"EXPLORATION OF AVIFAUNAL DIVERSITY IN AND AROUND P. G. DEPARTMENT OF BIOSCIENCES"

A

DISSERTATION THESIS SUBMITTED TO

B. R. D. SCHOOL OF BIOSCIENCES

SARDAR PATEL UNIVERSITY

VALLABH VIDYANAGAR

GUJARAT, INDIA

FOR THE PARTIAL FULFILLMENT FOR DEGREE OF

MASTER OF SCIENCE IN

ZOOLOGY

SUBMITTED BY

DEEPALI DAVE

EXAMINATION NO.: 14

APRIL 2019

UNDER THE GUIDANCE OF

PROF. UJJVAL B. TRIVEDI &

DR. RUPAL VASANT

B. R. D. SCHOOL OF BIOSCIENCES

SARDAR PATEL UNIVERSITY, VALLABH VIDYANAGAR

GUJARAT, INDIA

“EXPLORATION OF AVIFAUNAL DIVERSITY IN AND AROUND P. G. DEPARTMENT OF BIOSCIENCES”

A

DISSERTATION THESIS SUBMITTED TO

B. R. D. SCHOOL OF BIOSCIENCES

SARDAR PATEL UNIVERSITY

VALLABH VIDYANAGAR

GUJARAT, INDIA

FOR THE PARTIAL FULFILLMENT FOR DEGREE OF

MASTER OF SCIENCE IN

ZOOLOGY

SUBMITTED BY

DEEPALI DAVE

EXAMINATION NO.: 14

APRIL 2019

UNDER THE GUIDANCE OF

PROF. UJJVAL B. TRIVEDI &

DR. RUPAL VASANT

B. R. D. SCHOOL OF BIOSCIENCES

SARDAR PATEL UNIVERSITY, VALLABH VIDYANAGAR

GUJARAT, INDIA

DECLARATION

I, Deepali R. Dave, declare that the dissertation work which is being submitted for the degree of Master of Science (M. Sc.) in Zoology of Sardar Patel University was carried out under the supervision of Prof. Ujjval B. Trivedi and Dr. Rupal Vasant at B. R. D. School of Biosciences, Vallabh Vidhyanagar, Gujarat. It is an original work and has not been submitted previously for degree/diploma of any other institute.

Date: Deepali Dave

Place: P. G. Department of Biosciences
Satellite Campus
Bakrol – Vadtal road
388315

ACKNOWLEDGEMENT

A Pleasant task of reciprocation by words to those who helped directly or indirectly in shaping this research work is constrained only by a limited space for describing the nature of my debts to each of them.

I express my profound reverences and deep obligation to my parents, Mr. Ramesh N Dave and Mrs. Ansuyaben Dave for their constant inspiration and moral support throughout the study period. The beauty of mother nature has always been inspiration to study biodiversity.

At this unique moment of my academic career, I wish to express my heartfelt appreciation and indebtedness to my Guides Dr. Rupal Vasant and Prof. Ujjval B. Trivedi and all the faculties of P. G. Department of Biosciences, for their consistent encouragement, erudite and intellectual guidance, constructive suggestions and solicitous behavior, there by shaping during my whole M. Sc. program.

I extend identical feeling to acknowledge my deep sense of gratitude to Dr. A. S. Reddy and Ms. Richa Chauhan for their valuable help in identifying the flora species.

I am thankful to Mr. Ashok Mashru and Dhaval Vargiya for their valuable suggestions and help in identification regarding this study.

I cannot resist to mention Mayur Variya, Jigar Patel, Pallavi Kyada, Kajal Patel, Kamal Parikh, Sneha Singh, Sweta Thakar, Krupal Patel, Mukesh Koladiya for sharing their precious knowledge guided me on the right path.

At last, I cannot forget my classmates and my juniors who have inspired me and helped me throughout my field work.

Date: Deepali Dave

Place: P. G. Department of Biosciences

Satellite Campus

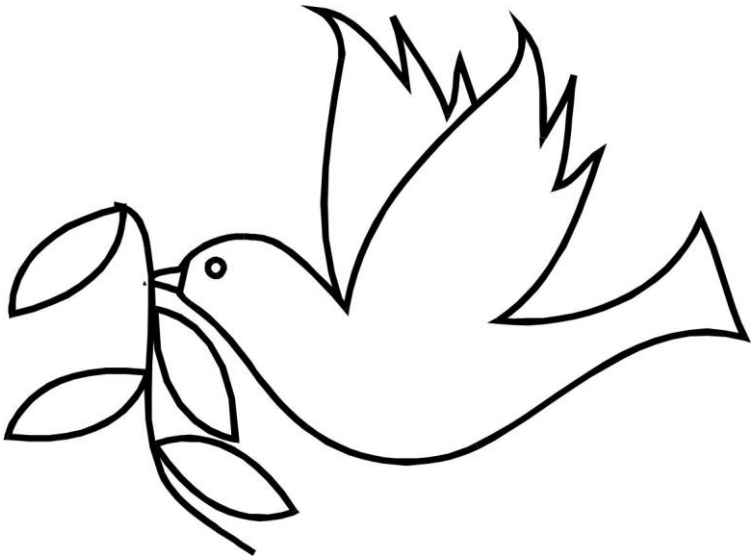
Bakrol – Vadtal road

388315

CONTENTS

LIST OF TABLES

LIST OF FIGURES



I. INTRODUCTION

1. General Introduction: Aves

The study of biodiversity is significant. The variability among living organisms from all sources including, terrestrial, marine, and other aquatic ecosystems and the ecological complexes of which they are apart this includes diversity within species, between species and of ecosystems (Ohemeng, *et al.* 2017).

Birds are warm blooded animals and the body is covered with non-conducting feathers that helps in thermoregulation. Their rate of metabolism is higher than mammals and they lack sweat glands (Ali, 2017). Aves are extensively distributed throughout the world as compared to other vertebrates. Avifauna is categorized according to their behavior, habitat and feeding mechanism. Birds are found from pole to equator almost everywhere on the earth and exhibit great diversity by their habitat and geographical conditions. Birds represent an important ecological component of global biodiversity. Aves are one of the most prominent species of Earth's biodiversity and being sensitive to environmental changes (Aggarwal, 2015). Certain parameters including species richness, abundance and community composition are often used by ecologists to understand the diversity of species in their natural occurrence (Singh, 2018).

The study of avifaunal diversity is an essential ecological tool, which act as an important indicator to evaluate different habitats both qualitatively and quantitatively (Helm, 2002). It also fulfills varieties of ecological importance.

Ornithological research has always played a pivotal role in the development of certain aspects of our science. Birds have attracted more than their fair share of our zoological attention.

Dense floral diversity in and around the Department of Biosciences attracts large number of faunal components. Avifaunal species are principally recorded. Some of the tempting components for bird population are immense in Department including availability of diet, refuge, reproductive opportunities and nesting material for birds. Vast diversity of invertebrates like bugs, beetles, butterflies, ants, flies play very important role in a part of food chain as birds feed on them.

2. Scientific Classification:

Kingdom : Animalia

Phylum : Chordata

Subphylum : Vertebrata

Class : Aves

Aves are differentiated into orders according to their habitat, feeding behavior, morphological patterns and phenotype. The orders include, Passeriformes, Cuculiformes, Psottaciformes, Accipitriformes, Charadriiformes, Pelecaniformes, Bucerotiformes, Piciformes, Columbiformes, Coraciiformes, Strigiformes, Gruiformes, Caprimulgiformes,Anseriformes, Galliformes, etc. Few orders are described further.

2.1 Order Passeriformes

Most passerine birds are small in size. They feed mainly on insects, spiders, annelids, seeds, fruits, and nectar (Payevsky, 2014). Greatest diversity belong to order Passeriformes. This order includes of about 5740 species, or 50% of all extant bird species. Passeriformes widely inhabit all terrestrial regions except Antarctica ices. The division of passerine into groups of songbirds began in the late 19th century (Sharpe, 1877-1890; Gadow, 1893). Passerine are very much numerous,

both in terms of number of species and number of population, that ornithologist in their daily work usually divide all the birds into passerine and non-passerine. Due to huge diversity, relative ease of observation, and field studies, including collecting, passerines have long attracted the attention of a wide range of biologists (Payevsky, 2014). Passeriformes include families like, Passeridae, Sturnidae, Dicruridae, etc. E.g. House Sparrow, Red vented Bulbul, Ashy Prinia, Plain Prinia, Jungle Babbler, Large grey Babbler, Wagtail etc.

Figure 1: Jungle Babbler

2.2 Order: Cuculiformes

Cuculiformes include Cuckoos, Koel and Coucals. Cuculiformes are widely distributed, yet they are concentrated in tropics because of comfortable habitat. Both terrestrial and arboreal behaviors are seen. Terrestrial cuckoos are considered to be the oldest (Payne 2005, Posso and Donatelli 2006), occuring in the Neotropics, Africa, Madagascar and South Asia. Arboreal cuckoos are cosmopolitan and are

concentrated in the tropics. Cuckoos are popular because of their reproductive behaviors and also for terrestrial and arboreal habits (Payne 1997-2005). The koel bird produces loud, characteristic and distinctive calls. Koel bird uses their calls for social cohesion and coordination of different behaviors (Khan, Qureshi 2017). The order Cuculiform includes family Cuculidae. E.g. Asian Koel, Common hawk Cukoo, Greater Coucal etc.

Figure 2: Asian Koel

2.3 Order: Coraciiformes

Coraciiformes order contain colorful and attractive birds. It includes bee-eaters, rollers, kingfishers etc. Bee-eating birds are widely distributed. Most of them are migratory species. They spend most of their time preying on honey bees before moving to another area. However, during their presence they produce specific

sounds that honey bees can recognize causing them to stay in their hives (Mohamed Ali and Taha, 2012). Bee eaters are one of the few bird species with the ability to modify the habitat by digging long burrows where it breeds. They are diurnal birds and spend their most of the time foraging for food. They are usually seen as sitting at a perch waiting for prey. They fly out to catch a prey and then return and sit back and consume it. E.g Common Kingfisher, European roller, Indian Roller, Pied Kingfisher etc

Figure 3: Green bee eater

3. Habitats

The area around the Indian subcontinent is roughly divided into forest, scrub, wetland, marine, grassland, desert and agricultural land.

3.1 Forest:

Huge varieties of forest are found like, tropical forests, dense evergreen forest, dry-deciduous forest, open-desert thorn forest. Tropical and subtropical broadleaved evergreen forest supports the greatest diversity of bird species. Tropical deciduous forest including moist and dry sal and teak forest, riverine forest and dry thorn forest contain a higher number of endemic and globally threatened species than any other habitat in the region.

3.2 Scrubland:

Scrubs are developed in the region where trees are unable to grow, either because soils are poor and thin, or because they are too wet, as the edges of wetland or on seasonally inundated floodplains. Scrubs also grow naturally in extreme climatic conditions, as in semi-desert or at high altitudes in Himalayas. Some birds prefer scrubland alone, but most of the birds choose scrubland alongwith grassland.

3.3 Wetland:

Wetland provide habitats for breeding resident species, they include most of the wintering ground for breeding. The region include wide variety of wetland types, distributed almost throughout, including mountain glacial lakes, freshwater and brackish marshes, large water storage reservoirs, village tanks, saline flats and coastal mangroves and mudflats.

3.4 Grassland:

The low land grassland supports many bird communities, with a number of specialist endemic species. Most of region's endemic grassland birds are at high risk, including Lesser Florican, Great Indian Bustard, Bristled Grassbird and Finn's weaver.

3.5 Dessert:

The Thar Desert is largest desert. It covers an area of 2000000 km northwest India and Pakistan. There are other extensive arid areas in Pakistan; the hot deserts of the Chagai, a vast plain west of the main mountain ranges of Baluchistan, and the Thal, Cholistan and Sibi deserts in central and eastern Pakistan. The far northern mountain regions, which the monsoon winds do not penetrate, experience a cold-desert climate. There is only one bird species, Stoliczka's Bushchat, which is virtually endemic to the region.

3.6 Seas:

Sea bird species include the threatened Barau's petrel, Long tailed skua. Sea bird colonies in the subcontinent are concentrated chiefly in the Maldives and Lakshadweep Islands (Grimmett, 2011).

4.Aerial Adaptation

4.1 Shape

The perfectly streamlined spindle-shaped body of a bird is designed to offer minimum resistance to the wind, and hence easily propelled through the air in the same manner as the fish swim through water quite easily without any waste of effort.

4.2 Compact body

The compact body, light but strong dorsally and heavier ventrally, helps in maintaining air balance. The attachment of the wings high up on the thorax, the high position of such light organs as lungs and air-sacs, the low and central position of the heavy muscles, sternum, and digestive organs beneath the midline of the attachment of two wings and consequently low center of gravity, are also structural facts of importance.

4.3 Feathers

The smooth, closely fitting and backwardly directed contour feathers make the body streamlined and further help its passage through the air by reducing friction to minimum. The light feathers hold a considerable blanket of enveloping air around the body. The nonconducting covering of feathers insulates the body perfectly and prevents loss of heat which enables the bird to endure intense cold at high altitudes and also maintain a constant temperature.

4.4 Modification of forelimb into wings

The elongated flight feathers of wings are called the remiges. The expanded membranous part or vane of each remex forms a flexible and continuous surface for striking the air in flight. The particular shape of the wing, with a thick strong leading edge, convex upper surface and concave lower surface, causes reduction in air pressure above and below, with minimum turbulence behind.

4.5 Short tail

The tail contains light caudal feathers in a fan-like manner and serves as a rudder for steering during flight, to suddenly check flight, and as a counterbalance in perching.

4.6 Beak

The mouth is drawn out into the horny beak, which is used as a forcep in picking up things. Besides procurement of food, the beak is also used for nest-building, which in other animals is done by forelimbs.

4.7 Mobile neck and head

The neck of bird is very long and flexible. Since the bill is used for feeding, preening, nest-building, offence and defense and the like, mobility of neck and freedom of movement of the head are very important.

4.8 Bipedal locomotion

The forelimbs being no longer available, the hind limbs or legs spring somewhat anteriorly from the trunk to balance and to support the entire weight of the body for locomotion on the ground or in water. Bipedality is as characteristic of birds as

flight, since flightless birds have all retained the habit of walking on two legs. The legs are also relatively stronger.

4.9 Integument

The loose skin is a modification for flight. It is responsible for extensive movement of the skeletal musculature.

4.10 Large muscles of flight

While the muscles of back are greatly reduced, the flight muscles on the breast are greatly developed, weighing nearly one-sixth of the whole bird. The wing is depressed or lowered by an enormous pectoralis major. It is raised by pectoralis minor the tendon of which passes through the foramen triosseum to be inserted dorsally on the head of humerus. There are other muscles of minor importance.

4.11 Perching

The hind limbs of birds are well suited for an arboreal life. Their muscles are well developed and help in perching. As the bird settles down on the tree, the bending of legs exerts a pull on the flexor tendons which make the toes automatically to flex and to grip the perch. Thus the bird, in resting or sleeping, is automatically clamped to its perch.

4.12 Endoskeleton

Most of bones are pneumatic and filled with airsacs instead of bone marrow. Skull bones are light and most of them firmly fused together. Uncinate processes of thoracic ribs help in producing compactness, necessary for flight, by concentrating the mass. The rigidity of the dorsal part of vertebral column, due to fusion of

vertebrae, provides a firm fulcrum for the action of wings. The absence of a mid-ventral symphasis of pubes and Ischia results in a more posterior displacement of viscera, shifting the center of gravity of the body near to the hindlegs.

4.13 Digestive system

The rate of metabolism in birds is very high, food requirements are great and digestion rapid. The food that is selected has a high caloric value, largely utilized, with a minimum indigestible waste. The rectum is short because the fecal matter is small.

4.14 Air-sacs and respiration

The inelastic lungs of birds are supplemented by a remarkable system of air-sacs, which grow out from lungs and occupy all the available space between internal organs, even extending to the cavities of hollow bones. The air-sacs secure more perfect aeration of lungs and help in internal perspiration, thus helping in the regulation of the body temperature. Avian lungs are completely emptied with each breathe, there being no residual air remaining, so that respiration is more effectively accomplished.

4.15 Warm-bloodness

Birds are warm blooded animals. The perfect aeration of blood is responsible for the high temperature of body (40°-46°C) that is essential for flight.

4.16 Circulatory system

Rapid metabolism and warm bloodness require a large oxygen supply and an efficient circulatory system. Accordingly, the avian heart is relatively large and

completely divided into four chambers. The high proportion of hemoglobin present in the red blood cells of avian blood is also responsible for its quick and perfect aeration.

4.17 Urecotelic excretion

Birds do not have urinary bladder for storage of urine unlike other animals. The water content from the excretory fluid is reabsorbed in the urinary tubules of kidney. The result is formation of semisolid excreta, chiefly containing the insoluble uric acid and urates.

4.18 Brain and sense organ

Birds depend on sight rather than smell, in contrast to reptile and mammals. Accordingly, the eyes are large with bigger optic lobes corresponding to the greater development of sight. The much developed and convoluted cerebellum indicates the delicate sense of equilibrium and the great power of muscular co-ordination belonging to birds.

4.19 Single ovary

Presence of single functional ovary of the left side in female birds also leads to reduction of weight that is so essential for flight (Kotpal, 2016)

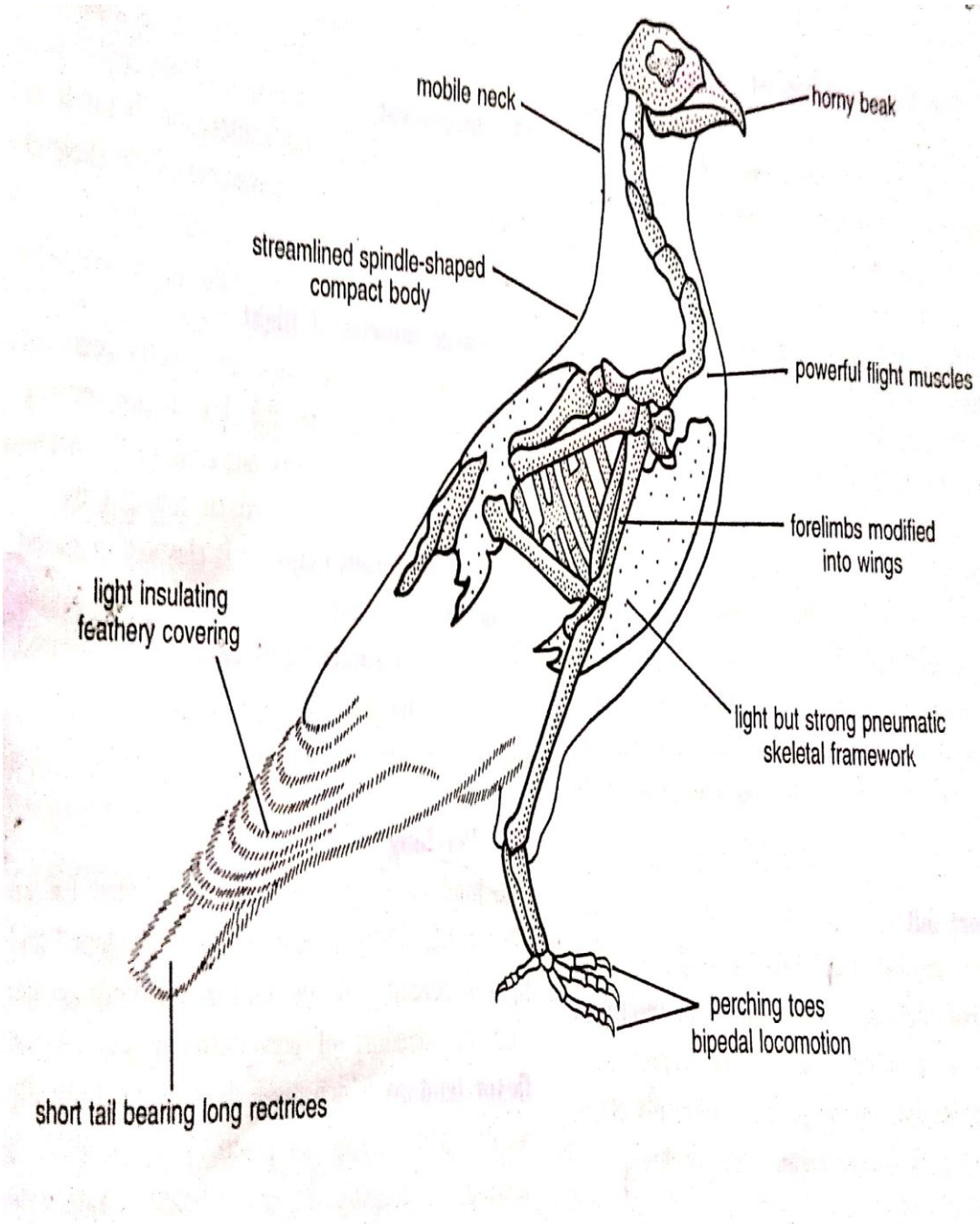


Figure 4: Aerial Adaptation in Birds (Kotpal, 2016)

5.Type of beaks

Aves are characterized by absence of teeth. The upper and lower jaw bones become elongated to form a peculiar beak or bill covered by a horny sheath called rhamphotheca. The diversity of form of beaks is mainly related to the type of food eaten and to the manner of feeding.

5.1 Seed-eating beaks

Short, stout, peg-like and conical beaks are characteristic of small granivorous or seed-eating birds, such as Sparrows, Finches and Cardinals.

5.2 Cutting beak

Birds like crows possess long and slender beaks with cutting edges which can be used variously.

5.3 Fruit-eating beaks

In parrots, the beak is sharp, massive, deeply hooked and extremely strong. It is well adapted for gnawing or breaking open hard seeds and nuts, which form their staple diet.

5.4 Insectivorous beak

In swallows and swifts, the beak is small, wide and delicate to scoop up their living insect prey while on wing. In fly catchers, the beak is short but strong, with mandibles notched at the tip and beset with numerous rectal bristles at base.

5.5 Wood-chiselling beak

Woodpeackers have elongated, strait and stout chisel-like beaks for drilling into the barks or wood for insect larvae or for nest construction. They have thickened, shock absorbent skull bones and strong neck muscles to make such pounding feasible.

5.6 Tearing and piercing beak

Carrion-feeding and flesh-eating birds, such as vultures, hawks, eagles, owls, kite, etc., have short, pointed, sharp-edged and powerful, hooked beaks for tearing flesh and operated by well-developed mandibular muscles.

5.7 Mud-probing beak

Familiar examples of mud probing beaks are found in Snipe, Stilt, Sandpiper, Jacana, Lapwing, etc. their beaks are extremely long and slender and are used as a probe for thrusting far down into water and mud in search of worms and larvae. Some of these birds are remarkable for the slenderness and extreme length of their beaks.

5.8 Water and mud-straining beak

In Ducks, Teals, and Geese, the beak is broad and flat. The edges of jaws are furnished with horny serrations, which act as a sieve or strainer, letting the mud and water pass out while retaining the food in mouth. Such a beak enables the bird to avail itself of the rich store of food in the shape of insects and other organism.

5.9 Fish-catching beak

Storks, Herons and Kingfishers have long, powerful and sharply pointed, spearing beaks to capture fish, frogs, tadpoles and similar aquatic animals.

5.10 Spatulate beak

The Spoonbill possesses a very specialized form of beak. It is flattened throughout its length but terminates in a broad, spatulate or spoon-like expansion meant for dabbling in water and mud in search of insects, worms, fish, mollusks and other small animals upon with the bird feed.

5.11 Pouched beak

Pelicans consume enormous quantities of fish. Their beak is large, with a capacious gular pouch of extensive skin attached to the lower mandible and serving as fishing net.

5.12 Flower-probing beak

The long, pointed and rapier-like probing beak of tropical Humming bird dive down the corollas of flower for sucking honey and insects. They suspend themselves in mid air before the flowers, while they extract their honey and insects. Their beaks are bent so as to suit the particular shape of flowers (Kotpal, 2016).

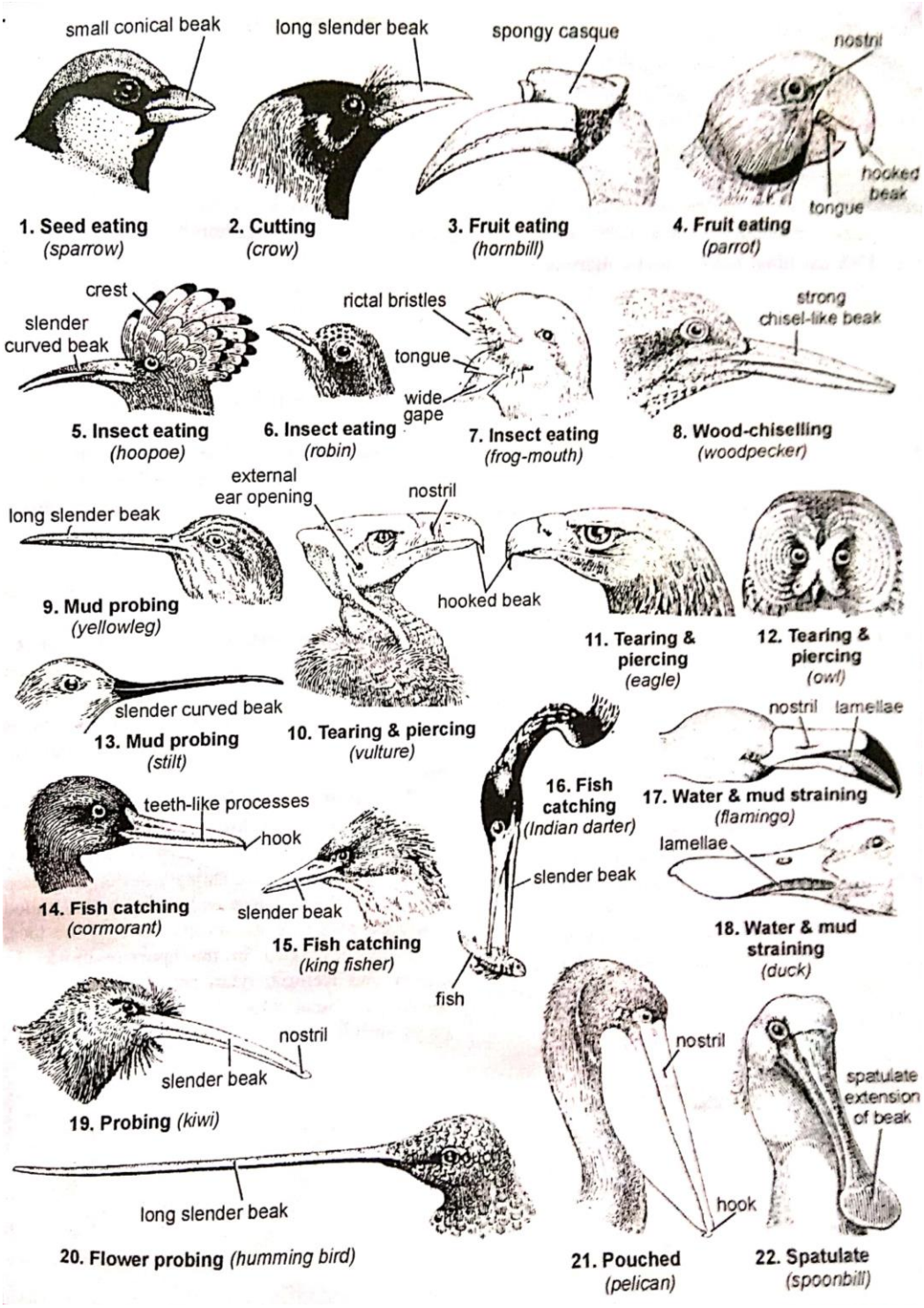


Figure 5: Type of beaks in birds (Kotpal, 2016)

6.Type of feet

6.1 Running feet

In running birds, the legs are powerful and the number of toes are reduced. The hind toe may be elevated, reduced or absent. In Bustards, Coursers and ratites such as Emu, Rhea and Crossowary, only three toes, directed forward are present. Ostrich has only two toes, of which the outer one is smaller and without a nail.

6.2 Perching feet

The majority of birds belong to the category of perching birds or passers, such as Sparrows, Crows, Bulbuls, Robins, Mynas, etc. Three toes are anterior and slender, while one toe is posterior, strongly built and opposable, so that they can securely fasten the foot to a branch or a perch.

6.3 Scratching feet

The feet of Fowls, Quails and Pheasant, etc., are stout, with strongly-developed claws and well adapted for running as well as scratching the earth. The foot of male bird is provided with a pointed bony spur for offense or defense.

6.4 Raptorial feet

Predatory or carnivorous birds such as Eagle, Kite, Vultures, Owls, etc., have strong feet for striking and grasping their prey. The toes have strongly-developed, sharp and curved claws. Large and fleshy bulbs, called tylari, are found on the under surface of toes, especially developed in the Sparrow-hawk.

6.5 Wading feet

The legs and toes are exceptionally long and slender in wading or marshy birds such as Herons, Snipes, Jacana, Lapwings, etc. These serve to walk over aquatic vegetation.

6.6 Swimming feet

In swimming birds, the toes are webbed, partially or completely. In diving birds, like Coots and Grebes, the web is lobate and the toes are free.

6.7 Climbing feet

In Parrots and Woodpeackers the feet are used as grasping organs and especially adapted for climbing vertical surfaces. The second and third toes point in front, while the first and the forth toes backwards.

6.8 Clinging feet

In Swifts, Martinets and Humming-birds, all four toes point forwards and serve to cling to steep faces of cliff or under caves of horses, etc. (Kotpal, 2016).

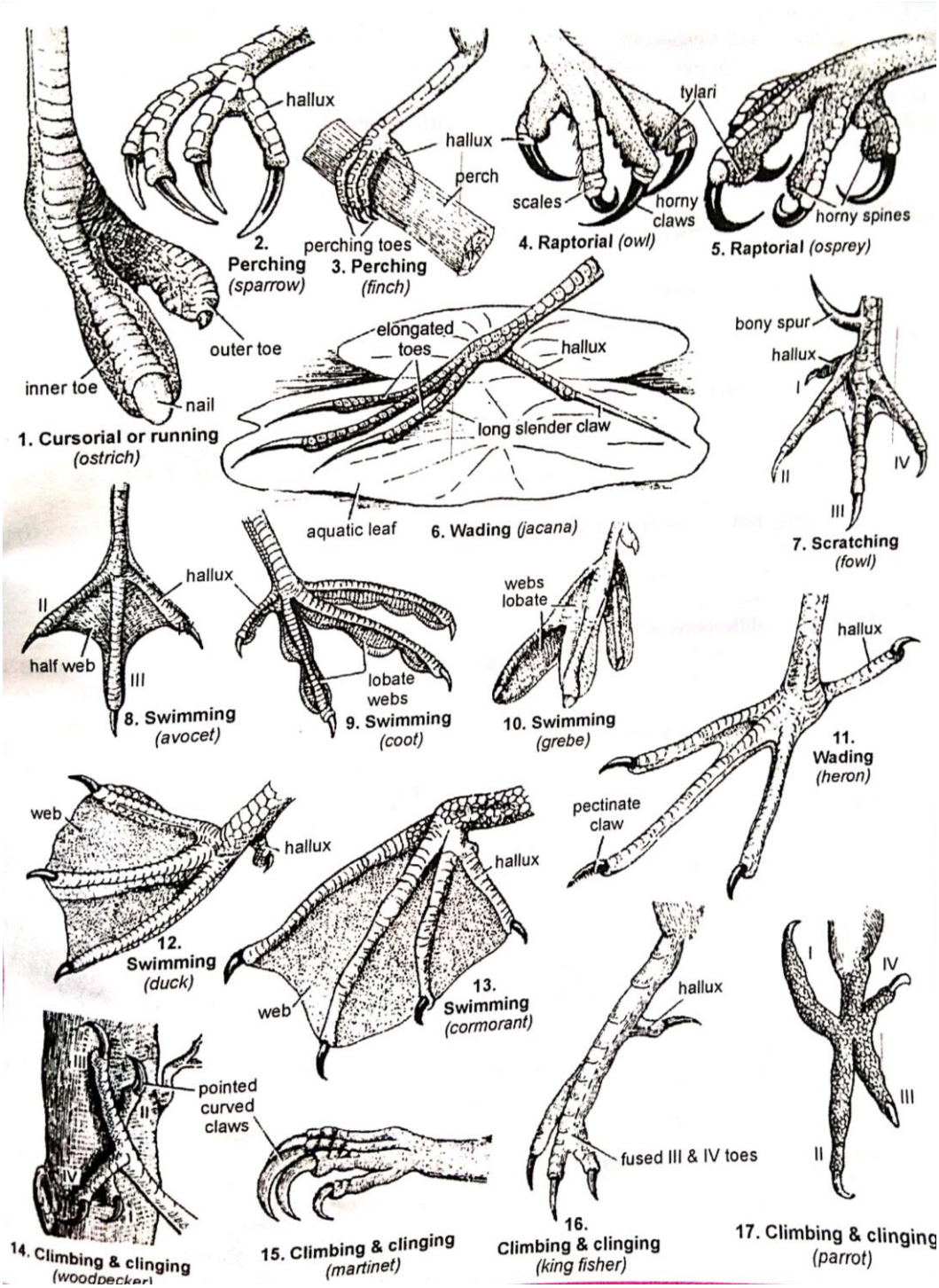


Figure 6: Type of feet in birds (Kotpal, 2016)

7.Behavior

7.1 Song:

Male bird sings a song to attract female. Correlation between male song trait such as size or singing rate and components of fitness reveal that important information about overall male quality. Indirect evidence that song is used to attract females. Unpaired males or those males who lose their female will sing far more than do their paired neighbors (Wasserman, 1977). In some species, singing ceases as soon as female enters the territory (Catchpole,1973). It was said that only territorial males can attract females (McDonald, 1989). Devocalized brown headed cowbirds fail to establish a high position in a dominance hierarchy and only dominant male can guard females (Dufty, 1986). Male northern mockingbirds increase their singing with the initiation of each nesting attempt throughout the season, suggesting that male song is important for stimulating the females to initiate the next clutch (Kroodsma and Byres, 1991).

7.2 Nesting:

For many year nest building in birds has been considered a remarkable behavior. Learning plays a significant role in variety of nest building decision. Birds build nests in an extraordinary range of different sites (Hansell, 2000). In case of the individual builders of most species are known, nest building is not necessarily restricted to one of the sexes and contribution by one or both partners and varies considerably from species to species (Collias and Collias, 1984; Hansell, 2000). Nest material composition is highly variable, encompassing a broad range of both natural sources like grasses, leaves, twigs, sticks, mud, mosses, lichens, feathers, or arthropod silk and man-made sources like cigarette butts, polypropylene string, and

bits of fence wire (Antczak *et al*., 2010; Hansell, 2000; Nicolakakis and Lefebvre, 2000). Birds build their nest from sculpting of burrows or cavities from substrate excavation, through the moulding of mud or salivary mucus by vibrating head and/or shaping breast and feet movements. The nest building process start with site selection and also include appropriate choice of available material from environment. Nest building is very important for birds in reproductive success.

7.3 Parental care:

Parental care can be explained by different modes. Some birds escape to incubate their eggs and provision their offspring. This is achieved by brood parasitism. When young is provided care, it can be either by male or female. In many cases brood care is done by biparental or cooperative breeding (Cockburn, 2006).

7.4 Migration:

The phenomenon called migration is distributed over a large area and several taxa, from insects to fishes, amphibians, birds and mammals undertake annual incredible circannual rhythms (Newton, 2008, Bauer, 2014) Most of the migration studies are focused on birds. There are certain factors that affect migration such as- genetic diversity, duration of migration, and migration strategies in bird populations. In addition, individual show a high degree of phenotypic plasticity in migration strategy (Delmore, 2012). Birds adjust their migration strategies on the basis of change in climate and ecological conditions.

Majority of bird species recorded are resident, although some of them are found to be winter visitors. Some residents are sedentary throughout the year, while other undertake irregular movements, either locally or more widely within the region,

depending on water conditions or availability of food (Grimmett, Inskipp, *et al* 2014).

Birds migrate primarily for food, shelter, breeding opportunities and as self defense mechanism. Few species of birds migrate seasonally, some of them are winter migrants and some of them migrate in summer. Many Himalayan residents are altitudinal migrants that migrate higher altitudes to lower regions to avoid cold environment (Grimmett, Inskipp, *et al* 2014). Migration can also take place from north to south or vice versa is called latitudinal migration. Movement of birds from east to west or vice versa is called longitudinal migration (Mathur,2014).

8.Effect of Urbanization

The main factor affecting the avian diversity is destruction of habitat. Therefore, the majority of avian species unintentionally enter into the urban area. The change in vegetation composition could impact the quality and quantity of habitat for birds in terms of food, water and shelter that could further affect diversity, abundance and distribution of birds (Aggrawal, 1998; Abdar MR, 2013). The bird community structure is affected by changes in vegetation structure either due to natural or anthropogenic disturbances.

Urban area development causes negative impact on biodiversity due to destruction of habitat and ecosystem divisions (McKinney, 2002). Due to urbanization ecosystem gets disturbed, predators number increases and noise levels also rises significantly that subsequently affect the richness, composition and functional structure of bird communities (Thom *et al.* 2001, Baker *et al.* 2008, Fischer *et al*. 2012, Marzluff 2001)

The composition and distribution of urban birds are influenced by habitat structure and urban development. Patterns of avian community composition within the urban landscape are mediated by species tolerance and ability to exploit urbanized areas. Species sensitive to habitat disturbance have been categorized as "urban avoiders" (McKinney, 2002) or "urban-sensitive" (Garden *et al.* 2007), while species that are common in urbanized areas have been categorized as "urban exploiters" (McKinney, 2002) or "synanthropes" (Marzluff *et al*. 2001).

Human population continues to grow and dominate ecosystems around the world (Horiuchi 1992; Vitousek *et al*. 1997). The lowest values of species richness are usually registered in the most intensively build-up areas (Marzluff *et al*. 2001).

Birds in urban ecosystems are usually opportunistic species with wide dispersal ability, whereas species with poor dispersal ability, slow reproduction or specialized diets disappear from urban assemblages as urbanization increase.

9.Ecological Importance of Birds

9.1 Role of birds in plant distribution

As birds feed on fruits, they also play a good role for distribution of plants. They eat berries and seeds are disposed along with it. Bird feces provide good fertilization for the seeds and making favorable conditions for the growth. In addition, a lot of bird species may have been significant browsers of forest vegetation.

9.2 Role of birds in Agriculture

The fecal material of bird has significant value in agriculture. In the agricultural land bird droppings are used as fertilizer as they contain potassium, nitrogen, phosphate and other nutrients.

9.3 Role of birds in food chain

Each faunal species is essential for regulating ecosystem as they are part of ecosystem. Birds occupy many levels in food chain. They either act as prey or predator in nature. Insectivore birds play a significant role as pest control. Thus, they maintain the level of prey and predators in the environment.

9.4 Role of birds in plant reproduction

Those species of birds feed on nectar or fruits help in important function of reproduction in plants. Birds provide impressive service as a pollinator or seed dispersers (Tabur, 2010).

10. Habitat of the P. G. Department of Biosciences

The P.G. Department of Biosciences is located in the Bakrol, Anand. The Anand city has agro-forestry type of habitat with scattered wetlands and scrublands. The sources are available throughout the year. Which result in healthy ecosystem. There is little area covering water which was formed due to water leakage from Samras hostel which can be called as puddle. This puddle act as a food source and preferable habitat for wetland birds and attracts some waders. Shrubs and bushes are distributed in some areas. The area surrounding the department has rich floral diversity, which furnish nesting material, shelter, food to fauna. There are extensive hedges over the roads, which could support many insect lives. There wide sports ground of Yugpurush Vivekananda beside the department. There is grassland. P. G. Department of Biosciences include grassland, small wetland, shrubs, trees and herbs which act as suitable habitat and attracts birds

II. REVIEW OF LITERATURE

1. Avifaunal diversity in India

A study to find out the diversity of birds at the Indian institute of forest Management (IIFM), Bhopal was carried out for nine months. Total 106 bird species belonging to 52 families were recorded during the study covering the area of about 93 hectares. According to the feeding habitat, birds were classified in carnivore, ground insectivore, sallying insectivore, canopy and bark insectivore, nectar insectivore, general insectivore, frugivore and water birds. Density analysis was done by DISTANCE software and density was found to be 32.7 birds per hectare (Aggrawal, *et al*. 2015).

A study on assessment of diversity and seasonal abundance of avifauna with vegetation, composition of habitat and foraging pattern among birds in and around Laxminarayan Institute of Technology, Nagpur recorded total 62 species of birds belonging to 11 orders and 38 families during January 2013 to December 2014. The species recorded including 57 residents, two passage migrants, one breeding migrant and two winter migrant. Passeriformes recorded as the most dominating order represented by 36 species (Dapke, *et al.* 2015).

Diversity of birds in Gorakhpur University campus was carried out from September 2017 to February 2018. They found 45 species of birds. The study was divided into different regions. Out of 45 bird species 4 were found to be migratory. Comparative data helped to understand the differences of biodiversity according to areas (Singh *et al.,* 2018).

2. Avifaunal diversity in Gujarat

A study carried out on diversity of birds in Vallabh Vidyanagar. Five major sites were selected for study. The survey of birds had been divided into three phases, pre-winter, winter, post-winter. Birds were counted a particular site for seven consecutive days in morning and evening by Quadrat method. Density, Diversity Index and Evenness Index of different bird species in Vallabh Vidyanagar were carried out. When the species of birds were counted for their numbers in different localities, out of 44 species, 15 were found to be abundant, 7 frequent, 10 common and 5 rare. Variation in the number of birds found in particular area during observation period might be because of variation in the minimum and maximum temperature which affects the available resources in terms of food, water and shelter. Some hardy species of birds were found to be present during the entire period of study which could be because of constant availability of food resources and also the availability of roosting site (Koladiya, *et al.* 2012).

In Banni grassland of Kachchh, Gujarat total 91 species were reecorded. A study was attempted to understand the distribution of birds in heterogeneous grassland. At last, it was concluded that bird species diversity and their population density estimates were varied among various heterogeneous habitat of banni grassland both in time and space gradient (Koladiya and Narasimhacharya, 2014).

A study was carried out in Vadodara for two years (2005-2007) to know the diversity of birds in urban cities. The density and diversity indices like species richness, Shannon-Weiner diversity index, evenness and abundance of birds were calculated for all habitats to check the status of birds. Total 82 species of birds observed. The study supports that highly disturbed areas have higher density of

birds due to the presence of urban exploiters such as pigeons but low species richness. One important point observed in the study was moderately disturbed areas have comparatively higher density as well as diversity of birds indicating that human settlement do favor terrestrial bird population (Rathod *et al.* 2017).

AIMS & OBJECTIVES

1. To prepare the checklist of Birds in and around P. G. Department of Biosciences.
2. To study the diversity of Birds in Botanical Garden of the Department.
3. To understand the correlation of avifaunal and Floral diversities
4. To discuss the correlation of avifaunal diversity and temperature variations.

III. METHODS AND MATERIAL

1. STUDY AREA

1.1 Anand City

The Anand district is a part of Gujarat. It is located between 22”07’ (N) and 22”57’ (N) latitude and 72”15’ (E) and 73”28’ (E) longitude. The Anand city is containing total area of 3204 km², which is about 1.63 % of Gujarat state. Anand city has agro-forestry type of habitats with scattered wetlands and scrublands. Anand is primarily an agricultural district with tobacco and paddy as the predominant crops cultivated are wheat, banana and some vegetables. However, this region harbors a lot of plant species, some of the common trees which are grown on the borders of agriculture farms and road side Babul, Neem, Asopalav etc.

1.2 Botanical Garden

The Botanical Garden of Sardar Patel University has 3.2 acres of land in Vallabh Vidyanagar. Altogether there are about 200 plant species, excluding the natural herbaceous flora, growing in this garden, out of which 60 species belong to trees. The germplasm of some rare, endangered and threatened wild plants and other academically important species from various parts of Gujarat state and India are collected and conserved here with proper care. Looking at the needs of present day, botanical garden has been reorganized with allocation of specific sections for different kinds of plants such as medicinal plants, horticultural plants, experimental plots and a nursery.

1.3 P. G. Department of Biosciences and Surroundings

The P. G. Department of Biosciences is located in Bakrol, Anand. The campus has a main building, on the right side Yugpurush Vivekananda Sports Complex (Yuvi Complex) and on the left side University ground is located. Behind the Department government hostel is located. Opposite to the department, there is village called Bakrol. Surrounding the backside area, there is farmlands, which provide a good source to study different floral and faunal diversity.

Figure 7: Map of Gujarat, India

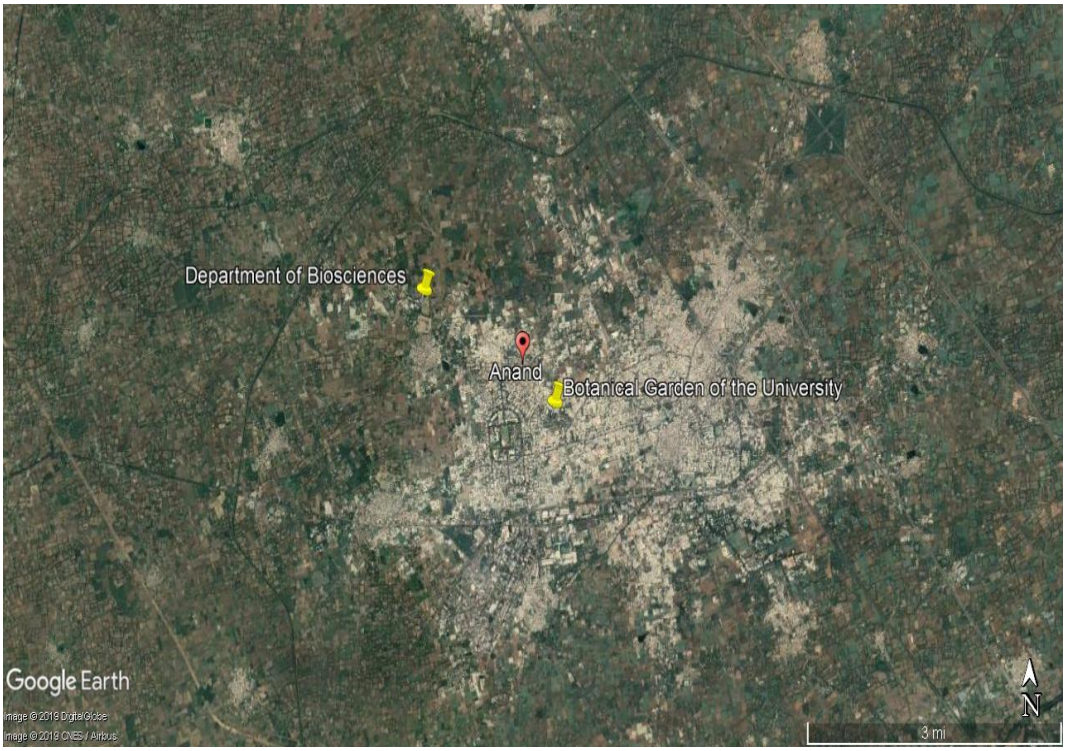


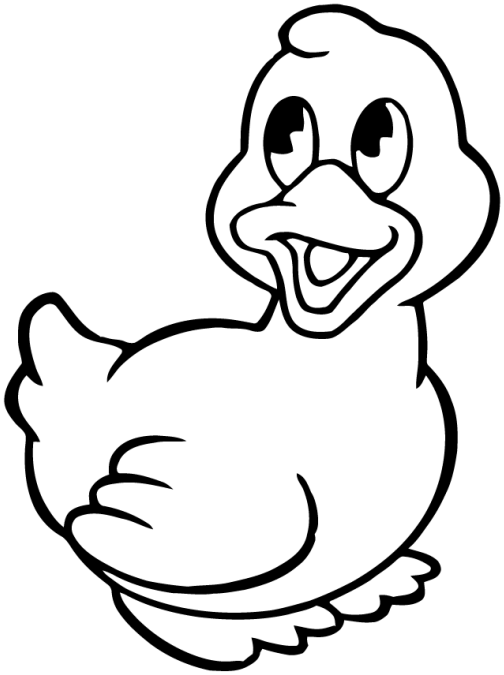
Figure 8: Map of Anand, Gujarat

Figure 9: Map of Botanical Garden of the Department, Vallabh Vidyanagar, Gujarat, India

Figure 10: Map of P. G. Department of Biosciences, Anand, Gujarat, India

2. METHODOLOGY

The fieldwork was carried out from November 2018 to February 2019 in and around the P. G. Department of Biosciences and Botanical garden of the University. The Reptilian and Mammalian diversity was also observed along Avian diversity. The observations were made between 7:00 to 12:00 hours in the morning and 16:00 to 19:00 hours in the evening. Avian species were documented and identified by using standard books (Ali 2017, Carol Inskipp and Richard Grimmett 2011). The specimens were observed with patience and compared with the plates given in the books. Identification was also done with the help of websites, mobile applications and experts. The birds were photographed using Canon 1200D with Canon EFS 55-250 mm and Canon EFS 18-55 mm lenses.



IV. RESULT AND DISCUSSION

1. Avian diversity in and around P. G. Department of Biosciences, Anand City, Gujarat (22˚34'13.98" N, 72˚54'36.22" E).

The study of diversity of birds in and around the Department of Bioscience has recorded 84, species, including 13 orders and 42 families. Orders such as Accipitrifomres, Bucerotiformes, Caprimulgiformes, Charadriiformes, Columbiformes, Coraciiformes, Cuculiformes, Gruiformes, Passeriformes, Pelecaniformes, Piciformes, Psittaciformes, Strigiformes are observed.

The majority of birds from order Passeriformes including 23 families and 48 species. During field work, 16 migratory species were also found. All 16 species are belonging to order Passeriformes. Most of Passeriformes belongs to Category of Perching birds.

Waders include order Charadriiformes, Pelecaniformes. Charadriiformes contain 3 families and 5 species. Pelecaniformes contain 2 families and 7 species. In spite of the absence of wetland in the study area small puddles are formed that might have provided essential habitat and food for waders. This puddle has attracted the total 12 species of waders. One species from Duck-like bird of Gruiformes order containing one family was observed.

Order Accipitriformes belong to category of Birds of prey. One family containing 3 species has been recorded. Upland ground bird category had recorded one Order Columbiformes, which include 1 family and 5 species. Category Tree-clinging birds include one Order Piciformes containing 2 families and 2 species. Night Birds category include predatory birds include one order Strigiformes and one family that include 2 species.

One uncommon sighting of Jerdon's leaf bird was also recorded. Usually this bird is known for its preference of woodland and forest areas. However, availability of food and refuge attracted this bird in the P. G. Department of Biosciences. During Monsoon season this bird was regularly sighted in pair and the visits became less frequent along with increase in the ambient temperature.

Interestingly, during the survey period, once flocks of around 1000 wagtails were recorded flying towards their roosting site on the backside of the department premises. Besides, according to IUCN red list 2 species from near threatened species, Alexandrine Parakeet and Black-headed Ibis were also noted.

Figure 11: Migratory flock of wagtails

Figure 12: White Wagtails

Figure 13: Diversity chart of total Orders and families

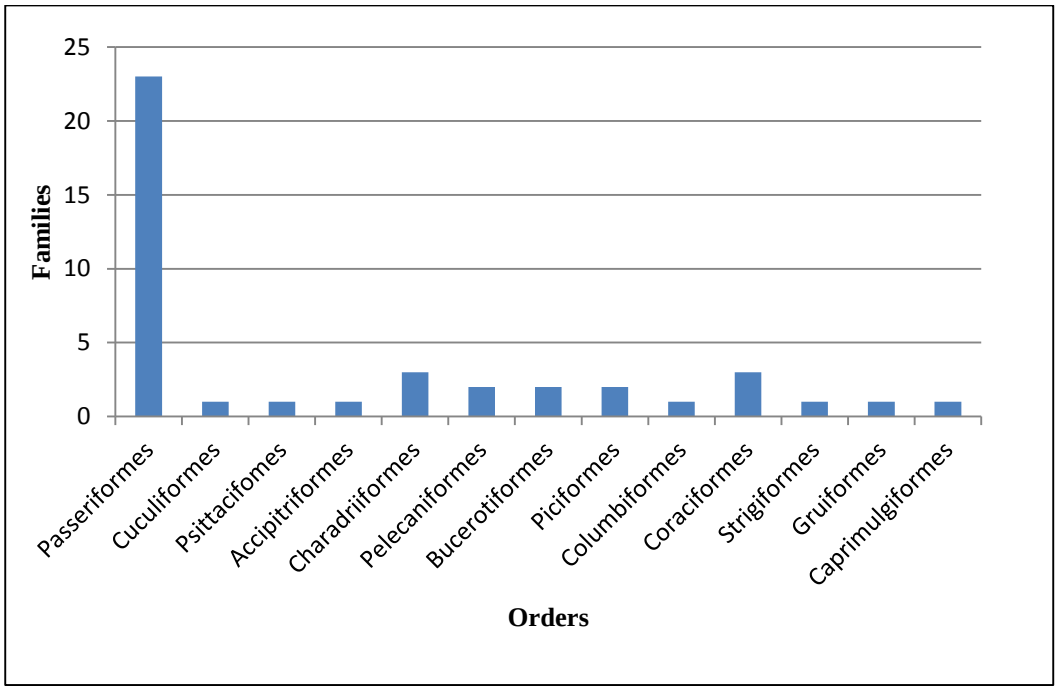


Figure 14: Diversity chart of Order Passeriformes and Families

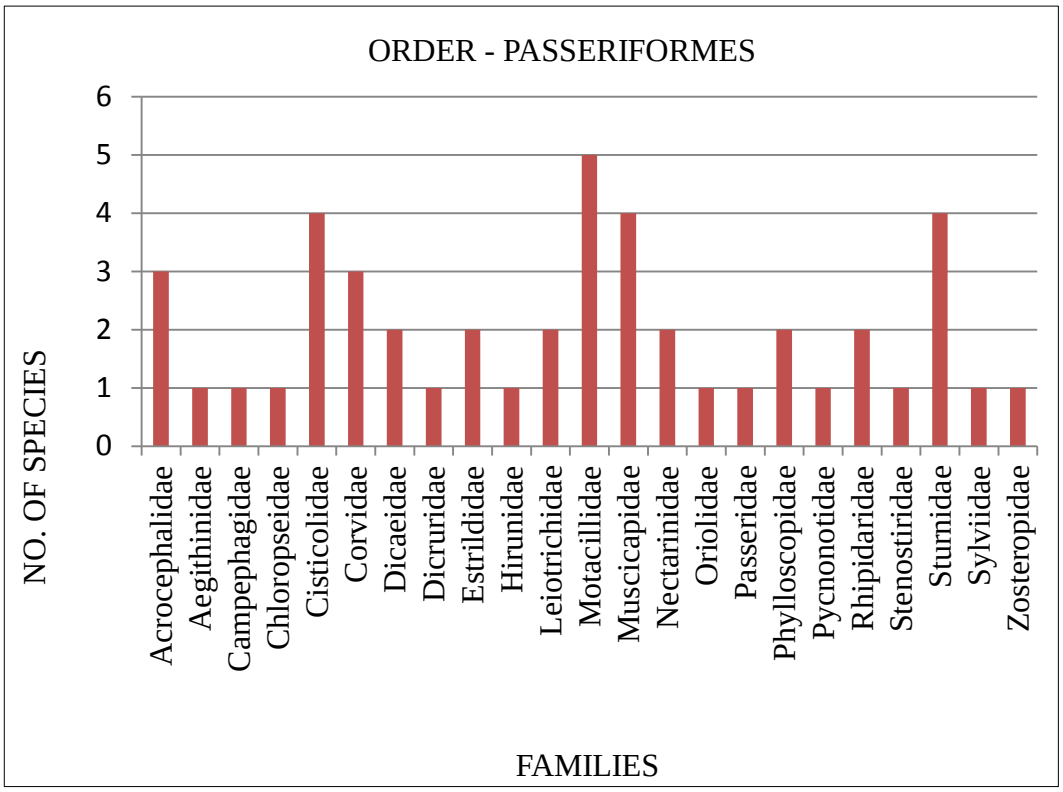


Figure 15: Diversity chart of Orders and Families

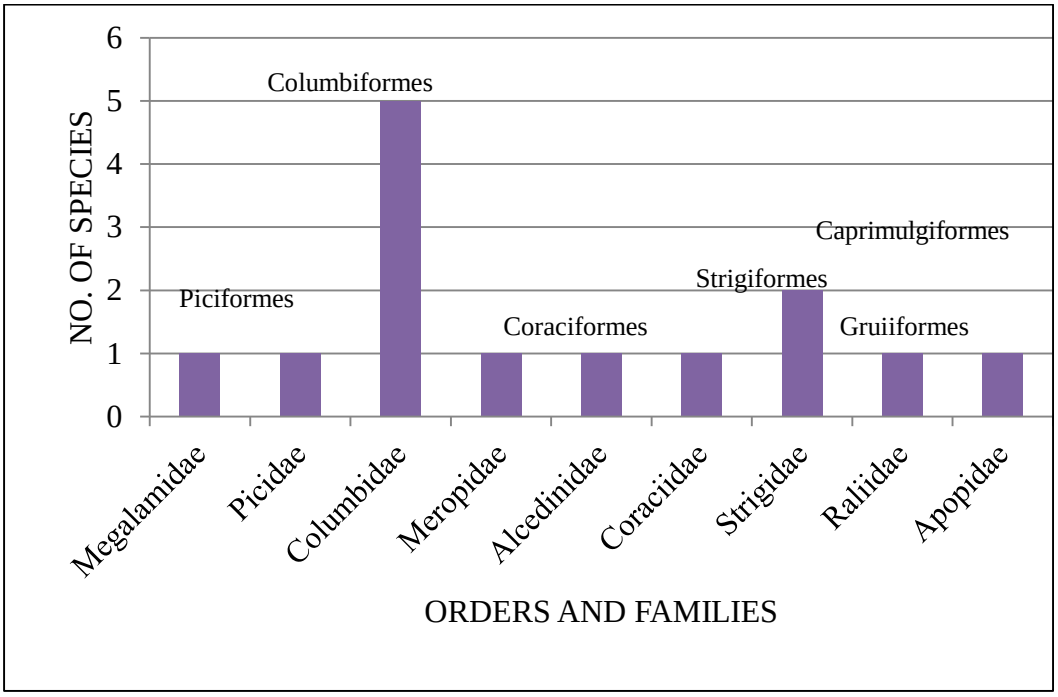
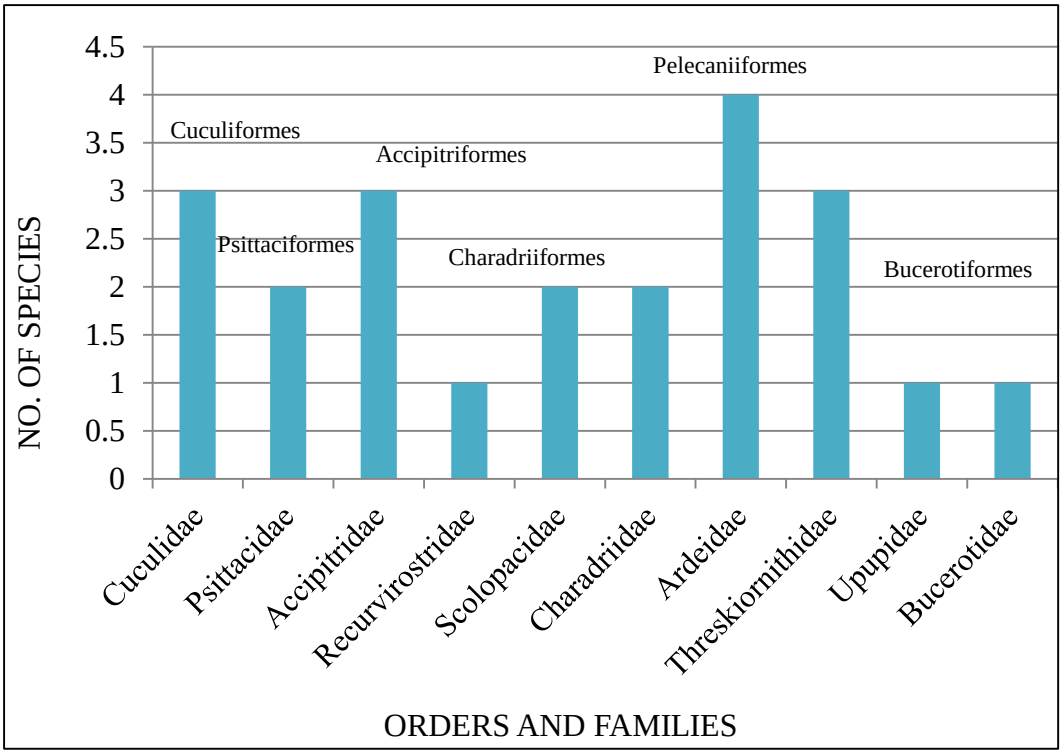


Figure 16: Diversity chart of Orders and Families



2. Diversity of Birds in Botanical garden of the Department, Vallabh Vidyanagar, Gujarat. (22˚33'18.72"N, 72˚56'3.00"E).

The botanical garden of the university has different kind of wild as well as cultivated trees, shrubs, climbers and herbs, all at one place which otherwise are found in varied geographical and climatic regions. Huge plant diversity attracts many faunas which indirectly in correlation with diversity of birds. The botanical garden has less avian diversity due to lack of water resources.

A survey in the Botanical garden of the University has recorded total 43 species including 9 orders and 26 families. All 9 orders are Accipitriformes, Bucerotiformes, Columbiformes, Coraciifromes, Cuculiformes, Passeriformes, Piciformes, Psittaciformes, Strigiformes

In the category of Perching birds, total 36 species were recorded. Majority of them were Passeriformes. Coraciformes, Bucerotiformes, Psittaciformes and Cuculiformes are also included in the category of Perching birds. Coraciiformes include 2 families and 2 species. Bucerotiformes include 2 families and 2 species. Psittaciformes include 1 family and 2 species. Order Cuculiformes contain 1 family and 3 species. Wide variety of Passeriformes had recorded including 15 families and 24 species. Most of the Perching birds were found to be Insectivores. Some of them are nectar feeders and fruit-eaters.

Alexandrine Parakeet is one of the near threatened species of IUCN red list, belong to Order Psittaciformes had been found in the Botanical garden of our Department.

The category of Upland ground birds includes Columbiformes, one family and 5 species. They rely on fruits. Birds of prey category has recorded Accipitriformes order, 1 family and 3 species. Strigiformes are in the category of night birds, which have recorded 1 family and 1 species. No wetland birds were recorded in the Botanical garden of the University during the study.

Figure: 17 Diversity chart of total Orders and Families of Birds

Figure 18: Diversity chart of Order Passeriformes and Families of birds

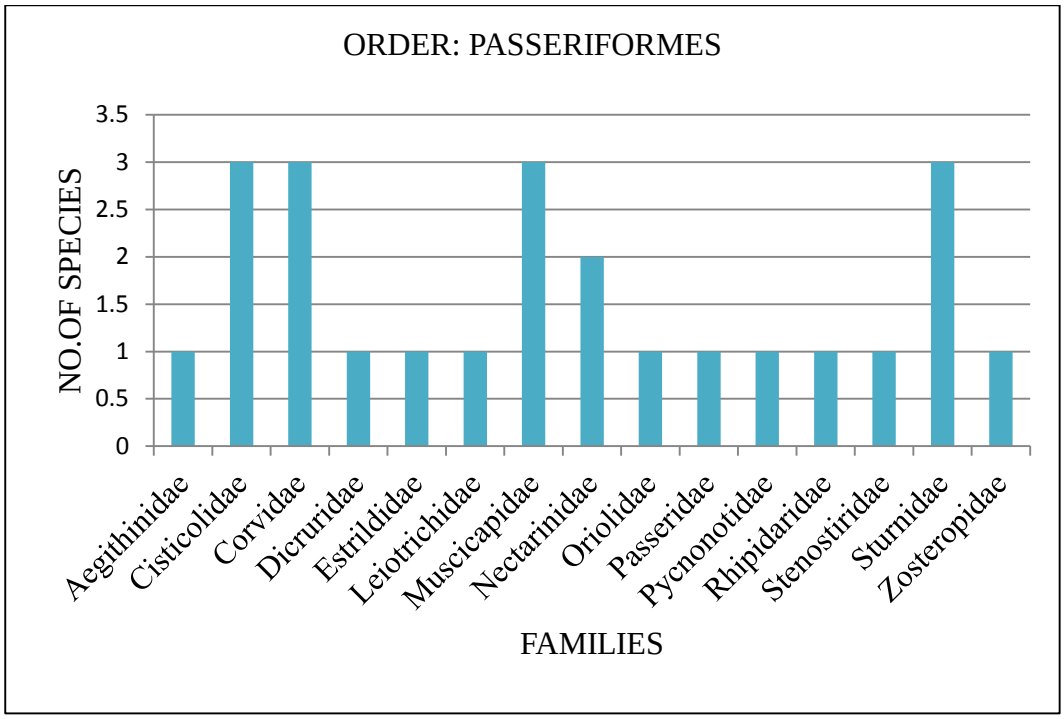


Figure 19: Diversity chart of Orders and Families of Birds

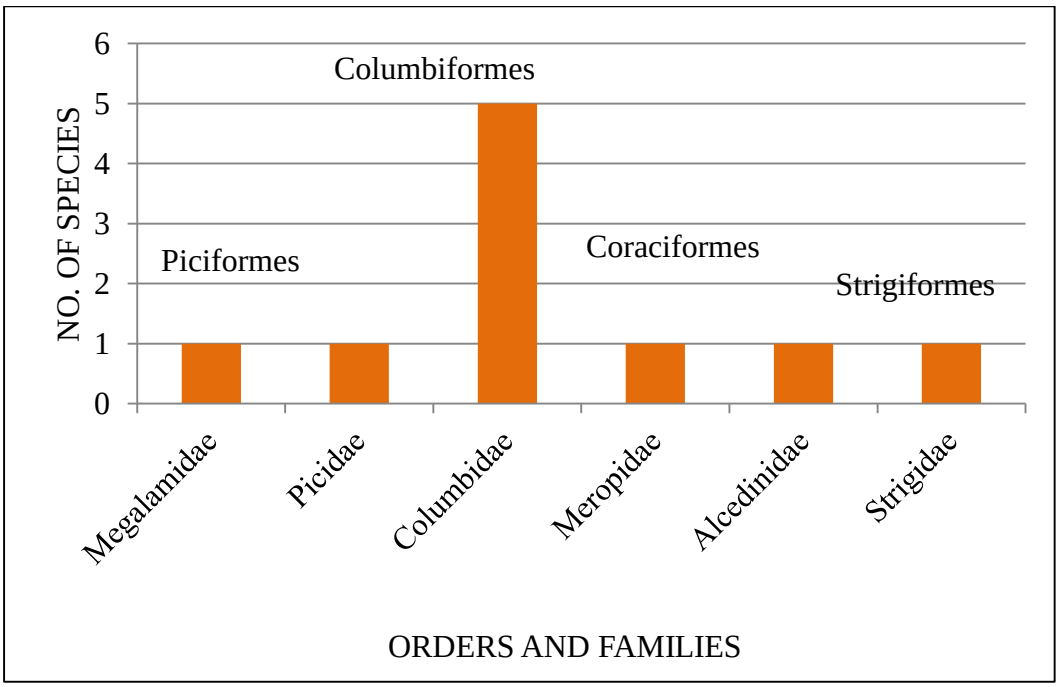


Figure 20: Diversity chart of Orders and Families of Birds

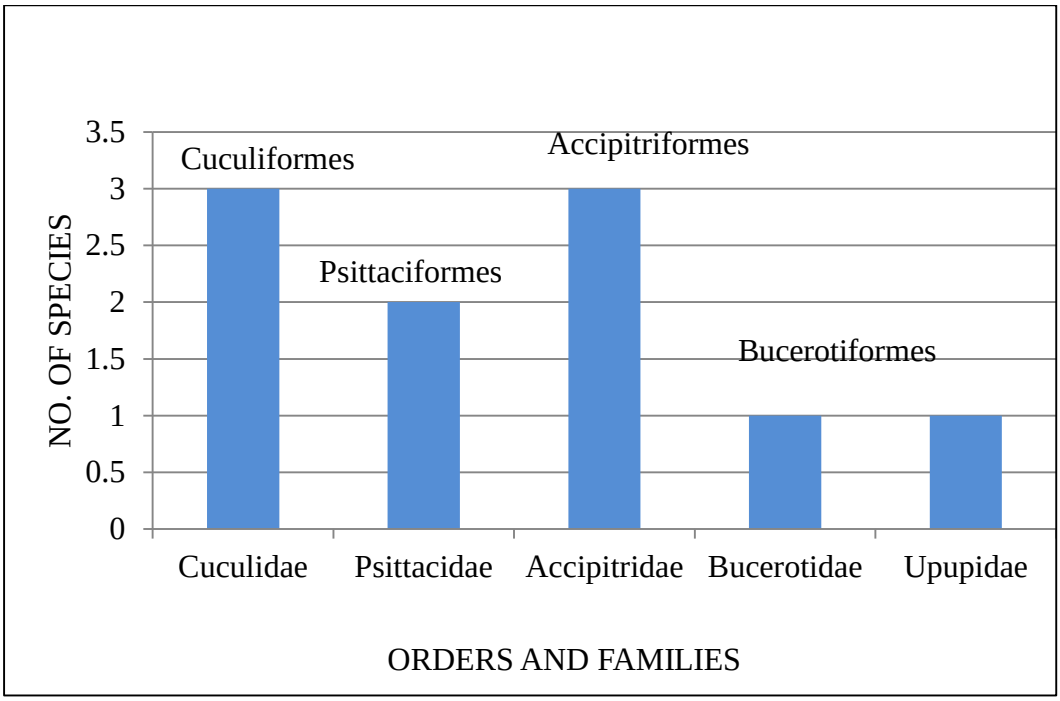


Table: 1 Checklist of Avian diversity

ORDER	FAMILY	COMMON NAME	SCIENTIFIC NAME	D	G
Accipitriformes	Accipitridae	Black Kite	*Milvus migrans*	✓	✓
		Oriental Honey Buzzard	*Pernis ptilorhynchus*	✓	✓
		Shikra	*Accipiter badius*	✓	✓
Bucerotiformes	Bucerrotidae	Indian grey Hornbill	*Ocyceros birostris*	✓	✓
	Upupidae	Common Hoopoe	*Upupa epops*	✓	✓
Caprimulgiformes	Apopidae	House Swift	*Apas nipalensis*	✓	×
Charadriiformes	Charadriidae	Red-wattled Lapwing	*Vanellus indicus*	✓	×
		Yellow-wattled Lapwing	*Vanellus malabaricus*	✓	×
	Recurvirostridae	Black winged Stilt	*Himantopus himantopus*	✓	×
	Scolopacidae	Green Sandpiper	*Tringa ochropus*	✓	×
		Wood Sandpiper	*Tringa glareola*	✓	×
Columbiformes	Columbidae	Common rock Pigeon	*Columba livia*	✓	✓

		Eurasian collared Dove	*Streptopelia decaocto*	✓	✓
		Laughing Dove	*Spilopelia senegalensis*	✓	✓
		Spotted Dove	*Spilopelia chinesis*	✓	✓
		Yellow-footed green Pigeon	*Treron phoenicopterus*	✓	✓
Coraciiformes	Alcedinidae	White-throated Kingfisher	*Halcyon smyrnensis*	✓	✓
	Coraciidae	Indian Roller	*Coracius benghalensis*	✓	×
	Meropidae	Green bee eater	*Merops orientalis*	✓	✓
		Blue-tailed bee eater	*Merops philippinus*	✓	×
Cuculiformes	Cuculidae	Asian koel	*Eudynamys scolopaceus*	✓	✓
		Common hawk Cuckoo	*Hierococcyx varius*	✓	✓
		Greater Coucal	*Centropus sinesis*	✓	✓
Gruiformes	Raliidae	White-breasted Waterhen	*Amaurornis phoenicurus*	✓	×
Passeriformes	Acrocephalidae	Blyth's reed Warbler	*Acrocephalus dumetorum*	✓	×
		Booted Warbler	*Iduna caligata*	✓	×
		Syke's Warbler	*Iduna rama*	✓	×
	Aegithinidae	Common Iora	*Aegithina tipia*	✓	✓
	Campephagidae	Small Minivet	*Pericrocotus cinnamomeus*	✓	×
	Cisticolidae	Ashy Prinia	*Prinia socialis*	✓	✓
		Common tailor bird	*Orthotomus sutorius*	✓	✓
		Grey-breasted Prinia	*Prinia hodgsoni*	✓	×
		Plain Prinia	*Prinia inornata*	✓	✓
	Chloropseidae	Jerdon's leaf bird	*Chloropsis jerdoni*	✓	×
	Corvidae	House Crow	*Corvus splendens*	✓	✓
		Jungle Crow	*Corvus macrorhynchos*	✓	✓
		Rufous Treepie	*Dendrocitta vagabunda*	✓	✓
	Dicaidae	Pale-billed Flowerpecker	*Dicaeum erythrorhynchos*	✓	×
		Thick-billed Flowerpecker	*Dicaeum agile*	✓	×
	Dicruridae	Black Drongo	*Dicrurus acrocercus*	✓	✓
	Estrildidae	Indian Silverbill	*Euodice malabarica*	✓	✓
		Scaly-breasted Munia	*Lonchura punctulata*	✓	×

	Hirudinidae	Red rumped Swallow	*Cecropis daurica*	✓	×
	Leiotrichidae	Jungle Babbler	*Turdoides striata*	✓	✓
		Large grey Babbler	*Argya malcolmi*	✓	×
	Muscicapidae	Asian brown flycatcher	*Muscicapa dauurica*	✓	×
		Indian Robin	*Saxicoloides fulicatus*	✓	✓
		Oriental magpie Robin	*Copsycus saularis*	✓	✓
		Red-breasted flycatcher	*Ficedula parva*	✓	✓
		Taiga Flycatcher	*Ficedula albicia*	✓	×
	Motacillidae	Citrine Wagtail	*Motacilla citreola*	✓	×
		Grey Wagtail	*Motacilla cinerea*	✓	×
		Long-billed Pipit	*Anthus similis*	✓	×
		Yellow Wagtail	*Motacilla flava*	✓	×
		White Wagtail	*Motacilla alba*	✓	×
	Nectariniidae	Purple-rumped Sunbird	*Leptocoma zeylonica*	✓	✓
		Purple Sunbird	*Cinnyris asiaticus*	✓	✓
	Oriolidae	Indian golden Oriole	*Oriolus oriolus*	✓	✓
	Passeridae	House Sparrrow	*Passer domesticus*	✓	✓
	Phylloscopidae	Common chiffchaff	*Phylloscopus collybita*	✓	×
		Greenish Warbler	*Phylloscopus trichiloides*	✓	×
	Pycnonotidae	Red vented Bulbul	*Pycnonotus cafer*	✓	✓
	Rhipidaridae	White-browed Fantail	*Rhipidura aureola*	✓	×
		White-spotted Fantail	*Rhipidura albogularis*	✓	✓
	Stenostriidae	Grey-headed canary Flycatcher	*Culicicapa ceylonensis*	✓	✓
	Sturnidae	Bank Myna	*Acridotheres ginginianus*	✓	✓
		Brahminy Starling	*Sturnia psagodarum*	✓	✓
		Common Myna	*Acridotheres tristis*	✓	✓
		Rosy Starling	*Pastor roseus*	✓	×
	Sylviidae	Lesser Whitethroat	*Sylvia curruca*	✓	×

	Zosteropidae	Oriental white eye	*Zosteropus palpebrosus*	✓	✓
Pelecaniformes	Ardeidae	Cattle Egret	*Bubulcus ibis*	✓	×
		Intermediate Egret	*Ardeaintermedia*	✓	×
		Indian pond Heron	*Ardeola grayii*	✓	×
		Little Egret	*Egretta garzetta*	✓	×
	Threskiornithidae	Black headed Ibis	*Threskiornis melanocephalus*	✓	×
		Glossy Ibis	*Plegadis falcinellus*	✓	×
		Red naped Ibis	*Pseudibis papillosa*	✓	×
Piciformes	Megalamidae	Coppersmith Barbet	*Psilopogon hemacephalus*	✓	✓
	Picidae	Lesser goldenback Woodpeacker	*Dinopium benghalense*	✓	✓
Psittaciformes	Psittacidae	Alexandrine Parakeet	*Psittacula eupatria*	✓	✓
		Rose-ringed Parakeet	*Psittacula crameri*	✓	✓
Strigiformes	Strigidae	Indian scops Owl	*Otus bakkamoena*	✓	×
		Spotted Owlet	*Athene brama*	✓	✓

***Note:** D – Department of Biosciences; G – Botanical Garden.

3. Diversity of Birds in correlation with Floral Diversity

Flora is an important source of matter and energy plays a key role in food chain. Flora provides nesting material, shelter and food for birds to survive. It either directly or indirectly affects the faunal diversity.

Around the P. G. Department of Bioscience, 150 species of floral species were recorded (Variya, 2018). Out of them 40 are shrubs, 1 plant, 46 herbs, 58 trees, and 5 climbers. Some of the species are host plants for butterflies (Variya, 2018).

Birds feed on invertebrates like insects, caterpillar (Variya, 2018), flies, spiders, bees, Grasshoppers etc. The richness in spider diversity was observed including 70 species (Patel *et al.*, 2019). The larval host plants of butterflies indirectly providing food to insectivore species of birds.

Few birds use plant leaves for construction of nest and laying eggs. Some species of birds primarily feed on fruits.

Nectarinidae family includes purple sunbird and purple-rumped sunbird. Purple sunbird feed on flower's nectar (97%) and on fruit's nectar (3%) (Dadras, Ghadirian, 2007).

Jerdon's leaf bird was observed regularly from August to September. A plant called was the reason for Jerdon's leaf bird to come regularly in the department. Jerdon's leaf bird can feed on nectars (Ali, 2017). Other than nectar, it feeds on insects and caterpillars.

Alexandrine parakeet feed on the fruits of *Cassia fistula* (Garmalo). The Indian Grey Hornbill, Yellow-footed green Pigeon, Flowerpecker, Coppersmith barbet

and Dove were observed eating fruits and roosting on Banyan tree and peepal tree. Some pictures of feeding and roosting behavior is shown below.

Figure 21: Jerdon's leaf bird male and female on Bottle brush

Figure 22: Jerdon's leaf bird feeding on insect

Figure 23: Indian golden oriole feeding on caterpillar

Figure 24: Rose ringed parakeet feeding on Bahunia (Kanchnar) species flower

Figure 25: Purple sunbird female nectar feeding on Hamelia patens

Figure 26: Yellow-footed green pigeon feeding on fruits of Banyan tree

Figure 27: Yellow-footed green pigeon on peepal tree

Figure 28: Pale-billed flowerpecker on peepal tree

Figure 29: Purple sunbird nectar feeding on flower of Calotropis (Aankado)

Figure 30: Alexandrine parakeet on Bahunia (Kanchnar) species

Figure 31: Alexandrine parakeet feeding on fruits of *Cassia fistula*

Figure 32: Purple sunbird nectar feeding on flower of Kanchnar (Bahunua)

Figure 33: Asian koel female feeding on Banyan tree fruit

Figure 34: Scaly breasted Munia using leaves for nest building

Birds fulfill many ecological functions in their habitat. They are good bio indicators of healthy ecosystem. Insectivores and raptors regulate disease vectors, including mosquitoes and rodents (Mistry and Slabbekoorn, 2008) Some of them may contribute to biomass recycling and aid in reducing disposable wastes. Those species that feed on fruits plays important role in seed dispersal of fleshy fruit-producing plants (Stevenson, 2002). Sunbirds is known to help in pollination and it provides good example of symbiotic relationship between plants and birds.

4. Diversity of Birds in correlation with Temperature

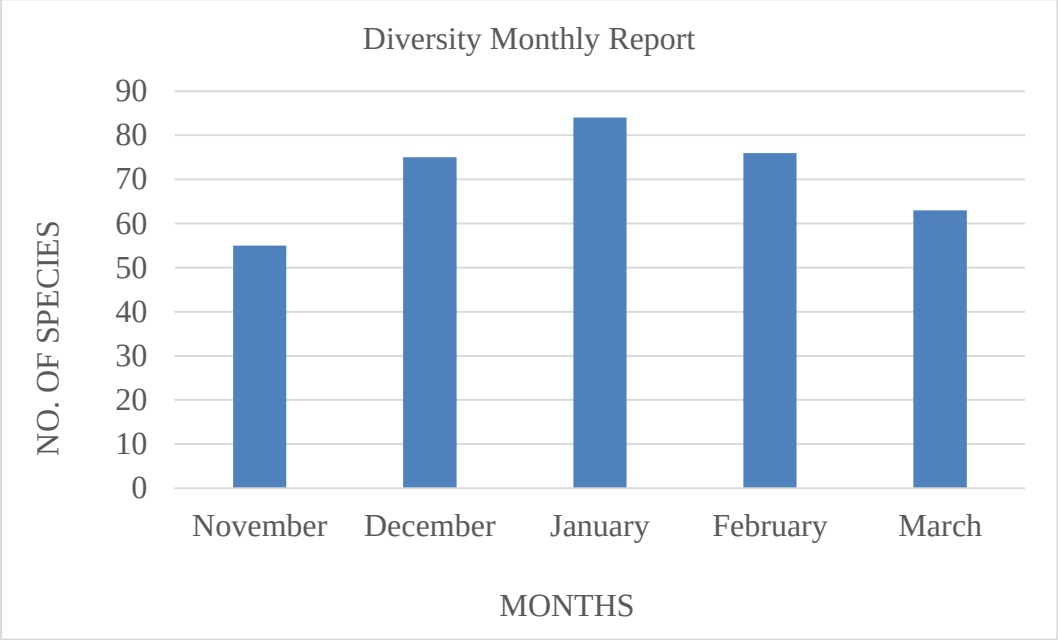
Seasonal diversity of birds is known to greatly influence by climatic conditions including temperature. Other factors including amount of precipitation, days of sunlight, wind speed, wind direction, rain fall and other variables. The annual increase in average temperature could create the biggest problem for plants, animals and human beings (Kumar, 2009). The temperature data from November 2018 to March 2019 was obtained from the Department of Meteorology, Anand Agricultural University, Anand.

Table: 2 Monthly report of Temperature

Month	Max. Temperature	Min. Temperature
November 2018	34˚ C	15˚ C
December 2018	28˚ C	10˚ C
January 2019	29˚ C	9˚ C
February 2019	29˚ C	12˚ C
March 2019	34˚ C	16˚ C

The species richness during all these months varied which could be due to climate change. The study was conducted during pre-winter, winter and post-winter.

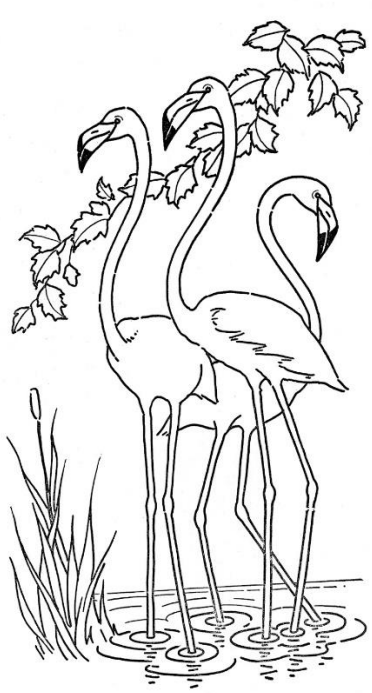
Figure 35: Diversity Monthly Report



During pre-winter period 55 birds were recorded followed by a gradual increase in their number in December and January (75 and 84 respectively). In the winter months, both local and migratory birds were found to be maximum that could be due to the narrow temperature range, humidity in the weather and availability of food resources. Further, there was a significant decrease in their number was observed in February (76) and March (63) that could be attributed to the dry climatic conditions and elevated temperature with broader range of minimum and maximum values.

From the above results, it could be surmised that each bird may have different preferences for food, shelter with species specific thermoregulatory characters. Additionally, the presence of local birds throughout the study period remained almost unaltered whereas sudden fluctuations in the temperature caused significant

reductions in the sighting of migratory birds that corroborates the earlier findings of Dury (1968) wherein they had demonstrated the correlation of density, ambient atmospheric pressure, humidity and velocity. Thus the variations in the density of birds during pre-winter, winter and early summer period could be ascribed to different temperature range during the study period. This study can be extended even for longer duration to study the effects of summer and monsoon and correlate with diversity and density of avian species in the study area.



V. CONCLUSION

Birds are most beautiful, attractive, diverse and they also help maintain ecological functions. As a part of food chain they play an important role by transferring matter and energy. Moreover, birds also regulate overpopulation of small insects and they aid in spreading the pollens. The avifaunal diversity directly or indirectly depends on floral diversity of the nearby vicinity. It provides various food resources and a place to reside, reproduce and protect themselves from the possible predators. However, the environmental factors such as scarcity of food, increased competition, temperature, humidity, rainfall etc may have greater impact on the avian diversity and density. A short term survey was undertaken during November- 2018 to March, 2019 to evaluate the diversity of birds in and around Department of Biosciences and in the Botanical Gardens of Sardar Patel University. We have observed a maximum of 84 birds in Department premises and 43 birds in Botanical Garden area. The present work has the promising aspects of studying the correlations and interrelationships within the avian species as well as presence and absence of other invertebrate and vertebrate species and also with humans.

The possible reason behind increase in diversity and monthly species richness of birds could be the temperature variation and flora around the area.

VI. REFERENCES

1. Amborsini, Borgoni, Rubolini, Diego Rubolini, Beatrice Sicurella, Wolfgang Fieldler, Franz Bairlein, Stephen R. Baillie, Robert A. Robinson, Jacquie A. Clark, Fernando Spina, Nicola Saino, 2014. Modelling the progression of Bird Migration with Conditional Autoregressive Models Applied to ringing data. PLoS ONE 9(7): e102440. https://doi.org/10.1371/journal.pone.0102440
2. Antczak, M., Hromada, M., Czechowski, P., Tabor, J. (2010). A new material for old solutions the case of plastic string used in Great Grey Shrike nests. Article in acta ethologica · October 2010 DOI: 10.1007/s10211-010-0077-2
3. Baker P.J.Molony S.E.,StoneE.,Cuthill I.C. & Harris S. 2008. Cats about town: is predation by free-ranging pet cats likely to affect urban bird populations. Ibis (2008), 150(Suppl. 1), 86–99 DOI: 10.1111/j.1474-919X.2008.00836.x
4. Bauer S, Hoye B (2014) Migratory animals couple biodiversity and ecosystem functioning worldwide. Science. 2014 Apr 4;344(6179):1242552. doi: 10.1126/science.1242552.
5. Bauer Silke, Barta Zoltan, Ens Bruno J., Hays Graeme C., McNamara John M. and Klaassen Marcel. Animal migration: linking models and data beyond taxonomic limits5Biology Lettershttp://doi.org/10.1098/rsbl.2009.0324
6. Blair 1996. Land use and avian species diversity along an urban gradient.Ecological Applications, Ecological Society of America. pp. 506-529https://doi.org/10.2307/2269387
7. Borrow, N. and Demey, R (2001). Helm Identification Guides: Birds of Western Africa, Christopher Helm Publisher. First Volume.
8. Breen, Guillette, 2016. What nest building birds teach us? Article *in* Comparative Cognition & Behavior Reviews 11(1):83-102 · January 2016. DOI: 10.3819/ccbr.2016.110005
9. C.T. Nisbet, Ian & H. Drury, William. (1968). Short-term effects of weather on bird migration: A field study using multivariate statistics. Animal Behaviour. 16. 496-530. 10.1016/0003-3472(68)90046-8.
10. Cockburn, 2006. Prevalence of different modes of parental care in birds. Proc Biol Sci. 2006 Jun 7; 273(1592): 1375–1383. doi: 10.1098/rspb.2005.3458
11. Collias, N.E., and Collias, E.C. (1984). Nest building and bird behavior. Princeton, NJ: Princeton University Press.
12. Dapke, Didolkar, Koushik, 2015. Studies on diversity and abundance of avifauna in and around Laxminarayan Institute of Technology campus, Nagpur, Central India. Journal of Entomology and zoology studies. 2015, Vol. 3, Issue 5
13. Delmore KE, Fox JW, Irwin DE (2012) Dramatic intraspecific differences in migratory routes, stopover sites and wintering areas,

revealed using light-level geolocators. Proc Biol Sci. 2012 Nov 22;279(1747):4582-9. doi: 10.1098/rspb.2012.1229. Epub 2012 Sep 26.

14. E. Kroodsma, Donald & Byers, Bruce. (1991). The Function(s) of Bird Song. American Zoologist. 31. 318-328. 10.1093/icb/31.2.318.
15. Evans Karl L., Gaston Kevin J., Frantz Alain C., Simeoni Michelle, Sharp Stuart P., McGowan Andrew, Dawson Deborah A., Walasz Kazimierz, Partecke Jesko, Burke Terry and Hatchwell Ben J.Independent colonization of multiple urban centres by a formerly forest specialist bird species276Proceedings of the Royal Society B: BiologicalScienceshttp://doi.org/10.1098/rspb.2008.1712
16. Garden J.G,McAlpine C.A., Possingham H.P.& Jones D.N. 2007. Using multiple survey methods to detect terrestrial reptiles and mammals: what are the most successful and cost-efficient combinations? *Wildlife Research* 34(3) 218-227 https://doi.org/10.1071/WR06111
17. Ghadirian, Taher & Qashqaei, Ali & Dadras, Mohsen. (2007). Notes on Feeding and Breeding Habits of the Purple Sunbird Nectarinia asiatica (Cinnyris asiaticus) in Bandar Abbas, Hormozgan, Southern Iran. Podoces. 2. 122-126.
18. H. Slabbekoorn and E. A. P. Ripmeester, "Birdsong and anthropogenic noise; implications and applications for conservation," *Molecular Ecology,* Vol. 17. View at Publisher View at Google Scholar View at Scopus.
19. Hansell, M, 2000. Bird nests and construction behavior. Cambridge, UK: Cambridge University Press. https://doi.org/10.1017/CBO9781139106788
20. Horiuchi, S.1992. Stagnation in the decline of the world population growth rate during the 1980s. *Science* 1992: Vol. 257, Issue 5071, pp. 761-765.
21. J. Mistry, A. Berardi, and M. Simpson, "Birds as indicators of wetland status and change in the North Rupununi, Guyana," *Biodiversity and Conservation,* Vol. 17, no. 10. View at Publisher View at Google Scholar View at Scopus.
22. Koladiya, Mahato, Gajera, Patel. 2014. Distribution pattern of birds in banni grassland of Kachchh district, Gujarat, India. Journal of Research in Biology (2014)4(1):1228-1239
23. Kumar Saikia, Kakati Saikia, 2000. Diversity of bird fauna in North East India. *Journal of the Assam Science Society;* Vol.41 No.4. December 2000, pp. 379-396.
24. Kumar, Vinod & Chopra, A. (2009). Impact of climate change on biodiversity of India with special reference to Himalayan region-An overview. Journal of Applied and Natural Science. 1. 117-122.
25. Marzluff J.M. (2001) Worldwide urbanization and its effects on birds. In: Marzluff J.M., Bowman R., Donnelly R. (eds) Avian Ecology and

Conservation in an Urbanizing World. Springer, Boston, MADOI https://doi.org/10.1007/978-1-4615-1531-9_2

26. Marzluff J.M., Bowman R., Donnelly R. (2001) A historical perspective on urban bird research: trends, terms, and approaches. In: Marzluff J.M., Bowman R., Donnelly R. (eds) Avian Ecology and Conservation in an Urbanizing World. Springer, Boston, MADOI https://doi.org/10.1007/978-1-4615-1531-9_1
27. Mayur Variya, Sujata Bhatt, Ujjval Trivedi, 2018. Evaluating the butterfly community in and around P. G. Department of Biosciences, Anand city, Gujarat, India. Unpublished M. Sc. Thesis. *Sardar Patel University*.
28. McKinney M.L. 2002, Urbanization, Biodiversity, and Conservation. BioScience 52(Oct 2002):883-890 · February 2009 *with* 3,101 Reads. DOI: 10.1641/0006-3568(2002)052[0883:UBAC]2.0.CO;2
29. Mehmet Ali Tabur, (2010). Ecological Importance of Birds. Conference: Second International Symposium on Sustainable Development. June 8-9 2010., At Sarajevo, Bosnia and Herzegovina, Volume: 560-565
30. Mohamed Ali and Taha, 2012. Bee-eating birds (Coraciiformes: Meropidae) reduce virgin honey bee queen survival during mating flights and foraging activity of honey bees. International Journal of Scientific & Engineering Research Volume 3, Issue 6, June-2012 ISSN 2229-5518
31. Mukesh H. Koladiya, A.V.R.L.Narasimhacharya, Geeta Padate, 2012. Avifaunal Diversity in Urban Area: A case study in Vallabh Vidhyanagar. Lambert Academic Publishing.
32. Newton, Ian. (2007). The Migration Ecology of Birds. The Migration Ecology of Birds. 10.1016/B978-0-12-517367-4.X5000-1.
33. Nicolakakis, N.,and Lefebvre, L.(2000). Forebrain size and innovation rate in European birds: Feeding, nesting and confounding variables. *Behaviour* Vol. 137, No. 11 (Nov., 2000), pp. 1415-1429
34. Patel, K. K. Narsimhacharya, A. V. R. L. (2018). Biological alternatives for Termite control: Plant extracts as possible candidate, P. G. Department of Biosciences, *Sardar Patel University*.
35. Payevsky,2014. Phylogeny and classification of passerine birds, Passeriformes. https://doi.org/10.1134/S2079086414020054
36. Payne, R.B. 1997. Order Cuculiformes, Cuculidae. Handbook of the birds of the world.
37. Posso, Dontelli, 2012. Posso, S.R. and R.J. Donatelli. 2010. When desicisions on homologus structures cause ambiguous taxa relationships: the Neomorphinae (Aves, Cuculidae) example. Brazilian Journal of Biology. Braz J Biol. 2010 Feb;70(1):195-204.

38. Rathod, Jagruti & Sonal, Deshkar & Padate, Geeta. (2017). Diversity of avifauna in Urban City, Vadodara, Gujarat. Biolife. 5. 8. 10.17812/blj.2017.5212.
39. Reena Mathur, 2014, Animal behavior. Rastogi Publication.
40. Robert B. Payne, Illustrated by Karen Klitz. Biogeography on the early distribution of cuckoos (Aves: Cuculiformes). The cuckoos. Oxford, Oxford University Press.
41. Sharpe, R.B., (1904). A hand-list of the Genera and species of birds, *Nature*, volume 69, pages218–219
42. Sharpe,R.B. Catalogue of birds in the British Museum, London.
43. T. Stevenson and J. Fanshawe, (2003). Field Guide to the Birds of East Africa: Kenya, Tanzania, Uganda, Rwanda, Burundi, Published by London: Christopher Helm / A & C Black The Book of Indian Birds, Salim Ali, thirteenth edition 2002, BNHS
44. Thom R.M., Borde A.B., Richer K.O. & Hibler L.F.2001. Influence of urbanization on ecological process in wetlands, Land use and watersheds; human influence on hydrology and geomorphology in urban and forest areas. Vol.1, Washington: American Geophysial Union.
45. UNCED (1992), *Agenda 21.* United Nations Conference On Environment and Development. https://sustainabledevelopment.un.org/content/documents/Agenda21.pdf Wilbur, S. R. & Jackson, J. A. eds. (1983). *Vulture Biology and Management.* University of California Press, Berkeley, California.
46. Vinicius Abilhoa, Rafael Amorin, 2017. Effects of urbanization on the avian community in a southern Brazilian city. Revista Brasileira de Ornitologia 25(1): 31–39.

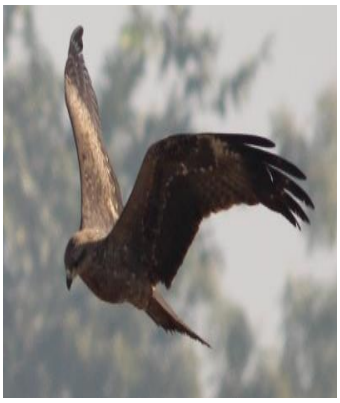
Web sources:

1. http://www.birdsofindia.org/
2. http://www.birdsofindia.org/
3. https://www.birdsofgujarat.in/

VII. APPENDICES

Appendix - 1 Plates (Birds of P. G. Deparrtment of Biosciences).

Accipitriformes

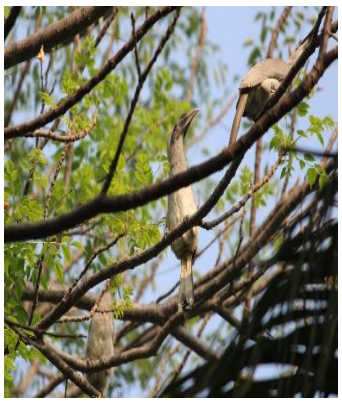


Black Kite

Oriental Honey Buzzard

Shikra

Bucerotiformes

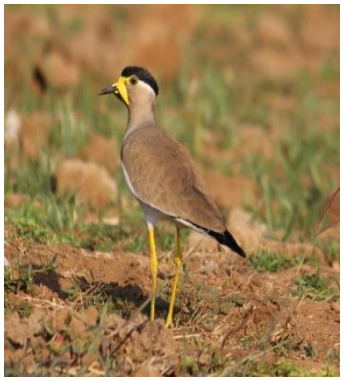


Indian grey Hornbill

Common Hoopoe

Charadriiformes

Red wattled Lapwing



Yellow wattled Lapwing

Black winged Stilt

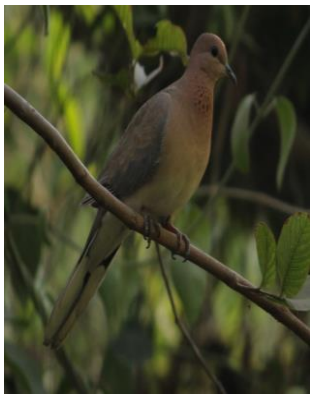
Green Sandpiper

Wood Sandpiper

Columbiformes

Common rock Pigeon

Eurasian collared Dove

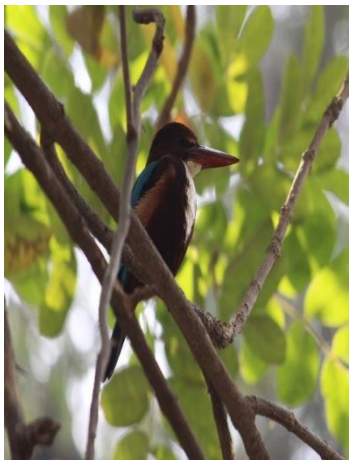


Laughing Dove

Spotted Dove

Yellow footed green Pigeon

Coraciformes



White-throated kingfisher

Indian Roller

Green bee eater

Blue-tailed bee eater

Cuculiformes

Asian Koel

Common Hawk Cuckoo

Greater Coucal

Gruiiformes

White-breasted waterhen

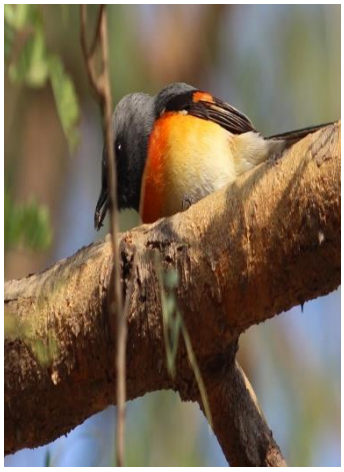
Passeriformes

Blyth's reed Warbler

Booted Warbler

Syke's Warbler

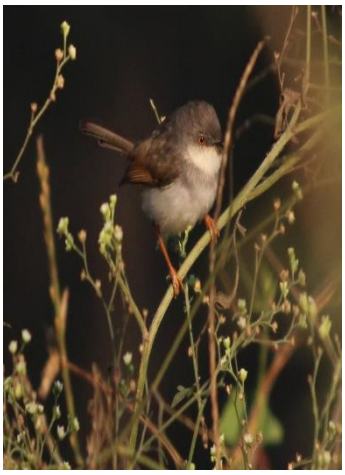
Common Iora



Small Minivet

Ashy Prinia

Common tailor bird

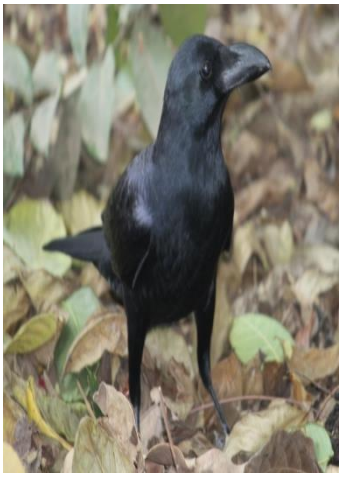


Grey-breasted Prinia

Plain Prinia

Jerdon's leaf bird

House Crow



Jungle Crow

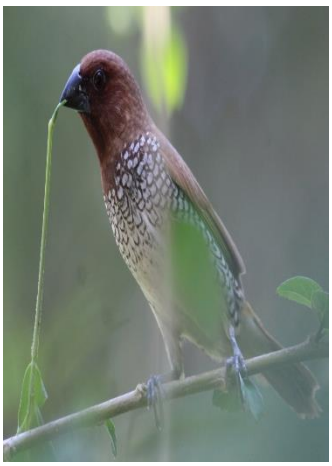
Rufous Treepie

Pale-billed Flowerpecker

Thick-billed Flowerpecker

Black Drongo

Indian Silverbill



Scaly-breasted Munia

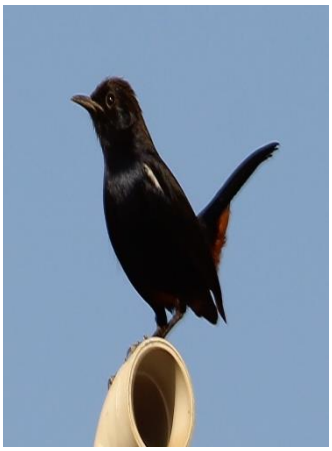
Red-rumped Swallow

Jungle Babbler

Large grey Babbler

Asian brown Flycatcher

Oriental magpie Robin



Indian Robin

Red-breasted Flycatcher

Taiga Flycatcher female

Citrine Wagtail

Grey Wagtail

Long billed Pipit

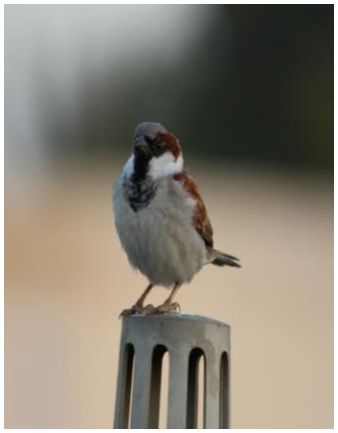
Yellow Wagtail

White Wagtail

Purple rumped Sunbird

Purple Sunbird

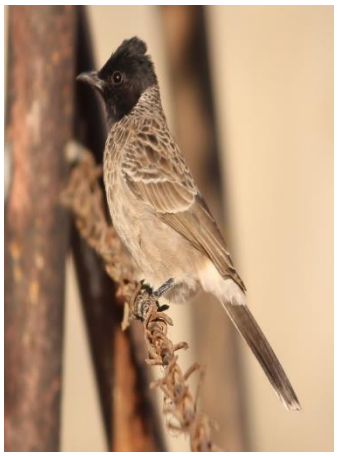
Indian golden Oriole



House Sparrow

Common Chiffchaff

Greenish Warbler



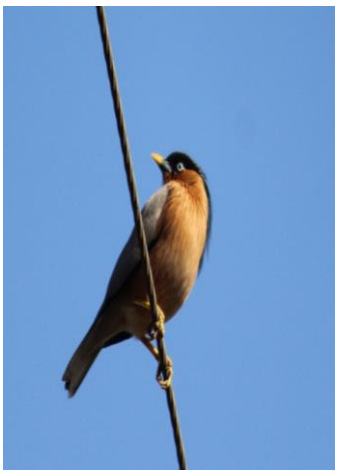
Red vented Bulbul

White browed Fantail

White spotted Fantail

Grey headed canary Flycatcher

Bank Myna



Brahminy Starling

Common Myna

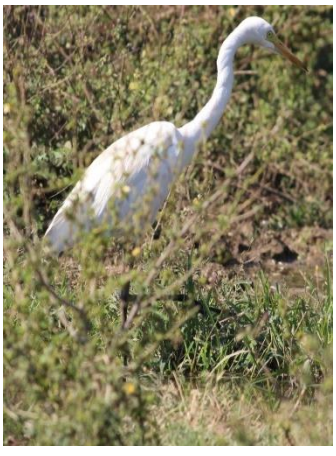
Rosy Starling

Lesser Whitethroat

Oriental white eye

Pelecaniformes

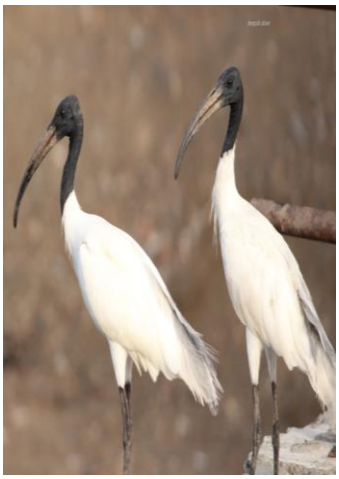
Cattle Egret



Intermediate Egret

Indian Pond Heron

Little Egret



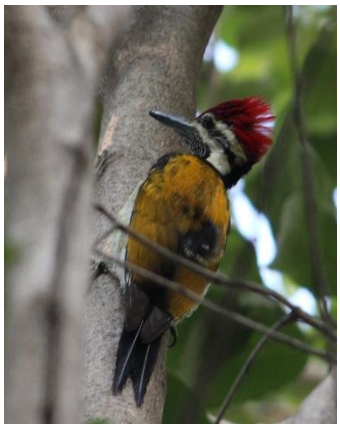
Black headed Ibis

Glossy Ibis

Red naped Ibis

Piciformes

Coppersmith Barbet



Lesser goldenback Woodpecker

Psittaciformes

Rose ringed Parakeet

Alexandrine Parakeet

Strigiformes

Spotted Owlet

Indian Scops Owl

Appendix - 2

Table: 3 List of butterflies found around the P. G. Department of Biosciences, during the study

SR. NO.	COMMON NAME	SR. NO.	COMMON NAME
1	Plain Tiger	14	Common Fourring
2	Common Jezebel	15	Common Crow
3	Common Jay	16	Danaid Eggfly
4	Tailed Jay	17	Great Eggfly
5	Common Rose	18	Common Leopard
6	Common Mormone	19	Tawny Coster
7	Common Pierrot	20	Common Emigrant
8	Lesser Glass blue	21	Crimson Tip
9	Indian Sunbeam	22	Plain Orange Tip
10	Forget me not	23	Small Orange Tip
11	Peacock Pansy	24	Blue Pansy
12	Lemon Pansy	25	Small Grass Jewel
13	Common Castor	26	Black Rajah

Table: 4 List of Reptiles found around P. G. Department of Biosciences, during the study.

SR. NO.	COMMON NAME
1	Common House Gecko
2	Monitor Lizard
3	Common Wolf Snake
4	Common Rat snake
5	Cobra
6	Saw-scaled Viper
7	Russel's Viper
8	Common krait

Table: 5 List of Mammals found around the P. G. Department of Biosciences, during the study.

SR. NO.	COMMON NAME
1	Hanuman Langur
2	Indian Palm Squirrel
3	Mangoose
4	Indian Hare

Table: 6 Floral Diversity

Table 4: Checklist of plants in and around P. G. Department of Biosciences.				
No.	**Family**	**Scientific Name**	**English Name (Local Name)**	**Type**
1	Acanthaceae	*Adhatoda vasica*	Malabar Nut (Aradusi)	Shrub
2		*Barleria prionitis*	Porcupine Flower (Vajradanti)	Herb
3		*Peristrophe bicalyculata*	Panicled Peristrophe (Kali Adhedi)	Herb
4		*Thunbergia erecta*	King's Mantle	Shrub
5	Alliaceae	*Allium cepa*	Onion (Dungali)	Herb
6	Amaranthaceae	*Achyranthes aspera*	Pricky Chaff Flower (Adhedo)	Herb
7		*Aerva lanata*	Knot Grass	Herb
8		*Alternanthera sessilis*	Dwarf Copperleaf (Jalajambo)	Herb
9		*Amaranthus hybridus*	(Tandaljo)	Herb
10		*Amaranthus gracilis*	Spiny Amarnath (Dhimado)	Herb
11		*Amaranthus spinosus*	(Kantalo Dabho)	Herb
12		*Gomphrena celosioides*	Prostate Gomphrena	Herb
13	Anacardiaceae	*Lannea coromandelica*	Indian Ash Tree (Moyano)	Tree
14		*Mangifera indica*	Mango (Aambo)	Tree
15	Annonaceae	*Annona reticulate*	Netted Custard Apple (Ramfal)	Tree
16		*Annona squamosal*	Sugar Apple (Sitafal)	Tree

17		*Polyalthia longifolia*	Ashok (Ashopalav)	Tree
18	Apiaceae	*Trachyspermum ammi*	Ajwan Caraway (Ajmo)	Herb
19	Apocynaceae	*Alstonia scholaris*	Scholar Tree (Saptaparni)	Tree
20		*Nerium odorum*	Oleander (Kanera)	Shrub
21		*Plumeria rubra*	Frangipani Red (Champo)	Tree
22		*Tabernaemontana divarticata*	Crape Jasmine (Tagari)	Shrub
23		*Vinca rosea*	Periwinkle (Baramasi)	Herb
24	Araceae	*Dieffenbachia sp.*	Dumb Cane	Shrub
25		*Colocasia esculenta*	Taro (Aaluki)	Herb
26	Arecaceae	*Cocos nucifera*	Coconut (Nariyer)	Tree
27		*Phoenix dactylifera*	Date Palm (Khajuri)	Tree
28	Asclepiadaceae	*Calotropis gigenta*	Calotropis (Aakado)	Shrub
29		*Calotropis procera*	Calotropis (Aakado)	Shrub
30	Asphodelaceae	*Aloe barbadensis*	Aloe Vera (Kuvar Pathu)	Herb
31	Asteraceae	*Bidens bipinnata*	Spanish Needles	Herb
32		*Blumea lacera*	Kakronda (Kapuriyo)	Herb
33		*Crysanthemum sp.*		Herb
34		*Eclipta alba*	False Daisy (Bhangaro)	Herb
35		*Tridax procumbens*	Tridax Daisy	Herb
36		*Helianthus annuus*	SuNIlower (Suraj Mukhi)	Herb
37		*Launae acapitata*		Herb
38		*Parthenium hysterophorus*	Carrot Grass (Congress Grass)	Herb

39		*Tagetes erecta*	Marigold (Yellow/Orange) (Galagota)	Herb
40		*Vernonia cinerea*	Little Ironweed (Sahadevi)	Herb
41	Bignoniaceae	*Kigelia pinnata*	Sausage Tree (Gorakh Kakadi)	Tree
42		*Millingtonia hortensis*	Indian Cork Tree (Jasmine)	Tree
43		*Tabebuia rosea*	Pink Trumpet Tree	Tree
44	Boraginaceae	*Cordia gharaf*	Gondani (Nani Gundi)	Tree
45		*Cordia sebestena*	Geiger Tree	Tree
46	Brassicaceae	*Raphanus sativus*	Radish (Mulo)	Herb
47	Caesalpiniaceae	*Bauhinia purpureae*	Purple Orchid Tree (Champakati)	Tree
48		*Bauhinia ravemosa*	(Asotaro)	Tree
49		*Bauhinia tomentosa*	Yellow Orchid Tree (Pilo Asundro)	Tree
50		*Bauhinia variegate*	Orchid Tree (Kanchanara)	Tree
51		*Cassia angustifolia*	East Indian Senna (Aval)	Herb
52		*Cassia fistula*	Golden Rain Tree (Garmalo)	Tree
53		*Cassia occidentalis*	Coffee Senna (Kasundari)	Herb
54		*Cassia siamea*	Cassia Tree (Kasid)	Tree
55		*Cassia tora*	Sickle Pod (Kunvadiyo)	Herb
56		*Hardwickia binate*	Indian Blackwood (Anjan)	Tree

57		*Piliostigma malabaricum*	Malabar Orchid (Khati Chamol)	Tree
58		*Tamarind usindicus*	Tamarind (Aamli)	Tree
59	Cannaceae	*Canna indica*	Indian Shot	Herb
60	Caricaceae	*Carica papaya*	Papaya (Papaiya)	Tree
61	Casuarinaceae	*Casuarina equisetifolia*	Whistling Pine (Saru)	Tree
62	Combretaceae	*Terminalia arjuna*	Arjun Tree (Sadado)	Tree
63	Compositeae	*BlumeaLacera*	(Kapurio)	Herb
64	Convolvulaceae	*Ipomoea dichroa*	(Safed Panavali)	Shrub
65		*Ipomoea obscura*	Obscure Morning Glory	Shrub
66		*Ipomoea fistulosa*		Shrub
67		*Cuscutareflexa*	Amar Bel (Amarvel)	Climber
68	Crassulaceae	*Bryophyllum pinnatum*	Air Plant (Khatumaro)	Shrub
69	Cucurbitaceae	*Coccinia indica*	Ivy Gourd (Kadavi Gilori)	Climber
70		*Luffa acutangula*	Silk Squash (Galka)	Climber
71	Cupressaceae	*Thuja occidentalis*	(Mayur Pankh)	Shrub
72	Euphorbiaceae	*Acalypha indica*	Indian Copperleaf	Tree
73		*Euphorbia milii*	Crown of Thorns	Shrub
74		*Euphorbia nivalvia*	Leafy Milk Hedge (Kantalo Thor)	Shrub
75		*Euphorbia tirucalli*	Indian Tree Spurge (Kharasani)	Shrub
76		*Jatropha curcas*	Physic Nut	Shrub
77		*Ricinus communis*	Castor Bean Plant (Arando)	Shrub
78	Fabaceae	*Abrus precatorius*	Gunj (Chanothi)	Herb
79		*Butea monosperma*	Palash (Keshudo)	Plant
80		*Cassia angustifolia*	TirunelveliSenna (Aval)	Tree

81		*Dalbergia sissoo*	Shisham (Shisham)	Tree
82		*Pithecellobium dulce*	Monkeypods (Goras Amli)	Tree
83		*Prosopis spicigera*	Cikura Pod (Samadi)	Tree
84		*Indigofera linnae*	(Bhonyagali)	Herb
85	Lamiaceae	*Leucas aspera*	CommanLeucas (Kobi)	Shrub
86		*Ocimum sanctum*	Tulsi (Tulasi)	Herb
87	Lythraceae	*Punica granatum*	Pomegranate (Dadam)	Shrub
88	Malvaceae	*Abelmoschus angulosus*	Ladies' Finger (Bhindo)	Shrub
89		*Abelmoschus manihot*	Sunset Muskmallow (Jangali Bhindo)	Shrub
90		*Abutilon indicum*	Indian Mallow (Kansaki)	Herb
91		*Hibiscus rosasinensis*	China Rose (Jasud)	Shrub
92		*Sida acuta*	Common Wireweed (Khapat)	Herb
93		*Sida glutinosa*		Herb
94		*Sida rhombifolia*	(Baladana)	Herb
95		*Thespesia populnea*	Portia Tree (Paaras Pipalo)	Tree
96		*Urena lobata*	Ceasarweed (Jangali Kapas)	Herb

97	Martyniaceae	*Martynia annua*	Devils Claws (Vichudo)	Herb
98	Meliaceae	*Azadirecta indica*	Neem (Limado)	Tree
99		*Melia azadirach*	Persian Lilac (Bakam Limdo)	Tree
100	Mimosaceae	*Acacia auriculiformis*	Earleaf Acacia (Fofa)	Tree
101		*Acacia nilotica*	TomatoseBabool (Baval)	Tree
102		*Albizia lebbeck*	Siris Tree (Siras)	Tree
103		*Samanea saman*	Rain Tree (Rato Shiris)	Tree
104	Moraceae	*Ficus glomeruta*	Indian Fig Tree (Goolar) (Umaro)	Tree
105		*Ficus pumila*	Climbing Fig	Shrub
106		*Ficus religiosa*	Peepal (Pipalo)	Tree
107		*Ficus Benghalensis*	Banyan (Vad)	Tree
108		*Morus alba*	Mulberries (Setur)	Shrub
109		*Streblus asper*	Sand Paper Tree (Sarelo)	Tree
110	Moringaceae	*Moringa oleifera*	Drumstick Tree (Saragavo)	Tree
111	Muscaceae	*Musa paradisica*	Banana (Kela)	Shrub
112	Myrtaceae	*Callistemon sp.*	Bottle Brush	Shrub

113		*Eucaluptus globulus*	Eucalyptus (Nilgiri)	Tree
114		*Psidium guajava*	Guava (Jamaphal)	Tree
115		*Syzygium cumini*	Jamun (Jambu)	Tree
116	Nictagineceae	*Boerhavia diffusa*	Punarnava (Satodi)	Herb
117	Oleaceae	*Nyctanthesarbor-tristis*	HarSingar (Parijat)	Shrub
118	Papilionaceae	*Clitoria biflora*	Bombay Bean (Galani)	Climber
119		*Clitoria ternatea*	Bombay Bean (Galani)	Climber
120	Pedaliaceae	*Sesamum indicum*	Sesame (Tal)	Herb
121	Phyllanthaceae	*Emblica officinalis*	Amla (Amla)	Tree
122		*Phyllanthus nirui*	BhoyAamali (Bhoy Aamli)	Herb
123	Plumbaginaceae	*Plumbago zeylanica*	Doctorbrush (Safed Chitaro)	Herb
124	Poaceae	*Dendrocalamus strictus*	Culcutta Bamboo (Vaas)	Tree
125	Putranajivaceae	*Putranajiva roxburghii*	(Putranjiva)	Tree
126	Rhamnaceae	*Ziziphus mauritiana*	Ber (Bor)	Shrub
127	Rosaceae	*Rosa centifolia*	Rose (Gulab)	Shrub
128	Rubiaceae	*Anthocephalus indicus*	Kadam (Kadam)	Tree

129		*Ixora coccina*	Ixora (Vasanti)	Shrub
130	Rutaceae	*Aegle marmelos*	Bel (Bili)	Tree
131		*Citrus acida*	Lemon (Limbu)	Shrub
132		*Feronia elephantum*	Wood Apple (Kothu)	Tree
133		*Murraya koenigii*	Curry Tree (Kadhi Limdo)	Tree
134	Santalaceae	*Santalum album*	Sandal Wood (Chandan)	Tree
135	Sapotaceae	*Manilkara zapota*	Chikoo (Chiku)	Tree
136		*Mimusops elengi*	Spanish Cherry (Bakul)	Tree
137	Sapindaceae	*Sapindus trifoliatus*	Soapnut (Aritha)	Shrub
138	Simarubaceae	*Alianthus excelsa*	Tree of Heaven (Arduso)	Tree
139	Solanaceae	*Capsicum annum*	Capsicum (Marachu)	Shrub
140		*Datura innoxia*	Datura (Dhaturo)	Shrub
141		*Lycopersicum esculentum*	Tomato (Tameta)	Herb
142		*Solanum malongena*	Brinjal (Ringana)	Shrub
143	Sterculiaceae	*Sterculia foetida*	Wild Almond Tree (Janali Badam)	Shrub
144	Tiliaceae	*Corchorus acutangulus*	East Indian Mallow (Chhunchh)	Herb

145	Verbenaceae	*Clerodendron inermis*	(Kadavi Mahendi)	Shrub
146		*Clerodendron phlomoides*	(Arani)	Shrub
147		*Lantana camara*	Tickberry	Shrub
148		*Tectona grandis*	Teak Wood (Sag)	Tree
149	Vitaceae	*Cissu squadrangularis*	Veldt Grape (Hadasankal)	Shrub
150	Zingiberaceae	*Zingiber officinale*	Ginger (Aadu)	Herb

Source: Patel, 2018.