SOME ASPECTS OF THE BIOLOGY OF FOUR COLUMBID SPECIES IN ZARIA, NIGERIA

BY

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AUGUST, 1999

DECLARATION

I declare that this work is wholly the author's and has not been part of any presentation for any other qualification.



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CERTIFICATION

This thesis entitled "Some Aspects of the Biology of Four Columbid species in Zaria, Nigeria" by ADANG, KOMBE LUCAS meets the regulations governing the award of the degree of Master of Science of Ahmadu Bello University, and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This thesis is dedicated to the following for their eminent contribution towards my education.

MR. ADANG JOSEPH ABANDA

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MR/MRS. EGEANDONG THOMAS ABIE

And above all, to God Almighty for his Grace and Mercy.

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ABSTRACT

Some aspects of the biology of four columbid species in Zaria, Nigeria were studied between the months of May 1998 and February 1999 to obtain baseline information for their management and possible domestication. The aspects examined were the food and feeding habits of wild birds using regurgitates obtained from the birds after the administration of an emetic and by direct observation of the birds as they fed in the wild. The food and feeding habits of wild birds were used to illustrate the concept of niche overlap and differentiation among the four columbid species under study, and also to determine any variation in food habits between the wet and dry seasons.

A total of 154 regurgitates were obtained and results from the analyses of the regurgitates showed that the birds feed on the seeds of both wild and cultivated plants as well as on animal matter. A food niche overlap of 31.3% and a total food niche differentiation of 33.5% were observed for the four columbid species. Analyses of regurgitates obtained from captured birds showed a variation in food habits between the wet and dry seasons.

The food habits of the birds in captivity were also examined through a trial-and-error approach to feeding using six selected seed types namely; maize, guinea corn, millet, cowpea, *Amaranthus* and *Spathodea* seeds. The birds consumed different amounts of the six seeds presented to them in captivity, suggesting some degree of preference. The birds consumed more of guinea corn

and maize thus showing more preference for these two seeds than for the other seeds.

The behaviour and survivorship of the birds under captive conditions were also observed and documented within the feeding period of 72 days. In captivity, the birds manifested some of the breeding behaviours exhibited in the wild. This indicates that the birds may breed in captivity if provided with suitable conditions that simulate those in the wild. Two of the 20 birds kept in captivity died from infectious diseases namely, aspergillosis and ascaridiasis. This shows that infectious and parasitic diseases can be a problem to columbids in captivity.

It is important to encourage the management and the possible domestication of these species, particularly as they feed on wild and cultivated seeds available in the area and based on the fact that the brids may survive and possibly breed in captivity if provided with favourable conditions. This will guarantee the existence of these species over future generations.

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ABBREVIATIONS AND SYMBOLS

LD = Laughing Dove.

RD = Red-eyed Dove.

MD = Mourning Dove.

SP = Speckled Pigeon.

MZ = Maize.

GC = Guinea corn.

ML = Millet.

CP = Cowpea.

AS = *Amaranthus* seed.

SS = *Spathodea* seed.

PSGF = Polyspecific group feeding.

N = North.

E = East.

m = metres.

g = grammes.

A.D. = After Christ.

B.C. = Before Christ.

n = intersection.

u = union.

U = Universal set.

? = Unobserved food items on which the birds may feed.

{ } = Set of food items.

{O} = Empty set.

% = Percentage.

A to P = Set of food items observed in regurgitates of the four Columbid species under study in various subsets.

%U = Percentage of food consumed.

%A = Percentage of food presented.

%Y = Percentage of niche overlap and differentiation.

\+ = Food item observed in regurgitates of that species.

– = Food item not observed in regurgitates of that species.

GLOSSARY

Columbids - Members of the family Columbidae.

Polyspecific feeding - Feeding of the four columbid species together as a single group.

Monospecific feeding - Feeding of the four species in separate groups according to their species.

Sympatric - Living together in the same environment.

Captivity - Confined to a given environment differemnt from the natural environment.

Conspecifics - Members of the same species.

Regurgitates - Food items obtained from the birds through the administration of an emetic.

Survivorship - Staying alive after some event or change in conditions.

"*Ad libitum*" - As desired.

Tasty - Tasteful

Animal food matter - Insects or invertebrate material observed in regurgitates.

Feeding period - A period of six days during which the six seed types were rotated.

Experimental feeding period - Each time the birds were fed, that is morning and evening.

Wet season - May to Octorber.

Dry season - November to February.

Food habits - What the birds feed on.

Feeding habits - How, where and when the birds feed.

Captive - Birds confined to a particular environment e.g. aviary.

Wild - Natural habitat of the birds.

CHAPTER 1

INTRODUCTION

The columbids (pigeons and doves) are members of the family Columbidae, order Columbiformes and class Aves. Goodwin (1983), describes the columbids as a large and successful family of birds.

They are medium-sized, strong-winged, fast-flying birds, with small heads, slender bills, short, strong legs and soft, usually delicate coloured plumage. The layman finds it difficult to distinguish between pigeons and doves. Ornithologically, there is no distinction but morphologically, the pigeons are large and stoutly built, with rounded or square tails, while the doves are slender in form with long graduated tails. Their calls are generally cooing in character and vary from one species to another and are useful in identification. The word "pigeon" is of French origin and word 'dove' of Anglo-saxon origin. In (common speech) in Britain, the word "pigeon"is usually applied to the large species such as the Wood Pigeon (*Columba palumbus*) and 'dove' to the smaller ones such as the Barbary Dove (*Streptopelia risoria*) (Goodwin, 1983).

The columbids are world wide in distribution, with different species found in the various zoogeographical regions of the world. They are typically arboreal, living in or at least nesting, roosting and taking cover on trees. They have however developed cliff and ground-dwelling forms. The nest is typically a simple platform of sticks, twigs and rootlets, usually 4-8 m off the ground.

Some are among the most vividly coloured birds in the world and others are clad in dull and cryptic plumage. Inspite of their variety, they are in many aspects of appearance and behaviour, a rather homogenous family. They are generally tasty and therefore much sought after by predators, including humans, for food.

They feed mainly on seeds, fruits or other food items small enough for them to swallow whole. They supplement their diets with insects and other invertebrates. Most pigeons drink regularly at least once and usually more often a day.

The columbids are both monomorphic and monogamous species. They lay small clutches of usually two eggs from which hatch altricial nestlings. The young are naked at hatching, altricial and tended by both parents. At first, they are fed on pigeon milk (crop milk), a nutritious secretion from the crop of both sexes. They have developed short incubation and fledging periods as a result of heavy predation on their eggs and nestlings (Goodwin, 1983).

Goodwin (1983) believes that the columbids owe their success to being physically and psychologically 'tough' inspite of their delicate, fragile appearance and their timidity. He also acknowledged that their high reproductive rate, efficient escaping behaviour, hardiness and longevity have contributed more to the success of the columbids than their production of crop milk.

According to Webb *et al.* (1979), the family Columbidae comprises of 40 genera and 280 species. Among the genera are the *Columba* and *Streptopelia*, four species of which are the subjects of the present study.

***Columba guinea* (Speckled Pigeon).**

Figure 1 shows the Speckled Pigeon (SP) as a large robust pale grey pigeon of farmland and gardens. It is also found on buildings and in trees and feeds on the ground (Elgood, 1960). It is much larger than several streptopelian species. The wing-coverts are conspicuously spotted with white and there is a large patch of bare red skin around the eye. The bill is black and the legs, dark red. These are useful field marks for identification (Serle *et al.*,1992). The back is chestnut and the rump light grey and very conspicuous in flight. It has an advertising cooing call like that of the feral Pigeons as described by Rowan (1983). The voice is a series of deep sonorous well-separated 'coos; (Serle *et al.*, 1992). It is a savanna species that penetrates as far as 15^0N, and is widespread, locally common in the area of study (Fry, 1965 and Nambu, 1997).

The nest is a typical platform of twigs and rootlets built in a tree or in buildings with two white eggs. The sexes are similar (monomorphic) and they are often gregarious when not breeding.

***Streptopelia decipiens* (African Mourning Dove).**

Figure 2 portrays the Mourning Dove(MD) as a dark–grey dove of green vegetation. It resembles the Red-eyed Dove *Streptopelia semitorquata* but is slightly smaller. The lower breast and belly are pale grey and the tail is tipped white and lacks the dark band of the Red–eyed Dove. It's voice and habitat are also different from that of the MD. (Serle *et al.*,1992). The quavering throaty chuckling call uttered by both sexes is a guide to their identification. The voice is a characteristic coo-roo-oo-oo or coo-roo-roo; the first note pitched higher than the last two. It also has a black half-collar at the base of the hind-neck like the Red–eyed Dove. It is a dry–country species with a more northerly range than the Red-eyed Dove though the two overlap. *S. decipiens* is fond of riverine fringing vegetation. The sexes are similar (monomorphic) and the nest is a flimsy platform mainly of twigs built at a height of 2 to 14 m in a variety of trees. The eggs are white and the clutch size is usually two.



Figure 1: Speckled Pigeon, *Columba guinea*



Figure 2: African Mourning Dove, *Streptopelia decipiens*

Streptopelia semitorquata **(Red-eyed Dove).**

Figure 3 shows the Red-eyed Dove (RD) as a large dark grey dove with grey head, greyish–brown upper parts, and vinous under parts. It has a black half-collar at the base of the neck and the bare skin round the eye is dark red and conspicuous. The tail is brown, crossed in the middle by a broad blackish band and is tipped white. The voice is a characteristic "coo-coo" followed after a short pause by a slow descending "coo-coo-coo", and this is the best distinguishing character from the Mourning Dove. The sexes are similar (monomorphic) and often gregarious. This species is abundant and widespread in the savanna and forest and is fond of cultivated ground with scattered shady trees (Elgood,1977). The nest is a platform mainly of twigs usually in a thick leafy tree and often near water. It lays two white eggs.

Streptopelia senegalensis **(Laughing Dove)**

Figure 4 portrays the Laughing Dove (LD) as a small subsaharan dove, that has a black spotted reddish foreneck, which distinguishes it from all other doves. The head is vinous, the mantle brown, the rump dark-grey and the under parts are vinous becoming white on the belly. The grey–blue wing coverts and secondaries are conspicuous at rest and in flight. This species is semi tame and is numerous in villages and towns spending much of its time on the ground feeding on fallen seeds (Elgood, 1960). The voice is a cooing "ro-too-too-too-too-", hurried in the middle and not very loud. It is widespread and very

common through out the area south of 18°N but absent from closed forest. It is mainly, but not entirely, restricted to villages and surrounding farmland. According, to Serle *et al.* (1992), the sexes are similar (monomorphic) and the nest is a very flimsy platform of twigs, rootlets and tendrils, built in a small tree at a height of 1 to 5 m. The eggs are usually two in mumber and white in colour.



Figure 3: Red-eyed Dove, *Streptopelia semitorquata*



Figure 4: Laughing Dove, *Streptopelia senegalensis*

The wild ancestor of the Domestic Pigeon *Columba livia* is considered to be the Rock Pigeon or the Rock Dove of Europe and Asia. It is probable that there has been some association of pigeons with man since the begining of agriculture in the neolithic times about 4,500 B.C. A dovecote pigeon culture was developed in western Asia that provided young pigeons (squabs) weighing 300–400g for the table. This form of production spread to the Mediterranean region and northeast Africa and eventually to Western Europe (Zerner, 1963). The first impression of pigeons on man appeared to have been not as an economic proposition, but as a symbol of love and fertility (Levi, 1967). Their courtship display is particularly striking and they are of a peaceful disposition.

More over paired individuals remain remarkably faithful to each other. The bird thus became the symbol of the western, Asiatic goddess of love, Astarte (Kligerman, 1978). Pigeons were popular both as temple birds that were kept alive within the precincts and as sacrifices by the Hebrews.

Christianity transferred the symbol to heavenly love and as a result the domestication of the pigeon became more and more common in Europe. In early times white pigeons were sacred and preferred because of the symbolism it implied. Whilst the Romans respected the religious qualities of the pigeons, they did not fail to eat them in quantity and in a fattened condition (Levi, 1967).

One application of the pigeon is that of a carrier of messages. Its homing ability was discovered early and carrier pigeons were used in Egypt in Roman

times. The massages were tied to the leg or to the neck of the bird. Pigeon racing was also well recognized in Palestine about A.D.200-220 and has now been developed as a sport in Europe (Belgium) and the United States (Zeuner,1963).

According to Christopher Imborden, a one time director of the International Council for Bird Preservation (ICBP), "The economic usefulness of birds can never be the most important rationale for their conservation. They contribute importantly to the quality of life of humans and so we must learn to appreciate their value as well as their price" (Diamond and Filion,1986). Several wild bird species are already in serious jeopardy and many are becoming endangered and threatened with extinction or extirpation at an alarming rate. This is probably due to the massive assaults from a multiplicity of human agents and activities (Ezealor,1984). Frith (1982) acknowledged that pigeons and doves tend to have been neglected as a subject for ornithological research particularly in the areas of pigeon biology and aviculture which are very important when considering conservation of some threatened species. As a result, there is the need to have a good knowledge of some aspects of the biology of these species, which are constantly in contact with the human-altered environment. Such knowledge may help in the breeding of these species of Columbidae in captivity whenever they become threatened. It may also help pigeon farmers who are interested in pigeon production as a form of animal husbandry, or pigeon

fanciers who may be interested in keeping any of these columbid species as pets or cage birds for aesthetic purposes in zoos or research purposes in laboratories. A knowledge of the food habits of these columbids may prove useful to agriculturists involved in pest damage control activities in areas where any of the species has attained a pest status. Although not presently threatened with extinction or extirpation, several other species of the columbids in the area of study like Red–Billed Wood Dove (*Turtur afer*), the Black–Billed wood Dove (*Turtur abyssinicus*), and the Green fruit Pigeon (*Treron autralis*) reported by earlier workers like Elgood (1960,1977), Fry (1965, 1975), Ezenwanne (1982), Ezealor (1984) and Elgood *et al* (1994), have been reported as uncommon by recent workers like Babatunde (1994) and Nambu (1997). This is an evidence of the possible decline in the population size of these species. Urban *et al* (1986) also reported the Speckled Pigeon to be locally shot for sport which is a threat to this species. An understanding therefore of the food and feeding habits, behaviour and survivorship in captivity of the species under study will aid in their management and in their possible domestication, whenever they become victims of the ever-threatening changes in the environment.

The aim of this study is to obtain basic information on the biology of four columbid species as part of baseline information for their management and eventual domestication.

This aim will be achieved through the following objectives:-

1. To collect and identify regurgitates of wild columbids in order to investigate food niche overlap and differentiation in the four columbid species.
2. To observe and document the feeding habits of four wild columbids.
3. To determine the food habits of the columbids in captivity, through a trial-and-error approach.
4. To observe and document the behaviour of the columbids in captivity.
5. To determine the survivorship of the columbids under captive conditions, through the registration of any casualty during the study period.

CHAPTER 2

LITERATURE REVIEW

2.1 General Review

One of the most outstanding standard works on the family Columbidae is Goodwin's (1983) revision of "Pigeons and Doves of the world". The book contains valuable information on the general biology of many individual species of the family.

Frith (1982) in his text, "Pigeons and Doves of Australia," gives information on pigeon biology, aviculture, breeding biology and food preferences based on crop sample analyses. The distribution maps provided in this text also give a positive contribution to the association of these species with human activities. Frith (1982) points out that much of the habitat of pigeons and doves is threatened not only by direct destruction but also by more subtle agriculturally-related changes. He further stated that some species are subjected to indiscriminate shooting. Frith's (1982) text covers a neglected facet of ornithology and undoubtedly represents a unique and authoritative work much like that of Goodwin (1983). These are indeed standard texts on the family Columbidae.

Abs (1983) believes that many advances in the understanding of avian physiology and behaviour have resulted from studies carried out on columbid species. This has enabled experts to come out with valuable collection of papers

on various aspects of avian physiology and behaviour. Data is also provided by Abs (1983) on food preference trials, crop contents and crop milk and its constituent. His section on behaviour presents the results of many painstaking hours of observation by Goodwin (1983).

Levi (1967) in his works captioned "The Pigeon", deals with the various aspects of the family Columbidae, which include; taxonomy and nomenclature, general biology, wild species and their origin, domestication and early history, recent history, present status and future prospects. Writing on birds in the Encyclopedia Brittanica, Rand (1965), dealt concisely on the general features of the Columbidae, their adaptive radiation, distribution and abundance, importance to man, natural history, feeding and reproductive behaviour.

Urban *et al* (1986) gave detailed information, on each species of the African columbids ranging from their range and status to the breeding habits. They described the subfamily columbinae as a cosmopolitan subfamily with 165 species. This subfamily comprises of the quail doves and the bronzewings; Rock doves and Wood Pigeons of genus *Columba* with 15 species in Africa, 12 of which are endemic; Turtle doves of the genus *Streptopelia* with 11 species in Africa, including six endemics. The four columbid species under study have been described by Urban *et al* (1986). In Nigeria, they reported these species to be abundant in villages, urban areas and farmlands throughout the Guinea and Sudan Savannah and less numerous in the Sahel. Aspects of the breeding

biology of the Speckled Pigeon have

been documented by Skead (1971), Wilson and Lewis in Urban *et al* (1986) and Brooke (1984). Elgood (1960) reported the SP, RD, LD, as birds of West African town and garden.

Bannerman (1951) made a vivid description of the four columbid species under study together with their distribution in West and Equatorial Africa while Serle *et al* (1992) described their voice, distribution, habitat and nesting characteristics. The breeding of these species according to Elgood *et al* (1994) occurs in all months. Sodeine (1993) studied breeding Laughing Doves in Ijebu-ode, South West Nigeria, and found the birds to breed in all months of the year. Sharland and Wilkinson (1980) reported the SP, MD, and LD as common resident birds of suburban parks and gardens in Kano state.

2.2 Food and feeding habits of columbids

Goodwin (1983) describes the food of each of the columbid species under study as mainly seeds. He reported the natural food of the LD to consist of very small seeds of various wild and cultivated plants mentioning maize *(Zea mays)*, millet *(Pennisetum typhoides)* and wheat *(Triticum vulgare)* For the RD, he reported seeds of many kinds including cultivated grains, peanuts(*Arachis hypogea),* red pepper *(Piper nigrum)* small tubers, termites(*Termes bellicosus*) and other invertebrates. For the MD, he mentioned seeds of various weeds and cultivated plants. He reported the SP to feed largely on seeds including

cultivated grains and fond of groundnuts (*Arachis hypogea)*. Barruel (1954) reported the columbids to feed largely on seeds, fruits and berries, supplementing their food in variable quantities with insects and other invertebrates. Goodwin (1983) classified the columbids into three main categories. Those that feed mainly on the ground, those that feed on the trees in vines and shrubs and those that feed both on trees and on the ground. Those that feed entirely on the ground are extremely well adapted to grain-eating and grazing habits and some conflict with man's agricultural activities and are considered as pests (Rand, 1965). Murton (1964) acknowledged that most pigeons drink regularly at least once and usually more often each day. Their drinking habit is a unique one within the avian class as they drink by inserting the bill and sucking up a continuous draft of water.

Wilson and Lewis in Urban *et al* (1986) reported the SP Ethiopia to feed on seeds, small fruits and wild foods to include figs(*Ficus carica)* and *Tribulus* seeds. But most of the diet being cash crops at planting and harvesting seasons. The crops included wheat, *Eragrostis tef*, lentils, barley *(Hordeum vulgare)* field beans(*Pisum sativum), Sorghum* and maize.

In South Africa they also reported the SP to feed on bread and grains in markets and *Helianthus* seed as well as snails and coarse salt. In Nigeria Urban *et al* (1986) reported this species to feed on groundnuts, guinea corn (*Sorghum bicolor)* and millet. Shotter in Urban *et al* (1986) also reported SP to have the

weight of the crop content lowest (7 g) in March to April and highest (21 g) in November to January. the crop content comprised of wild seeds, groundnuts, and guinea corn. Ezenwanne (1982) also reported the SP to feed on maize, guinea corn, leaves of dicotyledonous plants and invertebrates. Urban *et al* (1986) reported the MD to feed on seeds, berries and termites. In Senegambia, they reported this species to feed on 49 seeds and fruit species while examining 1,147. In the wet season, the bird fed, on grasses and cereals mainly *Panicum laetun* and *Dactyloctenium aegyptium* as well as *Tribulus terrestris* and *Gisekia pharnacioides*. In the dry years it feeds almost exclusively on dicotyledons. Other important foods of the MD as reported by Urban *et al* (1986) include; *Colocynthis, Arachis, Vigna, Cocculus pendulus, Maytenus senegalensis, Boscia senegalensis* and *Salvadora persica*. Urban *et al* (1986) reported the RD to feed on seeds, berries like *Lantana camara*, rhizomes like *Cyperus esculentus*, flowers like *Cedrella toona* and arthropods, like termites and millipede (*Polyxenus sp)*. Smithers in Urban *et al* (1986) reported 82 birds from Zimbabwean farmland to contain *Cyperus* rhizomes, seeds of *Helianthus, Ricinus communis*, *Pennisetum typhoides*, grasses *Sorghum* and groundnuts. Rowan (1983) reported that this species usually eats only one food item at a time while reporting the species to feed on maize, *Croton*, cowpea (*Vigna unguiculata)*, groundnuts, fruits of *Trema orientalis* and Mulberry *(Morus alba)*. Urban *et al* (1986) acknowledged the food of LD to be primarily seeds of sizes

mainly <2 mm but up to whole maize grains and sunflower *(Helianthus annuus)* wheat, oats *(Avena sativa) Sorghum,* millet, *Croton, Colosia, Amarathus spinosus, Oxalis, Rhus, Polygala, Acacia* and legumes, *Poa-annua* in Barberspan in South Africa. In Botswana, they reported the species to eat mainly herb and grass seeds from August to September and December to January particularly *Eleusine indica*, and cereals for the rest of the year with *Sorghum* making up to 70% of the food by weight. Rowan (1983) also reported the LD to eat salt, nectar of Aloe, fruits of *Securinega, Atriplex, Salvadora, Ficus*, pawpaw *(Carica papaya),* olive *(Olea europaea)* succulent stem of *Acacia cyclops*, termites particularly *Hodotermes mossambicus*, ants, fly larvae and pupae(Lepidopterans) and snails(Mollucs). Morel and Morel (1972) reported the species to eat 96 species of seeds and fruits while examining 1,214 birds in North Senegambia. The food items reported included *Panicum laetum, Gisekia pharnacioides, Tribulus terrestris, colocynthis, Arachis, Zornia glochidiata, Vigna* and *Pennisetum.* Ezenwanne (1982) reported maize, *Sorghum bicolor, Pennisetum typhoides*, dicotyledon leaves and invertebrates as food items for this species.

Lint and lint (1981) recommended seeds as part of the diet for pigeons in captivity.

Reports made by Morris (1955), Gilliard (1958), Brown (1969) and Gill (1989) showed that differences in external morphology such as body and bill sizes of the columbids may have led to inter- and intra-specific variation in seed

size preferences and handling cost and may reveal a profusion of subtled differences between closely related species in individuals and age groups.

Helesic (1981) studied the feeding ecology of *Streptopelia decaocto*, (Collared Dove) in which two hundred and seventy one doves were shot while roosting in Brno, a town in former Czechoslavakia, in order to study their diet. He reported the stomachs of the birds to contain a lower diversity of food types than the crops. The male and female diets did not differ but he observed that differences between roosting sites occurred as a result of variation in food availability. Food preferences and average daily consumption rates were determined experimentally. Frith *et al* (1976) also described the foods of eight species of columbids to be mainly or entirely seeds.

Bock (1966) and Fisher (1972) believe that seed preference also depends on the developmental stage of the birds. This is because birds which are molting or breeding may prefer certain seeds than others, because of their nutritional requirements during breeding. Other factors of the seed, which they think may determine preference, are the energy content or nutritional composition of the seeds, seed size, handling cost of seed, the potential metabolic energy and the oxygen or energy consumption in obtaining the food.

Frith *et al* (1974) reported the diet of the Pigeon *Ocyphaps loptes* to comprise of 5–85% seeds, 5–13% green leaves and 0.7% animate food while common Bronzewing, *Phaps chalcoptera* ate primarily seeds (98.8%).

A study of the Eared Dove, *Zenaida auriculata* in an area of arable cultivation interspersed with secondary thorn scrub near Cordoba, Argentina was carried out by Murton *et al* (1974). Analysing the crop contents and the nestling diets, they showed that the bird's main diet by weight (85%) was composed of cultivated seeds, particularly *sorghum,* wheat and millet.

Feeding on these crops probably made them agricultural pests. A detailed consideration of the ecology of a dockland population of feral pigeons by Murton *et al* (1972) reported that the birds depended on grain spillage for food and lived in a habitat of little seasonal variation.

Brown (1969) reported that, when given a choice of seeds, individuals of *C. livia* showed wide difference in preferences. These preferences were stable on the short term, but changed during the course of several months. Increased quantities of seeds given led to an increased intake, but no change in the proportion of different seeds taken.

Beck (1969) showed that krill *Euphausia superba* is by far the most important food of cape Pigeon using regurgitated food samples and direct observation at Signy Island, South Orkney.

Haverschmidt (1969) acknowledged having seen the *Zenaida* Doves feeding on waste grains.

Tollefson (1969) reported that, knowledge of the dietary requirements of many species of birds including the columbids can be based on observation of

their feeding habits in the wild, examination of the crop and gizzard contents and also through a trial-and -error approach to feeding in captivity. The availability of food according to Tollefson (1969) seems to be an important factor that determines a birds diet in the wild and within limits a bird may eat only what is readily available. Lafeber (1965) on the other hand suggested three other factors that may influence a bird's choice of food. These included; habit, appearance and personality. Litvaitis *et al* (1994) described three techniques for investigating food habits of wildlife. These include; the observational technique where animals are observed ingesting food, feeding site surveys and post ingestion samples technique where the remains of food in the gastrointestinal tracts, faeces or regurgitated materials are identified. Prys-Jones *et al* (1985), Tomback (1975) and Ezealor (1995) have also described how the crop contents of birds can be collected by the use of emetic which is administered to live birds. The regurgitated food items can then be obtained and sorted out.

2.3 Behaviour of the Columbids

Goodwin (1954, 1956, 1983) gives an elaborate description of the general behaviours of members of the family Columbidae in his text, "Pigeons and Doves of the world". He described each behaviour specifically giving the situation under which such behaviour is manifested both in the wild as well as in captivity for some captive species. He also highlights the functional need each of such behavioural attributes is geared to accomplish making relevant and

available references to each of the aspects treated by other authors for some of the species. These behaviours include the following.

Vocalization: which are in the form of cooing calls and there are five basic calls; the advertising coos, also called the song or territorial coo; the display or bowing coo; the distress call; the excitement cry and the nest call.

Displays and social behaviours which include aggressive or threat displays; bowing displays, display flights,

mutual nibbling display; parading and jumping; nodding, allo-preening or caressing; allo-feeding or billing, driving, interference with copulation and species recognition.

Feeding and foraging behaviours, involving food handling cost and "testing", foraging habit, flock feeding, and drinking habit. Maintenance preening and other behaviours which include, ritual preening or displacement preening, comfort and discomfort movements, bathing behaviour which involves sun and rain-bathing; head-shaking and scratching and head-bobbing.

In this treatment, Goodwin (1983) tries to examine Tinbergen's (1958) four questions about why animals behave in certain ways.

Goodwin (1983) describes what causes each behaviour, how each behaviour has evolved and developed and what its adaptive significance or function is. In a nutshell, he discusses the causes and effects of each behavioural attribute. Urban *et al* (1986), Rand (1965) and Babatunde (1994) also described some of

these behaviours when discussing the breeding habit and behaviour of the Columbidae in general and for some species specifically.

2.4 Survivorship Of Captive Columbids

Survivorship in captivity is the ability of an organism to strive or continue to exist and live its normal life under captive conditions inspite of the change from its natural environment. In a study of savanna birds in captivity in Zaria, Zinze (1983) observed that columbids had the highest longevity. His reason for this was that the columbids were easy to feed in captivity particularly as they feed mostly on seeds. Furthermore, their food could be kept for longer periods without going bad. The RD survived for 133 days and Black-billed wood Doves *(Turtur abyssinicus)* for 99 days, before the experiment was terminated. The columbids are believed to survive in captivity if well fed and catered for health-wise. This was the basis of their early domestication during the neolithic times for several purposes besides food (Zeuner, 1963).

2.5 Niche overlap and differentiation in birds

The niche of an organism has been described as the sum total of its role in its environment (Odum, 1971).

A famous Russian biologist, Gause, demonstrated that no two organisms can occupy the same niche. This has become known as the competitive exclusion principle or Gause's principle (Odum, 1971). Although the subjects of competition, niche separation, and differentiation have been investigated in some

bird species (Klopfer and MacArthur, 1961; Schoener, 1965, 1968; Klopfer, 1973; Kreb and Davies, 1979; Hutchinson, 1987; Ulfvens, 1987); Monda and Ratti, 1988), there is not to my knowledge any specific studies of these subjects as they relate to columbids of the Afrotropical savanna. This further justifies the need for the current study.

CHAPTER 3

MATERIALS AND METHODS

3.1. Study Area

The study was carried out on the Ahmadu Bello University Main campus, Samaru and its environs in Zaria.

Zaria is located on a plain at a latitude of 11°03'N and 7°42'E in the Kaduna state of Northern Nigeria. Zaria area falls within the Northern Guinea savanna belt and consists of open woodland, penetrable even in the wet season (Keay, 1959). The vegetation is more open in the dry season when grasses have dried up. Zaria experiences two seasons. The dry season which last for a period of four to six months starting from November to April and the rainy season which last for about seven months starting from May to October (Hore, 1970).

The annual rainfall is approximately between 100 to 114 cm^3. the average daily temperature is 36.6°C around April and in August, it falls to 23.3°C. The hottest month is April and the coldest is August (Anon, 1981). The relative humidity ranges from 70-80% in August to about 15-20% in December. The Zaria area measures about 293, 040 sqm (Anon, 1981). According to Fry (1966), the Zaria area consists of ten major fauna or ecological associations.

The Ahmadu Bello University main campus and its environs lies within the Zaria area and is considered to fall under the Sub-Urban type of fauna or ecological association (Fry, 1966).

The natural vegetation of the campus is typically that of the Northern Guinea savanna and is composed of shrubs, herbs, grasses and sparsely spaced trees. There are randomly located farmlands in the campus. There are also a good number of tall buildings surrounded by trees. The dominant trees within the campus include *Mangifera indica, Gmelina sp, Delonix regia, Azadirachta indica, Eucalyptus citriodor, Albezi lebec, Khaya senegalensis, Spathodea campanulata, Piostigma sp, Pisidium guajava* and *Carica papaya.*

Some of these trees serve as nesting, roosting, resting and feeding sites for the columbid species under study. The campus covers an area of about 12,000 sqm and is bounded in the south and west by an open countryside with small villages and in the south-east by an extensive water reservoir(Dam) (Keay, 1959). The open valley floor of the Kubani river system which flows across the southern part of the campus is cultivated as well as are the adjacent uplands providing feeding grounds for these columbid species.

The study comprised of two parts. The first phase involved the trapping of birds in the wild, the collection and identification of their regurgitates and the observation and documentation of feed habits of wild columbids.

The second phase involved the determination of food habits in captivity, observation and documentation of the behaviour and survivorship of the birds under captive conditions for 72 days.

3.2 **Trapping of birds**

The four species of columbids under study were captured using locally made live-bait traps. Locally made string and wire traps were also used.

3.2.1 **Live-bait traps**

The live-bait traps consisted of a cage made of bamboo and wire gauze, with five cells; a middle cell and four other cells at the ends. In the middle cell, was placed a live bird of the species to be captured together with food bait, such as guinea corn. The other four cells at the ends were also baited with guinea corn. The trap was constructed such that at the entrance of each of the four cells at the ends, were placed levers to which were attached triggers tied to the doors of the cells by means of strings. A rubber string was tied from each door of a cell to the top of the trap. The rubber string became tensed when the door was opened for the trap to be to be set. The trap was set by inserting the trigger into a hole created at one end of the lever at the entrance of the cell. When a bird stepped on the lever, in an attempt to reach the live bird or food bait in the middle cell, the door closed keeping the bird inside and the trapper quickly rushed to the trap to remove the bird from it into a portable cage. The floor of the trap was constructed such that the grains or food bait did not fall out. This trap was constructed purposely for the LD even though some RD and MD were captured using it.

3.2.2 String and Wire traps

These traps comprised of a series of wires to which were attached several strings. The ends of the wires were pointed and could easily be pushed firmly into the ground where the birds normally came to drink or feed. In setting the trap, the strings attached to the wires were opened and spread out at about 180 above the ground. The strings entangled the feet of the birds in their course of drinking or feeding, as they walked into them. Trapped birds were removed by the trapper and put into a carrying cage. Trapping was done mostly between the hours of 8-10 a.m. and 4-6 p.m. when the birds were most active as recommended by Hickery (1943), particularly during good weather since weather seems to affect most aspects of bird life and activities (Elkins, 1983).

3.3 Collection of regurgitates

As soon as a bird was caught, a dose of an emetic called "Ipecac" (short for Ipecacuanha, *Cephaelis ipecacuanha)* was administered to it. This is a chemical, which causes the bird to regurgitate (Prys-Jones *et al.,* 1985 and Tomback, 1975). The administration of the ipecac was carried out by means of a 5 ml plastic dropper. A narrow tube at the end of the dropper was inserted into the mouth of the bird above its tongue. With the beaks held open, the tube was pushed down gently through the oesophagus to the crop of the bird. When the tube got to the crop, the emetic was squeezed slowly into the crop (Figure 5). After the administration of the emetic, the bird was placed in a dark

cardboard box with the floor lined with absorbent paper to absorb any liquid present in the regurgitated sample. Through trial doses of the emetic, it was observed that about 3 ml of emetic induced regurgitation in the LD, 4 ml in RD and MD and 5 ml in SP. After about 30-45 minutes, the bird regurgitated its crop content and there after released back into the wild. Any bird that failed to regurgitate after 45 minutes was released immediately and any bird that regurgitated, was only released after about 15–20 minutes later. This was to enable it recover after regurgitation before being released back into the wild. Twenty of the birds, five of each species, were however kept for the captive feeding experiment. Any regurgitated food material was collected and stored in 5% fomalin in specimen bottles and taken to the laboratory for identification and analyses.



Figure 5: Administration of the Emetic to wild Birds

3.3.1 **Analyses of Regurgitates**

Each regurgitate was poured into a petri dish and its various food items sorted out. Identification was done by:

i Visual observation: With the aid of a dissecting microscope, those food items, which could be identified visually, were quantified and recorded.

ii Germination: some of the food items especially the weed and grass seeds that could not be identified were sown in pots and watered daily to enable them germinate for possible identification.

iii Feeding Site Survey; some of the food items were identified based on the area in which the bird was caught. A survey of the seed plants was made particularly around the immediate vicinity of catch. The seeds were then compared with those present in the regurgitates for possible identification. This was particularly done for tree seeds.

iv Photography: Food items, which could not be identified by any of these means were photographed.

Identification of seeds was done with the aid of the herbarium specimens of the Department of Biological Sciences and Department of Plant Science, Ahmadu Bello University, Zaria.

Some of the regurgitates made up entirely of a single food item were weighed using a balance sensitive to 0.01 g.

3.4 Feeding habits of wild columbids

This was done through regular field visits with the aid of a 8X 30 binocular and by direct viewing to observe the birds as they fed in the wild. The visits were made in the morning between 8–10 a.m. and in evening between 4–6 p.m. Observation and documentation was made of where, when and how the birds fed. Field visits were made around the study area.

3.5 Housing and Acclimatization of the birds

Twenty birds, five of each species were used for the second part of the study. These birds were housed in an aviary measuring 7.5 x 6 x 6.5 m. The birds were acclimatized for a period of one week before the start of the experiment.

3.6 Determination of Food Habits In Captivity

This was done by a trial-and-error approach to feeding of the birds in captivity, using six selected seeds. Birds were fed in mixed specific and conspecific groups.

3.6.1 Polyspecific group feeding (PSGF)

All the twenty birds of the four species of columbids were fed together for a period of 36 days and were monitored as described by Brown (1969). The birds were presented with the following seeds; Guinea corn (*Sorghum bicolor*), Millet (*Pennisetum typhoides*), Maize (*Zea mays*), Cowpea (*Vigna unguiculata*), seeds of *Amaranthus spinosus and Spathodea campanulata*. The six different

seeds were given to the birds one after the other for six suceessive days for a period of 36 days (Table 1). Two hundred grammes of each seed type was presented to the birds during each experimental feeding time. The seeds were placed in plastic bowls and then placed on widely spread nylon paper to take care of any spillage of seeds. Any spilled seeds were collected and added to the left-over after each feeding time before reweighing. The birds were fed twice a day between the hours of 8.00 to 12.00 a.m. in the morning and 2.00 to 6.00 p.m. in the evening. The left-over of each seed type presented was collected after the feeding period and reweighed at the end of each feeding time and then subtracted from what was initially presented to the birds

(200 g) to obtain the quantity of food consumed by the birds. The calculations were carried out as follows:

Amount of food consumed in grammes = Amount presented – Amount left-over.

$$\text{Percentage consumption} = \frac{\text{Amount of food consumed}}{\text{Amount of food presented}} \times 100$$

$$U + X = 200 \quad \ldots\ldots\ldots\ldots\ldots\ldots (i)$$

$$U = 200 - X \quad \ldots\ldots\ldots\ldots\ldots\ldots (ii)$$

$$\%U = \frac{U}{200} \times 100 = \frac{U}{2} \quad \ldots\ldots\ldots\ldots\ldots\ldots (iii)$$

$$U = 2U\% \quad \ldots\ldots\ldots\ldots\ldots\ldots (iv)$$

A = Amount presented
U = Amount consumed
%U = Percentage consumed
%A = Percentage presented

X = Amount of left-over

3.6.2 **Monospecific feeding**

The birds after the 36 days period of PSGF were separated by species into four different compartments of the aviary measuring 1.9x1.5x1.6 m and were also fed for a period of 36 days. The same procedure used for the PSGF was followed. Each species was presented with 50 g of seed during each experimental feeding time.

Table 1. Feeding schedule of the columbids in captivity

Period / Days	Feeding period and seed type					
	1	2	3	4	5	6
1	MZ	GC	ML	CP	AS	SS
2	GC	ML	CP	AS	SS	MZ
3	ML	CP	AS	SS	MZ	GC
4	CP	AS	SS	MZ	GC	ML
5	AS	SS	MZ	GC	ML	CP
6	SS	MZ	GC	ML	CP	AS

MZ = Maize CP = Cowpea

GC = Guinea corn AS = *Amaranthus seed.*

ML = Millet SS = *Spathodea seed.*

3.7 **Documentation of Behaviour of the Captive Columbids**

The behaviours of the birds in captivity were closely observed from a distance of about 2 m outside the aviary from a shed close to the aviary as described by Armstrong (1947). The observed behaviours were classified into four major types according to Glenn (1985).

i Foraging behaviour mostly concerned with feeding.

ii Social interaction involving courtship behaviour, territorial display and agonistic encounters.

iii Vocalizations, including songs and calls.

iv Maintenance preening and other behaviours in flight or resting

Such observations were done during very good weather since weather seems to affect the activity and behaviour of birds (Elkins, 1983). Although observations were made on a daily basis as recommended by Goodwin (1983) and Abs (1983), a good number of it was incidental.

3.8 **Survivorship of the Captive Columbids**

The survivorship of the twenty birds kept in captivity was observed by noting any death, ill health or ill conditions. Any sick bird was taken to the Ahmadu Bello University Veterinary Teaching Hospital for diagnosis and treatment. Any dead bird was also taken there for post–morten examination.

3.9 Data Analysis

The analysis of variance (ANOVA) was the statistical tool used to compare the total consumption versus each seed type, each feeding period (weeks) and each bird species for monospecific feeding and total consumption versus each seed type, and each feeding period (weeks) for all the four species fed together.

To calculate the percentage Niche overlap and differentiation, the formula below was used:

$$\frac{X}{48} \times 100 = Y\%$$

X = Number of food items overlapping or differentiating.

48 = Total number of food items observed in the study.

Y% = Percentage niche overlap or differentiation.

Calculation involving average daily consumptions, were carried out by the use of simple proportion.

For example: Total amount of food consumed by 5 birds over 36 days = 1595.6g

Total amount consumed by 1 bird over 36 days = $\frac{1595.6}{5}$

= 319.1 g.

Total amount consumed by 1 bird for 1 day = $\frac{319.1}{36}$ = 8.9 g/day

CHAPTER 4

RESULTS

4.1 Crop Contents of the Columbids

A total of 154 regurgitates were collected from 88 (57%) LDs, 20 (13%) from RDs, 21 (14%) from MDs and 25 (16%) from SPs. The food items recovered from the regurgitates of the columbids are presented in Table 2 and Figures 6-13.

Table 2. Food items observed in regurgitates of wild columbids, from May 1998 to Febuary 1999

S/No	Food items	Laughing Dove	Red-eyed Dove	Mourning Dove	Speckled Pigeon
	Cultivated seeds				
1	Guinea corn	+	+	+	+
2	*Unhusked rice*	+	+	+	+
3	Maize	+	+	+	+
4	Millet	+	+	+	+
5	Groundnut	+	+	+	+
6	Cowpea	+	+	+	+
7	Soya beans	+	+	+	+
8	Melon seed	+	+	+	-
9	Okra seed	+	-	-	+
10	Spathodea seed	+	-	-	+
11	Germinating cowpea	-	-	+	-
12	Amaranthus seed	+	+	+	-
13	Pepper seed	+	+	-	-
14	Tomato seed	+	+	-	-
	Wild seeds				
15	*Brachiaria seed*	+	+	+	+
16	Setaria seed	+	+	+	+
17	Panicum seed	+	-	-	+
18	Sporobolus seed	+	-	-	-
19	Commelina seed	+	-	-	-
20	Cassia seed	+	-	-	-
21	Crotolaria seed	+	-	-	-
22	*Wild pea seed*	+	+	+	+
23	Luffa seed	+	-	-	+
24	Unidentified (1)	-	-	-	+
25	Cassia seed	+	-	-	+
26	Unidentified (2)	+	+	-	-
27	Unidentified (3)	-	-	-	+

28	Unidentified)4)	-	-	+	-
29	Indigofera seed	-	-	+	+
30	Calopogonium seed	+	+	+	+
31	Monechma seed	-	-	-	+
32	Corchurus seed	+	-	-	+
33	Hibiscus seed	-	+	-	+
34	Unidentified(5)	-	+	-	+
35	Unidentified(6)	+	-	-	-
36	Unidentified leaves	+	+	+	+
	Tree seeds				
37	Eucalyptus seed	+	-	-	+
38	Neem seed	+	-	-	-
39	Guava seed	+	-	-	-
40	Pawpaw seed	+	-	-	-
	Animal matter				
41	Lepidopteran larvae	-	+	-	-
42	Termites	+	+	+	+
43	Earthworms	+	+	-	+
44	Millipedes	+	+	-	-
45	Unidentified insects parts	+	+	+	+
	Miscellaneous food items				
46	Dehusked rice	+	-	-	+
47	Beni seed	+	-	-	-
48	Sand and grit particles	+	+	+	+

+ = Food item observed

– = Food item not observed

The LDs had a variety of food items in their regurgitates ranging from cultivated seeds to unidentified food items. Most of the unidentified food items came from the regurgitates of the LDs.

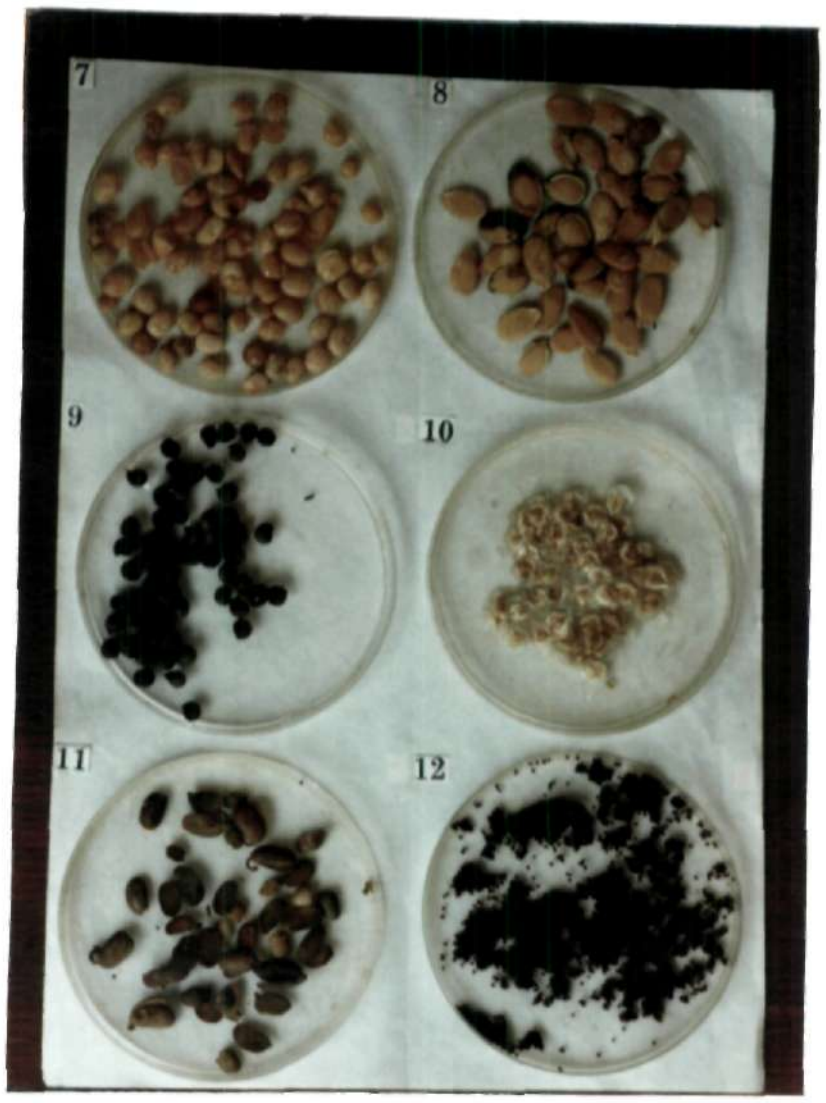
It was also observed that some of the regurgitates from the RDs usually contain a single food item. for example, two of the regurgitates collected were made up of Lepidopteran larvae weighing 3.2 g and 2.1 g respectively, two others entirely of termites weighing 3.2 g and 2.9 g respectively, one entirely of earthworms weighing 2.5 g and one of millipedes weighing

1.1 g. Some of the regurgitates from this species had a maximum of three food items with at least one predominating. Regurgitates of the MDs had a variety of food items. The SPs had regurgitates also with a variety of food items, mostly large seeds such as cowpea, maize, groundnut and unhusked rice.



1. *Sorghum bicolor* (Guinea corn)
2. *Oryza sativa* (Unhusked rice)
3. *Zea mays* (Maize)
4. *Pennisetum typhoides* (Millet)
5. *Arachis hypogea* (Groundnut)
6. *Vigna unguiculata* (Cowpea)

Figure 6: Food items from regurgitates of wild columbids



7. *Glycine max* (Soya beans)
8. *Cucumis melo* (Melon seed)
9. *Hibiscus esculentus* (Okra seed)
10. *Spathodea campanulata* (Spathodea seed)
11. *Vigna unguiculata* (Germinating Cowpea)
12. *Amaranthus spinosus* (Amaranthus seed)

Figure 7: Food items from regurgitates of wild columbids



13. *Capsium annum* (Pepper seed)

14. *Lycopersicum esculentum* (Tomato seed)

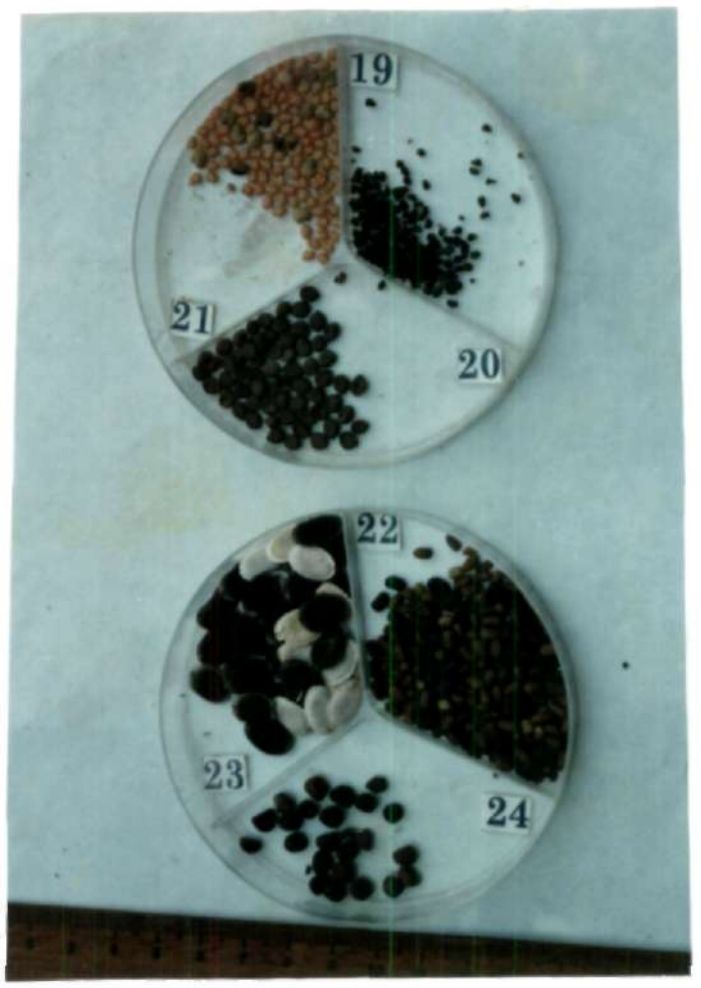
15. *Brachiaria lata* (Brachiaria seed)

16. *Setaria sp.* (Setaria seed)

17. *Panicum phragmitoides* (Panicum seed)

18. *Sporobolus pyramidalis* (Sporobolus seed)

Figure 8: Food items from regurgitates of wild columbids



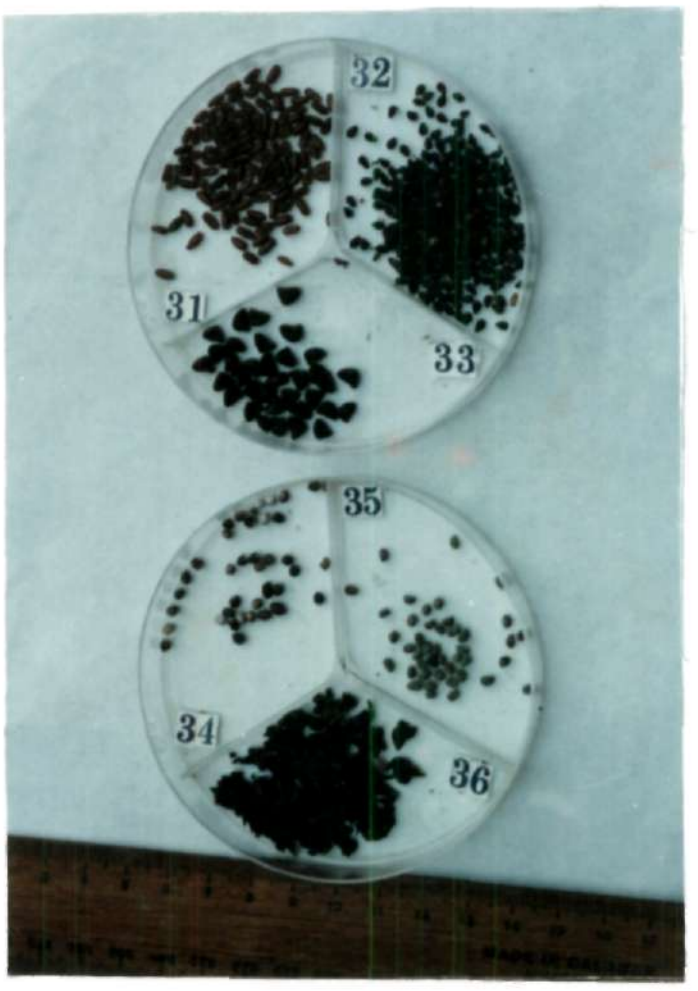
19. *Commelina sp.* (Commelina seed)
20. *Cassia occidentalis* (Cassia seed)
21. *Crotolaria sp.* (Crotolaria seed)
22. *Vigna reticulata* (Wild pea seed)
23. *Luffa aegyptica* (Luffa seed)
24. Unidentified seed(1)

Figure 9: Food items from regurgitates of wild columbids



25. *Cassia tora* (Cassia seed)
26. Unidentified seed(2)
27. Unidentified(3)
28. Unidentified seed(4)
29. *Indigofera arrecta* (Indigofer seed)
30. *Calopogonium mucunoides* (Calopogonium seed)

Figure 10: Food items from regurgitates of wild columbids



31. *Monechma cilliata* (Monechma seed)
32. *Corchurus oleitorius* (Corchurus seed)
33. *Hibiscus suratensis* (Hibiscus seed)
34. Unidentified seed(5)
35. Unidentified seed(6)
36. Unidentified leaves

Figure 11: Food items from regurgitates of wild columbids



37. *Eucalyptus citriodora* (Eucalyptus seed)
38. *Azadirachta indica* (Neem seed)
39. *Pisidium guajava* (Guava seed)
40. *Carica papaya* (Pawpaw seed)
41. *Papilio sp.* (Lepidopteran larvae)
42. *Termes bellicosus* (Termites)

Figure 12: Food items from regurgitates of wild columbids



43. *Lumbricus terrestris* (Earth worms)
44. *Polyxenus sp.* (Millipedes)
45. Unidentified insect parts
46. *Oryza sativa* (Dehusked rice)
47. Beni seed (Achia)
48. Sand and grit particles

Figure 13: Food items from regurgitates of wild columbids

4.1.1 Commonalities and differences in the food habits of the four columbid species adapted from table 2.

Table 3 is a set notation illustrating the food items observed in the regurgitates of the wild columbids, from which Figure 14 a diagramatic illustration of niche overlap and differentiation in food habits of the four sympatric columbid species in derived.

Table 3. Set Notations for food items observed in the regurgitates of wild Columbids.

U = {1,. . . . . 48, ... ? }

LD = {1,2,3,4,5,6,7,8,9,10,12,13,14,15,16,17,
18,19,20,21,22,23,25,26,30,32,35,36,37,
38, 39,40,42,43,45,46,47,48,} = 38

RD = { 1,2,3,4,5,6,7,8,12,13,14,15,16,22,26,30,
33,34,36,41,42,43,44,45,48,} = 25

MD = {1,2,3,4,5,6,7,8,11,12,15,16,22,28,29,30,
36,42,45,48,} = 20

SP = { 1,2,3,4,5,6,7,9,10,15,16,17,22,23,24,25,
27,29,30,31,32,33,34,36,37,42,43,45,46,
48} = 30

A = LDnRDnMDnSP = {1,2,3,4,5,6,7,15,16,22,30,36,42,
45,48,} = 15

B = LDnRDnMD only = {8,12} = 2

C = LDnRDnSP only = {43} =1

D* = LDnMDnSP only = {Ø} = 0

E = RDnMDnSP only = {Ø} = 0

F = LDnRD only = {13,14,26,} = 3

G* = LDnMD only = {Ø} =0

H = LDnSP only = {9,10,17,23,25,32,27,46,} = 8

I = RDnMD only = {Ø} = 0

J = RDnSP only = {33,34,} = 2

K = MDnSP only = {29} =1

L = LDn (RDuMDuSP)' = {18,19,20,21,35,38,39,
40,47} = 9

M = RDn (LDuMDuSP) = {41,44} = 2

N = MDn (LDuRDuSP) = {11,28,} = 2

O = SPn (LDuRDuMD) = {24,27,31} = 3

P = (LDuRDuMDuSP) =?

* = Not represented on Figure 14.

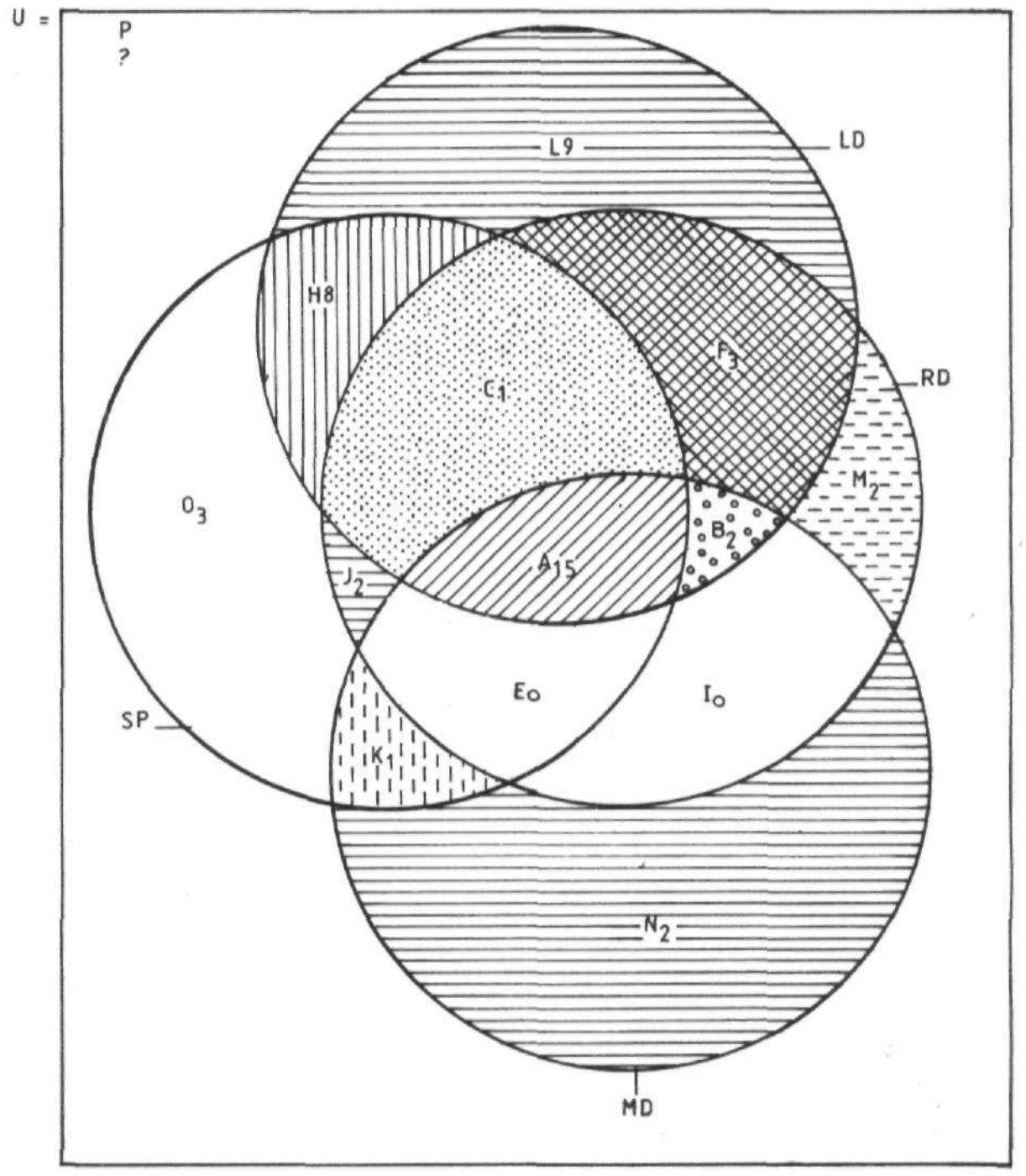


Figure 14: Venn diagram of niche overlap and differentiation in food habits of the four sympatric columbid species

KEY TO FIGURE 14

U = Universal set of the 48 food items observed in regurgitates of the four columbid species, including other food items present in the enviroment on which the birds may probably fed but were not observed in the regurgitates of the sampled birds

? = Food items present in the environment on which the birds may probably feed and not observed in the regurgitates of the sampled birds.

LD = Set of food items observed in the regurgitates of LDs.

RD = Set of food items observed in the regurgitates of RDs.

MD = Set of food items observed in the regurgitates of MDs.

SP = Set of food items observed in the regurgitates of SPs.

A = Food items common to all four species.

B = Food items common to LD, RD, and MD only.

C = Food items common to LD, RD, and SP only.

E = Food items common to RD, MD and SP only.

F = Food items common to LD, and RD only.

H = Food items common to LD and SP only.

I = Food items common to RD and MD only.

J = Food items common to RD and SP only.

K = Food items common to MD and SP only.

L = Food items common to LD only.

M = Food items common to RD only.

N = Food items common to MD only.

O = Food items common to SP only.

P = Food items not observed in the regurgitates of any of the four species but which may be present in the environment and on which the birds may feed.

Figure 14 shows a niche overlap of 31.3% for all the four species of birds; 4.2% for LD, RD and MD; 2.1% for LD, RD and SP; 0.0% for LD, MD and SP, 0.0% for RD, MD and SP; 6.3% for LD and RD; 0.0% for LD and MD; 16.7% for LD and SP; 0.0% for RD and MD; 4.2% for RD and SP; 2.1% for MD and SP. The diagram also shows a niche differentiation of 18.8% for LD; 4.2% for RD; 4.2% for MD and 6.3% for SP. This gives a total niche differentiation of 33.5%.

4.1.2 **Seasonal Variation in Food Habits of the Wild Columbids**

Table 4 gives the percentage frequency of occurrence of food items observed in the regurgitates of wild columbids during the wet and dry seasons.

Table 4. Percentage frequency of occurence of food items observed in regurgitates of wild columbids in the wet and dry seasons in Zaria (May, 1998-February, 1999).

		Percentage frequency of occurrence										
		Wet season(n=84)					Dry season(n=70)					
S/No	Food items	LD	RD	MD	SP	TOTAL	LD	RD	MD	SP	TOTAL	TOTAL (%)
		n=52	*n=12*	*n=10*	*n=10*	*n=84*	*n=36*	*n=8*	*n=11*	*n=15*	*n=70*	*n=154*
1	*Guinea corn*	*96.2*	*66/7*	*70/0*	*90.0*	*80.7*	*94.4*	*75.0*	*81.8*	*86.7*	*84.5*	*82.6*
2	*Unhusked rice*	*92.3*	*58.3*	*60.0*	*70.0*	*70.2*	*91.7*	*75.0*	*72.7*	*93.3*	*83.2*	*76.7*
3	Maize	*80.8*	*66.7*	*70.0*	*90.0*	*76.9*	*86.1*	*62.5*	*72.7*	*80.0*	*75.3*	*76.1*
4	Cowpea	*36.5*	*33.3*	*50.0*	*60.0*	*45.0*	*83.3*	*75.0*	*72.7*	*66.7*	*74.3*	*59.7*
5	Wild pea seeds	*28.8*	*25.0*	*60.0*	*70.0*	*46.0*	*80.6*	*62.5*	*63.6*	*73.3*	*70.0*	*58.0*
6	Brachiaria Seeds	*34.6*	*50.0*	*40.0*	*40.0*	*41.2*	*91.7*	*62.5*	*63.6*	*80.0*	*74.5*	*57.9*
7	Millet seeds	*57.7*	*41.7*	*70.0*	*60.0*	*57.4*	*55.6*	*50.0*	*63.6*	*53.3*	*55.6*	*56.5*
8	Groundnut	*50.0*	*41.7*	*40.0*	*80.0*	*52.9*	*52.8*	*50.0*	*45.5*	*73.3*	*55.4*	*54.2*
9	Soya beans	*25.0*	*33.3*	*20.0*	*50.0*	*32.1*	*80.6*	*50.0*	*54.5*	*60.0*	*61.3*	*46.7*
10	Setaria seeds	*19.2*	*33.3*	*30.0*	*40.0*	*30.6*	*47.2*	*37.5*	*45.5*	*53.3*	*45.9*	*38.3*
11	Amaranthus seeds	*67.3*	*58.3*	*60.0*	*00.0*	*46.4*	*33.3*	*50.0*	*36.4*	*00.0*	*29.9*	*38.2*
12	Unidentified leaves	*30.8*	*16.7*	*30.0*	*60.0*	*34.4*	*19.4*	*25.0*	*18.2*	*53.3*	*29.0*	*31.7*
13	Sand and grit particles	*23.1*	*25.0*	*20.0*	*40.0*	*27.0*	*22.2*	*37.5*	*27.3*	*26.7*	*28.4*	*27.7*
14	Unidentified insect parts	*07.7*	*33.3*	*30.0*	*60.0*	*32.8*	*05.5*	*37.5*	*00.0*	*13.3*	*14.1*	*23.5*
15	Eucalyptus tree seeds	*59.6*	*00.0*	*00.0*	*50.0*	*27.4*	*25.0*	*00.0*	*00.0*	*46.7*	*17.9*	*22.7*
16	*Melon seeds*	*30.8*	*33.3*	*50.0*	*00.0*	*28.5*	*11.1*	*12.5*	*09.1*	*00.0*	*08.2*	*18.4*
17	*Panicum seeds*	*17.3*	*00.0*	*00.0*	*30.0*	*11.8*	*52.8*	*00.0*	*00.0*	*40.0*	*23.2*	*17.5*
18	*Spathodea tree* seeds	*55.8*	*00.0*	*00.0*	*40.0*	*24.0*	*16.7*	*00.0*	*00.0*	*20.0*	*09.2*	*16.6*
19	Dehusked rice	*36.0*	*00.0*	*00.0*	*40.0*	*19.1*	*16.7*	*00.0*	*00.0*	*33.3*	*12.5*	*15.8*
20	Termites	*07.7*	*33.3*	*30.0*	*10.0*	*20.3*	*00.0*	*00.0*	*00.0*	*00.0*	*00.0*	*10.2*
21	Calopogonium seeds	*00.0*	*00.0*	*00.0*	*00.0*	*00.0*	*22.2*	*12.5*	*09.1*	*26.7*	*17.6*	*08.8*

22	Tomato seeds	21.2	16.7	00.0	00.0	09.5	27.8	00.0	00.0	00.0	07.0	08.3
23	Unidentified seeds(1)	00.0	00.0	00.0	20.0	05.0	00.0	00.0	00.0	40.0	10.0	07.5
24	Unidentified seeds(3)	00.0	00.0	00.0	20.0	05.0	00.0	00.0	00.0	33.3	08.3	06.7
25	Luffa seeds	00.0	00.0	00.0	10.0	02.5	08.3	00.0	00.0	33.3	10.4	06.5
26	Okra seeds	05.8	00.0	00.0	10.0	04.0	13.9	00.0	00.0	20.0	08.5	06.3
27	Earthworms	07.7	16.7	00.0	20.0	11.1	00.0	00.0	00.0	00.0	00.0	05.6
28	Cassia tora seeds	01.9	00.0	00.0	20.0	05.5	08.3	00.0	00.0	13.3	05.4	05.5
29	Germinating cowpea	00.0	00.0	40.0	00.0	10.0	00.0	00.0	00.0	00.0	00.0	05.0
30	Indigofera seeds	00.0	00.0	10.0	00.0	02.5	00.0	00.0	18.2	20.0	09.6	04.8
31	Unidentified seeds(4)	00.0	00.0	10.0	00.0	02.5	00.0	00.0	27.3	00.0	06.8	04.7
32	Unidentidied seeds(2)	00.0	00.0	00.0	00.0	00.0	11.1	25.0	00.0	00.0	09.0	04.5
33	Unidentified seeds(5)	00.0	00.0	00.0	00.0	00.0	00.0	25.0	00.0	06.7	07.9	03.9
34	Cassia occidentalis seeds	05.8	00.0	00.0	00.0	11.5	22.5	00.0	00.0	00.0	05.6	03.6
35	Hibiscus seeds	00.0	00.0	00.0	00.0	00.0	00.0	12.5	00.0	13.3	06.5	03.3
36	Sporobolus seeds	15.4	00.0	00.0	00.0	03.9	05.5	00.0	00.0	00.0	01.4	02.7
37	Crotolaria seeds	01.9	00.0	00.0	00.0	00.5	16.7	00.0	00.0	00.0	04.2	02.4
38	Neem tree seeds	17.3	00.0	00.0	00.0	04.3	00.0	00.0	00.0	00.0	00.0	02.2
39	Lepidopteran larvae	00.0	16.7	00.0	00.0	04.2	00.0	00.0	00.0	00.0	00.0	02.1
40	Commelina seeds	05.8	00.0	00.0	00.0	01.5	25.0	00.0	00.0	00.0	02.3	01.9
41	Corchurus seeds	00.0	00.0	00.0	00.0	00.0	08.3	00.0	00.0	06.7	03.8	01.9
42	Monechma seeds	00.0	00.0	00.0	00.0	00.0	00.0	00.0	00.0	13.3	03.3	01.7
43	Pepper seeds	01.9	08.3	00.0	00.0	02.6	02.8	00.0	00.0	00.0	00.7	01.7
44	Pawpaw tree seeds	03.8	00.0	00.0	00.0	01.0	08.3	00.0	00.0	00.0	02.1	01.6

45	*Millipedes*	*00.0*	*08.3*	*00.0*	*00.0*	*02.1*	*00.0*	*00.0*	*00.0*	*00.0*	*00.0*	*01.1*
46	Guava tree seeds	05.8	00.0	00.0	00.0	01.5	00.0	00.0	00.0	00.0	00.0	00.8
47	Unidentified *seeds(6)*	01.9	00.0	00.0	00.0	00.5	02.8	00.0	00.0	00.0	00.7	00.6
48	Beni seeds	03.8	00.0	00.0	00.0	00.1	00.0	00.0	00.0	00.0	00.0	00.5

From table 4, it could be seen that the seeds of cultivated plants were observed in regurgitates of birds trapped in both the wet and dry seasons. The seeds were observed in regurgitates from all the four columbids species.

Wild seeds of grasses and weeds were observed more in regurgitates obtained from birds caught during the dry than during the wet season. Such seeds were also observed in regurgitates from all the four columbid species under study. The unidentified seeds resembled wild seeds of grasses and weeds. Tree seeds were observed mostly in regurgitates fo birds trapped during the wet season. Such tree seeds were mostly found in regurgitates obtained from the LDs and SPs.

Animal matter was observed mostly in regurgitates obtained from birds caught in the wet season. Most of the animal matter was observed in regurgitates of the RDs. However, some unidentified insect parts were observed in regurgitates from birds caught during the dry season. Such parts resembled those of the black ants mostly the head and legs and of beetles, mostly wings and legs. Most of the unidentified leaves were found in regurgitates of the wet season birds and from all the four columbid species under study.

Sand and grit particles as well as some disposed food items were found in regurgitates from birds caught in all the seasons and from all the four species.

4.2. **Feeding Habits of the Wild Columbids**

The LDs were always seen feeding on the ground around the student hostels, staff residential areas, waste disposal sites, and under trees. They were also seen feeding on farmlands particularly during planting and harvesting, picking up spilled grains. The birds were also observed feeding on lawns where grasses have been burnt or cleared and also along streets. They were most often seen feeding in pairs and at times in flocks of up to ten. At times they were seen feeding in association with other species like the RD, MD, and SP particularly on farmland. Feeding was observed to occur mostly in the morning between 8 to 12 a.m. and in the afternoon between 2 to 6 p.m.

The RD and MD were seen feeding singly, in pairs or in association with other species mostly on farmland and at times around the student hostels and staff residential areas.

The SPs were seen to also feed on the ground. They were also seen in pairs and often in monospecific flocks or in association with other species feeding on farmland particularly on rice, guinea corn, maize, and millet farms at planting and harvesting. Birds of the four species were also observed drinking water from a common water spot either singly or in pairs or in small flocks of five to ten birds at several points in the study area particularly during the dry season.

4.3. **Food consumed by mixed-species group of captive columbids**

The food consumed by the poly-specific group over the 36 days captive feeding period is shown in Figure 15 and also Appendix 1. This shows the total amount of each seed type consumed in grammes during the captive feeding period of 36 days.

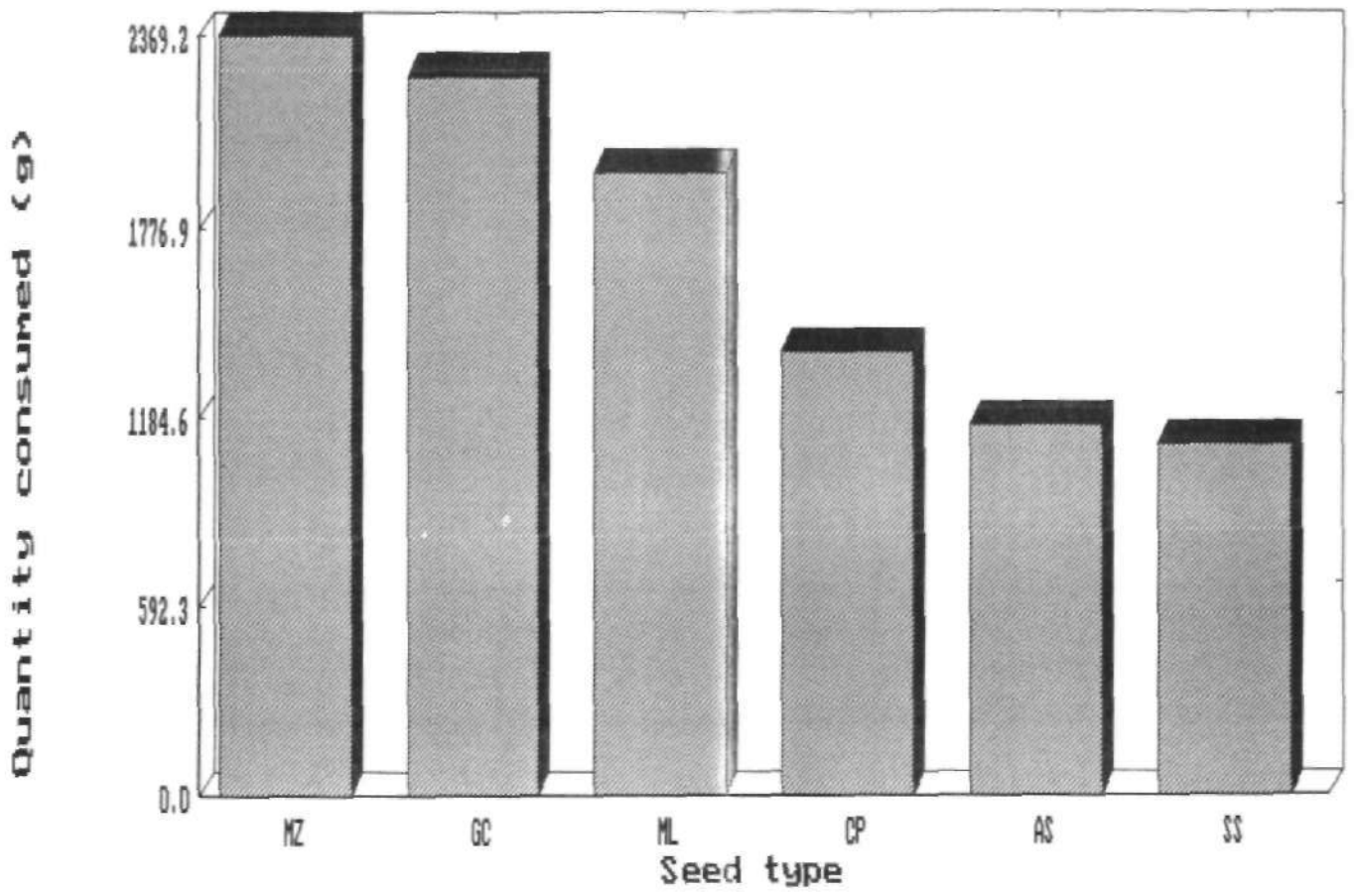


Figure 15: Food consumed by all four species fed together over 36 days

4.4 **Food consumed by monospecific groups of the four columbid species**

For the monospecific feeding, the various species consumed different amounts of the six seed types presented to them. The LD consumed the seeds in the order shown in Figure 16 and Appendix 2. GC(19.8%), AS(18.9%), ML(17.7%), SS (16.6%), MZ (15.4%) and CP(11.4%). The RD consumed the seeds in the order shown in Figure 17 and Appendix 3. MZ(21.3%), GC(20.7%), ML(18.1%), CP(14.3%), AS(13.9%), and SS(11.7%). The MD consumed the seeds in the order shown in Figure 18 and Appendix 4. MZ(20.30%), GC(19.8%), ML(17.4%), CP(17.3%), AS(14.3%), and SS(10.9%). The SP consumed the seeds in the order shown in Figure 19 and Appendix 5. MZ(18.7%), GC(18.7%), ML(18.74%), CP(17.5%), AS(14.6%) and SS(11.7%).

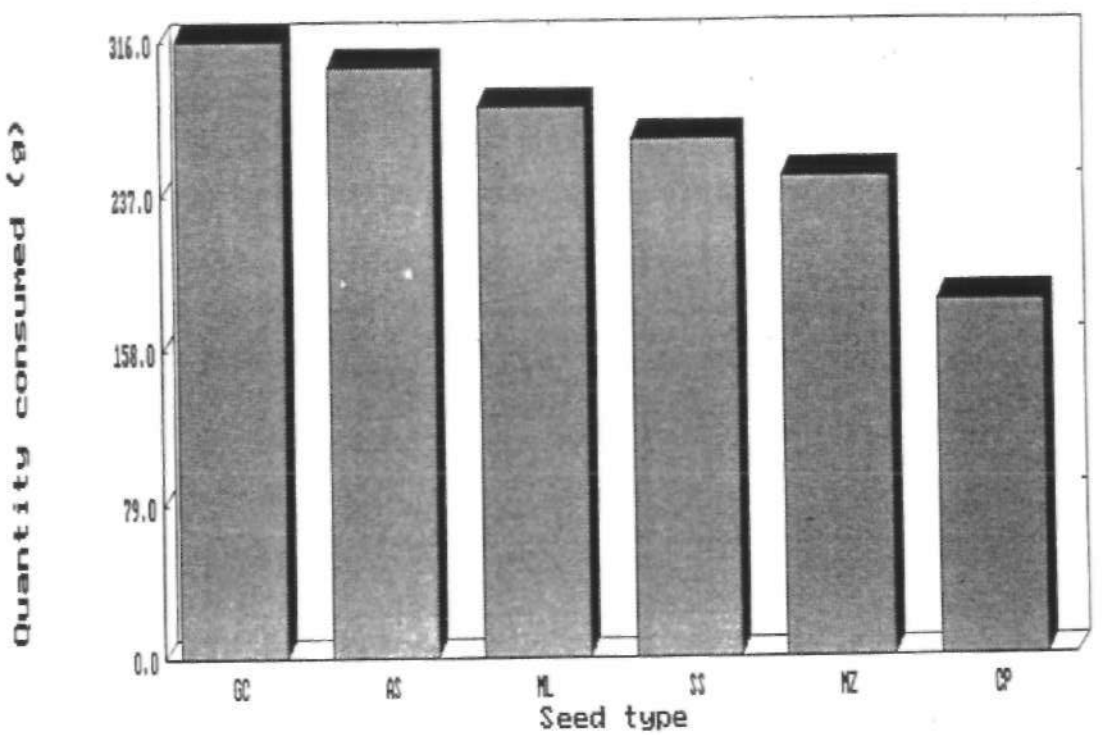


Figure 16: Food consumed by Laughing Dove, *S. senegalensis* over 36 days

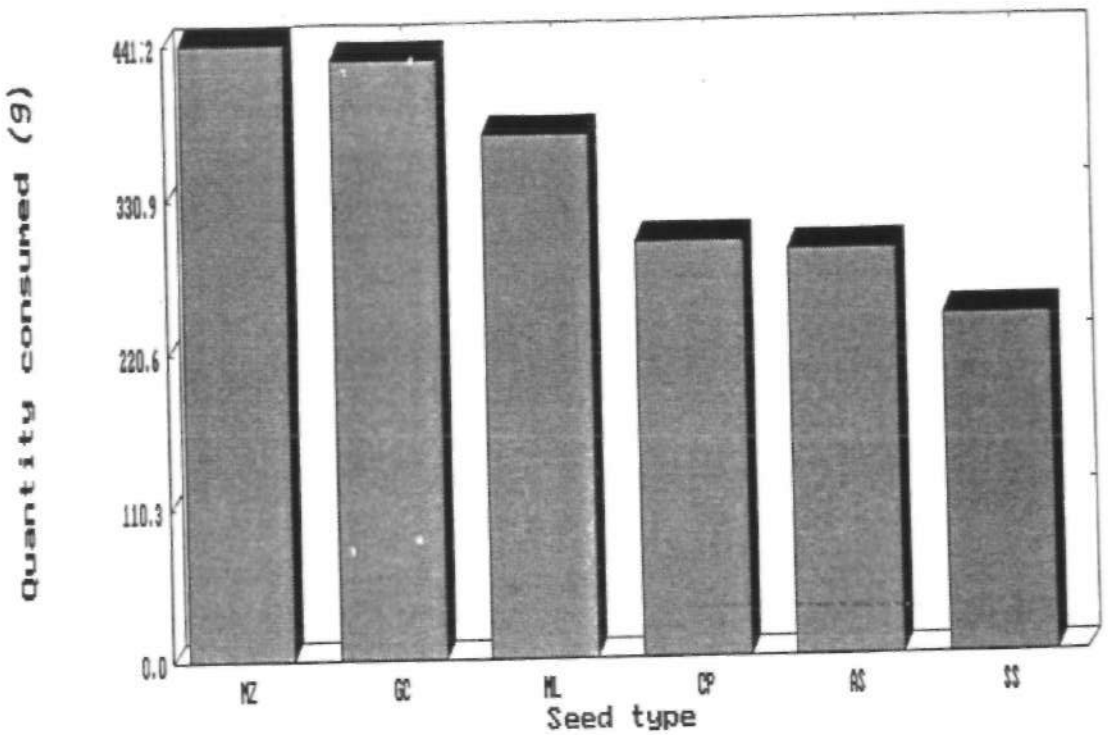


Figure 17. Food consumed by Red-eyed Dove, *S. semitorquata* over 36 days

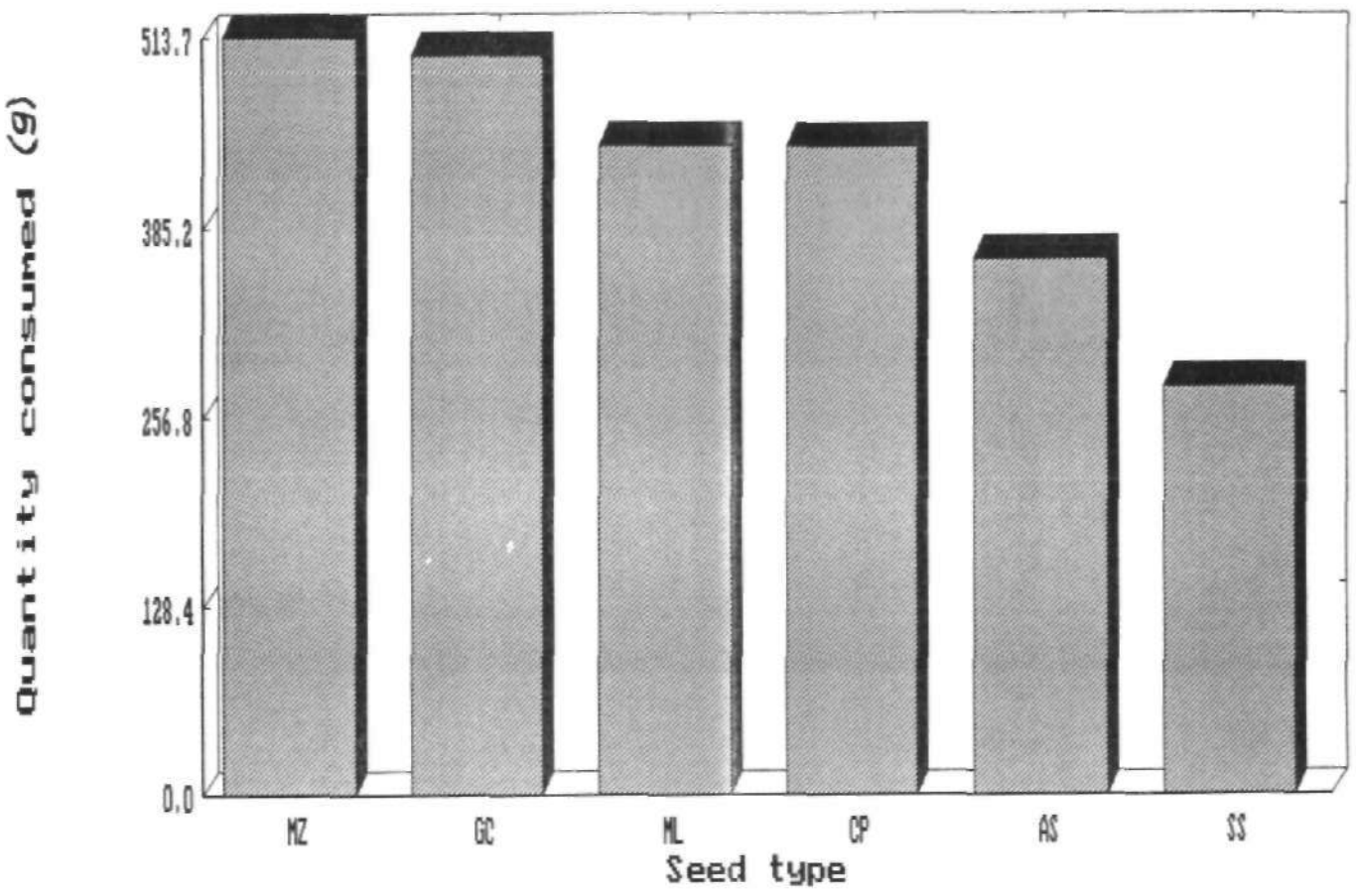


Figure 18: Food consumed by Mourning Dove, *S. decipiens* over 36 days

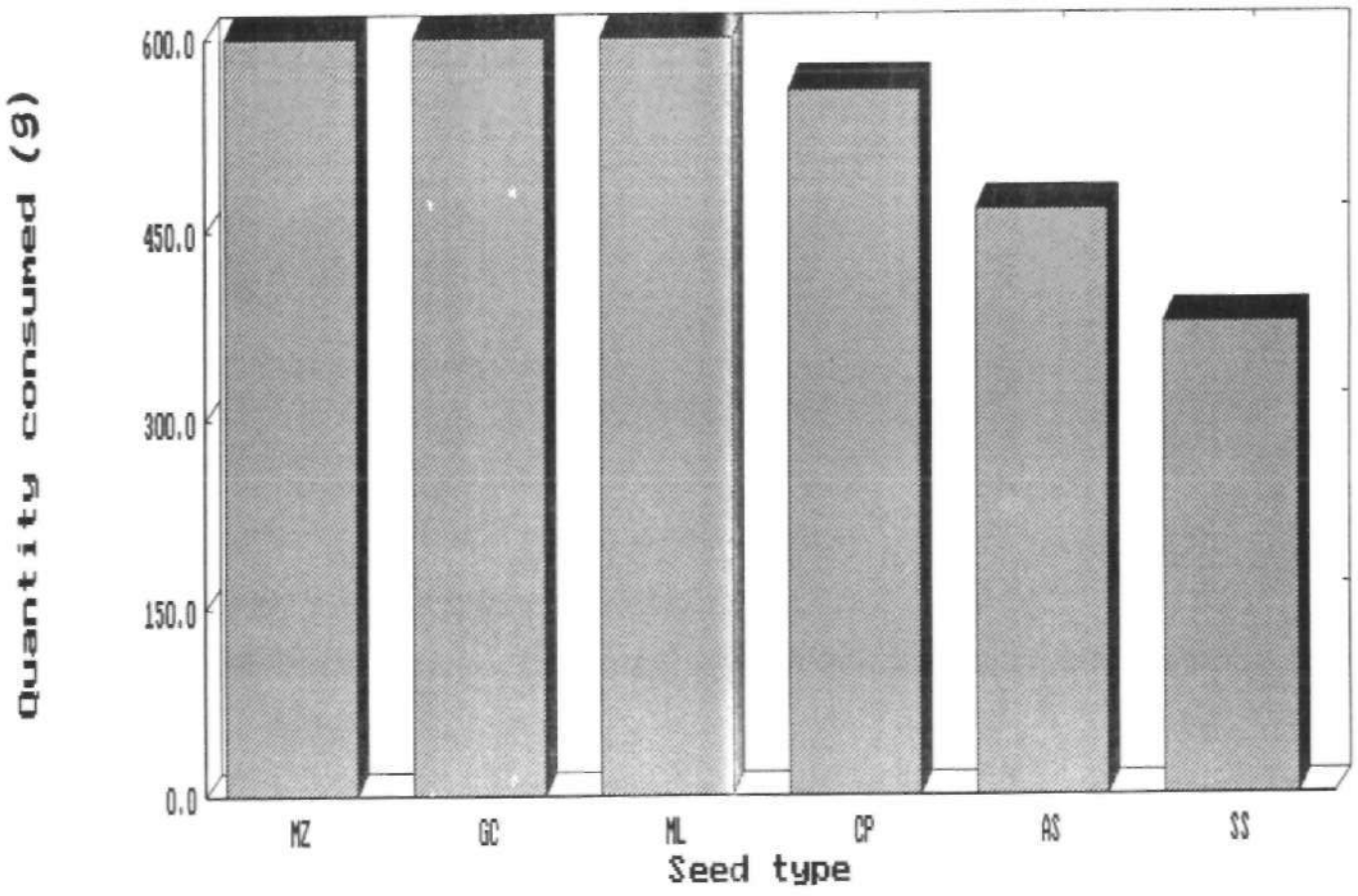


Figure 19: Food consumed by Speckled Pigeon, *C. guinea* over 36 days

The amount of each seed type consumed by each species per feeding period and the total amount of food consumed per feeding period increased in the course of the study period (Figure 20 and Appendix 2-5).

4.5 Behavioural observations in captivity

4.5.1 Foraging and Feeding behaviour

4.5.1.1 Food handling ability and "testing"

Some of the birds for example the LDs usually pecked at and pick up the seeds particularly the large-sized seeds and then drop them, peck and pick again and then drop several times trying to orientate the seeds in a way they could be swallowed. Some birds picked up the seeds and held them with their bills and when they realized that the seeds were too large for them to swallow, they dropped them. This "pecking and dropping" behaviour is termed "testing" (Goodwin, 1983). While feeding on the small-sized seeds, such testing was not observed. They pecked at the seeds continuously without raising their heads. The RDs, MDs, and the SPs fed conveniently on the large-sized seeds without any "testing" since their bills could comfortably accommodate the seeds but "testing" was however observed when they fed on the *Spathodea* seeds.

4.5.1.2 Foraging behaviour

The birds forage for food in the aviary (Figure 21). They pecked at food objects samll enough for them to swallow whole particularly when hungry. In several instances the birds were seen seizing earthworms and snalis found in the aviary and

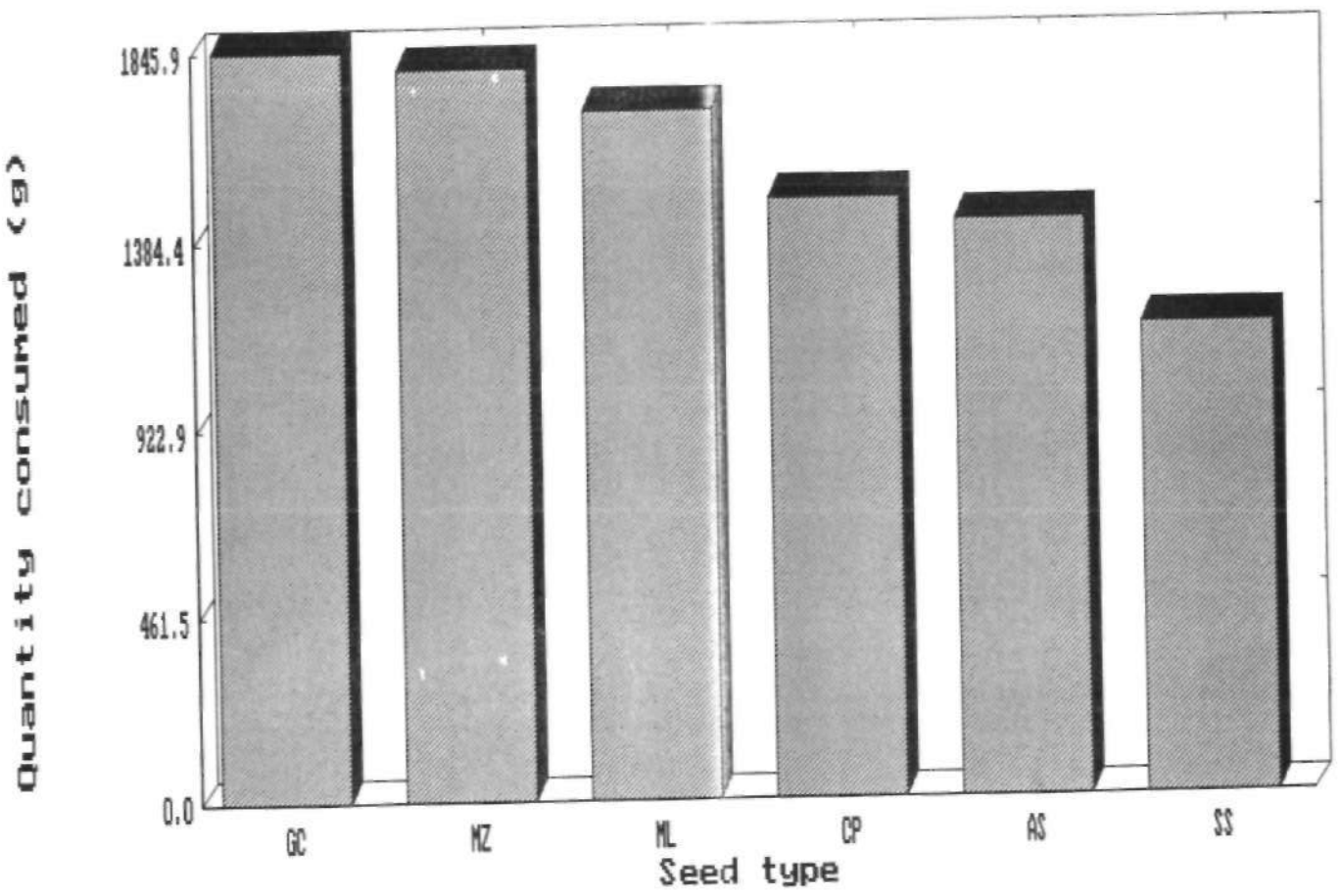


Figure 20: Total amount of each seed consumed in grammes over 36 days

swallowing them. In their foraging behaviour the birds did not scratch the ground with their feet as is the case with the phasianids (e.g. *Gallus gallus domesticus*).



Figure 21: Foraging birds in the aviary

4.5.1.3 Flock feeding

Birds tended to feed in flocks (Figure 21) whenever food was presented to them. The feeding movements of the first birds to arrive at the food source often served as an attraction to others to join. Such movements included the spreading of wings to send off competitors from grains that were in the immediate vicinity of a bird.



Figure 22: Flock feeding of captive columbids in the aviary

4.5.1.4 Drinking behaviour

The birds drank by "sucking" up water with their beaks (Figure 22) for a long time raising their heads momentarily from the water bowl and then getting them back to continue sucking. They drank mostly immediatley after feeding. After feeding and drinking the birds squatted on the ground or on the perches to rest and preen.

4.5.2 Social interactions; Courtship; territorial displays and agonistic encounters.

4.5.2.1 Aggressive or threat behaviour

The SP mostly exhibited this behaviour particularly during feeding and even on the perches. The Speckled Pigeons pecked the other smaller species and even their conspecifics with their beaks, at times driving then away from the food source or from the perches. Wing lifting (Figure 23) in which one or both wings were lifted was usually seen accompanying such threats or aggressive displays. The wings were either spread-out horizontally at about 180^0 or vertically at about 90^0, the bird puffed out its neck feathers stretching the neck slightly forward as if trying to attack an enemy. This puffing made the bird look larger than its normal size.

4.5.2.2 Species recognition

The birds could easily recognize members of their own species (conspecifics). This could be seen in the LDs and MDs in the fact that, they only chased

members of their own species in their bowing displays. The MDs seemed to recognize the calls of their conspecifics in the aviary and responded to them. The RDs, LDs and SPs responded to the calls of their conspecifics uttered outside the aviary. Other birds of similar species to those kept in captivity in the aviary were attracted to the aviary by their counterparts inside and attempted getting into the aviary to meet them. This was the concept underlying the trapping of the birds in the field using the live-bait cage trap, in which a live bird of the species to be trapped was placed as bait in one of the cells of the trap to attract its conspecifics.



Figure 23: Drinking behaviour of columbids



Figure 24: The bird in the middle of this figure is exhibiting a typical "wing-lifting" behaviour in an attempt to send off competitors

4.5.2.3 Bill movement

Most of the birds were seen moving their bills upward and downward as if trying to swallow something. The RDs most especially were often seen opening their bills and "panting" with the throat beating rapidly. This was usually seen after much activity, for example when an intruder entered the aviary. The birds were seen reacting seriously to a hawk (bird of prey) flying above the aviary. The birds flew from one part of the aviary to the other trying to escape. After such events, the birds squatted on the ground or perches and "panted".

4.5.2.4 Billing

The SPs were most often seen rubbing their bills together at times, slightly opened.

4.5.2.5 Bowing displays

The LDs and MDs could be seen performing bowing displays to their conspecifics,in which the male lowered and raised its head several times. This was often accompanied by the male chasing the female with feathers puffed. This in tend was usually accompanied by vocalizations, "bowing coos". Bowing usually occurred on the ground, but also occaisionally on perches. There were instances when a MD chased a RD and vice versa and also a RD chasing a LD in their bowing displays (Figure 25).



Figure 25: Bowing display in a Speckled Pigeon

4.5.3. Vocalisations

4.5.3.1 Advertising coos

The usual song or calls of the LDs in the wild which is a quiet, soft, rather high-pitched, hurried phrases of 4–8 coos (ro-too-too-too too) could be heard being uttered by the birds in the aviary. The SPs also made their cooing call, which is a series of deep sonorous well-separated "coos". The most interesting coos were those of the MDs uttered several times a day and very frequent. The coos were a quavering throaty chuckling call of "coo-roo-oo-oo" or"coo-roo-roo" and clear enough to be distinguished from that of the RDs, a closely related species. The calls of the RDs were also heard as a series of six deep coos "oo.00,oo-oo-oo-oo".

4.5.3.2 Bowing coos

Bowing coos of the LD, RD and MD were heard accompanying their bowing displays.

4.5.3.3 Distress calls

The birds gave these calls particularly when handled or frightened by an over-flying bird of prey or an intruder. It was given as a grunting, panting or gasping sound.

4.5.4 Maintenance preening and other behaviours

4.5.4.1 Ritual preening

The birds preened profusely particularly when at rest on the perches (Figure

26). During preening, the birds reached for the oil gland at the base of the tail, took some oil with its beak, and rubbed it on feathers on other parts of the body. The neck and the breast were the most preened parts in which the birds stretched their heads downwards to preen the neck and breast. Preening is very important in maintaining the water-repellant characteristics of feathers.

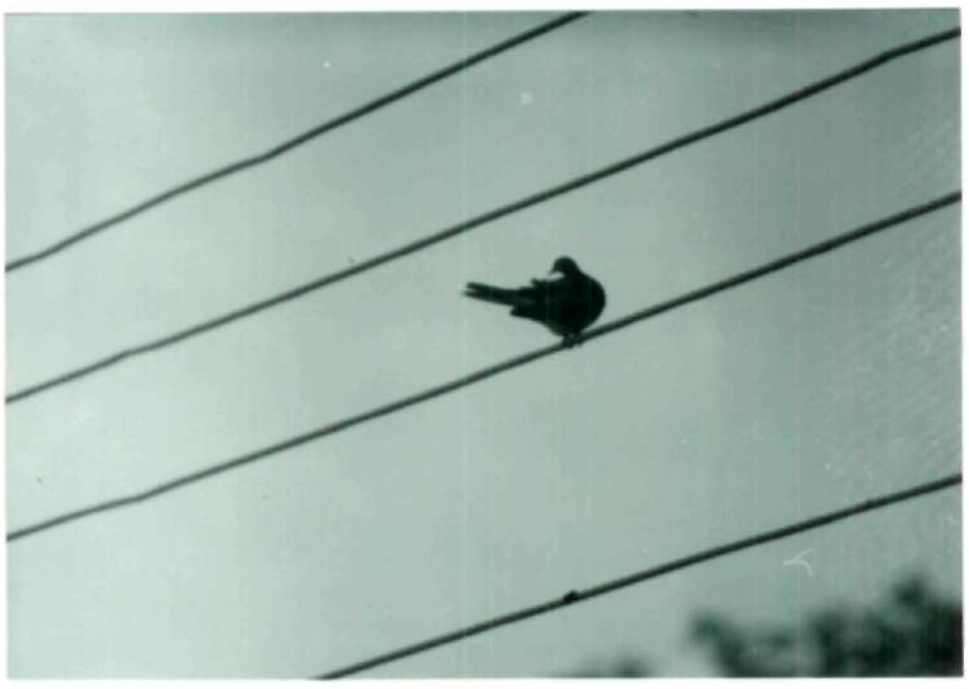


Figure 26: Preening behaviour in a columbid

4.5.4.2 Head-shaking and scratching

The birds were often seen shaking their heads as if trying to get rid of something that had got stuck in the throat in the course of swallowing. The birds were also seen head-scratching by lifting up the leg to scratch the head and bill probably because the bill could not reach these areas during preening.

4.5.4.3 Discomfort movements

In times of depression, stress, ill-health or cold, the birds dropsied, shivered and puffed their feathers with head dropped downwards as if sleeping.

4.6. Survivorship of the birds under captive conditions

Diseases

Out of the 20 birds kept in the aviary, two died from infectious diseases notably; aspergillosis, and ascaridiasis. This gave a percentage survival of 90 and a probability of survival of 0.9.

Theft

Fifteen out of the 20 birds under captivity were stolen away by unknown individuals who buggled the aviary several times.

CHAPTER 5

DISCUSSION, CONCLUSIONS AND RECOMENDATIONS

5.1 Food Habits of Wild Columbids

The following food items observed in the present study as food for the four columbid species under study have been reported by other workers. For example, for the LD, Urban *et al* (1986) reported maize, *Sorghum,* millet, *Amaranthus,* legumes, herb and grass seeds; Rowan (1983) reported termites and pawpaw seeds; Morel and Morel (1972) found *Panicum* seeds, *Arachis* and *Vigna*; Ezenwanne (1982) observed leaves of dicotyledonous plants, insects and other invertebrates and Goodwin (1983) reported very small seeds of various wild and cultivated plants as well as sand particles.

For the RD Smithers in Urban *et al* (1986) Goodwin (1983) and Rowan (1983) reported *Sorghum*, maize, termites and millipedes, while Elgood (1960) reported groundnut and red pepper in the birds diet. The reports by Rowan (1983) that this species (RD) usually eats one food items at a time seems to be true as was observed in this study. This shows that this species is quite specialized in its food habits. This species also seems to show more affinity for animal matter than the other species since most of the animal food items observed in the study were from this species.

For the MD, Goodwin (1983) reported seeds of wild grasses and weeds and also cultivated grains while Urban *et al* (1986) reported *Arachis* and *Vigna*.

For the SP, Shotter in Urban *et al* (1986), Ezenwanne (1982), and Goodwin (1983) reported *Sorghum,* maize and groundnut. Some of the food items reported by previous workers as food for the four columbid species under study were however not observed in this study. The following food items observed in the present study as food for these species have not been reported by previous workers. These include: unhusked and dehusked rice, soya beans, seeds of melon, tomato, *Brachiaria, Luffa, Cassia,* wild pea, *Sporobolus, Setaria, Commelina, Crotolaria Calopogonium, Corchurus, Spathodea,* neem, *Eucalyptus,* guava, *Hibiscus, Indigofera,* okra, *Monechma* and Beni plants.

The discrepancy in the food items observed in the present study with those reported in previous studies by other workers may be as a result of the areas and seasons in which the study was carried out and also on the number of birds examined.

The seeds of cultivated plants on which the birds fed are some of the plants grown in the area of study. This implies that the birds feed on what is available in the environment and the availability of food influences their food habits in the wild as has been reported by Lafeber (1965). Agricultural development, particularly in the growing of cereals in the study area has probably provided a good habitat for these seed-eating species of Columbidae. This type of situation was reported by Bucher and Orueta (1977) in Cordoba, Argentina for the Eared Dove, *Zenaida auriculata.* Feeding on seeds confirms the reports of Goodwin

(1983), Frith *et al* (1974, 1976) who reported seeds to comprise 5-85% for *Ocyphaps loptes* and 98.8% for *Phaps chalcoptera*. The feeding of these species on the seeds of cultivated plants may implicate them as pests (Rand, 1965 and Mellanby, 1967). However, no such reports have been made in the area of the columbid species under study (Ezenwanne, 1982 and Urban *et al*., 1986). These columbids probably feed on spilled grains during planting and harvesting and thus can not be implicated as pests (Murton *et al*., 1972). The fact that these birds feed on wild seeds implies that in the absence of the cultivated plant seeds, they can feed on the wild seeds. Feeding on wild seeds probably help to reduce the impact of weeds and grasses on farms which is a form of biological control. This prevents the use of herbicides on farms, which may pollute the environment. The presence of these birds on farm lands may provide fertilizer through their droppings, supplementing the use of artificial fertilizer (Verne, 1940).

Their feeding on tree seeds implies that the birds also depend on trees for their food besides using them as nest, roosting, and resting sites (Elgood, 1960 and Babatunde, 1994). The cutting down of these trees may therefore adversely affect the survival of these species. Preserving these trees, will probably enhance the conservation of these species in the area of study. The feeding on food items from waste disposal sites around the students' hostels may implicate these columbid species as scavengers (Dilks, 1975). Disposed food items from

our tables and kitchens may be presented to these birds under domestication provided such items are not contaminated. This may help to convert such food items into valuable protein rather than being wasted away. This reduces the cost of domestication and encourages as many as are interested to domesticate these species. The feeding of these species on animal matter implies that they require some amount of animal protein in their diet even though they are granivores, feeding mainly on seeds of wild and cultivated plants (Beck, 1969 and Whitman, 1919). Animal matter such as insects and other invertebrates may be fetched from the wild and presented to the birds in captivity. Animal matter formed 10.4% of the food items identified in the present study as opposed to 15% reported by Cameron (1975) and 0.7% by Frith *et al* (1974) for other columbid species. Frith *et al* (1974) also reported plant leaves to form 5-13% of the diet of *Ocyphaps loptes* as against 2.1% observed in the present for the diet of the four columbid species under study. These plant leaves may have served as a source of vitamins and mineral salts. The sand and grit particles may have also served as a source of mineral salts. The feeding of these species on plant leaves confirms the report of Ezenwanne (1982) while the feeding on sand and grit particles confirms the reports of Goodwin (1983), Urban *et al* (1986) and Rowan (1983).

The presence of the 48 food items observed in the present study amongst other food items not observed but which may be present in the enviroment, indicates

that the Zaria area and more specifically the Ahmadu Bello University main campus and its environs could be a good site for the conservation of these species.

5.1.1 Niche overlap and differentiation in food habits of the wild columbids

Niche overlap in the feeding ecology of the birds was brought about by the fact that the birds fed on a number of common food items, particularly the seeds of cultivated plants. This was an indication of some degree of competition for food among these four sympatric columbid species. The wide variety of seeds and other food items present in the environment on which the birds feed may have helped to reduce the intensity of the competition and probably contributed to their sympatricity. The fact that the various columbid species select food items or seeds of different sizes which are correlated with the sizes of the birds viz a' viz their bill sizes may also have helped to reduce the competition for food. The result of this study are in accordance with the reports of Kreb and Davies (1979) who reported the niche variation hypothesis to be based on food and feeding habits. Schoener (1968) also believes that niche differentiation may also be brought about as a result of differences in location or time of feeding. As adduced in the present study, Cleach (1967) and Hutchinson (1987) acknowledges time of feeding and differences in size of seeds, respectively as

possible causes of niche differentiation. Klopfer and MacArthur(1961), Schoener (1965) and Klopfer (1973) also reported that the differences in bill sizes of a group of birds commonly found feeding together could bring about niche separation in such competing species.

Other researchers have made reports of niche overlap and differentiation in other organisms in relation to food habits and other resources. For example, Bielsa and Labisky (1987) reported niche differentiation in two sympatric carnivorous fishes (the blue line tile fish and snowy grouper). Monda and Ratti (1988) reported mean niche overlap values in habitat use by sympatric ducks broods in eastern Washington to range from 0.62 to 0.94 as opposed to the 0.00 to 31.3% in food habits for the four sympatric columbid species in the present study. Ulfvens (1987) also reported niche overlap in the feeding habits of sympatrically breeding Tufted Ducks and Scaups but differences in their utilization of the feeding habitat in relation to time and site of feeding lead to proportional niche differentiation in line with results of this study. An assessement of the feeding ecology of four sympatric *Limax species* by Cook and Radford (1988) using direct observation and faecal analysis also showed a niche differentiation between these species in which *Limax maximus* had a light proportion of vascular plant materials in its diet while the other three species fed predominanthy on lichens. This showed a substantial niche separation between *L. maximus* and the other three species based mainly on its feeding preference.

In the present study, the SP differentiated its niche from that of the other three species by showing more preference for the large-sized seeds while the LD differentiated its niche by feeding on more variety of food items than the other species and the RD by showing more affinity for animal food matter. Zhigal'skii (1987) also found the food niches of two voles to overlap by 98%, confirming niche overlap in other organisms. Burkovskii (1987) has also reported niche overlap and niche differentiation in terms of food habits to be responsible for vertical distribution of infusorians (Rose, 1976; Gladfelter and Johnson, 1983; Bergstrand, 1983; Inozemtsev, 1987). Niche overlap and differentiation may increase or decrease from one season to the other depending on the availability of a diversity of food items at each season (Szekely, 1987 and Jenkins and Wright, 1988). Jenkins and Wright (1988) also found niche overlap to be greater between similar sized cervids than between species of dissimilar body size. Niche overlap between the four columbid species under study may actually be temporary based on the season of food scarcity or less based on the principle of body size differences and the amount of food consumed. Sampedro *et al* (1982) found statistical differences with respect to food items either qualitatively or quantitatively between two sympatric Cuban Anolis species which lead to niche differentiation. Rose (1976) also reported niche separation between two sympatric species of lizards being based on the differences in the mean length of preys selected by each species. Difference in

prey selection was as a result of the morphological variation in size of the two species. *Sceloporus graciosus* selected preys of smaller mean length than *S. occidentalis*. These differences enable the two species to coexist despite their extensive overlap in prey utilization and habit. In the present study the four sympatric columbids tended to select food items of different sizes based on their bill sizes which may be responsible for their coexistence. Porter and Duesser (1982) demonstrated a positive correlation between niche overlap and competition but in the light of the present study, a niche overlap of 31.3% may indicate less competition between the four species for food. Niche overlap according to M'closkey (1982) is related to the use of limited resources by coexisting species and proportional to resource availability. In the case of the present study, the diversity of food items available during the dry and wet seasons tends to limit the degree of food niche overlap between these species (Henderson *et al.*, 1981, Mohanty-Hejmadi and Acharya, 1982 and Rivera and Antonio, 1983).

5.1.2. Variation in food habits of the columbids between the wet and dry season

Reports on the seasonal variation in food habits have been made by Shotter in Urban *et al* (1986) for the SP and by Urban *et al* (1986) for the LD and MD. These confirms the results of the present study of the seasonal variation in food habits of the columbid species under study. The availability

of a wide variety of food items during the wet and dry season probably prevents the seasonal migration of these birds to other areas in search of food. Abundance in food supply is also probably the reason why the birds breed in all months of the year as reported by Sodeine (1993), Babatunde (1994) and Elgood *et al* (1994). According to Ayeni (1974) seasonal restriction in breeding is often brought about by marked variations in the abundance of food available to a species. Such a variation in abundance was not obvious in the food available for utilization by the four columbid species under study. Food availability is enhanced during the late dry season, which would have been a lean period, by the process of clearing and burning which expose more seed on which the birds feed. Dean (1980) however suggested that the columbids may have difficulty in finding food during the early wet season. This is probably because during this period, seeds that fell to the ground during the dry season are stimulated to germinate thereby lowering the availability of seeds during this period. However, the abundance of insects and other invertebrates during the early wet season may go along way to remedy this situation. The observation of tree seeds in the regurgitates of birds trapped during the wet season is probably an indication that the trees produce their seeds during the wet season. This may also give an idea of the phenology of the seed-producing plant and also an indication of the seed producing stage or period of the tree.

5.2. Feeding in captivity

5.2.1 Mixed-specific group feeding of the four species

For the large species (RD,MD and SP), there appeared to be no difference in the order of food consumption whether fed mono or polyspecifically. Only the small species (LD) showed a different order of food consumption when fed mono- specifically than in a mixed group. This implies that the mixed-specific group feeding or PSGF may not be the best approach to feeding of the birds in captivity; it is advisable therefore to separate the birds into their various species or sizes when feeding in captivity. Statistical analysis of the results shows that the birds when fed together consumed more of maize, guinea corn, millet and cowpea than of *Amaranthus* and *Spathodea* seed (Appendix 7) maize, guinea corn, millet and cowpea may be recommended for feeding the birds together in captivity. During the mixed-specific group feeding, the amount of each seed consumed per feeding period was seemingly constant over the 36 days period of observation (Appendix 8). The average daily consumption per bird was calculated to be 14.2 g.

5.2.2 Conspecific feeding

This LDs seemed to consume less food than the other species. They accounted for 16.9% of the total food consumed with an average daily consumption of 8.8 g/bird as against the 14.2 g/bird calculated for the PSGF.

They showed more preference for the small-sized seeds probably because of their small bill-sizes compared to the bills of the other species.

The order of seed consumption of the RDs was closely similar to that of the MDs. and SPs, but this species (RD) seemed to feed slightly less than the other species. It accounted for 22.1% of total food consumed. The average daily consumption for this species per bird was calculated to be 11.5 g.

There was however no significant difference between the amount of food consumed by the LD and RDs. The amount of food consumed by these two species was not statistically significant ($P > 0.05$) (Appendix 11).

The order of seed consumption of the MDs was closely similar to that of the SPs. The MDs accounted for a percentage slightly less than that of the SPs, taking 26.9% of total food consumed. The average daily consumption per bird being calculated as 14.1 g. The amount of food consumed by this species was statistically significant ($P < 0.05$) and was significantly different from the amounts consumed by the LDs and RDs. (Appendix 11).

The order of seed consumption of the SPs was similar to that of the RDs and MDs but it seemed to feed more than these other two species, accounting for 34.1% of the total food consumed. The average daily consumption was calculated to be 17.8 g/bird. This was probably because of

its large body size, the amount of food consumed by the SPs was also statistically significant ($P<0.05$) and was significantly different from the amounts consumed by the LD,RD and MD (Appendix 11).

Thus, in this respect, the amount of food consumed can be related to body size, since the LD with small body size fed least while the SP with large body size fed most (Figure 19 and Appendix 6). The seed consumption of the RD, MD and SP were probably not affected by the size of the seeds since their bills were large enough to accommodate the size of the seeds presented. These three species seemed to have consumed more of the seeds of large sizes than those of small sizes. Even within the three large species the SP which is the largest fed most. The amount of cowpea, *Amaranthus* and *Spathodea* seeds consumed by the SP per feeding period increased gradually over the 36 days period of observation while remaining constant for maize, guinea corn and millet. The SP consumed all the quantity (50 g each) of maize, guinea corn and millet presented to them and it was evident that they could consume more than the quantities of these seed types that were presented to them. The length of time taken to completely consume each seed type could be used to predict preference for these seed.

The amount of each seed consumed per feeding period and the total amount of food consumed per feeding period for all the four species were statistifically significant ($P<0.05$). But no significant differences existed

between them except for day 1-6 feeding period. A gradual increase over the 36 days period of observation is probably an indication that the bird became more acquainted to the seeds particularly those they encountered for the first time (Appendix 10).

The present study showed that guinea corn and maize were the most consumed or most preferred food for doves, confirming the reports of Ezenwanne (1982). This was closely followed by millet, cowpea, *Amaranthus* and *Spathodea* seeds (Figure 19, Appendix 6 and 9).

Seed selection in columbids based on seed size, bill and body size as well as handling cost has also been reported by Brown (1969).
Studies on food preferences and average daily consumption rates have also been carried out experimentally for the Collared Dove, *S. decaocto* by Helesic (1981) with similar results as obtained in the present study where average daily consumption rate increase overtime as the birds got more acquainted to the food items presented to them and showing different preference for the various food items by consuming more of the preferred and less of the unpreferred.

5.3 Feeding Habits and Other Behaviours in Captivity

Activities and vocalizations which are related to the search, capture and treatment of food, and to breeding, are important components of the daily lives of birds. Food handling ability and testing" has been described for a good number of columbid species by Goodwin (1983) and is usually observed when the birds encounter new food or food of large-size. The LDs manifested this behaviour when they were presented maize and cowpea because of the large sizes of the these seeds. The other species manifested this behaviour when presented with the spathodea seed which must have been new to them.

"Testing" probably protects the birds against the ingestion of unsuitable food items as they foraged. This is because the bird has to convince itself through this behaviour of the edibility of the new food before it can swallow the first morsel. The bird has to make some judgement as to how far the food item approaches or differs from food items it is accustomed to and known to be edible. This behaviour probably confirms the foraging behaviour of these birds and may be of importance when considering the conservation or domestication of these species.

A foraging behaviour in which the bird fed on snails and earth worms has been reported by Whitman (1919) for the White-crowned Pigeon and Goodwin (1983) for the SP in agreement with the results of the present study.

This foraging behaviour may have exposed the birds to the ingestion of parasite

eggs or spores leading to infection as observed in this study. Foraging indicates that the birds habitually feed on the ground (Elgood, 1960 and Goodwin, 1983), unlike other pigeons that seek for food in trees, shrubs, or vines or both in trees and on the ground. When foraging, the birds seemed to be looking downwards for much of the time. In the wild, this makes them vulnerable to predators such as foxes and humans (Goodwin, 1983). Some care should be taken in the use of poisonous chemicals particularly on the farms where these birds normally forage, in the area where the birds may be conserved. This is because such chemical may be ingested by the birds as they forage.

Flock feeding observed in the aviary implied some degree of interspecific tolerance among the birds and the fact that the birds fed together from a common food source demonstrates some degree of sociability. This conotes that the birds can be kept together in captivity, but must be fed "ad libitum" that is, as desired, providing the birds with a variety of food items of various sizes to reduce competition and aggressiveness. In the wild, a flock is considered as a party or groups of pigeons that set out together from their roosting site, fly together to their feeding grounds, alight and seek for food together, fly off together and move to a new feeding ground together. Conversely, a number of doves seeking food together in the field where they have flown singly or in pairs and from where they will similarly depart is considered as a mere aggregation rather than as a flock (Goodwin, 1983). In the wild therefore, a flock can rarely

be seen to compose of different species but mostly of the same species (Goodwin, 1983). Flock feeding especially in the wild accomplishes many functions. It probably facilitates the discovery and maximum utilization of food supplies that may be plentiful but scattered in distribution. It also enables young or inexperience individuals to benefit from the initiative or knowledge of local food or water supplies possessed by the older or more experienced birds, it can enable many individuals to meet and may thus facilitate pairing between unrelated individuals. It may also act as significant check against predation as it is probably true that a pigeon in a flock not only feels safer but actually is safe from most forms of predation (Goodwin, 1983). Under captive conditions, the situation seemed to be much different and flock feeding became a matter of a struggle for survival. The smaller species were suppressed and deprived of their share of the food. Thus, the advantages of flock feeding inherent in the wild, may not be inherent in captivity as there seems to be competition for food and space.

It could yet be advisable to separate the birds into their various species while in captivity to totally avoid this competition.

The drinking behaviour of at least once and usually more often each day supports the observation of Murton (1964). Their regular drinking habit corresponds to their foraging behaviour and they seemed to drink as much as they fed, for after foraging for a while, they normally went to suck or sip at

least a draft of water. As most of the foods consumed by the birds are dry, this probably facilities the movement of food down the gut by moistening them and possibly aids in digestion. Pigeons in the wild usually congregate at traditional watering spots to drink and this predisposes them to danger as hunters normally go to such spots to hunt or shot them (Goodwin,1983). This regular drinking of the columbids entails that, in captivity, the birds should be provided with adequate drinking bowls and in the wild, drinking spots should be made available particularly where the birds are being conserved. Adequate guard should be taken of such drinking spots to avoid primitive men or hunters from trapping or shooting the birds.

Aggressive behaviour, as observed in the present study during captive feeding has been described by Goodwin (1983) and Whitman (1919). In the wild, Goodwin (1983) reported this behaviour to be directed most frequently and intensely towards potential nests predators. The SP probably because of its large body size, used this behaviour to suppress the other smaller species particularly during feeding. This behaviour could also have evolved in reponse to competition for food, space or even mate. Aggression can both be intra- and inter- specific, as observed in this study. The exhibition of this behaviour further justifies why the birds could be separated into their variours species while in captivity or under domestication.

In specie recognition, like species appear to attract each other rather

than repel, hence the popular saying "Birds of the same feathers flock together". This Behaviour may be attributed to imprinting as reported by klinghammer and Hess (1964). In imprinting, the organism learns to recognize its own kind either by appearance, sound or other wise. The attraction to the aviary of other non-captive birds outside the aviary similar to the species kept in the aviary is an indication of a high level of species recognition supporting the works of Whitman (1919). Such a behaviour may facilitate breeding either in the wild or in captivity while conserving or domesticating the birds. Some of the bill movements observed in the present study served as a means of increasing the strength of bonding between two individuals, usually opposite sexes.

Billing in its fullest form as described by Goodwin (1956, 1983) and Whitman (1919) consists of the male offering his open bill to the female. The female inserts her bill into the male's mouth and is fed by him. This is termed "allo-feeding" but the male does not actually disgorge food but rather both birds make regurgitating movements while their bills are together. This is perharps different from what was observed in the present study, for the Speckled Pigeon. Billing was reduced to a momentarily brief "fencing" or touching of the bills. Billing probably indicated an attempt of the birds to copulate but rather hindered by some unfavourable conditions. Billing could as well indicate sexual excitement, arousement or stimulation, and the possible breeding of these birds in captivity if favourable conditions exists.

The bowing display is common to most pigeons and is primarily a sexual display shown by a male towards a female he is sexually attracted to. This is a pleading or beckoning behaviour of the male on the female to mate with her. The male trying to convince the female or cajoling her for sex. This behaviour is also intended to sexually excite the female or bring her into mood as the male indicates his sexual intentions to her by bowing. Bowing is probably geared towards tantalizing or attracting the female. The male communicating his intentions to her in a language she most probably understands through the bowing coo. Bowing probably indicates the hypersexual state of the male and also an intense state of courtship particularly in a situation where bowing is performed to a bird of another species.

Most pigeons utter cooing calls that usually involve inspirations and some degree of inflation of the neck as was observed in this study. Such coos can be divided into five basic calls which include, the advertising coos, the display or bowing coos, the distress calls, the nest calls and the excitement cry. In this study, only three of these calls were observed the advertising coos, the display or bowing coos, and the distress call.

The advertising coo is also called the perch coo, the song or territorial coo. It is uttered by a territory-holding bird and is confined to birds in some phase of the breeding cycle or coming into reproduction. It could also be uttered in a variety of situations (Goodwin, 1983). In some species, territory

holding males appear habitually to answer their neighbour's advertising coos (Goodwin, 1983). The function of this coo is probably to advertise the presence of a male in breeding condition to potential female mates and to maintain contact between members of a pair. The male also utters the advertising coo when the female is out of sight or to indicate to her the nest site. The female can possibly identify the advertising coo of her male mate.

Advertising coos may also be used to warn potential territory-seeking males that an area has been occupied by another male.

The bowing coo usually accompanies the bowing displays as observed in the present study. It is less loud compared to the advertising coo and could be indistinct and prone to variation even for the same species. This display coo functions at short range and is given when two birds are closed together and visible to each other (Goodwin 1983). This is in accordance with the observation of the present study. The advertising coo on the other hand functions at "long range" (Goodwin, 1983). The display coo seems to be a vital means of communication between the male and female during the bowing display. This behaviour serves as another important indication for possible breeding in captivity.

Distress calls given by the birds could indicate signs of fear, feelings of annoyance, discomfort or indecision and aggression (Goodwin,1983).

The nest calls and the excitement cries descried by Goodwin (1983) were

not observed in the present study. The nest calls, which are usually given at nest sites, could not be observed since the birds did not breed during the study. Further more, excitement cries normally given in flight could not be observed probably because the birds were not provided with enough flying space.

Ritual preening in the Columbidae is generally similar to that of other bird species. This behaviour aids in water- proofing the feathers with the powder that permeates the plumage of pigeons, which appears to function in lieu of preen oil in other birds (Goodwin, 1983). Ritual preening in these species is directed at the sides of the breast and neck (neck and breast preening) as observed in the present study. This act appears to provide auto-erotic stimulation and admiration as well as serving as a signal to the mate. The main function of ritual preening is probably to indicate the bird's sexual and peaceable intentions and to arouse a similar mood in the partner. Goodwin (1983) has also described ritual preening for a member of other columbid species. Ritual preening may possibly serve as a sign of relaxation, self-pleasure, satisfaction and may help in the removal of dirt irritants, foreign bodies or ectoparasites from the body of the bird. Allo preening or caressing, an intense form of courtship in which the male and female preen each other described by Goodwin (1983) was not observed in the present study. This indicates that the birds were not adequately stimulated to reach this state of courtship.

Head-shaking consists of a sudden, quick, shaking or jerk of the head.

The movement appears chiefly lateral, but at times seems to involve a rotatory movement also. This behaviour was shown immediately after drinking as in the present study and probably served to remove drops of water or other foreign objects adhering to the head or bill. The head and the bill which are all areas to which the bill cannot reach during preening are cleaned by scratching with the foot which is brought up directly confirming the reports of Goodwin (1983) and Simmons (1987). Head and bill scratching with the leg may serve as a means to remove irritants or foreign objects adhering to them.

Shivering, dropsy, puffing of the feathers and drooping of the head were signs of discomfort observed in the course of this study as have been described by Goodwin (1956,1983). This may well indicate the psychological and physiological state of the birds, signs of depressions, ill-health, hunger and lack of freedom.

Other behaviours described by Goodwin (1956,1983), Whitman (1919) and Murton (1964) for these and other species of Columbidae, were not observed in the present study. This may probably be due to the fact that the birds were held in captivity in the aviary. Factors that might have prevented these birds from breeding in captivity during the course of the study period of 72 days may include the following; poor sexing, lack of adequate space, improper or unbalanced diet, shyness, lack of nest sites and nest materials, lack of hormonal secretion or insufficient hormonal secretion probably due to

confinement. However, the manifestation of some of the behaviours like bowing displays, billing and some vocalizations which are peculiar to the breeding cycle of the columbids probably indicates that the birds could breed in captivity if provided with the necessary conditions that simulate those in the wild though perharps with great difficulty (Scott,1958).

5.4 Survivorship in captivity

This is a biological phenomenon that originates under one set of conditions and persists in a period when those conditions no longer exist. It is the ability to continue to live after some event, remaining alive and living on.

A percentage survival of 90 and probability of survival of 0.9 in the present study with respect to diseases shows that these columbid species have a high ability and probability of survival in captivity in relation to infectious diseases. This shows that all the birds may have survived during the period of this study if well catered for health- wise. The incidence of aspergillosis and ascaridiasis shows that infectious and parasitic diseases can be a threat to the survivorship of the birds in captivity. Infection must have been as a result of poor management and inhygienic conditions (Barus,1969; Petrak, 1969 and Davis *et al.*, 971). The affected birds must have been infected by swallowing the infective eggs of *Ascaridia columbae* which is the causative agent of Ascaridiasis or by inhaling or ingesting the fungus spores, which must have

grown on damp organic material or litter and droppings present in the aviary. Aspergillosis is one of the commonest of all avian diseases and has been reported by Verge (1927), Urbain and Guillot (1938), and O'meara and Chute (1959), being caused by *Aspergillus fumigatus* in both free living and captive birds. Ascaridiasis has also been reported for the LD by Kwaghe (1998) and for the Domestic Pigeon by Guilhon (1947), Kozar (1948), Wehr and Hwang (1964), Melendez and Linguist (1979). Other factors that may affect the survivorship of birds in captivity may include; improper feeding and shelter, inadequate space, over crowding, other diseases and predators.

Theft can be a major problem to the survivorship of the birds in captivity. This also shows the economic value of these birds, since the birds must have been stolen for food or for sale as source of income. Humans who are a threat to these birds in the wild also tend to follow them into captivity. There is thus the need to conserve or domesticate these species to guarantee constant source of food or money and to avoid man being a constant threat to the birds in the wild.

5.5 CONCLUSIONS

From the present study, the following conclusions can be made. The columbid species studied feed on the seeds of both cultivated and wild plants supplementing these with animal matter like insects and some other invertebrates.

Some of the species, for example the RD, feed on one food item at a time while some like the LD feed on a variety of food items at a time.

The amount of food consumed in captivity is directly related to the body size of the birds.

Maize and guinea corn are the most preferred foods for the species studied under captive conditions.

In captivity, these species exhibited some breeding behaviours observed in the wild. The exhibition of these behaviours suggests that the birds may breed in captivity, although the non-display of certain behaviours suggests that such breeding in captivity may occur with some difficulty.

The four columbid species may survive in captivity but diseases such as aspergillosis and ascaridiasis may affect the survivorship.

5.6 RECOMMENDATIONS

Based on the result of the present study, the following recommendations can be made.

That further study be conducted on the possible breeding of these species in captivity particularly in our zoological gardens and homes. Such a study should include the determination of the actual conditions and requirements necessary for such captive breeding or domestication since the present study could only provide baseline information.

Based on the information provided by this study on food and feeding

habit, as many as are interested, be encourage to try to domesticate these species as a source of food and income or for other reasons of interest, particularly as the feed on wild seeds which can be gathered from the wild as well as on disposed food items from our tables and kitchens which are less costly.

Since the species studied have been found to supplement their diet with insects and other invertebrates, such animal food items for example earth worms, may be cultivated in the laboratory or fetched from the wild and presented to the birds in captivity.

Further research is needed to determine the actual amount of food required by each species and the actual nutritive requirements of these birds as well as the nutrient composition of each food item other than the cultivated seeds for which this information is known, in order not to over-feed or under-feed the birds, for these may affect productivity. This information may also help in the production of compounded feed whenever the need arises.During feeding in captivity, the birds should be separated into their various species or sizes since they all have different feeding requirements, being influenced by the sizes of their bills. If for any reason, the birds must be kept and fed together in captivity, they should be supplied with enough food of varied sizes to guarantee each species of its own equal share or fed 'ad libitum'.

Maize and guinea corn are recommended for feeding of the birds in captivity since they are the most preferred or most consumed food for doves.

Good management and high standard of hygiene should be implemented as control and preventive measures against aspergillosis and ascaridiasis. Further research be conducted on other possible diseases that may affect the survivorship of these columbid species in captivity or under domestication and how these diseases can be prevented or controlled.

Proper housing and security should be provided to prevent theft or escape of the birds in captivity.

Further research be carried out to determine the survivorship of these birds in captivity and of other factors that may affect survivorship besides diseases and theft, since the time used in determining survivorship in the present study was relatively short.

Further research should also be conducted to illustrate the concept of niche overlap and differentiation and to determine any seasonal variation in food habits between the wet and dry seasons.

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Appendix 1.Food consumption by four species of *columbids* in grammes over 36 days

Seed type / Feeding Period	Maize	Guinea corn	Millet	Cowpea	Amaranthus seed	Spathodea seed	Total consumption per feeding period	Percentage consumption per feeding period
1-6	400.0	400.0	300.0	161.8	103.8	92.6	1458.2	14.3
7-12	400.0	350.2	329.9	222.0	160.8	204.4	1667.3	16.3
13-18	392.8	357.6	320.8	224.7	168.6	210.0	1674.6	16.4
19-24	400.0	394.4	358.5	226.5	204.8	164.6	1748.71	17.14
25-30	382.0	387.3	320.8	272.8	249.5	221.6	1834.0	17.9
31-36	394.4	351.6	314.6	280.5	273.5	205.2	1819.7	17.8
Total consumption per seed	2369.2	2241.1	1944.5	1388.4	1161.0	1098.4	10202.6	-
Percentage consumption per seed	23.2	21.9	19.1	13.6	11.4	10.8	-	100.0
Degree of preference	1.4	1.3	1.1	0.8	0.7	0.6	-	-

Appendix 2. Food consumption by five Laughing Doves (*S. senegalensis*) in grammes over 36 days

Seed type / Feeding Period	Guinea corn	Amaranthus seed	Millet	Spathodea seed	Maize	Cowpea	Total consumption per feeding period	Percentage consumption per feeding period
1-6	63.0	34.9	19.3	22.2	21.7	15.3	176.4	11.1
7-12	33.5	47.7	37.4	42.5	38.8	22.9	222.9	13.9
13-18	35.1	46.3	54.2	52.2	40.0	33.5	261.2	16.4
19-24	57.3	54.9	38.0	43.1	50.7	36.0	280.0	17.6
25-30	54.0	56.3	59.5	50.8	42.9	36.2	299.6	18.8
31-36	73.1	62.3	73.2	54.2	51.5	38.1	352.4	22.1
Total consumption per seed	316.0	302.4	281.6	265.0	245.6	182.0	1592.5	-
Percentage consumption per seed(%U)	19.8	18.9	17.7	16.6	15.4	11.4	-	100
Degree of Preference (U/A)	1.2	1.1	1.1	1.0	0.9	0.7	-	-

Appendix 3. Food consumption by five Red-eyed Doves (*S. semitorquata*) in grammes over 36 days

Seed type / Feeding Period	Maize	Guinea corn	Millet	Cowpea	Amaranthus seed	Spathodea seed	Total consumption per feeding period	Percentage consumption per feeding period
1-6	24.7	62.1	31.7	33.7	23.0	12.4	187.6	9.0
7-12	63.2	47.4	55.1	45.5	30.7	40.4	282.2	13.6
13-18	83.3	68.4	59.4	53.3	54.0	42.2	360.6	17.4
19-24	70.0	70.0	77.4	51.2	50.5	45.0	364.1	17.6
25-30	100.0	89.2	69.4	52.1	64.2	50.6	425.5	20.5
31-36	100.0	91.9	82.4	61.4	67.7	51.7	455.1	21.9
Total consumption per seed	441.2	429.0	375.5	297.1	290.0	242.3	2075.0	-
Percentage consumption per seed(%U)	21.3	20.7	18.1	14.3	13.9	11.7	-	100
Degree of preference (U/A)	1.3	1.2	1.1	0.9	0.8	0.7	-	-

Appendix 4. Food consumption by five Mourning Doves (*S. decipiens*) in grammes over 36 days

Seed type / Feeding Period	Maize	Guinea corn	Millet	Cowpea	Amaranthus seed	Spathodea seed	Total consumption per feeding period	Percentage consumption per feeding period
1-6	44.9	62.3	34.7	59.5	27.5	15.4	244.3	09.6
7-12	91.9	98.4	58.8	89.7	54.3	45.8	438.9	17.3
13-18	85.2	79.0	83.0	74.3	71.9	58.5	452.0	17.8
19-24	100.0	98.5	87.9	60.6	67.9	48.3	463.2	18.3
25-30	91.7	80.6	80.7	84.3	73.8	53.1	464.2	18.3
31-36	100.0	82.0	94.9	70.8	68.2	56.1	472.1	18.6
Total consumption per seed	513.7	500.9	440.1	439.2	363.6	277.2	2534.7	-
Percentage consumption per seed(%U)	20.3	19.8	17.4	17.3	14.3	10.9	-	100.0
Degree of preference (U/A)	1.2	1.2	1.0	1.0	0.8	0.6	-	-

Appendix 5. Food consumption by five Speckled Pigeons (*Columba guinea*) in grammes over 36 days

Seed type / Feeding Period	Maize	Guinea corn	Millet	Cowpea	Amaranthus seed	Spathodea seed	Total consumption per feeding period	Percentage consumption per feeding period
1-6	100.0	100.0	100.0	90.0	62.8	26.6	479.3	14.9
7-12	100.0	100.0	100.0	70.1	72.1	56.8	499.1	15.6
13-18	100.0	100.0	100.0	100.0	77.9	76.3	554.3	17.3
19-24	100.0	100.0	100.0	100.0	85.9	68.5	554.4	17.3
25-30	100.0	100.0	100.0	100.0	81.8	74.1	555.9	17.4
31-36	100.0	100.0	100.0	100.0	85.4	73.8	559.2	17.5
Total consumption per seed	600.0	600.0	600.0	560.1	465.9	376.1	3202.1	-
Percentage consumption per seed (%U)	18.7	18.7	18.7	17.5	14.6	11.7	-	100.0
Degree of preference (U/A)	1.1	1.1	1.1	1.1	0.8	0.7	-	-

Appendix 6. Food consumption by each species on each seed type in grammes and percentages over 36 days

Bird species / Seed type	Laughing Dove	Red-eyed Dove	Mourning Dove	Speckled Pigeon	Total seed consumption
Guinea corn	316.0 (19.8)	428.9 (20.7)	500.9 (19.8)	600.0 (18.7)	1845.9 (19.6)
Maize	245.6 (15.4)	441.2 (21.3)	513.7 (20.3)	600.0 (18.7)	1800.5 (19.2)
Millet	281.6 (17.7)	375.5 (18.1)	440.1 (17.4)	600.0 (18.7)	1697.2 (18.1)
Cowpea	181.9 (11.4)	297.1 (14.3)	439.2 (17.3)	560.1 (17.5)	1478.4 (15.7)
Amaranthus seed	302.4 (18.9)	290.0 (13.9)	363.6 (14.3)	465.9 (14.6)	1421.9 (15.1)
Spathodea seed	264.9 (16.6)	242.3 (11.7)	277.2 (10.3)	376.1 (11.7)	1160.5 (12.3)
Total	1592.5 (16.9)	2075.0 (22.1)	2534.7 (26.9)	3202.1 (34.1)	9404.3 (100)

Appendix 7. Polyspecific group feeding of all four species for 36 days
Analysis of variance

Variable V5, Total seed consumption
By Variable V1, Seed type

Source	D.F.	Sum of squares	Mean squares	F-ratio
Treatments	5	258343.5	51668.7	34.5
Residuals	30	44955.7	1498.5	
Total	35	303299.2		

Treatment	Mean	Standard Deviation	Standard Error	Duncan Grouping
Maize	394.9	7.0	2.9	a *****
Guinea corn	373.5	22.8	9.3	a *****
Millet	324.1	19.6	7.9	b ***
Cowpea	231.4	42.7	17.4	c *
Amaranthus seed	193.5	62.3	25.4	d
Spathodea seed	183.1	48.3	19.7	d
Total	283.4	93.1	15.5	

(*) Denotes pairs of groups significantly different ($P < 0.05$)
Means with the same letter are not significantly different

Appendix 8. Analysis of Variance

Variable V5, Total seed consumption
By Variable V2, Days

Source	D.F.	Sum of squares	Mean squares	F-ratio
Treatments	5	15803.2	3160.6	.3298
Residuals	30	28745.9	9583.2	
Total	35	303299.1		

Treatment	Mean	Standard Deviation	Standard Error	Duncan Grouping
Maize	243.0	142.2	58.1	a
Guinea corn	277.9	94.9	38.8	a
Millet	279.1	90.3	36.9	a
Cowpea	291.5	104.6	42.7	a
Amaranthus seed	305.7	69.3	28.3	a
Spathodea seed	303.3	66.0	26.9	a
Total	283.5	93.1	15.5	

(*) No two groups are significantly different ($P > 0.05$)
Means with the same letter are not significantly different

Appendix 9. Monospecific feeding of each species for 36 days

Analysis of Variance

Variable V6, Total seed consumption
By Variable V1, Seed type

Source	D.F.	Sum of squares	Mean squares	F-ratio
Treatments	5	12510.1	2502.0	4.5
Residuals	138	76920.5	557.4	
Total	143	89430.6		

Treatment	Mean	Standard Deviation	Standard Error	Duncan Grouping
Guinea corn	73.5	22.2	5.6	a **
Maize	71.0	27.6	4.5	b *
Millet	67.6	26.2	5.3	b *
Cowpea	59.3	27.4	5.6	c
Amaranthus seed	56.7	18.6	3.8	c
Spathodea seed	46.4	17.5	3.6	c
Total	62.4	25.0	2.1	

(*) Denotes pairs of groups significantly different ($P < 0.05$)
Means with the same letter are not significantly different

Appendix 10. Analysis of Variance

Variable V6, Total seed consumption
By Variable V2, Days

Source	D.F.	Sum of squares	Mean squares	F-ratio
Treatments	5	10062.2	2012.4	3.5
Residuals	138	79368.4	575.1	
Total	143	89430.6		

Treatment (Days)	Mean	Standard Deviation	Standard Error	Duncan Grouping
1-6	45.3	28.8	5.9	a
7-12	59.3	24.9	5.1	b *
13-18	65.2	22.8	4.6	b *
19-24	66.2	23.9	4.9	b *
25-30	69.1	20.9	4.3	b *
31-36	69.5	21.8	4.4	b *
Total	62.4	25.0	2.1	

(*) Denotes pairs of groups significantly different ($P < 0.05$)
Means with the same letter are not significantly different

Appendix 11. Analysis of Variance

Variable V6, Total seed consumption
By Variable V3, Bird species

Source	D.F.	Sum of squares	Mean squares	F-ratio
Treatments	3	49062.8	16354.3	56.7
Residuals	140	40367.7	288.3	
Total	143	89430.5		

Treatment	Mean	Standard Deviation	Standard Error	Duncan Grouping
Laughing Dove	44.2	14.3	2.4	a
Red-eyed Dove	46.1	14.5	2.4	a
Mourning Dove	70.2	21.2	3.5	b **
Speckled Pigeon	88.9	17.2	2.8	c ***
Total	62.4	25.0	2.1	

(*)Denotes pairs of groups significantly different ($P < 0.05$)
Means with the same letter are not significantly different