46	24	40.00	111	47.23
3	Road kill (Vertebrate)	31	17	17.71	69	20.47	21	35.00	84	35.74
4	Vertebrate	1	0	0.00	0	0.00	1	1.67	1	0.43
5	Non-vegetarian food waste and carcasses	3	3	3.13	40	11.87	3	5.00	24	10.21
6	Water	23	12	12.50	22	6.53	11	18.33	15	6.38
	Total	**135**	**96**	**100**	**337**	**100**	**60**	**100**	**235**	**100**

Note: N = Total number of observations, F = Frequency of observation, RA = Relative Abundance, Count = Total number of species individual counted

4.1.3 Food Habit of Crows in Entire Study Area

Frequency and relative abundance of crows feeding on various food types in the entire study area is given in Table 7.

Frequency and relative abundance of House Crow feeding on kitchen waste (50 % F and 47.35 % R. A.) was higher followed by non-vegetarian food waste and carcasses (12.14 % F and 26.32 % R. A.) (Plate 2; (A) and (F)) and road killed vertebrates (16.43 % F and 14.07 % R. A.). No House Crow was recorded feeding on fruits and vertebrates. But Dharmakumarsinhji (1955) recorded that during breeding season, House Crow gather in flocks and destroy the eggs and chicks of birds. Agricultural market waste (2.14 % and 2.57 %), food grains (5 % and 2.87 %) and invertebrate (2.86 % and 1.97 %) consumption was recorded with very low frequency and relative abundance respectively. Dharmakumarsinhji (1955) recorded that House Crows were useful birds once the rains have set in, as they feed upon many injurious insects, especially grasshoppers, beetles and locusts which destroy the young crops.

Frequency and relative abundance of Jungle Crow feeding on non-vegetarian food waste and carcasses (11.31 % F and 28.10 % R. A.) was higher followed by kitchen waste (24.40 % F and 24.56 % R. A.) and road killed vertebrates (18.45 % and 18.55 % respectively) in the study area. No Jungle Crow was recorded feeding on agricultural market waste. Invertebrate (10.71 % and 6.55 % respectively), live vertebrates (6.55 % and 2.73 % respectively) and food grains (7.14 % and 1.50 % respectively) consumption was recorded with very low frequency and relative abundance, respectively.

Frequency and relative abundance of House Crow feeding on kitchen waste (50 % and 47.35 % respectively) was higher compared to Jungle Crow (24.40 % and 24.56 %). Relative abundance of Jungle Crow feeding on non-vegetarian food waste and carcasses

(28.10 %), road killed vertebrates (18.55 %), depredation on fruits (10.50 %), predation on invertebrates (6.55 %) and vertebrates (2.73 %) was higher compared to House Crow in the study area. In short, the Jungle Crow was observed feeding mainly on animal matter whereas House Crow was observed feeding mainly on plant matter. Jungle Crow depreation on blue rock pigeon was given in Plate 3; (E). Verghese and Sriharan (1993) observed that House Crows were most important predators of the borer, *Adisura atkinsoni* in mixed stands of field bean. Predation was enhanced if trees were available nearby for resting. The birds plucked infested pods, took it away, then split it open and fed 4 ± 0.19 larvae per minute.

Table 8. List fruits depredated by Jungle Crows from the study area

Sr. No.	Fruits	Botanical Name
1	Mango	*Mangifera indica*
2	Guava	*Psidium gujava*
3	Sapota	*Manilkara achras*
4	Papaya	*Carica papaya*
5	Pilu	*Salvadora persica*
6	Mulberry	*Morus alba*
7	Fig	*Ficus carica*
8	Aankh Futamani	*Ctenolepis cerasiformis* (Stocks) Hook. f.
9	Ghamoriyu	*Tinospora sinensis* (Lour.) Merr.

Jungle Crow was recorded damaging the ripe fruits of papaya in the study area and Plate 3;(D) indicated damaging pattern of Jungle Crow on fruits. House Crow recorded feeding on ripe berry of *Salvadora persica*. At Mudigere (Karnataka), guava fruits were depredated by Jungle Crow (Krishnappa and Kumar, 1993).

Thyagaraj and Somasekhara (1993) recorded that Jungle Crow was the most dominant in depredating orange fruits (50 – 55 % fruit losses) at Mudigere, Karnataka. Crow damaged the fruits by making circular cuts on the skin to feed on the internal contents, leaving empty or hollow skin intact with plant or detached. On an average, 178 fruits /tree /week were damaged by the Jungle Crow.

Jungle Crow was recorded to be most dominant species damaging pineapple. The crows preferred well-ripened (6 months old) fruits but also attacked partially ripened ones (4 – 5 months old). A fruit was destroyed by a crow on an average 12 minutes (n = 14).

Table 7. Frequency and relative abundance of crows feeding on various food types in entire study area

Sr. No.	Food Type	N	House Crow				Jungle Crow				Proportion	
			F	F (%)	Count	RA (%)	F	F (%)	Count	RA (%)	H. C.	J. C.
1	Food grains	12	7	5.00	19	2.87	12	7.14	11	1.50	100	0
2	Kitchen Waste	91	70	50.00	313	47.35	41	24.40	180	24.56	45.8	54.2
3	Agri market waste	3	3	2.14	17	2.57	0	0.00	0	0	63.3	36.7
4	Fruits (depredated)	15	0	0.00	0	0.00	15	8.93	77	10.50	0	100
5	Road Kill (Vertebrate)	43	23	16.43	93	14.07	31	18.45	136	18.55	24.3	78.7
6	Invertebrate	22	4	2.86	13	1.97	18	10.71	48	6.55	63.5	36.5
7	Vertebrate	11	0	0.00	0	0.00	11	6.55	20	2.73	40.6	59.4
8	Carcasses + Non-veg. food waste	19	17	12.14	174	26.32	19	11.31	206	28.10	0	100
9	Water	33	16	11.43	32	4.84	21	12.50	55	7.50	36.8	63.2
	Grand Total	**249**	**140**	**100**	**661**	**100**	**168**	**100**	**733**	**100**	**47.4**	**52.6**

Note: N = Total number of observations, F = Frequency of observation, RA = Relative Abundance,
Count = Total number of species individual counted, H. C. = House Crow, J. C. = Jungle Crow

4.2 DISTRIBUTION OF CROWS WITHIN AGRICULTURAL LANDSCAPE

(Agricultural area, Human habitation: Rural, Urban)

Overall frequency and relative abundance of crows in major habitats is presented in Table 9. A total of 565 encounters of crows were recorded of which House Crow was encountered for 297 times and Jungle Crow was encountered for 313 times. Both species of crows were found together in 23.14 per cent encounters from the study area. Frequency and relative abundance of House Crow was higher in area of human habitation (72.39 % F and 62.63 % R. A.) compared to agricultural habitat (27.61 F % and 37.37 % R. A.). Reverse was the case of Jungle Crow where its distribution in agricultural habitat (71.25 % F and 78.27 % R. A.) was higher compared to human habitation (28.75 % F and 21.73 % R. A.). Overall distribution of House Crow was higher in human habitation compared to Jungle Crow, whereas Jungle Crow was recorded most abundant in agricultural habitat. In fact human food waste was dumped at three places in the rural area which strongly influenced numbers and proportion of two crow species in agricultural habitat. Urban waste was dumped in agricultural habitat hence more House Crows.

Table 9. Distribution of crows in two major habitat of study area

Sr. No.	Major habitat	N	House Crow				Jungle Crow			
			F	**%F**	**count**	**%RA**	**F**	**%F**	**count**	**%RA**
1	Agricultural habitat	279	82	27.61	349	37.37	223	71.25	652	78.27
2	Human habitation	286	215	72.39	585	62.63	90	28.75	181	21.73
	Grand Total	**565**	**297**	**100**	**934**	**100**	**313**	**100**	**833**	**100**
Note: N = Total number of observations, F = Frequency of observation, RA = Relative Abundance, Count = Total number of species individual counted										

Major habitats were further classified into 13 habitat components to assess crow distribution pattern in study area were listed given below.

Sr. No.	Habitat	Description
Agricultural Habitat		
1	Cropped area	Area utilized for crop production
2	Commercial building (A)	Building area not utilized by human for residency in agricultural habitat
3	Livestock farm	Large and small animal shed of area
4	Orchard	Horticultural fruit crop orchards
5	Poultry farm	Poultry fowl domestication area
6	Roadside plantations (A)	Tree plantations along roadside in agricultural habitat
7	Waste dump area (*Agricultural market waste*)	Agriculture produce market committee waste dumping site
8	Waste dump area (*Vegetarian food waste*)	Restaurant's vegetarian food waste dumping site
9	Waste dump area (*non-vegetarian food waste and carcasses*)	Killed animals, bone meal waste, and non- vegetarian food waste dumping site
Human habitation		
10	Commercial building (H)	Building area not utilized by human for residency
11	Residential	Area which are utilized by human for residency, both urban and rural
12	Roadside plantations (H)	Tree plantations along roadside in human habitation
13	Waste dump area (*non-vegetarian food waste -H)*	Non-vegetarian food waste dumping site within human habitation

4.2.1 Distribution Pattern of Crows in Agricultural Habitat

Frequency and relative abundance of crows distributed in various habitat components in an agricultural habitat is given in Table 10.

Amongst various habitat components, nine components were recognized from agricultural habitat where crows were distributed (Table 10). Relative abundance of House Crow was recorded highest at non-vegetarian food waste and carcasses dumping site (32.66 %), followed by roadside plantations (22.92 %) vegetarian food waste dumping site (20.92 %), whereas its relative frequency was highest at roadside plantations (40.96 %) followed by cropped area (20.48 %) and non-vegetarian food waste dumping site (14.46 %). No House Crow was observed in commercial building area which was not utilized by humans for residency. The House Crows were distributed with lower frequency and relative abundance in the livestock farm (3.61 % F and3.15 % R. A.), poultry farm (4.82 % F and 3.44 % R. A.), Orchard (2.41 % F and 2.87 % R. A.), and agricultural produce waste dumping site (3.61 % F and 4.87 % R. A.).

Relative frequency of Jungle Crow distribution in cropped area (27.80 %) was highest followed by roadside plantation (21.08 %) and orchards (19.73 %) of agricultural habitat, whereas relative abundance of Jungle Crow was recorded highest in orchards (26.69 %) followed by non-vegetarian food waste dumping site (23.16 %) and cropped area (17.02 %). No Jungle Crow was observed at agricultural produce waste dumping site. In various habitat components, *viz.,* commercial building area (which was not human residence; 10.76 % F and 7.52 % R. A.), livestock farm (8.07 % F and 5.98 % R. A.), vegetarian food waste dumping site (3.14 % F and 5.98 % R. A.) and poultry farm (2.69 % F and 1.53 % R. A.), the Jungle Crow were distributed with lower frequency and relative abundance.

Relative abundance of House Crow was higher at non-vegetarian (32.66 %) and vegetarian (20.92 %) dumping site compared to Jungle Crow (23.16 % and 5.98 % respectively). Relative abundance of Jungle Crow was higher in orchards (26.69 %) and cropped area (17.02 %) compared to House Crow (2.87 % and 9.17 % respectively). Higher frequency of House Crow (40.96 %) was observed at roadside plantations of agricultural habitat compared to Jungle Crow (21.08 %) whereas higher frequency of Jungle Crow (27.80 %) was recorded in the cropped area compared to House Crow (20.48 %).

4.2.2 Distribution Pattern of Crows in Human Habitation

Frequency and relative abundance of crows distributed in various habitat components in an agricultural habitat is given in Table 11.

Amongst various habitat components, four components were recognized from human habitation where crows were distributed (Table 11). Frequency and relative abundance of House Crow was highest in residential area (73.02 % F and 63.42 % R. A.) followed by roadside plantations (22.33 % F and 32.31 % R. A.). Lower frequency and relative abundance of House Crow was observed in non-vegetarian waste dumping site (2.79 % F and 2.56 % R. A.) due to lower number of observations at such site. Commercial building areas which were non residential had lower frequency and relative abundance of House Crow (1.86 % and 1.71 % respectively). Frequency and relative abundance of Jungle Crow was recorded higher in residential area (82.22 % F and 85.08 % R. A. respectively) followed by roadside plantations (14.44 % F and 11.60 % R. A. respectively) of human habitation. Lower frequency and relative abundance of Jungle Crow was observed in non-vegetarian waste dumping site (3.33 % and 3.31 % respectively) within human habitation but it was due to lower number of observations at such site. No Jungle Crow was recorded at commercial building area (non residential) in human habitation. Both House Crow and Jungle Crow were abundant at residential and roadside plantations of the human habitation.

Table 10. Distribution of crows in various components of the agricultural habitat

Sr. No.	Habitat components	N	House Crow				Jungle Crow			
			F	%F	count	%RA	F	%F	count	%RA
1	Cropped area	79	17	20.48	32	9.17	62	27.80	111	17.02
2	Commercial building (A)	24	0	0.00	0	0.00	24	10.76	49	7.52
3	Livestock farm	20	3	3.61	11	3.15	18	8.07	39	5.98
4	Orchard	44	2	2.41	10	2.87	44	19.73	174	26.69
5	Poultry farm	6	4	4.82	12	3.44	6	2.69	10	1.53
6	Road side plantation (A)	79	34	40.96	80	22.92	47	21.08	79	12.12
7	Waste dumping area (Agricultural market waste)	3	3	3.61	17	4.87	0	0.00	0	0.00
8	Waste dumping area (Vegetarian food waste)	8	8	9.64	73	20.92	7	3.14	39	5.98
9	Waste Dumping Area (Non- Vegetarian dump in Agricultural habitat)	16	12	14.46	114	32.66	15	6.73	151	23.16
	Total	**279**	**83**	**100**	**349**	**100**	**223**	**100**	**652**	**100**

Note: N = Total number of observations, F = Frequency of observation, RA = Relative Abundance,
Count = Total number of species individual counted

Table 11. Distribution of crows in two in various components of the human habitation

Sr. No.	Habitat components	N	House Crow				Jungle Crow			
			F	%F	count	%RA	F	%F	count	%RA
1	Commercial building (H)	4	4	1.86	10	1.71	0	0.00	0	0.00
2	Residential area	221	157	73.02	371	63.42	74	82.22	154	85.08
3	Road side plantation (H)	55	48	22.33	189	32.31	13	14.44	21	11.60
4	Waste dumping area (Non-Vegetarian dump in Human area)	6	6	2.79	15	2.56	3	3.33	6	3.31
	Total	**286**	**215**	**100**	**585**	**100**	**90**	**100**	**181**	**100**

Note: N = Total number of observations, F = Frequency of observation, RA = Relative Abundance, Count = Total number of species individual counted

4.2.3 Distribution Pattern of Crows in Entire Study Area

Frequency and relative abundance of crows distributed in various habitat components in entire study area is given in Table 12.

Frequency and relative abundance of House Crow was a higher in residential area (52.68 % F and 39.72 % R. A.) followed by roadside plantations in agricultural habitat (16.11 % F and 20.24 % R. A.) and roadside plantations in human residency (11.41 % F and 8.57 % R. A.). Lower frequency and relative abundance of House Crow was at non-vegetarian waste dumping site (2.79 % F and 2.56 % R. A.) within human habitation but it was due to lower number of observations at such site. No House Crow was observed at commercial buildings of agricultural habitat which non-residential.

Relative abundance of Jungle Crow was higher in orchards (20.89 %) followed by residential area (18.49 %) and non-vegetarian food waste dumping site of human habitation. Lower frequency and relative abundance of Jungle Crow was observed at non-vegetarian waste dumping site (3.33 % F and 3.31 % R. A. respectively) within human habitation but it was due to lower number of observations at such site. No Jungle Crow was recorded at agricultural produce waste dumping site.

In short, House Crow distribution was higher in residential (39.72 % R. A.) and roadside plantations at human habitation (20.24 % R. A.) compared to Jungle Crow (18.49 % F and 2.52 % R. A. of residential and roadside plantation at human habitation respectively). Highest distribution of Jungle Crow was recorded in orchard (20.89 % R. A.) and cropped area (13.33 %) compared to House Crow (1.07 % and 3.43 % R. A. of orchard and cropped area respectively).

Table 12. Distribution of crows in various components of entire study area

Sr. No.	Habitat components	N	House Crow				Jungle Crow			
			F	F %	count	RA %	F	F %	count	RA %
1	Cropped Area	79	17	5.70	32	3.43	62	19.81	111	13.33
2	Commercial Building (A)	24	0	0.00	0	0.00	24	7.67	49	5.88
3	Livestock farm	20	3	1.01	11	1.18	18	5.75	39	4.68
4	Orchard	44	2	0.67	10	1.07	44	14.06	174	20.89
5	Poultry farm	6	4	1.34	12	1.28	6	1.92	10	1.20
6	Road side plantation (A)	79	34	11.41	80	8.57	47	15.02	79	9.48
7	Waste Dumping Area (Agri market waste)	3	3	1.01	17	1.82	0	0.00	0	0.00
8	Waste Dumping Area (Veg. food waste)	8	8	2.68	73	7.82	7	2.24	39	4.68
9	Waste Dumping Area (Non-Veg. at Agri. habitat)	16	12	4.03	114	12.21	15	4.79	151	18.13
10	Commercial Building (H)	4	4	1.34	10	1.07	0	0.00	0	0.00
11	Residential Area	221	157	52.68	371	39.72	74	23.64	154	18.49
12	Road side plantation (H)	55	48	16.11	189	20.24	13	4.15	21	2.52
13	Waste Dumping Area (Non-Veg. Residential)	6	6	2.01	15	1.61	3	0.96	6	0.72
	Total	565	298	100	934	100	313	100	833	100

Note: N = Total number of observations, F = Frequency of observation, RA = Relative Abundance,
Count = Total number of species individual counted

4.3 SIGNIFICANCE OF CROWS IN AVIAN ASSEMBLAGES DURING FARM OPERATIONS

Avian assemblages were recorded at different farm operations in given area during study period. Different farm operations on which avian assemblage were recorded for evaluating significance of crows is discussed and are listed hereunder.

- 4.3.1 Land Preparation (ploughing by cultivator, mouldboard plough and disc plough)
- 4.3.2 Green manuring
- 4.3.3 Sowing
- 4.3.4 Irrigation
- 4.3.5 Inter-culturing
- 4.3.6 Harvesting

This study was carried out during September 2011 to July 2012 in given area.

4.3.1 Land Preparation

Land preparation is the primary requirement for growing any crop in the field. It includes operations like tillage, harrowing and planking. Tillage can be done with the help of different implements *viz.,* cultivator, disk plough, mould board plough, chisel plough etc. Harrowing can be done by disk harrow along with disk ploughing and planking can be done with the help of planker along with cultivator during ploughing. Here, observation on avian assemblages during land preparation was divided into land leveling, disk ploughing, mould board ploughing and ploughing by cultivator.

4.3.1.1 Avian Assemblages During Cultivator Ploughing

Cultivator is the tool attach to tractor for secondary tillage before sowing new crop and to remove weed from fallow land (Sharma and Behera, 2008). Number of bird species observed during cultivator ploughing is given in Table 13.

Twenty five bird species were recorded during 60 observations on avian assemblage during cultivator ploughing operation. During cultivator ploughing, frequency of occurrence and relative abundance of Jungle Crow (4.98 % F, 2.09 % R. A.) and House Crow (0.31 % F, 0.04 % R. A.) were very low. Less numbers of crows observed during ploughing operation might not play significant role in reduction of insects exposed during cultivator ploughing. Cattle Egret was most frequent (18.07 %) and most abundant (43.30 %) followed by Common Myna (16.82 % F and 28.87 % R. A.) and Black Drongo (6.82 % F and 3.80 % R. A). Value of index of importance was also higher for Cattle Egret (30.7) and Common Myna (22.8) followed by Black Drongo (10.3) which indicated that these were the important species amongst all bird assemblage during cultivator ploughing.

Table 13. Bird community structure during ploughing operation done by cultivator

Cultivator Ploughing (n=60)							
Sr. No.	**Species**	**Scientific Name**	**F**	**%F**	**Count**	**%RA**	**I**
1	Cattle Egret	*Bubulcus ibis*	58	18.07	1095	43.30	30.7
2	Oriental White Ibis	*Threskiornis melanocephalus*	2	0.62	3	0.12	0.4
3	Black Ibis	*Pseudibis papillosa*	3	0.93	5	0.20	0.6
4	Red-wattled Lapwing	*Vanellus indicus*	13	4.05	31	1.23	2.6
5	Yellow-wattled Lapwing	*Vanellus malabaricus*	1	0.31	4	0.16	0.2
6	Blue Rock Pigeon	*Columba livia*	2	0.62	47	1.86	1.2
7	Eurasian Collared-Dove	*Streptopelia decaocto*	3	0.93	6	0.24	0.6
8	Spotted Dove	*Streptopelia chinensis*	1	0.31	2	0.08	0.2
9	White-breasted Kingfisher	*Halcyon smyrnensis*	11	3.43	12	0.47	2.0
10	Small Bee-eater	*Merops orientalis*	6	1.87	13	0.51	1.2
11	Indian Roller	*Coracias benghalensis*	10	3.12	11	0.43	1.8
12	Dusky Crag-Martin	*Hirundo concolor*	14	4.36	45	1.78	3.1
13	Common Swallow	*Hirundo rustica*	10	3.12	122	4.82	4.0
14	Red-rumped Swallow	*Hirundo daurica*	5	1.56	25	0.99	1.3
15	Black Drongo	*Dicrurus macrocercus*	54	16.82	96	3.80	10.3
16	Brahminy Starling	*Sturnus pagodarum*	16	4.98	46	1.82	3.4
17	Common Myna	*Acridotheres tristis*	54	16.82	730	28.87	22.8
18	Bank Myna	*Acridotheres ginginianus*	20	6.23	83	3.28	4.8
19	House Crow	*Corvus splendens*	1	0.31	1	0.04	0.2
20	Jungle Crow	*Corvus macrorhynchos*	16	4.98	56	2.21	3.6
21	Red-vented Bulbul	*Pycnonotus cafer*	2	0.62	3	0.12	0.4
22	Common Babbler	*Turdoides caudatus*	1	0.31	8	0.32	0.3
23	Jungle Babbler	*Turdoides striatus*	9	2.80	63	2.49	2.6
24	Indian Robin	*Saxicoloides fulicata*	8	2.49	16	0.63	1.6
25	House Sparrow	*Passer domesticus*	1	0.31	6	0.24	0.3
Toptal			**321**	**100**	**2679**	**100**	**100**
Note: n = number of observations, F = frequency of individual, RA = Relative Abundance, I =Index of Importance							

4.3.1.2 Avian Assemblages During Disk Ploughing

Disk plough is useful for preparatory tillage which includes the first cutting and inverting of the soil that is done after the harvest of the crop (turn around period) or untilled fallow or to bring virgin or new land under cultivation (Sharma and Behera, 2008). Number of bird species observed during disk ploughing operation is shown in Table 14. Total 18 bird species were recorded. During disk ploughing operation, frequency and relative abundance of Jungle Crow was 7.35 % and 1.81 % respectively and 1.47 % and 0.10 % respectively for House Crow (Table 14). During disk ploughing operation, very low number of both crows was recorded. However, frequency and relative abundance of Jungle Crows was more during disk ploughing compared to ploughing by cultivator. Bird species *viz.,* Cattle Egret (I = 31.86), Common Myna (I = 20.91) and Black Drongo (I = 8.51) were dominant species during disk ploughing.

4.3.1.3 Avian Assemblages During Mould Board Ploughing

Mould board plough is useful for preparatory tillage mainly for deep ploughing during summer and pre-monsoon season (Sharma and Behera, 2008). Number of bird species observed during mould board ploughing operation is shown in Table 15. Total 18 bird species were recorded. Amongst all bird species recorded, frequency and relative abundance of Jungle Crow and House Crow was very low 2.17 % and 0.17 % respectively (Table 15) and did not show significant population compared to other bird species. The Cattle Egret (I = 29.97), Common Myna (I = 12.92) and Black Drongo (I = 10.54) were important species during mould board ploughing operation.

Table 14. Bird community structure during disk ploughing

Disk Ploughing (n = 11)							
Sr.	Species	Scientific Name	F	%F	Count	%RA	I

No.							
1	Cattle Egret	*Bubulcus ibis*	11	16.18	473	47.54	31.86
2	Red-Wattled Lapwing	*Vanellus indicus*	2	2.94	3	0.3	1.62
3	Yellow-Wattled Lapwing	*Vanellus malabaricus*	1	1.47	2	0.2	0.84
4	White-breasted kingfisher	*Halcyon smyrnensis*	1	1.47	1	0.1	0.79
5	Small Bee-eater	*Merops orientalis*	1	1.47	1	0.1	0.79
6	Indian Roller	*Coracias benghalensis*	1	1.47	1	0.1	0.79
7	Dusky Crag Martin	*Hirundo concolor*	5	7.35	43	4.32	5.84
8	Common Swallow	*Hirundo rustica*	3	4.41	28	2.81	3.61
9	Red-Rumped Swallow	*Hirundo daurica*	5	7.35	40	4.02	5.69
10	Black Drongo	*Dicrurus macrocercus*	10	14.71	23	2.31	8.51
11	Brahminy Starling	*Sturnus pagodarum*	4	5.88	13	1.31	3.60
12	Common Myna	*Acridotheres tristis*	8	11.76	299	30.05	20.91
13	Bank Myna	*Acridotheres ginginianus*	5	7.35	32	3.22	5.29
14	House Crow	*Corvus splendens*	1	1.47	1	0.1	0.79
15	Jungle Crow	*Corvus macrorhynchos*	5	7.35	18	1.81	4.58
16	Red-Vented Bulbul	*Pycnonotus cafer*	1	1.47	2	0.2	0.84
17	Jungle Babbler	*Turdoides striatus*	3	4.41	13	1.31	2.86
18	Indian Robin	*Saxicoloides fulicata*	1	1.47	2	0.2	0.84
Total			**68**	**100**	**995**	**100**	**100**

Note: n = number of observations, F = frequency of individual, RA = Relative Abundance, I =Index of Importance

Table 15. Bird community structure during mould board ploughing

Mould Board Ploughing (n = 7)							
Sr. No.	**Species**	**Scientific Name**	**F**	**%F**	**Count**	**%RA**	**I**
1	Cattle Egret	*Bubulcus ibis*	6	13.04	128	46.89	29.97
2	Red-Wattled Lapwing	*Vanellus indicus*	1	2.17	1	0.37	1.27
3	White-breasted kingfisher	*Halcyon smyrnensis*	1	2.17	1	0.37	1.27
4	Small Bee-eater	*Merops orientalis*	1	2.17	1	0.37	1.27
5	Dusky Crag Martin	*Hirundo concolor*	2	4.35	17	6.23	5.29
6	Common Swallow	*Hirundo rustica*	1	2.17	14	5.13	3.65
7	Red-Rumped Swallow	*Hirundo daurica*	2	4.35	11	4.03	4.19
8	Black Drongo	*Dicrurus macrocercus*	7	15.22	16	5.86	10.54
9	Brahminy Starling	*Sturnus pagodarum*	3	6.52	6	2.2	4.36
10	Common Myna	*Acridotheres tristis*	7	15.22	29	10.62	12.92
11	Bank Myna	*Acridotheres ginginianus*	5	10.87	18	6.59	8.73
12	House Crow	*Corvus splendens*	1	2.17	2	0.73	1.45
13	Jungle Crow	*Corvus macrorhynchos*	1	2.17	1	0.37	1.27
14	Red-Vented Bulbul	*Pycnonotus cafer*	1	2.17	2	0.73	1.45
15	Jungle Babbler	*Turdoides striatus*	4	8.7	21	7.69	8.20
16	Indian Robin	*Saxicoloides fulicata*	3	6.52	5	1.83	4.18
Total			**46**	**100**	**273**	**100**	**100**
Note: n = number of observations, F = frequency of individual, RA = Relative Abundance, I =Index of Importance							

4.3.2 Avian Assemblages During Green Manuring

Use of Green manure crops in cropping system is called 'Green Manuring' where the crop is grown *in situ* or brought from outside and incorporated when it is purposely grown (Sharma and Behera, 2008). Only one observation on green manuring operation was recorded from given area. Bird community recorded during this operation is given in Table 16.

Total eight bird species were recorded during one observation of green manuring operation. Relative abundance of Jungle Crow was 2.94 % (Table 16). Common Myna (38.24 %) and Cattle Egret (36.76 %) were most dominant and important species with index of importance 25.37 and 24.63, respectively.

Table 16. Bird community structure during green manuring

Green manuring (n = 1)							
Sr. No.	**Species**	**Scientific Name**	**F**	**%F**	**Count**	**%RA**	**I**
1	Cattle Egret	*Bubulcus ibis*	1	12.5	25	36.76	24.63
2	Eurasian Collared Dove	*Streptopelia decaocto*	1	12.5	1	1.47	6.99
3	White-breasted kingfisher	*Halcyon smyrnensis*	1	12.5	1	1.47	6.99
4	Red-Rumped Swallow	*Hirundo daurica*	1	12.5	6	8.82	10.66
5	Black Drongo	*Dicrurus macrocercus*	1	12.5	2	2.94	7.72
6	Common Myna	*Acridotheres tristis*	1	12.5	26	38.24	25.37
7	Jungle Crow	*Corvus macrorhynchos*	1	12.5	2	2.94	7.72
8	Jungle Babbler	*Turdoides striatus*	1	12.5	5	7.35	9.93
Total			**8**	**100**	**68**	**100**	**100**
Note: n = number of observations, F = frequency of individual, RA = Relative Abundance, I =Index of Importance							

4.3.3 Avian Assemblages During Sowing

Avian assemblage observed during sowing operation is given in Table 17. Total 11 observations were recorded during sowing of various crops (food grain crops, vegetable crop, oil seed crop) and from that 17 bird species were recorded. Amongst all bird species, Jungle Crow was observed with 4.76 % frequency and 1.56 % relative abundance. A group of 7 Jungle Crows were recorded feeding upon groundnut during sowing and cause considerable loss of seed grains. Rock Pigeon (15.87 %) and

Eurasian Collared Dove (12.70 %) were observed to feed upon bajra seeds during sowing. On the basis of value of index of importance Blue rock pigeon (33.72) and Common Myna (10.09) were important species, Eurasian Collared Dove appeared in high frequency but with low relative abundance which reduces its index of importance.

Table 17. Bird community structure during sowing operation

Sowing (n = 11)							
Sr. No.	**Species**	**Scientific Name**	**F**	**%F**	**Count**	**%RA**	**I**
1	Cattle Egret	*Bubulcus ibis*	6	9.52	33	8.59	9.06
2	Oriental White Ibis	*Threskiornis melanocephalus*	3	4.76	7	1.82	3.29
3	Black Ibis	*Pseudibis papillosa*	5	7.94	20	5.21	6.58
4	Grey Francolin	*Francolinus pondicerianus*	1	1.59	2	0.52	1.06
5	Indian Peafowl	*Pavo cristatus*	2	3.17	4	1.04	2.11
6	Red-Wattled Lapwing	*Vanellus indicus*	5	7.94	11	2.86	5.40
7	Yellow-Wattled Lapwing	*Vanellus malabaricus*	1	1.59	1	0.26	0.93
8	Blue Rock Pigeon	*Columba livia*	10	15.87	198	51.56	33.72
9	Eurasian Collared Dove	*Streptopelia decaocto*	8	12.7	12	3.13	7.92
10	Spotted Dove	*Streptopelia chinensis*	2	3.17	7	1.82	2.50
11	Little Brown Dove	*Streptopelia senegalensis*	4	6.35	11	2.86	4.61
12	Black Drongo	*Dicrurus macrocercus*	4	6.35	7	1.82	4.09
13	Common Myna	*Acridotheres tristis*	5	7.94	47	12.24	10.09
14	Bank Myna	*Acridotheres ginginianus*	1	1.59	4	1.04	1.32
15	Jungle Crow	*Corvus macrorhynchos*	3	4.76	6	1.56	3.16
16	Jungle Babbler	*Turdoides striatus*	2	3.17	12	3.13	3.15
17	Indian Robin	*Saxicoloides fulicata*	1	1.59	2	0.52	1.06
	Total		**63**	**100**	**384**	**100**	**100**

Note: n = number of observations, F = frequency of individual, RA = Relative Abundance, I =Index of Importance

4.3.4 Avian Assemblages During Irrigation

The application of water to soil to assist in the production of crops, especially during stress periods (Sharma and Gangaiah, 2009). Avian assemblage during irrigation operation is given in Table 18. Out of 20 bird species, frequency of Jungle Crow and House Crow was 5.26 % and 2.63 % and relative abundance was 2.96 % and 0.42 % respectively. It indicates that during irrigation operation very small numbers of crows observed and do not play important role in predation of invertebrates from wet soil. Plate 3; (B) shows assemblage during irrigation operation in which no crow species were recorded. Cattle Egret (I = 26.42), Black Ibis (I = 18.64), Common Oriental White Ibis (I = 13.46) and Common Myna (I = 10.27) were most important bird species recorded during irrigation in the field

4.3.5 Avian Assemblages During Interculturing

Interculturing performed in standing crop for removing weeds from field with the help of hand hoe or tractor-drawn cultivator (Sharma and Gangaiah, 2009). Out of 6 bird species, Jungle Crow was observed at high frequency (20 %) and relative abundance (8.36 %) (Table 19).

Most interculturing operations were recorded from orchard habitats of a given area which had higher numbers of Jungle Crows. So, during interculturing in such areas, higher numbers of Jungle crows were observed feeding on invertebrates from soil with index of importance of 14.06. Other most abundant species recorded during interculturing were Cattle Egret (I = 51.34), Black Drongo (I = 15.07) and Common Myna (I = 14.06).

Table 18. Bird community structure during irrigation

Irrigation (n = 25)							
Sr. No.	**Species**	**Scientific Name**	**F**	**%F**	**Count**	**%RA**	**I**
1	Cattle Egret	*Bubulcus ibis*	23	20.18	309	32.66	26.42
2	Oriental White Ibis	*Threskiornis melanocephalus*	12	10.53	155	16.38	13.46
3	Black Ibis	*Pseudibis papillosa*	19	16.67	195	20.61	18.64
4	Indian Peafowl	*Pavo cristatus*	1	0.88	2	0.21	0.55
5	Red-Wattled Lapwing	*Vanellus indicus*	4	3.51	10	1.06	2.29
6	Yellow-Wattled Lapwing	*Vanellus malabaricus*	2	1.75	5	0.53	1.14
7	Blue Rock Pigeon	*Columba livia*	1	0.88	18	1.9	1.39
8	Little Brown Dove	*Streptopelia senegalensis*	1	0.88	2	0.21	0.55
9	Dusky Crag Martin	*Hirundo concolor*	1	0.88	10	1.06	0.97
10	Red-Rumped Swallow	*Hirundo daurica*	1	0.88	4	0.42	0.65
11	Black Drongo	*Dicrurus macrocercus*	11	9.65	23	2.43	6.04
12	Rosy Starling	*Sturnus roseus*	1	0.88	8	0.85	0.87
13	Common Myna	*Acridotheres tristis*	14	12.28	78	8.25	10.27
14	Bank Myna	*Acridotheres ginginianus*	1	0.88	8	0.85	0.87
15	House Crow	*Corvus splendens*	3	2.63	4	0.42	1.53
16	Jungle Crow	*Corvus macrorhynchos*	6	5.26	28	2.96	4.11
17	Jungle Babbler	*Turdoides striatus*	5	4.39	28	2.96	3.68
18	Ashy Prinia	*Prinia socialis*	1	0.88	1	0.11	0.50
19	Yellow Wagtail	*Motacilla flava*	6	5.26	53	5.6	5.43
20	Grey Wagtail	*Motacilla cinerea*	1	0.88	5	0.53	0.71
	Total		**114**	**100**	**946**	**100**	**100**

Note: n = number of observations, F = frequency of individual, RA = Relative Abundance, I =Index of Importance

Table 19. Bird community structure during interculturing

Interculturing (n = 12)							
Sr. No.	**Species**	**Scientific Name**	**F**	**%F**	**Count**	**%RA**	**I**
1	Cattle Egret	*Bubulcus ibis*	12	30	226	72.67	51.34
2	Red-Wattled Lapwing	*Vanellus indicus*	1	2.5	1	0.32	1.41
3	Black Drongo	*Dicrurus macrocercus*	10	25	16	5.14	15.07
4	Common Myna	*Acridotheres tristis*	7	17.5	33	10.61	14.06
5	Bank Myna	*Acridotheres ginginianus*	2	5	9	2.89	3.95
6	Jungle Crow	*Corvus macrorhynchos*	8	20	26	8.36	14.18
Total			**40**	**100**	**311**	**100**	**100**
Note: n = number of observations, F = frequency of individual, RA = Relative Abundance, I =Index of Importance							

4.3.6 Avian Assemblages During Harvesting

The operation of cutting, picking, plucking or digging, or combination of these for removing the useful part or economic part from the plants (Sharma and Gangaiah, 2009). Avian assemblage was recorded during harvesting of various crops from a given area. Total bird community structure and its frequency distribution along with relative abundance are given in Table 20.

Total 21 bird species were recorded during harvesting stage of various crops. Jungle Crow was observed only at one observation feeding on uprooted harvested groundnut with relative abundance of 0.95 % of the total bird community. During harvesting of paddy crop, three House Crows were recorded feeding on insects & other vertebrates exposed during harvesting but not from study area (Plate 3; (C). Black Drongo, Common Myna and Rock Pigeon occurred most frequently during harvesting of the grain crops with relative abundance of 5.51 %, 19.58 % and 12.17 % and Index of Importance value 9.19, 15.51 and 11.09, respectively.

Table 20. Bird community structure during harvesting

Harvesting (n = 11)							
Sr. No.	**Species**	**Scientific Name**	**F**	**%F**	**Count**	**%RA**	**I**
1	Cattle Egret	*Bubulcus ibis*	6	8.57	80	15.21	11.89
2	Black Ibis	*Pseudibis papillosa*	1	1.43	2	0.38	0.91
3	Blue Rock Pigeon	*Columba livia*	7	10	64	12.17	11.09
4	Eurasian Collared Dove	*Streptopelia decaocto*	3	4.29	5	0.95	2.62
5	Spotted Dove	*Streptopelia chinensis*	3	4.29	13	2.47	3.38
6	Little Brown Dove	*Streptopelia senegalensis*	4	5.71	10	1.9	3.81
7	Small Bee-eater	*Merops orientalis*	1	1.43	1	0.19	0.81
8	Dusky Crag Martin	*Hirundo concolor*	3	4.29	41	7.79	6.04
9	Common Swallow	*Acridotheres tristis*	4	5.71	30	5.7	5.71
10	Red-Rumped Swallow	*Pycnonotus cafer*	4	5.71	23	4.37	5.04
11	Black Drongo	*Dicrurus macrocercus*	9	12.86	29	5.51	9.19
12	Brahminy Starling	*Sturnus pagodarum*	1	1.43	3	0.57	1.00
13	Rosy Starling	*Sturnus roseus*	2	2.86	31	5.89	4.38
14	Common Myna	*Acridotheres tristis*	8	11.43	103	19.58	15.51
15	Bank Myna	*Acridotheres ginginianus*	3	4.29	22	4.18	4.24
16	Jungle Crow	*Corvus macrorhynchos*	1	1.43	5	0.95	1.19
17	Red-Vented Bulbul	*Pycnonotus cafer*	2	2.86	4	0.76	1.81
18	Jungle Babbler	*Turdoides striatus*	5	7.14	44	8.37	7.76
19	Yellow Wagtail	*Motacilla flava*	2	2.86	10	1.9	2.38
20	House Sparrow	*Passer domesticus*	1	1.43	6	1.14	1.29
Total			**70**	**100**	**526**	**100**	**100**

Note: n = number of observations, F = frequency of individual, RA = Relative Abundance, I =Index of Importance

4.3.7 Comparison of Avian Assemblages During Various Agricultural Operations

Table 21. Bird community structure during various agricultural operations

Species		House Crow			Jungle Crow		
Sr. No.	**Operation**	**F (%)**	**RA (%)**	**I**	**F (%)**	**RA (%)**	**I**
1	Cultivator ploughing	0.31	0.04	0.2	4.98	2.21	3.6
2	Disk ploughing	1.47	0.1	0.79	7.35	1.81	4.58
3	Mould board ploughing	2.17	0.73	1.45	2.17	0.37	1.27
4	Green manuring	0	0	0	12.5	2.94	7.72
5	Sowing	0	0	0	4.76	1.56	3.16
6	Irrigation	2.63	0.42	1.53	5.26	2.96	4.11
7	Interculturing	0	0	0	20	8.36	14.18
8	Harvesting	0	0	0	1.43	0.95	1.19
	Total	**6.58**	**1.29**	**3.97**	**58.45**	**21.16**	**39.81**
Note: n = number of observations, F = frequency of individual, RA = Relative Abundance, I =Index of Importance							

Jungle Crow was observed in all farm operations. House Crow was present in ploughing and irrigation operations but it was absent during green manuring, sowing, interculturing and harvesting operations. This might be due to distribution pattern of House Crow which was very low in agricultural habitat compared to the Jungle Crow. Index of importance of Jungle Crow (39.81) was greater compared to House Crow (3.97). Amongst all farm operations, interculturing (20 % F) and green manuring (12.5 % F) operations showed higher relative frequency of Jungle Crow compared to other farm operations even though Jungle crow did not show any significant role in reducing insect-pest population from fields (Table 21). More than 23 Jungle Crows were recorded during land preparation operation at horticultural farm in the study area (Plate 3; A).

4.3.8 Entire Result of Bird Community Structure During Farm Operations

Most of all observations on farm operations were recorded from Anand Agricultural University farms. This area was pre-dominated distributed by Jungle Crows, so in all farm operations except land leveling Jungle Crow was observed whereas House Crow was only observed during ploughing and irrigation operations recorded at nearby village. Except assemblage during sowing and harvesting, most important species recorded during all other farm operations were Cattle Egret, Black Drongo and Common Myna.

Very low numbers of Jungle Crows were noticed during farm operations. So it did not reveal its significant role as predator of insect pest during farm operations. In past, when insect pest population was higher in standing crops Jungle Crows were found preying upon the insect pest. Patel (1988) at AAU, Anand recorded that amongst different bird species preying on *Spodoptera litura*, Jungle Crow appeared in greater number (27) than House Crow (5), Common Myna (7) and Bank Myan (6).

Results of experiments carried out by All India Network Project on Agricultural Ornithology in different regions are shown as under (Table 22). Experiments reveled that before 14 years; number of House Crows recorded during irrigation (2.07 % R. A.) and tractor ploughing (8.99 % R. A.) were higher compared to Jungle Crow from same the study area at AAU, Anand (Anno., 1999). But now (year 2011-12) present study showed that House Crow numbers have vanished from agricultural habitat and have moved into urban residential area. So very low numbers of House Crows were observed during farm operations whereas relative abundance of Jungle Crow recorded higher during this study in year 2011-12 was high compared to previous years studies.

Table 22. List of experiments on relative abundance of crows during farm operation

Sr. No.	Report Name & Year	Farm operation	House Crow %R. A.	Jungle Crow %R. A.	Place
1	Biennial report (2007-09) ANGRAU, Hydrabad	Paddy sowing	18.50	0.00	PAU, Ludhiana
2	Biennial report (2007-09) ANGRAU, Hydrabad	Paddy harvesting	15.00	0.00	PAU, Ludhiana
3	Biennial report (2007-09) ANGRAU, Hydrabad	Wheat sowing	18.71	0.00	PAU, Ludhiana
4	Biennial report (2007-09) ANGRAU, Hydrabad	Wheat harvesting	15.00	0.00	PAU, Ludhiana
5	Annual report, AAU, Anand (1998)	Irrigation	2.07	0.14	AAU, Anand
6	Annual report, AAU, Anand (1998)	Tractor ploughing	8.99	4.83	AAU, Anand

Report of PAU, Ludhiana showed higher relative abundance of House Crow during sowing and harvesting of paddy and wheat. No Jungle Crow was recorded from same experiment. However, Verghese and Sriharan (1993) had recorded Jungle Crows following plough or tractors and feeding on exposed grubs of *Holotrichia spp.* and pupating larvae of *Spodoptera litura*. It appears that there are regional variations in the distribution of two crow species across the country and over the time period at same location.

4.4 NESTING ECOLOGY

Nesting ecology is the study of various nest parameters *viz*., nest site characters, nesting substrate characters, nest structure, nest position, nest diametric, along with ecological parameters related to breeding event like breeding season, schedule, and breeding performance and various factors influencing breeding activity.

Intensive survey was done at the University campus and surrounding villages for the identification of nest sites of Jungle Crow during February - May, 2011 and for House Crow during June – September, 2011. Whenever some resource person (field worker, assistant, school students, and village person) informed about the presence of crows at any site and their sighting in a particular area with nesting material, it was confirmed immediately by checking of all the trees thoroughly. If the crows were seen on a tree, all the branches of that particular tree were thoroughly checked with the help of binoculars to confirm nesting. Nearby trees were also thoroughly checked to confirm nesting. At the time of survey, single bird flying or calling gave a clue for its nesting or presence in the nearby area which was helpful to find its nest.

This study of nesting ecology is divided into two main sections:

1. Nest site characteristics

   Jungle Crow

   House Crow

2. Breeding ecology

   Jungle Crow

   House Crow

4.4.1 Nest Site Characteristics of Jungle Crow

Amongst two species of crows, Jungle Crow bred early during hot summer while House Crow bred during south-west monsoon. Jungle Crow distribution sites were identified first to search its nest sites. Total 36 active nests of Jungle Crow were recorded of which, 61.11 per cent nests were found in agricultural landscape and 38.89 per cent nests in residential area. This indicates that Jungle Crows prefer nesting sites in agricultural landscape, away from human habitation. Various nesting sites occupied by Jungle Crow are shown in Plate 4. Many of the nest platforms on trees and poles were too high and hence were difficult to examine.

4.4.1.1 Nesting Substrate Types and Preferences

Tree substrates used by Jungle Crow for the nesting purpose is shown in Table 23. Eighteen out of thirty tree species available in the study area were used for nesting purpose. Frequency of available and utilized trees is presented in Table 23.

Availability of mango (20.90 %) was maximum followed by neem (17.41 %), copperpod (6.97 %) and banyan tree (6.47 %). Mango utilization (28.57 %) was the highest followed by banyan tree (11.43 %) for the nesting purpose (Figure 2). This indicated that mango and banyan trees having dense foliage canopy cover were preferred for setting nest platform. Ivlev's selectivity index showed that peepal (0.70), was strongly preferred by Jungle Crow for nesting purpose whereas indian tree of heaven (0.49) and khejari and silver Oak (0.30) banyan (0.24), rain tree (0.23), ashok and lebbeck tree (0.18) and remaining all occupied trees were neither preferred nor avoided by Jungle Crow. Frequency of utilized trees almost matched with its availability in the environment. The amaltas, aonla, maulsari, bel, coconut, messmate, wild tamarind, cashew, neem, oil palm, sapota, devil tree and silk cotton were negatively preferred for nesting purpose. In other words, these trees were avoided for nesting purpose. The availability of Neem (17.41 %) was very high but it was never occupied probably due to short height and less density foliage on the tree.

4.4.1.2 Nest Location

Among thirty-six active nests of Jungle Crow recorded, thirty-five nest platforms (97.22 %) were on the tree while only one nest (2.78 %) was on the telecommunication tower. The nest platforms on the tree were classified in to three categories *viz*., primary, secondary and tertiary branches. There were 86.11 % on tertiary branch and 13.89 % nests on secondary branch whereas no nest was found on primary branch.

4.4.1.3 Nesting Tree and Nest Characters

The characteristics of nesting trees, nearest surrounding 5 trees of nesting site and nests of Jungle Crow are presented in Table 24.

Mean tree height of the nesting substrate was 14.27 ± 3.79 m ranging from 8.2 m to 23.4 m (n = 35). The circumference at breast height (CBH), canopy cover (measured as diameter of covered area), crown height and bole height of the nesting trees were 1.82 ± 1.30 m, 14.63 ± 6.71 m, 9.15 ± 3.78 m and 4.16 ± 2.88 m, respectively.

The distance of tree canopy over nest platform was 1.50 ± 1.07 (ranging from 0.20 m to 5.20 m, n=29). Most of the nests were present under high foliage density cover of trees.

Table 23. Frequency of utilized and available trees for nesting by Jungle Crow

Sr. No.	Common Name	Scientific Name	Utilized Tree		Available tree		Selectivity Index
			Num.	% R. A.	Num.	% R. A.	
1	Babool	*Acacia Arabica*	1	2.86	6	2.99	-0.02
2	Indian tree of heaven	*Ailanthus excelsa*	3	8.57	6	2.97	0.49
3	Ashok	*Polyalthia longifolia*	2	5.71	8	3.98	0.18
4	Banyan tree	*Ficus bengalensis*	4	11.43	13	6.47	0.28
5	Bottle palm	*Hypophorbe lagenicaulis*	2	5.71	12	5.97	-0.02
6	Gulmohar	*Delonix regia*	1	2.86	6	2.99	-0.02
7	Indian almond	*Terminalia catappa*	1	2.78	6	2.97	-0.03
8	Jamun	*Syzygium cumini*	1	2.78	5	2.49	0.06
9	Pongam tree	*Pongamia pinnata*	1	2.78	5	2.48	0.06
10	Khejari	*Prosopis cineraria*	1	2.78	3	1.49	0.30
11	Lebbek tree	*Albizia lebbeck*	1	2.78	4	1.99	0.17
12	Mango	*Mangiferae indica*	10	28.57	42	20.90	0.16
13	Peepal	*Ficus religiosa*	1	2.78	1	0.50	0.70
14	Rain tree	*Samanea saman*	2	5.56	7	3.48	0.23
15	Silver oak	*Grevillea robusta*	1	2.78	3	1.49	0.30
16	Copperpod	*Peltophorum pterocarpum*	2	5.56	14	6.97	-0.11
17	Tamarind	*Tamarindus indica*	1	2.78	3	1.49	0.30
18	Amaltas	*Cassia fistula*	-	-	1	0.50	-1.00
19	Aonla	*Phyllanthus emblica*	-	-	4	1.98	-1.00
20	Maulsari	*Mimusops elengi*	-	-	3	1.49	-1.00
21	Bel	*Aegle marmelos*	-	-	1	0.50	-1.00
22	Coconut	*Cocos nucifera*	-	-	1	0.50	-1.00
23	Messmate	*Eucalyptus oblique*	-	-	1	0.50	-1.00
24	Wild tamarind	*Leucaena leucocephala*		-	1	0.50	-1.00
25	Cashew	*Anacardium occidentale*	-	-	1	0.50	-1.00
26	Neem	*Azadirachta indica*	-	-	35	17.41	-1.00
27	Oil palm	*Elaeis oleifera*	-	-	1	0.50	-1.00
28	Sapota	*Achras sapota*	-	-	2	1.00	-1.00
29	Devil tree	*Alstonia scholaris*	-	-	2	0.99	-1.00
30	Silk cotton	*Bombax ceiba*	-	-	4	1.98	-1.00
Total			35	100	201	100	-
Note: RA= Relative Abundance							

Only one active nest was present on each nesting substrate. Mean number of extra nest platforms per active nests was 0.23 ± 0.42. There were 7 nesting sites which had extra nest platforms recorded on nearby tree or substrate at mean distance 13.6 ± 2.34 m ranging from 10 to 17 m. This indicated that there was at least 0.23 ± 0.42 extra platforms on the nearby tree and the Jungle Crow had sufficient scope of choice. Such behavior of Jungle Crow might be useful to escape from predator attack or it might have been prepared as trial nests for right choice of nest site. The mean nest height from the ground level was 12.57 ± 3.92 m (Table 23) when it nested on trees. A single nest observed on a telecom tower was at 24.60 m height above ground. Jungle Crow used dry wooden twigs for making nest platform.

The nest cavity was cup shaped with lining of plant fibers or animal hairs. The depth of nest depression was 0.15 ± 0.03 m (ranged from 0.10 to 0.22 m, n = 24). External and internal diameter of nest was 0.42 ± 0.04 m. and 0.15 ± 0.02 respectively. The circumference of branch on which nest platform was placed was 0.24 ± 0.14 m which ranged from 0.12 m to 0.65 m (n = 32). This shows that very thin branches of the tree were selected for nesting purpose.

Characters of the nearest 5 trees surrounding the nesting trees are presented in Table 25. Mean tree height of nesting tree (14.27 ± 3.79 m) was significantly higher than the surrounding trees (11.67 ± 3.17 m) ($t = 4.95$, $df = 214$, $P < 0.05$). The values of CBH, canopy cover and crown height were slightly lower in the surrounding trees as compared to the nesting trees however all these parameters showed significant difference when compared with "t" test ($t > 2.58$) (Table 25). The result showed that slightly taller and older trees with an availability of high density foliage cover were selected by the Jungle Crow for nesting purpose.

Table 25: Comparison of tree characteristics between occupied substrates and surrounding substrates for Jungle Crow

Tree Characteristics	Occupied Trees	Unoccupied Trees	Cal t	Result

	N	Mean ± S. D.	N	Mean ± S. D.		
Tree height (m)	35	14.27 ± 3.79	180	11.71 ± 3.11	4.35	S
CBH (m)	35	1.82 ± 1.30	180	1.43 ± 0.72	2.28	S
Canopy cover (m)	35	14.63 ± 6.71	180	11.91 ± 4.59	2.83	S
Crown height (m)	35	9.15 ± 3.78	180	8.14 ± 9.23	2.89	S
Bole height (m)	35	4.16 ± 2.88	180	3.75 ± 2.34	0.96	NS

Table T at 214 df = 2.58 P = 0.05
Note: NS = Non Significant, S = Significant

4.4.1.4 Comparison of Nest Site Characters Between Residential and Agricultural Area

A comparison of the characteristics of nesting trees and nests of Jungle Crow in residential and agricultural areas is presented in Table 26. All these characters of nest trees showed non-significant difference between residential and agriculture area when compared with “t” test ($t < 2.042$, df = 30, $P > 0.05$). The average tree height(15.25 ± 4 m), CBH (1.97 ± 1.42 m), canopy cover (16.03 ± 6.46 m) and crown height (9.65 ± 4.42 m) of residential area was numerically higher compared to the tree height (13.62 ± 3.59 m), CBH (1.71 ± 1.24), canopy cover (13.70 ± 6.86 m) and crown height (8.81 ± 3.37 m) in agriculture area but this difference was not significant. Only the bole height of nest tree in agricultural area was slightly higher compared to the residential area which might be attributed to the species specific characters of the trees available in respective area.

Table 24: Characteristics of Nest trees, Surrounding trees and Nests for Jungle Crow

Characteristics	N	Minimum	Maximum	Mean ± S. D.	S. E.	C. V. %
Tree						
Tree height (m)	35	8.2	23.4	14.27 ± 3.79	0.64	26.54
CBH (m)	35	0.74	6.15	1.82 ± 1.30	0.22	71.49
Canopy cover (as diameter of covered area) (m)	35	4.25	30.60	14.63 ± 6.71	1.13	45.83
Crown height (m)	35	1.85	18.25	9.15 ± 3.78	0.64	41.34
Bole height (m)	35	0.67	13.60	4.16 ± 2.88	0.48	69.22
Nest						
No. of nest platforms on tree (n)	35	1	1	1 ± 0		
Nest height (m)	35	6.20	20.40	12.22 ± 3.38	0.57	27.65
Nest depth (m)	24	0.10	0.22	0.15 ± 0.03	0.01	20.86
Nest External Diameter (m)	24	0.34	0.49	0.42 ± 0.04	0.01	9.25
Nest Internal Diameter (m)	24	0.11	0.19	0.15 ± 0.02	0.004	15.05
Circumference of Branch Nest (m)	32	0.12	0.65	0.24 ± 0.14	0.02	59.23
Distance from canopy (m)	29	0.20	5.20	1.50 ± 1.07	0.20	71.36
Surrounding trees						
Tree height (m)	180	4.60	20.20	11.67 ± 3.17	0.23	26.55
Canopy cover (m)	180	2.27	25.38	11.96 ± 4.74	0.35	38.53
CBH (m)	180	0.35	4.40	1.45 ± 0.77	0.06	50.43

Crown height (m)	180	0.35	13.60	3.72 ± 2.33	0.17	62.29
Bole height (m)	180	1.35	17.50	7.48 ± 3.01	0.22	40.13
Note: N = Total number of observations, S. E. = Standard Error, C. V. = Coefficient of Variance						

The non-significant difference in all the nest character parameters indicated that there was hardly any variation between these two areas which might be due to the presence of the same tree species on roadside plantation in both residential and agricultural area. Moreover, nest dimensions and characteristics of a species are not likely to change much between microhabitats unless there is significant difference in available nest material.

Table 26: Comparison of nest site characteristics between Residential and Agricultural Habitat of Jungle Crow

Characteristics	Residential Habitat		Agricultural Habitat		Cal t	Result
	N	Mean ± S. D.	N	Mean ± S. D.		
Trees						
Tree height (m)	14	15.25 ± 4	21	13.62 ± 3.59	1.75	NS
CBH (m)	14	1.97 ± 1.42	21	1.71 ± 1.24	0.81	NS
Canopy cover (m)	14	16.03 ± 6.46	21	13.70 ± 6.86	0.63	NS
Crown height (m)	14	9.65 ± 4.42	21	8.81 ± 3.37	0.64	NS
Bole height (m)	14	3.97 ± 2.25	21	4.28 ± 3.28	0.31	NS
Nests						
No. of nests on tree (n)	15	1 ± 0	21	1 ± 0	0	NS
Nest height (m)	14	12.56 ± 3.73	21	12.00 ± 3.2	1.03	NS
Nest depth (m)	9	0.15 ± 0.03	15	0.15 ± 0.03	0	NS
Top diameter (m)	9	0.41 ± 0.05	15	0.43 ± 0.03	1.24	NS
Bottom diameter (m)	9	0.14 ± 0.02	15	0.15 ± 0.02	1.17	NS
Distance from canopy (m)	12	1.42 ± 1.46	17	1.47 ± 0.04	0.18	NS
Circumference of tree branch on which nest present	14	0.23 ± 0.15	21	0.22 ± 0.14	0.31	NS
Table T at 30 d. f. = 2.042 P > 0.05 Note: NS = Non-Significant, Cal T = Calculated t value						

4.4.1.5 Character of Nesting Tree and Nest

Total eighteen tree species were used by Jungle Crow for nesting. Amongst them, mango was the most dominant tree species available. Average tree height of all occupied trees was 14.27 m (Table 27). Amongst them, rain tree (20.50 m) had highest tree height followed by peepal (20.10 m), copperpod (18.90 m) and lebbeck tree (17.20 m). The lowest tree height was recorded in pongam tree (10.80 m). A telecom tower of 42.60 m height was used on which nest was made at 24.60 m height above ground.

The average CBH of different plant species used by Jungle Crow was 1.82 m. The highest CBH was recorded in banyan (4.98 m) while lowest CBH was recorded in jamun (0.78 m). The highest tree canopy cover was recorded in banyan (27.38 m), rain tree (22.34 m), lebbeck tree (20.21) and peepal (14.65 m). The average tree canopy cover (as diameter of canopy area) in different plant species was 14.63 m. The highest nest height from ground level was observed on artificial structure (Telecom tower) (24.60 m) followed by rain tree (17.70 m), peepal (17.60 m), copperpod (15.90 m) and lebbeck tree (15.60 m) while lower nest height was observed in pongam tree (7.20 m). Average nest height from ground on trees was 12.22 m.

4.4.1.6 Other Nest Characters

Other characters like direction of the nest platform on tree, distance to next Jungle Crow nest and detactibility rank were important in the selection of the nest site.

The direction of nesting platform is an important parameter in the nest site selection by the birds. In the present study, 55.56 % nest platforms were in the east, 22.22 % nests were in west direction, 13.89 % nests had northern direction and only 8.33 % nests faced south.

The distance of next Jungle Crow nest is one of the important factors to study the territorial behavior of Jungle Crow. In the present study, mean distance of next Jungle Crow nest was 112.82 ± 63.13 m apart ranging from 20.50 m to 235.60 m. Jungle Crow had habit of defending a large territory and maintaining larger distance from another nests of same species. This kind of behavior may be developed to avoid competition for food while breeding. A regular spacing pattern implied that breeding pairs were defending space, and usually the space contained some resource(s) necessary for either successful breeding or survival.

If all resources were super abundant then, there would be little point in birds defending them. This means that competition for scarce resources was a crucial factor in the evolution of territoriality. The benefit of territoriality is that it resulted in owners having either more of a particular resource, or better quality resource, than they would otherwise have. The main resources which birds may defend in territories include food. In some species the resource could be space it self, since an increased distance between neighbors may reduce interference, cannibalism or predation (Perrins and Birkhead, 1983).

For determining the predation risks around the nests, detactibility rank was given to each nest based on its visibility from the ground level, ranging between 0 – 1. When a nest could not be detected, it's ranked zero and when detected with little efforts, it was ranked one. As the rank given to the nests increased, the predation risk increased. Amongst thirty-six nests, 66.67 % nests had rank zero indicating that they were almost safe against ground predators. Remaining 33.33 % nests had predation risk around the nests with a detactibility rank one. In fact Jungle Crow nests were very difficult to detect from the ground. Low nest detectibility was largely attributed to the fact that nests were made above 12.0 m height, just below the canopy. Moreover, trees having dense foliage were preferred for nesting. Hence, it was difficult to locate a nest from the ground.

Table 27: Characteristics of nest trees and nests of Jungle Crow in different species of trees

Sr. no.	Substrate Species	Scientific Name	Sample size (n)	Substrate Ht. (m)	Crown Ht. (m)	Bole Ht. (m)	CBH (m)	Canopy diameter (m)	Nest Ht. (m)
1	Babool	*Acacia Arabica*	1	14.00	4.13	2.80	1.15	12.15	12.80
2	Indian tree of heaven	*Aillanthus excels*	3	14.80 ± 3.82	7.66 ± 2.80	5.30 ± 1.35	1.42 ± 0.21	13.94 ± 5.75	12.07 ± 2.53
3	Ashok	*Polyalthia longifolia*	2	12.70 ± 5.80	8.45 ± 2.47	4.35 ± 3.46	1.23 ± 0.32	5.04 ± 1.11	9.90 ± 3.82
4	Banyan	*Ficus bengalensis*	4	16.83 ± 2.40	11.86 ± 2.77	3.64 ± 1.31	4.98 ± 1.33	27.38 ± 2.42	14.10 ± 2.96
5	Bottle Palm	*Hypophorbe lagenicaulis*	2	14.35 ± 0.35	4.60 ± 0.85	9.80 ± 0.57	1.46 ± 0.11	7.61 ± 1.57	9.90 ± 0.71
6	Gulmohar	*Delonix regia*	1	16.60	13.75	2.92	1.55	15.12	14.20
7	Indian Almond	*Terminalia catappa*	1	12.20	3.17	3.02	0.87	18.55	11.40
8	Jamun	*Syzygium cumini*	1	14.50	10.38	3.15	0.78	9.12	13.20
9	Pongam tree	*Pongamia pinnata*	1	10.80	7.20	2.30	1.17	12.35	7.20
10	Khejari	*Prosopis cineraria*	1	11.20	7.25	4.45	0.96	10.60	9.40
11	Lebbek Tree	*Albizia lebbeck*	1	17.20	10.85	8.60	1.48	20.21	15.60
12	Mango	*Mangiferae indica*	10	11.03 ± 2.43	8.44 ± 3.32	1.87 ± 0.89	1.46 ± 0.59	13.36 ± 3.85	10.31 ± 2.98
13	Peepal	*Ficus religiosa*	1	20.10	15.80	4.20	1.28	14.65	17.60
14	Rain tree	*Samanea saman*	2	20.50 ± 4.10	15.03 ± 4.56	4.80 ± 1.41	2.43 ± 0.32	22.34 ± 3.06	17.70 ± 3.82
15	Silver Oak	*Grevillea robusta*	1	13.60	6.20	7.20	1.18	6.15	11.80
16	Copperpod	*Peltophorum pterocarpum*	2	18.90 ± 2.40	9.68 ± 4.07	8.31 ± 7.48	1.43 ± 0.14	13.58 ± 6.26	15.90 ± 0.71
17	Tamarind	*Tamarindus indica*	1	14.40	11.20	3.20	1.32	11.15	12.10
	Mean			14.27 ± 3.79	9.15 ±3.78	4.16 ± 2.88	1.82 ± 1.30	14.63 ± 6.71	12.22 ± 3.38
Note: CBH = Circumference at Breast Height, Ht. = height									

Nest predation was the major cause of reproductive loss in birds (Ricklefs, 1969; Berry, 2001) and was considered a strong selective force in nest-site selection (Martin, 1988; 1998; Lloyd *et al*., 2000). Most birds had a wide variety of potential nest sites to select from (Sakai and Noon, 1991) and the commonly selected nest sites that reduced the probability of clutch predation. In the present study, high predation risk around the nests was observed. Loss of entire clutch or brood was frequently noted.

Distance of JC nest from Human habitation, Animal shed, Garbage/waste dump site, Water source/wetland are also important factors influencing nest site selection by Jungle Crow. Average distance of J. C. nest from human habitation was 72.94 ± 66.30 m ranging from 7 to 213.25 m (n=37). It indicates that Jungle Crow preferred nest site, away from human habitation, in distant high tree covered area. Distance of animal shed was 216.27 ± 176.17 m ranging from 10.49 to 535.21 m (n=31), while distance of garbage or waste dump site and water source were 90.62 ± 67.40 m (R: 7.10 m – 278.47 m; n=37) and 58.67 ± 58.96 m (R: 7.10 ± 273.25 m; n=37) respectively (Table 28).

Table 28 Distance of Jungle Crow nest from Human habitation, Animal shed, Garbage waste dump site and Wetland/Water source

Distance from J. C. nest	Minimum	Maximum	Mean ± S. D.	S. E.	C. V. %
Human Habitation	7	213.25	72.94 ± 66.30	11.15	90.89
Animal Shed	10.49	535.21	216.27 ± 176.17	32.16	81.46
Garbage/ Waste dump site	7.10	278.47	90.62 ± 67.40	11.23	74.38
Water source/ Wetland	7.10	273.25	58.67 ± 58.96	9.83	100.50
Note: N = Total number of observations, S. E. = Standard Error, C. V. = Coefficient of Variance					

Amongst thirty-six nest sites, only at nine locations (25 %) people were not tolerant to the nesting pair while, at all other locations they had no objection toward the nesting pair. A pair of Jungle Crow nesting in a farm (Mogri) used to attack eggs and chicks of Black Ibis nesting on same tree and occasionally to the owner of the farm. Anoid by the crow's behavior, the owner had chopped off the branch on which Jungle Crow nest was present.

The result of nest site character of Jungle Crow showed that, if the area having tall trees with high density of foliage and away from human residency available then such area can be utilized by Jungle Crow for nesting purpose.

4.4.2 Nest Site Characteristics of House Crow

House Crow distribution sites were identified in study area and nest searching was started from late May to September 2011 (Pre-monsoon & monsoon season). Most of nests (98.67 %) of House Crow were found in residential area whereas agricultural landscape had only 1 nest (1.33 %). This indicated that House Crows preferred nesting sites in the human inhabited area. Various nesting sites occupied by House Crow are shown in Plate 4. Some of the nest platforms on trees and poles were too high and it was difficult to examine.

4.4.2.1 Nesting Substrate Types and Preferences

House Crow utilized natural substrates (trees) as well as artificial substrates (Banner pole, electric pole, telecommunication tower, etc) for nesting. House Crow utilized sixteen tree species for nesting purpose out of twenty five species available in the study area. Frequency of available and utilized trees is presented in Table 29.

Availability of neem (21.20 %) was maximum followed by copperpod (12.72 %), babool (11.72 %) and rain tree (9.98 %). Among all available substrates, banyan & copperpod (13.85 %) utilization for the nesting purpose was the highest followed by babool & raintree (10.77 %) (Figure 3). Ivlev's selectivity index showed that lebbeck tree (0.72) was strongly preferred whereas cluster fig (0.47), tooth brush tree (0.47), banyan (0.41), indian tree of heaven (0.38) and mango (0.35) were positively selected; their utilization was slightly higher than the proportion of their availability. The amaltas, tamarind, subabool, indian almond, maulsari, pongam tree, mahudo, khejari and mulberry were strongly negatively preferred for nesting purpose. In other words, these trees were avoided for nesting purpose. Normally a thin vertical fork near the top, or on one of the outermost branches of any larger tree, like *Dalbergia sisoo*, *Acacia arabica*, *Tamarindus indicus*, *Azadirachta indica* or *Ficus sp.* was a favourite site (Lamba, 1976). Figure 3 shows a comparison of relative abundance of trees available and those utilized for nesting by House Crow. House Crow also utilized various artificial structures like banner pole, electric wire pole, telecommunication tower etc. for nesting purpose. Ten nests (13.33 %) of House Crow were found on artificial structures. There were four telecommunication towers present in the area and all were utilized by House Crow as nesting sites.

4.4.2.2 Nest Location

Among 75 nests of House Crow, 13.33 % nests were observed on tower / poles whereas 86.67 % nests were on trees. Location of nest platforms on tree was classified in to three categories viz., primary, secondary and tertiary branch. Most of the nests (74.67 %) were on tertiary branch but primary branch (17.33 %) and secondary branches (8.00 %) were also utilized for placing nest platform.

4.4.2.3 Nesting Tree and Nest Characters

The characteristics of nesting trees, nests and characteristics of the nearest surrounding trees of nesting site are presented in Table 30.

The mean tree height of the nesting substrate was 11.45 ± 4.71 m ranging from 4.2 m to 30.50 m (n=65). The circumference at breast height (CBH), canopy cover, crown height and bole height of the nesting trees were 1.57 ± 1.8 m (n=65), 11.43 ± 5.20 m (n=65), 7.71 ± 3.25 m (n=65) and 3.71 ± 2.80 m (n=65), respectively.

The distance from canopy of nest platform on tree was 2.41 ± 1.87 m (ranging from 0.4 m to 7.2 m, n=65). Most House Crow nests were present with canopy cover over nest platform. However, the canopy was not dense and hence the nest was always visible from ground and often directly exposed to sunlight. Besides active nest, an extra nest platform was present on each nesting substrate.

Table 29: Nesting tree species preference and utilization by House Crow

Sr. No.	Common Name	Scientific Name	Utilized Tree		Available tree		Selectivity Index
			No.	R. A. %	No.	R. A. %	
1	Babool	*Acacia Arabica*	7	10.77	47	11.72	-0.04
2	Indian tree of heaven	*Ailanthus excelsa*	5	7.69	14	3.49	0.38
3	Cluster fig	*Ficus racemosa*	4	6.15	9	2.24	0.47
4	Banyan	*Ficus bengalensis*	9	13.85	23	5.74	0.41
5	Messmate	*Eucalyptus oblique*	3	4.62	17	3.93	0.08
6	Goldmohr	*Delonix regia*	1	1.54	14	3.49	-0.39
7	Jamun	*Syzygium cumini*	1	1.54	8	2.00	-0.13
8	Lebbek Tree	*Albizia lebbeck*	1	1.54	1	0.25	0.72
9	Mango	*Mangiferae indica*	1	1.54	3	0.75	0.35
10	Neem	*Azadirachta indica*	8	12.31	85	21.20	-0.27
11	Peeple	*Ficus religiosa*	4	6.15	16	3.99	0.21
12	Ashok	*Polyalthia longifolia*	1	1.54	11	2.74	-0.28
13	Tooth brush tree	*Salvadora persica*	1	1.54	3	0.56	0.47
14	Rain tree	*Samanea saman*	7	10.77	40	9.98	0.04
15	Devil tree	*Alstonia scholaris*	3	4.62	30	7.48	-0.24
16	Copperpod	*Peltophorum pterocarpum*	9	13.85	51	12.72	0.04
17	Amaltas	*Cassia fistula*	-	-	2	0.56	-1.00
18	Tamarind	*Tamarindus indica*	-	-	4	1.00	-1.00
19	Subabool	*Leucaena leucocephala*	-	-	8	2.00	-1.00
20	Indian almond	*Terminalia catappa*	-	-	2	0.56	-1.00
21	Maulsari	*Mimusops elengi*	-	-	1	0.28	-1.00
22	Pongam tree	*Pongamia pinnata*	-	-	8	2.00	-1.00
23	Mahudo	*Mathuca indica*	-	-	1	0.28	-1.00
24	Khejari	*Prosopis cineraria*	-	-	2	0.56	-1.00
25	Mulberry	*Morus alba*	-	-	1	0.28	-1.00
	Total		65	100	401	100	-

Note: R. A. = Relative Abundance

The mean number of nest platforms present on the tree was 1.72 ± 1.42 (ranging from 1 to 6). At some nesting sites (n=16), extra nest platforms were recorded on same or nearby nesting tree or substrate. This indicated that there was at least one extra platform on the nearby tree and the House Crow had sufficient scope of choice. Probably the crow made a fresh nest every season and that empty platform on same substrate may be old one of previous season. Sometime, House Crow used nest material from old nest to make a fresh nest.

The mean nest height from the ground level was 8.85 ± 3.82 m (Table 4.7) which ranged from 3.1 m to 18.40 m (n =65). Internal nest cavity was cup shape and was lined with plant fiber, cotton or plastic threads. The House Crow also used plastic or metal wires to make nest platform (Plate 5).The depth of nest was 0.14 ± 0.10 m (ranged from 0.08 to 0.80 m, n =46). External and internal diameter of nest was 0.37 ± 0.02 m. and 0.13 ± 0.02 m (n=46) respectively. The circumference of branch on which nest platform was made was 0.23 ± 0.25 m which ranged from 0.05 m to 1.5 m (n = 62).

Characters of the nearest 5 trees surrounding the nesting trees are presented in Table 31. Mean height of nearest tree was 10.04 ± 4.12 m which ranged from 2.7 m to 30.5 m (n = 339) and it was lower as compared to the nesting tree height (11.45± 4.71). Difference in mean tree height of nesting and surrounding trees were statistically significant ($t = 2.42$, $df = 402$, $P < 0.05$) when compared with paired “t” test (Table 31). The values of CBH, canopy cover and crown height were slightly lower in the surrounding trees as compared to the nesting trees and all these parameters showed significant difference when compared by “t” test ($t > 2.58$) (Table 31). Only Values of mean Bole height of nesting and surrounding trees were non-significant when compared with t test (0.198).

Table 31: Comparison of tree characteristics between occupied substrates and surrounding trees for House Crow

Tree Characteristics	Occupied Trees		Surrounding Trees		Cal t	Result
	N	Mean ± S. D.	N	Mean ± S. D.		
Tree height (m)	65	11.45± 4.71	339	10.04 ± 4.12	2.42	S
CBH (m)	65	1.57 ± 1.78	337	0.97 ± 0.71	4.06	S
Canopy cover (m)	65	11.43 ± 5.2	337	9.9 ± 4.5	2.39	S
Crown height (m)	65	7.71 ± 3.25	337	6.3 ± 2.7	4.06	S
Bole height (m)	65	3.71 ± 2.8	337	3.7 ± 2.4	0.198	NS

Table T at 402 df = 2.42 P = 0.05
Note: NS = Non Significant, S = Significant

4.4.2.4 Comparison of Nest Site between Residential and Agricultural Area

All House Crow nests were present in residential area except one which was present in agricultural landscape but it was also very close to human habitation. The name of House Crow itself indicates that they are present only if human house is present in a given area.

4.4.2.5 Characters of Nesting Tree and Nest

Characters of trees used by House Crow are given in Table 32. Total sixteen tree species were used by House Crow for nesting. Mean tree height of all occupied trees was 11.45m (Table 32). Amongst them, ashok (18.6 m) had highest tree height followed by lebbeck (16.8 m), messmate (23.23 ± 6.37 m), indian tree of heaven (16.64 ± 1.65 m) and peepal (13.50 ± 2.19 m). The lowest tree height was recorded in babool (7.15± 0.55 m). Average height of artificial structures was 29.49 m (Ranging from 8.2 to 44.4 m) on which nests were made at 21.14 m (Ranging from 5.0 to 37.8 m) height above ground.

Table 30: Characteristics of nest trees, surrounding trees and nests of House Crow

Characteristics	N	Minimum	Maximum	Mean ± S. D.	S. E.	C. V. %
Tree						
Tree height (m)	65	4.2	30.50	11.45± 4.71		39.55
CBH (m)	65	0.22	6.8	1.57 ± 1.78	0.22	113.08
Canopy cover (m)	65	1.20	20.87	11.43 ± 5.20	0.65	45.53
Crown height (m)	65	2.6	20.30	7.71 ± 3.25	0.39	40.58
Bole height (m)	65	0.50	10.40	3.71 ± 2.80	0.35	74.53
Nest						
No. of nest platforms on tree (n)	65	1	6			
Nest height (m)	65	3.10	18.40	8.85 ± 3.82		42.58
Nest depth (m)	46	0.08	0.80	0.14 ± 0.10	0.015	72.06
Nest External Diameter (m)	46	0.32	0.42	0.37 ± 0.02	0.004	7.63
Nest Internal Diameter (m)	46	0.10	0.16	0.13 ± 0.02	0.002	14.78
Circumference of Branch Nest (m)	59	0.05	0.3	0.10 ± 0.13	0.03	131.50
Distance from canopy (m)	65	0.4	7.2	2.41 ± 1.87	0.20	102.3
Surrounding trees						
Tree height (m)	339	2.7	35	10 ± 4.4	0.24	43.30
CBH (m)	337	0.20	3.8	0.97 ± 0.71	0.04	73.23
Canopy cover (m)	337	0.55	22	9.9 ± 4.5	0.25	45.31
Crown height (m)	337	0.88	20	6.3 ± 2.7	0.15	43.04
Bole height (m)	337	0.45	12	3.7 ± 2.4	0.13	65.88
Note: N = Total number of observations, S. E. = Standard Error, C. V. = Coefficient of Variance						

Average value of CBH of plant species used by House Crow was 1.57 m. The highest CBH was recorded in banyan (5.02 ± 2.22 m) while lowest CBH was recorded in jamun and tooth brush tree (0.48 m). The highest tree canopy cover was recorded in lebbeck tree (15.28 m), rain tree (16.25 ± 3.15 m), mango (15.17 m) and banyan (16.99 ± 6.88 m). The average tree canopy diameter (it was diameter of circumference of tree canopy measured at 1200 hrs. by putting up a string on the periphery of the canopy shadow) in different plant species was 11.43 m. The highest nest height from ground level was observed on messmate (16.87 ± 1.50 m), indian tree of heaven (13.46 ± 2.41 m) while lower nest height was observed in gulmohar (6.6 m). Average nest height from ground was 8.93 m.

4.4.2.6 Other Nest Characters

Other characters like direction of the nest platform, detactibility rank and distance to next House Crow nest were important in the selection of the nest site by House Crow.

The direction of nesting platform is an important parameter in the nest site selection by the birds. In present study, 36.99 % nest platforms were in the north, 28.77 % nests were in east direction, 21.92 % nests had southern direction and only 9 % nests faced west. In the present study, more number of nests was facing Northern followed by East direction. Frequency of nest distribution in four directions was significantly different from expected nest frequency ($\chi^2 = 8.67$, df = 3, $P < 0.05$), however, there is no obvious reason for such difference.

Sr. no.	Substrate Species	Scientific Name	Sample size (n)	Substrate Ht. (m)	Crown Ht. (m)	Bole Ht. (m)	CBH (m)	Canopy diameter (m)	Nest Ht. (m)
1	Babool	*Acacia Arabica*	7	7.15± 0.55	4.84 ± 1.26	2.29 ± 0.80	0.57 ± 0.30	8.31 ± 0.89	7 ± 1.11
2	Indian tree of heaven	*Ailanthus excels*	5	16.64 ± 1.65	7.64 ± 1.06	8.88 ± 2.41	1.55 ± 0.58	12.28 ± 2.67	13.46 ± 2.41
3	Cluster fig	*Ficus racemosa*	4	10.65 ± 2.64	7.54 ± 1.57	3.32 ± 1.53	0.76 ± 0.35	9.03 ± 2.74	8.70 ± 3.04
4	Banyan	*Ficus bengalensis*	9	11.18 ± 3.85	9.71 ± 3.81	2.20 ± 0.46	5.02 ± 2.22	16.99 ± 6.88	6.59 ± 2.48
5	Messmate	*Eucalyptus oblique*	3	23.23 ± 6.37	13.57 ± 5.83	9.40 ± 1.56	0.67 ± 0.58	1.84 ± 0.81	16.87 ± 1.50
6	Gulmohar	*Delonix regia*	1	7.6	5.7	1.9	0.58	10.62	6.6
7	Jamun	*Syzygium cumini*	1	11.2	6.4	4.8	0.48	9.2	10.8
8	Lebbek Tree	*Albizia lebbeck*	1	16.8	8.6	7.2	1.98	15.28	15.5
9	Mango	*Mangiferae indica*	1	13.6	6.8	6.8	1.48	15.17	10.4
10	Neem	*Azadirachta indica*	8	10.25 ± 3.97	6.67 ± 3.05	3.56 ± 1.95	1.08 ± 0.61	10.99 ± 3.74	7.26 ± 3.52
11	Peepal	*Ficus religiosa*	4	13.50 ± 2.19	6.84 ± 2.57	6.11 ± 2.12	1.38 ± 0.37	11.51 ± 2.77	10.38 ± 2.09
12	Ashok	*Polyalthia longifolia*	1	18.6	13	5.6	0.73	1.2	17.8
13	Tooth Brush tree	*Salvadora persica*	1	8.6	8.1	6.5	0.48	10.35	8.4
14	Rain tree	*Samanea saman*	7	12.89 ±1.19	10.40 ± 0.97	1.94 ± 2.15	1.47 ± 0.46	16.25 ± 3.15	9.33 ± 3.20
15	Devil tree	*Alstonia scholaris*	3	6.40 ±1.80	4.60 ± 1.15	1.74 ± 0.65	0.49 ± 0.15	5.71 ± 0.43	5.87 ± 1.81
[illegible]	[illegible]	*Peltophorum*	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible] 2.86
									3.80

✍……………………………………………………………………………………………………Results & Discussion

Table 32: Characteristics of nest trees and nests of House Crow in different species of trees

For determining the predation risks around the nests, detactibility rank was given to each nest based on its visibility from the ground level. Ranking 0 – 1, increasing rank show greater predation risk. Amongst thirty-six nests, 6.67 % nests had zero rank indicating that they were almost safe against ground predators. Remaining 93.33 % nests had predation risk around the nests with a detactibility rank one (Figure 3). In fact House Crow nests were very easily detected from the ground.

The distance of next House Crow nest is one of the important factors to study the territorial behavior of House Crow. In the present study, mean distance of next House Crow nest was 49.07 ± 84.39 m apart ranging from 2.5 to 111.93 m. In some large trees, two or three active nests were recorded, which indicates that they are not territorial while breeding. House Crow maintained small territory against conspecifics while breeding. This kind of behavior may be developed to form colony of crows at nest site for combined defense.

Distance of House Crow nest from Human habitation, Garbage/waste dump site, Water source/wetland are also important factors influencing nest site selection by House Crow. Average distance of House Crow nest from human habitation was 26.59 ± 29.42 m ranging from 8.43 to 178.45 m (n=37). It indicates that House Crow prefer nest site, close to human habitation. Distance of garbage or waste dump site and water source were 37.59 ± 41.25 m (R: 3.83 m – 204.77 m; n=) & 28.62 ± 28.77 m (R: 3.10 – 61.88 m; n=37) respectively (Table 33).

Table 33. Distance of House Crow nest from Human habitation, Animal shed, Garbage waste dump site and Wetland/Water source

Distance from H. C. nest	Sample Size (n)	Minimum	Maximum	Mean ± S. D.	S. E.	C. V. %
Human Habitation	73	8.43	178.45	26.59 ± 29.42	3.44	110.66
Garbage/ Waste dump site	72	3.83	204.77	37.59 ± 41.25	4.86	109.75
Water source/ Wetland	61	3.1	61.88	28.62 ± 28.77	3.68	100.54

Note: N = Total number of observations, S. E. = Standard Error, C. V. = Coefficient of Variance

Amongst seventy five nest sites, only at ten locations, people were not tolerant to the nesting pair while, at all other locations people had no objection toward the nesting pair. At one nesting site in Ismailnagar (Anand), House Crow became aggressive after fall of their chick on ground which was picked up by a child. The crow family became aggressive and started attacking family members present near the nesting site. To get rid of aggressive crow pair, owner of the tree cut down all the branches of tree on which House Crow nesting.

4.4.3 Comparison of Nest Site Characteristics of Jungle Crow & House Crow

4.4.3.1 Nest site of Crows

The Jungle Crow showed tendency to nest in agricultural area (61.11 % nests) whereas House Crow showed preference to nest exclusively in residential habitat (98.67 %). On the other hand, Jungle Crow nests were occasionally observed in residential area and House Crow nests were rare in agricultural areas (Table 34). This indicates that Jungle Crow preferred areas having more tree cover and less human habitation whereas House Crows preferred areas closer to human being and also used man-made structures for nesting purpose.

Table 34. Jungle Crow & House Crow nest distribution in agricultural & residential habitat during breeding season 2011

Habitat	Per cent nests of Jungle Crow in area	Per cent nests of House Crow in area
Agricultural	61.11	1.33
Residential	38.89	98.67

4.4.3.2 Nest Location

Both crow species utilized trees and artificial structures for setting up of nest platform with different frequencies. Jungle Crow preferred trees (97.22 %) for nesting and occasionally utilized artificial structure (2.78 %). House Crow utilized artificial structures (13.33 %) in higher frequency compared to Jungle Crow (2.78 %) (Table 35). Placement of nest platforms on tree substrate was classified in to three categories *viz*., primary, secondary and tertiary branches. Both Jungle Crow (86.11 % nests) and House Crow (74.67 %) largely used tertiary branches for setting up their nest platform. The House Crow used both primary and secondary branches for nesting but the Jungle Crow never used primary branches for nesting but built 13.89 % nests on secondary branch (Table 35).

Table 35. Substrate utilization by crows

Substrate utilized for nest location	% nests of Jungle Crow	% nests of House Crow
Trees	97.22	86.67
Artificial structure	2.78	13.33
Location of nest platforms on tree substrate		
Primary branch	0	17.33
Secondary branch	13.89	8.00
Tertiary branch	86.11	74.67

4.4.3.3 Nesting Substrate Types & Preferences of Crows

Tree species used by Jungle Crow and House Crow were Eighteen and sixteen respectively. Mango and banyan trees were most utilized by Jungle Crow whereas copper pod, banyan tree, babool and rain tree were more utilized by House Crow in the study area. Tree species used by the crows in respective habitat were largely those which were available.

4.4.3.4 Comparison of Nesting tree & Nest Characters

Characteristics of nesting trees and nests of both crow species are presented in Table 36. Tree height (14.27 ± 3.79 m) and canopy cover (14.63 ± 6.71 m) of Jungle Crow nesting trees were significantly higher compared to tree height (11.45 ± 4.71 m) and canopy cover (11.43 ± 5.20 m) of House Crow nesting trees. The average CBH, crown height and bole height of nesting trees occupied by Jungle Crow were numerically higher compared to trees occupied by House Crow but this difference was statistically non-significant (Table 36). Nest height of Jungle Crow nests was significantly higher compared to House Crow nests ($t = 4.297$, $df = 98$, $P < 0.05$). The

Jungle Crow preferred to set nest platform at more heights than House Crow probably to avoid predator attack. Moreover, in residential areas (urban area of Anand city), tree dimensions were lower than the agricultural area. This also shows adaptations of House Crow to human habitation. Size of nest platform of Jungle Crow was also larger compared to House Crow nest and showed significant difference when compared with‘t’ test ($t = 6.924$, $df = 66$, $P < 0.05$). Jungle Crows preferred to make large nest platforms as their body size is larger than House Crow. Distance of canopy cover over the nest of House Crow (2.41 ± 1.87 m) was higher compared to nest of Jungle Crow (1.50 ± 1.07 m). The risk of avian predators and extreme environmental conditions was more in House Crow nest than the nests of Jungle Crow.

Table 36. Comparison of nesting tree & nest characters of both crow species

Characteristics	Jungle Crow Nesting Trees		House Crow Nesting Trees		Cal t	Results
Tree						
Tree height (m)	35	14.27 ± 3.79	65	11.45± 4.71	2.93	S
CBH (m)	35	1.82 ± 1.30	65	1.57 ± 1.78	0.72	NS
Canopy cover (as diameter of covered area) (m)	35	14.63 ± 6.71	65	11.43 ± 5.20	2.65	S
Crown height (m)	35	9.15 ± 3.78	65	7.71 ± 3.25	1.86	NS
Bole height (m)	35	4.16 ± 2.88	65	3.71 ± 2.80	0.68	NS
Nest						
No. of nest platforms on tree (n)	35	1 ± 0	65			
Nest height (m)	35	12.22 ± 3.38	65	8.85 ± 3.82	4.29	S
Nest depth (m)	24	0.15 ± 0.03	46	0.14 ± 0.10	0.18	NS
Nest External Diameter (m)	24	0.42 ± 0.04	44	0.37 ± 0.02	6.92	S
Nest Internal Diameter (m)	24	0.15 ± 0.02	44	0.13 ± 0.02	3.02	S
Circumference of Branch Nest (m)	32	0.24 ± 0.14	59	0.10 ± 0.13	1.76	NS
Distance from canopy (m)	29	1.50 ± 1.07	65	2.41 ± 1.87	3.18	S
Table T at 30 d. f. = 2.042 P > 0.05 Note: NS = Non-Significant, S = Significant, Cal T = Calculated t value						

4.4.3.5 Comparison of Other Nest Characters

Detectability rank is important nest site characters in defining risk potential from ground predators to the species. Table values indicate that House Crow nests can easily be detected from ground and also had higher risk potential from ground predators compared to Jungle Crow nests (Table 37). In fact, threat from ground predators is very low in residential area compared to the agricultural habitat.

Table 37. Comparison of detectibility rank between nests of both species of crows

D rank	% JC nests	% HC nests
0	66.67	6.67
1	33.33	93.33
Note: D = Detectibility rank		

Inter-nest distance of same species is important in character of territoriality in crows. Amongst both the species of crows, inter-nest distance was significantly higher in the Jungle Crow (112.82 ± 63.13 m) compared to House Crow (49.07 ± 84.39 m) ($t = 3.521$, $df = 99$, $P < 0.05$). This indicates Jungle Crow possess larger territorial area than House Crow, to avoid competition among same species. In House Crow, 2 or 3 active nests on the same tree were seen but such condition was never seen in Jungle Crow.

Distance of crow nest from human habitation, garbage / dumping site and water / wetland site are important characters for selection of nesting sites by crows.

Distance of Jungle Crow nest from human habitation (72.94 ± 66.30 m) was significantly larger compared to House Crow (26.59 ± 29.42 m) ($t = 5.06$, $df = 107$, $P < 0.05$). That indicates more affinity of House Crows to nest close to human habitation.

Distances of House Crow nest from garbage (37.59 ± 41.25 m) and water source (28.62 ± 28.77 m) were significantly lower compared to Jungle Crow (90.62 ± 67.40 m; 58.67 ± 58.96 m) (t = 5.05, df = 106, P > 0.05). It implies that House Crows preferred more garbage and dumping sites as food source and prepared their nests near such area. The Jungle Crow nests were far away from such waste dump sites (Table 38), which indicates lesser dependency.

Table 38. Distances of crow nest from Human habitation, Garbage / dumping site, wetland / water source

Parameters	Distance from crow nests (m)					
	N	Jungle Crow nest	N	House Crow Nest	Cal t	Result
Human Habitation	36	72.94 ± 66.30	73	26.59 ± 29.42	5.06	S
Garbage/ Waste dump site	36	90.62 ± 67.40	72	37.59 ± 41.25	5.05	S
Water source/ Wetland	36	58.67 ± 58.96	61	28.62 ± 28.77	3.36	S
Note: N = total number of observations						

4.4.3.6 Discussion:

The name of Jungle Crow itself indicating that they are inhabitants of the jungle area and the result from this study area was also reflecting the same thing. During this study, higher numbers of nest of Jungle Crows were recorded from agricultural habitat compared to House Crow. So result also indicated that Jungle Crow population was higher in agricultural habitat. On other hand, the name of House Crow is given on the basis that the crows which are present at houses of human being. During course of this study, 98.67 per cent nests of House Crow were recorded from human residential area compared to Jungle Crow. It indicates that Jungle Crow prefer the area having less human disturbance. It also reflecting their population was higher in the non-residential area.

The House Crow utilized more artificial structure for nesting purpose compared to Jungle Crow. Utilization of mango tree for nesting purpose was highest recorded in Jungle Crow while banyan and copper pod trees utilization for nesting purpose was higher in case of House Crow. Both crow species preferred to locate the nest on tertiary branches of trees, but many times primary and secondary branches were also utilized by House Crow.

Jungle Crow preferred more height of substrate for nesting purpose compared to House Crow, as the mean nest height of Jungle Crow was higher compared to House Crow.

4.4.4 Breeding Ecology

The areas where Jungle Crows and House Crows were regularly occurring were checked during their respective breeding seasons in year 2011and 2012. Amongst two sympatric species of crows, the Jungle Crow breeds during summer season whereas the House Crow breeds during monsoon; thereby avoiding competition in time and space. Most of the nests were found at the time of clutch initiation but some of the nests were found during last phase of nestling period. For such nests, characteristics of the chick were compared with the characters of the chicks of known age to determine their age. For such nests, chick age and incubation period determined in this study were used to extrapolate the date of clutch initiation.

Very little is known about the breeding habits of the Jungle Crow. Hume (1873) was perhaps the first ornithologist to collate the data available on the Jungle Crow breeding but many interesting aspects were left untouched.

Detailed study on breeding ecology of Jungle Crow was done over two seasons in 2011 and 2012. Results are presented separately for 2011 and 2012.

Breeding Ecology of Jungle Crow during 2011

4.4.4.1 Breeding Season Schedule

Breeding season is defined as the period between the initiation of the first and the last clutches in the populations. The clutch initiation started from the last week of February and continued till the second week of May. This shows that the Jungle Crow is a seasonal breeder and has a restricted breeding season of 2 to 3 months. The Jungle Crow started pairing in January and showed courtship and nest-building activity in early February.

The frequency distribution of the clutch initiation (Table 39) revealed that at-least one clutch was initiated in each week, starting from the last week of February and ending in second week of May 2011. Maximum numbers of clutches were laid in the second week of April followed by fourth week of April. Even during the third week of April, at least 5 clutches (14.29 %) were initiated.

New clutch initiation continued up to second week of May. Fluctuating pattern of the clutch initiation during these weeks might be due to limited study area and sample size. When weekly data was pooled on monthly bases, it showed that the clutch initiation started in the month of February which reached to its peak in the April and ceased in May.

Table 39. Number of clutches initiated by Jungle Crow during breeding season 2011

Month	Week	Clutch Initiation	Clutch frequency (%)
February	1	0	0.0
	2	0	0.0
	3	0	0.0
	4	1	2.9
March	1	0	0.0
	2	1	2.9
	3	1	2.9
	4	3	8.6
April	1	2	5.7
	2	9	25.7
	3	5	14.3
	4	8	22.9
May	1	3	8.6
	2	2	5.7
	3	0	0.0
	4	0	0.0
	Total	35	100

During the course of study, the numbers of clutches laid per calendar week were correlated with the maximum and minimum temperatures and relative humidity (R. H. %) as depicted in Figure 4. Number of clutch initiation in Jungle Crow was significantly positively correlated with maximum temperature and significantly negatively correlated with relative humidity (%). When minimum and maximum temperatures increased and relative humidity started decreasing, the clutch initiation took place. Jungle Crow clutch initiation was observed from last week February where maximum temperature and minimum temperature were 31.1^0 C and 13.3^0 C, respectively and R H was 56.7 %. Maximum clutch initiation was observed in second week of April where minimum and maximum temperatures were 19.0^0 C and 37.8^0 C, respectively and R H was 46.7 %. The minimum and maximum temperatures continuously increased and the R H continuously decreased as the breeding season progressed. When minimum and maximum temperatures reached to its peak, became stable and the R H started to increase, the Jungle Crow stopped egg laying.

Weather and food availability influence the instigation of breeding activities.

4.4.4.2 Clutch Size

The clutch size ranged from 1 to 5. The frequency distribution of the clutch size is presented in Table 40 and Figure 4. The most common clutch size was three and four (30.76 % each) followed by the clutch size of two and five (15.38 % each). One eggs clutch was rarely found (7.69 %).

Factors which determine the clutch size probably depend on the age of the female, season, food availability, intensity of predation, length of the day light, climate, type of habitat and geographic ranges (Jhonson, 1978).

Mean clutch size of Jungle Crow was 3.31 ± 0.96 (Table 40), ranging from 1 to 5 eggs. Similar mean clutch size (3.5) has been reported by Lamba (1976). Baker (1934) reported that Jungle Crow generally laid three to five eggs.

Table 40 : Distribution of clutches of Jungle Crow during 2011

Month	Week	No. of Clutch with no. of eggs					Total no. of eggs	Total no. of clutch
		1	2	3	4	5	-	-
April	1	1	0	1	0	0	4	2
	2	0	1	1	2	0	13	4
	3	0	0	1	2	1	16	4
	4	0	0	1	0	1	8	2
May	1	0	0	0	0	0		
	2	0	1	0	0	0	2	1
	3	0	0	0	0	0		
	4	0	0	0	0	0		
Total	**-**	**1**	**2**	**4**	**4**	**2**	**43**	**13**
% clutch frequency	**-**	**7.69**	**15.38**	**30.76**	**30.76**	**15.38**	**-**	**-**
Average Clutch Size = No. of eggs laid / Total no. of Clutch = 43 / 13 = 3.31 ± 0.96 S. D.								

4.4.4.3 Egg Shape and Color

The eggs of Jungle Crow were sky blue in color with brownish speckled spots and oval in shape (Plate 5 A). The shape of the eggs varied from egg to egg to some extent in the same clutch.

4.4.4.4 Egg Diametric

The diametric of Jungle Crow eggs are presented in Table 41. Average length, width and weight of eggs were 41.35 ± 2.73 mm, 28.84 ± 1.20 mm and 17.31 ± 1.96 g, respectively. There was no significant difference in the egg length from different clutch size ($F = 0.56$, $df = 3$, $P > 0.05$). As the clutch size increased, the width of the eggs also increased. There was no significant difference in egg width ($F = 0.70$, $df =3$, $P > 0.05$) and weight ($F = 0.69$, $df =3$, $P > 0.05$) between different clutch size when compared with "F" test.

Table 41: Diametric of Jungle Crow eggs (Mean ± S.D.)

Clutch Size	Egg Measurements					
	N	**Length (mm)**	**Width (mm)**	**Weight (g)**	**ESI (%)**	**Volume (mm^3)**
1	1	42.52	29.85	20	70.20	1917.05
2	2	41.74 ± 2.96	29.15 ± 0.91	16.75 ± 1.32	69.99 ± 2.95	1801.57 ± 232.18
3	3	40.15 ± 1.61	27.58 ± 0.82	15.94 ± 1.26	68.80 ± 3.57	1547.27 ± 112.08
4	3	41.52 ± 3.01	29.06 ± 0.95	18.08 ± 1.77	70.29 ± 4.88	1778.60 ± 197.28
5	2	42.57 ± 2.43	29.71 ± 0.75	18 ± 1.83	70.04 ± 5.03	1900.07 ± 104.03
Mean		**41.35 ± 2.73**	**28.84 ± 1.20**	**17.31 ± 1.96**	**69.97 ± 4.29**	**1747.45 ± 215.27**
Note: **ESI** = Egg Shape Index **N** = No. of Clutches						

The clutch size of three and four eggs had sufficient sample size for analysis. All the parameters of the egg diametric in the clutch size of three and four eggs were at par when compared with paired "t" test ($T = 1.23$, $df = 19$, $P > 0.05$). ESI and volume varied from egg to egg within the clutch. As the clutch size increased, ESI and volume of the eggs also increased. Mean of ESI and Volume of Jungle Crow eggs were 69.97 ± 4.29 and 1747.45 ± 215.27 mm^3 respectively.

The average egg size and weight given by Lamba (1976) was 42.0 × 28.6 m and 18.39 g which was slightly higher than this study. The egg size given by Baker (1934) was 38 × 28.1 mm was very close to the present study.

4.4.4.5 Incubation Period

Incubation is the application of heat to the eggs for the development of embryo. During incubation period, eggs became slightly darker as compared to its color at the time of laying. Observations during present studies revealed that sometimes only one adult was present in nest platform at the time of nest checking but, mostly two adults flew around nesting tree when the nest was disturbed. Changeover of incubation duty was observed on some occasions indicating that both the sexes perform this duty. Hume and Oates (1889), Dewar (1905) and Ali (1933) reported that both the sexes incubate the eggs.

The mean incubation period of Jungle Crow eggs was 17.61 ± 0.97 days (n=16) ranging from 16 – 20 days, which was slightly lower compared to incubation period (19 days) worked out by Lamba (1976) at Poona, India.

The incubation period reported from the other parts of the country was higher as compared to the present studies. This might be due to the environmental conditions in the study area. Climatic conditions of the area and characteristics of nest sites are probably the principal reasons which control the incubation periods of crow species.

4.4.4.6 Nestling and Nesting Period

Nestling period is considered as an interval between the hatching of egg and the day chicks leave the nest. The nestling period ranged from 35 to 45 days with mean of 39.5 ± 3.21 days (n=36).

Nesting period is defined as the interval of time between laying of first egg to the nest and the day last chick leave the nest. Average nesting period was 46.97 ± 3.19 days (Table 42) which ranged from 40 to 52 days (n = 36).

4.4.4.7 Reproductive Success

Breeding success is the ratio of the young ones that fly from the nest to the number of eggs laid. Reproductive performance of Jungle Crow is presented in Table 42. Total 13 nests were monitored to estimate the breeding success. In six nests (46.2 %) all the eggs hatched while in 7 nests (53.8 %), at least one egg failed to hatch.

A total of 43 eggs were laid in 13 nests of which 26 eggs hatched. Therefore, hatching success was 60.5 %.

Fifteen chicks could successfully fledge out of 26 chicks hatched. Fledging success was 57.7 %. On an average, one chick fledged per nest during the present study.

Nesting success was calculated as the percentage of nests that successfully fledged at least one chick. Nesting success was 76.9 % in present study. Overall breeding success was 34.9 % (Table 42).

4.4.4.8 Reproductive Losses

During the period of study, 7 eggs (53.8 %) and 11 chicks (42.3 %) were missed due to unknown reasons. Ground predator like snake was an important factor for the loss of eggs and newly hatched chicks.

Breeding success of Jungle Crow depends on many factors such as human interference, availability of food and predator pressure. The higher hatching and nesting success observed in the present study might be due to less human interference and low predator pressure.

4.4.4.9 Brood Parasitism

Asian Koel (*Eudynamys scolopacea*) does not build its own nest to raise its own family but lay eggs in the nests of the members of Corvidae family, i.e. House Crow (*Corvus splendens*) and Jungle Crow (*Corvus macrorhynchos*). The breeding season of this brood parasite (Asian Koel) coincides with that of its host (House Crow and Jungle Crow) during February to August. However, two crow species has distinct breeding season. Lamba (1976) recorded breeding season of Asian Koel from mid-April to mid-July. In present study, out of 13 nests, 53.85 % nests were parasitised by Asian Koel. Asian Koel laid 17 eggs in 7 nests of Jungle Crow of which 7 chicks successfully fledged. Overall breeding success of Asian Koel in the nests of Jungle Crow was 41.18 %. During 2011, average egg length, width and weight of Asian Koel eggs (n = 13) were 31.43 ± 0.73 mm, 22.76 ± 0.82 mm and 8.33 ± 1.04 g., respectively. Mean of ESI and volume of Koel eggs were 72.45 ± 2.59 and 825.37 ± 68.62 mm^3, respectively.

Parasitised nests of Jungle Crows (40.90 %) had lower survival of their own chicks than un-parasitised nests (50 %).

Table 42: Reproductive success of Jungle Crow during breeding season 2011

Sr. no.	Particulars	Number	Per cent
1	Total Nests	13	-
2	No. of Nests where all the eggs hatched	6	46.2
3	No. of Nests where at least one egg missed	7	53.8
4	No. of Nests where at least one egg failed to hatch	0	0
Eggs			
5	No. of Eggs laid	43	-
6	No. of Eggs hatched	26	-
7	No. of Eggs failed to hatch	0	
8	No. of Eggs missed due to unknown reason	17	39.5
9	Hatching Success	-	60.5
Chicks			
10	No. of Chicks	26	-
11	No. of Chicks fledged	15	-
12	No. of chicks died due to unknown reasons	11	42.3
13	Fledging Success	-	57.7
14	No. of Nests that successfully fledged at least one chicks	10	-
15	No. of Nests in which no chick fledge	3	-
16	Nesting Success	-	76.9
17	Overall Breeding Success	-	34.9

Asian Koel eggs formed 20 per cent to 80 per cent of total eggs in the Jungle Crow nests. Of the 7 parasitised clutches, one nest had 80 per cent Asian Koel eggs, 3 nests had more than 40 per cent and 3 nests had more than 20 per cent Asian Koel eggs in them. On an average, 43.59 per cent Asian Koel eggs were present in the parasitised nests of Jungle Crow (Table 43).

Table 43: Number of Jungle Crow and Asian Koel eggs in the parasitised nests of the Jungle Crow in 2011

Sr. No.	Nest no	Total eggs	Jungle Crow eggs	Asian Koel eggs
1	2	5	4 (80)	1 (20)
2	4	5	3 (60)	2 (40)
3	5	5	4 (80)	1 (20)
4	16	8	5 (62.5)	3 (37.5)
5	18	5	3 (60)	2 (40)
6	26	5	1 (20)	4 (80)
7	37	6	2 (33.33)	4 (66.67)
	Total	**39**	**22 (56.41)**	**17 (43.59)**

Breeding Ecology of Jungle Crow 2012

4.4.4.10 Breeding Season Schedule during 2012

During study period, the clutch initiation started in the third week of March and continued till fourth week of May. Total 19 nests were recorded during study period from the study area. The frequency distribution of the clutch initiation during breeding season of 2012 is given in Table 44. Maximum numbers of clutches were laid in the first week of April (31.58 %) followed by the third week of April (21.05 %). During the second week of April also at least 3 clutches (15.79 %) were initiated.

New clutch initiation continued up to fourth week of May. Fluctuating pattern of the clutch initiation during these weeks might be due to the limited study area and sample size.

Table 44: Number of clutches initiated by Jungle Crow during breeding season 2012

Month	Week	Clutch Initiation	Clutch frequency (%)
March	1	0	0.00
	2	0	0.00
	3	1	5.26
	4	2	10.53
April	1	5	26.32
	2	3	15.79
	3	4	21.05
	4	2	10.53
May	1	1	5.26
	2	0	0.00
	3	0	0.00
	4	1	5.26
	Total	**19**	**100**

During the course of study, the numbers of clutches laid per calendar week were correlated with the maximum and minimum temperatures and relative humidity (R. H. %) as depicted in Figure 5. Number of clutch initiation in Jungle Crow was not correlated with maximum temperature and relative humidity (%). When minimum and maximum temperatures increased and relative humidity started decreasing, the clutch initiation took place. Initiation of clutches started from 3 week of March having minimum and maximum temperatures 12.9^{o} C and 32.0^{o} C, respectively and it was nearly same as previous year 2011 breeding season. In 2011, such temperature values were recorded on first week of February. Maximum clutch initiation was observed in first week of April where minimum and maximum temperatures were 18.8^{o} C and 39.8^{o} C, respectively and R H was 39.9 %. The minimum and maximum temperatures continuously increased and the R H continuously progressive decrease as the breeding season progressed. In 2012, breeding season was very short compared to 2011.

4.4.4.11 Clutch Size

The clutch size ranged from 2 to 5. The frequency distribution of the clutch size is presented in Table 45 and Figure 5. The most common clutch size was three and four (36.84 % each) followed by the clutch size of two (21.06 %) which was nearly same as the result of previous year breeding season (year 2011). Only one clutch was recorded having five eggs (5.26 %).

Mean clutch size was 3.26 ± 0.87 during 2012 (Table 45).

Table 45: Distribution of clutches of Jungle Crow (n=19) during 2012

Month	**Week**	**No. of clutch with no. of eggs**					**Total no. of eggs**	**Total no. of clutch**
		1	**2**	**3**	**4**	**5**	-	-
March	3	0	0	1	0	0	3	
	4	0	1	0	1	0	6	2
April	1	0	0	3	1	1	18	6
	2	0	2	0	1	0	8	3
	3	0	1	1	2	0	13	4
	4	0	0	1	1	0	7	2
May	1	0	0	0	1	0	4	1
	2	0	0	0	0	0	0	0
	3	0	0	0	0	0	0	0
	4	0	0	1	0	0	3	1
Total	**-**	**0**	**4**	**7**	**7**	**1**	**62**	**19**
% clutch frequency	**-**	**0**	**21.06**	**36.84**	**36.84**	**5.26**	**-**	**-**
Average clutch size = No. of eggs laid / Total no. of clutch = 62 / 19 = 3.26 ± 0.87 S. D.								

4.4.4.12 Egg Diametric

The diametric of Jungle Crow eggs are presented in Table 46. It is evident from the table that average length, width and weight of eggs were 40.12 ± 2.25 mm, 28.25 ± 1.78 mm and 17.01 ± 1.45 g, respectively.

Table 46: Diametric of Jungle Crow eggs (Mean ± S.D.) during 2012

Clutch size	Egg Measurements					
	N	Length (mm)	Width (mm)	Weight (g)	ESI (%)	Volume (mm^3)
2	2	38.66 ± 2.73	28.84 ± 1.31	16.51 ± 0.71	74.78 ± 4.52	1633.42 ± 236.91
3	4	41.62 ± 2.56	27.89 ± 2.76	17.00 ± 1.83	67.14 ± 6.89	1658.22 ± 328.21
4	5	39.27 ± 1.51	28.03 ± 0.94	16.98 ± 1.06	71.45 ± 3.12	1564.24 ± 137.09
5	1	41.08 ± 1.55	29.53 ± 1.45	17.60 ± 2.33	71.87 ± 1.33	1821.36 ± 244.62
Mean		**40.12 ± 2.25**	**28.25 ± 1.78**	**17.01 ± 1.45**	**70.56 ± 5.03**	**1629.85 ± 236.00**
Note: **ESI** = Egg Shape Index **N** = No. of clutches						

The clutch size of three and four eggs had sufficient sample size for analysis. All the parameters of the egg diametric in the clutch size of three and four eggs were at par when compared with paired “t” test (t =1.23, df = 19, P > 0.05). Mean of ESI and volume of Jungle Crow eggs were 70.56 ± 5.03 and 1629.85 ± 236.06 mm^3 respectively.

Average egg size given by Baker (1934) was 38 × 28.1 mm was lower than result obtained. Egg diametric values were more or less similar as per season 2011 during study in 2012.

4.4.4.13 Incubation Period

The mean incubation period of Jungle Crow eggs was 18.42 ± 0.79 (n = 12) ranging from 17 – 20 days which was slightly higher compared to previous breeding season (17.61 ± 0.97 days; n=16) ranging from 16 – 20 days.

4.4.4.14 Nestling and Nesting Period

The nestling period ranged from 26 to 46 days with mean of 34.54 ± 11.79 (n = 12) days which was lower than previous season 39.5 ± 3.21 days (n=36).

Average nesting days were 49.33 ± 5.43 days which ranged from 40 to 57 days (n = 12) and was higher than previous year (46.97 ± 3.19 days).

4.4.4.15 Reproductive Success

Reproductive performance of Jungle Crow in year 2012 is presented in Table 47. Total 19 nests were monitored to estimate the breeding success. In three nests (15.79 %) all the eggs hatched while in 17 nests (89.47 %), at least one egg was missed due to unknown reason.

A total of 62 eggs were laid in 19 nests of which 35 eggs hatched. Therefore, hatching success was 56.45 % (Table 47).

Seventeen chicks could successfully fledge out of 35 chicks hatched. Fledging success was 48.57 %. On an average, one chick fledged per nest during the present study. Nesting success was 63.15 % in present study. Overall breeding success was 27.42 % (Table 47).

4.4.4.16 Reproductive Losses

During the period of study, 27 eggs (43.55 %) and 18 chicks (51.43 %) were missed due to unknown reasons. In four nests, sudden loss of eggs and chicks was observed but reason for such loss cannot be worked out (Table 47).

4.4.4.17 Brood Parasitism

Total 19 nests of Jungle Crow were recorded of which 73.68 per cent nests were parasitised by Asian Koel which was much higher compared to previous season (53.85 %). The probable reason behind higher nest parasitism during year 2012 is likely to be the late initiation of Jungle Crow breeding season. Breeding season was almost month delayed compared to 2011. Asian Koel laid total 42 eggs in 14 nests of Jungle Crow of which 15 chicks were successfully fledged. Overall breeding success of Asian Koel in the nests of Jungle Crow was 35.71 % which was slightly lower compared to previous year (41.18 %). During breeding study in 2012, average egg length, width and weight of Asian Koel eggs (n = 24) were 29.97 ± 1.16 mm, 22.97 ±

0.84 mm and 8.79 ± 0.83 g., respectively. Mean of ESI and volume of Koel eggs were 76.69 ± 2.35 and 802.98 ± 82.10 mm^3, respectively. By parasitizing more number of Jungle Crow nests (74 %), the Asian Koel could not improve its breeding success. Parasitised nests of Jungle Crows (20.93 %) had lower survival of their own chicks than un-parasitised nests (42.11 %).

Table 47: Reproductive success and losses of Jungle Crow during 2012

Sr. no.	Particulars	Number	Per cent
1	Total Nests	19	-
2	No. of Nests where all the eggs hatched	3	15.79
3	No. of Nests where at least one egg missed	17	89.47
4	No. of Nests where at least one egg failed to hatch	0	0
	Eggs		
5	No. of Eggs laid	62	-
6	No. of Eggs hatched	35	-
7	No. of Eggs failed to hatch	0	0
8	No. of Eggs missed due to unknown reason	27	43.55
9	Hatching Success	-	56.45
	Chicks		
10	No. of Chicks	35	-
11	No. of Chicks fledged	17	-
12	No. of chicks died due to unknown reasons	18	51.43
13	Fledging Success	-	48.57
14	No. of Nests that successfully fledged at least one chicks	12	-
15	No. of Nests in which no chick fledged	7	-
16	Nesting Success	12/19	63.15
	Overall Breeding Success	17/62	27.42

Table 48 gives information about the number of host and parasite eggs in the Asian Koel parasitised nests of Jungle Crow. In 2012, Asian Koel eggs ranged from 20 - 77.78 per cent in the Jungle Crow nests. Of the 14 parasitised clutches, 2 nests had more than 70 per cent and 4 nests had more than 50 per cent eggs of parasite. On an average, 49.41 per cent Koel eggs were present in the Koel-parasitised nests of Jungle Crow.

Table 48: Number of Jungle Crow and Koel eggs in the parasitised nests of the Jungle Crow during 2012

Sr. No.	Nest No.	Total eggs	Jungle Crow eggs	Koel eggs
1	1	5	4 (80)	1 (20)
2	2	6	4 (66.67)	2 (33.33)
3	3	7	4 (57.14)	3 (42.86)
4	4	7	3 (42.86)	4 (57.14)
5	5	3	2 (66.67)	1 (33.33)
6	6	4	3 (75)	1 (25)
7	19	6	3 (50)	3 (50)
8	14	4	2 (50)	2 (50)
9	15	9	2 (22.22)	7 (77.78)
10	7	5	3 (60)	2 (40)
11	23	5	2 (40)	3 (60)
12	24	7	4 (57.14)	3 (42.86)
13	25	7	4 (57.14)	3 (42.86)
14	29	10	3 (30)	7 (70)
	Total	**85**	**43 (50.59)**	**42 (49.41)**

4.4.4.18 Comparison of Jungle Crow breeding season during year 2011 and 2012

4.4.4.18.1 Breeding season schedule

At Anand the Jungle Crow breaded only once a year, although it has been recorded to breed twice (Hume, 1873; Whistler, 1986 and Baker, 1934) a year in some parts of India. The single breeding season recorded by Lamba at Poona, was of about four months duration starting from end of February to the end of June which was similar to this study. Clutch initiation of Jungle Crow during breeding season in 2011 was started from last week of February (Maximum temperature 31.1^{o} C & Minimum temperature 13.1^{o} C) and whereas clutch initiation during 2012 started from third week of March (Maximum temperature 32.0^{o} C & Minimum temperature 12.9^{o} C) and continued till last week of May. It indicated that breeding season during 2012 was two weeks late compared to previous year. During both the years, breeding activity terminated in last week of May. In short, initiation of egg laying was recorded when minimum temperature at 13^{o} C and maximum temperature at 31^{o} C started rapidly. Maximum numbers of clutches were laid in second week of April in 2011 while in 2012 maximum clutches were laid in first week of April.

4.4.4.18.2 Clutch size

During both breeding season clutch size ranged from 2 - 5 and most common clutch size was three and four, with mean 3.31 and 3.28 eggs in 2011 and 2012 respectively. Mean clutch size recorded by Lamba (1976) for the years 1965, 1966 and 1967 was 3.5, 3.46 and 3.5 respectively. Abundance of food in the locality appears to induce birds to lay bigger clutches than normal (Schneider, 1928). Even the quality of food available sometimes affects the clutch size (Lack, 1947).

4.4.4.18.3 Egg Diametric

Average length, width and weight of eggs during 2011 was 41.35 ± 2.73 mm, 28.84 ± 1.20 mm and 17.31 ± 1.96 g, respectively and during 2012 it was 40.12 ± 2.25 mm, 28.25 ± 1.78 mm and 17.01 ± 1.45 g, respectively. It showed that egg diametric values of eggs obtained during 2012 were same to the values recorded in 2011. However egg diametric value of present study were slightly smaller than the one given by Lamba (1963).

4.4.4.18.4 Incubation Period

The mean incubation period of Jungle crow eggs during year 2011 was 17.61 ± 0.97 (n = 16) days ranging from 16 - 20 days while during season 2012 it was 18.42 ± 0.79 (n = 12) ranging from 17 - 20 days.

4.4.4.18.5 Nestling and Nesting Period

Nestling period during breeding season 2011 ranged from 35 to 45 days (39.5 ± 3.21; n = 36) was higher compared to breeding season 2012 (34.54 ± 11.79; n =12, ranged from 26 to 46 days) and also higher compared to nestling success (33.65 %) recorded by Lamba (1976) at Poona.

Nesting period of Jungle Crow during season 2012 (49.33 ± 5.43; n = 12, ranged from 40 – 57 days) was higher compared to season 2011 (46.97 ± 3.19 days; n = 36, ranged from 40 to 52 days).

4.4.4.18.6 Reproductive Success and Losses

Hatching success (60.5 %), fledgling success (57.7 %), nesting success (76.9 %) and breeding success (34.9 %) of Jungle Crow during year 2011 were higher compared to season 2012 (56.45 %, 18.57 %, 63.15 % and 27.42 % respectively). This difference was attributed to higher losses of eggs and chicks of Jungle Crow during season 2012 compared to previous season (Table 49). Higher hatching success

(80.2 %) compared to this study was recorded by Lamba (1976) at Poona. Nestling mortality during 2011 and 2012 was 42.3 % and 51.43 %, respectively which was lower compared to nestling mortality (23.3 %) observed by Lamba at Poona. Nesting success of 66 % was recorded by Lamba (1963) who opined that nesting success in the Jungle Crow depends on a number of factors, the most important ones being the amount of food available for the young at nestling stage, fertility of the eggs laid and interference by predators.

Table 49: Comparison of reproductive success and losses of Jungle Crow during breeding season during 2011 - 2012

Sr. No.	Particulars	Jungle Crow breeding season	
		2011	**2012**
1	Total nests	13	19
2	Hatching success (%)	60.5	56.45
3	Fledgling success (%)	57.7	48.57
4	Nesting success (%)	76.9	63.15
5	Breeding success (%)	34.9	27.42
6	Loss of eggs (missed) (%)	39.5	43.55
7	Loss of chicks (%)	42.3	51.43

4.4.4.18.7 Brood parasitism in Jungle Crow Nests During Season 2011 and 2012

Per cent brood parasitism and eggs of Asian Koel in the nests of Jungle Crow was higher in season 2012 (73.68 % and 49.41 %) compared to season 2011 (53.85 % and 43.59 %), this might be possible due to late initiation of breeding season during 2012. Breeding success of Asian Koel chicks was higher during season 2011 compared to 2012. Host survival rate in Asian Koel parasitised nests was very low during season 2012 (20.93 %) due to higher nest parasitism by Asian Koel recorded in this season compared to season 2011 which having higher host survival per cent

(Table 50). In short, survival value of both host and parasite were high when parasitism rate was low (2011).

Table 50: Comparison of brood parasitism of Asian Koel on Jungle Crow during breeding season during 2011 and 2012

Sr. No.	Particulars	Jungle Crow breeding season	
		2011	2012
1	Nest parasitism (%)	53.85	73.68
2	Asian Koel eggs in parasitised nests (%)	43.59	49.41
3	Breeding success of Asian Koel (%)	41.18	35.71
4	Jungle Crow breeding success in Asian Koel parasitised nests (%)	40.90	20.93
5	Jungle Crow breeding success in un-parasitised nests (%)	50	42.11

4.4.5 Breeding Ecology of House Crow

Areas having House Crows population were checked during breeding season in year 2011. Out of 73 nests recorded, only in 2 nests, observations starting from egg laying to fully developed fledglings were recorded. All other nests were recorded directly at fledgling stage, so actual clutch size of such nests and per cent parasitism by Asian Koel couldn't be worked out. Hence, the study was repeated in 2012 (May - July) on 21 nests of House Crow to fulfill the gap of breeding performance and brood parasitism by Asian Koel.

4.4.5.1 Breeding Season Schedule in 2012

The House Crow started pairing in last week of May in 2012 and showed courtship and nest-building activity in early June.

The frequency distribution of clutches during breeding season (Table 51) revealed that at-least one clutch was initiated in each week, starting from the last week of May. Maximum numbers of clutches (n = 8) were laid in the first week of June (38.10 %) followed by the second week of June (28.57 %). Lamba (1976) recorded that most House Crow started egg laying from the end of May to early June, at Poona.

Fluctuating pattern of the clutch initiation during these weeks might be due to the limited study area and sample size. When weekly data was pooled on monthly bases, it showed the clutch initiation started in the month of May which reached to its peak in the June. Clutch initiation ceased in late July.

Table 51: Number of clutches initiated by House Crow during breeding season in 2012

Month	Week	Clutch Initiation	Clutch frequency (%)
May	5	3	14.29
June	1	8	38.10
	2	6	28.57
	3	3	14.29
	4	0	0.00
July	1	1	4.76
	2	0	0.00
	3	0	0.00
	4	0	0.00
Total		**21**	**100**

During the course of study, the numbers of clutches laid per calendar week were correlated with the maximum and minimum temperatures and % relative humidity as depicted in Figure 6. There was no significant correlation observed between number of clutch initiation and maximum and minimum temperature and per cent relative humidity. The figure revealed that when minimum and maximum temperatures decreased and relative humidity started increasing, the clutch initiation took place. Maximum clutch initiation was observed in first week of June where minimum and maximum temperatures were 25.7° C and 39.9° C, respectively and R H was 54.6 per cent. Based on the results it could be concluded that, these temperatures and R H are favorable for egg laying by House Crow. The minimum and maximum temperatures continuously decreased and the R H continuously increased as the breeding season progressed. When minimum and maximum temperatures continually decrease and the R H started to increase, the birds stopped egg laying.

4.4.5.2 Clutch Size

The clutch size ranged from 3 to 6 eggs. The frequency distribution of the clutch size is presented in Table 52 and Figure 6. The most common clutch size was three, four and five (31.58 % each) followed by six (5.26 %). The factors which determine the clutch size probably depend on the age of the female, season, food availability, intensity of predation, length of the day light, climate, type of habitat and geographic ranges.

Mean clutch size of House Crow was 4.11 ± 0.94 (Table 52) ranging from 3 to 6 eggs. Clutch size (3.5) reported by Lamba (1976) from Poona was lower compared to this study but Ali (2008) recorded clutch size of 4.1 eggs from Pakistan.

Table 52: Distribution of clutches of House Crow

Month	**Week**	**No. of clutch with no. of eggs**						**Total no. of eggs**	**Total no. of clutch**
		1	**2**	**3**	**4**	**5**	6	-	-
May	5	0	0	1	1	1	0	12	3
June	1	0	0	3	2	2	0	27	7
	2	0	0	1	2	3	0	26	6
	3	0	0	1	1	0	0	7	2
	4	0	0	0	0	0	0	0	0
July	1	0	0	0	0	0	1	6	1
	2	0	0	0	0	0	0	0	0
Total	**-**	**0**	**0**	**6**	**6**	**6**	**1**	**78**	**19**
% clutch frequency	-	0	0	31.58	31.58	31.58	5.26	-	-
Average Clutch Size = No. of eggs laid / Total no. of Clutch = 78/ 19 = 4.11 ± 0.94 S. D.									

Egg Shape and Color

The eggs of House Crow were blue-green, speckled and blotched with brown, grey or black, oval in shape (Ali, 2008). The eggs are conical or pyriform in shape. The shape of the eggs varied from egg to egg to some extent in the same clutch. Similar types of variations were also observed by Ali & Ripley (1983). The eggs of

Asian Koel in the nest of House Crow could be distinguished by comparatively smaller size and oval or ovate shape.

4.4.5.3 Egg Diametric

The diametric of House Crow eggs are presented in Table 53. The average length, width and weight of eggs were 37.82 ± 1.19 mm, 26.78 ± 1.01 mm and 14.70 ± 1.31 g, respectively. In one nest of House Crow exceptionally larger size eggs (41.99 mm × 29.84 mm; length and width of egg respectively and egg weight 20.5 g) were observed compared to normal eggs. There was no significant difference in the egg length from different clutch size ($F = 0.58$, $df = 3$, $P > 0.05$). As the clutch size increased, the width of the eggs also decreased. There was a significant difference in egg width between different clutch size when compared with "F" test ($F = 10.9$, $df = 3$, $P < 0.01$). Non-significant difference was observed between egg weight of different clutch size ($F = 1.415$, $df = 3$, $P > 0.01$).

Table 53: Diametric of House Crow eggs (Mean ± S.D.)

Clutch Size	Egg Measurements					
	N	Length (mm)	Width (mm)	Weight (g)	ESI (%)	Volume (mm^3)
3	7	37.88 ± 1.08	27.04 ± 0.10	15.09 ± 1.33	71.41 ± 2.05	1404.82 ± 132.00
4	4	37.82 ± 1.57	26.40 ± 0.70	14.41 ± 1.37	69.89 ± 2.50	1336.39 ± 111.84
5	2	37.59 ± 0.80	25.94 ± 0.32	14.25 ± 1.38	69.04 ± 1.42	1280.01 ± 47.79
6	1	37.31 ± 0.81	28.04 ± 0.71	15.33 ± 0.26	75.19 ± 1.81	1485.94 ± 93.12
Mean	**14**	**37.82 ± 1.19**	**26.78 ± 1.01**	**14.70 ± 1.31**	**70.85 ± 2.70**	**1375.77 ± 127.66**
Note: **ESI** = Egg Shape Index, **N** = No. of Clutches						

The clutch size of three and four eggs had sufficient sample size for analysis. All the parameters of the egg diametric in the clutch size of three and four eggs were at par when compared with paired "t" test ($T = 1.21$, $df = 35$, $P > 0.05$). ESI and volume varied from egg to egg within the clutch. As the clutch size increased, ESI and volume of the eggs also decreased. Mean of ESI and volume of House Crow eggs were 70.85 ± 2.70 % and 1375.77 ± 127.66 mm^3 respectively (Table 53).

Comparison of egg diametric values of House Crow eggs were worked out by Lamba were nearly similar compared to this course of study was given below.

Reference	Study site	Egg diametric
Lamba (1976)	Poona, India	33-40 mm × 24-29 mm
Lamba (1963)	Culcutta, India	38.5 mm × 25.0 mm
Present study (2012)	Anand, Anand	37.82 mm × 26.78 mm

4.4.5.4 Incubation Period

In House Crow, hatching was asynchronous. The mean incubation period of House Crow eggs was 17.53 ± 0.99 days (n=15) ranging from 16 – 20 days, which was similar to incubation period worked out by Ali (2008) at Pakistan and slightly higher compared to incubation period (16 days) worked out by Lamba (1976) at Poona, India.

4.4.5.5 Nestling and Nesting Period

Nestling period is considered as an interval between the hatching of egg and the day chicks leave the nest. The nestling period ranged from 25 to 31 days with mean of 28.23 ± 2.17 days (n=13) which was nearly similar nestling period (28.5 days) recorded by Lamba (1976) at Poona.

Nesting period is defined as the interval of time between the egg laying of first egg to the nest leaving by the last chick. The average nesting days were 44.23 ± 4.27 days (Table 54) which ranged from 35 to 50 days (n = 13).

4.4.5.6 Reproductive Success

Breeding success is the ratio of the young ones that fly from the nest to the number of eggs laid. Reproductive performance of House Crow is presented in Table 54. Total 20 nests were examined to estimate the breeding success. 2 nests (10 %) out of 20 nests were those in which all the eggs hatched while in 5 nests (25 %), at least one egg failed to hatch and 15 nests (75 %) were those in which at least one egg missed due to unknown reason.

A total of 75 eggs were laid in 20 nests of which 33 eggs hatched. Therefore, hatching success was 44 per cent. Lamba (1976) recorded hatching success of House Crow as 93.51 per cent at Poona.

Twenty one chicks could successfully fledge out of 33 chicks hatched. Fledging success was 63.64 per cent. On an average, one chick fledged per nest during the present study.

Nesting success was calculated as the percentage of nests that successfully fledged at least one chick. Nesting success was 60 per cent in present study which was higher compared to nesting success (54 per cent) worked out by Lamba (1963). Overall breeding success was 28 per cent (Table 54).

4.4.5.7 Reproductive Losses

During the period of study, 29 eggs (38.66 %) and 9 chicks (27.27 %) were missed due to unknown reason or might be due to predation by Kites as such nests were present in non-food waste dumping area where Kite population recorded higher during study. Ground predators like snakes was an important factor for the loss of eggs and newly hatched chicks. At two nesting sites House Crow used to attack on human passing from nesting tree and such nests were destroyed by crow harassed people. Four eggs and three chicks lost due to human disturbance were recorded from such sites. Chick mortality in House Crow recorded by Lamba (1976) as 41.4 per cent and found that most deaths among the young House Crows are due to want of food which is largely precipitated and accentuated by the young parasitic Asian Koels, who hatch out earlier than their foster brethren and devour a major portion of the food brought by the parents. Breeding success of House Crow depends on many factors such as human interference, availability of food and presence of predators. The higher hatching and nesting success was observed in the present study which might be due to the less human interference and other predators.

Table 54: Reproductive success of House Crow during 2012

Sr. no.	Particulars	Number	Per cent
1	Total Nests	20	-
2	No. of Nests where all the eggs hatched	2	10
3	No. of Nests where at least one egg missed	15	75
4	No. of Nests where at least one egg failed to hatch	5	25
Eggs			
5	No. of Eggs laid	75	-
6	No. of Eggs hatched	33	-
7	No. of Eggs failed to hatch	9	12
8	No. of Eggs missed due to predation	29	38.66
9	No. of Eggs missed due to human disturbance	4	5.33
10	Hatching Success	-	44
Chicks			
10	No. of Chicks	33	-
11	No. of Chicks fledged	21	-
12	No. of chicks died due to unknown reasons	9	27.27
13	No. of chicks died due to Human disturbance	3	9.09
14	Fledging Success	-	63.64
15	No. of Nests that successfully fledged at least one chicks	12	-
16	No. of Nests that not fledged at least one chicks	8	-
17	Nesting Success	-	60
	Overall Breeding Success	-	28

4.4.5.8 Brood Parasitism

Total 21 nests of House Crow recorded of which 33.33 per cent nests of House Crow were parasitised by Asian Koel. Total 19 eggs were laid by Asian Koel in 7 nests of House Crow of which 10 chicks were successfully raised by House Crow. Overall breeding success of Asian Koel in nests of House Crow was 52.63 %. The average egg length, width and weight of Asian Koel eggs were 28.08 ± 0.66 mm, 22.05 ± 0.59 mm and 8.18 ±0.35 g., respectively. ESI and volume of Asian Koel eggs were 78.52 ± 0.99 and 691.74 ± 51.49, respectively. Parasitised nests of House Crows had lower survival of their own chicks (20.83 %) than un-parasitised nests (28.07 %). Table 55 gives information about the number of host and parasite eggs in parasitised nests of House Crow. In 2012, Asian Koel eggs ranged from 25 - 66.67 per cent in the House Crow nests. Of the 8 parasitised clutches, 2 nests had more than 50 per cent Asian Koel eggs and 4 nests had more than 30 per cent Asian Koel eggs in them. On an average, 44.19 per cent Asian Koel eggs were present in the parasitised nests of House Crow.

Table 55: Number of House Crow and Koel eggs in the parasitised nests of the House Crow

Sr. No.	Nest No.	Total eggs in nest	No. of House Crow eggs (%)	No. of Koel Eggs (%)
1	1	9	3 (33.33)	6 (66.67)
2	8	4	3 (75)	1 (25)
3	12	6	4 (66.67)	2 (33.33)
4	13	7	4 (57.14)	3 (42.86)
5	17	5	3 (60)	2 (40)
6	19	6	3 (50)	3 (50)
7	20	6	4 (66.67)	2 (33.33)
	Total	**43**	**24 (55.81)**	**19 (44.19)**

4.4.6 Comparison of Breeding Ecology of House Crow and Jungle Crow (during 2012)

4.4.6.1 Breeding Season Schedule

Clutch initiation of Jungle Crow during breeding season of 2012 was started from last week of March to last week of May and then breeding season of House Crow initiated from last week of May with slightly overlapping the Jungle Crow breeding season. It indicated that Jungle Crow and House Crow have separate breeding season, during summer and monsoon respectively. Maximum numbers of clutches were laid in first week of April by Jungle Crow when there was no rainfall (wind velocity 3.3 Km/hr**,** maximum temperature 39.8 C and relative humidity 39.9 per cent) while maximum numbers of clutches of House Crow observed in the first week of June which had no rainfall (wind velocity 6.6 Km/hr, maximum temperature 39.9 C and relative humidity 54.6 per cent) recorded.

4.4.6.2 Clutch Size

Clutch size of Jungle Crow ranged from 2 - 5 and most common clutch size was three and four (36.84 %) whereas clutch size of House Crow ranged from 3 - 6 and most common clutch size was three, four and five (31.58 %).

4.4.6.3 Egg Diametric

The eggs of Jungle Crow were sky blue in color with brownish speckled spots and oval in shape while eggs of House Crow are blue-green colored with speckled and blotched with brown, grey or black and oval in shape (Plate 5). Average length, width and weight of eggs of Jungle Crow was 40.12 ± 2.25 mm, 28.25 ± 1.78 mm and 17.01 ± 1.45 g, respectively and for House Crow it was 37.96 ± 1.27 mm, 26.87 ± 1.04 mm and 14.90

± 1.51 g, respectively. It showed that egg diametric values of Jungle Crow eggs were higher compared to House Crow eggs.

4.4.6.4 Incubation Period

The mean incubation period of Jungle crow eggs was 18.42 ± 0.79 (n = 12) ranging from 17 - 20 days and for House Crow it was 17.53 ± 0.99 days (n=15) ranging from 16 – 20 days. It showed that incubation period of Jungle Crow and House Crow was more or less similar but Jungle Crow eggs required one day more compared to House Crow eggs.

4.4.6.5 Nestling and Nesting Period

Nestling period of Jungle Crow was (34.54 ± 11.79; n =12, ranged from 26 to 46 days) and of House Crow it was 25 to 31 days with mean of 28.23 ± 2.17 days (n=13).

Nesting period of Jungle Crow was 49.33 ± 5.43 days (n = 12) ranged from 40 – 57 days was higher compared to House Crow (Mean: 44.23 ± 4.27 days; ranged from 35 to 50 days; n = 13).

4.4.6.6 Reproductive Success and Losses

Though hatching success of House Crow (44 %) was lower compared Jungle Crow (56.45 %) its fledgling success (63.64 %) was higher compared to Jungle crow (48.57 %). Overall breeding success of House Crow (28 %) and Jungle Crow (27.42 %) was nearly similar during year 2012 (Table 56).

Loss of eggs due to unknown reason was also similar in both crow species. But loss of chicks might be due to predation was higher in Jungle Crow (51.43 %) compared to House Crow (36.36 %). Twelve per cent eggs of House Crow were failed to hatch whereas no Jungle Crow egg recorded failed to hatch (Table 56).

Table 56: Comparison of reproductive success and losses of Jungle Crow and House Crow during breeding season 2012

Sr. No.	Particulars	Species	
		House Crow	Jungle Crow
1	Total nests	20	19
2	Hatching success (%)	44	56.45
3	Fledgling success (%)	63.64	48.57
4	Nesting success (%)	60	63.15
5	Breeding success (%)	28	27.42
6	Loss of eggs (missed) (%)	44	43.55
7	Loss of eggs (failed to hatch) (%)	12	0.00
8	Loss of chicks (%)	36.36	51.43

4.4.6.7 Brood Parasitism in Both Species of Crows

Per cent brood parasitism and eggs of Asian Koel was observed higher in the nests of Jungle Crow (73.68 %) compared to House Crow (33.33 %). Though lower parasitism was recorded in the nests of House Crow, survival of Asian Koel chicks was greater in the nests of House Crow (52.63 %) compared to Jungle Crow (35.71 %) (Table 57). This might be due to Asian Koel eggs were differing from Jungle Crow eggs in outer appearance and in size, and may be Jungle Crow able to distinguish eggs of parasite from own eggs and destroy them. Comparison of Jungle Crow, House Crow and Asian Koel egg colour, size and shape are shown in Plate 6. Length, width and weight of Asian Koel eggs in the nest of Jungle Crow was 29.97 ± 1.16 mm, 22.97 ± 0.84 mm and 8.79 ± 0.83 g, respectively and in House Crow nests it was recorded as 28.08 ± 0.66 mm, 22.05 ± 0.59 mm and 8.18 ±0.35 g., respectively. Average egg size of 21 Asian Koel eggs was worked out by Lamba (1976) as 30.8 mm × 23.2 mm which was higher compared to this study.

Host survival per cent in Asian Koel parasitised nests was observed similar in both crow species (House Crow and Jungle Crow) with very low rate (20.83 % and 20.93 % respectively) compared to un-parasitised nests.

Table 57: Comparison of brood parasitism of Asian Koel in the nests of Jungle Crow and House Crow during breeding season 2012

Sr. No.	Particulars	Species	
		House Crow	**Jungle Crow**
1	Nest parasitism (%)	33.33	73.68
2	Asian Koel eggs in parasitised nests (%)	44.19	49.41
3	Breeding success of Asian Koel (%)	52.63	35.71
4	Host breeding success in parasitised nests (%)	20.83	20.93

V. SUMMARY & CONCLUSION

This study on "Ecology of House Crow (*Corvus splendens*) and Jungle Crow (*Corvus macrorhynchos*) in Agricultural Landscape" was carried out from January 2011 to July 2012 at Anand Agricultural University campus, Anand city and adjoining villages in central Gujarat, India. The study was focused on food and foraging behavior of crows, their distribution within agricultural landscape, significance of crows in avian assemblages during farm operations and nesting ecology of both House Crow and Jungle Crow. Portion of two major habitat types *viz.,* agricultural habitat and human habitation were considered to be important factors influencing distribution, nesting and breeding ecology of two species. The results are summarized and concluded hereunder.

FOOD AND FORAGING BEHAVIOR OF CROWS:

Food of crows was classified into two major categories *viz*., animal and plant matter. Jungle Crow mainly consumed animal matter (56.43 % F & 60.47 % R. A.) whereas House Crow was chiefly feeding on plant matter (65.04 % F and 55.48 % R. A.).

Major food categories were further classified into food types which were assessed by crows from two major habitats *viz*., agricultural habitat and human habitation.

In agricultural habitat highest frequency of House Crow (30.23 % F & 41.36 % R. A.) and Jungle Crow (15.84 % F & 36.55 % R. A.) was recorded feeding on non-vegetarian food waste and carcasses, whereas in human habitation highest frequency of House Crow (62.50 % F & 58.46 % R. A.) and Jungle Crow (48.98 % F & 47.23 % R. A.) was recorded feeding on kitchen waste of residential area. Both the species in residential area largely relied upon kitchen waste and flesh of road-killed vertebrates.

In the entire study area, the House Crow was recorded feeding on kitchen waste (50 % F & 47.35 % R. A.) and Jungle Crow was recorded feeding on non-vegetarian food waste and carcasses (24.40 % F & 24.56 % R. A.). Only House Crow recorded feeding on agricultural market waste (2.14 % & 2.57 %). Jungle Crow depredation on fruits (10.50 %) and predation on invertebrates (6.55 %) & vertebrates (2.73 %) was higher compared to House Crow in the study area. It indicates that Jungle Crow act as predator of insect pest of important food crops as well as act as pest on fruit crops at some extent. In short, the Jungle Crow was observed feeding mainly on animal matter whereas House Crow was observed feeding mainly on plant matter.

DISTRIBUTION OF CROWS WITHIN AGRICULTURAL LANDSCAPE:

Study area was divided into two major habitats *viz*., agricultural habitat and human habitation, and these major habitats were further classified into habitat components. It revealed that frequency and relative abundance of House Crow was higher in area of human habitation (72.39 % F & 62.63 % R. A.) compared to agricultural habitat (27.61 F % & 37.37 % R. A.) while Jungle Crow distribution in agricultural habitat (71.25 % F & 78.27 % R. A.) was higher compared to area of human habitation (28.75 % F & 21.73 % R. A.). Overall distribution of House Crow was higher in human habitation compared to Jungle Crow, whereas Jungle Crow was most abundant in agricultural habitat. Distribution pattern of crows in various components of entire study area revealed that frequency and relative abundance of House Crow was recorded higher residential area (52.68 % F & 39.72 % R. A.) followed by roadside plantations in agricultural habitat (16.11 % F & 20.24 % R. A.) and roadside plantations in human residency (11.41 % F & 8.57 % R. A.) whereas relative abundance of Jungle Crow was higher in orchards (20.89 %) followed by residential area (18.49 %) and non-vegetarian food waste dumping site.

It can be concluded that House Crow distribution was recorded in the area close to human residency whereas Jungle Crow distribution was observed highest in agricultural habitat, away from human residency. The name of Jungle Crow itself indicates that they are inhabitants of the jungle area while the name of House Crow indicates that they are present close to human residency; the result from this study also reflects the same thing.

SIGNIFICANCE OF CROWS IN AVIAN ASSEMBLAGES DURING FARM OPERATIONS:

Avian community attending different farm operations *viz*., land preparation, green manuring, sowing, irrigation, interculturing and harvesting were recorded during this study.

Land preparation operation were recorded as cultivator ploughing, disk ploughing and mould board ploughing, total 25, 18 and 16 bird species were recorded respectively from each operation. Frequency of occurrence and relative abundance of Jungle Crow and House Crow during cultivator ploughing (4.98 % F; 2.09 % R. A. & 0.31 % F, 0.04 % R. A., respectively), disk ploughing (7.35 % F and 1.81 % R. A.& 1.47 % F and 0.10 % R. A. respectively) and mould board ploughing (2.17 % F and 0.17 % R. A. & 2.17 % F and 0.17 % R. A. respectively) were very low compared to other bird species recorded during these operations and did not show any significance in feeding on insect pests exposed during ploughing. Cattle Egret, Common Myna and Black Drongo were recorded as important species during land preparation operations.

During green manuring operation, eight bird species were recorded of which Jungle Crow had importance value index of 7.72 which was similar to the Black Drongo. Insects exposed during green manuring were preyed by Jungle Crow but not at significant level. Common Myan and Cattle egret were most dominant species observed during green manuring operation.

During sowing operation, total 17 bird species were recorded in which abundance of Jungle Crow was negligible whereas Blue rock pigeon (I = 33.72) and Common Myna (I = 10.09) were important species recorded during sowing operation.

During irrigation operation, total 20 bird species were recorded. Frequency of Jungle Crow and House Crow was 5.26 % and 2.63 % and relative abundance was 2.96 % and 0.42 % respectively. It indicates that crows do not play important role in predation of invertebrates from wet soil during irrigation operation. Cattle Egret (I = 26.42), Black Ibis (I = 18.64) and Common Oriental White Ibis (I = 13.46) were most important species recorded during irrigation.

During intercultural operation, total six bird species were recorded. Jungle crows were observed feeding on invertebrates from soil with index of importance of 14.06. Other most abundant species recorded during interculturing were Cattle Egret (I = 51.34), Black Drongo (I = 15.07) and Common Myna (I = 14.06).

During harvesting operation, total 21 bird species were recorded. Jungle Crow was observed only at one observation feeding on uprooted harvested groundnut with relative abundance of 0.95 % of the total bird community. Therefore, during harvesting also, the crows does not play important role in depredation of harvested seeds or predation on emerged insect fauna.

Very few House Crow were observed during various farm operations during this study because the farm operations are done only in agricultural habitat and House Crow distribution was very low in this habitat.

Amongst all farm operations, interculturing (20 % F) and green manuring (12.5 % F) operations showed higher relative frequency of Jungle Crow compared to other farm operations even though Jungle crow did not play any significant role in reducing insect-pest population from fields.

NESTING ECOLOGY

The Jungle Crow showed tendency to nest in agricultural habitat (61.11 % nests) whereas House Crow showed tendency to nest exclusively in residential habitat (98.67 %). Nests of Jungle Crow were occasionally recorded in residential area but House Crow nests were rare in agricultural areas. Jungle Crow largely used trees (97.22 %) as substrate for nesting and occasionally utilized artificial structure (2.78 %) while House Crow utilized artificial structures (13.33 %) in higher frequency compared to Jungle Crow (2.78 %). Jungle Crow occupied 17 different tree species from 30 tree species available in the study area. Availability (20.90 %) and utilization (28.57 %) of mango by the Jungle Crow was the highest in the study. The House Crow occupied 16 different tree species for nesting from 25 tree species available in the study area. Availability of neem (21.20 %) was maximum but was not utilized in proportion of its availability. Utilization of banyan and copperpod (13.85 %) for the nesting purpose was the highest in the study area. Both Jungle Crow (86.11 % nests) and House Crow (74.67 %) largely used tertiary branches for setting up their nest platform.

Tree height (14.27 ± 3.79 m) and canopy cover (14.63 ± 6.71 m) of Jungle Crow nesting trees were significantly higher compared to tree height (11.45 ± 4.71 m) and canopy cover (11.43 ± 5.20 m) of trees occupied by House Crow. Average Jungle Crow nest height (12.57 ± 3.92 m) from the ground level was higher compared to House Crow nest height (8.85 ± 3.82 m). Moreover, in residential areas, tree dimensions were lower than the agricultural area which indicated that House Crow preferred to nest on trees of human habitation. The Jungle Crow set nest platform at greater heights than the House Crow, probably to avoid ground predator attack. Size of nest platform of Jungle Crow (0.42 m × 0.15 m) was significantly larger compared to House Crow nest (0.37 m × 0.13 m) ($t = 6.924$, $df = 66$, $P < 0.05$).

Certain characters of trees surrounding nesting tree were studied and compared with trees actually occupied. Trees characters of *viz*., tree height, CBH, canopy diameter and crown height of trees occupied by both species of crows were significantly higher compared to surrounding trees.

Characters of occupied tree and nest parameters in residential and agricultural area of each species did not show significant difference, indicating that distinction of the study area into residential and agricultural was not valid as they may be structurally same.

Among eighteen tree species used by Jungle Crow, the highest tree height was in Rain tree (20.50 m) followed by peepal (20.10 m), copper pod (18.90 m) and lebbeck tree (17.20 m). The lowest tree height was recorded in pongam tree (10.80 m).

Among eighteen tree species used by House Crow, the highest tree height was in messmate (23.23 ± 6.37 m) followed by ashok (18.6 m), lebbeck (16.8 m), and indian tree of heaven (16.64 ± 1.65 m). The lowest tree height was recorded in babool (7.15± 0.55 m).

Detectibility of 66.67 % nests had zero rank indicating that they were almost safe against ground predators. On the other hand in House Crow, only 6.67 % nests had zero rank detectibility while remaining 93.33 % nests had predation risk from the ground. This indicated that risk of avian predators and extreme environmental conditions was more in House Crow nest compared to the nests of Jungle Crow. As a matter of fact, the risk of ground predator was more in Jungle Crow nests than House Crow nests as threat from ground predators is very low in residential area compared to the agricultural habitat. Amongst both the species of crows, inter-nest distance was significantly higher in the Jungle Crow (112.82 ± 63.13 m) compared to House Crow (49.07 ± 84.39 m) ($t = 3.521$, $df = 99$, $P < 0.05$). This indicates Jungle Crow possess larger territorial area than House Crow, to avoid competition with conspecifics. Distance of Jungle Crow nest from human habitation (72.94 ± 66.30 m) was significantly greater compared to House Crow (26.59 ± 29.42 m) ($t = 5.06$, $df = 107$, $P < 0.05$) indicates more affinity of House Crows to nest close to human habitation. Distances of House Crow nest from garbage (37.59 ± 41.25 m) and water source (28.62 ± 28.77 m) were significantly lower compared to Jungle Crow (90.62 ± 67.40 m; 58.67 ± 58.96 m) ($t = 5.05$, $df = 106$, $P > 0.05$). It implies that House Crows preferred more garbage and dumping sites as food source and prepared their nests close to such area. The Jungle Crow nests were far away from such waste dump sites (Table 14), which indicates lesser dependency.

The area having tall trees with high density of foliage and away from human residency is utilized by Jungle Crow for nesting purpose whereas area close to human residency with availability of trees and some artificial structures is utilized by House Crow for nesting purpose.

Breeding performance:

Jungle Crow breeding season 2011-12

During breeding season in 2011 clutch initiation started from last week of February whereas during 2012 it started from third week of March and continued till last week of May. It indicated that initiation of breeding season during 2012 was two weeks late compared to previous year. During both the years, breeding activity terminated in last week of May. In short, initiation of egg laying was recorded when minimum temperature reached at 13° C and maximum temperature at 31° C. Maximum numbers of clutches were laid in second week of April in 2011 and first week of April in 2012.

The eggs were sky blue in color with brownish speckled spots and oval in shape. During both breeding season clutch size ranged from 2 - 5 and most common clutch size was three and four, with mean 3.31 and 3.28 eggs in 2011 and 2012 respectively. The mean incubation period of Jungle crow eggs was 17.61 days during 2011 and 18.42 days during 2012. Average length, width and weight of eggs during 2011 was 41.35 ± 2.73 mm, 28.84 ± 1.20 mm and 17.31 ± 1.96 g, respectively and during 2012 it was 40.12 ± 2.25 mm, 28.25 ± 1.78 mm and 17.01 ± 1.45 g, respectively. Egg diametric values did not differ significantly during two years.

Nestling period during breeding season of 2011 was 39.5 days which was higher compared to breeding season of 2012 (Mean = 34.54 days). Nesting period during season 2012 (Mean = 49.33 days) was higher compared to season of 2011 (Mean = 46.97 days). Hatching success (60.5 %), fledgling success (57.7 %), nesting success (76.9 %) and breeding success (34.9 %) during year 2011 were higher compared to the season of 2012 (56.45 %, 18.57 %, 63.15 % and 27.42 % respectively). Brood parasitism per cent and number of eggs of Asian Koel in the nests of Jungle Crow was higher in 2012 compared to 2011, which may be attributed to late initiation of breeding season during

2012. Breeding success of Asian Koel as well as Jungle Crow was higher during season 2011 compared to 2012. Host survival rate in Asian Koel parasitised nests was very low during season 2012 (20.93 %) due to higher nest parasitism by Asian Koel. In short, survival value of both host and parasite were high when parasitism rate was low (2011).

Comparison of breeding season of Jungle Crow and House Crow in 2012:

During breeding season of 2012 clutch initiation of Jungle Crow started from third week of March and continued till last week of May whereas House Crow initiated clutches from last week of May showing slightly overlapping breeding season. It indicated that Jungle Crow and House Crow have distinct breeding season i. e., during summer and monsoon respectively. Jungle Crow laid maximum clutches in first week of April while House Crow laid maximum clutches in the first week of June.

Clutch size of Jungle Crow ranged from 2 - 5 and most common clutch size was three and four (36.84 %) whereas clutch size of House Crow ranged from 3 - 6 and most common clutch size was three, four and five (31.58 %).

The eggs of Jungle Crow were sky blue in color with brownish speckled spots and oval in shape while eggs of House Crow were blue-green colored with speckled and blotched with brown, grey or black and were oval in shape. Average length, width and weight of eggs of Jungle Crow was 40.12 ± 2.25 mm, 28.25 ± 1.78 mm and 17.01 ± 1.45 g, respectively and for House Crow it was 37.96 ± 1.27 mm, 26.87 ± 1.04 mm and 14.90 ± 1.51 g, respectively. The egg diametric values of Jungle Crow eggs were higher compared to House Crow eggs. The mean incubation period of Jungle crow (18.42 ± 0.79 days) eggs was higher compared to House Crow (17.53 ± 0.99 days).

Nestling period (34.54 days) and nesting period (49.33 days) of Jungle Crow was higher compared to House Crow (28.23 days and 44.23 days, respectively). Though hatching success of House Crow (44 %) was lower compared to Jungle Crow (56.45 %), its fledgling success (63.64 %) was higher compared to Jungle crow (48.57 %). Overall breeding success of House Crow (28 %) and Jungle Crow (27.42 %) was nearly similar during year 2012. Loss of eggs due to unknown reason was also similar in both crow species. Loss of chicks, probably due to predation was higher in Jungle Crow (51.43 %) compared to House Crow (36.36 %). Twelve per cent eggs of House Crow failed to hatch whereas no hatching failure was recorded in Jungle Crow eggs during 2012.

Brood parasitism of Asian Koel was higher in the nests of Jungle Crow (73.68 %) compared to House Crow (33.33 %). Though lower parasitism was recorded in the nests of House Crow, survival of Asian Koel chicks was greater in the nests of House Crow (52.63 %) compared to Jungle Crow (35.71 %). The Asian Koel's eggs were differ from Jungle Crow eggs in outer appearance and in size, and it is abite likely that Jungle Crow may be able to distinguish eggs of parasite from their own eggs and destroyed them. Comparison of Jungle Crow, House Crow and Asian Koel egg color, size and shape. Host survival per cent in parasitised nests was similar in both crow species (House Crow 20.83 % & Jungle Crow 20.93 %) with very low rate compared to un-parasitised nests.

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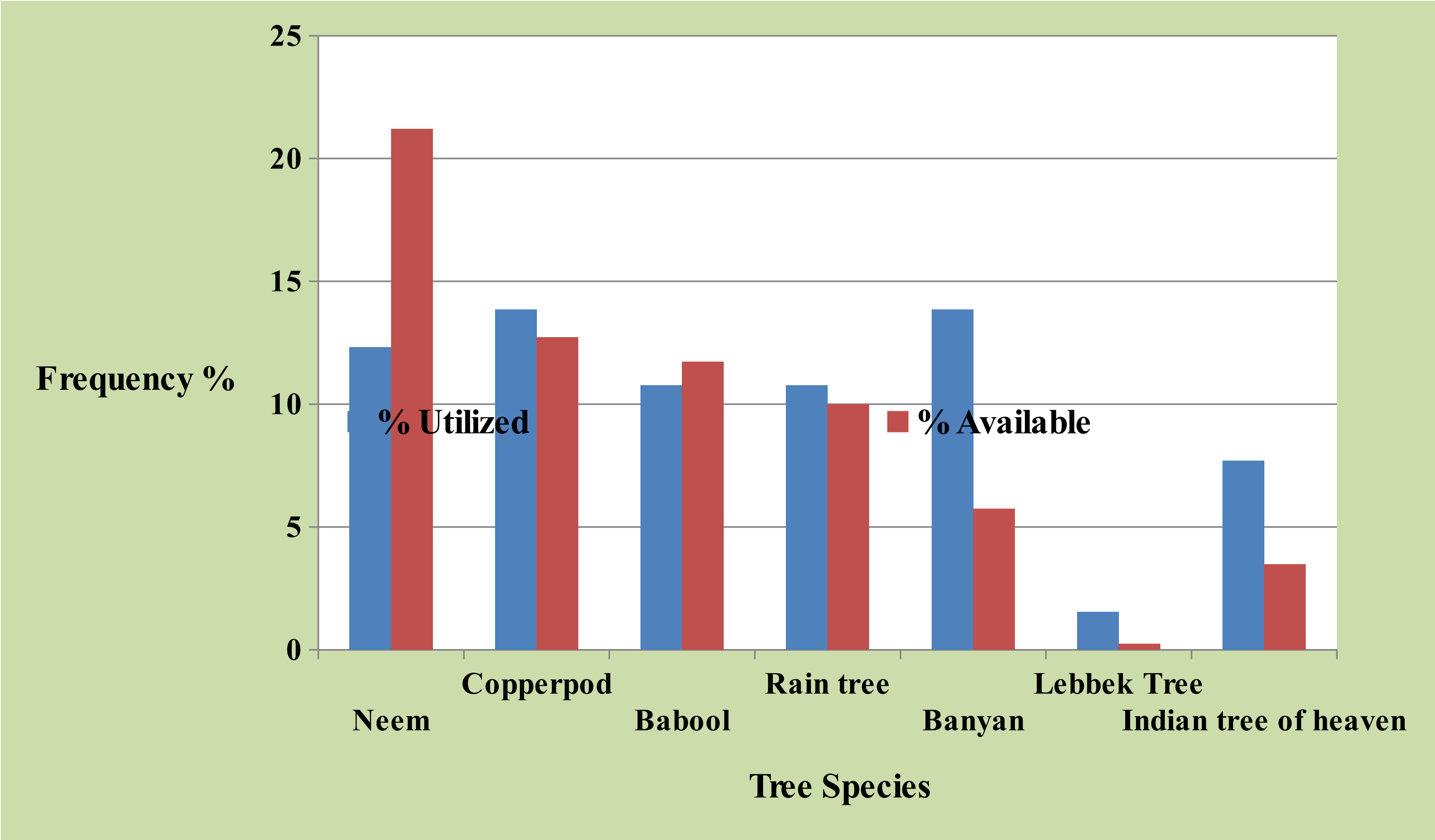

Figure 3: Comparison of availability and utilization of some important tree species used for nesting by House Crow

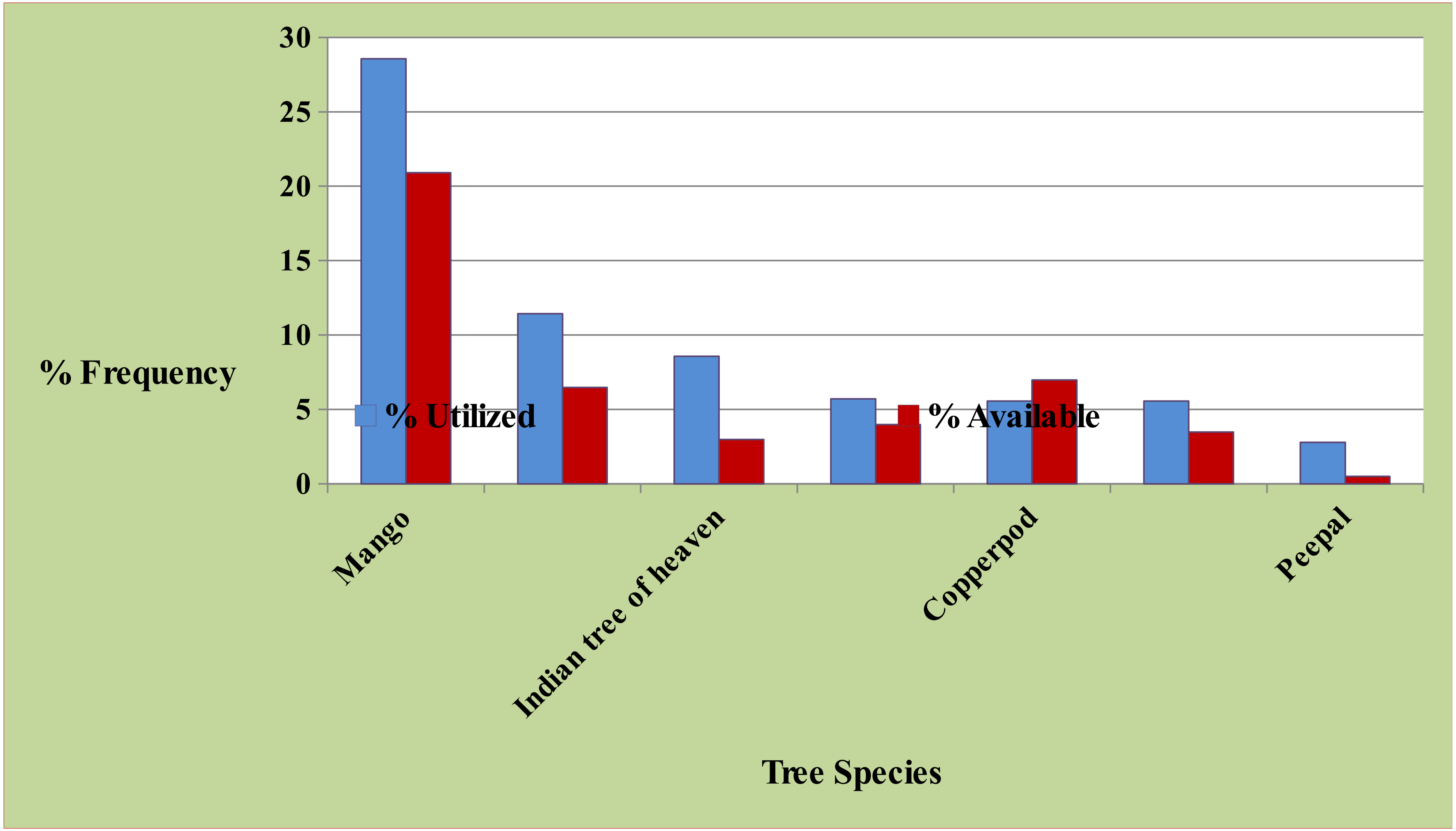

Figure 2: Comparison of availability and utilization of some important tree species used for nesting by Jungle Crow

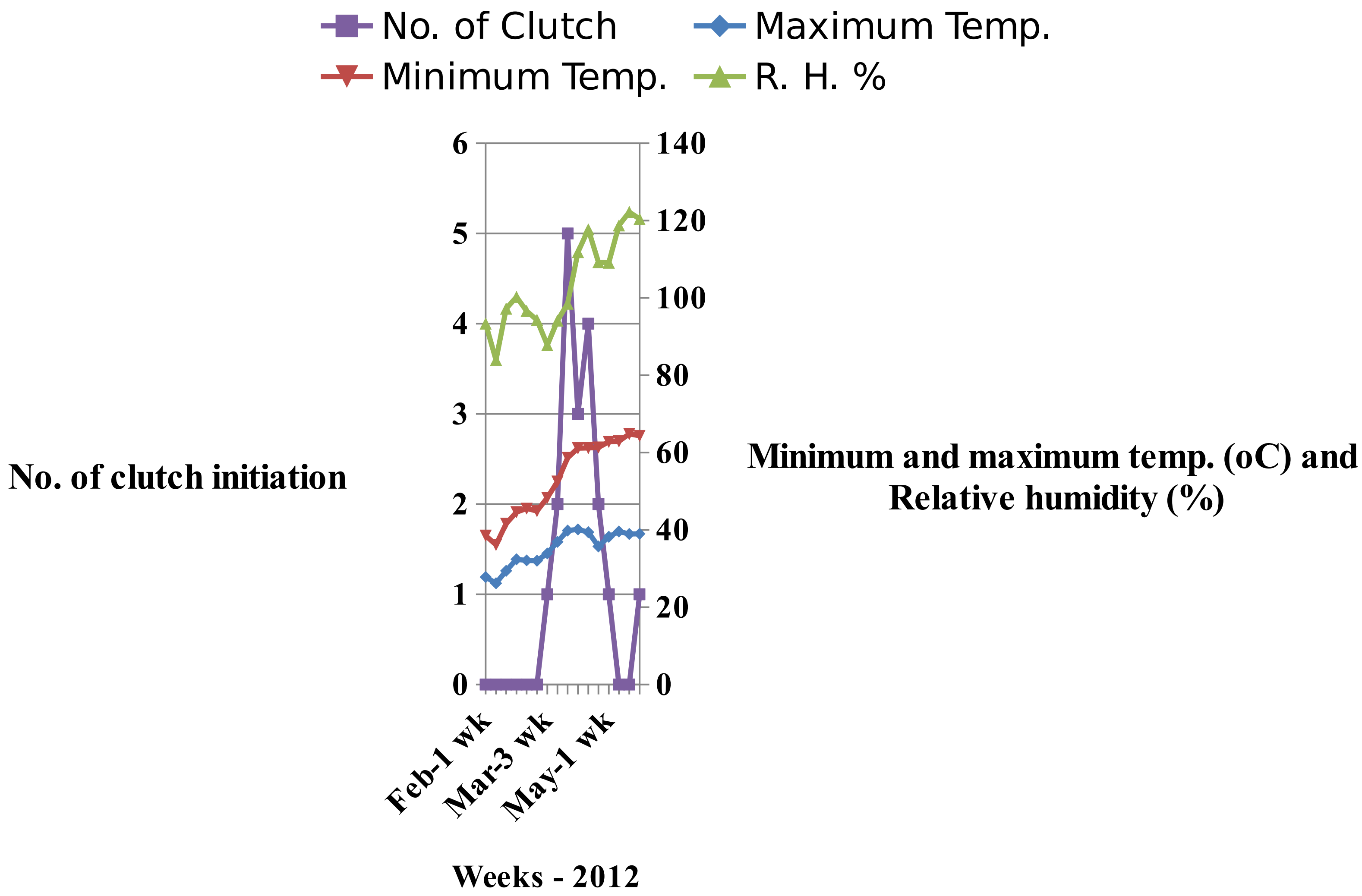

Figure 5: Correlation between numbers of clutches initiated, minimum & maximum temperature and relative humidity % during Jungle Crow breeding season 2012

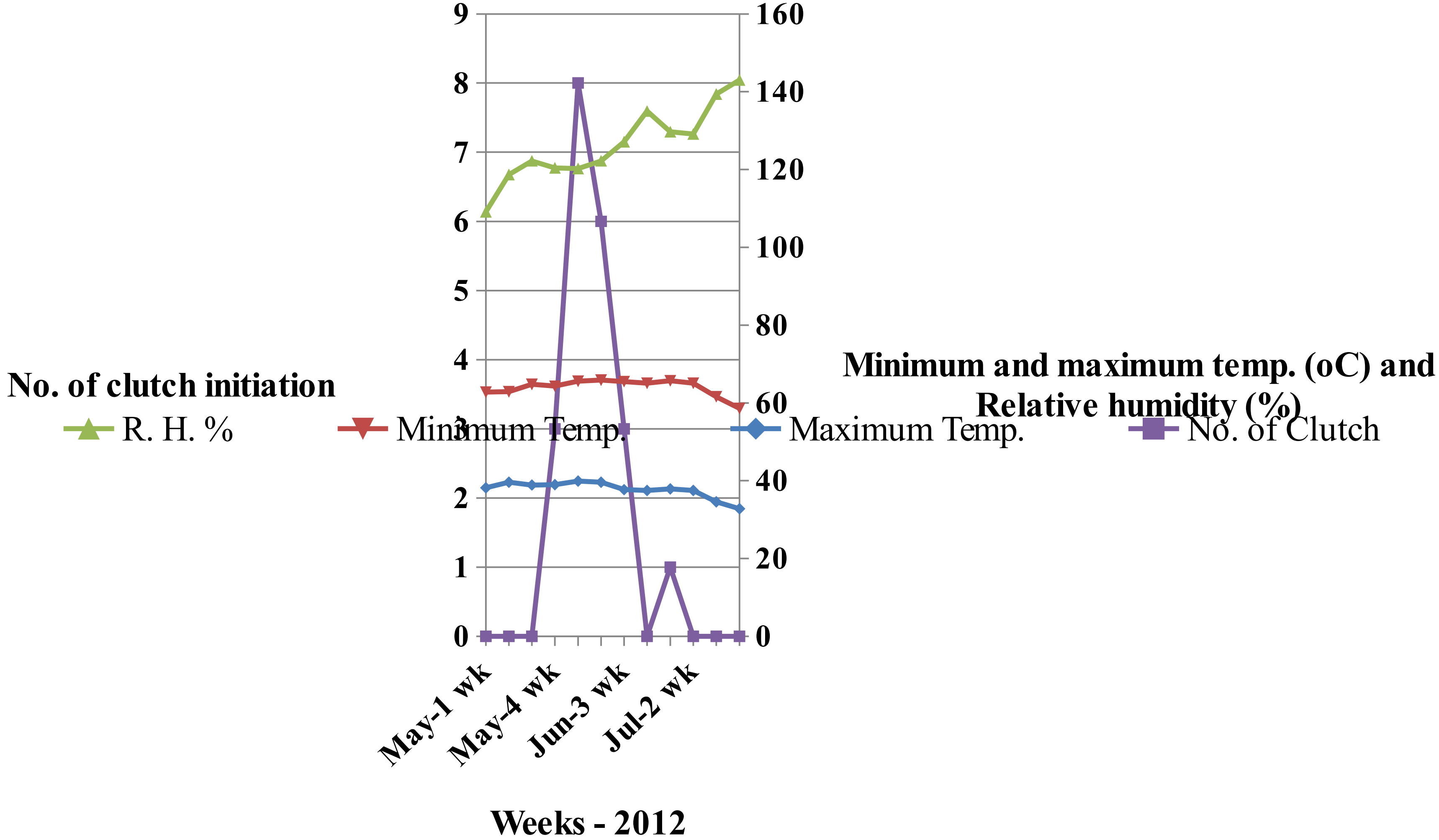

Figure 6: Correlation between numbers of clutches initiated, minimum & maximum temperature and relative humidity % during House Crow breeding season 2012

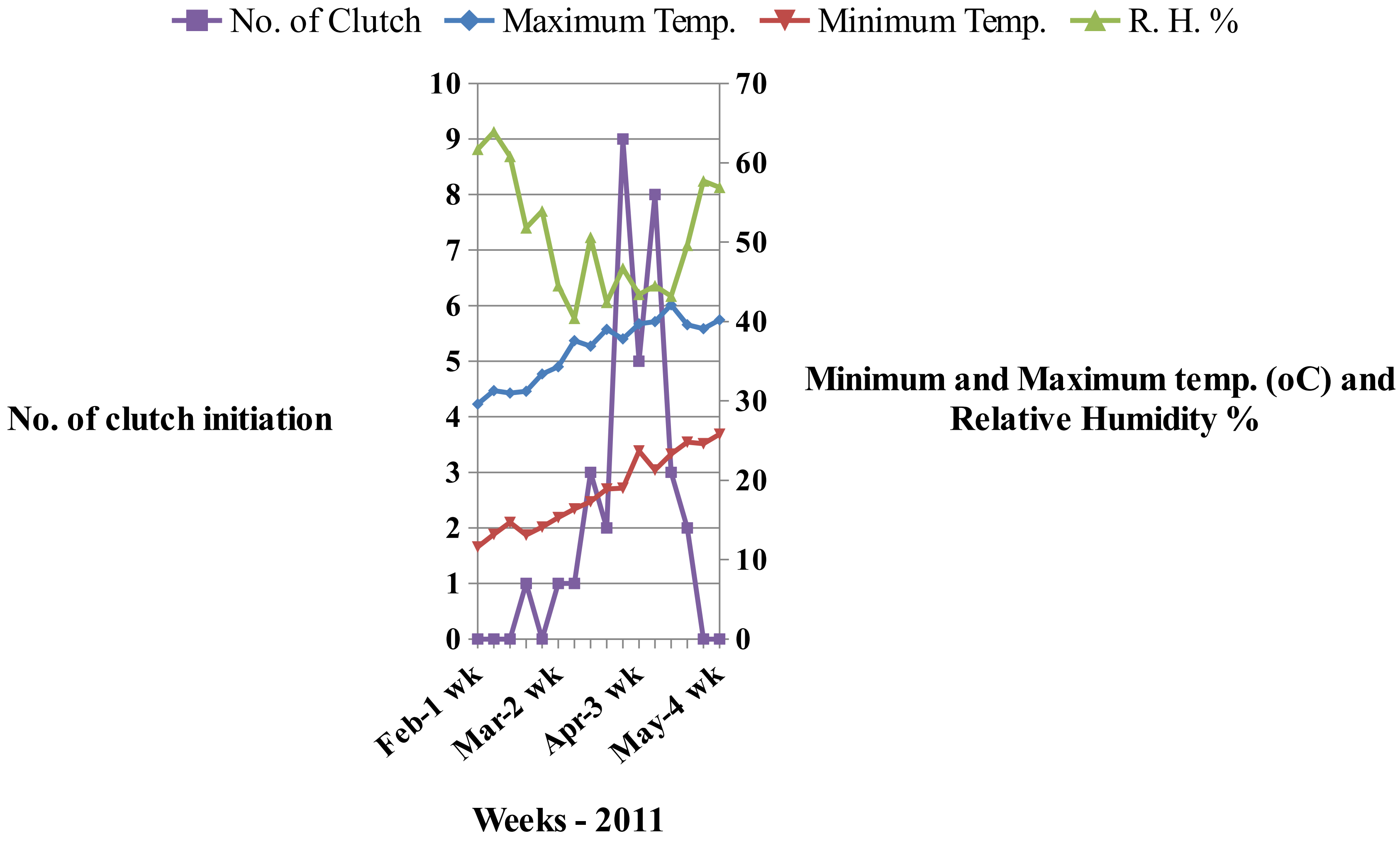

Figure 4: Correlation between numbers of clutches initiated, minimum & maximum temperature and relative humidity % during Jungle Crow breeding season 2011