THE GRAIN-EATING BIRDS OF SUB-SAHARAN AFRICA

IDENTIFICATION, BIOLOGY AND MANAGEMENT

an NRI Publication

NATURAL RESOURCES INSTITUTE
The University of Greenwich

ODA

Birds are not normally viewed as pests but, in the case of cereals and soft fruit, both resident and migrant species can cause significant losses. In sub-Saharan Africa, the expansion of the area under cereal crops, especially in displacing the normal food plants of the grain-eating birds, has exacerbated the problem and rendered ineffective many traditional methods of crop protection. Environmental considerations mean that management strategies must now be tackled at the government and community level, rather than solely by the individual farmer.

Grain-eating Birds of Sub-Saharan Africa provides the background information needed for an understanding of the birds which cause the damage, their identification, biology and feeding habits. It also presents the variety of techniques necessary to assess the likelihood and extent of crop damage from season to season and so facilitate the choice of cost-effective methods and levels of control.

Intended as a comprehensive reference for policy makers and extensionists, this handbook will also be useful to all public and private sector management staff who are involved in loss assessment and the implementation of control methods in cereal production.

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ERRATA

Page 17. para 3, line 9, for '*kramer*' read '*krameri*'.
Page 42. **Perching Birds.** para 2, line 1, insert 'which' after 'families'
Page 55. Magpie Mannikin. line 1, insert 'common' after 'less'.
Page 60. **Quelea Birds**. para 2, line 3, delete 'the' before 'wild'.
Page 133. **Lethal Control**. para 2, line 8, change 'cover' to 'covering'.
Page 146. 2nd line change 'p. 154' to 'p. 156'.

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R Allan

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The Natural Resources Institute (NRI) is a scientific institute within the University of Greenwich, and is an internationally recognised centre of expertise in research and consultancy in the environment and natural resources sector. Its principal aim is to increase the productivity of renewable natural resources in developing countries in a sustainable way by promoting development through science.

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Cover Illustration: The Red-billed Quelea – *Quelea quelea* (S. Lauer)

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Foreword

As soon as humans first became farmers and began cultivating the early varieties of cereals as their staple foods, they found themselves competing for this new resource with a vast community of pests and pathogens that had always naturally exploited the wild grasses from which these novel crops were derived. Fungi, insects, rodents and even larger mammals continue to claim a significant share of grain crops today, but few appear as highly visible and persistent as the many species of specialised granivorous birds that occur wherever ecological conditions are suitable for cereal cultivation.

Each major region of the world harbours one or more bird species that seem pre-adapted to become pests of cereal crops. Africa seems particularly unlucky. It is a vast continent, one-third of whose vegetated area is open woodland/savanna grassland supporting a rich diversity of seed-eating birds at high population densities, that are immediately on hand to take advantage of cereal crops planted there. Much of the remaining area of Africa that is closed-canopy woodland or forest is also periodically cleared for farmland, often to grow cereals, and in the process creates a savanna-like environment that is soon invaded by these same, highly adaptable, savanna granivores.

Africa is especially unfortunate in being home to the most notorious of the world's bird pests, the Red-billed Quelea, *Quelea quelea*, whose depredations of the traditional small-grain cereals, mainly sorghum and millet, have for centuries been the scourge of smallholders and frequently caused them to face starvation. In more recent decades, as large-scale wheat and rice schemes have been developed, damage has extended to these too, causing severe economic losses at a national scale. Bird control operations, and the accompanying research work carried out on quelea ecology and behaviour, on the patterns of crop damage and the reasons for it, and on ways of most effectively controlling the birds and limiting economic losses, have cost millions of dollars over many decades. Much has been learnt, and our efforts at quelea control are undoubtedly much better targeted and more cost-effective than in the past.

To a certain extent, however, the catastrophic but sporadic damage inflicted by queleas has overshadowed the lower level losses imposed year after year by a varied mix of other bird species, many of them only casual crop raiders. Few of the numerous other weavers and sparrows, doves and pigeons, parrots and parakeets, that villagers thoughout Africa must contend with in most years, have attracted the same concern from aid agencies and much less research has been done. As a result, little useful information about these other species filters through to agricultural extension officers in the field, who often have no means even to identify the species concerned, let alone access to the expertise that may help them to assess the damage and respond effectively. Even where queleas are concerned and agricultural officers are well-versed in the appropriate methods of crop damage assessment and bird control techniques, their expertise is often lost when they are transferred to other posts or when departmental re-organisations supervene. As often as not, their successors find their previous training in another discipline unhelpful, the essential technical literature unavailable, and any sort of accessible management handbook non-existent.

This book surely redresses the balance. Dick Allan has spent a large part of his working life as an applied ornithologist involved with quelea research and control over much of Africa. His first-hand experience, not only of queleas but the whole range of other potential pest birds, as well as the difficulties faced by agricultural officers and control teams dealing with bird problems in the field, make him uniquely qualified to write this much-needed handbook. As a source of information on the identification, biology and management of Africa's grain-eating birds, it is unrivalled in its scope. It will be warmly welcomed by everyone concerned with bird pest problems throughout Africa but especially by the man in the field, who now has the 'one-stop' reference point he has long awaited.

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I am particularly indebted to two further people, Hans Dobson, a staff member of NRI and Sasha Lauer. Hans, I thank for his critical review of the spray technology section of Chapter 4, the chapter on control. His expertise in this field has helped to clarify much of the text which might otherwise have led readers astray. My indebtedness to Sasha is for the excellence of her art work in the preparation of all the figures and for her editing of the first draft document. The handbook, deriving from an earlier FAO manual which lacked any figures, has been enlivened and considerably enhanced by the illustrations prepared by Sasha, and her painting of the principal problem birds, the male and female, is outstanding in its execution and accuracy.

Introduction

This handbook is a reference work for agricultural officers and farmers concerned with the problem of protecting cereal crops from the depredations of birds. It is also intended as a source of information for government and private sector management staff who are responsible for assessing the impact of birds on cereal production. Pest management options for reducing losses caused by birds are described in detail so that a choice can be made to alleviate the situation cost-effectively and with minimum environmental impact. It is hoped that teachers of agriculture will also find the text useful.

The study of birds is referred to as *Ornithology* and those who study birds as Ornithologists. Very few, if any, formally trained agriculturists or farmers are familiar with this science in the way that they are familiar with entomology, the study of insects, or more particularly economic entomology, the study of insects as they affect man. This is unfortunate for those harassed by bird problems, but is no doubt due to the limited role that birds play as agricultural crop pests. However, cereal producers in almost every country of Africa south of the Sahara regard birds as major pests and ought to know some ornithology in order to avoid any confusion with damage caused by other pests. It is unhelpful to look on the problem of birds simply as an extension of the insect pest problem. Although similar in effect, it needs to be solved using a distinctly different approach.

The inspiration for the handbook stems from the need for a revision, and wider distribution, of the FAO *Crop Protection Manual: African Grain-eating Birds* which was edited by the author in 1978 and is now out of print. A variety of sources has been consulted in the preparation of the text and a new format has been used. The FAO manual was prepared for a limited area of Africa (from the Sahel* southwards in West Africa to the Sudan in the east) whereas the present work caters for the whole of sub-Saharan Africa. This area of Africa is referred to in terms of its fauna as the Afrotropical Zoogeographical Region or Afrotropical region for short. The northern boundary which separates it from the Palaearctic Zoogeographical Region is not clearly defined but lies between latitudes 18° and 20°N. In the east it swings north to meet the Red Sea at

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* The Sahel is the name given to a narrow belt of savanna vegetation running across the continent roughly parallel to the equator characterised by an annual rainfall regime of some 250–500 mm concentrated in a 4 to 5 month long wet season. It lies between the Sahara desert and the next higher rainbelt, the Sudan savanna.

about 22°N. The whole of Africa south of this line and including all its islands is the area covered by the handbook and is generally referred to in the text as the Afrotropical region.

The Afrotropical region is itself divided into ecological zones which are useful in generalising on the distribution of the birds mentioned in the text. It must be understood that the limits of the areas are broad generalisations based on average annual rainfall and expected vegetation types, each zone merging imperceptibly with its neighbour (see Annex for more detailed information on this topic). Birds, by their very nature, are never strictly confined to any one zone but most of the members of any one species are usually found to occur more commonly in one climatic zone than in any other. The bulk of the small-grained cereals which suffer most from bird damage are grown in the semi-arid areas and hence this is where the majority of the birds referred to in the handbook are found.

The handbook has five chapters covering the following topics: the grain-eating birds, the cereal crops and crop damage, bird pest monitoring, crop protection and, finally, some of the products used in the management of bird pests. The chapter on the grain-eating birds covers many aspects of the identity and biology of the birds known to feed on cereals and makes passing reference to birds which may cause losses to other agricultural crops. Similarly, Chapter 4, which deals with the methods used to protect cereals from birds, also refers to methods which may be used to protect crops other than cereals which suffer economically important losses to birds. The remaining chapters deal exclusively with cereals and their bird depredators, particularly the Red-billed Quelea, *Quelea quelea,* a major pest of cereals in Africa.

Generally speaking, birds are not looked upon as pests of crops except in the case of cereals and certain soft fruits. The reasons for this may be that damage to cereals is usually caused by conspicuous flocks of small birds of various kinds and, in the case of soft fruits, the damage is very obvious and disheartening. The large flocks of grain-eaters descend on cereals after all the tribulations of soil fertility, erratic rainfall, insect pests and weeds have been overcome and a farmer is beginning to assess the yield of grain which he will be reaping. It is easy to understand his response in reaching for a gun or urging his family out to the field to scare away the unwelcome flocks. Tradition holds that this is an annual event to be expected as the cereals ripen and, perennially, steps are taken to ensure that an appropriate response is made. Scarecrows and other devices are put up in the fields or platforms are prepared so that bird scarers can oversee the crop and through noise and movement would-be depredators are frightened off. Such tactics have long protected small fields or plots of cereals and the ingenuity of man has ensured that good farmers have evolved satisfactory methods of protecting their crops from such conspicuous pests. Modernisation has, however, brought greater problems in the conflict between the farmer and the grain-eating birds.

The traditional methods of bird scaring are rendered obsolete as the methods become costly in terms of the manpower required to effectively scare off the marauding birds from large-scale cereal production, both rainfed and irrigated, which are increasingly developed to meet the needs of a growing world population. This is particularly so where cereals are grown in areas which were previously natural grassland. Here birds, which relied on the natural grasses for sustenance, have resorted to living on the cereals, man's high-yielding *cultivars** of the wild grasses planted in their place. In Africa the need to increase the human food supply means that ever greater areas are given over to the cultivation of cereal crops – rice, wheat, sorghum, millet and maize – and more and more schemes of industrial agriculture are developed. Losses to pests must be reduced to a minimum if the huge investment in the development schemes is to be successful and adequate human food supplies assured. In place of the comparatively benign and cost-effective traditional methods of protecting cereals new, potentially dangerous and costly, control methods have been developed which concentrate on destroying the birds causing the damage. The mobility of the birds and their tendency to feed over a wide area means that the problem becomes one of the community or, more usually, the government rather than one of individual farmers.

Generally the birds which feed on cereals are of two types, those which are resident in the area where the crops are grown and those which are migratory occurring only seasonally in the area. The resident, or local, birds have a varied diet which allows them to remain in the one place through all the seasonal changes. Although they may move locally in search of different sources of food they rarely travel very far and, in comparison to the migrants, their numbers, or populations, are comparatively small. The subsistence farmer with a small patch of cereals may be bothered by these birds every season and may suffer a significant loss of yield if he does nothing to keep the birds off his crop. On the other hand, the large-scale farmer is unlikely to suffer significant crop loss from these birds which do not increase in numbers proportionally as the area under crops increases. It is the food available during the leanest season which keeps the number of resident birds in check. The migratory birds, on the other hand, may cause devastating crop losses to both the subsistence and the large-scale farmer, when they are present during the cropping season. Such losses will not occur every season, however, and it is the likelihood of the migrants causing crop damage in any particular season which will determine whether or not reducing the losses would be cost-effective. The likelihood of crop damage from the migrants depends on a variety of circumstances and it is the purpose of this handbook to present the information and methodology necessary to determine this likelihood.

Appropriate measures to reduce the amount of cereals lost to birds cannot be devised unless the problem is fully understood. The handbook brings together as much information as is considered appropriate for an understanding of the birds which cause the damage, their identification, biology and feeding habits and the variety of techniques which have been devised for their management. The information is set out as training material for personnel involved at different levels in cereal production.

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* A cultivated variety of a wild plant.

1

The Grain-eating Birds

INTRODUCTION

There are many species of grain-eating birds in Africa and most of them, at one time or another, feed on cereal crops. It is doubtful if any prefer the crops to the wild grains on which they have usually been nurtured but if crops are ripening when other grains are in short supply, as is often the case with irrigated crops, then they are highly attractive. It is ironical, but often the case, that birds are not attracted to good stands of crops but to those fields which are poorly cultivated because they offer a rich variety of weed seeds and insects in addition to the cereal grains available.

Damage by birds may occur at all stages of the growth cycle of cereals. At planting time, the seeds are close enough to the soil surface for them to be easily extracted. A common example of this is when the Helmeted Guineafowl,[1] *Numida meleagris*, or francolin, *Francolinus* spp.,[2] scratch up the seeds in the same way as does their close relative the domestic hen. Birds with probing bills, such as cranes, Gruidae, and delving bills, for example the familiar, and commonly domesticated, Egyptian Goose, *Alopochen ægyptiacus*, follow the planter and devour the seeds as they are sown.

During the growing stage, plant leaves and shoots can be eaten by a number of different species. In rice fields the most notorious is probably the White-faced Whistling Duck, *Dendrocygna viduata*, which often grazes on rice seedlings at night. Overall, however, the greatest damage is undoubtedly done at the fruiting stage.

One reason why birds feed so readily on cereals in Africa is that the cereals are, for the most part, cultivated forms of the wild grasses which occur naturally in the vast grasslands covering much of the continent. The most important and widespread cereal crops, sorghum and millet, are indigenous to the continent and have been cultivated there for centuries. Cultivated rice, although originating from Asia, has closely related species growing wild in inundated areas of Africa. Wheat and maize are introduced crops with grains which are, when ripe, larger than the natural seeds on which most of the grain eaters feed.

Certain birds are adapted to life in the grasslands where they take advantage of the large quantity of seeds produced. Some which may feed on cereals, such as weavers, Ploceidae[3], canaries, *Serinus* spp., doves, *Streptopelia* spp., and starlings, Sturnidae, also feed on other cultivated seed crops such as oilseed rape and sunflower. There are a few birds, however, which depend almost entirely on grass seeds for their sustenance.

Amongst these, the Red-billed Quelea, *Quelea quelea,* is the most notorious, most numerous and probably the most dependent. This is the bird which causes the greatest amount of damage to cereals and hence is the bird which is most frequently, and in the greatest detail, referred to throughout the handbook.

A BIRD DEFINED

A bird is a warm-blooded vertebrate with a body covering of feathers. Its fore limbs are extended into elaborately mobile planes by specialised flight feathers, forming the wings which enable it to fly. This ability limits the bird to a body form which is streamlined to reduce air resistance when flying but, in most birds, is also balanced and mobile on the ground. These limitations of form give the bird its unique shape which has been copied by man when developing flying machines! The head is in the form of an egg pointing forwards with a hard bill, in place of a mouth, at the pointed end where it forms an air shearing nose-cone. The body is also egg-shaped with the tapered end at the rear terminating in a steering rudder, the tail. The bird alters from a horizontal flight shape on landing by raising its head and tilting its body into a more upright stance. This allows it to hop or run about on two legs on the ground or in vegetation.

The skeleton is remarkably light but strong owing to the principal bones being hollow, air-filled and strengthened with internal bony struts. The construction is of the standard vertebrate type consisting of a backbone supporting a skull at one end and a tail at the other. The jaws are extended into the form of a bill sheathed in a horny covering. A pectoral girdle supports the fore limbs, modified as wings, and a pelvic girdle supports the hind limbs, the legs. The legs are sturdy enough to support the comparatively lightweight body on land and are retracted, or trailed under the tail, during flight. In some birds, notably the web-footed ducks, the feet can be used as air brakes when landing, and paddles when swimming. The size of the bird and the form of the bill and of the feet are the principal characters by which different birds are seen to be related and hence grouped into distinct orders. An identification key to the orders is to be found later in this chapter.

The rib cage is suspended from the backbone containing the vital organs but is uniquely joined by a keeled sternum to which the principal flight muscles are attached. The backbone is modified to accommodate two requirements necessary in birds. First the neck is usually made up of numerous very mobile vertebrae. This compensates for the poor mobility of the eyes, the head being able to turn through a wide arc, in some cases almost 360°. Secondly, the thoracic and the sacral vertebrae are strongly fused to form platforms for the comparatively rigid pelvic and pectoral girdles. The art of flying is enhanced by the reproductive strategy of the female which lays an egg in a nest to be brooded and hatched allowing it to rear a number of young without being encumbered by the extra weight of embryos which would hinder its ability to fly. There are no external sexual organs in the majority of birds so that the streamlining is not compromised. Excretion and copulation are effected through a common external opening, the *cloaca*[4].

MORPHOLOGY

Topography of a Bird

The topography (description of the external features) of a bird is named in a particular way in the literature and it is necessary to use the correct terms when describing a bird, particularly the colour of the plumage, in order to be sure of its identity. The names of the parts of a bird are illustrated in Figure 1.

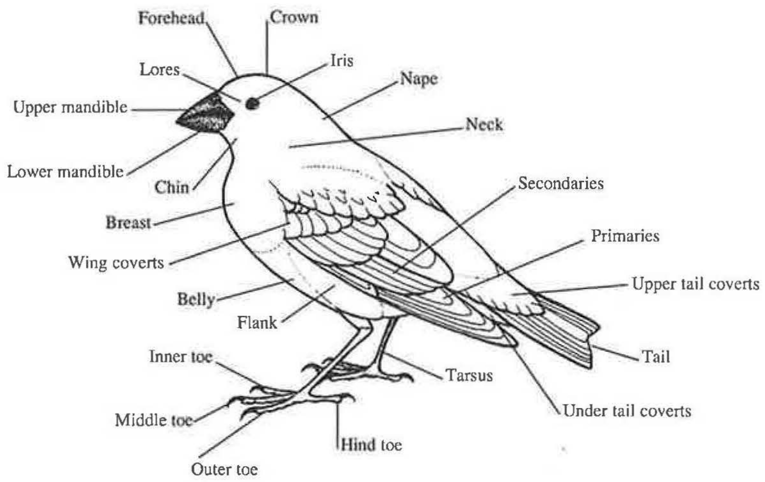


Figure 1 The topography of a bird

When identifying a bird, apart from the description of the plumage, it is essential to give an indication of the size. Size is best judged by making a mental comparison of the bird being identified with a familiar one of known size. The following table gives an example of the size classes of what should be well known birds into which the unknown bird may be placed.

SIZE	CLASS	EXAMPLE
70–80 cm	Very large goose-sized	Spur-winged Goose *Plectropterus gambensis*
50 cm	Large chicken-sized	Pied Crow *Corvus alba*
25 cm	Medium to large dove-sized	Mourning Dove *Streptopelia decipiens*
20 cm	Medium starling-sized	Blue-eared Glossy Starling *Lamprotornis chalybaeus*
15 cm	Small to medium sparrow-sized	Village Weaver *Ploceus cucullatus*
12 cm	Small quelea-sized	Red-billed Quelea *Quelea quelea*
10 cm	Very small mannikin-sized	Bronze Mannikin *Lonchura cucullata*

A reasonably accurate judgement of the size of a bird can be made if this table is memorised and the birds used as examples are known. Intermediate sizes can be used to extend the table by, for example, recording a bird to be larger than a weaver but smaller than a starling, i.e. about 17.5 cm in size.

Plumage

The principal distinguishing feature of a bird is its feathers which make up the plumage or body covering. They are remarkably light-weight, waterproof and excellent insulators. This is important as birds are warm-blooded and need protection from rain, cold and the sun. Plumage is divided into three major components, the flight feathers, the contour feathers and the down feathers. In all grain-eating birds the plumage is renewed (*moulted*) at least once every year.

The feathers of the plumage come in a variety of forms. All are growths from papillae in the skin and are made of keratin, the same substance which forms, for example, the hard part of a man's heel (the product of dead *epidermal*, or outer skin, cells). Structurally they have a common form: a stem, or *rachis*, which may, or may not, have branches (*barbs*), usually in two opposite rows flattened in the same plane, forming the *vane* of the feather. The principal, or contour, feathers occur in two basic forms depending on whether the barbs are free, *plumae*, or united, the *pennae*, by rows of secondary branches, or *barbules*. The barbules occur in two rows on each barb in the same plane as the vane and interlock with the barbules on the neighbouring barbs thus stiffening the vane (Figure 2). The flight feathers of the wing, the *remiges*, and the tail feathers, the *rectrices*, are all rigid pennae as are the *coverts*, the feathers which cover their bases conferring perfect streamlining to these organs of flight. The feathers of the head, body and legs, the contour feathers, are arranged in rows, or tracts. The contour feathers are usually pennae but, in some birds, there are mixtures of the two. Other feathers which are of less importance are the down feathers, *plumulae*, which form an undercoat in many species, *semiplumae*, which are pennae with downy bases, hair-like feathers, *filoplumes*, and specialised stiff, bristle-like feathers, *vibrissae*. One final component of the plumage, which only occurs among parrots amongst the grain-eating birds, is powder down. Powder down is a soft downy material which gives off a dusty substance used by parrots in cleaning their feathers.

Moult

The feathers of birds become worn with time and thus need to be replaced. The process by which the feathers are renewed is called the moult, old feathers are pushed out by the growth of new feathers. The moult is not a simple replacement of a worn feather by a new one as, and when, necessary but is a periodic event controlled by hormones. There are two types of moult: a complete moult when all the feathers are replaced and a partial moult when only some of the feathers are replaced. Most birds undergo a complete moult annually. In many species there are two moults: one into, and the other out of, a distinctive breeding plumage. In such species, male birds are generally more elaborately adorned than the females in the breeding season, moulting to resemble the females when in non-breeding plumage.

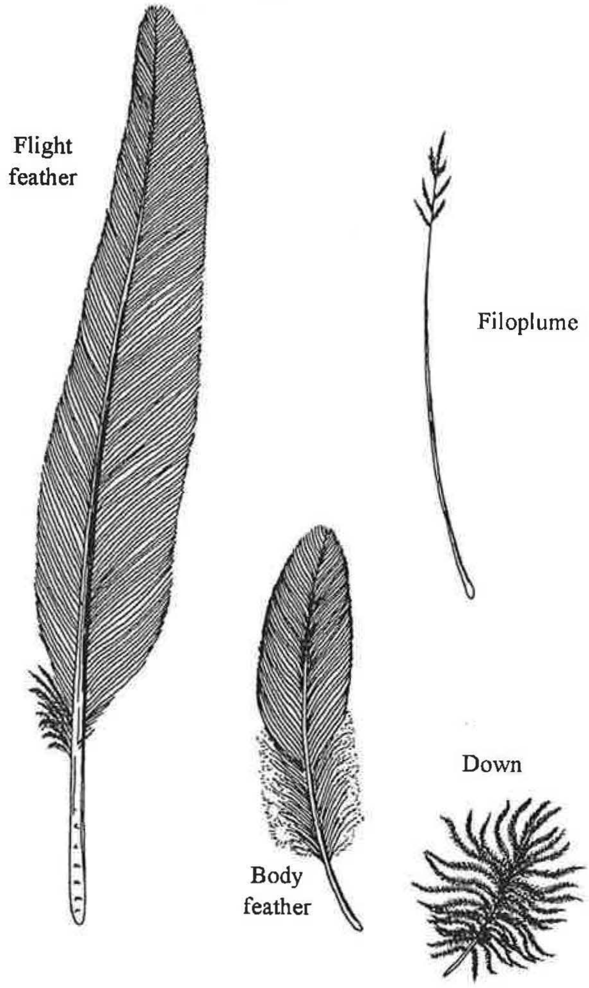


Figure 2 General feather types

New feathers first appear as a *pin,* which is the new feather enclosed in a sheath. The sheath breaks down from the tip allowing the vane to unfold gradually as the feather grows (Figure 13, p. 108). The old feather is pushed out by the developing pin but the nestling feathers may continue to bear the down feathers, which they are replacing, from their tip.

A typical moult sequence is that of the Red-billed Quelea. The chick hatches from the egg almost naked but soon develops a sparse downy covering. This is gradually pushed out by the pins of the nestling feathers some of which continue to carry the downy feather attached to their tip. The nestling begins to venture from the nest while the new plumage is still developing. However it does not quit the nest, or *fledge,* until the flight feathers are fully grown and it is able to fly. At this stage, the *fledgling* stage, all the down has been worn off except from the head and tail which may bear a few tufts of down. Although similar to adult plumage, fledgling plumage is less deeply pigmented, much weaker (darker coloration due to melanin pigmentation is believed to confer greater strength to the keratin of adult feathers) and starts to be replaced soon after the fledgling leaves the nest. This is the *juvenile moult,* and is a complete moult of all the nestling plumage. Some moult directly into breeding plumage but generally juveniles moult into the typical non-breeding plumage. The juvenile moult lasts through the current breeding season and most of the following, non-breeding season.

At the start of the next breeding season, the juvenile undergoes a *pre-nuptial moult* (i.e. before mating) of the body feathers only. The first year adult, or *sub-adult,* whether or not it breeds, starts a *post-nuptial* moult of the entire plumage as the breeding season comes to an end and finishes towards the end of the non-breeding season. Now adult, the Quelea will continue the sequence of a pre-nuptial moult followed by breeding then a post-nuptial moult through the non-breeding season.

A moult which does not result in the replacement of old feathers by new ones is that of the *brood patch.* The brood patch is the name given to the bare patch of belly, formed between the ventral feather tracts, where down feathers are moulted during the breeding season.

The Bill

It is only the bill, the eyes and the feet of a bird which are not generally covered by feathers. The bill is a form of mouth unique to birds and some primitive mammals. It consists of an upper *maxillary* bone covered with a horny shield like a fingernail and a lower *mandible* similarly sheathed. The upper shield has a pair of holes in its wider end, the *nares,* or nostrils. Birds breathe through the bill, either directly when this is open or indirectly through two slits or holes (the *nares*) in the upper mandible. The horny sheaths have cutting edges but no teeth, the upper maxilla fitting over the mandible or meeting it along its length. The bill in seed-eaters is hard, pointed and usually deep at its wider end. The maxilla carries the nostrils close together high on its deeper part. Inside the bill the maxillary bone forms a hard palate at the outer end and a soft palate inwardly. The mandible in grain-eating birds houses the tongue and is hinged to the skull allowing a very wide *gape,* the name for the expanse of the opened mouth parts (see Figure 5).

The Wings

The fore limbs are modified into wings and are the most notable feature, distinguishing the bird from all other vertebrates except bats. However, the skeletal support of the wings is very different in birds and bats despite both being based on the standard pattern for vertebrates. In a bird the flight feathers are carried on the forearm and modified bones of the palm, three fingers only playing a minor role in flight, whereas in bats it is the greatly elongated fingers which support the wing membrane.

The external appearance of the wing is greatly altered by the covering of feathers but when partially opened, the pattern is fairly clear (Figure 3). The leading edge of the wings is covered with small feathers, the *marginal coverts.* These in turn cover, both above and below the wing, the bases of successively larger feathers (the upper and under wing coverts) in tiled rows until the large powerful flight feathers (the *remiges*) are exposed. The flight feathers are in particular groups according to which part of the wing they are connected. The innermost ones (the *tertials*) are attached to the upper arm. They are few in number (usually 3 or 4), long, pointed and cover the gap between the true flight feathers and the trunk of the bird's body. The middle and outer rows are the true flight feathers (the *secondaries* and *primaries* respectively) and are attached to the forearm and hand including the second and third fingers. The secondaries are usually shorter than the longest of the tertials and wider with more rounded ends. The

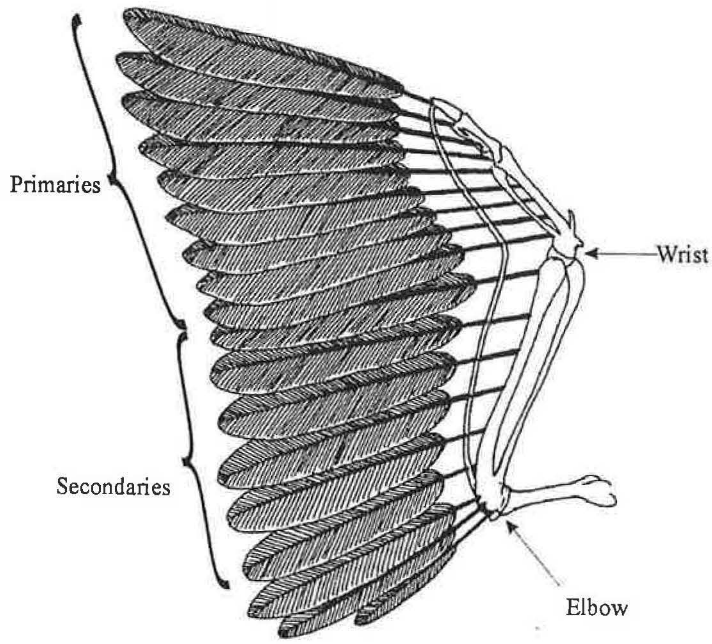


Figure 3 Structure of the wing of a bird (based on a quelea)

primaries generally increase in length outwards from the last secondary to form the point of the wing. They are nine or ten in number in most birds and are long, strong and more pointed than the secondaries. The first finger of the hand carries a few feathers which form the bastard wing (or *alula*). This mini-wing, on the last joint of the main wing, forms a slot in the leading edge when raised and is generally used to prevent the bird from stalling (losing lift) when landing.

The Legs

The unfeathered part of a bird's leg, the most obvious part, is basically equivalent (*homologous*) to a mammal's foot, not its lower leg. This can be seen by comparing the leg to that of a man (Figure 4).

The thigh (the *femur*) is contained within the body wall, as is the forward-pointing knee (Figure 5). It is invariably feathered, although very lightly in the case of the Ostrich. The lower leg (the *tibiotarsus*) is generally feathered, and appears to be the upper leg or thigh although it terminates in a backward pointing 'ankle'. The bones of the ankle and foot are reduced in number, modified and elongated as the *tarsus*, or 'leg', which is covered in scales in place of feathers (exceptions are the owls and sandgrouse which have feathered tarsi). The toes are generally four in number, three directed forwards and one, the first or *hallux*, directed backwards.

The majority of the grain-eating birds are members of the Order Passeriformes, the Perching Birds. The form of the foot in the Order is specially adapted for perching on, or gripping, slender branches, twigs, reeds or grass stems. The muscles and tendons of the leg are specially adapted so that the grip of the toes automatically tightens when the bird squats down on a perch. The grip can only be released when the bird raises itself up from the squatting position. Thus the grain-eaters in this Order of birds can

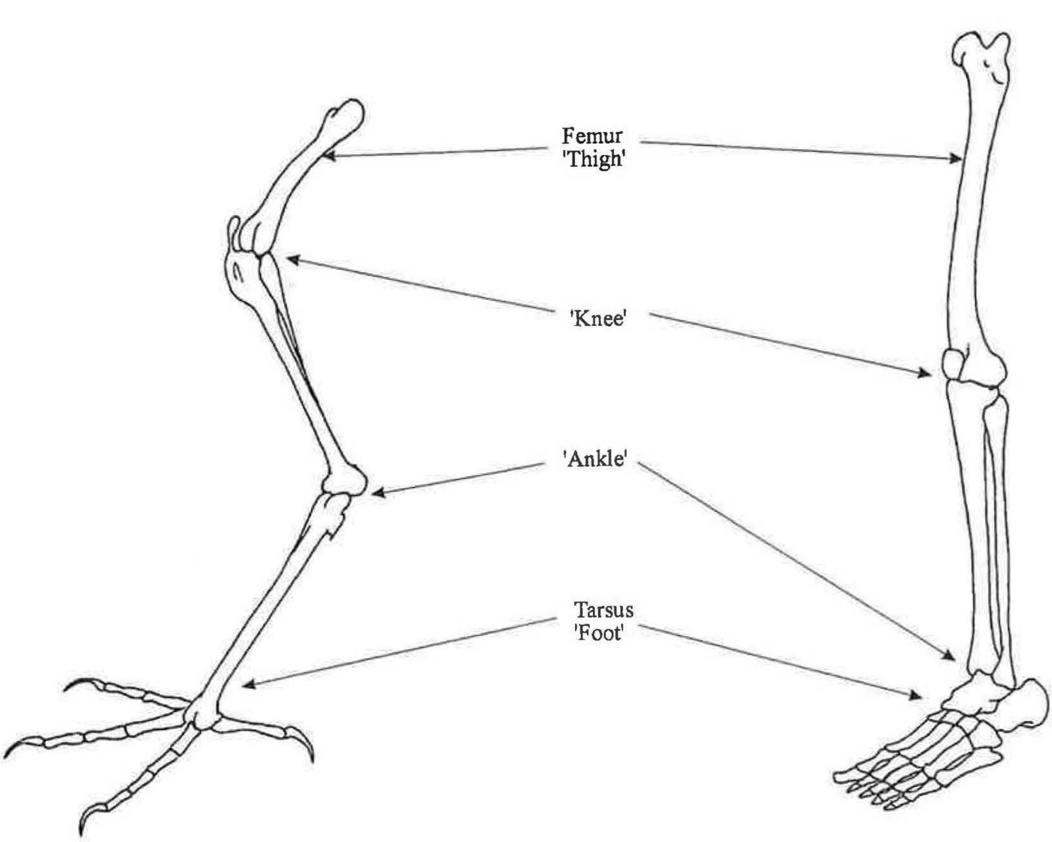


Figure 4 The leg of a bird in comparison with the leg of a man

grip the seed heads of cereals while removing the grains, build elaborate nests with grass blades and roost, or sleep, while perched on slender branches or reeds and grasses.

The Eye

Sight is the most developed sense of birds. The eye of a bird is round in shape with a narrow iris surrounding the black pupil (Figure 5). The iris is coloured and this colour is sometimes used to distinguish otherwise similar species, for example the Masked Weaver, *Ploceus velatus*, and the Lesser Masked Weaver, *P. intermedius*, can be distinguished readily by 'eye' (iris) colour; the former red and the latter pale yellow. The eye has an upper and a lower lid generally each bearing a single row of very small feathers on the thickened leading edge. A *nictitating* membrane is hidden under the lids to the front of the eye and periodically sweeps backwards across the eye to keep it clean.

Birds have a wide field of view. This is due to the eyes being comparatively large and set to the side of the head, instead of to the front as in man. Consequently the grain-eating passerine can see about twice the total field seen by man (some 250° compared with 120°). However, where the image seen by each eye overlaps, giving binocular vision, the situation is reversed. A passerine can see a field of some 35° only (this is approximately the field seen by an observer looking through 8-times magnification binoculars) whereas man has binocular vision through about 60°. As the eyes are virtually immobile within their sockets, the grain-eater must move its head in order to see with both eyes in this narrow binocular field (Figure 6). In contrast hunting birds,

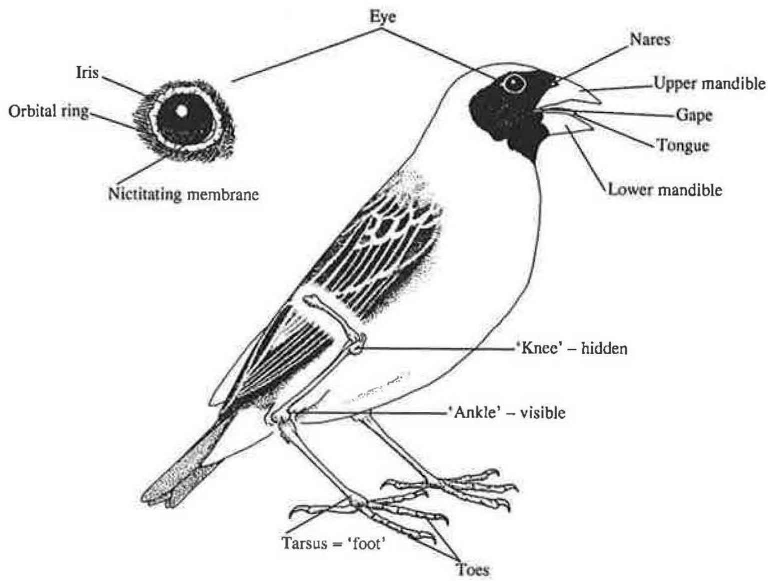


Figure 5 The eye, beak and leg of a bird (based on a quelea)

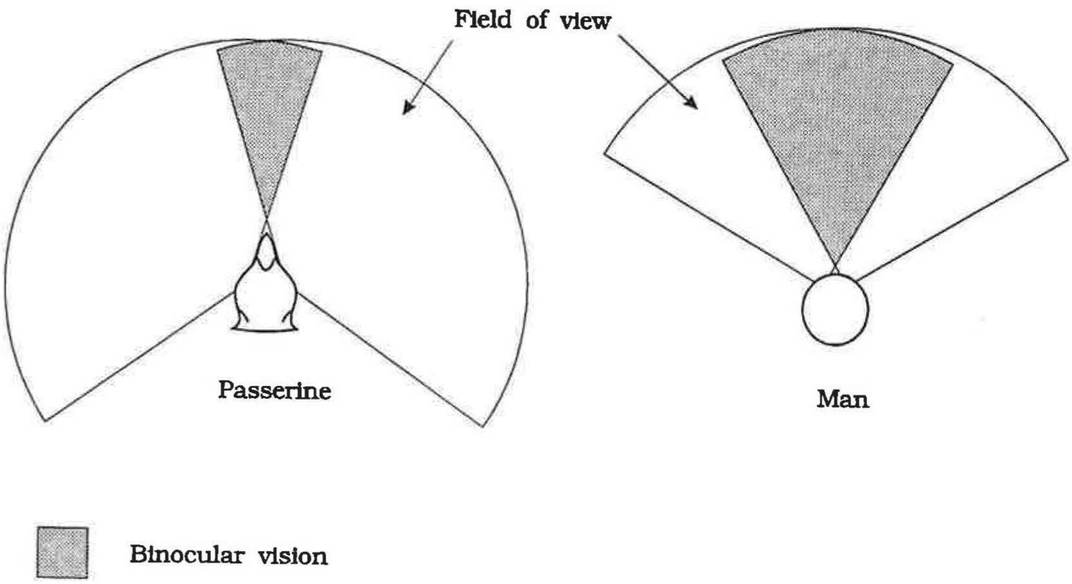


Figure 6 The field of view of a passerine compared to that of a man

such as birds of prey *(raptors)* and insect-eaters *(insectivores)*, have eyes which are more frontally placed giving them wider binocular vision similar to that of man. The sharp-sightedness, or *visual acuity*, of grain-eating birds is comparable to that of man but that of raptors is about eight times more acute.

The Ear

There are no external ears although some birds may have tufts of feathers which look like ears. A simple earhole is protected by a ring of modified contour feathers and hidden under the *ear coverts*, a group of feathers which cover the ear opening (Figure 7). The coverts can be raised to expose the earhole. Bird song, calls and alarms play a major part in the lives of birds so hearing is an important faculty. The sound frequencies heard by birds are similar to those heard by man although in most species the range of sound heard may be somewhat less than that heard by man.

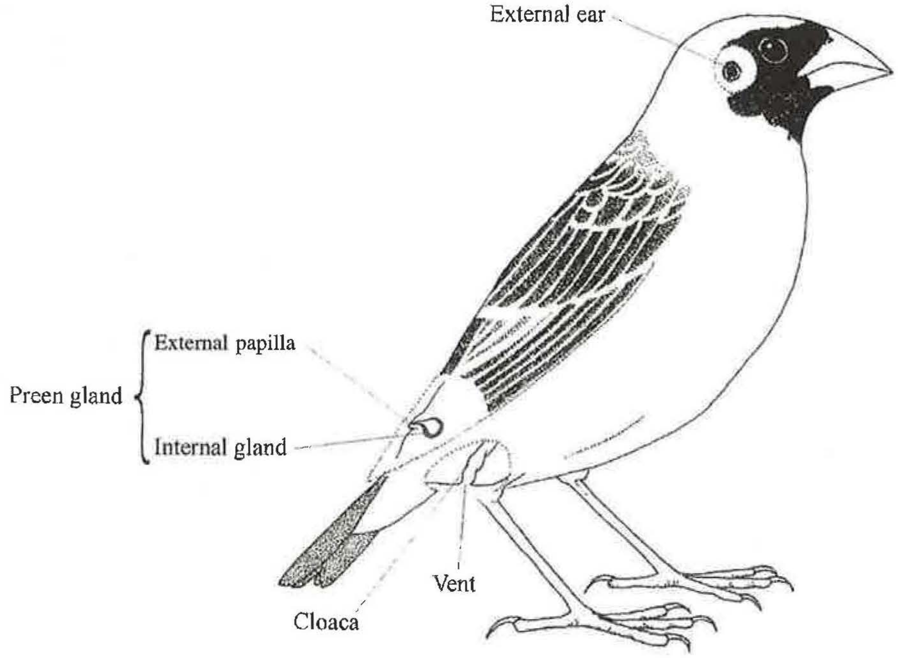


Figure 7 The ear, vent and preen gland of a bird (based on a quelea)

The Vent

The vent is the external opening of the cavity (*cloaca*) into which the excretory and egg (*oviduct*) or sperm (*vas deferens*) ducts open (Figure 7). It is surrounded by a bare patch of skin, markedly distended in females at the time of egg laying. Normally the vent is well concealed by feathers and is only exposed when the bird defaecates. During copulation, the cloaca in both sexes is everted, bringing the oviduct and the sensory papillae surrounding the vas deferens into contact for the transmission of the sperm. In some birds, part of the cloaca is modified into a penis-like organ (for example in the family Anatidae, the ducks and geese).

The Preen Gland

Feather maintenance is a daily preoccupation of birds. A major part of the maintenance is the 'oiling' of the feathers with a secretion from the preen gland located on the lower back at the base of the tail. The gland opens through a papilla of bare skin well hidden by the feathers of the upper tail coverts (Figure 7).

BIOLOGY

General Introduction

An important part of the study of birds which may cause damage to agricultural crops is the description and delimitation of the type of country in which the birds prefer to live (their *habitat*), and their way of life within these areas – in other words their natural history.

The world-wide distribution of birds is considered in terms of distinct zoogeographical regions. The continent of Africa belongs to two regions: that part which is south of a line between the 18° and 20°N latitude (south of the Ahaggar and north of the Aïr and Ennedi mountains) is in the Afrotropical region. The remainder of Africa is in the Palaearctic region which includes all of Europe, the Arabian Peninsula and most of Asia north of the tropic of Cancer.

This handbook is concerned with birds occurring in the Afrotropical region, which may be divided into two major groups according to their place of origin: the inhabitants which breed in the region and the visitors, the palæarctic migrants, which breed elsewhere. The palæarctic migrants travel north across the Sahara every year to breed in the northern hemisphere during the long-day summer season. When the days begin to shorten (autumn) the migrants travel back to the Afrotropical region where they remain until the inherent rhythm of the birds' internal clock dictates the time for the return migration northwards to the palæarctic where the days are lengthening once more.

The birds which breed in Africa do not necessarily spend their lives in one place or in one country. Some, notably the Quelea, also migrate but only within the Afrotropical region. Grain-eating birds move over short or long distances to where their food supply is most plentiful. As the quantity of grains available to the birds at any one time in any one area is dependent on the rainfall in that area, it can be seen that the birds move from one area to another according to the seasons of rainfall.

Birds essentially have two crucial habitat requirements. First and foremost they need a place where conditions are suitable for them to reproduce successfully and secondly, a place where they can survive when the conditions become severe. It is unusual for both conditions to be met in the one place. In the case of the palæarctic migrants the first requirement is met in the northern, long day summer months and the second in the Afrotropical region. This means the migrants have only one breeding season in the year although they may rear more than one brood during the season. The Afrotropical inhabitants, on the other hand, may move from place to place two or more times in the year determined by the number of alternating wet and dry seasons. Grain-eating birds generally breed towards the end of the rains when grains are developing in the grass heads. Thus the inhabitants may have more than one breeding season in the year.

All grain-eating birds are gregarious, living together in small groups (parrots) or large flocks (queleas). When the flocks assemble to breed they require a good site where they can build their nests, sufficient nest-making material, a good source of drinking water and a plentiful food supply on which to support themselves and raise their young. During the dry season, the requirements are for a sufficient food and water source and a safe refuge for the night (the roost site).

Food and Feeding Habits

The birds which feed on grain crops in the field cannot depend on this food source for any length of time. The grain is only available for a short period in most areas although cropping can be prolonged if the rains are of more than 4 months duration. In the Acacia steppe, where most of the small grain cereals are grown, the crop raiders must find some other food to keep them going between cropping seasons. That is unless they can follow the seasonal rain belt as it advances in its annual journey north and south over the continent. However, it is not possible for any population of grain-eaters to do this continually.

The period when the crops are ripening is the season of most plentiful food for the birds and is the reason that they breed at this time. Breeding includes nest building, courtship and mating, egg laying, incubating and finally feeding the young. All this requires extra energy above that used for daily maintenance. Inevitably a period of recovery is necessary after breeding and if the birds need to have the extra energy to undertake a long journey to catch up with the rain belt they must have a good food supply. Only a few particularly specialised birds can manage to follow the rain belt. Even they, however, are hard pressed to do more than enjoy two cropping seasons at the most, and hence raise two clutches during one breeding season.

There are other factors which ensure that no grain-eaters rely solely on the crops. No grain-eaters feed their young on grains during the first few days after they hatch from the egg. Insects, soft seeds other than cereals, and fruit are commonly fed to the newly hatched nestlings and some grain-eaters, the pigeons, feed their young on a secretion of *crop milk*, a cheesy substance secreted in the crops of both parents.

Outside the breeding season there are many alternative sources of food. Those birds which feed almost exclusively on grass seeds can find them readily on the parched earth where they were shed towards the end of the rains. Although easily found, the grass seeds are sought by many other granivores throughout the dry season, day and night. Harvester termites and ants and a variety of small rodents are the main foragers which compete with the birds.

Migration

One of the advantages which birds have by virtue of their possession of the power of flight is the ability to move far from an area where food is short and seek a more benign habitat where the food situation is better. Through evolutionary time the habit has become more prevalent in some species than in others. Different degrees of the migratory instinct have evolved to meet different requirements in different species.

In Africa all stages of migration occur and the movement of birds within, into and out of the continent plays a major role in the occurrence of crop damage. The principal, and most noticeable, migration is that of the palaearctic migrants into and out of Africa. The birds which undertake this migration breed in the northern hemisphere, mostly in its more northerly reaches. In these areas day length in summer is long, approaching 24 hours in the most northerly latitudes. Here the birds find an abundance of insects but the season is short. Short day lengths, low temperatures and snow-covered ground make bird life there intolerable in the winter. All the breeding birds from these northern latitudes migrate southwards in late summer and many of them travel as far as the tropics in Africa. Overwintering in Africa, where they may remain for longer than they do in their breeding haunts, these birds find sufficient food to keep them throughout the non-breeding season. The shorter day length and the less abundant food, however, prevent the birds attaining full breeding condition so that they do not breed in Africa, except in a few isolated instances. Once the northern days begin to lengthen, the birds instinctively return there to complete their annual two-way migration. Characteristically, before each migration, the migrating birds tend to build up a store of energy in the form of fat, to sustain them on the long journeys which they are about to undertake.

Birds which migrate within the continent of Africa, *the intra-African migrants,* do so for the same purpose. In the case of the cereal-eaters, there is a gradation in the level of migration determined by the degree to which they are dependent on grass seeds. Those which are entirely dependent on grass seeds for their sustenance may find seeds hard to find seasonally and move from one area to another where seeds are more plentiful. Seed-eaters which feed on a variety of seeds in addition to those of grasses may find an alternative food source less difficult to find and, finally, those seed-eaters which have a wider variety of foods in their diet including fruit and insects may not have to quit an area at all just because grass seeds become scarce.

The scarcity of grass seeds can be manifest in different ways. For example a solitary dove, such as the Emerald-spotted Wood Dove, *Turtur chalcospilos,* feeds almost exclusively on seeds, but as it is solitary and creeps about on the ground, often in dense vegetation, it always finds enough in one place to sustain it throughout the year. On the other hand the exclusively grass seed-eating Quelea cannot exist in the same situation because it is highly gregarious and the grass seed is not available in sufficient quantity to sustain the tightly knit feeding flocks. When the available grass seed stock becomes impoverished the Quelea do not search for it more diligently but move out to where the stocks are more plentiful. The Rose-ringed Parakeet, *Psittacula kramer,* another gregarious bird, has an extremely varied diet which includes lentils, seeds of Acacia trees, fruits of the Tamarind tree, guavas, dates, fruits of the Baobab, mangoes and others including the flowers and nectar of coffee bushes. Having such a varied diet there is little incentive for the parakeets to move far in their search for food, but they do seem to move into cropping areas when the sorghums and millets are ripening. This localised type of movement when birds change their diet is quite common and can be seen in birds which move up and down mountain sides in their quest for seasonal seeds and fruits.

The hunt for food thus seems to be the driving force behind seasonal movements of the birds which remain within the African continent. The feature which separates the true migrants from the other locally wandering birds is that the birds which undertake a true migration over some considerable distance do so after laying down food reserves in the form of fat. The Quelea may increase its weight by some 15% as food is becoming scarce and it prepares to migrate.

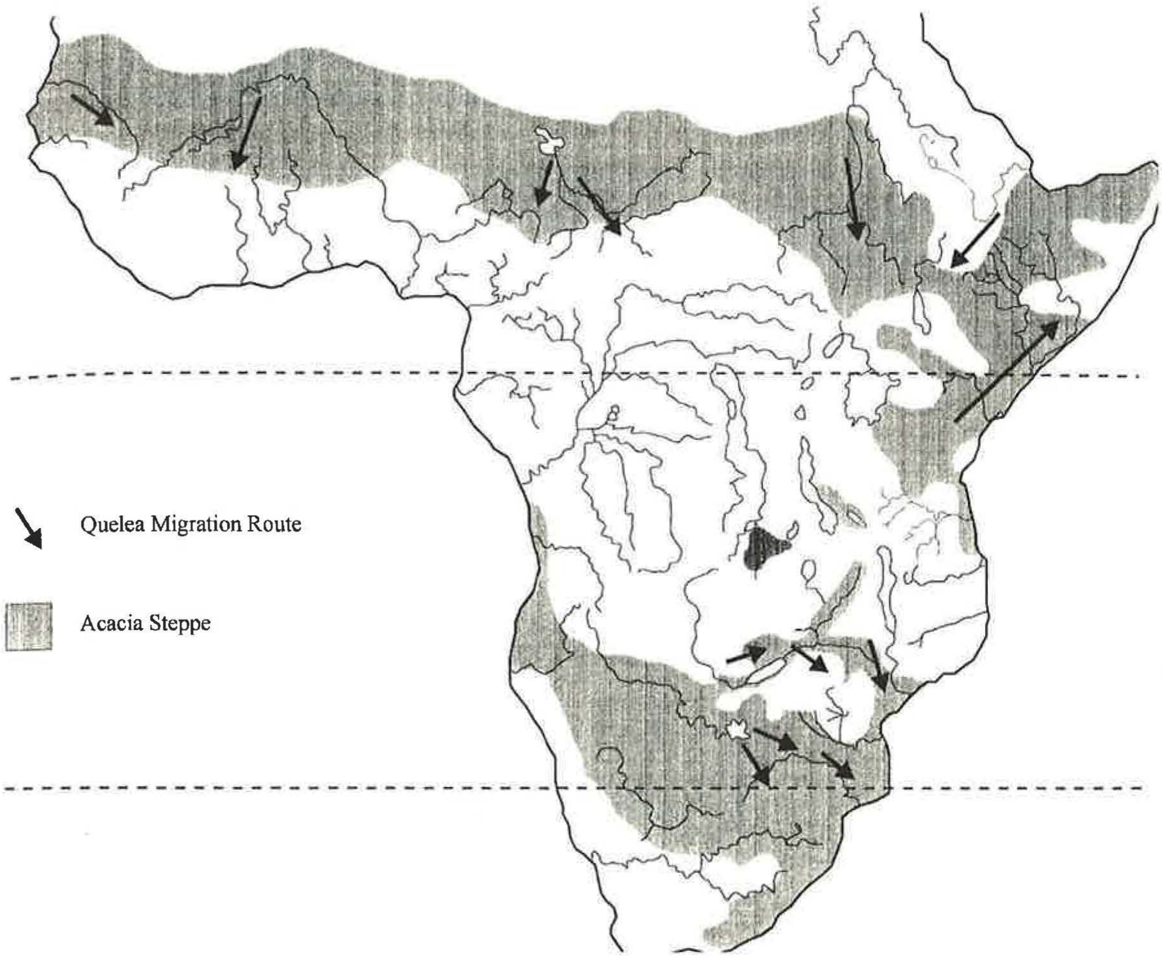
The events which lead to the migration of the Quelea build up during the time when the flocks are feeding on the gradually diminishing supply of annual grass seeds which they have been exploiting for some time during the dry season. During this period they have been moving about nomadically in their non-breeding quarters, slowly concentrating their numbers in the last remaining and most productive areas rich in fallen annual grass seeds. These are usually areas which in some seasons are shallowly flooded over wide areas. Examples are the Mababe Depression in north-western Botswana, the Maasai Steppe in Tanzania, the Shebelle flood plains in Somalia, the Sobat River area in the Sudan, Lake Chad, the flood plains of the Niger River in Mali and the Senegal River area of Senegal and Mauritania. When widespread rains occur in these areas much of the grass seed on which the Quelea were feeding germinates and the quantity necessary to sustain the vast flocks disappears almost overnight. The Quelea quickly turn to an immediately available alternative food, the vast hoards of winged termites (*alates*) which emerge with the onset of the rains. Gorging on this plentiful supply of protein rich food, the Quelea soon put on weight and prepare to migrate through the advancing rain belt to where grass seed is once again being produced in vast quantities by grasses many hundreds of kilometres away, where the rains have been falling for some six weeks or more. This true migration is undertaken once annually by most Quelea populations throughout Africa (see Map 1).

Quelea, among grain-eating birds, are not alone in undertaking such a migration. However, not enough is known about other species to be certain of their movements or the circumstances which fuel them. Certainly, the three species of Quelea are migratory, as is the Harlequin Quail, the Chestnut Weaver, the Red Bishop, the White-winged Widowbird, the Namaqua Dove and the Laughing Dove.

Breeding Habits

The African grain-eating birds show great diversity in their breeding habits. Generally speaking the non-passerines such as the doves, the ducks and geese, the parrots, and the game birds do not have a conspicuous breeding plumage. In contrast, male passerines generally moult into a much brighter plumage during the breeding season. In the non-breeding season the male and female passerines are almost indistinguishable in plumage. The non-passerines retain a distinctive plumage throughout the year according to their sex, the males invariably being more colourful.

Throughout the cereal-growing areas of Africa there is generally only one breeding season. The exception is a considerable portion of eastern Africa from north-eastern Tanzania through most of Kenya, Somalia and Ethiopia to Eritrea where there are two breeding seasons. The breeding seasons correspond to the rain seasons and where these are long more than one brood may be raised in a single season.



Map 1 Some Quelea migration routes in the Afrotropical region

There are a variety of breeding strategies shown by the grain-eaters. Most of those which cause damage of any significance to crops are colonial, that is to say they breed together in colonies of varying density and synchrony. The commonest habit in large colonies is monogamy when a single pair of birds remain together raising one or more broods during the breeding season. If the birds change the breeding location to rear the second, or subsequent, broods it is possible that a change of partner will take place with each move. The males of the Red-headed Quelea and the Chestnut Weaver, although monogamous, quit the colony after the eggs are laid and lead an independent existence away from the breeding colonies. In the case of the Cardinal Quelea, the Village Weaver and many of the widowbirds, the males are polygamous building more than one nest and mating with more than one female. The Village Weaver may have as many as five females occupying active nests which it has built, all in the same colony. In this case the male does not take part in rearing the young but, with other males in the colony, protects the nests against predators by mobbing and attacking them.

The density of the colonies varies in the granivorous seed-eaters according to the habitat in which they establish their colonies. The Red-billed Quelea which occupies wooded savanna has the densest colonies with each male occupying a territory which barely extends beyond the nest. In the grassland species of granivores, the colonies established in the tall grasses are much less dense, the males holding larger territories in which they can build more nests for additional females. Colonies established over water also tend to be dense but the density is limited by the height of the reeds in which the nests are built.

Male seed-eating weaver birds generally build the nest whilst displaying vigorously to attract a mate. The display starts when the initial 'ring' of the nest is built (Figure 8).

Figure 8 Male Red-billed Quelea displaying in initial 'nest ring'

The male completes the nest but the female often lines it with grass heads. In the ducks, parrots and doves both the male and the female take part in nest building. The number of eggs laid varies very little and is commonly 2–3, although the White-faced Tree Duck may lay up to 13, Fischer's Lovebird and francolins 6 and the Red-billed Quelea, unusually, 7. Both the male and female incubate the eggs except in the case of the polygamous Ploceidae. In the monogamous species both parents take part in feeding the young, although the male may be less active in this than the female. Males generally play some part in defending the nest against intruders.

Populations and their Natural Regulation

The number of grain-eating birds has a particular relevance to the damage which they may be capable of doing to agricultural crops. Most species show a remarkable stability in their numbers. The general density of the birds of a particular species in a particular area may fluctuate seasonally, but overall the number of pairs which breed varies very little from year to year. The reason for this is that two opposing forces act on the population to determine its numbers, the first is the rate at which the birds reproduce and the second is the stress, or restraint, imposed on them by the environment.

Grain-eating birds, in general, lay the same average number of eggs each year. There may be small variations due to unusually good or unusually hard years. For example, in a few cases, Quelea bird colonies have been recorded with an average clutch size of 4 eggs per nest when conditions have been particularly favourable, whereas the average number of eggs laid in a colony is 2 or 3 (average 2.8). Similarly, in years of extreme hardship when rains have failed, as in the Sahel drought of the early 1970s, little or no breeding of grain-eating birds may occur.

To breed successfully the birds must be in prime condition at the beginning of the breeding season and must be able to maintain that condition at least until the brood fledges. In poor years a smaller clutch may be laid or, if the average clutch is laid, the parents may be unable to find enough of the right food to rear the full brood, one or two dying of starvation in the nest. In this way there will be fluctuations in the number of recruits to the population at the end of the breeding season. In many of the populations studied in the tropics, the grain-eating passerines rear about 80% of their brood. Theoretically, the potential for increase in the population of small birds is enormous. In parts of East Africa and much of southern Africa, Quelea populations can rear two broods in each year. One pair of birds is thus able to produce 4.5 progeny (80% of 2 x 2.8) to add to the population annually. Depending on how long the adults live, and at what age the young birds can start to breed, the potential for rapid population increase is enormous.

Opposing this potential population explosion are the environmental factors which impose a limit on the rate at which the birds can increase. The major limiting factor is food. For birds which rely on grains for the bulk of their diet the dry season following the rains is a period when their food supply is gradually diminishing. Many small mammals and insects are also granivores and live in the same habitat as the birds feeding on the same food resource. Towards the end of the dry season the birds have to spend more energy in finding enough food to keep them alive and this increased activity, coupled with the decrease in the quality of the remaining grains, causes privation and starvation in the weaker members of the population. Unable to maintain the necessary energy to keep up with the fitter birds, many die or fall easy prey to predators. The environmental pressure on the birds brings their number back down to what can be considered the carrying capacity of their habitat. The annual fluctuations in the population tend to be brought back to an average for the area and the peaks and troughs of good years and bad years are balanced around the limiting carrying capacity.

Major changes in the conditions within the habitat, such as large-scale bush clearing for tsetse control, or the establishment of a vast irrigation scheme in what was formerly a swamp, may cause sufficient disruption in the ecology of the area to alter its effect on the population. The population will stabilise at a new level conditioned by the new limiting factors at work under the new conditions. Suitable nesting grounds may be lost or gained, feeding grounds may also change in their extent and quality and new competitors may be introduced or old ones lost. The position of the birds within their habitat is dynamic and they are constantly reacting to it and its other inhabitants, man included. The potential for conflict with man is present as soon as cereals are planted in the birds' habitat. The severity of the conflict will depend in part on the number of grain-eating birds which the habitat can carry.

Knowing the carrying capacity of an agricultural area in terms of the number and type of grain-eaters which it contains can help a survey officer to predict the likelihood of crop damage in any particular year and prepare accordingly.

Classification

There are many species of birds which may be found in cereal crops in Africa. Birds may enter the crops for a number of different reasons. They may seek shelter there, either to roost or to build their nests, or they may enter the crop to feed. They may find a variety of things on which to feed: insects, other invertebrate or small vertebrate animals, weed seeds or fruits, and various herbs in addition, or in preference, to the crop. In some parts of Africa the commonest cereal pest may be confined to one country, or at most a few neighbouring countries and may be unknown, or rare, in others. In this section of the handbook, a general outline is given of some of the better known species which may be found feeding on cereal crops throughout the Afrotropical region of Africa. Species which are of widespread distribution and major importance are marked with an asterisk wherever they are mentioned in the text and those of less importance, or only limited distribution, are enclosed in brackets.

All birds belong to a single class of animals Aves, the Birds, and all living birds belong to a single subclass Neornithes which is divided into some 29 orders of birds living today. The orders, into which all bird are placed, are the primary divisions of use to field observers when identifying birds. No-one, who has any interest in birds, should have difficulty in assigning any bird seen to its correct order. Eleven of the orders contain birds of some interest to agriculturists – some as pests, but others of particular benefit. The birds in each of these orders are distinctive in form and habit and are readily distinguishable.

Each order is subdivided to families and it takes keener observation to place a bird into its correct family. Nonetheless, with practice, this is not difficult. Once the bird is placed in its correct family, further identification is possible, though more difficult.

The genus is the category below the family level to which the bird can be assigned fairly readily with the aid of a pair of binoculars or field glasses. The genus links together those birds which are closely enough related to have a very similar general form – that is to say more or less the same size, body shape, bill type and leg length. Finally, to identify the free-flying bird and give it its correct specific name, the last category in its classification, it is essential to have a good pair of binoculars.

The eventual name given to the bird when it has been identified, the species name, can cause some confusion if the local name, or the English name is used. There are many birds which are very well known but different countries may use different names for the same bird, even different districts within a country or, in extreme cases, different individuals. This is true whatever language is used to name a particular species except in the case of the scientific name which is universally accepted. In order to avoid confusion, the birds mentioned in the text are given the scientific name in italics and also the English name commonly used in East Africa. Subsequent references are given in the English name only for the sake of simplicity.

Reference is also made to books available in different countries which describe and illustrate the birds which occur there. Simple keys have been prepared to help field workers to identify the birds most likely to be seen damaging cereals and, after naming a bird with the keys, the local reference book can be used to verify that a correct identification has been made. If the species does not appear in the local book then pictures and descriptions of other members of the same genus should be looked up to see if any fit the bird observed. It is most likely that any bird seen in a cultivated field in any numbers will be described in the local guide, it is not likely to be rare or scarce. However, there can be problems if all the different plumages are not well described. It may be that the bird seen, and on which notes were taken in the field, is a juvenile in juvenile plumage whereas the guidebook, and the keys in this handbook, only refer to the adult in full breeding plumage. In this case further observations are necessary to see if any birds are in adult plumage and further descriptive notes made in the field. Good local field guides generally list the local names used to describe the commoner birds and knowledge of these names can help to run down the bird in the guide. If all else fails a specimen has to be obtained for identification by a specialist usually to be found in the national museum of the country concerned.

Classification

Key to the Orders of Birds of Particular Interest to Farmers in Africa

1. Immense, conspicuous, flightless, black and white birds with long legs and long necks: **Struthioniformes**

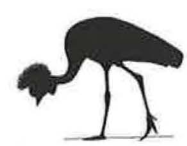
– Not immense, capable of flight 2

2. Long-legged and long-necked, bill pointed. Mostly tall, but if short hunched in appearance and long neck retracted except when feeding 3

– Considerably less than 1 m in height or, if tall, bill not noticeably pointed 4

3. Tall or short, bill spear-like longer than head: **Ciconiiformes**

– Most about 1 m tall, bill not as long as the head: **Gruiformes**



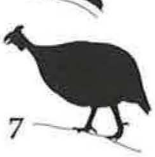
4. Bill markedly hooked, adapted for tearing flesh; feet modified as talons 5

– Bill not noticeably adapted for flesh-eating 6

5. Eyes usually hooded, large, positioned to the side of the normal head: **Falconiformes**

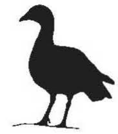
– Eyes large, round and noticeably forward-facing; head round, nocturnal: **Strigiformes**

6. Chicken-like, ground-dwelling birds: **Galliformes**



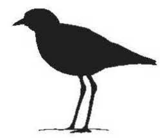
– Not chicken-like 7

7. Able to swim, toes webbed, bill more or less horizontally flattened: **Anseriformes**



– Bill not flattened like that of a duck 8

8. Medium-sized wading bird commonly associated with water with a thin bill longer than the head: **Charadriiformes**



– Only visiting water to drink; bill not longer than the head unless very massive 9

9. Bill not as long as head, with fleshy base (*cere*) and nostrils; strong swift fliers 10

– Bill without fleshy cere, normally shaped 11

10. Plump, compact birds with comparatively small heads and bill short and straight: **Columbiformes**

– Bill broad and strongly hooked: **Psittaciformes**

11. Mouse-like with hooked bills and long, graduated tails, erectile crest: **Coliiformes**

– Bill not markedly hooked, tail very variable 12

12. Bill long (except forest-dwelling, bright green and red Trogons), strong and sometimes curved: **Coraciiformes**

– Perching and singing birds: bill very variable but in grain-eating birds ordinary, generally sharply pointed, sometimes conical: **Passeriformes**

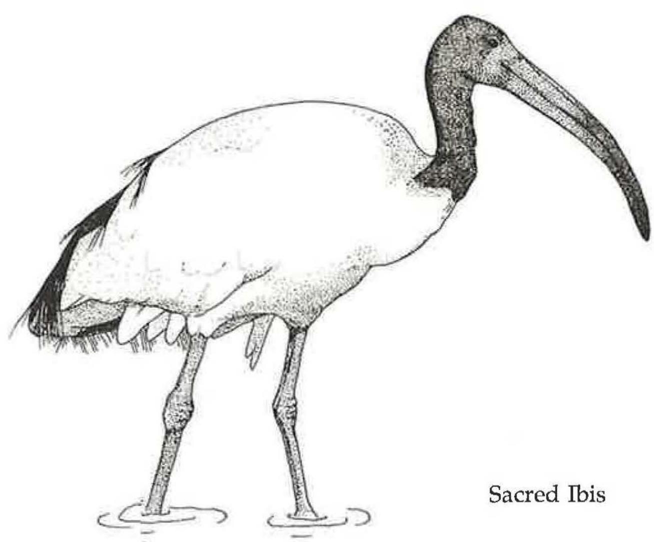
The species of birds which may be found in cereal crops in the Afrotropical region of Africa are reviewed below. The orders, families, genera and species which cause substantial damage to cereals are marked with an asterisk, *. The names of species which are unlikely to cause serious damage are enclosed in brackets, ( ), whereas those which are neither marked with an asterisk, nor enclosed in brackets, may occasionally cause a problem.

Ostriches: STRUTHIONIFORMES

The Ostrich, *Struthio camelus,* is a bird of semi-arid areas and needs little description. It is the largest living bird and is flightless. Males are black and white and up to 8 feet tall. Females are brown coloured and smaller than the males. Ostriches often occur in herds and are recorded as causing damage to sorghum and millet.

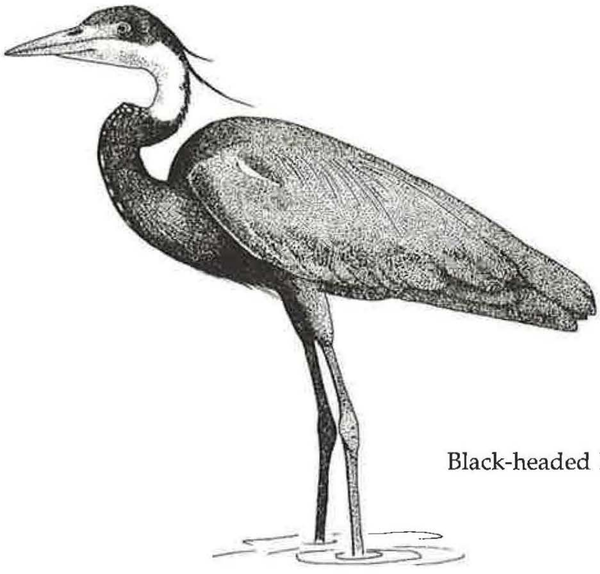
Herons and Storks: CICONIIFORMES

Storks and herons are conspicuous, large to very large, tall birds widespread in Africa and usually associated with wetlands. They have long legs, adapted for wading and walking, and long, pointed bills. They do not swim but their long legs allow them to fish in quite deep water. One species, the Sacred Ibis, *Threskiornis aethiopica,* has been accused of feeding on recently sown irrigated crops, but the birds were probably feeding on insects or worms disturbed by the planter. Their food, like that of many other species in the order, is mainly grasshoppers, locusts, crickets and other insects as well as worms, molluscs, fish, crocodile eggs, carrion and offal. Misinterpreting the reason for birds being present in cultivated fields can cause much harm. Any grain eaten by a Sacred Ibis is paid for many times over by the benefit it confers by eating much more damaging pests.



Sacred Ibis

Another member of the order, the Black-headed Heron, *Ardea melanocephala,* is also widespread throughout Africa and is a major predator of the Grass Rat *Arvicanthis niloticus* during outbreaks of this serious agricultural pest.

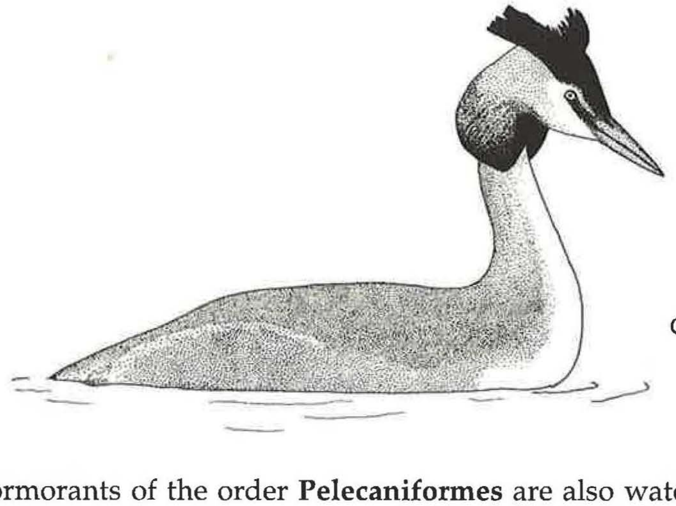


Black-headed Heron

Ducks and Geese: ANSERIFORMES*

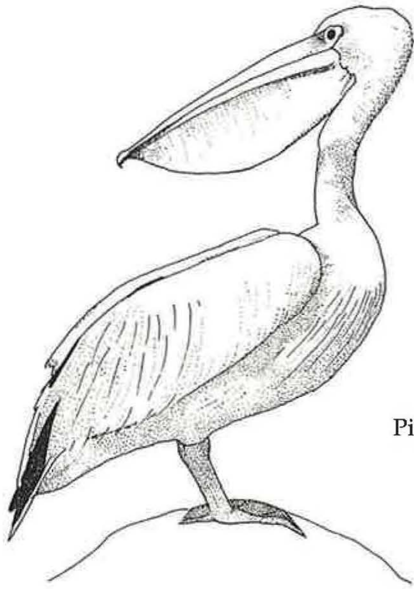
This order of birds is familiar to most people. A number of ducks and geese have been domesticated and many are hunted as they make good eating. They are medium to large water birds with a characteristic, horizontally flattened bill and webbed feet which are used in swimming. Many ducks and geese feed on grain and young grass plants. Other ducks commonly feed on spilled grain in fields after the harvest.

The grebes of the order **Podicipediformes** should be recognised because they are harmless birds which may be mistaken for ducks. Grebes are common residents on large lakes, rivers, and saline waters. They can be distinguished from ducks by their pointed bills and their lack of a noticeable tail. They rarely fly preferring to escape danger by diving and swimming. Most ducks fly much more readily.



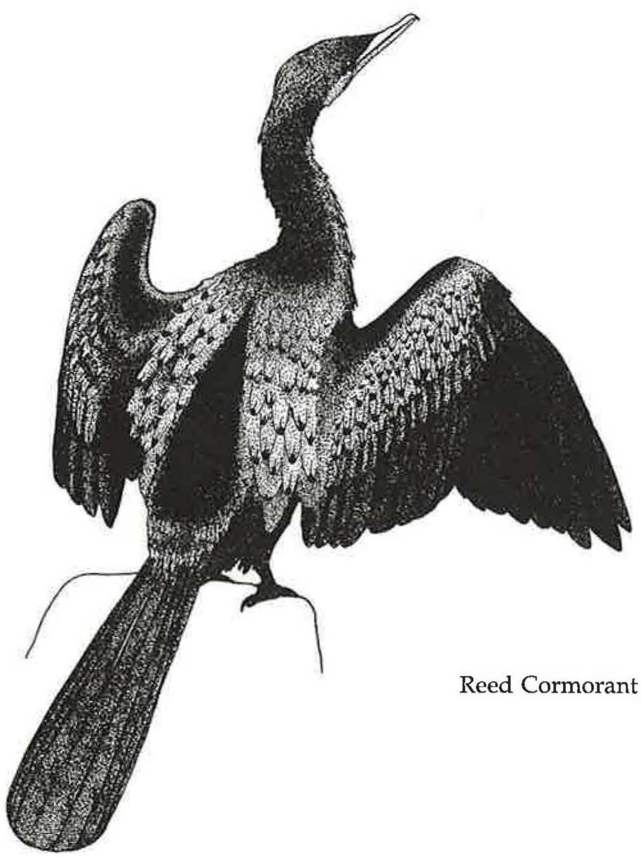
Great Crested Grebe

Pelicans and Cormorants of the order **Pelecaniformes** are also water birds but are very unlikely to be mistaken for ducks or geese. White pelicans can be distinguished by their colour and very large size.



Pink-backed Pelican

Cormorants may be identified by their long necks and long, slightly hooked or spear-like bills.



Reed Cormorant

Only one family of the **Anseriformes** is recorded as causing damage to cereals. The Egyptian Goose, *Alopochen aegyptiacus,* and the White-faced Whistling Duck, *Dendrocygna viduata,* reach pest status particularly on irrigated rice crops. The Spur-winged Goose, *Plectropteris gambensis,* does occur in crops and has occasionally been reported as causing serious crop losses.

Family: Anatidae

Four species in three genera recorded damaging cereal crops.

Key to the Genera

1. Large, black and white with red colouring on the head and bill: *Plectropterus*
- Smaller, not black and white 2
2. Medium-sized, brown in colour with extensive white patches on the wings: *Alopochen*
- Smaller, size of a chicken, with noticeable and characteristic upright stance: *Dendrocygna*

Genus: *Plectropterus* A genus with only one species (*monotypic*).

(*P. gambensis* – Spur-winged Goose)

This is the largest goose in Africa and occurs throughout the Afrotropical region except lowland evergreen forest and desert areas. It is an untidy looking, black and white goose with spurs on the 'wrist' joint of the wing. The male is considerably larger than the female. They often roost in large numbers in rice or other cereal fields, causing damage by trampling.

Genus: *Alopochen* Another genus of African duck which is monotypic.

A. aegyptiacus – Egyptian Goose

A common and widespread duck in Africa which is distinctively coloured in brown, with extensive white and black patches. The white shoulders are prominent in flight and the birds fly in formation. They often occur in large numbers and are recorded as feeding on wheat and trampling irrigated seedlings.

Genus: *Dendrocygna*

Two species have been recorded damaging cereals. The ducks have a characteristic whistling cry which they utter when in flight to and from their feeding grounds. They have a noticeably upright stance unlike that of any other African duck.

Key to the Species

Uniformly brown with conspicuous white upper and lower tail coverts: *D. bicolor*

Striking white face, tail coverts not white: *D. viduata*

Dendrocygna bicolor – Fulvous Whistling Duck

The Fulvous Whistling Duck is unevenly distributed through Afrotropical region occurring in large numbers in some areas but sparse in others. It is not a grain-eater, but feeds on the shoots of young seedlings. It feeds to a large extent by diving and causes damage in rice fields through puddling as much as through feeding on the rice.

*Dendrocygna viduata**– White-faced Whistling Duck

The White-faced Whistling Duck sometimes causes serious damage to rice in nurseries. It is widespread and common throughout the region and is distinguished by its white face. It also feeds on germinating cereals, particularly in irrigation schemes. The White-faced feeds more on the surface than the Fulvous and probably causes more damage to rice seedlings. Much of the feeding is done at night and large quantities of young rice leaves floating on the irrigation water is a sign of their activity.

Vultures, Eagles, Hawks and Falcons: FALCONIFORMES

The daytime (*diurnal*) birds of prey (*raptors*) belong to this order. They are well known and easily recognised. All possess markedly hooked, flesh-eating bills and most have long, strong, heavily clawed talons. A few are quite small and are principally insect-eaters, such as the Pygmy Falcon, *Polihierax semitorquatus*, of eastern and southern Africa, which is small enough to take possession of the nest of a weaver bird for its own use. A familiar bird in cultivated fields throughout Africa south of the Sahara is the Black-shouldered Kite, *Elanus coeruleus*. This bird is a major predator of rodents especially the Grass Rat, *Arvicanthis niloticus*, the Vlei Rats, *Otomys* spp., and the Striped Rat, *Rhabdomys pumilio*, all of which can cause serious damage to cereals. The Long-crested Eagle, *Lophaetus occipitalis*, is another bird highly beneficial to farmers as it feeds principally on rodents.

Game-birds: GALLIFORMES

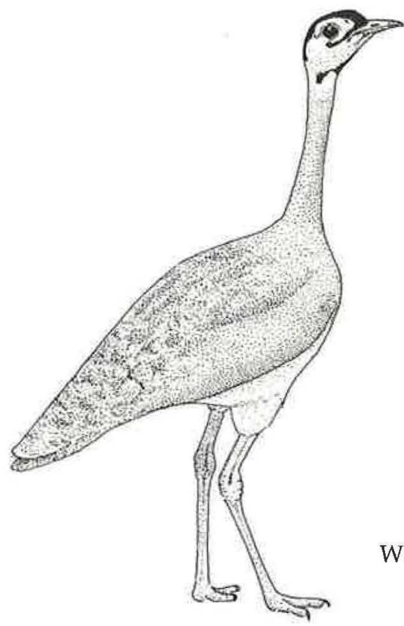
This is the order of birds to which the chicken and its wild relatives belong. Most of these birds are small to large, chicken-like in body shape with long, strong legs often with noticeable 'spurs' on the legs of males. Guineafowl are very well known and, like the ducks, are hunted and eaten by man. This makes them generally wary. Despite this the Helmeted Guineafowl, *Numida meleagris*, which is commonly domesticated, will feed on both the germinating seeds and mature crops of millets and sorghums. However, any loss of crops is more than made up for by their preference for weed seeds, harvester termites, *Hodotermes* spp., grasshoppers and the tubers of the harmful weed, nutgrass (*Cyperus* spp.).

Helmeted Guineafowl

Cranes and Bustards: GRUIFORMES*

N.B. Cranes and bustards are generally declining in numbers and in many countries are protected by law. The cranes are very large birds superficially similar to the storks of the Order Ciconiiformes but have a much smaller bill, shorter than the head which is more rounded in shape. They are very conspicuous birds, some with crests or plumes. Cranes often occur in large flocks and fly in precise formation. They can cause damage to crops, particularly sorghum and wheat, but are also beneficial feeding on locusts, grasshoppers, the African Armyworm, *Spodoptera exempta,* and cutworms (*Agrotis* spp.).

The bustards are another family of medium to large birds belonging to this order. Some species are occasionally seen in crops, usually singly, and taking very little, if any, grain. Their presence is only transitory as they range over wide areas feeding, for the most part, on insects and occasionally small birds and rodents. Their numbers are considerably reduced in Africa as they are good to eat and are easily shot.



White-bellied Bustard

One family is recorded damaging cereal crops.

Family: Balearicidae

Three genera are recorded causing damage to cereals.

Key to the Genera

1. Large, bill almost as long as head. Appear uniformly grey with or without black head and upper neck 2
- Bill shorter. Body grey, wings noticeably tri-coloured, primaries black, secondaries chestnut and greater coverts white. Crown-like tuft on head: *Balearica*

2. Inner secondaries elongated, often drooping over tail which appears bushy: *Grus*
- Inner secondaries elongated without giving bushy effect: *Anthropoides*

Genus: *Balearica*

Two very similar species can cause some damage to cereals at planting time or, after germination, by trampling.

Key to the Species

Neck dark slate grey, small red throat wattle:	*B. pavonina*
Neck light grey, large red throat wattle:	*B. regulorum*

(*B. regulorum* – Grey Crowned Crane)

A very distinctive and beautiful African bird and the national emblem of Uganda. A slender slate grey crane with prominent red and white cheek marks and a crown of upright stiff feathers. Occurs in moderately sized flocks and has been recorded feeding on cereal seedlings, particularly maize and wheat at planting time. When numbers gather on rice fields they can cause damage by trampling.

(*B. pavonina* – Black Crowned Crane)

The Black Crowned Crane is almost indistinguishable in habit and appearance from the Grey Crowned Crane which is lighter in colour, has a larger neck wattle and a more musical call. It is widespread in West Africa from Senegal to the Sudan and Ethiopia and is recorded from northern Uganda and north-western Kenya.

Genus: *Grus*

Only one species of this genus occurs in Africa.

(*Grus grus* – Common Crane)

A large, robust crane, uniformly grey in colour with a black and white head pattern and black upper neck. It is similar to the Demoiselle Crane which is slimmer and neater in appearance with a white tuft of feathers behind the eye extending down the black neck. A palaearctic migrant which only occurs along the Blue and White Niles and their tributaries in the Sudan and Ethiopia. It reportedly damages grain crops in its winter quarters.

Genus: *Anthropoides*

Two species are recorded damaging crops.

Key to the Species

Upper neck and breast black, white plumes behind eye:	*A. virgo*
Uniformly grey-blue with long black ornamental secondaries:	*A. paradisea*

(*A. virgo* – Demoiselle Crane)

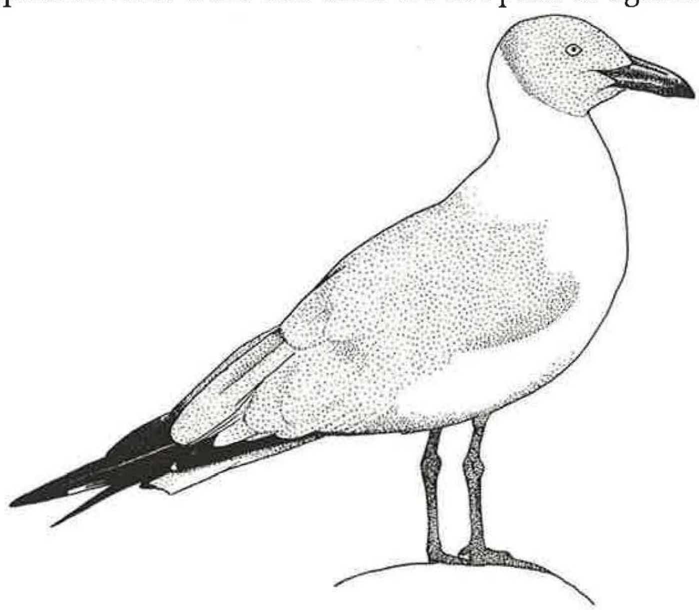
A medium-sized crane with a short bill and neck. Not easily distinguished from the Common Crane at a distance. The Demoiselle Crane is a palaearctic migrant with the same distribution in Africa as the Common Crane. It is recorded causing damage to sorghum and wheat in the Sudan. However, it is also beneficial as it is known to feed on locusts.

(*A. paradisea* – Blue Crane)

The Blue Crane is distinguishable from all other African cranes by its uniform blue-grey plumage and long, black ornamental secondaries which curve down to the ground in adults. The Blue Crane is confined to South Africa and Namibia where it is reported to feed on maize and wheat. However, like the Demoiselle Crane, it is also beneficial as it feeds on insects, particularly grasshoppers and locusts.

Gulls, Terns and Waders: CHARADRIIFORMES*

The birds of this order are small to large generally associated with water. The terns and gulls are mostly coastal but a number of species occur on inland waters. They swim buoyantly on the water and feed from the surface like many ducks. Unlike ducks, most of them are strikingly white in colour, have only slightly webbed feet and have laterally compressed bills. Gulls and terns are not pests of agriculture in Africa.



Grey-headed Gull

The waders are small, usually dull-coloured, birds which swim infrequently and many feed while wading in water, hence their name. They are common along rivers, around lake shores and in irrigated agricultural land. Many of them are migrants from Asia and Europe and are abundant in Africa during the northern winter months from October to March. Only two species of one family have been recorded damaging cereal crops.

Family: Scolopacidae

Two species recorded damaging cereals.

Key to the Species

Bill very long and slender twice as long as the head and slightly upturned. Tail white at base with broad black end: (*Limosa limosa*)

Bill only slightly longer than head. No white in tail. Usually in large flocks: *Philomachus pugnax**

(*L. limosa* – Black-tailed Godwit)

A tall, handsome wader with a long, slender and slightly upturned bill. It is a winter migrant from Europe, always associated with water and common in irrigation schemes in West Africa. It often feeds on germinating rice.

P. pugnax – Ruff*

A mottled brownish wader with light underparts which occurs in large flocks during the winter months as a visitor from Europe. It is also commonly associated with irrigation schemes, and recorded as a pest of sown rice in West Africa. In the Sudan it has been recorded damaging irrigated wheat by trampling the seedlings.

Pigeons and Doves: COLUMBIFORMES*

The well known birds of this order are medium sized seed-eaters, often domesticated and valued as food. They are short-legged, tree and bush dwellers which commonly feed on the ground, often around houses and in towns. The pigeons and doves are usually dull coloured but can be distinguished by their very different calls and 'cooing' songs. The difference between pigeons and doves is an arbitrary one related to their size, the pigeons being larger. There are 29 species recorded in the Afrotropical region and of these 12 may feed on cereals. Only eight of the species are of any importance as crop pests.

One genus of one family is recorded damaging cereal crops.

Family: Columbidae*

Genus: *Streptopelia**

The members of this genus are all typical grey doves with conspicuous black markings on some part of the neck and no chestnut colouring in their wings. Seven African species and one migrant are recorded feeding on cereal crops. Most are ground feeders and feed mainly on fallen grain and weed seeds. Their pest status is thus questionable but on occasion, probably during drought conditions, they can descend on crops in flocks causing considerable alarm and some damage. They are most easily identified by their calls which are characteristic sounds of the African bush.

Key to the Species

1. Hind neck with black half collar 2
– No collar on hind neck 6
2. 'Shoulders'[5] blue-grey 3
– 'Shoulders' dark not pale, red eye-ring, no white in tail: *S. semitorquata*

3. Iris dark brown 4

– Iris dark red or yellowish 5

4. Forehead grey, undersides of wings dark grey: *S. capicola**

– Forehead pink, undersides of wings pale grey:... *S. vinacea*

5. Smaller, narrow white eye-ring, iris dark red: *S. roseogrisea*

– Eye-ring red, iris bright yellow or red/yellow: *S. decipiens**

6. Broad half collar on throat and sides of neck, the feathers black with forked, copper coloured tips: *S. senegalensis*

– Sides of neck with black, or black and white, patches 7

7. Sides of neck with black and white patch: *S. turtur*

– Sides of neck with black patch: *S. lugens*

S. semitorquata – Red-eyed Dove

The largest and darkest of the 'collared' doves and widespread in distribution. The tail has a distinctive light and dark pattern without any white in it. The call is a loud and cheerful sounding "**coo**-cuk, cuck-oo, cuck-oo".

*S. capicola** – Ring-necked Dove

A widespread species in eastern and southern Africa. At the northern limit of its range in Ethiopia and Uganda the Ring-necked Dove overlaps the most easterly limit of the range of the very similar Vinaceous Dove of West Africa. The Ring-necked Dove frequents dry, open country and cultivation where it feeds mainly on the ground but also perches and feeds on standing cereal heads. It is recorded feeding on sorghum and oats and assembling, sometimes, in thousands in harvested sorghum fields in Zimbabwe and Botswana. The monotonous, far-reaching call "koo-**koor**-koo" or "how's **Fa**-ther" is repeated many times and may be heard day and night throughout the bird's range.

S. vinacea – Vinaceous Dove

A widespread West African species of dry savanna and thorn scrub. Very similar in appearance and habit to the Ring-necked Dove of eastern and southern Africa. Recorded feeding on the seed heads of sorghum and millet in northern Nigeria and rice after sowing in Burkina Faso. The call is similar in monotony and pervasiveness to that of the Ring-necked Dove but has four unstressed syllables, "koo-koo-koo-koo" or "better go home".

S. roseogrisea – African Collared Dove

A dove of the Sahel where it can reputedly survive without need of water, presumably obtaining what it needs from fruit. It is a ground feeder, not prone to feed on heads of grain crops. The underwing is white which can help in identification. Call is a voiced, gutteral "koo-k'r**roo**".

*S. decipiens** – African Mourning Dove

Widespread throughout the Afrotropical region. It feeds mainly on the ground but has been recorded feeding on the heads of sorghum, millet and rice, the latter taken, presumably, from the ground as the flowering stem is too weak to support the weight of a dove. It is common, and well known throughout the higher rainfall areas. The call has been rendered as "**kroo**krrroooo-**kroo**krrroooo" followed by "prickly**heat**-prickly**heat**-prickly**heat**".

S. senegalensis – Laughing Dove

Distinct from all other *Streptopelia* doves, the Laughing Dove has a broad band of unique dark feathers with double tips of a shiny copper colour forming a bib on the sides and front of the neck. The feathers of the bib are used in display when they are raised and fluffed out as the birds bow to one another. It is widespread and commonly associated with human habitations where it feeds on the ground, mainly on grains up to the size of maize. It has been recorded feeding on the heads of millet and sorghum. The call is unlike any other *Streptopelia* being a soft, musical call of about five notes variously described but sounding like "uguru-too-tu".

S. turtur – European Turtle Dove

A winter visitor from Europe, common in grain fields at harvest time in the Sahel. It reportedly feeds on sorghum in the Sudan. The black and white throat patches on the side of the neck are diagnostic and the black spotted wing coverts distinguish it from all other *Streptopelia* in Africa. It roosts in very large numbers in its winter quarters. The bird is named after its call "tur-tur".

S. lugens – Dusky Turtle Dove

A large, dark-coloured dove with characteristically mottled, or chequered looking wing coverts, the feathers having dark centres fringed with buff or chestnut. It feeds mainly on the ground but has been recorded feeding on the heads of sorghum. Call "cu-oor, cu-oor".

Parrots and Parakeets: PSITTACIFORMES*

This is another well known and easily identified order. The bright colours, the ease with which they can be fed in captivity and in some cases the ability to imitate man's voice, has led to their popularity as pets. This popularity has led to a marked decline in the populations of some species, which are protected by law in a number of countries. The bill is short, stout and strongly hooked and the base of the upper mandible (*cere*) is fleshy and feathered. Parrots are small to medium/large in size, brightly coloured (often green) and have raucous calls. Many of them cause damage to cereals but none is dependent on grain.

There is only one family of parrots in the order and many species are recorded damaging cereal crops.

Family: Psittacidae*

Four genera recorded damaging cereal crops.

Key to the Genera

1. All grey bird with scarlet tail: (*Psittacus*)
- Green or brown birds, tail not strikingly coloured........2
2. Slim green bird with long tail: *Psittacula**
- Squat bird with short tail........3
3. Robust medium/large sized birds: *Poicephalus*
- Medium/small to small birds with bright coloured bills: *Agapornis*

Genus: *Psittacus*

A genus with only one species (*monotypic*).

(*Psittacus erithacus* – African Grey Parrot)

A formerly common and widespread parrot throughout much of Africa which has suffered severe reduction in numbers due to being trapped for sale as a cage bird. Occurs in flocks of 2–12, assembling in roosts of up to 200 birds. It was a pest on maize crops but is now shy and wary and unlikely to be of significance as a pest.

Genus: *Psittacula**

Only one species of the genus occurs in Africa. In evolutionary terms it is a comparatively recent immigrant from the Indian continent and has exploited man's crops in its dispersion through the Sudano-Sahelian zone where it occurs. Feral[6] populations of cage escapes occur in Natal Province of South Africa, Abidjan and coastal Ivory Coast, Nairobi National Park and Mombasa in Kenya and the Bwamba forest in Uganda.

P. krameri – Rose-ringed Parakeet*

A bright green, long-tailed parakeet with red bill which flies about swiftly and noisily in small parties of up to a dozen birds. Flocks up to 50 birds but occasionally hundreds or even thousands concentrate at food sources. They are recorded feeding on the heads of maize, sorghum and millet, on lentils, and on the berries, blossom and nectar of coffee. They also damage ripening guavas, dates and mangoes.

Genus: *Poicephalus*

Four species are recorded damaging cereal crops.

Key to the Species

1. Medium/large parrot with large heavy bill, red thighs and coverts on leading edge of wing: *P. robustus*
- Medium sized parrots, thighs never red........2
2. Small green parrot with orange-yellow belly: *P. senegalus*
- Underparts bright green........3
3. Head brown with noticeable grey cheeks, iris red: *P. crassus*
- Cheeks concolorous with rest of brown head, iris yellow: *P. cryptoxanthus*

(*P. robustus* – Brown-necked Parrot)

The largest of the *Poicephalus* parrots. It is a forest species in West Africa but elsewhere an inhabitant of woodland and savannas. It feeds on fruits and seeds, reportedly damaging sorghum in Zimbabwe and Malawi. They occur in flocks of up to 20, sometimes 50, birds and can fly up to 90 km from roost site to feeding site.

(*P. senegalus* – Senegal Parrot)

A dark-headed green parrot with yellow underparts and an orange or scarlet belly. It occurs in flocks in the semi-desert and grassland savannas of West Africa where it feeds on old agricultural land and grassland. They nest in holes in large trees, commonly the Baobab. Pairs or small flocks feed on millet and sorghum and can cause considerable damage to cereal crops.

(*P. crassus* – Niam-Niam)

A grass-green parrot of limited distribution in the south-west Sudan, the Central African Republic, north-east Zaire and south-east Chad. They occur in pairs or small flocks and feed on millet and other seeds.

(*P. cryptoxanthus* – Brown-headed Parrot)

A dull-coloured parrot with bright green underparts which occurs throughout Mozambique and in neighbouring parts of Tanzania, Malawi and South Africa. Flocks of 4–12, sometimes up to 40, birds feed on millet and maize.

Genus: *Agapornis*

The birds of this genus are referred to as Lovebirds. The name is probably given to them because of their tendency to perch in close contact with one another and mutually preen each other's feathers. They are all stocky little green parrots with short rounded tails. There are six species recorded causing damage to cereals.

Key to the Species

1. Head and face green, bill black, iris yellow: *A. swinderniana*
– Face not green 2
2. Face pink, rump blue, bill white, tinged greenish: *A. roseicollis*
– Face neither pink nor green, bill red 3
3. Face brownish-black: *A. personata*
– Face red, orange or yellow 4
4. No noticeable orbital ring: *A. pullaria*
– Noticeable white orbital ring 5
5. Upper tail coverts pale blue: *A. fischeri*
– Upper tail coverts green: *A. lilianae*

(*A. pullaria* – Red-headed Lovebird)

An inhabitant of moist savanna woodland in West and Central Africa. They occur in pairs or in groups of up to 30 and are recorded feeding on sorghum heads in the milky stage.

(*A. swinderniana* – Black-collared Lovebird)

A small green lovebird with a thin black half collar on the back of the neck. It is a forest-dwelling species in Central Africa and feeds in small flocks, usually less than 20, but sometimes up to 60 in the dry season. It is recorded feeding on maize.

(*A roseicollis* – Rosy-faced Lovebird)

A pink-faced lovebird which occurs in the dry savannas of Namibia, south-west Angola and north eastern Namaqualand. It inhabits trees along watercourses and is generally seen feeding in parties of less than 20 but up to 300 may gather when feeding on ripening grass seeds or drinking at watering points. Reported to feed on millet crops.

A. personata – Yellow-collared Lovebird (Only feral populations of pest status.)

An abundant lovebird in the wooded parts of the Maasai steppe in Tanzania. Escaped cage-birds have established themselves in urban areas of East Africa namely Dar-es-Salaam, Tanga, Nairobi and Mombasa. A feral population also occurs at Lake Naivasha in Kenya. In Nairobi a feral population of hybrid *personata x fischeri* has become established. They are usually seen in groups of 4 or 5 but over 100 can assemble during the dry season. They are recorded feeding on millet and the feral populations can be a major pest of small stands of maize grown out of season.

A. fischeri – Fischer's Lovebird

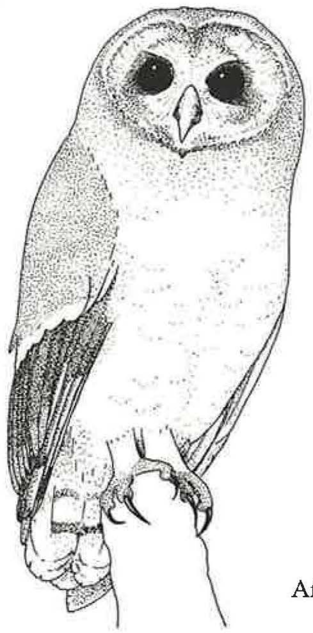
A common and widespread lovebird in Tanzania to the south and east of Lake Victoria, and just across the border in Rwanda and Burundi. It is common in agricultural land where it feeds extensively on millets. Feral populations occur alongside those of the Yellow-collared Lovebirds, with which it has occasionally hybridised. They occur in Dar-es-Salaam, Tanga, Mombasa, Nairobi and at Lake Naivasha.

(*A. lilianae* – Black-cheeked Lovebird)

This lovebird occurs in isolated populations in Mopane[7] woodland, Acacia savannas and riparian fringing forest separated by Miombo[8] which it avoids. Flocks of 200–300 birds were formerly common feeding in vleis (seasonally flooded perennial grassland) and millet fields but numbers are greatly reduced now due to trapping.

Owls: STRIGIFORMES

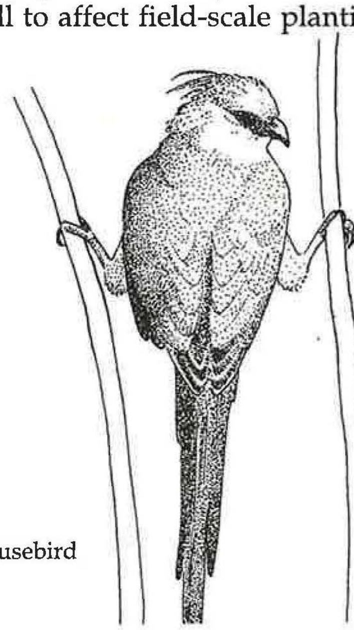
Owls are the nocturnal birds of prey. Small to large in size and recognisable by their forward-looking round face, the owls are often held in awe. Their flight is silent and their hooting calls in the night can be alarming but there is no doubt that their benefit to farmers and householders is enormous. A large proportion of their diet is nocturnal rodents such as the Multimammate Rat, *Rattus (Praomys) natalensis*, a periodically serious crop pest and carrier of Bubonic Plague. Others feed on small Passerine grain-eaters such as weaver birds, *Ploceus* spp., bishops, *Euplectes* spp., and Quelea, *Quelea quelea*. Their effect on the numbers of the birds is negligible but rodent numbers can be markedly affected by their predation.



African Marsh Owl

Mousebirds or Colies: COLIIFORMES

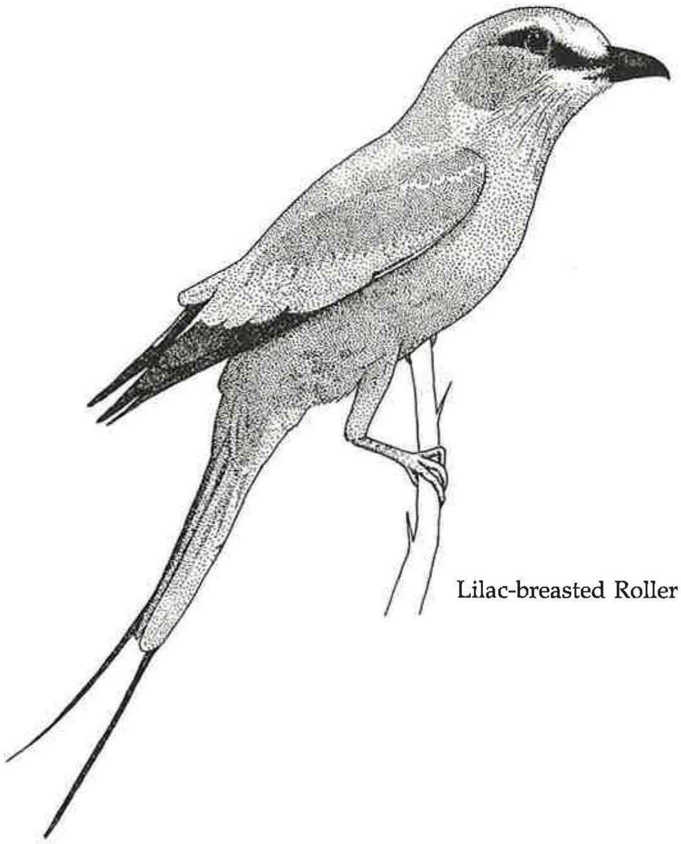
A group of relatively common, long-tailed birds which get their English name from their habit of creeping about in trees and bushes looking like mice. Their long tails are used for support and they usually occur in small parties of up to ten or so birds. They are superficially like small, long-tailed parrots but their bill, although hooked, is much less markedly modified than that of the parrots. Their diet is mainly fruit and leaves and they can cause havoc in small gardens by eating recently germinated seedlings of a variety of broad-leaved vegetables. They are not, however, an agricultural pest as their numbers are too small to affect field-scale plantings.



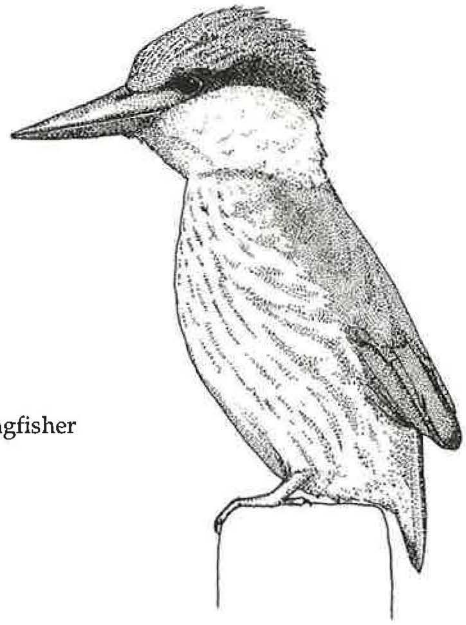
Blue-naped Mousebird

Rollers, Kingfishers, Bee-eaters and Hornbills: CORACIIFORMES

A large order of diverse, usually brightly coloured birds. Most have relatively large beaks, some strikingly so, which are modified for the specialised feeding habits of the different families. Those which are likely to occur in cultivation are beneficial birds feeding for the most part on grasshoppers, including locusts and small rodents.



Lilac-breasted Roller



Striped Kingfisher

Little Bee-eater

Only the Grey Hornbill, *Tockus nasutus*, occasionally feeds on sorghum heads. However, like other hornbills, its main diet is fruit, insects and small reptiles – a diet which more than compensates for any loss in grain it may cause.

Family: Bucerotidae

(*Tockus nasutus* – Grey Hornbill)

A greyish brown hornbill with a black bill. The dark tail has a broad white tip to it. The bill of the female is reddish in colour. Widespread in open woodland and thornbush country. Reported to feed on sorghum in the milky stage in the Sudan.

Perching Birds: PASSERIFORMES*

This is the largest order of birds. There are some 28 families occurring in Africa, seven of which contain birds which reach pest status. The birds in the order are unremarkable in form but possess two characteristics which unite them. They are all perching birds with a muscle and ligament structure which allows them to 'lock' themselves into a perching position and, with the exception of two families in Africa, they also have the ability to sing. Many of the birds can be identified by their particular song.

Six of the seven families have been recorded damaging agricultural crops feed on cereals. The seventh, Pycnonotidae, the bulbuls, contains one species, the Common Bulbul *Pycnonotis barbatus*, which causes damage to cultivated fruit. It is probable that the Common Bulbul more than makes up for any damage it does by the number of injurious insects it feeds on in orchards.

Key to the Families

1. Large (largest perching birds), black, or black and white, with longish powerful bill: Corvidae
– Medium to small birds 2
2. Streaky brown ground-dwelling birds sometimes occurring in large flocks: Alaudidae
– Not streaky brown or ground dwelling, living mainly in trees or shrubs 3

3. Medium-sized stocky birds with comparatively long, slender, pointed bills: Sturnidae

– Smaller and slimmer with shorter, stouter bills 4

4. Small seed-eaters, plumage drab or with conspicuous amount of yellow, red, brown or black 5

– Very small seed-eaters, plumage never drab although subdued in tone, often marked with fine spots or bars: Estrildidae

5. Male and female plumage generally similar, yellowy green or variously patterned in browns, black and white. Males good singers, feed mainly on the ground. Do not nest in colonies, nest an open cup: Fringillidae

– Male and female plumage generally different. Males more colourful. If yellow, generally bright, not greenish. Females tend to have streaky plumage. Males do not sing, only chirp and chatter. Commonly nest in colonies, nest globular: Ploceidae

Family: Alaudidae

Birds in this family are small inconspicuous ground feeders with more or less curved bills. They are common and widespread in agricultural areas. Larks like open cultivation where they feed on insects and small seeds. Two genera are recorded feeding on cereals.

Key to the Genera

Large, robust lark with heavy bill. Pair of large dark patches on breast: *Melanocorypha*

Small, neat lark. Head of male mainly black. Female sparrow-like, brown and streaky: *Eremopterix*

Genus: *Melanocorypha*

One species recorded feeding on cereals.

M. bimaculata – Bimaculated Lark

A dull-coloured brown bird, which is usually seen on the ground where it runs about actively. Two distinct patches of black on each side of the breast distinguish it from other larks. Larger than a sparrow. A palaearctic migrant from the Middle East to the Sudan and Red Sea coast of Eritrea. Recorded as causing crop damage by digging up freshly sown sorghum seeds and feeding on the ripening ears of sorghum in the Sudan.

Genus: *Eremopterix*

One species recorded causing damage to sorghum.

(*E. leucotis* – Chestnut-backed Sparrow-lark)

A dark coloured sparrow-lark with an entirely black head except for white cheek patches. The belly is white. The female is duller and has a black belly. Widespread in the Sahel and Sudan savannas. They occasionally gather in large flocks and raid sorghum fields like weavers.

Family: Corvidae

One species recorded damaging cereal crops.

Genus: *Corvus*

C. alba – Pied Crow

All black with a white patch on the upper back extending onto the belly to form a complete ring around the bird in front of the wings. It occurs throughout most of the Afrotropical region except in northern Kenya and in Somalia where it is replaced by the Brown-necked Raven, *Corvus ruficollis.* It is reported to dig out and eat the seeds of groundnuts, cotton, sorghum, maize and other crops after sowing and also feeds on ripe groundnuts and maize cobs.

Family: Sturnidae

One species of one genus is recorded damaging cereal crops

Genus: *Lamprotornis*

L. chalybaeus – Blue-eared Glossy Starling

Common resident bird throughout most of Africa except the north. There are six species of Glossy Starlings and they are all very similar in appearance. The Blue-eared Glossy Starling is very glossy green above particularly on the tail, has a blackish ear patch and two distinct rows of black spots on the wing coverts. The abdomen is violet and the eye bright yellow. They occur in large flocks in the non-breeding season and cause locally severe damage to small grain crops.

Family: Ploceidae*

Nine genera recorded damaging cereal crops.

Key to the Genera (males only)

1. Larger, over 15 cm in length, no yellow in plumage 2
– Smaller, 15 cm or less in length 3
2. Black: (*Bubalornis*)
– White and black with reddish coloured rump: (*Dinemellia*)
3. Small, less than 11 cm in length, grey-buff with pale, almost white, crown: (*Pseudonigrita*)
– Larger 11–15 cm in length, crown never pale in colour 4
4. Tail normal; bill not red or yellow 5

- Noticeably short-tailed 9
5. Underparts mainly white or buffy-white 6
- Underparts bright yellow or cinnamon 8
6. Forehead speckled black and white: (*Sporopipes*)
- Forehead not speckled 7
7. Dark brown above and white below, rump white: (*Plocepasser*)
- No distinguishing marks except in some males a black chin and throat: *Passer (part)*
8. Back mottled: *Passer (part)*
- Back not mottled: *Ploceus**
9. Underparts not black, thick heavy bill: *Quelea**
- Underparts mainly black: *Euplectes**

Genus: *Bubalornis*

Two species only, one of which has been recorded damaging crops.

(*B. albirostris* – Buffalo Weaver)

A starling-sized black weaver with bases of feathers white, bill white and swollen at the base during the breeding season. It occurs in the Sudano-Sahelian zone from Senegal to the Sudan and in Ethiopia, Somalia, Uganda and Western Kenya. They feed in moderate-sized parties often in association with starlings. The nests are built as large communal stick piles in trees containing individual grass nests. Recorded as a pest of sorghum.

Genus: *Dinemellia*

One species.

(*Dinemellia dinemellia* – White-headed Buffalo Weaver)

A black or brown weaver, smaller than a starling, with a wholly white head and underparts, a large white patch on the wing and brilliant scarlet and orange upper and under tail coverts. It occurs only in eastern Africa and nests in small colonies building an untidy, haystack-type nest. It sometimes feeds on grain crops.

Genus: *Pseudonigrita*

Two species occur in this genus both of which are confined to eastern Africa. Only one species has been reported damaging crops.

(*Pseudonigrita arnaudi* – Grey-headed Social Weaver)

A very small weaver occurring in small flocks. It is greyish buff in colour, with a pale greyish white cap distinguishing it from the other species in the genus, the Black-capped Social Weaver, *P. cabanisi*. It nests in small colonies, apparently always associated with ants which 'repel' humans, or other animals, who interfere with the nest. It is recorded as damaging millets and even, on occasion, sorghum.

Genus: *Sporopipes*

A genus of two species, one occurring throughout the drier areas of western, eastern and central Africa, the other in southern Africa.

(*Sporopipes frontalis* – Speckle-fronted Weaver)

A very common weaver, usually in large flocks but nests singly in straggling nests built with grass heads. The Speckled-fronted Weaver occurs throughout the Sahelian zone of West Africa through the Sudan to East Africa. It is a small bird, grey on the back and white below. The crown and a moustachial stripe are characteristically speckled black and white. It sometimes feeds on cultivated grain.

(*Sporopipes squamifrons* – Scaly Weaver)

The Scaly Weaver is the southern African representative of the genus, occurring in Zimbabwe, Mozambique, South Africa, Botswana, Namibia and Angola. The species can exist far from water and is common around farmsteads in dry thorn-bush country.

Genus: *Plocepasser*

There are four species of sparrow weavers. All are heavily built weavers rather like sparrows. Both sexes are mainly brown and white in general colour. Two of the species have been recorded feeding on cereals.

(*Plocepasser mahali* – White-browed Sparrow Weaver)

This brown weaver is larger than a sparrow, with white rump and white underparts. It is a common resident of eastern and southern Africa and sometimes feeds on cereals, especially sorghum.

(*Plocepasser superciliosus* – Chestnut-crowned Sparrow Weaver)

The West African representative of the genus which occurs in small numbers extensively through the Sahelian zone into the Sudan, Ethiopia, Western Kenya and Uganda. It is not reported to cause damage to crops in West Africa. It occasionally feeds on cereals but its numbers are low and any damage done would be of little significance.

Genus: *Passer**

Six species have been recorded damaging crops in the Afrotropical region. A seventh species, the Spanish Sparrow *P. hispaniolensis*, does not quite enter the region. It occurs as a serious crop pest in North Africa only, penetrating the Sahara down the River Nile into northern Sudan.

Key to the Species

1.	Underparts with some yellow	2
–	Underparts mainly white or buffy-white, not yellow	3
2.	Head and underparts yellow in breeding plumage, suffused with yellow at other seasons. No black streaking on chestnut back:	*P. luteus*
–	Underparts only suffused yellow in breeding season. Black streaking on chestnut back:	*P. castanopterus*
3.	Back plain, unstreaked	4
–	Back streaky brown, throat black, crown grey	5
4.	Head and neck grey: mantle, rump and shoulders tawny:	*P. griseus*
–	Male with head, throat and upper mantle black, upper mantle grey Female head and most of back grey:	*P. melanurus*
5.	Back dark chestnut, rump grey, mantle dark cinnamon:	(*P. domesticus*)
–	Back and rump cinnamon rufous, upper mantle grey:	(*P. iagoensis*)

Passer luteus – Golden Sparrow*

An unmistakable yellow and chestnut sparrow occurring on the edge of the Sahara and into the Sahelian climatic zone of West Africa and the Sudan but does not occur in Somalia. It occurs in moderate-sized flocks and nests in loose colonies over a wide area. It is recorded as a pest of sorghum, wheat and pennisetum millet.

P. castanopterus – Somalia Sparrow*

Only occurs in Somalia, coastal Eritrea and the Ogaden area of Ethiopia. The head, neck and wing coverts of the male are chocolate brown, the mantle and rump grey. The female is dirty brown above, the mantle being streaked with ashy black. It periodically occurs in large flocks and causes considerable damage to sorghum and millet crops in Somalia and Ethiopia.

(*P. griseus* – Grey-headed Sparrow)

Common and widespread throughout most of the Afrotropical region. Both the male and the female have the head and neck plain grey except for the chin and throat which are white. It is often reported causing damage to cereal crops but is not a species which occurs in large flocks and is therefore of little consequence as a pest species.

P. domesticus – House Sparrow

The common town sparrow of the Nile Valley, introduced to the Kenya coast (from where it is spreading inland) and South Africa. The crown and rump of the male are grey, the sides of the crown chestnut and the cheeks white. Nests are often associated with houses and other buildings or man-made structures. Recorded as a pest of grains, dates and figs in the Sudan.

(*P. iagoensis* – Rufous Sparrow)

Very similar to the House Sparrow of which it is the African representative. It is common in parts of eastern and southern Africa never going far from man's habitations. Recorded as a pest of grain crops.

Genus: *Ploceus**

A very important genus with nine pest species recorded feeding on grain crops.

Key to the Species (males in breeding plumage only)

(Females, and males in non-breeding plumage, are difficult to identify.)

1.	Golden yellow, whole head and throat orange:	(*P. bojeri*)
–	Some black in plumage	2
2.	Entirely black including bill. Iris yellow:	*P. nigerrimus*
–	Yellow or chestnut and black in plumage	3
3.	Underparts mainly bright yellow	4
–	Underparts mainly chestnut	7
4.	Forehead, sides of face and chin chestnut, throat yellow:	*P. galbula*
–	Sides of face and throat black	5
5.	Forehead black	6
–	Forehead cinnamon or yellow	7
6.	Mantle and scapulars mottled yellow and black:	*P. cucullatus*
–	Nape and rump yellow, mantle and wing coverts olivaceous yellow:	*P. melanocephalus*
7.	Head black, remainder of plumage entirely chestnut:	*P. rubiginosus*
–	Black mask, underparts yellow washed with saffron	8
8.	Black throat cut off square, not ending in point:	*P. velatus*
–	Black of throat ending in point on upper breast:	*P. taeniopterus*

(*P. bojeri* – Golden Palm-Weaver)

Confined to riverine areas of the East African coast, this orange-headed, bright yellow species is recorded as a pest of sorghum, millet and rice in Somalia. The female is duller yellow above with slight dark streaking. The bill of the male is black whereas that of the female is horn-coloured. There is no non-breeding plumage change. It breeds in small colonies, the nests usually built in palm trees.

(*P. nigerrimus* – Vieillot's Black Weaver)

A West African species of forest clearings extending eastwards into Uganda, Rwanda, Burundi and western Tanzania and commonly occurring in villages. The female is olive-green above with blackish streaking and olive-yellow below. The bill is horn-coloured whereas that of the male is black. There is no non-breeding plumage change in this species. Vieillot's Black Weaver is omnivorous and, like the closely related *P. cucullatus,* it can cause extensive damage to small plots of cereals. It nests in small, dense colonies in palm trees.

(*P. galbula* – Ruppell's Weaver)

The 'mask' of the breeding male is cinnamon-chestnut in colour, not black as in the other yellow weavers. In non-breeding plumage the mask is yellowish green, the same colour as the back. The female is greyish brown above with darker streaks, buffish below with a white belly. It occurs in large flocks along the southern coast of the Sudan, in north-eastern Ethiopia and in northern Somalia. Colonies are usually established in Acacia trees overhanging water. It is recorded as a pest of grain crops.

P. cucullatus – Village Weaver*

A robust, noisy weaver which nests in small colonies after stripping off the leaves in the tree selected for nesting. It is common throughout the Afrotropical region except for the rain forests and is recorded as damaging grain crops, especially sorghum. The male in breeding plumage has a black head, the black of which extends to a point down the chest. The upper parts are yellow with black mottling and the underparts yellow or orangy-yellow. The male moults to a non-breeding plumage similar to that of the non-breeding female which is smaller. The crown and sides of the head are greenish yellow, the upper parts greyish brown with darker streaks, the chin and upper breast yellow and the rest of the underparts white. The female in breeding plumage has the top of the head and the face green, the upper parts yellowy green and the underparts yellow except for the centre of the belly which is white. Both sexes have black bills during the breeding season which change to horn-coloured at other times. It frequents damper habitats, often associated with villages and commonly nests in palms, sometimes in association with Vieillot's Weaver with which it has hybridised. There are a number of different races which show variations of the above generalised plumage pattern. A race is the name given to the level of classification below a species. The racial name distinguishes populations of a species which have become isolated genetically through geographical or behavioural separation and have developed recognisable characteristics of their own. The races may freely interbreed where their boundaries meet.

P. melanocephalus – Yellow-backed Weaver

A distinct yellow collar separates the black head from the greenish yellow back. In non-breeding plumage the head is greenish-yellow contrasting with the brownish back which is broadly streaked with black. The underside is white with buff-coloured chest and flanks. There is some yellow in the throat and chin. The plumage of the female is similar to that of the non-breeding male. Colonies are often mixed with other species and are generally associated with water. It is recorded as a pest of sorghum and pennisetum millet.

P. rubiginosus – Chestnut Weaver*

An East African species which occurs in large flocks. The male in non-breeding plumage is pale brown above streaked with black, the chest and flanks very light brown and the throat and belly white. The female plumage is similar to that of the male in non-breeding plumage. Small dense colonies are established in a variety of tall trees, commonly Acacias. Colonies can be extensive but scattered according to the density of suitable trees. It causes damage to wheat and sorghum in Tanzania and Kenya and sorghum in Somalia.

(*P. velatus* – Vitelline Masked Weaver)

A black masked yellow weaver with the black cut off square at the throat, not ending in a point. The forehead and lower edge of the mask are orange-yellow (vitelline – egg yolk coloured, deriving from *vitellus* meaning egg yolk), fading out on the crown and breast into yellowish green on the back and yellow below. The female is greenish-yellow above with darker streaks on the mantle and scapulars and pale yellow below, the chest and flanks yellow-buff with a white centre to the belly. The male in non-breeding plumage is dull greenish above with darker streaks and pale yellow below with a white belly. The female in the non-breeding season is less greenish above and white below without any buff colouring. It is very common in dry savannas throughout the Afrotropical region and nests in small colonies often in thick bush and often in, or near to, colonies of the Red-billed Quelea. It is recorded as a pest of cereals. The species is often confused with *P. taeniopterus* and *P. melanocephalus.*

(*P. taeniopterus* – Northern Masked Weaver)

The plumage is similar to that of the Vitelline Masked Weaver but the black of the throat in the males ends in a point on the upper breast. The black mask is much less clearly defined, merging through brownish-yellow to orangy-yellow on the hind neck and underparts. There are traces of chestnut colouring on the breast. The back is greenish yellow and the rump bright yellow. In non-breeding plumage the head is greenish grey with thin darker streaks and the back is buffish-brown with broad black streaks. The underparts are light buffy-brown, the centre of the belly being white. The female plumage is similar to that of the non-breeding male. It occurs throughout the Nile Valley from Khartoum southwards, often in enormous numbers, breeding in large colonies in tall grass or swamps. It is recorded as a pest of grain fields.

Genus: *Quelea**

The most important genus of grain-eating birds in Africa, with two species causing serious damage to cereals and one species which causes only minor damage. A fourth species *Q. anomala* is recognised by some systematists but its correct classification is still controversial. It is sometimes assigned to a monotypic genus, *Brachycope* and called the Bob-tail Weaver. It resembles the other members of the genus in its general shape and has a black mask. The forehead, crown and upper breast are yellow. It occurs in riverside clearings in the lowland rainforest areas of Central Africa. Its status as a pest is not clear but it does feed on cereals.

Key to the Species

1. Red head in male in breeding season, in other seasons some yellow tinge on the head 2
– No red in plumage although occasionally suffused with pink; no yellow tinge on head in non-breeding plumage: *Q. quelea*
2. Notably smaller, all red head without any black feathering: *Q. cardinalis*
– Larger, black feathering in otherwise red chin: *Q. erythrops*

Quelea quelea – Red-billed Quelea*

An unmistakable bird with a large, deep red bill at all times except during the breeding season when the bill of the female turns bright yellow. It occurs in large flocks and causes considerable damage to cereal crops throughout the wooded grassland savannas of the Afrotropical region.

Q. erythrops – Red-headed Quelea*

A black-billed Quelea occurring in wetter habitats than the Red-billed Quelea. A major pest of rice wherever it occurs. Males are distinctive but easily confused with the smaller *Q. cardinalis.* During the breeding season the males desert the breeding colonies which may then be mistaken for colonies of the Red-billed Quelea. The red or yellow colour of the bill of breeding *Q. quelea* is, however, diagnostic.

Q. cardinalis – Cardinal Quelea

The Cardinal Quelea is distinctly smaller than the other two Queleas. The size difference is particularly noticeable in the bill which is very much smaller. The Cardinal Quelea does not occur in large colonies and occupies a habitat intermediate between that of the other two species, i.e. seasonally flooded grassland.

Genus: *Euplectes**

An important genus of noticeably small weavers which frequent grain fields in medium sized flocks. Eight species are recorded damaging cereal crops.

Key to the Species (males in breeding plumage only)

1. Short tailed, plumage predominantly red or yellow 2
– Long or broad tailed, plumage predominantly black 5
2. Plumage scarlet and black 3
– Plumage yellow and black 4
3. Crown of male black, very small: *E. franciscanus*
– Crown of male red, wings black, small: *E. hordeaceus*
4. All black except shoulders, lower back and rump which are yellow: *E. capensis*
– Crown, lower back and rump yellow. Black mask and underparts: *E. afer*

5. Tail short, broad and fan shaped. All black with orange-red shoulders: *E. axillaris**
- Tail longer than body 6
6. No coloured shoulder patch. With or without red band on lower neck: *E. ardens*
- Noticeable yellow or white shoulder patch 7
7. No white in the wings: *E. macrourus*
- Primary, secondary and under wing coverts mostly white: *E. albonotatus*

E. franciscanus – Red Bishop

A widely distributed and common bishop in grasslands across Africa from Senegal to Somalia and south to Uganda and Kenya. The male in breeding plumage is bright red with a black crown, face and belly. It is very conspicuous during the breeding season when the males display over small territories, often in grain fields. The female is sandy coloured with the back broadly streaked with brown and black. The underparts are unstreaked except for the chest and flanks. The belly is whitish. The non-breeding plumage of the male resembles that of the female.

The Red Bishop is a polygamous species, the male mating with about three females, each with a nest in the male's territory. In the non-breeding season, they occur in large flocks with other weavers. They raid millet and sorghum fields. From Tanzania and Uganda southwards, the Red Bishop is replaced by another species the Southern Red Bishop, *E. orix*, with similar habits. It differs from the Red Bishop by being larger and having the black of the head only on the forehead and chin.

E. hordeaceus – Black-winged Red Bishop

This species is larger than the Red Bishop, which it resembles, but the crown is red with only a narrow band of black over the forehead. The tail is noticeably longer than that of the Red Bishop. The female is similar to the female Red Bishop from which it can be distinguished by having black wings, and tail. The male in non-breeding plumage can be distinguished from the female by its larger size and having no yellowish colour to the underparts. The distribution is similar to that of the Red Bishop but the Black-winged Red Bishop occurs in wetter localities and is absent from southern Africa. It is recorded damaging rice and millet.

(*E. capensis* – Yellow Bishop)

A bishop which occurs most commonly in upland grasslands. The distribution is patchy with birds occurring in the high pastures in Cameroon, Ethiopia, East Africa, Rwanda, Burundi, Malawi and on through Swaziland and the Drakensburg range to the Cape. The male in breeding dress is mainly black with yellow shoulder patches and lower back. The female is like other female bishops except that it has a yellowy-brown rump and yellow wing shoulders. The non-breeding plumage of the male is similar to that of the female but the wing shoulders and rump are bright yellow. It collects in the usual flocks with other weavers in the non-breeding season when it enters fields of grain crops.

E. afer – Yellow-crowned Bishop

Like the Yellow Bishop, the Yellow-crowned is usually associated with a wetter habitat than the Red Bishop. The male in the breeding season is very conspicuous, fluffing up its back feathers so that it looks like a yellow ball bouncing about over the area where it has its nests. The female in breeding plumage is very similar to other bishops but has a broad white, or pale yellow eye-stripe above the eye, extending well behind it. The non-breeding plumage of the male is similar to the non-breeding plumage of the female and has no particularly distinguishing feature. The Yellow-crowned Bishop occurs along most of the major river systems of the Afrotropical region. It often establishes colonies in rice fields and is recorded damaging sorghum, millet, rice and wheat.

E. axillaris – Fan-tailed Widowbird*

A black widowbird with a large chestnut and orange-red shoulder patch. The females are typical *Euplectes* but have noticeable shoulder patches of black feathers edged with orange. The non-breeding plumage of the male is similar to that of the female but the bird is larger and the shoulder patch brighter in colour. It is a bird of swamps in much of the Afrotropical region but absent from most of Central Africa. Unlike the bishops, it displays by flying slowly, with drooping wings, over the grassland where it is breeding, nesting in loose colonies in swamps. A common bird in rice fields where it can do considerable damage, it occurs in large flocks when not breeding.

E. ardens – Red-collared Widowbird

A small, all black widowbird, with or without a red neck adornment, and with a long graduated tail the middle feathers of which are the shortest. There are a number of races, each differing in the extent of red they have around the neck. In Ethiopia and Kenya, the birds have a broad collar from the crown to the nape joining a collar on the lower neck in front. From coastal Guinea eastwards to Uganda and western Tanzania the birds are entirely black without a red collar. In the remainder of their range from Tanzania southwards they only have a scarlet half collar on the lower neck. The female is a typical *Euplectes* and is impossible to identify in the field. Common in patches of suitable grass throughout their range, the Red-collared Widowbirds roost in large numbers in grasses such as Elephant Grass, *Pennisetum purpureum*. It is recorded feeding on millet and rice.

(*E. macrourus* – Yellow-shouldered Widowbird)

Another wholly black widowbird except for the shoulder and edge of the wing which is yellow. Two races occur, one in Ethiopia, Eritrea and Uganda and the other, which has the mantle yellow, is very widely distributed through the moist woodland savannas of West Africa and Uganda, and the Miombo of Tanzania, Zambia, Malawi, Zimbabwe, Mozambique, Angola and Zaire. The female is very similar to the next species both having unremarkable plumage except that the Yellow-shouldered Widow has yellow edging on the feathers of the wing shoulders. It is a bird of tall grasslands around swamps, where it commonly roosts in reedbeds, and is found in large flocks in the non-breeding season. It is recorded feeding on rice.

(*E. albonotatus* – White-winged Widowbird)

This widowbird is very similar to the Yellow-shouldered Widowbird but smaller with a shorter, less graduated, tail. There are two distinct races, one in eastern Africa with brownish coloured wing shoulders and one in southern Africa with yellow shoulders. Both have white wing coverts. The females are difficult to distinguish in the field. The non-breeding male is similar to the female except that it still shows the colouring in the wing shoulders. Found in dry woodland savannas from Ethiopia southwards to the Eastern Cape in South Africa and along the Angolan coast but absent from Namibia and most of Botswana. It occasionally feeds on millets.

Family: Estrildidae

A family of very small seed-eaters generally referred to as waxbills. Four genera are recorded causing losses to cereal crops.

Key to the Genera

1. Scaly brown appearance. Male with red band across throat: *Amadina*
– Plumage plain on back and head 2
2. Head entirely black: *Lonchura*
– No black in head 3
3. Forehead to nape grey: *Estrilda*
– Head rosy red: *Lagonosticta*

Genus: *Lonchura*

Four of the five species of mannikins and silverbills are recorded causing damage to cereal crops. Unlike the bishops and widowbirds, the sexes are alike in this genus.

Key to the Species

1. Tail graduated, central tail feathers pointed. Without glossy sheen: *L. malabarica*
– Glossy blue, green or violet sheen in plumage 2
2. Mantle, head, wings and tail glossy black with violet sheen: *L. bicolor*
– Mantle without glossy sheen, brown or ashy 3
3. Top of head, sides of face, shoulder and flanks glossy bottle green: *L. cucullata*
– Head, neck, sides of chest, tail and lower rump glossy blue black: *L. fringilloides*

(*L. malabarica* – Silverbill)

There are two species of silverbill but only one is reported to feed on crops. They are small, brown-backed birds with light edges to the feathers of the crown giving them a scaly appearance. The underparts are white, the upper tail coverts, tail and flight feathers bronzy black. They differ from the mannikins of the same genus by having longer, more pointed tails and not being black and white in general appearance. The silverbill is widespread from Senegal to the Sudan except for coastal West Africa. It does not occur in large numbers so its effect on crops is negligible.

(*L. bicolor* – Black and White Mannikin)

A typical black and white mannikin with a glossy black colouring washed with a violet sheen. It occurs throughout the wetter forest edges of the Afrotropical region in small flocks up to about 30 birds. Although feeding on rice, its impact on the crop is fairly negligible.

L. cucullata – Bronze Mannikin

The Bronze Mannikin is found in large numbers in some coastal areas in West Africa where it does extensive damage to millet crops and rice. It has a notable glossy bottle green sheen and black head.

(*L. fringilloides* – Magpie Mannikin)

A less mannikin, distinguishable by its glossy blue black rump and tail contrasting with a brown back. Its distribution is very similar to that of the Bronze Mannikin with which it commonly associates. It breeds prolifically and as frequently as opportunity permits. However, numbers are kept in check by heavy predation. This is typical of all mannikins which are preyed on by kingfishers, shrikes, coucals, hornbills and other birds as well as snakes and small mammals. It feeds on rice but is not a serious problem.

Genus: *Amadina*

One species recorded damaging cereal crops.

A. fasciata – Cut-throat

The Cut-throat is an unmistakable species. A small brownish coloured bird with blackish bars on the head and neck, and lighter underparts. The male characteristically has a blood red band across the throat. The female lacks the red throat band and is paler in colour. They breed solitarily in grass nests lined with feathers, often in the old nests of weaver birds. In the non-breeding season they gather into dense flocks in dry bush, or open country, and occasionally damage grain crops.

Genus: *Lagonosticta*

Five species in the genus but only one reportedly feeding on rice.

(*Lagonosticta rubricata* – African Firefinch)

A common and widespread species of firefinch in the Guinean zone of West Africa and in the Sudan, Uganda, Zaire, Tanzania, Zambia, Malawi, and Mozambique. It is dullish red in colour with darker wings and back, and a red rump. At close quarters, small white spots are noticeable on the flanks. The female is much paler than the male. It occurs in wetter long grass Acacia scrub and is suspected of feeding on rice in West Africa.

Genus: *Estrilda*

This is a widespread and common genus of true waxbills which occupy grasslands and clearings throughout the Afrotropical region. Only one species of the 15 *Estrilda* waxbills has been suspected of feeding on rice.

(*Estrilda melpoda* – Orange-cheeked Waxbill)

Both male and female have similar plumage characterised by the orange cheeks. The forehead to nape is grey and the rest of the upperparts brown. The lower rump and upper tail coverts are red, the tail black. It occurs in large numbers in cultivation in both the breeding and non-breeding seasons. Distributed across Africa from the Gambia to Angola, Zaire and Zambia, it is suspected of feeding on rice.

Family: Fringillidae

The finches are a family of seed-eaters very similar in form to weaver birds but differing in being good singers, building open 'cup' nests and never breeding in colonies. Their singing ability makes them popular as cage-birds. Members of only one genus are recorded damaging cereals.

Genus: *Serinus*

Three species are known to cause damage to crops and others may cause damage to garden plants.

Key to the Species

1. Plumage predominantly yellow. Distinguished from other canaries by yellow forehead and all yellow underparts: *S. mozambicus*

– Plumage predominantly streaky brown, little, if any, yellow in plumage..................2

2. Small with a conspicuous white rump: *S. leucopygius*

– Larger with the rump similar in colour to the back and tail: *S. gularis*

(*S. mozambicus* – Yellow-fronted Canary)

A common species throughout the savannas of the Afrotropical region. The name 'canary' belongs to the species *S. canaria,* from the Canary Islands but is generally applied to all the yellow-plumaged members of the genus. The sexes are similar, the female slightly browner above than the male which is greenish above with a bright yellow rump and mainly yellow underparts. They are gregarious in the non-breeding season and have been recorded feeding on wheat in Kenya and Malawi. The closely related White-bellied Canary, *S. dorsostriatus,* of eastern Africa is not recorded as feeding on grain crops.

(*S. leucopygius* – White-rumped Seed-eater)

A bird of the dry woodland savannas of West Africa, extending through the Sudan into Uganda. The sexes are alike, the plumage being greyish above with darker spots and streaks, an unpatterned face and white below. The white rump is conspicuous. They are recorded feeding on millets in the Sudan.

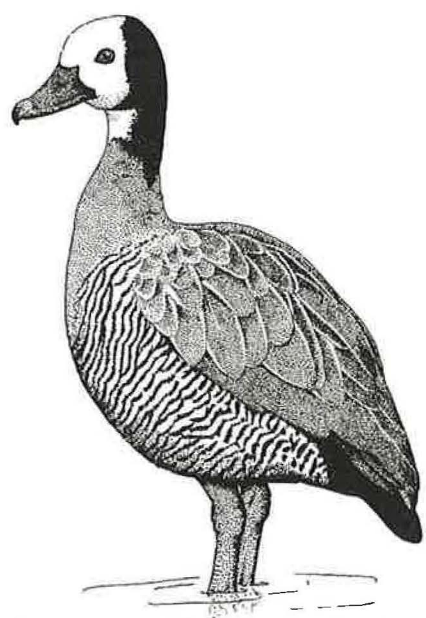
S. gularis – Streaky-headed Seed-eater

The Streaky-headed Seed-eater is widespread through the moist woodland savannas, but absent from the Miombo, of the Afrotropical region and generally absent from Acacia scrub. It is a plain bird with notable streaking on the head (as its name implies) and a white eye-stripe and throat contrasting with the grey-brown breast. In the non-breeding season it occurs in large flocks and is recorded damaging wheat.

Detailed Review of Selected Pest Species

The White-faced Whistling Duck – Dendrocygna viduata

The White-faced Whistling Duck is found on waters of many kinds, including freshwater lakes, swamps, flooded land and estuaries throughout the Afrotropical region. It is a common bird in rice schemes. The similarly distributed Fulvous Whistling Duck, *Dendrocygna bicolor*, is also found in rice schemes but does not cause the same amount of damage to the crop. The White-faced is a surface feeder filtering or grubbing for food in shallow water whereas the Fulvous tends to feed under water, immersing the head, upending or diving and feeding off the bottom in deeper waters. Nests during the rains.



White-faced Whistling Duck

Distribution Occurs throughout except for the lowland rain forests of Zaire and highland areas. Also absent from the Horn of Africa and the Kalahari.

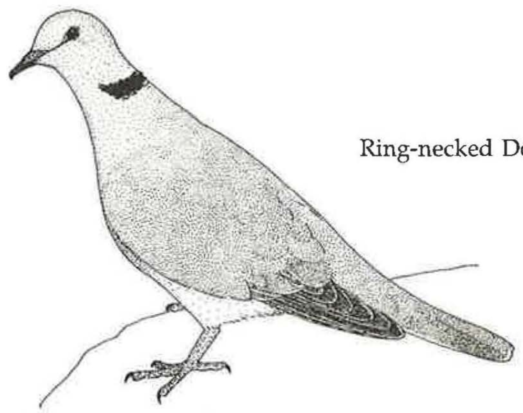
Annual cycle The Whistling Duck undergoes a complete moult once a year after the end of the breeding season. During the moult the adult birds are flightless. It is a highly gregarious duck occurring in flocks of up to some 400 birds. They spend a good deal of time on dry land which they prefer to water, only occurring on water while feeding. The ducks move about quite extensively, according to the availability of food, and have been reported moving up to 540 km. The call is a three note whistle "whee-whee-wheeoo" uttered almost continually when flocks are in flight. The sexes are indistinguishable. Breeding takes place during the rains.

Food habits The ducks generally feed in marshy areas and flooded grasslands and are purely vegetarian, feeding on grasses, seeds and floating plant material. They feed mainly at dusk and dawn but commonly at night in rice fields. They are attracted to large-scale rice schemes where they can do considerable damage, especially in nurseries where rice seedlings are grown prior to transplanting in the field. Damage can be assessed in flooded fields by the quantity of leaves floating on the irrigation water after a night of feeding by the ducks.

Breeding biology The White-faced Whistling Duck is monogamous; pairs nest on the ground by water at least 75 m distant from other nesting pairs. Four to 13 eggs are laid and incubation is mainly carried out by the male. Incubation takes 26–28 days and ducklings are looked after by both parents until they become independent. Juveniles remain with their parents through the dry season following the breeding season.

The Ring-necked Dove – Streptopelia capicola

The call of the Ring-necked Dove is one of the most familiar sounds of the savanna where it occurs. The small, pale grey dove mates for life and occurs in all woodland and bushed savanna throughout its range, including villages, plantations and farmland. They sometimes congregate in thousands in cereal fields where they can cause damage of economic importance.



Ring-necked Dove

Distribution The Ring-necked Dove occurs throughout the eastern and southern parts of the Afrotropical region excluding the lowland rainforests. In western Africa its place is taken by the very similar Vinaceous Dove, *S. vinacea*, from which it differs mainly in distribution and in its call.

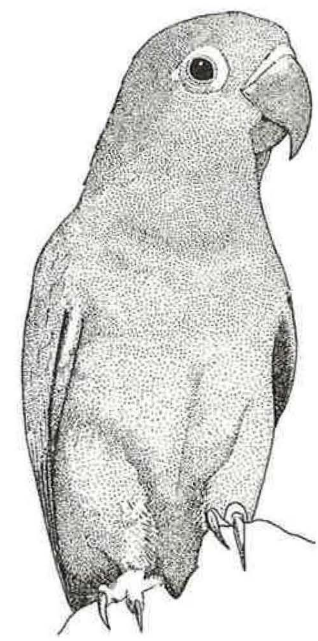
Annual cycle The movements of this dove are irregular depending on the quantity of the natural foods available in its wooded savanna habitat. It sometimes invades fields of sorghum in large numbers, but is generally a species which remains in established territory where it regularly breeds. A very shy and easily disturbed bird, it rests during the heat of the day and congregates in communal roosts at night.

Food habits The dove feeds on a large variety of seeds, plant material and some invertebrates such as termites and can eat grain up to the size of maize kernels. Birds perch and feed on the heads of sorghum and reportedly pull down wheat heads in order to feed on them on the ground. It drinks at any time of the day, often with other doves. This species is considered to be increasing in numbers as deforestation and agricultural development spreads.

Breeding biology Breeding territories are about half an hectare in extent. The nest is the pigeon's usual flimsy platform of twigs and is built in a tree by the female, the male providing the twigs. Two eggs are laid with an incubation period of 13–15 days. The female incubates the eggs overnight from late afternoon to mid-morning, the male taking over for the rest of the day. The young fledge 16–17 days after hatching and become independent of the parents 12–18 days after leaving the nest.

Lovebird superspecies – Agapornis personata

A superspecies is a group of very closely related species which have only recently, in evolutionary terms, become distinct from one another. They share the same habits and therefore the three species *A. fischeri, A. personata* and *A. lilianae* which make up the superspecies will be treated together for convenience.



Lovebird

Distribution The three species occur in central Tanzania (*personata*), north-western Tanzania (*fischeri*) and *lilianae* in Malawi (Lower Shire), Zambia (Zambezi and Luangwa Valleys), Zimbabwe and Mozambique (Zambezi Valley as far as Tete).

Annual cycle The birds are sedentary, only moving locally in search of feeding grounds. All have been drastically reduced in numbers by trapping for sale as cagebirds. They are gregarious birds usually occurring in small groups but sometimes assemble in numbers of up to 100 and roost in the old nests of other birds, often weaver birds. Lovebirds require a regular supply of drinking water and in dry weather may drink four or five times a day.

Feeding habits Lovebirds often feed on the ground where they pick up seeds and are very partial to millet and sorghum seed taken from the ripening heads of the plants. They have also acquired the habit of tearing open the sheaths of maize cobs and feeding on the developing grains and can cause considerable damage to small plots of cereals.

Breeding biology Lovebirds are monogamous and nest colonially in holes in trees, or in other bird's nests if these are roofed. Clutches are of 3–8 eggs and the incubation period lasts about 23 days, the fledging period about 10 days longer.

Quelea Birds

The Red-billed Quelea – Quelea quelea

Quelea birds occur only in Africa and are represented by four species. The Red-billed Quelea is the major crop pest of the four and is the bird generally referred to as 'the Quelea'. They are weaver birds, a family of closely related birds which weave domed nests out of plant material. They are most closely related, to the bishops and widowbirds (described elsewhere). The queleas, bishops and widowbirds are the typical seed-eaters of the African grassland savannas.

The Red-billed Quelea occurs throughout the short grass Acacia steppe or shrub savanna of Africa (see Annex). Within this range, the birds seek areas where there is an abundance of the wild grass seed, a plentiful supply of fresh drinking water and a dense enough cover in which large numbers can assemble to roost or breed. It is migratory over comparatively long distances, but occurs in sufficiently isolated populations to have evolved more or less recognisable races.

Major population centres of Quelea occur in the area of the inland delta of the River Niger, the Lake Chad basin area, the Sudan savannas, the Rift Valleys of Ethiopia, southern Somalia, central Tanzania, Zimbabwe, Botswana and South Africa. In each of these areas the populations are commonly associated with permanent rivers.

Distribution of races The races of Quelea are identified by differences in the breeding plumage of the males. The species occurs in two distinct forms, a black-masked type or **morph** and a white-masked morph. The more common black morph shows most clearly the racial coloration. There are three distinct races, the nominate race of West Africa, *Q. q. quelea,* with the facial mask extending above the bill in a broad frontal band, the South African race, *Q. q. lathamii,* with a similar mask and, in between, the Sudanese race, *Q. q. aethiopica,* with the facial mask restricted to the chin, cheeks and ear coverts. There are no known ecological differences between the races which appear to be simply geographically isolated.

In *aethiopica* the forehead and crown are completely without any black feathering. Less clearly defined are intermediate populations between *æthiopica* and the two other races. The intermediate populations have been described as hybrid swarms, and given the racial names *intermedia* and *chadensis*. Both populations contain some males with the masks of their two neighbouring races, but most with intermediate mask types. Seven mask types have been defined (Figure 9) according to a scale based on the increasing extent of the mask over the forehead and fore-crown. A pure population of the races *quelea* or *lathamii* would have all the males in class 7 with the frontal band of the mask extending well onto the crown and a pure population of the race *aethiopica* would have all the males in class 1 with no frontal band, the mask being confined to the chin, throat and lores. Generally, the population in the Sudan seems to be more homogeneous than any other population.

Whether or not populations with mixed mask types maintain the same proportion of different mask types from year to year has not been determined as insufficient collections have been made of male birds in breeding plumage. The situation in West Africa, where the hybrid swarm or race '*chadensis*' occurs, is better known than that of East and southern Africa where the movements of the birds are more complex. Populations of 'pure' races are not present but each population has a unique mix of mask types. Only collections from close to Lake Chad (between approximately latitudes 11° and 18°E) have all types of mask. This is the point of intergradation of the two extremes: populations to the West have increasing proportions of the *quelea* type and those to the East increasing proportions of the *æthiopica* type.

In addition to the populations which occur over wide areas there are smaller, less well known populations which have also been named. One occupies the western Rift Valley from western Uganda down through Rwanda, Burundi and western Tanzania to Zaire and has been named *Q. q. centralis*. The other named race is a population which seems to be confined to South Africa during the breeding season but ranges more widely at other times. It has been named *Q. q. spoliator*. Too little critical examination of these birds has been undertaken to either accept, or reject, their classification.

Annual cycle A thorough knowledge of the annual life cycle of the birds is necessary if an effective economical management strategy is to be adopted to reduce their impact.

During the dry seasons the birds spend their time searching for food, drinking, loafing and sleeping. Their food searching behaviour may result in crop damage. Very large flocks search for food and water and rest during the day in **day roosts** usually near water. Towards dusk, the flocks asssemble together to roost for the night in immense concentrations, the **night roost**. When the rains start the birds are obliged to seek new areas in which to feed. This often means a return to their breeding haunts where the rains have not yet started. Here they may join their progeny of the previous breeding season and feeding becomes intense and competitive.

The rainy seasons of most of Africa are controlled by the Inter-tropical Convergence Zone (ITCZ) which is a broad weather band formed where the northern and the southern tropical air masses meet and rainfall is produced. The ITCZ follows the sun northwards crossing the equator during the first half of the year and then returning back southwards during the second half of the year. Wherever it goes the ITCZ brings rain but the amount it brings is very variable. These rains, when they arrive at an area where Quelea are wintering or spending the dry season, cause the annual grass seeds to germinate and begin to grow. This deprives the birds of their preferred food and compels them to move. If the rains are widespread, the birds may be obliged to travel some considerable distance to find a new food source. In this they are aided by the flush of insects, particularly termites, which the rains promote. For a short time the birds gorge themselves on this rich food source, building up a fat reserve sufficient to sustain them on their migration. This migration is known as the **'early rains migration'**. In years of scattered or poor rains the Quelea may not move far, or may not move at all. A sufficient source of seed may remain ungerminated and available.

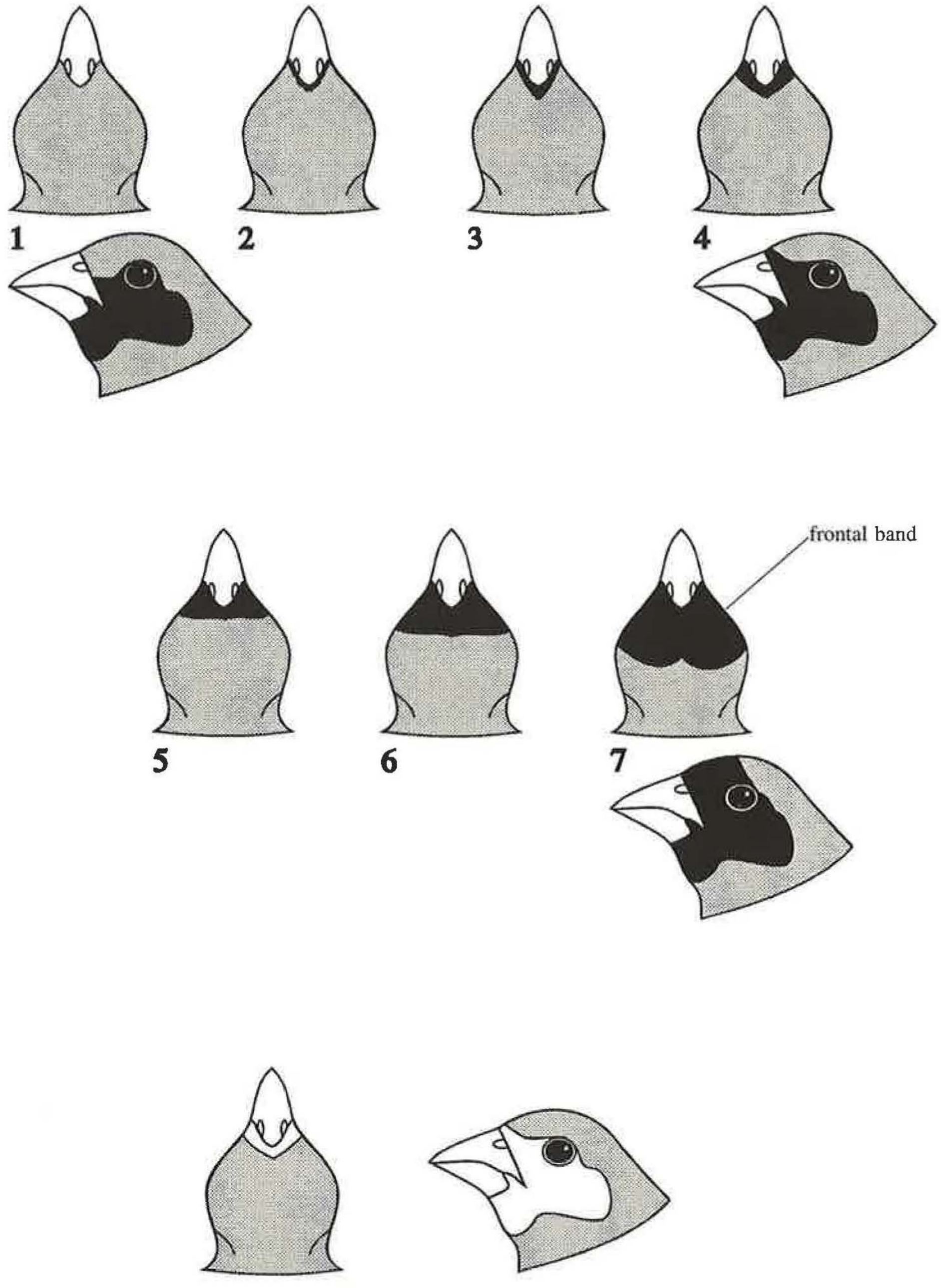


Figure 9 The seven mask types of *Quelea quelea*

After four to six weeks, grasses in areas nearby, where sufficient 'growing rains' fell, begin to set seed. This maintains the food source and, possibly, allows the birds to attain breeding condition.

Birds undertaking the early rains migration through the rain belt arrive at areas of prolific grass growth at the time when seed setting is taking place. Feeding on developing seeds, they come into full breeding condition, evident from their change in plumage. Males acquire black facial masks and females change the colour of their bills from red to yellow. This is the end result of the **pre-nuptial moult**[9] which has been proceeding under the influence of hormones released into the circulatory system from the gonads developing as a result of the rich diet. The birds undergo a complete replacement of the body plumage but do not replace the flight feathers.

The area where the early rains migrants end up is referred to as the **'early rains quarters'**. Some birds may develop full breeding condition very quickly after arriving and establish a colony there, but generally move back towards the rain front on what is now termed the **'breeding migration'**. The breeding migration, particularly in West and southern Africa, often follows river valleys as the birds search for ideal sites to establish their breeding colonies. In eastern Africa, the migrations are north to south and south to north whereas the rivers tend to flow from west to east. Here the movements are from one river system to another, or one flood plain to another. The males usually attain sexual maturity before the females and precede them on this migration.

During the breeding season the Quelea moult the feathers of the belly and develop a highly vascular and fatty brood patch for incubating the eggs. After the breeding season is over the Quelea disperse, the adults usually doing so before the juveniles which remain in the breeding quarters. At this time a **post-nuptial moult** is in progress and the birds undergo a complete replacement of the entire plumage.

The non-breeding season is the dry season and is characterised by a continuing search for food which becomes scarcer as the season advances. The moulting of the flight feathers continues through the dry season so that by the time the rains arrive the birds have a new set of flight feathers in time for the early rains migration. The night roosts tend to become larger and fewer during the dry season as birds tend to gather together where grass seed is most readily available.

Food habits Quelea are usually characterised as obligate grass seed-eating birds. That is to say they are obliged, or conditioned, to feed entirely on grass seeds and nothing else. This is not strictly true as occasional seeds of other plants are eaten and at certain times of the year insects are eaten. It is easy to accept that they can identify the growing plants on which they descend to remove the developing grains, grasses or cereal crops. However, it is difficult to imagine that the Quelea identify seeds on the ground, on which they feed during the dry season, before they pick them up. It is probable that only grass seeds occur on the ground in sufficient quantities to attract and satisfy the large feeding flocks which Quelea are 'obliged' to form by instinct. It is perhaps more correct to characterise them, and the other species of the genus, as obligate feeders on bulk food supplies, most frequently grass seeds when, and where, these are plentiful.

Grass seeds germinate at the onset of the rains forcing the Quelea to look elsewhere for a bulk food supply. The rains also bring forth an abundance of certain insects, notably termites and ants in their winged mating forms, and it is to this food source that Quelea turn for a short period.

Insects are also utilised as food at the start of the breeding season when eggs are hatching. Caterpillars and grasshopper nymphs are abundant when the grasses are flowering and this coincides with the time when Quelea are establishing their colonies. At this time the flocking instinct of the Quelea is subjugated to nest building, incubation of eggs and feeding of nestlings. Consequently the feeding behaviour becomes less social and more solitary, the birds feeding, and food gathering, in small unstructured flocks. The females, and to a lesser extent the males, feed themselves on the abundant insects and particularly feed them to the nestlings for the first few days after they hatch from the eggs. In summary then, the Red-billed Quelea feeds on grass seeds throughout the year supplemented by insects for a short period at the onset of the rains and in the early stages of the breeding season.

In the dry season, roosting Quelea become active about 30 minutes before sunrise, beginning to twitter and chirrup as they restlessly disengage from the tight packing of the night roost, moving away from each other towards the periphery of the site. At this time the birds have digested all the seed they gathered before entering the roost the previous evening. At sunrise (or later if the sky is overcast), they leave the roost in large flocks flying towards a drinking place, if the weather is hot, and feeding grounds where they begin to feed about half an hour after sunrise.

After feeding for a time sufficient to fill the crops[10] (*oesophageal pouches*) of most of the flock, the birds drink and rest while starting to digest the seeds. When their crops empty, the flocks continue feeding and refill them before leaving the feeding grounds and moving towards a convenient site, usually associated with a source of drinking water, the day roost, where they spend the hot period of the day. They return to the feeding grounds 2–3 hours before sunset to repeat the morning's feeding pattern, stopping some 30–60 minutes before sunset to drink and return to the night roost.

Times of drinking and feeding are conditioned by the prevailing temperature and humidity and by the richness of the food supply. Many variations of the above pattern occur according to the seasonal situation. On average, 1–1.5 g of seed are consumed during each feeding period. The time spent in collecting the food varies with its source and richness. In the middle of the dry season, when the Quelea feed on seeds in fallow land, they may spend less than an hour feeding. However, while feeding on the flowering heads of grasses, including cultivated cereals, they may spend two or three hours on each feed. Rich sources of food are involved in both cases and it seems that Quelea prefer to feed on the ground rather than on standing plants.

Most birds leave the roosts in a single flight. However, there are minor flights in all directions. The result is that the birds exploit a large area of the available food source. The two elements of daily activity, dispersion and congregation, enable the Quelea to find, and exploit, the best feeding grounds. A flock feeding on a good source attracts other flocks by its purposeful behaviour. In the same way those birds which are in prime condition from good feeding leave the night roost, purposefully in large flocks, in the direction from which they obtained a good food supply and attract others to follow in their wake. The origin of the large flocks, noticeable over fallows and certain crops, is a result of this behaviour. When food is plentiful, Quelea disperse widely and feed in smaller flocks.

Oval-shaped seeds, 1–2 mm in diameter (1–22 mg in weight; such as seeds of the grass tribe Paniceae[11]) are preferred. The annual grasses belonging to this group form a very dense cover, often as if planted, on seasonally flooded land or pans, and on river banks and flood plains. Large numbers of Quelea concentrate in these areas. Early in the dry season, ripe seeds are shed into the dying grass foliage. Flocks of adult Quelea are unable to exploit this food source as entering the tangle of vegetation would disrupt the structure of the feeding flock. Juvenile birds, on the other hand, can search out the seeds in the tangled undergrowth as their flocking behaviour is still developing. At the end of the dry season, when there is a decrease in the stock of seeds, Quelea turn to smaller seeds such as those of the genus *Dactyloctenium*[12], of various shapes (tapered, such as in the genus *Chloris*[13]) or larger seeds (wild rice[14] and sorghum[15], and cultivated grains) if and when available.

Like most of the Ploceidae that damage crops, Quelea drink at least once a day. They may drink at the midday roost or on the return flight to the night roost. Quelea usually drink from the edge of shallow water sources standing on the bank or perched on branches or grasses overlooking or standing in the water. In the absence of a perch they may drink on the wing above the water. Sometimes they drink in large shallow wells, and on occasion numbers may drown while drinking. They are often heavily predated on at drinking sites if these are few. Many species of birds take advantage of the large vulnerable flocks as they jockey for a place from which to drink. Ungainly Marabou Storks, *Leptoptilos crumeniferus*, compete with skilled falcons for a share of the bounty.

At the end of the dry season, Quelea are sometimes forced to scratch the ground with their feet or dig with their beaks to unearth buried seeds. Although they may be forced to feed far from their roosts, most crop damage occurs close to roost sites or breeding colonies.

Breeding biology The Red-billed Quelea establishes its breeding colonies from some five weeks into the rains until the end. Sometimes very large colonies are formed, covering several scores of hectares with 3000–30 000 nests per hectare. Almost everywhere there are some late colonies in which reproduction appears to have been delayed by a month or more with respect to the whole region. This is perhaps a result of a second nesting taking place.

Nest building starts as soon as the males arrive at a suitable site but it may take a day or two before the females arrive and take an interest in this early activity. When they do, however, the colony is quickly established and, under optimum conditions, complete synchrony of egg laying occurs throughout the colony. Nests may be built in a variety of trees, shrubs or reeds but generally thorny Acacias are preferred such as *Acacia spirocarpa*, *A. mellifera* and *Macrostachys cinerea* or other thorny shrubs such as *Zizyphus mucronata*. A canopy covering 20–50% of the area, and shrubs of 4–6 m in height, either evenly distributed or slightly clumped, seems to be the preferred situation. The herb layer may be of grasses or other herbs but is often dominated by one species and is closed except under the canopies of clumped trees. The nesting sites are relatively humid, but rarely completely flooded. Habitats where there is least variation between day and night temperatures seem to be selected.

The male Quelea alone builds the nest to which it attracts the female during the early stage of construction by displaying within the first formed ring of the nest. The nest may be completed within two days and the male builds one nest and mates with one female only, the species being monogamous. Both birds may take part in incubation but only the female incubates after nightfall. The male also assists in feeding the young when they hatch from the eggs. The behaviour of the males is in marked contrast to that of male Red-headed Quelea which quit the colony at the time of egg laying and take no part in incubation, or in rearing the brood.

The clutch size varies from 2 to 7 eggs with an average of 2.8. The nest has the shape of a small pouch woven with grass, with a side entrance at the top overhung by a flap, or porch. It is not lined inside. Usually two or three young are reared to leave the colony a month after hatching. The breeding cycle is very short being completed in 5–6 weeks. Quelea may nest more than once in a year when conditions are ideal.

Adult birds in prime condition may continue the breeding migration after successfully rearing one brood. Remaining in the rain belt, they move to areas where grasses are still flowering and breed again. This is called **'itinerant breeding'**. Birds in poor condition and birds which have reached the limit of suitable breeding habitat for that season will disperse to areas where the season's grass seed is available to them exposed on open ground. This characterises the beginning of the dry season. During the course of the dry season, good feeding grounds gradually become scarcer and the Quelea assemble in increasingly larger roosts to exploit the diminishing food reserves. The areas where these large roosts are established are called the **'dry season concentration zones'**. It is in these zones that irrigated crops are at high risk to Quelea depredation.

The young birds left behind in the colonies may remain in the area using the site of the colony as a roost for a few weeks after the adults have left. Soon, however, the seed supply diminishes and the juveniles also have to move away to better feeding grounds. Some may join adults passing through on their breeding migration but many stay, often finding fields of cereals on which to appease their appetites. It is the young birds which cause the greatest losses to rainfed crops. In time the young birds may move on and catch up with the adults in the dry season concentration zones. Others, which remain dispersed throughout the breeding areas, may join the main body of Quelea as they pass over on the early rains migration to start the annual cycle again.

Roosts and loafing places Quelea nearly always roost in large groups of several thousand birds. At the beginning of the dry season, immediately after the breeding season is over, they may roost in small groups, numbering sometimes only a few thousand birds. Roosts may be formed in different types of vegetation but birds seem to prefer a dense and homogeneous vegetation, often *Typhus* (or tall grass or bushes) on water at the beginning of the dry season, and *Acacia* or *Balanites* trees at the end of this season. Other ploceids, such as Golden Sparrows, bishops and weavers, and occasionally starlings sometimes roost with Quelea. Few other bird species have been recorded in a Quelea roost.

It is often difficult to assess the area occupied by a roost, especially when it is in grass. On arriving in the evening, the birds scatter over a wide area and only assemble at the main roost when the sun sets. Birds disturbed from roosts in trees and bushes tend to return to their perch soon afterwards whereas those roosting in grasses do not return after being disturbed. Quelea are generally silent in night roosts (see Chapter 4 for a more detailed description of roosting behaviour).

In addition to the normal night assembly into roosts, Quelea also congregate into day roosts or loafing places where they spend a considerable part of each day preening, roosting and drinking. This last activity generally governs the site of the loafing place which is always associated with a convenient watering place. The day roost assembly is never as densely packed as is the night roost and many other species of bird are commonly associated with the roost. Quelea are intermittently noisy in the day roosts, and are very easily disturbed from them.

The Red-headed Quelea – Q. erythrops

The male Red-headed Quelea is clearly distinguishable from the Red-billed Quelea in the breeding season on account of its scarlet head. It is not easily distinguished in the non-breeding season, however, as it is similarly sized, and has a similar non-breeding plumage. The distinguishing feature is the bill which is black in the breeding season and horn-coloured at other times. The Cardinal Quelea is noticeably smaller than the other Queleas and has a much less robust bill. The male Red-headed Quelea has black tips to the feathers of the chin and throat when in breeding plumage which distinguishes it from the male Cardinal Quelea which has a more extensive pure red mask extending on to the breast.

Distribution The Red-headed Quelea is a bird of swamps in much of the range of the Red-billed Quelea, but it is absent from Botswana and Namibia. In West Africa, its range extends well into the Guinea Savanna where the Red-billed Quelea is generally absent and it is rare in semi-arid areas. Wherever rice is grown in former swamps the Red-headed Quelea is likely to be found at one time or another. No racial distinction has been made between any populations of the species.

Annual cycle The annual cycle of the Red-headed Quelea has not received the same attention as that of the Red-billed Quelea which it closely resembles. In West Africa there is some suggestion that a distinct migration takes place between the Guinean rainfall zone, where breeding begins in May and June, and wetlands in the Sudano-Sahelian rainfall zone, where a second nesting occurs in August, September and October.

The movement of the population to and from the preferred breeding areas is influenced by the time and degree of flooding which determines the food availability. The movement is not an innate migratory shift from one inundated area to another but is flexible varying from year to year according to the local conditions in the flooded grasslands.

Food habits The Red-headed Quelea is a granivore which, like the Red-billed, feeds the recently hatched nestlings on insects and at certain times of the year adds insects to its own diet. It feeds on cereal crops, particularly rice, from the milky stage until maturation. It is considered to be a major deterrent to rice cultivation in some areas, particularly the West African coastal region.

Breeding biology The oval, finely woven nests are built by the males. The nests are similar to those of the Red-billed Quelea and are attached to the stems of reeds and swamp grasses, occasionally sorghum and sugarcane but never trees. The males leave the site of the colony after mating and completion of the nest, the female alone rearing the brood. For this reason, the identity of colonies is sometimes mistaken and some old breeding records are unreliable. Care must be taken, when examining a Quelea breeding colony established in reeds, to identify the birds by the colour of their bills, not just to assume that it is a Red-headed colony because it is in a swamp. The clutch is usually of two or three blue eggs similar to those of the Red-billed Quelea.

Roosts and loafing places The roosts of the Red-headed Quelea are usually established in tall reeds. During the night, possibly on account of temperature inversion, the scattered birds re-assemble more and more compactly until the sun rises. This activity makes control by aerial application of avicides particularly difficult. Day roosts or loafing places are often established in tall grasses close to rice cultivation. For this reason rice cultivators should always be advised to destroy weeds on canal banks and other sites close to their fields. Irrigation schemes, where sugarcane is cultivated alongside rice, offer ideal conditions for the Red-headed Quelea by providing food and shelter in their favoured wetland habitat. On such schemes, losses to Quelea, and other grain-eating ploceids, are liable to be severe.

The Cardinal Quelea – Q. cardinalis

The smallest of the queleas, the Cardinal Quelea male in breeding plumage has an unblemished red mask which extends well down the chest unlike the truncated black-flecked mask of the Red-headed Quelea. The small size and less robust bill help to identify the male in non-breeding plumage which is similar to that of the other Queleas. The female is, however, distinctive as it has a yellowish eye-stripe and yellow wash to the face.

Distribution The Cardinal Quelea is much more restricted in distribution than the other Queleas. It occurs in eastern Africa from south-eastern Sudan and southern Ethiopia through Kenya, Uganda, Rwanda, Burundi and Tanzania to eastern Zaire, Zambia and Malawi. A bird of tall grass Acacia savanna, the Cardinal Quelea occupies a habitat somewhat intermediate between the semi-arid habitat of the Red-billed Quelea and the swamp habitat of the Red-headed Quelea.

Annual cycle The species is very nomadic in habit but almost nothing is known about its movements. It establishes small roosts of hundreds, occasionally thousands, of birds in tall grasses, often in crops such as maize. During the late rains, large flocks feed in grasslands and crops, particularly millets. In the dry season they range widely feeding in the wetter areas fringing swamps and large rivers.

Food habits The feeding habits of the Cardinal Quelea are very similar to those of the other Queleas and it is essentially graminivorous occasionally taking insects when they are plentiful and feeding them to their recently hatched nestlings. The damage done to crops is mostly confined to Finger Millet but wheat, sorghum and rice are also eaten. Generally speaking, the flocks of the Cardinal Quelea are too small to cause serious damage to crops.

Breeding habits The Cardinal Quelea is polygamous breeding in loose extensive colonies where each male builds 2–3 nests in a territory of some 25 m^2 within the general area occupied by other breeding males. The nest is the typical Quelea 'pouch' type and is built between two stems of a tall grass, commonly a wild sorghum, at 1–2 m height. The two to three eggs differ from those of the other Queleas in that they are pale bluish white, densely mottled with reddish brown streaks and whorls.

Ploceus Weavers

There are 51 species of weaver birds in the genus *Ploceus* in Africa. The males are nearly all characteristically bright yellow in colour at some stage in their life cycle. Those which occur in large numbers in the grasslands, where they feed on grass seed, are noticeable dull coloured and streaky during the non-breeding season. In the breeding season the males generally moult into a more or less bright yellow plumage with some black or dark colouring around the head.

There is a tendency within the genus for the grassland birds to be polygamous grass seed-eaters and for the closed evergreen forest species to be monogamous insect-eaters.

The nests of the genus are characteristic. There are two general types: kidney-shaped and retort-shaped. The nests are developed from an initial vertical ring, to one side of which is built the egg chamber and to the other side an antechamber, in the case of the kidney-shaped nests, or a tube in the case of the retort nests. Generally, the forest-dwelling insectivores build retort nests and the savanna-dwelling seed-eaters build kidney-shaped nests.

Two of the most widely distributed species known to cause damage to cereal crops are the Village Weaver and the Black-headed Weaver.

The Village Weaver – *Ploceus cucullatus*

The Village Weaver occurs throughout the Afrotropical region except for closed evergreen forest. In deciduous tall grass savanna the birds may be monogamous, sedentary and have an extended breeding season of 9 or 10 months. At the other extreme in semi-arid areas they are polygamous, migratory and have only a 3–4 months breeding season.

The bird is twice as large as a Quelea. In breeding plumage the male has a black head and a heavily mottled yellow and black back. The undersides are bright yellow. There are a number of races distinguished by the colouring of the back and the extent of the black on the head. In the more humid part of their range they do not show a seasonal change in plumage but in the drier areas they do.

Breeding colonies are established in trees or tall shrubs often either near human habitations or overhanging water. The colonies are comparatively small, rarely exceeding a few hundred nests per colony. The nest is kidney-shaped with a middle roof layer and a lining generally of flowering grass heads. The antechamber to the nest may be extended to form a short tube. The normal clutch is two eggs. In the polygamous colonies there are nests in all stages of development as the males no sooner complete one nest successfully than they start another, all the time having to defend each nest from neighbours in the colony intent on stealing material for their own nests. This constant nest building and bickering prevents the males from taking any part in incubation or rearing the brood.

The Village Weaver feeds almost exclusively on seeds and fruits but the females feed the nestlings on insects. The size of the bird and its ability to strip the modified leaves from the cobs of maize to expose the developing grains make it one of the principal bird pests of this crop. In cage tests, the birds have selected maize grains in the presence of smaller cereal grains.

In some countries of West Africa, the birds are protected in the villages where they breed but in parts of East Africa nests are commonly raided for the fat nestlings which are eaten.

The Chestnut Weaver – P. rubiginosus

The Chestnut Weaver has an unusual distribution occurring in two well separated populations; one in Eritrea, Ethiopia, Somalia, Kenya, Uganda and Tanzania, the other in Namibia and Angola. A closely related, and similarly dark-chestnut weaver, the Cinnamon Weaver, *P. badius*, occurs in the Sudan along the two Niles as far north as Khartoum and on the River Dinder. The male Chestnut Weaver in breeding plumage has a black head, the rest of the plumage being dark chocolate in colour. It is one of the largest of the masked weavers and has the longest bill. It is gregarious in its East African quarters but less so in the south-west population.

Chestnut Weaver

Relatively large colonies occur in East Africa sometimes spread over a wide area, the trees in which the nests are built being far apart. The males, like those of the Red-headed Quelea, quit the colony after the eggs are laid and roam about in male flocks whilst moulting out of the breeding plumage. The nests are large, retort-shaped and untidy, often built so densely in a single tree that they almost obliterate it giving it the appearance of a haystack.

The large flocks of Chestnut Weavers which congregate during the non-breeding season in East Africa cause considerable damage to wheat crops and are often controlled at their night roosts by aerial spraying. The roosts are always in tall trees, commonly in Eucalyptus trees grown as wind-breaks in farming areas.

The Yellow-backed Weaver – P. melanocephalus

The Yellow-backed Weaver is essentially a West and Central African species of weaver bird associated with rivers and marshlands. Its range extends down the Western Rift Valley of Central Africa through Uganda, Rwanda and Burundi along the western shores of Lake Tanganyika to the upper reaches of the River Congo in Zaire. The bird's habitat preference assures its presence in irrigated rice schemes in the areas where it occurs. It is smaller than the Village Weaver, being approximately the size of a Quelea. The head is completely black in the breeding male, the nape bright yellow, the back greenish and the underparts bright yellow. There is a seasonal change in plumage and the females and non-breeding males have a dull, undistinguished weaver bird plumage.

Breeding colonies are small in comparison with those of Quelea and the birds are polygamous. The normal clutch size is two. The nests are kidney-shaped made of tightly woven grass strips with a lining. The antechamber is not extended to form a tube as it is in the nest of the Village Weaver.

The Yellow-backed Weaver is both insectivorous and graminivorous. It is recorded causing damage to rice, millet, sorghum and maize.

Bishops and Widowbirds

There are sixteen members of the genus in the Afrotropical region, nine bishops and seven widowbirds. The bishops are short-tailed, most of them smaller than the Quelea, and live almost entirely in long grass habitats. The breeding plumage of the males is generally marked by conspicuous black, highlighted with large areas of bright yellow, red or plain white. The long-tailed, black widowbirds differ from each other only by the length of their tails and the colour of their wing coverts which may be white, yellow or red. The males show a seasonal change in plumage.

The birds of the genus *Euplectes* are gregarious and graminivorous like Quelea and breed in small, dispersed colonies similar to those of the Cardinal Quelea, comprising variably sized territories held by polygamous males. The nests are of the same 'pouch' form as those of Quelea but without the small porch over the entrance. They are generally built attached to grasses and are unlined, thin but strongly woven.

During the dry season, flocks assemble of quite considerable size, usually of mixed species. The bishops are graminivorous but, like most of the weavers, feed their brood on insects to a variable extent.

Seasonal movements occur in most species but the ranges are not well known. Small-grained cereals are damaged by a number of species, the two most widespread being the Yellow-crowned Bishop and the Red Bishop. However it is the Fan-tailed Widowbird which is the most serious pest species.

The Fan-Tailed Widowbird – Euplectus axillaris

The male Fan-tailed Widowbird in breeding plumage is wholly black with an orange-red 'shoulder' patch. The lesser wing coverts and under wing coverts are brown. The female is a typical nondescript widowbird but the wing shoulders do show up as orange-black patches. The male in non-breeding plumage is similar to the female but is noticeably larger. The tail is shorter than that of other widowbirds and is moderately graduated.

The species is sparsely distributed in West Africa but occurs throughout the treed savannas of eastern and southern Africa. It is a bird of swamps, wet grass and river edges.

The Fan-tailed Widowbird breeds in marshes and rank growth as well as on the edges of sugarcane and rice plantations. The nest is well concealed and made of coarse grass lined with finer grass, the roof over the nest often incorporating living grasses. The clutch size is two to four glossy, greenish eggs scrolled and marbled with purplish spots and scrawls. The male, which is polygamous, flies back and forth conspicuously with unusually slow wing beats over its territory where two to three nests may be built. Breeding takes place during the rains.

Fan-tailed Widowbird

In the non-breeding season the Fan-tailed Widowbird congregates into large flocks which can devastate rice crops. This is a bird difficult to keep out of rice fields and the best defence against it is clean weeding of irrigation canals and utilisation, or drainage, of swamps close to rice schemes.

Sparrows

There are 14 species of sparrow in the Afrotropical region of Africa. They are generally grey-brown birds with pale underparts and dark heads. Most are omnivorous feeding much of the time on the ground. They show varying degrees of association into feeding flocks but do not generally nest in colonies. The nests are domed structures well-lined with feathers and other materials distinct from the general framework. No weaving is done with the nesting material, much use being made of holes, crevices and dense shrubs for support. One of the most widespread species in the arid cereal-producing areas is the Golden Sparrow. With increasing desertification in the Sahel, the Golden Sparrow is extending its range southwards from the fringes of the Sahara to the semi-arid regions of West Africa and the Sudan.

The Golden Sparrow – Passer luteus

A small bird about the size of Quelea. The male is golden yellow with a chocolate brown back and wings. The female and the young are mouse-coloured above and yellowish below. This species does not undergo a seasonal change in plumage. The male has a black bill during the breeding season. It nests in the rainy season in deciduous thorn steppe bordering the desert.

The nest is built of moderately-sized twigs often of *Balanites* lodged in the fork of a shrub. It is domed with a vertical entrance to a well-lined egg chamber. One to five nests are found per tree, with three to four young birds hatched per nest. The young birds are usually fed on insects. In the dry season, the sparrow moves southwards (Senegal and Niger Valleys, Lake Chad, Sudan) where they form large flocks sometimes approaching in size those formed by Quelea. They cause damage to millet, rice, sorghum and wheat. Damage to tomatoes is reported from Senegal.

Glossy Starlings

There are 15 species of glossy starlings in Africa. The species are not easy to identify correctly in the field. The one certain character which distinguishes them is the outline of the individual primary feathers. They are essentially dark blue-black birds with varying amounts of glossy metallic greens, blues, bronzes or violets on the backs, wings (especially the shoulder) and heads. They may have either short (11 species) or long (4 species) tails.

The glossy starlings are omnivorous, feeding on fruits, seeds and insects. Occasionally cereal crops are reported to be damaged by starlings. Nests are often in holes of large trees or termite mounds. The starlings are monogamous and solitary during the breeding season. During the dry season family parties may congregate and feed in small flocks. Roosts of a few hundred individuals may be established. The species have a very wide range in Africa but north of the Equator they are essentially birds of dry habitats, particularly the Blue-eared Glossy Starling, *Lamprotornis chalybaeus.*

The Blue-eared Glossy Starling – Lamprotornis chalybaeus

The Blue-eared Glossy Starling is metallic green with a bright yellow eye and velvety black spots on the tips of the wing coverts. The abdomen is violet, as are the conspicuous shoulder patches. The blue ear coverts are not glossy like the rest of the plumage but noticeably dull matt in appearance.

It is a characteristic bird of Acacia semi-arid scrub, migratory within its range probably following fruit ripening cycles in the scrub-land in which it lives. Nests are built in holes in trees and a clutch of 2–4 eggs is normal. Fruit, insects and grains are eaten and damage to millet, sorghum and tomatoes is recorded. During the breeding season the Blue-eared Glossy Starling is territorial and solitary but in the dry season feeding flocks of up to 100 birds may assemble. Roosts of a few hundred birds are occasionally recorded usually associated with other species.

NOTES

1 Throughout the handbook bird names in English will be given initial capitals when they refer to a particular species. They will also be given their correct scientific name in italics when first mentioned and in the keys, which should be used for reference. This will prevent ambiguity where different common names are used in different countries. Names for types, or related groups, of birds will not have an initial capital but will have the group name in italics when first mentioned and in the keys.

2 *spp.* is an abbreviation of the plural word species and in the context used here stands for a number of different species all members of the same genus *Francolinus*. For a definition of species and genus see p. 22.

3 the ending *-idae* on italicised bird names denotes a Family name for closely related birds. See p. 22.

4 Scientific terms are italicised when first used. They are included for information only except for those which are commonly used by ornithologists and subsequently repeated in the text without italics.

5 A term loosely applied to the outermost wing coverts, i.e. the leading edge of the inner wing.

6 A feral animal is one which has established itself in the wild, away from its natural range, after escaping, or having been released, from captivity or domestication.

7 Open woodland with a discontinuous canopy usually found on badly drained clay soils. A purely southern African vegetation type occurring from the Luangwa valley in Zambia to the Northern Transvaal in South Africa. Named after the dominant tree *Colophospermum mopane*. (Refer to annex.)

8 A more or less closed canopy woodland which covers much of southern Africa from Tanzania to Zimbabwe. Dominant trees are *Brachystegia* spp. and *Julbernadia* spp. (Refer to annex.)

9 Nuptial means wedding, in human terms, or breeding, in biological terms.

10 The sac or pouch in which the Quelea store the seeds on which they are feeding. It is a pouch of the oesophagus in the bird's neck loosely referred to as the crop. A true crop exists as a muscular stomach for grinding the grains before they pass into the stomach where digestion begins.

11 The family of grasses Gramineae is divided for, systematic convenience, into some 50 or 60 Tribes. The Tribe Paniceae includes the genera *Panicum, Cenchrus, Digitaria, Paspalum* and *Pennisetum*, often referred to as the sweet annual grasses.

12 Tribe Eragrostideae.

13 and *Schoenefeldia* both of the Tribe Chlorideae.

14 Genus *Oryza* of the Tribe Oryzeae.

15 *Sorghum* spp. of the Tribe Andropogoneae which also contains grasses of the genus *Ischaemum* the grains of which are eaten by Quelea.

2

The Cereal Crops

The cereal crops which suffer greatest loss due to birds are those grown in the drier areas in the Afrotropical region of Africa. Many of the small-grained cereals have been locally selected from indigenous grasses some of which are still harvested, particularly during times of serious local crop failure. It is generally true that the smaller the grain, the more drought-resistant the crop and the more attractive it is to seed-eating birds. In periods of drought the small-grained cereals gain great attention because of their drought resistance and it is, to some extent, the serious loss to birds which prevents more widespread cereal cultivation in the drier areas of Africa.

The development of irrigation schemes in river systems and lake basins helps to promote the cultivation of higher yielding cereals, such as rice, in the dry areas. This does, however, improve the local conditions for increasing the grain-eating bird population.

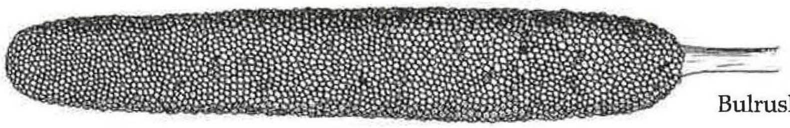
Agronomists have long sought characters in the varieties of cereals which might make them less attractive to birds but an infallible character has yet to be found. Cereals with a high tannin content, lax head and stiff awns are avoided by birds when alternative food is plentiful but when conditions are severe the birds' aversions disappear.

A sound knowledge of the crops and their particular uses is essential for anyone investigating the damage done to them by birds.

MILLETS

A number of small-grained cereals are known under this name and to these, for convenience, the unique Afrotropical cereal Teff, *Eragrostis tef*, may be added. Millets are very important cereals in the semi-arid areas of Africa because of their drought-resistant properties. The most extensively cultivated species are Finger Millet, *Eleusine coracana* and Bulrush Millet, *Pennisetum typhoides*. Both species suffer heavy losses due to birds and the seed size seems to be that preferred by Quelea.

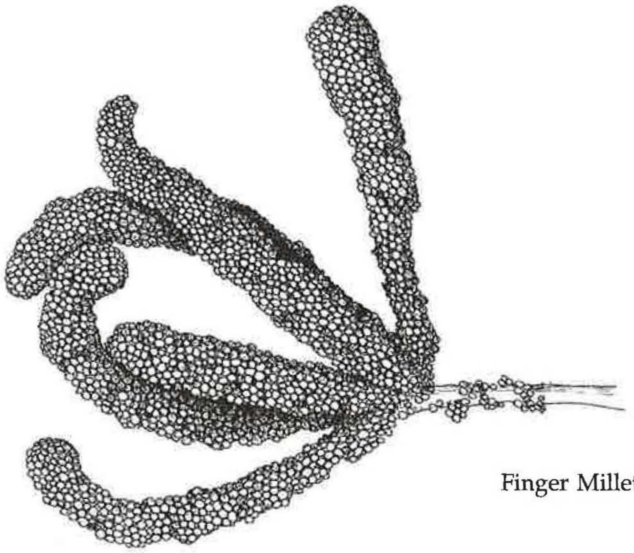
Bulrush Millet probably originated in Africa and is one of the most drought-resistant millets. It is grown extensively in the Sahel and other areas of very low rainfall. Some varieties have needle-like awns which confer a certain degree of resistance to birds but generally this is only where awnless varieties are also available, that is to say it is a matter of choice, not aversion. Bulrush Millet is a short-season crop grown on poor or sandy soils where annual rainfall may be less than 600 mm. The plant is tall and in the leaf stage is remarkably like sorghum or maize in form. The long cylindrical ears of grain, which give the plant its name, look like the heads of a bulrush (*Typha* spp.). The grains are naked and yellowish grey to whitish in colour. The stalks are strong, round and hairy. The hairiness of the stems and the leaves contribute to the plant's drought resistance.



Bulrush Millet

The crop is usually planted by hand in hills spaced 50 cm apart, in rows usually 1 m apart. The growing period to maturity is about 3–4 months. At maturity the heads are cut by hand and, when dry, are flailed out on the hardened ground around the homestead. If bird damage is likely, the heads are sometimes harvested at the dough stage and dried out on the roofs of huts or other convenient places. Grain stores must be treated for insect infestations if the grain is to be kept for any length of time.

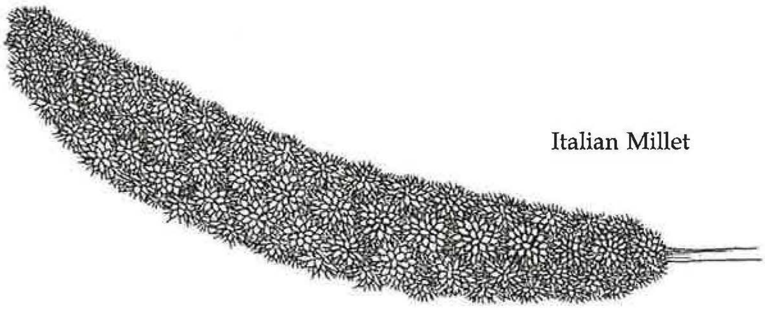
Finger Millet is generally grown at higher altitudes than Bulrush Millet, on fertile, well drained soils in areas with an average annual rainfall of about 900 mm. It is a short-stemmed millet growing to the height of wheat, with an ear of about five, somewhat twisted spikes.



Finger Millet

The grain can be stored for long periods without deteriorating or attracting the usual weevil pests of stored grains, the grains being too small to sustain their developing larvae. For this reason it is a very important famine reserve food in semi-arid areas. Finger Millet is either broadcast or planted in closely spaced rows 20–30 cm apart. The seed germinates in 5–10 days and reaches maturity in 3–5 months. The mature plants are generally cut close to the ground, tied into sheaves and stacked to dry. As with Bulrush Millet, the naked grains are thrashed out by beating on a hard baked earth floor.

The smaller millets such as Italian Millet, *Setaria italica,* and Teff, *Eragrostis tef,* are more locally cultivated and are liked mainly for their drought resistance and short growth cycle. Both are less commonly damaged by the Red-billed Quelea, probably due to the weak stems which bend under the birds' weight, taking them into the foliage, a situation which they avoid.



Italian Millet

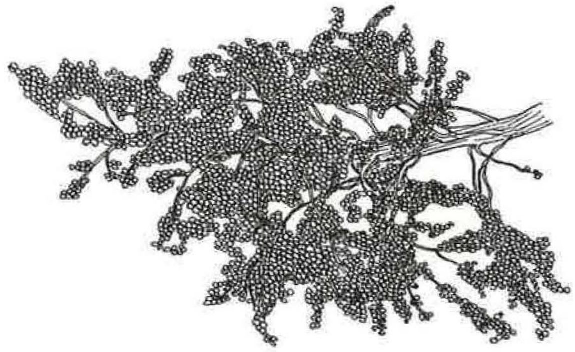
Teff

SORGHUM – *Sorghum vulgare*

Sorghum is the preferred cereal crop in the drier areas of the Afrotropical region. It grows on poor soils and is comparatively drought-resistant. The plant has a well branched root system which is twice as extensive as that of maize. This character, linked with an ability to remain dormant during periods of water shortage, makes sorghum an ideal cereal for semi-arid areas. It is generally grown where the rainfall is between 600 and 1200 mm on poor, often briefly waterlogged, soils. Its ability to do well on waterlogged soils has led to the common practice of growing the crop in the dry season on heavy clays from which water is slowly receding.

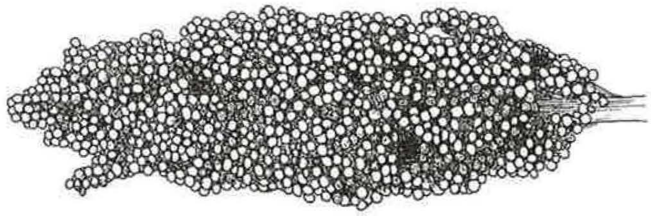
Many varieties of sorghum are grown. Those with a compact head, white grains and no tannin content are extremely susceptible to bird damage. Such sorghums belong to the group generally referred to as grain sorghums. The other two groups are the sorgho type, which have the seeds completely enclosed in glumes even when they are threshed, and the grassy, or wild, types. The sorgho varieties often have brown or red coloured pigments in the outer layers of the seed coat. This pigment contains tannin compounds which give the grain a bitter taste. The tannins reduce the digestibility of protein and are generally avoided by birds if they have another food source available. The pigmented varieties are also less palatable to man and are more commonly used for brewing than for making porridge. A variety with a high tannin content in a non-persistent seed coat which could be removed by threshing would, theoretically, give the best resistance and human palatability. Such a variety is yet to be bred successfully.

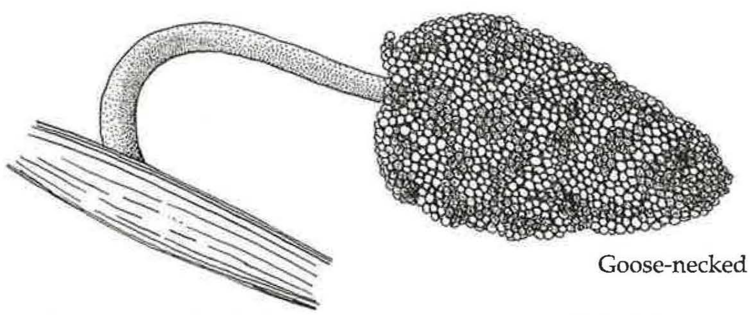
Sorghum is generally broadcast into a finely tilled seed bed. Inter-cropping is a common practice with sorghum cultivators. Finger millet, pulses, simsim or sweet potatoes are commonly interplanted. Sorghum is a very vigorous plant, some varieties growing to over 4 m in height. The grain-bearing heads can be lax-panicled, tight-panicled or goose-necked in form.



Lax-panicled Sorghum

Tight-panicled Sorghum





Goose-necked Sorghum

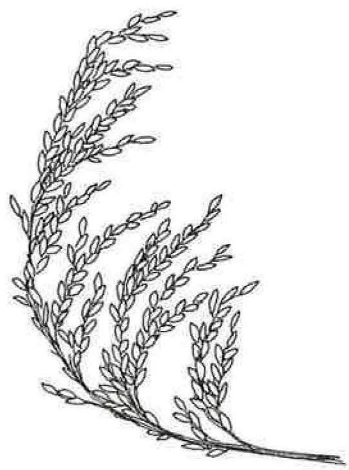
The loose-panicled and goose-necked forms are considered to be less damaged by birds. The birds have difficulty obtaining the grains of the loose-panicled varieties as the weak peduncles cannot support their weight and, in the case of the goose-necked varieties, much of the grain is out of reach of the birds unless they hang upside down.

The heads of mature sorghum are generally broken off and sun-dried before being stored. The plants mature in 2–8 months, depending on the variety and the altitude at which they are grown. Sorghum tillers freely and, after the first harvest in areas with a bimodal rainfall, a ratoon[1] crop is commonly established in the shorter of the two rain seasons.

RICE – *Oryza sativa*

Rice is unique among cereal crops in its ability to germinate and grow in inundated soils. This ability is due to the hollow stems of the plant which allow oxygen to enter the roots even when they are under water. Two methods of cultivation are practised, one usually referred to as **lowland**, when the rice is generally irrigated, and the other **upland** when it tends to be rainfed. Irrigated rice may be germinated in nurseries and transplanted into fields when it is about 15 cm tall or when the fields can be irrigated to a sufficient depth to suppress weeds. Another practice is to pregerminate the seed and to broadcast it into puddled fields. Rice seed will not germinate if it is under water nor will seedlings survive if they are submerged in water. Upland rice, and some lowland rice, is sown into dry soil at the start of the rain season. It is not necessary for rice to be grown in water but this is done to suppress weeds which are generally intolerant of flooding.

Rice commonly grows to just over a metre in height and tillers variably according to the variety. The flowering head is an open panicle and grows to maturity in 3–4 months. Transplanted rice takes one or two weeks longer from sowing to harvest although it is in the field for a shorter time.



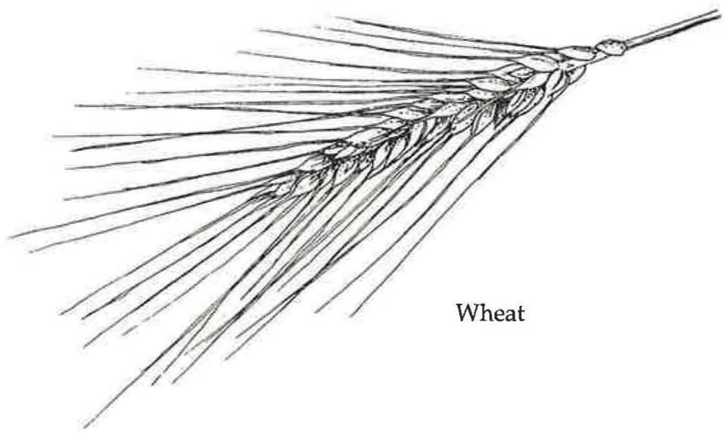
Rice

Most rice grown in Africa is lowland rice and the sites chosen for irrigation schemes are often much frequented by grain-eating birds. In some cases, particularly in the more densely forested areas, rice schemes improve the local conditions for grain-eating species such as the bishops and the Red-headed Quelea to such an extent that they now thrive in areas in which they used to be uncommon visitors. Extensive, featureless irrigation schemes, established well away from vegetation in which small grain-eating birds could establish roosts, may suffer negligible loss to birds. However, Whistling Ducks and Egyptian Geese, if present, can cause a certain amount of crop loss at such sites. The combination of sugarcane and rice in an irrigation scheme generally leads to a high population of small grain-eating birds living in the cane and feeding on the rice crop. Rice nurseries often have to be protected from birds which feed on the germinating seeds and the young seedlings.

WHEAT – *Triticum aestivum*

Durum wheats, *T. durum*, despite being indigenous to Africa have been in decline for a number of years in desert areas. Bread wheat on the other hand is grown increasingly in the Afrotropical region particularly in the highlands of East Africa and under irrigation in the Sudan and southern Africa. Wheat in the area is usually grown at high altitudes (1500–3000 m) or in irrigation schemes during the cooler months of the year. The crop is most suited to good, well-drained soils in areas with a prolonged rainfall. Both irrigated and rain grown crops suffer losses from grain-eating birds. Only wheat grown at the highest altitudes, outside the range of most grain-eating species, escapes their attention.

Wheat grows to a height of about 1 m and matures in 4–7 months depending on the variety and the altitude at which it is grown. There are several tillers to each plant and the flowering spikes of 15–18 spikelets, which each produce 2–3 grains, may be awnless or 'bearded'.



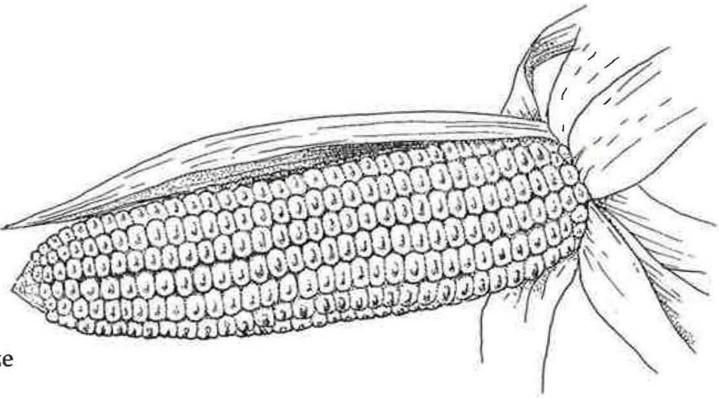
Wheat

The wheat crop usually ripens about 30 days after the florets have flowered. The kernels are completely filled when they reach the dough stage when the leaves, stalk and spikes begin to turn yellow. Smallholder wheat can be harvested by hand but usually the crop is cut and threshed by combine harvester when it has dried to less than 14% moisture content. It can be harvested when at a higher moisture content if drying facilities are available. When damage by birds is threatened, the crop can be cut and stooked or windrowed. This prevents damage from the small gregarious seed-eaters but does expose the grain to attack by other birds, such as doves, and also by rodents.

MAIZE – *Zea mays*

Maize, like rice, is not indigenous to Africa. It is probably the preferred crop wherever it can be successfully grown. The preference is due to two major considerations: first, it out-yields all other cereals and second it is comparatively untouched by birds. The drawback to its widespread use is the intolerance the crop shows to adverse conditions. The soil in which it grows must be rich, not too moist and not too dry. The least waterlogging may kill the plant and dry conditions when the crop is flowering can cause a serious loss in yield.

Maize is an annual plant and is grown at very different altitudes in Africa. It can grow to over 4 m in height, usually producing only one cob per plant although high-yielding hybrids can produce two or three cobs.



Maize

The time to maturity is extremely variable according to variety and the altitude at which the crop is grown. Extremes are the shortest maturing varieties grown at low altitudes, some of which can flower in two months and mature in four, and the longest maturing varieties grown at altitudes above 2000 m which can take 6 months to flowering and 12 months to maturity. Maize is usually left in the field to dry until the moisture content is about 20%. Sometimes it is stooked to avoid lodging and it is usually harvested by hand. The husks are removed from the cobs which are then stored in cribs to dry off. Stored grain must be treated to prevent insect attack.

Two characteristics of maize make it unattractive to grain-eating birds. The ear, or cob, of developing grain is covered by a husk of modified leaves tightly pressed around it and the grains, when mature, are too large to be eaten by most grain-eating birds. A few species, such as the Village Weaver and some parrots, can tear open the husks and eat the grains from the ear. In other cases, certain high-yielding varieties produce large ears which protrude beyond the husks and expose the developing grains to the attack of grain-eating birds. There is evidence to suggest that bishops feed on the stamens of male flowers but, to date, no suggestion has been made that this affects yield.

MISCELLANEOUS MINOR CEREAL CROPS

Barley, *Hordeum* spp. and Oats, *Avena sativa*, are grown on a limited scale in Africa, mostly in South Africa. Barley is generally grown for malting under contract to breweries and oats more as a fodder crop than a grain crop. Barley crops are susceptible to bird damage but as the crop is generally grown at high altitudes the number of grain-eating birds is limited. Oats are rarely damaged by birds and are used for making oatmeal.

CROP DAMAGE

Damage to a crop may be considered as a loss in the quality or quantity of the crop due to an outside agent and measurable in economic terms. Birds are one of the more noticeable outside agents which damage cereal crops. They may directly deplete the crop or only damage it slightly, allowing the entry of other damaging agents such as fungi. Slight damage alone can decrease the trade value of a crop, particularly if it is a fruit or a vegetable.

In cereal crops, bird damage occurs both during the early stages of sowing, germination and sprouting, and in the later stages of grain formation from the milk stage through the dough stages to the ripening-off stage. Different species of birds may damage the crop during the various stages. At the early cropping stages, damage is caused by birds eating the newly sown seeds and young plants, or, in the case of heavier birds such as waterfowl, damage may be caused by trampling.

There is a tendency for birds to eat seeds and young plants by following the rows. A large number of birds may cause large gaps and compel farmers to re-sow. Ducks and waders cause gaps in flooded ricefields by dabbling about in the mud, feeding on insects and other invertebrates as much as feeding on the rice. Replanting is often unsuccessful because of competition with the established plants; and because birds often pay particular attention to resown patches in fields.

The greatest damage is caused during grain formation, i.e. the milk, dough and ripening stages. The damage is usually caused by small granivorous birds and, if they occur in flocks, can be devastating.

Most birds feed on the seeds before they are fully ripe. This may be because the ripe seeds are too large for the particular species causing the damage, as is the case with Quelea and bishops feeding on sorghum, or they are too hard to be split. Hungry birds attack crops at every stage of seed development. The damage caused is very variable and difficult to measure accurately. However it is important for governments to know something about the extent of the losses which can be attributed to birds so that they may determine the financial implications of taking preventive action. Generally speaking it is costly to try to prevent birds from damaging crops. In many countries bird trappers and scarers play their part but this is often done by children at the expense of their education. The breeding of bird-resistant crops is another method which, if successful, costs the farmer very little. None the less, in the case of cereal crops, neither of these preventive methods is very effective against large flocks of grain-eating birds. If the losses to birds are shown to be substantial then it will be necessary for governments to invest in reducing the losses. The extent of the investment will depend on the extent of the losses which must be properly assessed.

Young Quelea, recently out of the nest, are the birds which can be most destructive to rain-sown crops (see Chapter 3). They are known in Arabic as the 'deaf ones' as they are particularly difficult to scare from crops. So far, no effective bird-resistant variety of cereal has been produced although a great deal of effort has been, and is still being put in to breed a resistant line. Currently, the only effective way to reduce the damage caused by the Quelea is to locate those causing the damage and to kill them. The birds are killed either with chemical pesticides called avicides or by so-called 'firebombs' (see Chapter 4). **Both techniques are expensive, potentially damaging to the environment, and can only be used when absolutely necessary.**

The amount of crop lost to the birds is dependent on the number of them feeding on the crop, the amount each is capable of eating and the amount of time that they spend in the crop. When large flocks of birds are obviously feeding in a crop, and the damage they are doing is quite apparent, then there is no question that something needs to be done to reduce the damage. However, what has to be done must be determined by the cost of whatever action is to be taken to reduce the damage, its effectiveness, and the possible hazard it may pose to the environment. When the value of the crop lost is known accurately, then the best decision can be taken on whether or not to control the birds causing the loss. The value of the lost crop is best determined by good crop damage assessments.

It is the Quelea and its effect on cereal crops for which crop damage assessment is particularly necessary. The Quelea is a migratory bird which crosses international boundaries with impunity and inter-governmental co-operation is needed to deal with the problem of this migratory bird pest. The Quelea is also very numerous where it occurs: flocks of millions may suddenly appear in a cropping area and cause extensive damage over a period of weeks and then, just as suddenly, disappear. Some countries have a bird problem in cereal crops, but neither the extent of the problem, nor the species of birds causing the damage, is known. It is for this reason that governments need to find the answers to the two questions: what is the level of damage to cereal crops caused by birds and what are the birds causing the damage?

It is not easy to obtain meaningful bird damage assessments in field crops. The mobility of birds, and their seemingly random descent onto particular fields, means that the estimates made are generally unacceptable, from a statistical point of view, because of the high variance of the damage levels recorded. There are, however, ways in which the variance can be lowered. The most obvious is to take a very large sample, but this is impractical both economically and logistically. Instead careful sampling design, and a system of stratification, can lead to results which are statistically acceptable and thus meaningful.

In the future when good monitoring data is available (see Chapter 3) it should be possible to estimate damage from an energetics model. Such a model requires information on the population of birds causing the damage and the weight of crop they would consume. The modelling approach which has been developed by Wiens and Dyer (1975) can provide inexpensive and apparently reliable estimates of damage once baseline information has been obtained.

This chapter outlines current methods suggested for the more important cereal crops.

Planning

It is obviously impossible to obtain the complete figure for damage caused by birds in any particular crop as this would mean examining every plant in every field throughout the country. It is thus necessary to take a representative sample in order to arrive at a good estimate of the level of damage.

The first consideration is to know what you are trying to achieve. Is your assessment for experimental purposes only or is it to look at the overall picture of damage to an entire crop throughout the country? Usually it will be something in between the two, such as the level of damage to rice in an irrigation scheme. With a clear idea of the objective it is then easy to calculate the area throughout which the damage assessment is to be undertaken. This can be an experimental plot, a field, a particular crop in a wider area such as a district or, perhaps, the total crop grown in the country.

Some variation is bound to occur in the area to be sampled unless it is very small and has been carefully treated, such as an experimental plot. Different crop varieties, planting date, usage of fertiliser, altitude, soil type, level of insect damage, weed control, fungal or viral infection, pesticide treatment, etc., may all influence the level of damage caused by birds. It is as well to take into consideration those which are thought to have an effect and, if possible, to record other conditions which could be important.

The number of staff available as assessors and the time it will take them to carry out the assessment must be known as this will determine the workable sample size. Most grain-eating birds which cause damage of economic importance, and certainly the Quelea, feed in flocks. The flocks cause damage in patches scattered widely over the cropping area. For this reason it is best to examine many small samples rather than a few large ones. It is also best to sample the damage as close to harvest as possible to ensure that the full period when the birds are feeding on the crop is covered.

The steps to be followed in planning where to take the samples are as follows.

1. **Prepare a map of the area to be sampled.**

2. **Mark on the map the areas of variation which are important, e.g. different crop varieties, soil types, altitude, planting date, etc. Those variables which offer a choice to the birds should be taken into account.**

The next procedures to follow vary according to the crop being assessed.

Irrigated Crops

Irrigated crops are probably the easiest for which to prepare a sampling plan. The following detailed outline for irrigated rice can be adapted to suit any scheme and any irrigated crop for which an assessment is to be undertaken.

Suppose that there are two varieties of rice grown on a scheme, IR5061 and Bluebell, and two soil types, a clay and a silt. The two varieties may differ in colour or appearance according to their type and the soil on which they are growing and this could affect their attractiveness to the birds. The various criteria affecting the sampling can be shown in a simple table thus:

SOIL TYPE	VARIETY	
	IR 5061	Bluebell
Clay		
Alluvium		

If there are 100 ha of IR 5061 on clay, 50 on alluvium and 250 ha Bluebell on clay and 25 on alluvium the table can be filled in:

Total crop hectarage

SOIL TYPE	VARIETY	
	IR 5061	Bluebell
Clay	100	250
Alluvium	50	25

Finally to decide how many plots, or fields, to sample the table is simplified to the following ratios:

Ratio of varieties and soil type

SOIL TYPE	VARIETY	
	IR 5061	Bluebell
Clay	4	10
Alluvium	2	1

From this table the minimum number of plots to sample is the sum of the proportional values, i.e. 17. The number of plots sampled must be 17 or any multiple of 17 so that each variant is sampled in proportion to its area.

3. **The sampling unit is now chosen. In the case of an irrigation scheme this is relatively simple and will usually be the smallest plot or field which is cultivated as a single irrigation unit. A plot size of 0.1 ha can be taken as an example, i.e. a plot 50 m by 20 m.**

4. **It is now necessary to consider how many staff there are who can participate in the assessment. It is possible for one man to assess and record the damage in the field on his own but the best way to undertake this work is to have a two-man team of an assessor and a recorder. There will be three teams of two men each if six men are available.**

5. Time is the next consideration.

- *How many days can the six men be employed on the assignment?*
- *How many hours in the day is it possible for them to work? (Consideration must be given to the probability that their efficiency will be less during the heat of the day.)*
- *How long does it take each team to examine a fixed number of rice heads in a fixed number of sample plots per field or plot?*

Let it be assumed that the three teams are available for three working days and that they can work intensively for 2 hours in the morning and two in the afternoon then there will be 36 'team-hours' available for carrying out the assessment (4 hours per day x 3 days x 3 teams).

Sampling five units in a field of 0.1 ha might take the two-man team 30 minutes to complete including the time taken to move between fields. Hence, 72 fields can be sampled by the six-man team (Para 2 above. 36 'team-hours' x 2 = 72 'team ½-hours'). The number of plots sampled must be a multiple of 17 and rounded to the nearest whole number so dividing 72 by 17 gives 4 to the nearest whole number. The total number of fields to be sampled in the time available will be 4 x 17, i.e. 68 apportioned as follows:

No. of samples to be taken

SOIL TYPE	VARIETY	
	IR 5061	Bluebell
Clay	16	40
Alluvium	8	4

6. Selection of the fields to be assessed is the last item to be considered. It is necessary to have all the sampling units labelled in some way, usually numbered. In our example there are 425 ha of rice growing in 4250 plots 50 m by 20 m in size.

Total no. of plots

SOIL TYPE	VARIETY	
	IR 5061	Bluebell
Clay	1000	2500
Alluvium	500	250

It is impractical to assign numbers to so many plots and larger units must be selected.

Supposing the 0.1 ha plots are in units of 25 ha blocks then we have 1 block of Bluebell and 2 blocks of IR5061 on alluvium, and 4 blocks IR5061 and 10 blocks of Bluebell on clay. Each block contains 250 plots, still a sizeable number for assigning a label to each one. If the holdings average 0.5 ha each, i.e. a holding of five plots we can use this to further subdivide the cropping area to units of 50 holdings. The number is now manageable as there are 17 blocks each containing 50 holdings.

In order to select the holdings where the assessments will be done random numbers can be generated on a calculating machine which has this facility. In the absence of a calculator two series of tokens, or cards, can be marked, one with the letters A to J for the 10 blocks and the other 1 to 50 for the holdings. The tokens are placed in bags from which they are picked at random after being well mixed by shaking. Cards can be shuffled and cut to reveal random letters or numbers. After each letter and number is picked it should be returned to the bag or pack and reshaken or shuffled before the next is picked. In the event that the same number is repeated this is ignored and an additional letter and number chosen. A random selection should result like this:

Bluebell on alluvium	*A 15, A 32, A 3, A 46.*
IR 5061 on alluvium	*A 19, A 36, B 41, A 33, B 9, A 49, ~~B41~~* (a repeat) *A 24, B 2.*
Bluebell on clay	*D 19, D 3, A 11, C 39, B 41, A 50, A 7, C 33, etc.,*
IR 5061 on clay	*I 16, C 48, J 30, B 29, B 41, D 11, E 7, etc.*

The randomly selected holdings are now marked on the map and routes planned for the three teams so that each has a group of plots to sample for which an easy access route can be mapped out.

This completes the initial selection stage.

Assessment

Assessment is the last item to be considered. The subplot within the field where the assessment is to be carried out should generally be not less than a 20 cm length of field row or about 10 rice heads. All the rice heads should be removed from each subplot, sorted according to whether or not they are damaged, and then weighed. The number and weight of damaged heads is then compared with the number and weight of undamaged heads to arrive at an estimate of the percentage loss as follows:

$$100\left\{\left(1-\frac{\text{Av. wt. g. damaged heads}}{\text{Av. wt. g. undamaged heads}}\right)\times\left(\frac{\text{No. damaged heads}}{\text{Total no. heads sampled}}\right)\right\}$$

The problem with this method is that if birds choose to feed on a particular type of head, for example the largest, then there will be a bias in the damage estimate.

Another consideration is that a certain amount of equipment is required such as bags for collecting the heads, an accurate balance for weighing and scissors, or a knife, for removing the heads. None the less this is the best method for obtaining an accurate damage assessment and should be used whenever possible.

The simplest method, but in some ways the more difficult, is to measure the percentage of grains lost per rice head examined. If this can be done accurately then it is an excellent method but it does depend on the efficiency of the assessor. Ideally the exact percentage should be scored but in practice it is reasonably accurate to use discrete classes or levels of damage. The more classes used the more accurate the estimate. Ten classes of 10% damage levels should be attempted as follows:

Class 1	1–10%
Class 2	11–20%

Class 3	21–30%
Class 4	31–40%
Class 5	41–50%
Class 6	51–60%
Class 7	61–70%
Class 8	71–80%
Class 9	81–90%
Class 10	91–100%

If this is found to be too difficult, or time consuming, then five classes of 20% damage steps can be used. The assessors should be tested in the office to make sure that they can accurately assign the different levels of damage to the correct classes. The following procedure is suggested.

Collect a number of rice heads with varying amounts of damage from 0 to 100%. Accurately count the damage level for every head and label it with a letter or figure – not the percentage damage! Present each assessor with a head for a short period of about 10 seconds and then have him write down the score. There should be enough heads so that the assessor does not learn to identify a particular head with a particular level of damage. If it is not possible to collect sufficient heads with varying levels of damage then damage charts can be used for training and testing the assessors.

The preliminary work for the damage assessment is now completed. The field assessment can now be undertaken.

The field assessment

Two more randomisations are needed to get the teams to the sites where the assessment will be made.

1. A random number between 1 and 5 to direct the team to the sample plot in the holding.
2. A random selection of the row and the distance along the row where the assessment is to be made.

The assessment is carried out in the field as close to harvest time as possible. The recorder should be equipped with a clipboard, appropriate recording forms, a pencil, and enough random number tokens or cards to make the necessary sample point selections. On arrival at the selected holding the recorder should carry out the following procedures.

1. Pick a random number from the series 1 to 5 to indicate the selected plot.
2. Select 5 random numbers from the series 1 to 50 to indicate the rows from which the samples will be taken.
3. Select 5 random numbers from the series 1 to 20 to
4. Indicate the distance along the row the assessor has to travel to make the assessment.

5. Direct the assessor to the sample points by standing at the end of the selected row telling the assessor the number of paces to take along the row before making his assessment.
6. Record the score on the appropriate form for each rice head assessed by the assessor.
7. Advise the assessor when the appropriate number of heads has been assessed.
8. Move to the next row and so on until the 50 heads from the plot have been assessed.

The assessor simply follows the directions given to him by the recorder pacing out the distance given along the row selected. On arrival at the sample subplot the assessor takes the first rice head in the row in front of him and makes his assessment of the percentage damage. He then continues along the row calling to the recorder the percentage damage assessed on every head until advised to stop by the recorder when 25 heads have been assessed. He then moves to the next row indicated by the recorder and repeats the procedure.

The field assessment completed, the teams hand in the forms to the appropriate officer for analysis.

Millet and Sorghum

Millets and sorghums are generally cultivated in small scattered patches. For this reason the extent of planting is not generally known accurately and maps or plans of the cultivated area are not usually available. Fields are often poorly defined and it is necessary to approach the sampling in a different way than, for example, in a crop such as wheat which is planted in reasonably well delimited fields.

It is possible to arrive at an approximation of the area planted if no map or plan of the planted area is available. This is best done by undertaking an aerial survey of the area, or region, where the assessment is to be made. A map is used to plan the survey and parallel transect lines are plotted to give good coverage of the area. An aircraft is flown along the transect lines at 100 m altitude and at a speed of 200 km/hour while observers record the incidence of cultivation. For this purpose, two observers are trained to identify the crop from the air. The observers sit on either side of the aircraft and, at predetermined intervals, using a sight fixed to the aircraft, record whether or not the sight, at that precise moment, is lined up with the crop. Subsequent application of a formula to the observations made gives an acceptable approximation of the extent of the area under cultivation.

Having estimated the area planted to the crop it is now necessary to consider how to locate the plots to be sampled. Most grain-eating birds which cause damage of economic importance, and certainly Quelea, feed in flocks. The flocks cause damage in patches scattered widely over the cropping area. For this reason it is best to examine many small samples rather than a few large ones. It is also best to sample the damage as close to harvest as possible to ensure that the full period when the birds are feeding on the crop is covered.

It would be very difficult to use the data obtained in the aerial survey to locate the sample plots as they cannot be used to plot an accurate map of cultivation. The data obtained can only help to estimate the total area under cultivation. The first consideration, as in all crop damage assessments, is to arrive at a method of sampling the area planted in such a way that every plant has an equal opportunity of being assessed for damage. In the case of millets and sorghum, or any crop planted indiscriminately over large areas, a compromise has to be reached to permit a reasonable random selection of sample plots. The method suggested by Otis (1989) is recommended and can be summarised as follows.

1. **The sampling unit.** A map is prepared of the motorable road network throughout the area to be sampled. The road network is divided into equal sections each of which is given a reference. The length of the section is chosen in such a way that there will not be so many as to make the labelling unmanageable. As a guide, a distance of about 2 km is probably not unreasonable in most circumstances.

2. **The number of staff available as assessors,** and the time required to travel along the selected routes, must now be used to determine the feasible sample size. At each sampling point an assessor will have to walk about 1.5 km examining heads of the crop for evidence of bird damage.

3. **The time to undertake this part of the work must be calculated.** When this is known the assessment can be planned.

If there are three vehicles available and three teams of two assessors then the road network is divided into three parts each of more or less equal distance and these are labelled A, B and C. On the map the three sections are marked off into equal lengths of sampling sections.

Every 2 km section of parts A, B and C of the road network is now given a number (i.e. A1, A2, A3,...An: B1, B2, B3,...Bn: and C1, C2, C3,...Cn; n being the number of 2 km lengths in each section). Assuming that it takes 1 hour for one team of assessors to complete one sample, including travel between the sections to be sampled, then it might be reasonably expected that 6 samples can be done in one day (i.e. 6 hours work). If 2 days are allocated to the work then a total of 36 samples can be undertaken by the three teams.

Twelve random numbers, within the range of the number of 2 km sections for each route, are generated with a calculator or 12 are drawn at random from a bag of tokens or pack of cards to select the 2 km stretches of the roads over which the survey will be undertaken. After this, the selected sections are marked on the map and a route worked out for each day of the survey. The routes will, of course, be chosen to minimise travel time.

To take an example, a crop damage assessment was planned for the Lower Shire Valley in Malawi. A sketch map of the road network in the area was prepared. The road network on the map was divided into 2 km lengths throughout except for the escarpment road out of the valley to Blantyre. The network was 440 km long giving 220 sampling units. Three vehicles were available for the assessment and therefore the network was divided to three equal parts of 73 units each. It was expected that six samples could be done in one day on the assumption that it would take 1 hour to complete one sample, including travel between sampling points. Two days were allocated to the work so that a total of 36 samples were expected to be completed in this time, i.e. 16% of the total sampling area, which is a reasonable proportion.

The 73 units in each sector of the network were given a number and 12 of the numbers were drawn at random to select the 2 km stretches of the roads over which the survey was to be undertaken. After drawing the numbers, the sections were marked on the map and a route worked out for each day of the survey. The routes were chosen to minimise travel time. After this was completed the assessments were started.

First it was necessary to select randomly 12 of the numbered units in each section of the road network. In order to select the units where the assessments were to be done random numbers were generated on a calculating machine which had this facility. In the absence of a calculator a series of tokens, or cards, can be prepared for however many 2 km sections there are in each half of the road network to be sampled. The tokens are placed in bags from which they are picked at random after being well mixed by shaking. Cards can be shuffled and cut to reveal the random numbers.

The selected sections are the sample points where the assessments are to be carried out. The assessment team arrives at the first point on its route measured accurately on the vehicle tachometer. Should the road not be straight at this point then they may travel on for as short a distance as possible until they arrive at a stretch of road which is straight for the next 1 km or so. On arrival the first assessor is dropped off and walks at right angles to the road in a straight line for a distance of 500 m. The side of the road on which the assessor starts his transect is decided randomly by tossing a coin. Along this route he stops to make an assessment (according to the assessment method being used, see below) in every patch of crop he encounters along his path or within 50 m on either side of it.

Having completed his 500 m walk he turns at right angles and continues for another 500 m parallel to the road and in the same direction as the vehicle is travelling. The same sampling procedure is followed as he continues along this second traverse. At the end he turns through another right angle and walks back towards the road for a final 500 m continuing his sampling. This completes the first half sample.

In the meantime the vehicle has continued along the road for 500 m to the point where the first assessor will return and drops off the second assessor. The second assessor carries out a traverse in exactly the same way as the first but on the opposite side of the road (see Figure 10). The first sample is now completed and the team moves on to the second sample point where the same procedure is followed. At the end of the day having completed six transects the team returns to base and hands in its damage assessment papers. Problems are discussed, sorted out and preparations made for the following day's continuation of the assessment.

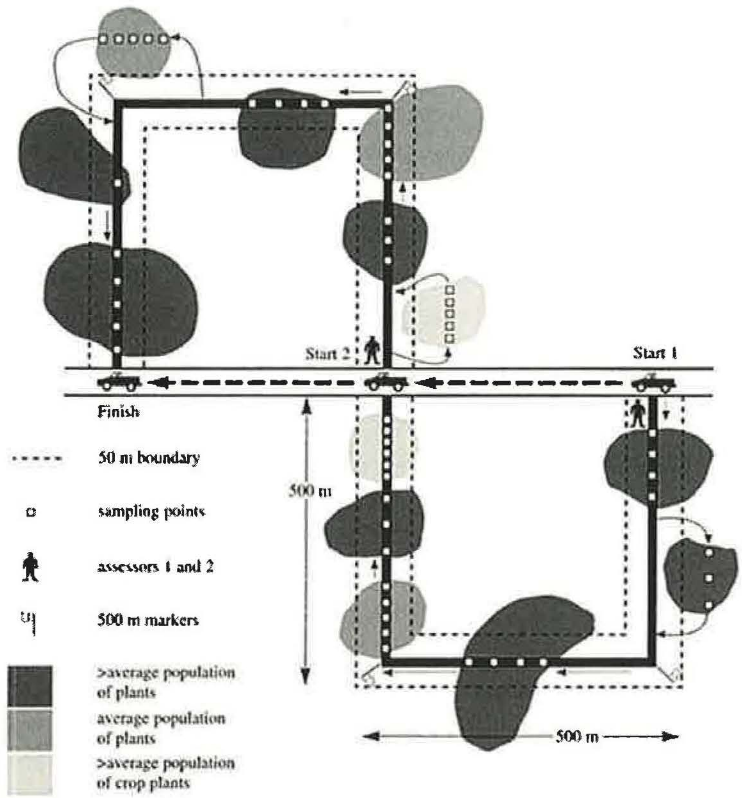


Figure 10 Assessment of crop damage

Assessment

The assessment is the final part of the work to be done to arrive at the level of damage caused by the birds. This part is the most exacting and the success, or otherwise, of the whole assessment will depend on it. Assessors must be chosen with care and trained to identify bird damage to the crop under examination. Each will carry with them into the field a clipboard with assessment forms, a pencil and 50 random number tokens, or a calculator with a random number generation facility.

When the assessor enters the first patch of cultivation, directly on his transect line or within 50 m of it, he selects a random number between 1 and 50. The number selected is the number of paces he will continue along the transect, or parallel to it if he has deviated, to the point where he will make the first assessment. At this point he will record, on an appropriate assessment form (Figure 11), the level of damage to each ear of the crop within a radius of 1 m around him, i.e. within arms-length. The method of assessing the damage is different for sorghum and millet and will be dealt with later.

Having completed the first assessment, he will continue along the transect line, or parallel to it if he has moved off the line, a fixed distance, between 20 and 50 m, according to the density of the crop. This distance will be constant and should be chosen beforehand (if the crop is dense 50 m, if moderate 35 m and if sparse 20 m). Here he will undertake another assessment. He repeats his assessments at the pre-arranged distances until he comes to the end of the cultivation or until he completes the first 500 m of his transect, whichever comes first. If he has come to the end of the cultivation he will continue on his transect, or he will return to his original transect line if he deviated to the cultivation he has just completed assessing. In this way he continues along the transect line until encountering more cultivation when the assessment procedure is repeated.

SORGHUM

Assessor...
Date ..../......./.......

Key
M = Mixed planting
H = Harvested
P = Protected
I = Immature
L = Local variety
S = Improved variety

				Head size: u = unripe d = diseased		
Sample	Field	Station	Code	Below av.	Average	Above av.

etc

MILLET

Assessor...
Date ..../......./......

Key
M = Mixed planting
H = Harvested
P = Protected (windrowed)
I = Immature

Sample	Field	Station	Code	Damaged	Undamaged

etc

Figure 11 Bird damage assessment forms

In summary:

- On arrival at the edge of a field a random number is chosen to determine how many paces to walk into the crop before making the first assessment;
- Pacing out the distance chosen along the transect line, or parallel to it, the assessor arrives at the first assessment point;
- Here the assessment is made of the amount of damage caused by birds to each head of sorghum or millet within arms-length;

- Having completed the assessment and recorded the level of damage for each head, the assessor paces out the distance pre-arranged for the density of the crop (plant population low 20 paces, normal 35 paces and high 50 paces) to the second assessment point;

and so on to the end of the cultivation.

Every patch of cultivation along the transect line, or within 50 m on either side of it, is treated in the same way until the assessor arrives back on the road having completed a 1.5 km transect.

Table 1 Correlation between total percentage damage to cereals and proportion of ears showing damage

% ears damaged	equivalent % damage	% ears damaged	equivalent % damage
10	1	60	42
15	5	65	46
20	9	70	50
25	13	75	55
30	17	80	59
35	22	85	63
40	26	90	67
45	30	95	71
50	34	100	75
55	38		

Millet The assessment on millet is very simple if it is based on a correlation worked out by FAO in Chad. The assessor simply records the total number of heads within the 1 m radius sampling point and the number of those which show any damage by birds. The % damaged is then calculated for each transect sample (i.e. the two transects undertaken by the two assessors added together is one transect sample). The % damage this represents for the area as a whole is read off the correlation table (Table 1). However, the correlation should be verified for the crop being assessed as it may not hold true for different varieties in different areas.

A refinement of the assessment can be made by recording the relative size of the millet heads such as small, average and large. This will give a better indication of the overall yield reduction and possible selection by Quelea of certain categories of crop.

Sorghum The assessment on sorghum is difficult and requires training of the assessors. Ideally an estimate is made of the actual level of damage to each head. Classes are chosen, preferably at 5% intervals and each damaged head assigned to one of 20 classes from 5% to 100%.

Wheat

There are two ways in which wheat is cultivated in Africa. The first is very similar to the traditional method for sorghum and millet. Seeds are planted by random dibbling so that there are no well defined crop rows. The second method of cultivation is that undertaken on large lands, or fields, when cultivation of the land through planting to harvest is done entirely by machine. Wheat is never interplanted with another crop and therefore the fields are generally well defined. The crop is also a cash crop and for this reason the number and situation of the fields are generally known to agricultural staff in the area. This situation is ideal for taking a good random sample of the crop in the area when carrying out a crop damage assessment.

In the first place a plan should be made of the area if one does not already exist. This needs to be at a scale of 1:50 000. All the fields of wheat should be plotted on the plan. In many cases this will not be necessary as one will already exist in the local agricultural office. A very useful tool for making a plan, if one does not already exist, is a hand-held **Global Positioning System** or GPS. This is a site plotting system which records the latitude, longitude and altitude of any position using transmissions from navigation satellites. Using this instrument every field is visited and a plot of its position read off on the GPS. The positions are then plotted on a map from which the plan can be made. The instrument will also give an accurate read-out of the area of the field if this is not already known. This refinement is not very useful, however, as it will be necessary to take a reading from every corner of each field which will be more time-consuming than measuring two sides of the field with a chain or pedometer.

Having prepared, or acquired, a plan, it is now necessary to decide how many fields can be assessed. The number of fields to be assessed will depend on the same criteria as were outlined for irrigated rice in steps 1 and 2 on p. 88 above. First the fields will be stratified according to criteria decided on as important for the area. For example, the most obvious category will be the variety of wheat grown in the different fields. Other categories can be the altitude of the field, the site of the field, whether it is at the top of a hill, on a slope or in a valley, and whether or not there is any cover for birds close to the field. An example might be as follows.

In an area where 500 ha of wheat were planted 108 fields were measured and plotted on a 1:50 000 map. Three categories were chosen for the aspect of the fields recorded as hilltop fields (plateau), hillside fields (slope) and riverside fields (valley). The fields were further stratified according to whether they were with cover (treed) or without cover (untreed). A simple table was made with the number of fields in each category.

Aspect	Cover	No. Fields	Fields sampled
Slope	untreed	37	9
	treed	23	6
Plateau	untreed	23	6
	treed	16	4
Valley	untreed	5	1
	treed	4	1

The number of fields sampled is proportional to the number in each category. How many fields to sample will be determined by the time it will take to do the assessment, the time, and the number of staff available for the work. The assessment must be carried out between the end of the damage period and the harvest of the crop. This limits the time available for the assessment and also makes it time-consuming if there is a wide variation in the planting dates of the crops in an area. All these constraints must be taken into consideration when planning the assessment.

The optimum number of samples to be taken is determined by the degree of patchiness of the damage but should be somewhere between 20 and 60 per field. Attention should be given to increasing the number of fields to be sampled and minimising the number of samples per field according to the manpower available.

The final assessment on a wheat field is made as follows.

A sample should consist of a 20 cm length of crop row. This will yield some 4–5 heads of wheat which should be cut from the plant. A visual assessment is made of the % damage and a tally entered in the field notebook in the appropriate 10% damage class. The head, if damaged, should be placed in one bag reserved for damaged heads. Undamaged heads should be kept in the second bag. The two bags can be weighed to the nearest gram after all the heads from the sample points in the field have been assessed and gathered.

The % loss by weight is calculated from the formula:

$$100\left\{\left(1-\frac{\text{Av. wt. g. damaged heads}}{\text{Av. wt. g. undamaged heads}}\right)\times\left(\frac{\text{No. damaged heads}}{\text{Total no. heads sampled}}\right)\right\}$$

The loss by visual estimation is calculated as follows:

1. Multiply the number of tally marks in each class by the % level of the class;
2. Add all the products together;
3. Divide by the total number of heads examined; and
4. Multiply by 100.

Maize

Maize is unlikely to be seriously damaged by birds in Africa except in unusual circumstances. In Kenya a feral population of Fischer's Lovebirds, escapees from an aviary, built up a large population around Lake Naivasha where they fed, for the most part, on the seeds of *Acacia xanthophloea* but also turned their attention to small plots of maize grown out of season under irrigation. The maize was extensively damaged by the lovebirds.

The cob of maize is easily assessed for damage either by measuring the proportion damaged on four opposing sides or assigning the head to a category of damage based on 10% classes. The sample sites should be chosen as outlined above for wheat.

NOTES

[1]A ratoon crop is one produced by new shoots from the ground after the first cropping.

3

Bird Pest Surveys and Monitoring

INTRODUCTION

To monitor pest birds is to keep a check on where the birds are, what their numbers are and what they are doing. This is a task which might be thought difficult for a crop protection officer to undertake on his own and to be of limited use in alleviating the problem caused by birds. A conscientious officer, however, who wants to be in a position to give good advice to farmers, would do well to keep an eye on the birds he knows to be pests and to keep a record of their numbers and their activity. In doing so he would be able to advise farmers of the likelihood of birds causing damage and whether or not any need will arise to take action against them. Such a record can be kept by anyone as he goes about his daily work. Birds feeding on fallow ground during the dry season give a hint of the overall population from the size of the flocks and their number. At the beginning of the breeding season the number and density of the nesting colonies being established can be recorded and, knowing the time it will take until the young birds fledge, the likelihood of crop damage in the immediate vicinity can be predicted. This simple type of monitoring is easily undertaken and can be useful in helping agricultural staff to appreciate the role played by birds in cereal production. The real importance and difficulty of monitoring becomes apparent, however, when it is devoted to those birds which 'invade' agricultural areas periodically and are capable of causing serious losses in a very short time.

The only bird which warrants serious monitoring on an international scale is the Quelea. A considerable amount of work has been done on establishing monitoring techniques for Quelea and in training field staff to undertake the work. Unfortunately, the effort expended over the years has failed to give rise to a system which operates successfully. This poses the important question whether or not there is any point in continuing to advocate the establishment and maintenance of a monitoring network.

First then what is a monitoring network and how is it supposed to assist in crop protection? The behaviour of Quelea is well known and their importance as a crop pest is undoubted. What is less well known and what gives rise to concern is what is their real impact on crop production, and do they invariably have to be controlled as ruthlessly and expensively as they currently are? It is only by carefully monitoring their activity that answers to these questions will be forthcoming. Quelea monitoring has to be undertaken internationally and there must be a body to analyse the data obtained and to use it for planning a good management strategy. The organisations established for undertaking co-operative pest control internationally in Africa are the locust control organisations. There are three of these, the Organisation Commune de Lutte Antiacridienne et de Lutte Antiaviare (OCLALAV) in West Africa, the Desert Locust Control Organisation for Eastern Africa (DLCO-EA) and the International Red Locust Control Organisation for Central and Southern Africa (IRLCO-CSA). Each has, at one time or another, been mandated to establish a monitoring network and advise on Quelea control in the countries which are their contributing members. So far the locust organisations have failed to establish a functional monitoring system. The main reason for the failure of the organisations to maintain a monitoring system is that their annual budgets have been insufficient to allow them to do so. At the request and at the expense of the governments of their member countries, they have been called on to undertake aerial control operations against Quelea, but have never been party to a co-ordinated effort to predict problems and contain them rationally under a sound management programme.

The principal function of a monitoring network is to collect data on Quelea, to log and analyse these centrally and to issue early warnings of impending 'invasions' based on the data received. In an ideal situation a regional body receives information from sources throughout the range of the Quelea population under surveillance. The information is analysed, linked to rainfall and other data, interpreted and redistributed back to the data sources as a report and forecast. The unit receiving the forecast can make an early assessment of the need for control and, if necessary, plan a strategy for containment of the forecast situation. There is no doubt that a properly run system will bring major benefits to those responsible for protecting crops from pests. Armed with a concrete forecast they can approach the authorities responsible for disbursing emergency funds in a timely manner so that action can be taken before the problem gets out of hand. This would be in marked contrast to the current situation where the problem is only addressed when farmers begin to report damage to their crops. The result is hasty, and often costly, decisions being taken too late to stop much of the damage, exasperation of the farmers, government officers being blamed and the launching of environmentally risky operations to show willing when no meaningful result can be expected.

Accepting the need for a monitoring system, the problem is to establish one which will not overtax the budgets of hard-up locust control organisations. Collection of the data is, as always, the responsibility of the staff on the ground in the areas where Quelea are a problem. This is a matter for national extension services and agricultural departments. Data can be collected as outlined below on appropriate forms and sent to a central office in the country where it is collected. Here the information can be stored on a computer and shared with a regional organisation, if one exists, and all neighbouring countries sharing the problem, either by fax or electronic mail. If there is a functional regional office this would be the logical place for the interpretation of the information and its correlation with rainfall data from the different meteorological stations in the area and from satellite imagery. In the absence of a regional office, each national office would make its own interpretation of the data and link this with rainfall data to make forecasts which would be shared regionally. In this way, the expenditure on logging and interpretation would be minimal and feasible. The problem now is what data should be collected, how is this done and how is it interpreted. The following guidelines should help in the understanding of the methods recommended.

QUELEA SURVEYS

Surveys are generally carried out in areas where crops are known to attract the attention of grain-eating birds. The purpose of the surveys is to locate concentrations of birds and to assess the likelihood that they will attack susceptible crops in the vicinity. In the absence of a regular monitoring programme, surveys are often undertaken when farmers begin to complain about flocks of birds entering their crops to feed.

Quelea birds damage crops at two periods during their annual life cycle. The first period is towards the end of the breeding season when the young birds become independent and leave the colony to search for good feeding grounds. If there are cereal crops close to the colony then these may attract the attention of the young birds. The second stage is during the winter in southern Africa, or the dry season in western and eastern Africa, when irrigated cereals are ripening. At this time the adults and juveniles from the earlier breeding season are having difficulty in finding adequate sources of their natural diet of annual grass seeds. In both seasons it is necessary to survey for Quelea in the vicinity of susceptible crops in areas which they are known to frequent.

Quelea colonies are generally established some 6 to 8 weeks after the main rains have started. This is also the time when wild grasses are setting seed so that the birds have an adequate source of food readily available for the rearing of their broods. Unfortunately this is also the time when rainfed cereals planted at the onset of the rains are beginning to set seed. If these cereals are close to Quelea colonies then they are under threat of attack from the young birds as they slowly disperse from the colony. Studies on Quelea have shown that cereal crops within 5 km of a colony are at risk during the life of the colony but late developing crops ripening after the colonies have dispersed may be at risk up to 30 km from the breeding sites.

When farmers begin to report crop damage then it is necessary for Crop Protection Officers (CPOs) to consider what can be done to prevent the damage. No chemical or physical method of keeping the birds from the crop, such as repellents, soporific agents, noise-making devices, nets or scaring devices is known to be effective although a small field can be protected by a network of rattles controlled from a site in, or beside, the field (see Chapter 4 for methods of protection).

Generally, many individual farmers are affected by the problem in any one area and timely control by a National Plant Protection Service using a lethal avicide to kill the birds has been shown to be the only effective means of protecting the crops. This requires the CPO to arrange for a survey around the area affected to try to find the source of the birds causing the damage. Once located, either by the farmers themselves or by the CPO and his staff, the concentration of birds, in either night roosts or colonies, can be controlled by ground sprayers or aircraft (see Chapter 4).

If the concentration of birds causing the damage turns out to be juveniles recently dispersed from a breeding colony, there is a risk attached to this method of control as the young birds are not faithful to their roost site which they can change unpredictably. Also the roosts may be small and numerous. This means that much time can be wasted looking for the roosts, arranging a control operation then having to abort the operation because the birds have changed the roost site. Meanwhile the damage goes on!

In order to avoid this risk, CPOs should not wait for farmers to report crop damage but should undertake surveys to locate the breeding colonies long before the young birds leave their nests. It is through international monitoring that CPOs can be advised when to start surveying for colonies in their area.

In the case of crop damage occurring during the winter, or dry season, then it is reasonable to wait for the birds to turn their attention to crops as long as the CPO is ready to undertake control whenever reports are confirmed. The reason for the difference between controlling roosts at this time and during the breeding season is that the adults and older juveniles which occupy these roosts are more faithful to the sites, many of which are traditional ones having been used year after year. In this case it is only necessary to launch a survey to locate the roost site which is usually large and well established. Once located it is unlikely to be moved before the control operation can be undertaken.

Breeding Colony Surveys

Quelea birds are among the most numerous birds in Africa, yet finding their breeding colonies, even though they may number many millions of birds, can be a difficult task. The reason for this is that the birds concentrate at the breeding site rarely straying more than 5 km from the colony during its early stages. Colonies are usually established in areas of undisturbed bush well away from human habitation, and often far from roads or tracks. The season when Quelea breed is 5–6 weeks into the main rains when heavy downpours, flooded rivers and marshy ground conditions often make approach to the colony difficult but, despite this, it is by surveying on foot that most colonies are found. Aerial surveys, particularly by helicopter, are ideal, but the high cost means that the method is rarely used. Information can be obtained from game scouts, villagers, herdsmen and sometimes farmers themselves who know traditional sites and keep their eye on them. CPOs should enlist the services of such people early in the breeding season in areas where, from previous experience, they may expect colonies to be established.

The method of finding colonies once birds have been in the area is to backtrack on their flight lines which converge on the site of the colony. Birds fly in and out of the colony throughout most of the day in straight flight lines to their feeding or drinking places. Following one flight line direction may bring you to the feeding grounds instead of the colony and it would be a long walk back – quite a daunting task during the rainy season. It is better to watch two separate flight lines to determine in which direction they are converging as this will lead straight to the colony. First light is the best time to backtrack on flight lines, as flocks will be coming directly from the breeding site.

Once at the colony three things should be done to complete the survey.

1. Measure the size of the colony.
2. Determine its age.

3. Measure, or estimate, the type, height and density of the vegetation in which the colony is established.

Ideally, if there is time and trained staff are available, more information may be collected. The additional information is obtained by randomly selecting at least five sites (quadrats) within the colony, measuring 10 m by 10 m, and recording the number of trees or bushes in each site and the number of active nests in one or two trees per quadrat. The following calculation will give a reasonably accurate estimate of the total number of female birds in the colony:

$$\frac{\text{Total number of trees/bushes per quadrat}}{\text{Number of quadrats}} \times \frac{\text{Area of colony in m}^2}{100\ \text{m}^2} \times \text{average number of occupied nests per tree}$$

The age of the colony is calculated by examining a random sample of nests, the more the better, and determining the age from a chart (Table 2).

Table 2 Determination of age of colony

Activity in colony	Approximate age in days
Nest building in progress, no eggs.	1–3
Nest building in progress. Eggs in some nests.	3–4
Little or no nest building. Eggs in most nests (usually 2–4 per nest).	4–13*
Hatching in progress. Nests contain eggs and/or very small nestlings.	13–15
Nestlings in most nests. Any remaining eggs infertile or abandoned (cold).	15–22
Some nestlings in nest and some fledglings outside nests in surrounding vegetation (e.g. young leaving nests).	23–26
Majority of young outside nests but not able to fly.	26–30
Young mostly able to fly short distances within colony.	31–39
Young abandoned by parents and feeding themselves outside the colony.	over 40

N.B. The optimum time for control is from day 4 to day 22 (tint panel).

* Age can also be told by the degree of incubation; clear whites = fresh = days 3 or 4; visibly formed chicks = 8–10 days; fully formed chicks = 11–13 days.

All the information obtained should be recorded on a report form. The filling in of report forms is one of the most important elements of a successful survey. Many different forms have been used by different organisations but none has ever been accepted as a standard for all surveys. This is unfortunate but perhaps understandable as staff of many different persuasions are often co-opted to undertake the surveys. One recommendation which always crops up is that only one form should be used and it should be easy to fill in. In the past, and with good reason, there have been different forms for roosts, colonies, and control operations and the information requested has been time-consuming to collect. A form, drawn up with the co-operation of a variety of field staff is illustrated in Figure 12 and it is recommended that such a form should become standard for reporting purposes. It is a single form and it is easy to fill in. However, it is difficult to see how such a form can be used in the field and also submitted as a report because it will be used at different times for first reporting a roost or colony and then for recording its control. The ideal would be to have the report card printed in triplicate on 'no-carbon' paper. The top copy would be submitted after the preliminary survey, the second after the control operation and the third kept by the recorder. In this way only one form is made out but copies are used to submit the report in two stages.

QUELEA REPORT FORM

Country.............................. Province.............................. District..............................

Sub District...................... Locality.............................. Date ..../......./.......

Recorder.. Serial No.....................

Part A **SURVEY**

breeding COLONY ☐ ROOST ☐ approx SIZE ☐ ha

Traditional site? YES/NO Distance from water ☐ m

Vegetation type: REEDBED ☐ Dense? YES/NO
Acacia et. SCRUB ☐
TREES <5M ☐ Rough ground? YES/NO
TREES>5M ☐
OTHER ☐

Ground condition: Dry ☐ Moist ☐ Wet ☐ Flooded ☐

Part B **COLONY**

NESTS: Building ☐ With eggs ☐ With nestlings ☐

FLEDGLINGS: Unable to fly far ☐ Flying freely ☐

Colony ABANDONED ☐

Part C **CROPS**

Nearby cereals: millet ☐ sorghum ☐ rice ☐ wheat ☐

Distance from colony/roost | 5 | 10 | 15 | 20 | 25 | 30 | >30 km |

Stage of crop: newly sown ☐ vegetative ☐ panicle initiation ☐
milky ☐ ripening ☐

CROP DAMAGE YES/NO

DO YOU RECOMMEND CONTROL? YES/NO

Figure 12 Quelea report form, Sections A–C

Roost Surveys

The survey for dry season roosts requires a different technique from that for colonies. The reason is that the birds can only be traced to their roosts in the evening towards nightfall. Quelea do not begin to move towards their roost site until some 30 to 45 minutes before sunset. This means that the observer has to be in the field about an hour before sunset and be prepared to track the flocks back to their roosts, usually on foot, as soon as they begin to leave. The search for the roosts may take a few evenings work as the birds can roost up to 30 km from their feeding grounds. Once again it is best for CPOs to utilise local expertise to trace the roosts.

Once the roost has been found it is necessary to estimate its area and to determine the best method to carry out the control operation. It may also be necessary, in deciding whether or not to undertake control, to estimate the number of birds in the roost. In general, roosts of less than 250 000 birds rarely need to be controlled.

The area of the roost can be measured easily in daylight when the birds are absent. The limits of the roost are generally easily seen from the numerous white droppings of the birds which cover the ground under the roost. The type of vegetation in which the roost is established must be noted and, if it is in trees, their height. The density of the

Part D **CONTROL**

Date of operation ..../......./....... SPRAYER used..

AVICIDE...

AMOUNT USED [ ] RATE APPLIED [ ] l per ha

Estimated number of birds in roost/colony [ ]

Estimated kill % [ ]

NON-TARGET KILLS: Number [ ]
Species..
....
....

Part E **COST OF OPERATIONS**

Currency [ ]

CHEMICAL Cost	[ ]	litres	@	[ ]	per litre	[ ]	total
FUEL & TRANSPORT Cost	[ ]	km	@	[ ]	per km	[ ]	total
HIRE OF AIRCRAFT	[ ]	sorties	@	[ ]	per sortie	[ ]	total
Ferry	[ ]	km	@	[ ]	per km	[ ]	total
MANPOWER							
Site preparation	[ ]	days	@	[ ]	per day	[ ]	total
Control operation	[ ]	days	@	[ ]	per day	[ ]	total
Overtime: Weekdays	[ ]	hrs	@	[ ]	per hr	[ ]	total
Weekends	[ ]	hrs	@	[ ]	per hr	[ ]	total

TOTAL COST OF OPERATION [ ]

Figure 12 (continued) Sections D and E; reverse or detachable part of form vegetation and the ground condition, i.e. whether it is very rough or reasonably passable for a ground spray, whether it is flooded, or otherwise impassable and, from the point of view of enviromental hazard, how close the roost is to a water source.

A method of estimating the number of birds entering the roost which is used in Zimbabwe is to observe the flocks carefully as they enter the roost and determine their numbers in the following way:

- Small flocks less than 10 m in diameter spaced 300 m apart....................100 000 birds.
- Larger flocks of up to 50 m in diameter spaced 200 m apart....................200 000 birds.
- Larger snake-like flocks spaced 100–200 m apart .... 1 000 000 birds.
- A continuous stream of birds 100 m wide ....5 000 000+ birds.

All the information obtained about the roost is entered on the report card with a recommendation either to control or not to control it. The form is made out in duplicate and forwarded to the relevant CPO for his action.

Summary

- Surveys should be undertaken as soon as birds arrive in an area where they are known to breed and where cereal crops are cultivated.
- In the non-breeding season surveys should be carried out as soon as crop damage is reported.
- When a colony is found the following information should be obtained:
  (a) The size of the colony;
  (b) Whether or not it is a traditional site;
  (c) The distance from open water;
  (d) Type of vegetation and, if trees, their height;
  (e) The density of the vegetation;
  (f) The ground condition of the site;
  (g) The age of the colony;
  (h) The distance of the colony from cereal crops;
  (i) The growth stage of the crops and their type.
- When a roost is found the identical information should be obtained except that (g) refers only to colonies and an attempt should be made to estimate the number of birds in a roost.
- Report forms should be completed as fully as possible and the information forwarded to the CPO in charge of control operations immediately after the survey is completed.

REMEMBER TIMELY SURVEYING SAVES CROPS AND SAVES MONEY. GOOD SURVEYING LEADS TO ECONOMICAL AND EFFECTIVE CONTROL.

MONITORING

Monitoring is keeping an eye on the birds, recording their movements, recording their activity, recording their numbers, recording their breeding success, plotting their rains migration, delimiting their early rains quarters, plotting their breeding migrations, delimiting their dry season concentration zones.

Methodology

Monitoring methods can be divided for convenience into four components – surveys, population sampling, rainfall plotting and vegetation mapping.

Surveys

The recording of data from breeding colony and roost surveys is a major component of the monitoring system. Timely and accurate records, as outlined above for Quelea surveys, must be kept everywhere that crop damage by Quelea is reported. The data on control operations, entered on the survey forms whenever control is undertaken, and any crop damage estimates complete the surveys carried out by CPOs. Careful attention to accurate surveying will establish a record of the annual effect of the birds on the national economy and how this varies from year to year. It is only through the use of such records that requests for adequate funding to manage the problem successfully will receive due consideration.

Population sampling

The sampling of Quelea is a most important part of monitoring but is perhaps the most difficult to carry out regularly. Ideally each country in which Quelea occur should have monitors in those areas where they are habitually found. A minimum of six monitors in each country would be a start but as many as possible should be incorporated into a national network. The monitors are equipped with mistnets which are set up once a month at sites regularly frequented by the birds. The nets are set to catch as many Quelea as possible but a target of 100 should be sought. Once caught the birds are killed and examined for a number of characters which tell their own story.

First the plumage is examined to determine to which population the birds belong (Figure 9). Next the flight feathers are examined to see if the bird is in moult, i.e. changing its feathers.[1] If this is the case, then the moult index is scored (Figure 13). The importance of this is that the birds only moult their flight feathers after the end of the breeding migration, i.e. when the breeding season is over. The moult of all nine flight feathers takes a period of about three months so that examination of a sample of birds in moult can give an accurate estimate of when they last bred and therefore, possibly, where that was likely to have occurred.

After examining the primaries, the age of the bird is recorded by baring the skull and checking the degree of pneumatisation (Figure 14). Pneumatisation of the cranium occurs in young birds as an air space develops between its two layers of bone separated by bony struts which appear as dots on the surface of the bared skull.

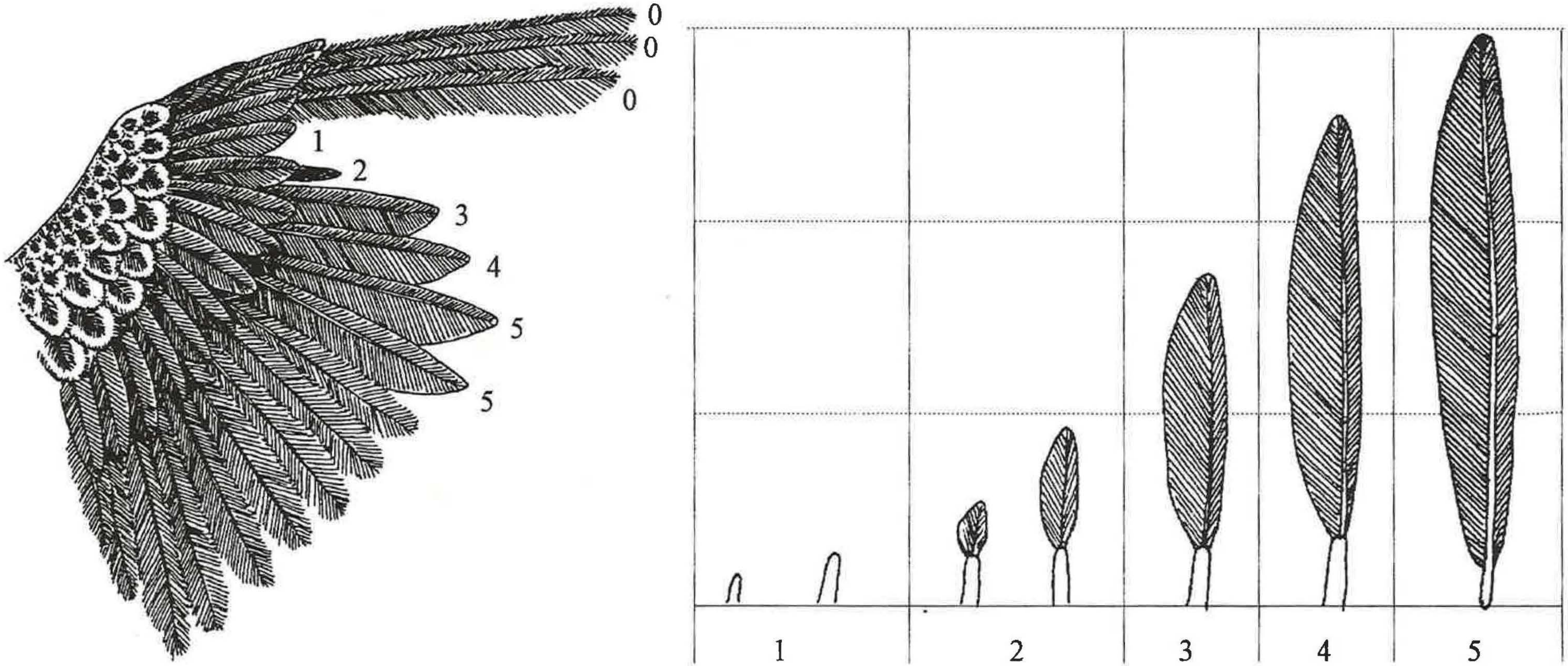


Figure 13 Primary Moult Index – each of the nine primary feathers is examined and given a score, according to the growth of the feather. An old, unmoulted feather is recognisable by its frayed appearance and given a score of 0. A pin feather that has not yet emerged from its sheath scores 1. An emerged feather less than a third of the full grown size scores 2. A feather between one and two thirds the size of a full grown feather scores 3. A feather over two thirds grown scores 4 and a fully grown new primary scores 5. The scores for each of the nine feathers are added up to give the moult index. In this example it is 20.

A final external examination is made of the birds neck where a sac of the oesophagus (the crop) is used to store food gathered in the field. When the bird retires to a roost site, it gradually swallows the content of this sac. If the crop, which is visible through the skin on the right hand side of the bird's neck, is distended with food, it is opened with a pair of scissors and the contents examined to see whether they are wild grass seeds, cultivated seeds and/or insects (Figure 15).

The implication of whether or not the birds are eating cultivated seeds is obvious and, in the case of insects in the diet, the bird is either preparing for the early rains migration, a female preparing to lay eggs, or feeding recently hatched chicks. It must be borne in mind, however, that cultivated seeds in the crop may come from spilled grain in the field or farmstead.

Once the content of the crop has been removed the bird is weighed. The average weight of an adult male is 19 g, the female about 0.5–1 g lighter. Heavy birds may be about to migrate and light ones may be under stress due to a shortage of food, or to having exhausted their reserves during breeding.

The bird, having been weighed, is now cut open so that the gonads can be examined. If the birds are in breeding plumage then their sex is obvious, males having a black mask and females a yellow bill. In the non-breeding plumage birds cannot be sexed without dissection. Examination of the gonads (Figure 16) allows the monitor to determine the sex of the bird and its breeding status.

Males in non-breeding plumage with enlarged testes are either in post-breeding condition, which will be borne out by the primary moult score, or they are approaching the time for the early rains migration. Females with red bills and enlarged oviducts but no enlarged ovules have recently completed breeding but those with yellow bills and enlarged ovules are about to breed. Ovules turning yellow and greatly enlarged indicate that egg laying is imminent.

This interesting detective work need only involve one man for one day a month but the information gathered can go a long way to furthering knowledge about the Quelea bird and is a vital part of monitoring. Anyone can be trained to undertake this work and it need not always involve the use of mistnets. When control operations are being undertaken the monitor can obtain his sample of birds from those killed during the operation.

Rainfall Plotting

The collection of rainfall data from rain-gauges is an important part of monitoring. The information obtained is graphed and linked to the information on the occurrence of the birds at any one time and at any one place. The rainfall graph and the Quelea activity data are linked to give important information on such events as the early rains migration. The likelihood of the birds' ultimate destination can be ascertained from the distribution and quantity of the earlier rains in the known, or suspected, early-rains quarters. The usefulness of remote sensing data in enhancing this information is yet to be shown.

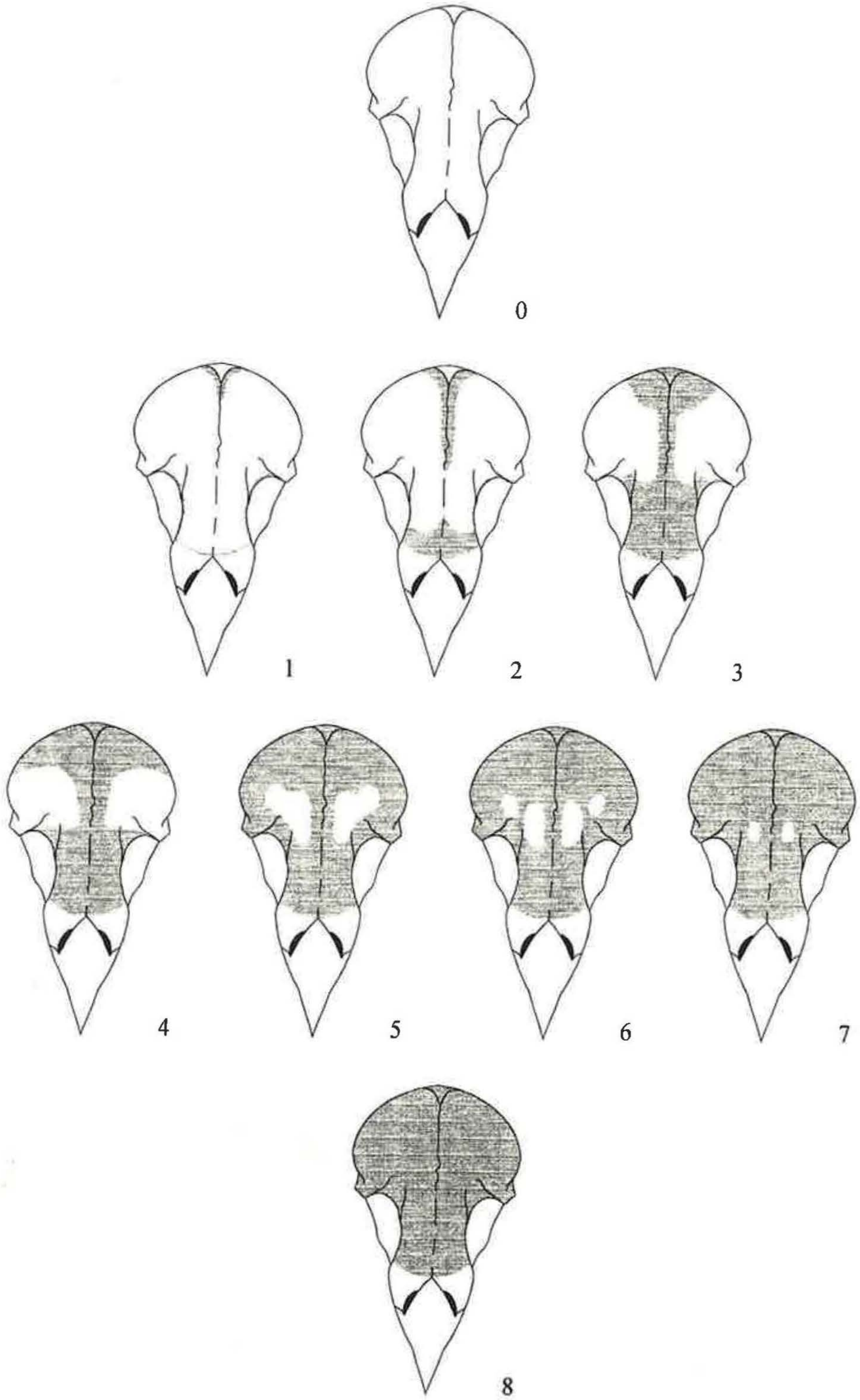


Figure 14 Skull pneumatisation; juvenile birds with no pneumatisation score 0, adult, fully pneumatised birds score 8. Immature and sub-adult birds score according to the amount of pneumatisation that has taken place.

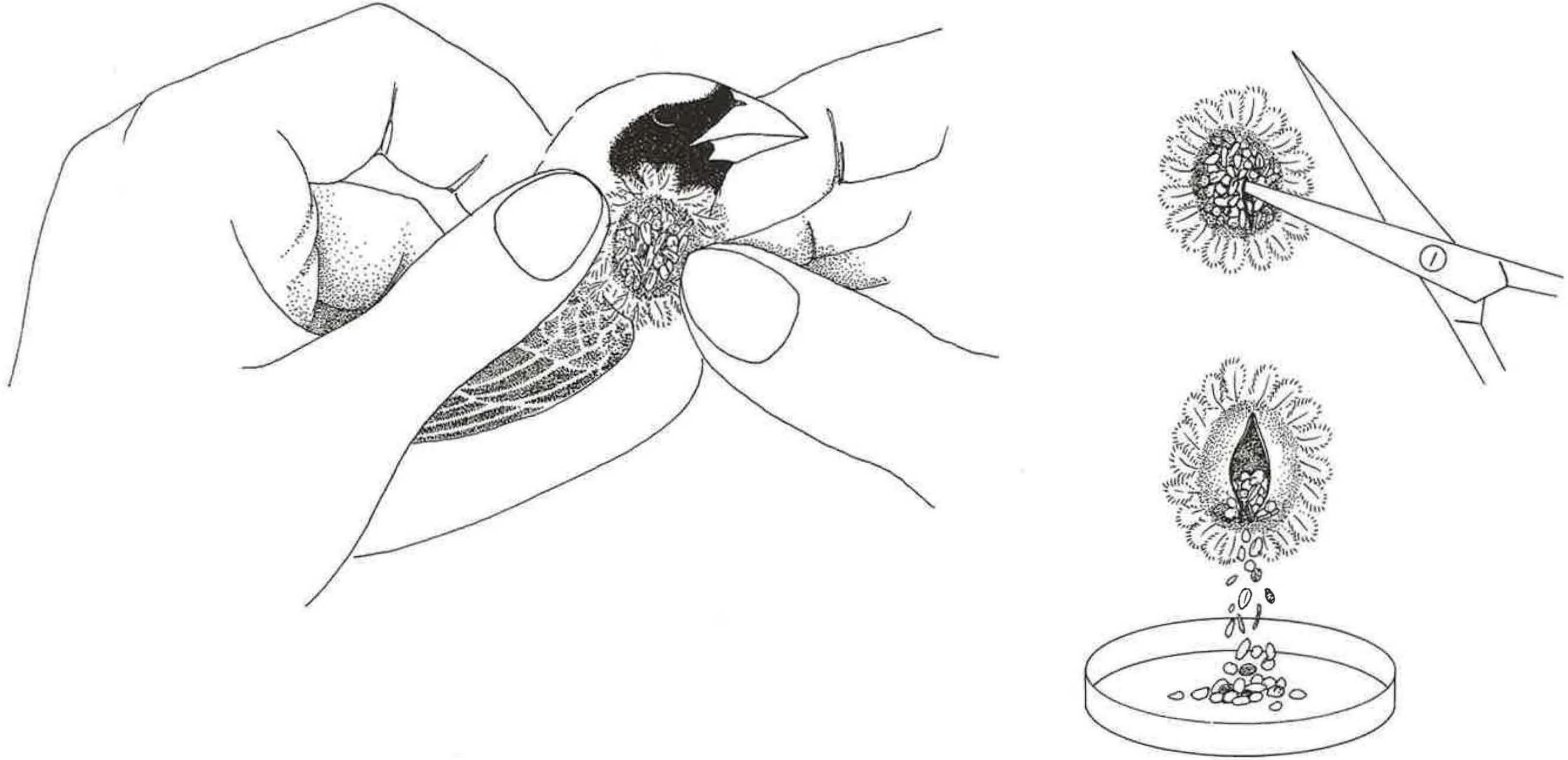


Figure 15 Examination of crop contents

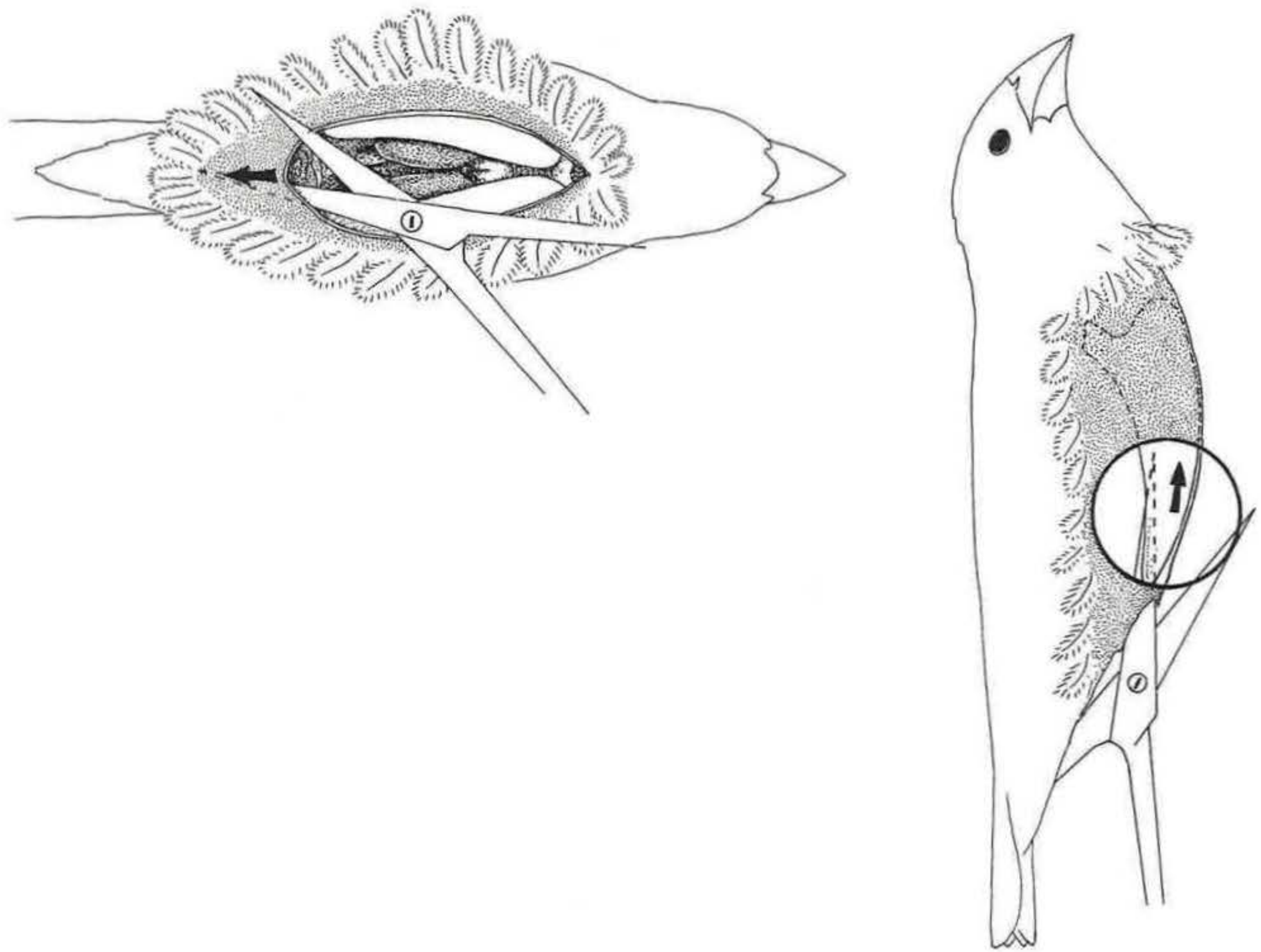


Figure 16 Examination of gonads

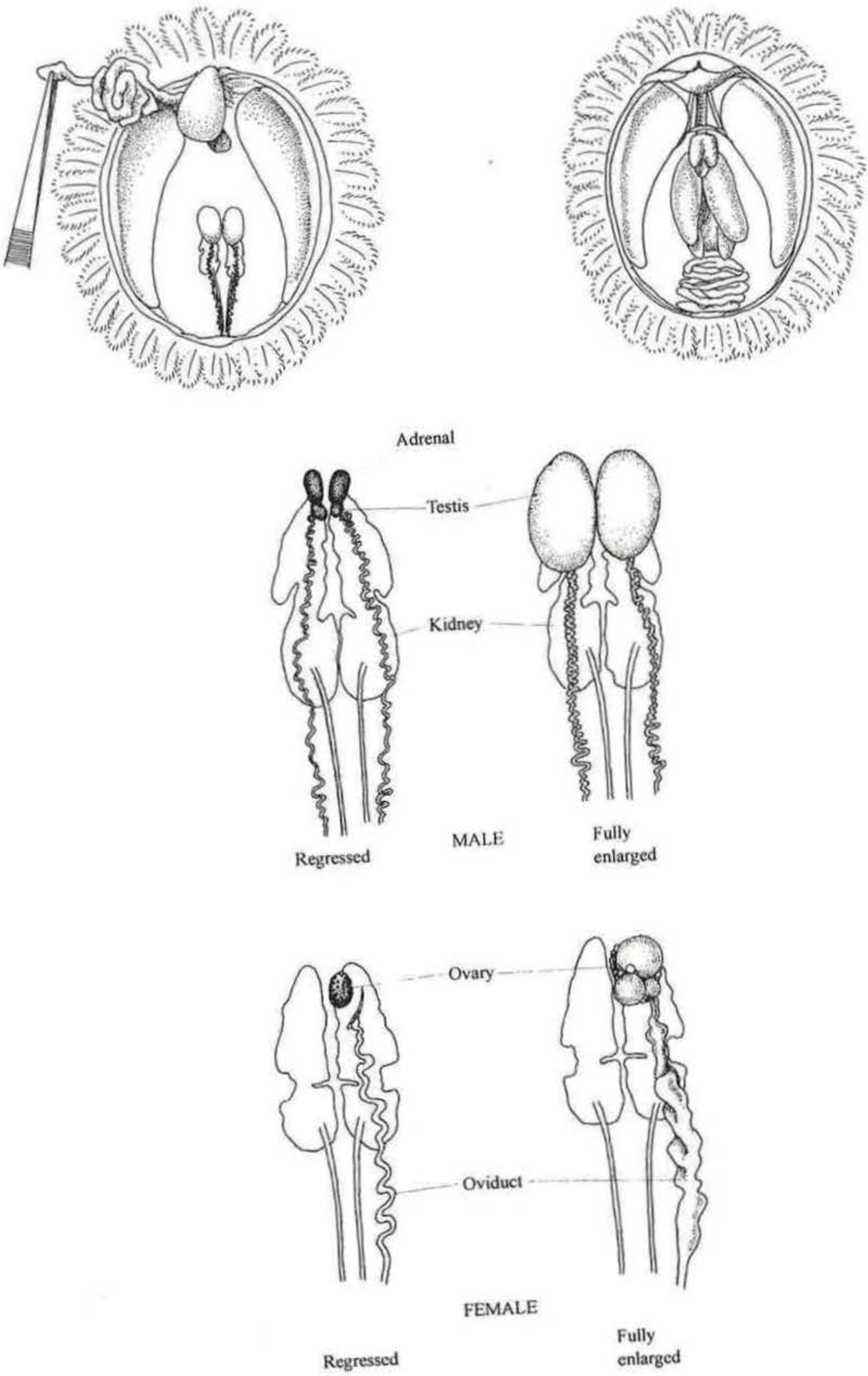


Figure 16 continued

Vegetation Mapping

The distribution of the preferred grasses within the Quelea range provides information on those areas where Quelea may establish their breeding colonies and where the dry season concentration areas are most likely to be. The onset of the rains in these areas and the development of the grasses can indicate the time when colony installation is likely to occur and also when it is too late for breeding in any particular area. It can also give an indication as to whether or not, in any one season, Quelea are likely to attack crops. Such information is important for CPOs to enable them to arrange their surveys and prepare for control operations.

The Monitoring System

It is obvious from our knowledge of the habits of Quelea that monitoring can only be successful if it is undertaken on a regional scale. Ideally, CPOs will gather survey information data on standardised forms such as shown in Figure 17.

Copies of the form would be passed on to a national centre where the monitoring data will also be collected and analysed. Part of the analysis would be the preparation of 'population profile' cards (Figure 18) which summarise the data and, once enough have been prepared, identify the population to which the card refers. An officer at this centre will obtain further data from the mistnet operators in his country and rainfall data from the meteorological department. Vegetation mapping is more difficult to undertake but it is possible that range management or other interested departments may be monitoring these data for other purposes and be willing to share the necessary information.

Country	Botswana
Locality	Shashe-mooke
Date	12.2.93
Monitor	T. O. Onalenna
Sample method	Mistnet

No	Sex	mask index	bill colour	cranial index	seeds	grain	insects	primary moult 1	2	3	4	5	6	7	8	9	moult score
1	M	4	red	9	no												
2	M	6	red	9													
3	M	7	red	9	no												
4	M	6	red	9	yes												
5	M	5	red	9	no												
6	M	4	red	9	yes		yes										
7	M	6	red	9	no												
8	M	7	red	9	yes												
9	M	7	red	9	yes												
10	M	7	red	9	yes		yes										
11	M	6	red	9	no												
12	M	7	red	9	yes												
13	M	wh/m	red	9	yes												
14	M	wh/m	red	9	yes												
15	M	wh/m	red	9	yes												
16	F		yellow	9	no												
17	F		yellow	9	no												
18	F		yellow	9	yes		yes										

Figure 17 Example of data sheet for monitoring purposes

QUELEA POPULATION PROFILE

Serial No. [| | |]

Country [ ] Locality [ ]

Skull Pnematisation

	♂♂	♀♀
No		
mn		
0		
1		
2		
3		
4		
5		
6		
7		
8		

Method of Collection

Mistnet	
Gun	
Post-spray	
Other	

Sample size [ ] Date [| |]

	No.	%
Adults		
Juveniles		

	No.	%
Males		
Females		

Mask Index	1	2	3	4	5	6	7	wh/m	Total
Number									
Black morph %									

	No. in sample	Mean index
Mask moult		
Testes Size		
Follicle Size		

	Sample size	%
♀♀ with developing follicles		
♀♀ with yellow beaks		
mean adult weight: ♂♂		
mean adult weight: ♀♀		

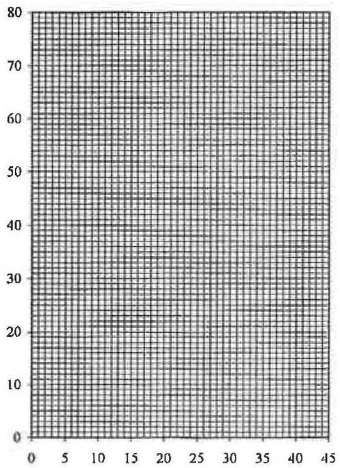
Collection Site

Colony	
Roost	
Day roost	
Mixed	
Other	

Recorder [ ]

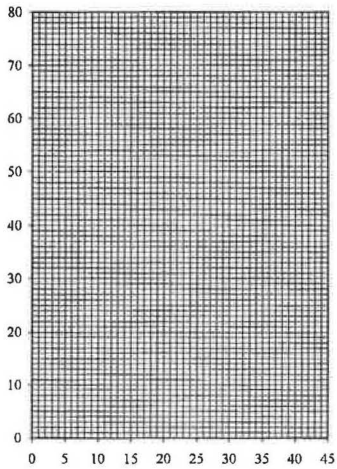
MOULT SCORE HISTOGRAM

Sample Size [ ]



ADULTS

Sample Size [ ]



JUVENILES

Interrupted Moult Sample Size [ ] No

Pattern	1	2	3	4	5	6	7	8	9	
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										

Primary

Notes

Figure 18 Quelea population profile card

Finally the data gathered needs to be combined with similar data collected from other countries where the same population of birds occurs. The compilation of the data can be undertaken by the Quelea officers in the regional locust control organisations if member countries are willing to support them or by co-operating national monitoring networks. In this event, with the help of a common computerised Quelea database a meaningful and useful monitoring network can be set up allowing an early warning system to be established thus improving the efficiency of National Crop Protection Quelea control operations.

Use of Mistnets for Quelea Monitoring

Types of net

Quelea may be collected readily by the use of 'mistnets' (Figure 19). These are very fine, black nets – usually made of terylene or nylon – which are hung vertically between poles. Birds which fly into the nearly invisible net are not immediately entangled in the mesh, but fall into pockets of loose netting which then hang behind one of the strong, tight, 'shelf-strings'. Mistnets should only be used by licensed practitioners.

Nets may be bought in different lengths, heights and mesh-sizes. For Quelea, a mesh of 1¼ inches (about 30 mm) is suitable. Nets 60 feet (20 m) in length, and 9 feet (3 m) high provide a very large catching area and are therefore the most useful for obtaining large samples. Shorter nets, 30 ft (10 m) in length, are also of value for use in narrow valleys and other confined spaces. The nets normally have three or four shelves. Single-shelf nets, only 3 ft (1 m) high have a relatively small catching area, but are of use when netting in open conditions where the birds are flying low among tall grasses. Under such conditions tall nets may be inefficient because of their conspicuousness. Single-shelf nets have also been used successfully in Botswana for catching Quelea over deep water. The nets are attached to long poles, driven into the mud, and are tended from a boat. For the tall nets, poles about 12 ft (4 m) in length are needed. These may be of bamboo, wood, or metal; the most convenient to carry are poles of light alloy, cut into short length about 4 ft (1.5 m) long, that can be joined together as required. Light-coloured poles may be rendered less conspicuous by painting them brown or dark-green.

Erecting the net

Before a net is erected, a clear space for it must be found, or prepared. This should be 2 m longer than the net and at least 3 m wide; in a strong wind the net can be blown far out from the centre-line. In clearing the space, the ground should be cleaned of broken branches, for although the empty net is erected with a space beneath it, when it becomes full of Quelea (up to 200 may be caught in a single net) it hangs down onto the ground and may become badly entangled with any thorn branches lying there.

The poles should be placed in holes dug into the ground, or pushed in if the ground is soft. No matter how rigid the erected net may appear to be, the poles at each end of the net should be supported by two strong cords tied to metal tent-pegs driven firmly into the ground with a rock or hammer. Otherwise, if a large flock of Quelea enters the net, the weight will cause it to collapse – and if it falls onto Acacia or other thornbushes, it may be completely ruined. In a correctly erected net, the horizontal shelf-

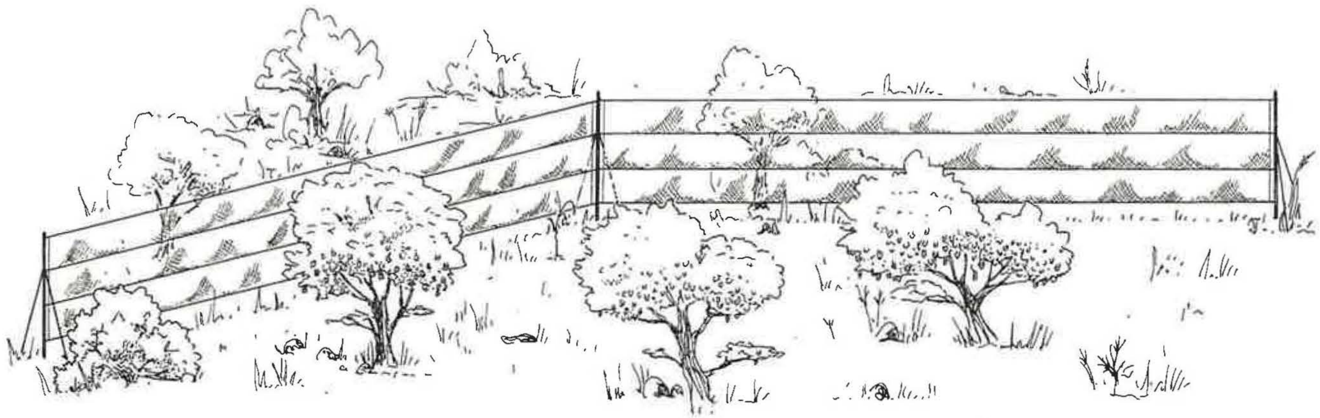


Figure 19 A three-shelf mistnet in position

strings should be taut, and the vertical strings at the ends of the net quite loose. The bottom of the net can be adjusted so that it is about 8 inches (20 cm) above the ground. Sometimes it is better placed higher on the poles; the exact positioning can only be determined by watching the net as first set up from a distance and adjusting it according to the birds' behaviour. To test that the net is properly adjusted, stand a little way from it, on either side, and throw a light object (such as a tightly knotted handkerchief) at the net. It should fall into a pocket, and hang well below the level of one of the shelf-strings. If it bounces back from the net, or goes into a shallow pocket (from which a bird would escape), the vertical spacing of the shelves should be reduced by moving them up or down the poles.

Once it has been set up, the net must be watched continuously, from a distance, or at least visited frequently (at no longer than 15 minute intervals). Small birds die very quickly if they are left hanging in the net in the sun. Also large birds occasionally get caught and will tear the net if not liberated quickly. Other common hazards include attacks on birds in the lowest shelf by predatory small mammals, and large animals walking into the net. It is generally unwise to leave a net out at night; small bats may get caught and chew their way out of the net – producing enormous holes in the process.

Removing the birds

The longer birds are left in the net the more difficult it becomes to remove them. Upon removal they can conveniently be placed in small cloth bags; a few birds may be put together in a single bag. When the net has been cleared, the Queleas can be killed by putting the cloth bags holding the birds into a large plastic bag containing a little chloroform. If they are wanted alive, they should be transferred to cages. Or, alternatively, they can be carried back to the laboratory in the cloth bags (suspended from the roof of the vehicle). In this case each bird should be carried in its own bag, or two to three may be carried together in a larger bag. They must not be kept in this way for more than a few hours, otherwise they may die of starvation.

The technique for removing Queleas from the net can only be learnt by working alongside someone who is well experienced in the procedure. A bird can only be taken out of the net from the side which it entered; it cannot be pushed through the netting. First the feet are cleared of the netting and are held by one hand, to prevent the bird gripping the net again, then the loose netting round the bird is peeled forward over the wings, body and finally over the head. This process can be varied in the case of badly tangled individuals, but the release of such birds requires much practice. Other species of bird caught in the net must be removed with great care and liberated immediately.

Dismantling

After netting is completed, the net is taken down by 'feeding it' into a cloth bag. With large nets it is advisable to have two people for this operation, one to keep the net off the ground, while the other feeds it into the bag.

NOTES

1 **There are two abnormal primary moult sequences:**

1. *Arrested moult.* The moult of the primaries stops before completion. This is evident when all the primaries are fully grown but a number of the inner ones are new, all the outer ones being old. The condition occurs for either of two reasons:
   (a) If, during the dry season, birds fail to maintain condition due to a shortage of adequate food. When birds survive and regain condition in the breeding season the primary moult will be restarted at the end of the season beginning with the inner primary NOT where the moult was arrested.
   (b) If, during the nomadic dispersion of birds after the breeding season, birds encounter a situation ideal for breeding the post-nuptial moult of the primaries stops, breeding condition is attained and a colony is established. After breeding ceases the post-nuptial moult recurs again beginning with the inner primary NOT where the moult was arrested.

2 *Interrupted moult.* The moult of the primaries is temporarily interrupted, resuming after an interval where it left off. This occurs during the course of itinerant breeding when a bird begins to lose condition towards the end of a breeding cycle, starts the post-nuptial moult, then moves to a new breeding site where it regains condition and the primary moult is interrupted. At the end of the breeding season the interrupted moult of the primaries is resumed where it left off.

The table illustrates the scoring of the different moult sequences completing the growth of new feathers following arrest and interruption of the moult.

PRIMARIES	1	2	3	4	5	6	7	8	9	Score
Normal primary moult	5	5	4	3	1	0	0	0	0	18
Arrested moult	5	4	3	1	5	0	0	0	0	18
Interrupted moult	5	5	5	2	1	0	0	0	0	18

Moult will usually be arrested well into the dry season towards the end of the primary moult whereas moult will be interrupted towards the end of the rains, hence early in the primary moult sequence. When the birds are actively moulting, as in the examples in the table, the pattern is readily spotted when the moult score is being recorded. The primaries generally grow in 'stepped' pairs as in this hypothetical illustration of the primary moult cycle.

Weeks	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1	1	2	3	4	5	5	5	5	5	5	5	5	5	5	5	5	5
2	0	1	2	3	4	5	5	5	5	5	5	5	5	5	5	5	5
3	0	0	0	1	2	3	4	5	5	5	5	5	5	5	5	5	5
4	0	0	0	0	1	2	3	4	5	5	5	5	5	5	5	5	5
5	0	0	0	0	0	0	1	2	3	4	5	5	5	5	5	5	5
6	0	0	0	0	0	0	0	1	2	3	4	5	5	5	5	5	5
7	0	0	0	0	0	0	0	0	0	1	2	3	4	5	5	5	5
8	0	0	0	0	0	0	0	0	0	0	1	2	3	4	5	5	5
9	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	4	5
Score	1	3	5	8	12	15	18	22	25	28	32	35	38	41	43	44	45

The shaded cells mark the start of the growth of each primary.

The next table illustrates the cycle of arrested moult. In this hypothetical case the moult sequence has stopped about two months into the dry season. Towards the end of the dry season, and until well into the breeding season, this bird will have primaries 6, 7, 8 and 9 well worn compared to the inner primaries – a sure sign of arrested moult.

Arrested moult

Bird loses condition ↓ Moult ceases ↓ ↓ Moult recommences

Primary											
1	1	2	3	4	5	5	5	5	5	5	5
2	0	1	2	3	4	5	5	5	5	5	5
3	0	0	0	1	2	3	4	5	5	5	5
4	0	0	0	0	1	2	3	4	5	5	5
5	0	0	0	0	0	0	1	2	3	4	5
6	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0
	1	3	5	8	12	15	18	21	23	24	25

1	2	3	4	5	5	5	5	5	5	5	5	5	5	0	0	0
5	1	2	3	4	5	5	5	5	5	5	5	5	5	5	0	0
5	5	5	1	2	3	4	5	5	5	5	5	5	5	5	5	5
5	5	5	5	1	2	3	4	5	5	5	5	5	5	5	5	5
5	5	5	5	5	5	1	2	3	4	5	5	5	5	5	5	5
0	0	0	0	0	0	0	1	2	3	4	5	5	5	5	5	5
0	0	0	0	0	0	0	0	0	1	2	3	4	5	5	5	5
0	0	0	0	0	0	0	0	0	0	1	2	3	4	5	5	5
0	0	0	0	0	0	0	0	0	0	0	0	1	2	3	4	5
21	18	20	18	17	20	18	22	25	28	32	35	38	41	38	34	35

0=worn feathers

The final table illustrates the cycle of interrupted moult. In this hypothetical case the post-nuptial moult has been interrupted after about 2 weeks when the bird regained condition and attempted to breed again. During the extension of the breeding season the bird showed two new inner primaries and seven old primaries. At the end of the breeding season it resumed the post-nuptial moult starting where it had left off. By the time the post-nuptial moult had finished the two inner primaries were beginning to show their age distinguishing them from the other seven newer primaries. Throughout most of the period of the primary moult arrested and interrupted moult are distinguishable but at the end of the moult they are indistinguishable.

Interrupted moult

Bird looses condition ↓ ↓ Bird regains condition ↓ Moult recommences

1	1	2	3	4	5	5	5	5	5	5	5
2	0	1	2	3	4	5	5	5	5	5	5
3	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	30	0
9	0	0	0	0	0	0	0	0	0	0	0
Moult score	1	3	5	7	9	10	10	10	10	10	10

5	5	5	0	0	0	0	0	0	0	0	0	0	0
5	5	5	5	0	0	0	0	0	0	0	0	0	0
1	2	3	4	5	5	5	5	5	5	5	5	5	5
0	1	2	3	4	5	5	5	5	5	5	5	5	5
0	0	0	1	2	3	4	5	5	5	5	5	5	5
0	0	0	0	1	2	3	4	5	5	5	5	5	5
0	0	0	0	0	0	1	2	3	4	5	5	5	5
0	0	0	0	0	0	0	1	2	3	4	5	5	5
0	0	0	0	0	0	0	0	0	1	2	3	4	5
11	13	15	13	12	15	18	22	25	28	31	33	34	35

0=worn feathers

4

Crop Protection

INTRODUCTION

Many birds, as we have seen, feed on cereals but it is only those which do so in comparatively large numbers which seriously affect the final yield. Subsistence farmers in marginal areas try to save all the grain they can and large-scale farmers do their best to maximise yields. Neither look with favour on birds entering and feeding on their crops but each will approach crop protection in a different way. The smaller the field the smaller the flocks which will cause noticeable damage but also the easier it will be to keep the birds out. The traditional farmer may be tolerant of small numbers of seed-eaters in his field. He and his family can compensate for small losses by trapping the birds or raiding their nests to remove the nestlings. This is not simply to protect the crops but is a means of obtaining food or cash. The birds may be cooked and eaten by the family or sold in the market to others for cash. The large-scale farmer, on the other hand, will want to calculate the value of the crop lost to birds and, if possible, protect his crop by any means costing less than the value of the crop lost.

The obvious way to prevent damage to a crop is to scare away any birds seen feeding on it. Over the centuries bird scaring has been variously refined and is the method used by the traditional farmer. To-day scaring is still practised with a variety of ingenious scarecrows, with cloth or plastic flags tied to poles, and with guards roaming fields, shouting, cracking whips and throwing missiles. Bird scaring is practical, economical and it works when properly done as is illustrated below. One energetic and well motivated person can protect up to one hectare of cereal crop in all but the most exceptional circumstances.

Most of the grain-eaters are social birds which nest in colonies. The colonies are established during the rains when rainfed crops are in the fields and the wild grasses are in full flower. Being dependent on grass seeds to rear their young, the birds establish the breeding colonies just at this time thus ensuring that there is an adequate quantity of seeds in the milky stage just when needed for feeding the nestlings. A great deal of the damage to crops is caused, not by the adults, but by the fledglings, the young birds which have just become independent of their parents and are having to forage for their own food. The six weeks or so from the time of flowering to maturation of the crops means that the grains are ripe just when the fledglings leave the nest. The fledglings are naturally attracted to the plentiful supply of food in the surrounding grain fields. Consequently searching for the colonies and removing the eggs or nestlings from the nest has been a common practice variably successful in lowering the incidence of damage. The practice is less popular today because of the environmental damage done by cutting down trees or bushes in order to get at the nests and because people seem to be less inclined to co-operate in this physically exhausting work which brings comparatively minor gain.

African farmers have always known that certain varieties of their grain crops are less attractive to the attention of the birds than others. In those areas where traditional cereals are still grown the, so-called, resistant varieties are planted where birds are a major problem. The resistant varieties tend to be more primitive (i.e. lax-headed), lower yielding and less palatable (see Chapter 3). Elsewhere the specially selected, more palatable, higher yielding and, inevitably, more susceptible varieties are grown.

The development of large-scale farming has brought about a change in the methods used to protect crops. Mechanical, chemical and electrical noise-making devices have been used to replace the traditional bird-scarer. Flame-throwers have been used to destroy nests and plant breeders have tried to breed resistance into high-yielding and palatable cereal varieties. Attempts have been made to grow crops extensively in large rainfed or irrigated schemes out of synchrony with the birds' breeding season.

Neither the traditional methods nor their modern equivalents have offered any real protection against the major pest species, such as the Quelea, and more drastic measures have been adopted. The most successful methods used are aimed at targeting and killing the birds with pesticides known to be particularly toxic to birds. The pesticides are referred to as *avicides* and are used against the birds in either their breeding colonies or their night roosts. **The use of avicides to kill grain-eating birds is a management strategy which can only be recommended against a concentration of no less than 250 000 birds known to be feeding on a cereal crop.** Non-lethal methods of protecting crops should be used against smaller concentrations in most situations.

Chemical control of any agricultural pest has an impact on a much wider spectrum of organisms than the pest itself. This impact has both an immediate effect and a long-term effect on the non-targets and on the environment. Two studies of these effects, (Keith *et al.* (1994) and Bruggers *et al.* (1989)), have been undertaken by the Denver Wildlife Research Center in co-operation with the Government of Kenya. The studies concerned the immediate and short-term effect of the application by air of the avicide fenthion for the control of Quelea in a breeding colony and a mixed assembly of grain-eating birds in a night roost. The studies, in themselves, are inadequate for advocating the use of chemical control in the management of bird problems unreservedly. Departments of Agriculture considering the use of chemical control of birds in crop protection situations are advised to undertake a careful environmental impact assessment (EIA) beforehand.

PROTECTION METHODS FOR BREEDING SEASON (RAINFED) CROPS

Farmers who grow rainfed cereals are well aware of the damage caused by birds and are generally knowledgeable about the birds which are responsible. The better known habits are those of the highly gregarious, or social, birds which establish noisy colonies in trees or bushes on the boundaries of crops or around the homestead. A few less sociable seed-eaters, mostly *Euplectes*, may nest in the crop itself or in surrounding grasses. These birds are tolerated in good years when they are not inclined to feed exclusively on the crops. Noisy very active colonies can be a sign of plenty heralding a good year both for the birds and for the farmer. The natural food of the birds, which includes insects and weed seeds, is plentiful and crop damage is correspondingly low. Readily accessible nests may be robbed of their nestlings to enrich the diet of the farmer's family or adult birds may be trapped for the same purpose. Otherwise nothing may be done to keep the birds from the crops. However, in seasons of poor rainfall the situation is different and the farmer has to take more action if he is to protect his crops. Lean years for the farmer are also lean years for the birds which become more dependent on the crops. The poor yield of the stressed crops can be drastically reduced by the birds unless something is done to keep them out.

Scaring the birds is usually the only option open to the subsistence farmer but other methods can be considered by the large-scale farmer. Keeping the birds out of the fields by whatever means is essentially direct crop protection. The alternative is to act against the birds away from the crops and this may require co-operative action as the birds against which such action is directed will usually be causing damage to more than one person's crop. This indirect action will generally involve killing the birds or their progeny. The farmer and the extension worker must consider all avenues open to them before resorting to methods which could be costly or environmentally threatening. Current approaches to protecting crops can be categorised as follows.

Direct Protection

Direct methods are often the easiest and the most economical but do require a good understanding of the behaviour of the bird causing the damage. There are two direct ways to protect standing cereal crops. First you can keep the birds out of the crop, and second you can make the crop unattractive to the birds. Birds can be killed to keep them out of the crops (lethal control) or they can be prevented from entering the crops (non-lethal control). Of the two, non-lethal control is the preferred option.

Non-lethal control

Cages

There is only one method of non-lethal control which is fully effective but it is costly. Particularly valuable crops, such as those grown on research farms for variety testing, hybrid development or seed multiplication, can be fully protected from birds by being grown in cages (Figure 20). The cages are expensive as they require a wooden or metal framework supporting either wire or fabric net with a small enough mesh (20–25 mm) to exclude all seed-eaters. This is not a practical method for general farmers. Less effective but much less expensive is the use of fibres and nets instead of cages to keep the birds out of the crops.

Nets and fibres

Loose nets or synthetic fibres can be placed directly onto a crop. However, if not done carefully, the birds can still feed on the taller ears of the crop through the net. A simple structure of posts and string, similar to that used in the construction of a cage but less elaborate, will give better support for the net and keep the birds away from the ears.

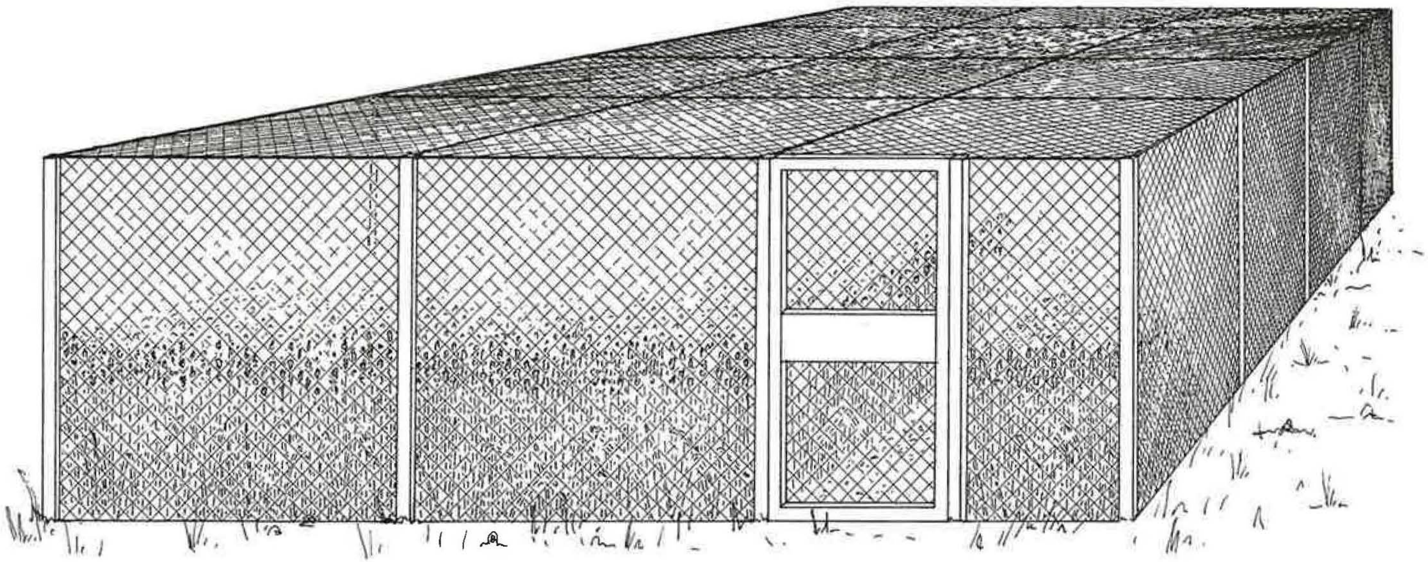


Figure 20 Cage protecting plot of wheat

Figure 21 Translucent floating fleece being laid over vulnerable seedlings

An acrylic fibre manufactured in the form of a web-like unknotted net is retailed under the trade name Cryldé®. The material is teased out so that it covers the entire crop. The fibre is inexpensive when compared with nets but is badly affected by heavy rains and strong winds which dislodge it. The direction and strength of the prevailing wind must be taken into account when considering the use of this material. Installation and removal of Cryldé from a crop requires care if it is to be used again. Although less costly than a net the use of fibres cannot be economical except in special circumstances, possibly the multiplication of cereal varieties for commercial seed production. Cryldé has been used successfully for the protection of rice nurseries on irrigation schemes where seedling transplants are used for the main crop instead of broadcast sowing. The fibre can be used for protecting any small plots of seedlings where bird damage is a problem. Perforated film or translucent floating fleece, used for growing vegetables in temperate regions, could serve the same purpose in nurseries (Figure 21).

Bird scarers

Birds respond to sound, movement, shape, colour, touch and taste. Unfamiliar expression of any of these sensations causes varying degrees of alarm in the bird. Exploiting those which cause the greatest alarm will naturally cause the bird to avoid the source of the disturbance. Birds flying into crops will not alight if they are sufficiently alarmed. Birds already in the crop will respond by remaining motionless to avoid detection, or will hide or take flight and try to escape. Taking flight and escaping is, obviously, the desired response to best protect the crop. Scaring the birds from entering the crop or scaring them out of it can be effective but only if the following is borne in mind: the greater the variety of the scaring methods used the better their effect. Continuous use of the same scaring device will only work for a short time as the birds soon learn to accept the disturbance and ignore it (they become *habituated*). Variety and irregularity of scare tactics give the best protection to the crops.

The subsistence farmer usually has no alternative but to try to scare the birds from his crops. None of the manufactured bird-scaring devices can be considered by him as the cost would be prohibitive. Locally available manpower and materials must be used to produce a combination of noise, movement and impact to scare the birds from the crop. In its simplest form bird scaring is done by someone shouting, waving and run-

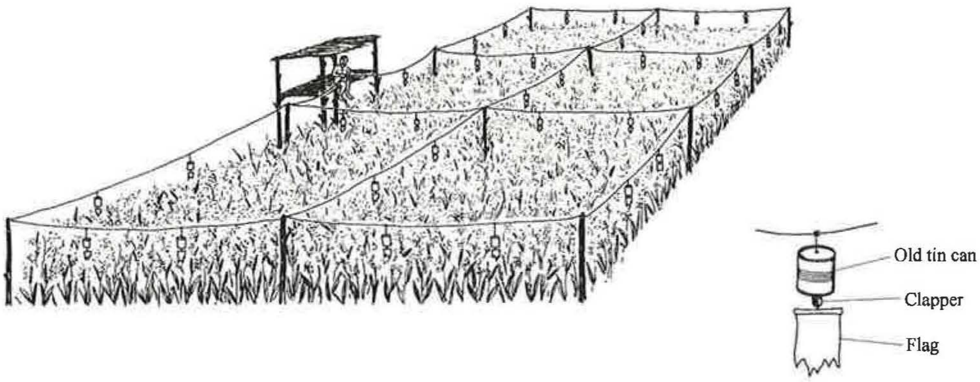


Figure 22 Suggested method of bird scaring

ning through the field. In addition to shouting and waving the effective bird scarer re-inforces his shouts with other noise such as the beating of empty tins or the cracking of a whip as well as hurling missiles in the form of lumps of mud or gravel at any flock of birds trying to land in the field. If the scarer does not re-inforce his noise making with other activity, the birds will eventually become habituated to the noise and ignore him. An excellent weapon for the bird scarer is a braided sling with the free end long and tapered. After releasing the 'shot' (gravel or earth balls) the sling is 'cracked' like a whip. Slings are used extensively in Somalia and Malawi and, undoubtedly, elsewhere. The job of bird scaring can be made easier by the construction of a platform on top of which the scarer stands to overlook the crop.

The most successful bird scaring technique in terms of low cost in manpower and materials is to erect a system as illustrated in Figure 22. A platform is constructed on the edge of, or in, the field from which the bird scarer can survey the crop. This is especially useful if the crop is tall sorghum or millet. A network of lines is set out over the field supported on poles. A variety of things which can make a noise when shaken, such as cans with clappers, calabashes with stones inside or a few pieces of metal scrap tied together are suspended at intervals from the cross-strings. Strips of brightly coloured material hanging from the rattles add to their effectiveness. The bird scarer, sitting on his platform, has a line attached to the network which, when tugged, shakes the rattles and waves the flags. Pulling the line, shouting and throwing gravel or mud whenever a flock of birds approaches keeps them away. Sound, movement, shape, colour and touch are all incorporated into the system when it is properly installed. The method will only fail when birds are driven, by near starvation, to ignore the bird scarer. Bird scaring where crops are extensively grown is, however, a labour-intensive method of protecting crops and the labour may not always be available. In order to circumvent the labour problem various repellent devices have been introduced.

Repellents

Threads and tapes A simple and inexpensive scaring device which has been employed in certain situations is the use of black cotton thread strung over the crop (Figure 23). The method only exploits one sense of the birds, touch, but because of its invisibility and, hence, unexpectedness birds do not become habituated to it. The

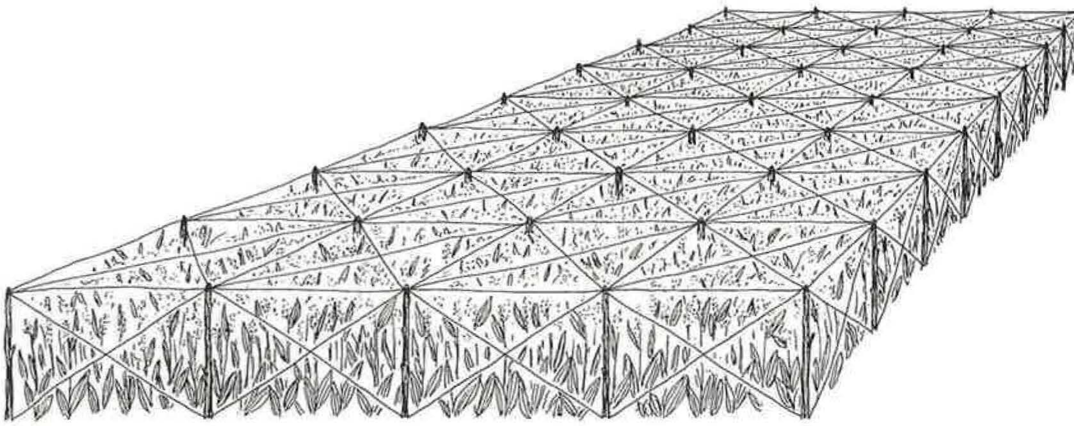


Figure 23 Network of black threads protecting a field of sorghum

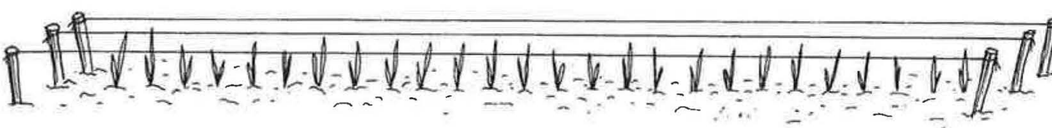


Figure 24 Threads protecting a row of seedlings

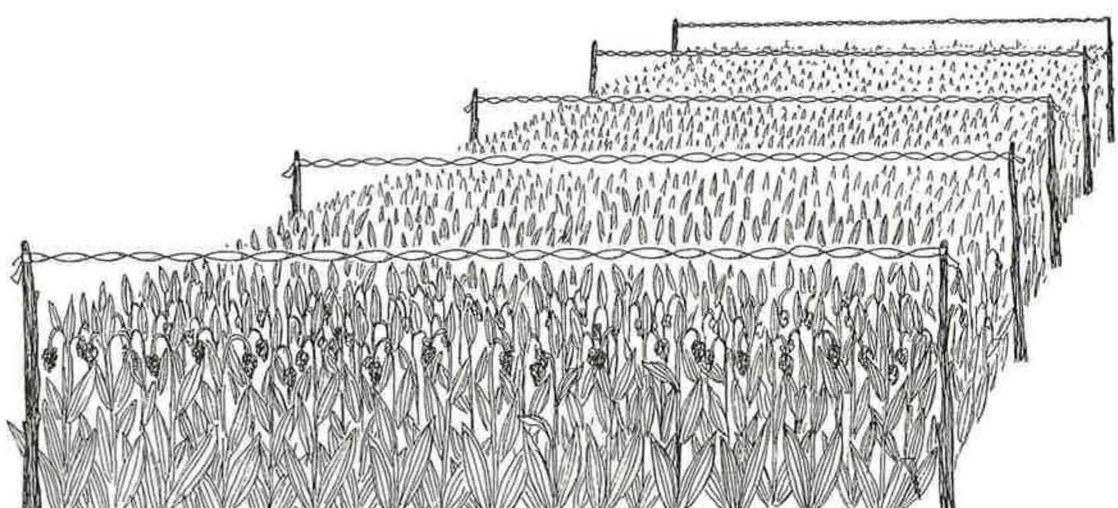


Figure 25 Metallic tapes stretched across a field of gooseneck sorghum

thread is almost invisible to the bird which blunders into it when flying into the crop. The threads are held taut and the bird quickly frees itself and flies off. Social birds emit alarm calls when they hit the thread and warn off the flock.

Birds returning to the crop soon give up due to the constant disturbance from contact with the thread. The system works well against doves but is less effective against ploceids. Three lines of thread stretched along lines of seedlings can also afford some degree of protection against ground-feeding herbivorous birds (Figure 24).

A development of this technique has been the use of flashing tapes which are stretched above the crop in parallel lines (Figure 25). The metallic tapes are usually silvered on one side and fluorescent on the other. They are sold in reels like ribbon. Attached at one end to a post taller than the crop they are twisted as they are unwound from the reel and then attached to another post on the other side of the crop. The twist in the tape runs up and down it in any light breeze flashing in bright sunlight. If taut enough it also emits a noise in the wind. The tape, in reality however, only involves one of the birds senses – sight.

Although initially effective the birds soon become habituated and ignore the tapes. The technique is mentioned here to emphasise the effectiveness of the 'invisible' threads to which the birds cannot habituate. The black thread is simpler, cheaper and more effective.

Sound-making devices Techniques which exploit sound are also limited in effectiveness through habituation. Acetylene and propane exploders, called carbide guns or canons, produce loud explosions at regular intervals. They can be useful in certain situations such as scaring waterfowl from rice fields at night. Their effectiveness is increased if more than one is used, if the firing interval is staggered and if their direction is altered periodically. Some models rotate and change firing direction automatically. Firecrackers, rockets and exploding cartridges suffer from the same problem of habituation and, in addition, they can present a fire risk in arid areas.

Expensive and variably effective noise-making instruments have also been introduced. One such is the Avalarm®, a battery-operated electronic amplifier which broadcasts complex, intermittent sounds which can be varied in pitch and pulse. The noises are intended to irritate or cause anxiety in birds but their effectiveness is limited and they cannot be recommended except for experimental purposes where noise might be of special importance. The use of recorded alarm calls of birds has similarly little application in crop protection although its use for some birds, such as parrots, cannot be ruled out.

Chemical repellents Taste aversion in grain-eating birds is well known in Africa particularly amongst sorghum and millet growers. Both of these grain crops have varieties with varying amounts of tannin in their seeds (see Chapter 2). Seeds with a high tannin content are generally avoided by birds especially if they have an alternative available. The problem with naturally occurring tannins in the millets and sorghums is that they are also less palatable to man. Where the bird problem is severe, resistant varieties are grown and eaten but elsewhere they are used more commonly for brewing.

Chemicals which are non-toxic but unpalatable to birds can, in theory, be applied to a crop and, in theory, protect it from damage. Some experimental work has been carried out and results have been good with some crops, such as sunflowers, but very variable when used to protect cereals. The most promising material, methiocarb, has reduced damage to grains under experimental conditions at reasonable cost but insufficient work has been done for any specific recommendation to be made. Another use for chemical repellents is as a seed dressing. One chemical tested in Africa has been the fungicide thiram. Although unpromising, the use of thiram as a fungicidal seed dressing may be beneficial even though it is only mildly repellent. Use should be made of chemical repellents for experimental purposes whenever bird pest management strategies are under examination, but the likelihood of a cost-effective use of chemical repellents in cereal crops is doubtful.

Modification of cropping practices

Good farming practice, that is to say a weed- and insect-free crop in a well tilled field can deter birds. Many seed-eaters are attracted to fields, not by the grain crop but by the gappiness of a crop grown on a badly tilled field, its weed burden and the insects which abound there. The birds turn to the crop after the weed seeds and insects have been fully exploited. For example, wheat fields in Kenya infested by Love Grass, *Setaria verticillata*, are more attractive to Quelea than those which are not. Many seed-eaters require insects to feed to their nestlings and poor insect control is to their advantage. Good husbandry of irrigated cereals, particularly rice, to give a dense and uniform crop stand without gaps, can discourage water birds. In the Sudan and Uganda, palaearctic migrant, or local, ducks such as Gadwall, Spur-winged Geese and White-faced Whistling Ducks and in West Africa palaearctic waders such as the Black-tailed Godwit and the Ruff may assemble in a sparse and patchy crop, causing as much damage by trampling the seedlings into the wet soil as they do by feeding on it.

The area in which the crop is grown can also attract birds. Rainfed grain crops are ripening, and hence susceptible, when the granivorous birds are either breeding or have just finished breeding. Areas with the necessary requirements for them to establish their breeding colonies are not the best places to grow cereals! Suitable trees in which to hang their nests, lush grasses with which to build them, and a good source of drinking water will attract birds to an area. The ripening cereal is an added bonus on which the birds can feed. Reducing the attractiveness of the area by draining water sources and cutting down trees is not to be encouraged but if there is a choice of site for the grain crop, a place away from trees and away from a drinking source may reduce the problem. Trees on the edge of a field of millet are an invitation to Village Weavers to build their nests there. The trees are ideal for the establishment of a small colony as long as there is material close by with which the birds can build their nests. A swamp beside a field of sorghum is perfect for the establishment of a colony of Yellow-backed Weavers. Growing rice next to sugarcane in an irrigation scheme is a formula for disaster. The birds roost, and sometimes nest, in the cane and feed on the rice. Knowing the requirements of the birds can help the farmer, or his adviser, to select the best place for the cereal crop on the land available for cultivation.

Growing the crops where the birds are unlikely to occur can only arise in special circumstances. Crops grown sufficiently far away from areas to which birds are attracted to breed, and this usually means at least 10 km, may escape the attention of the birds. This is difficult to plan, and is not an option for a subsistence farmer, but it should be considered when the alternative is costly chemical control of the birds. Preliminary appraisal of an area and its use by grain-eating birds may indicate a better place which, for one reason or another, is not attractive to them. The likely features which will attract the birds are a sufficient food supply in the form of dense stands of wild annual grasses, adequate cover – either bush or woodland, adequate safe drinking places either natural, such as rivers or ponds, or man-made, such as dams and canals.

Rainfed crops grown where there are two rain seasons, for example in large parts of East Africa, may escape damage in one of the seasons but not the other. Here, obviously, the planting of susceptible crops can be restricted to the season in which crop damage does not occur. Where there is one long rainy season of at least six months it may be that the principal grain-eating birds only arrive in the area to breed in mid season. In such a case early synchronous planting will avoid damage whereas late planting will not. On an irrigation scheme the planting season can, in some cases, be changed so that the susceptible seed-setting stage is out of synchrony with the breeding season of the birds.

Lethal Control

Killing birds in the crop is an alternative approach which is sometimes practised by farmers. There are two ways in which the birds are killed, either by poisoning or by trapping.

Chemical poisoning

Much of the damage to cereals is caused around the field edge particularly in places close to cover, either trees or shrubs. A swath about 5 to 10 m into the crop is sprayed with a pesticide known to be toxic to birds. Any grain-eating bird eating the treated crop is killed. In theory the technique is simple, effective and precise – only the culprit is killed. In practice, however, there are major drawbacks. To be effective the pesticide must be persistent to avoid costly repeat spraying. Persistent pesticides are not permitted in a grain crop close to harvest if the grain is destined for human or animal consumption. Hence the sprayed swath has to be marked off and harvested separately for use as SEED ONLY. The risks attendant on this practice are such as to make a recommendation for its use most unwise. Usually the amount of crop saved, when only patches of a comparatively narrow band of the field edge are affected, is of no real consequence to the total yield, unpleasant as the damage may appear. An additional consideration is that the major cereal pests, such as the Quelea, do not limit damage to the field edge but descend anywhere in the field to feed.

Trapping

A number of ingenious traps are used in the field to trap unwary birds, especially those small seed-eaters such as bishops and whydahs which may nest in the crop. Although giving satisfaction to the farmer the method has very little effect on the crop yield unless it is a very small field which is being damaged. A large portable modified Australian Crow Trap has been used experimentally in the Sudan (Figure 26). The trap is baited with grain and live decoy birds. The trap has caught numbers of Golden Sparrows, House Sparrows and bishops. Although easily made the trap is probably too costly in materials to be useful to the subsistence farmer and too many would be required to have any effect in large-scale cultivation.

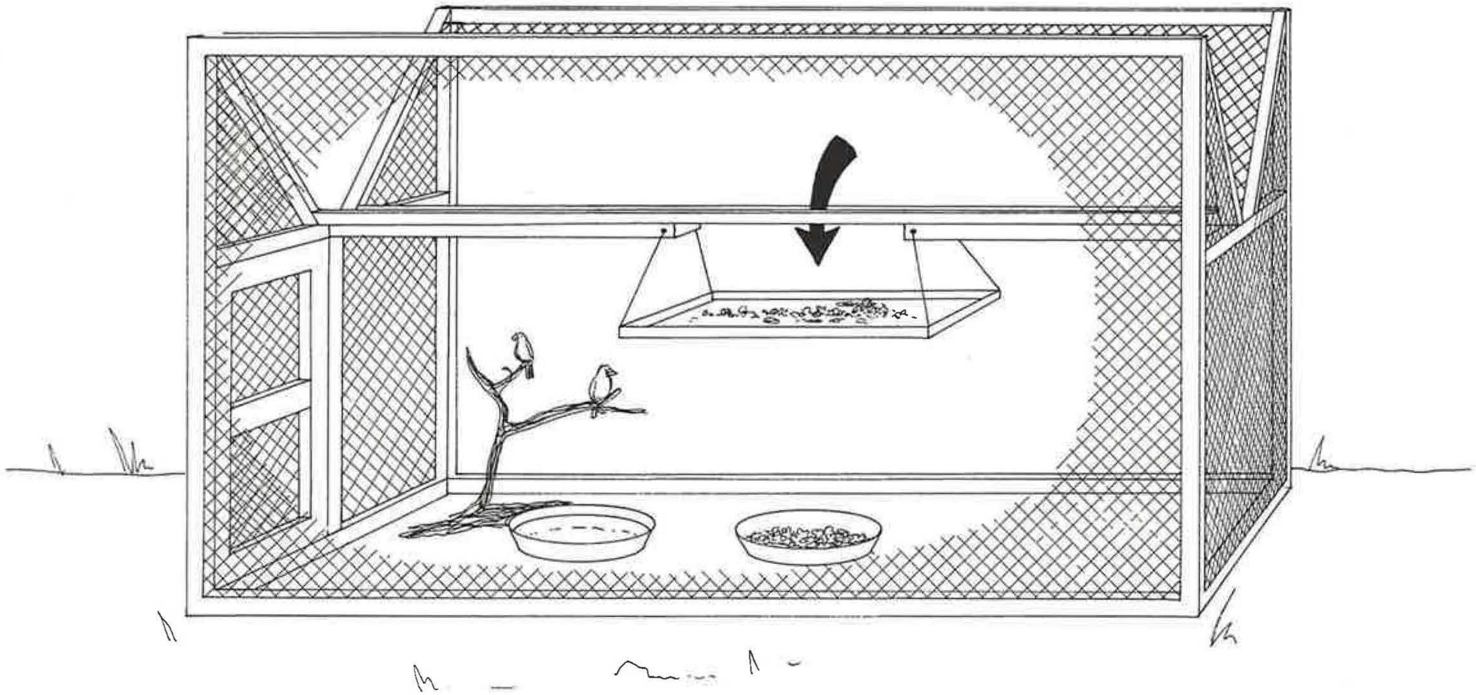


Figure 26 Modified Australian Crow Trap: birds enter through a narrow slit in the sunken top, attracted by bait and decoy birds within the trap. When inside, they are unable to find their way back out.

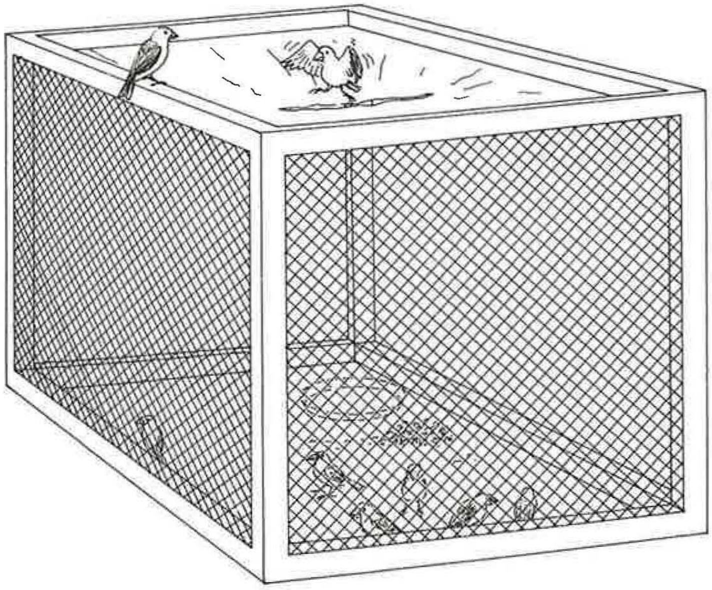


Figure 27 False water trap

The use of water as a bait has been successfully demonstrated at a Quelea colony in Chad. Wire cages 1 m^3 in size were used, with a sagging plastic sheet as the top side of the cage (Figure 27). A slit was made in the plastic sheet and the fledglings, desperate for water, mistook the shimmering plastic for water. Landing on the surface, they slid inexorably through the slit into the trap and were unable to find the way out. The trap has not been used in a crop but it has potential; water is not always found close to field crops and the trap is easily made, inexpensive and reusable.

When none of the direct control methods is effective or, more particularly, when the crops are threatened by nearby colonies of the highly gregarious migrant seed-eaters, such as the Red-billed Quelea, then more consideration has to be given to tackling the birds before they approach the fields. Taking the battle to the birds away from the fields can be considered as indirect crop protection

Indirect Protection

Non-lethal Control

The control of birds away from the crop is usually undertaken by killing the birds where they assemble, either in colonies to breed or in night roosts. The only non-lethal approach would be the provision of an alternative site made more attractive to the birds than the crop fields. This approach has, as yet, received scant attention in Africa. Its main application could be the provision of a special wetland reserve in the vicinity of large-scale rice schemes where ducks and waders would find sanctuary and food of better quality than that available in the rice fields. This method of control is followed with some success in Europe and America. It deserves more attention in Africa and should be considered wherever possible.

Lethal Control

Indirect control by lethal methods launched some 50 years ago has, for the most part, been directed against the Red-billed Quelea. Other species such as the Red-headed Quelea, the Chestnut Weaver, the Golden Sparrow and the Black-headed Weaver have more recently been subjected to these control methods. The early strategy used against Quelea was to search out and destroy all colonies and roosts found throughout the year. The assumption was that the Quelea problem could only be solved by greatly reducing, or even eradicating, the whole population. It is now generally agreed that this strategy is impossible to achieve, uneconomical and ecologically unsound. There are, and probably always will be, parts of Africa where flocks of grain-eating birds can live on their natural diet of grass seeds and insects and breed successfully without any risk of coming into conflict with cereal producers.

The earliest method of dealing with Quelea was to destroy the nests in breeding colonies and to trap the birds with nets in night roosts. The usual method of destroying the nests, still employed to-day, was to pull the nests out of the thorn bushes with hooked sticks or to cut down the bushes in which the nests were built and destroy the eggs in the nests or take the nestlings for food destroying the remainder. Destruction of the nests has some merit in providing a supply of much needed protein to the diet of the villagers involved but could be damaging to the neighbourhood through the destruction of the bush cover, sometimes, quite large areas of tens of hectares. Such damage was of little consequence when vast areas of secondary bush, such as *Acacia mellifera*, were involved but in other areas where demands on the bush for firewood around settled areas were high, the damage added to local soil erosion problems. The main objection to this approach to crop protection is that the adults survive to re-establish the colony elsewhere. For this reason, if the method is used, trees should not be cut down. The later it is undertaken in the life of the colony then the greater the food value of the nestlings taken and the less the chance of a repeat nesting taking place in the same area.

The currently accepted strategy is aimed specifically at Quelea and involves controlling only those concentrations which are close to, and threatening, vulnerable cereal crops without jeopardising the existence of the pest species through over-zealous persecution.

Certain guidelines for deciding when to control Quelea were proposed by Elliot and Allan (1979). The principles contained in the guide-lines also apply to the other species mentioned above, if their numbers warrant control, and depend on the following information:

(a) the closeness of the birds to the crop;

(b) the vulnerability of the crop;

(c) the importance of the crop.

The guide-lines are still valid and have been generally accepted with some further elaborations added in the late 1980s. Everyone involved in planning control operations should follow the guide-lines carefully.

(a) The closeness of Quelea to a crop and the degree to which their presence poses a threat depends on whether a roost or a breeding colony is involved. Quelea can range about 30 km from a roost to their feeding grounds. A roost further than 30 km from vulnerable cereals is thus not a justifiable target for control.

(b) The feeding range of a breeding colony varies but observations suggest that it is between 2 and about 10 km. Cultivation further than 10 km from a colony is therefore unlikely to be attacked while the colony is active. However, after breeding, the adults move on leaving the newly independent young birds (juveniles) which gradually move well beyond the 10 km feeding range and can cause heavy damage to susceptible cereal cultivation as they disperse. Control of colonies further than 10 km from susceptible crops can therefore be considered if there is some historical evidence of a link between a breeding area and damage to more remote cereal crops.

(c) The vulnerability of the principal crops attacked, millet, sorghum, wheat and rice, is from the milky stage to harvest. Once the harvest is in the necessity to control ceases.

(d) The importance of the crop has to be looked at in three ways, local importance, national importance and political importance. Considerations may be summarised as follows:

- *Local importance* A village may depend on 100 ha of cereals to provide its staple food for the next year. If so, the crop is exceedingly important and control should be undertaken even if it may not appear economical to do so. If serious losses due to birds occur, food aid may be required, costing more than the control operation.

- *National importance* The government may designate certain areas of the country as areas for the production of specific cereal crops because of their suitability and the rainfall pattern. For example, semi-arid areas may be designated for the production of sorghum in place of drought-prone maize. This policy would promote a crop at risk to Quelea attack in place of one which is not and if farmers are to accept it they must feel confident that their crops will be protected. Any concentration of Quelea in such an area will need to be considered for control.

- *Political importance* If crop owners have powerful political connections allowing them to complain directly to a high authority in government, the Quelea control officer risks serious criticism if he does not carry out control when this is demanded. Political influence has to be accepted as part of reality in decision-making in many African countries today.

Another method used to destroy colonies was to burn them out with flame-throwers. This was an advance on the simple burning of nests often attempted by villagers but which was never very effective, nests only being dry enough to burn readily after the fledglings had flown. The flame-throwers were also a failure mainly because their use was expensive and very dangerous, some fatal accidents to field staff putting an end to their use.

Roosts and colonies were also controlled at night with nets into which the birds were driven and, in some areas, spectacular results were claimed. Clapnets 20 m long and 4 m high were reportedly used by 10 men to clear a 60 ha nesting colony of Quelea in 10 days in the Sudan.

N.B. For whatever reason bird control is undertaken, cost effectiveness should not be ignored. An estimate of the bird population feeding on the crop, the average quantity of grain eaten, or wasted by the species concerned, the current value of the crop and the cost of the contol operation should be used to calculate the cost effectiveness of the operation. The control of grain-eating birds is quite unnecessary unless a sufficient number of them is likely to feed on the crops to be protected. It is only the small gregarious grain-eaters which are likely to assemble in sufficient numbers to warrant control. Legitimate targets are, for the most part, only Quelea assembled in numbers in excess of 250 000 individual birds. The comparable number of birds of other species will depend on the quantity of their daily diet taken from the crop under threat.

Aerial spraying

An aerial spray operation should only be undertaken by fully trained and specialised national plant protection staff, members of international control teams called in for the task, or contract spray operators acting under the direction of national plant protection staff. Senior plant protection staff will have been alerted by their field staff who have collected all the necessary data for the operation.

Properly trained field staff should be alerted to the presence of breeding colonies in vulnerable areas before crop damage occurs (Chapter 3). If they are, then the recognised monitoring and survey procedures will have been followed by the time that the control operator is advised of an impending operation. All that remains to be done is to make the operational plan. An isolated colony will present no planning problem. The pilot of the spray aircraft will be placed on stand-by and assisted in preparing his aircraft for the operation. The correct chemical will be available and the aircraft engineer advised on the quantity to be carried, the droplet spectrum required and the emission rate. These will be discussed later. Once the decision has been taken to control the birds, the planning of the operation is dependent on the following criteria.

Necessary criteria for optimum control These depend on the life cycle of the birds, the time of day and the weather.

1. The stage of the colony for optimum control.

- If eggs or young nestlings are in the nest.

  If the nests have been completed and egg laying has just started then the pilot has a period of some 14 days in which to carry out the control operation.

  If all eggs are hatched and no nestlings have yet left the nest then the operation should be undertaken as soon as possible, but certainly within 7 days.

  If nestlings are beginning to venture from the nest the operation must be carried out without delay.

- If the young birds have left the nest and are beginning to fly within the colony, the operation must be treated as a roost spray operation (see below).

2. Time of operation for optimum control. (Sunset but before it is too dark to see. This is the time at which all the birds have returned to their roost or colony for the night.)

- West, eastern and Central Africa

  10 minutes before sunset to 20 minutes after sunset.

- Southern Africa

  Summer – sunset to 45 minutes after sunset.

  Winter – as for West and eastern Africa.

3. Meteorological conditions for optimum control.

- Wind speed

  1–3 m per second. That is from a light air, when smoke drifts from the vertical, to a light breeze, which rustles leaves or stirs a flag and is felt on the face.

  Control must not be carried out in still air nor in a gentle breeze enough to extend marker flags of light-weight material unless the droplet size is adjusted (see below).

- Humidity

  Operations must be carried out under dry conditions. As soon as rain falls the operation must be aborted.

The application technique There are a number of factors which must be considered when aerially spraying a Quelea breeding colony. They are as follows:

- In what direction will the aircraft pass over the spray site?
- What will be the interval between spray passes?
- How many passes will be required?
- How should the site be marked?
- At what altitude must the aircraft fly?
- How are the birds going to behave when the aircraft makes its passes?
- What size of spray droplet is going to give optimum kill?
- How fast will the droplet fall (what is its *sedimentation* rate)?
- How far will it drift if there is any air movement?
- Is there an atmospheric temperature inversion?
- At what time will the first spray run be made?
- When must the operation be completed?

It is impossible to generalise about the operations; each will be different with a unique solution giving the best results in each case. It is for this reason that the person in charge of the operation must be experienced and must use his judgement in making the final plan. An experienced officer will understand, and take into consideration, all the following effects when planning a control operation.

Impacting the birds The instinctive behaviour of the birds to return quickly to the nests at nightfall has led to the development of the current aerial application technique. A thick cloud of spray droplets is drifted into the breeding colony at dusk when all the birds are settling down for the night. The noise of the spray aircraft, and the low altitude at which it must fly, disturbs the birds which fly away from it, some through the spray cloud. If the time of application is right, both with regard to the age of the colony and the time of day, the birds will very soon return to their nest site flying through the cloud again, picking up a lethal dose of avicide. The cloud of droplets must remain in the air for a few minutes, to allow the birds time to return through it, and this will only occur if the droplets are small enough and if the wind speed is at a minimum. The application technique developed to produce such a cloud of small spray droplets is referred to as ultra-low-volume spraying (ULV[1]). The technique requires the atomisation of the spray to droplets in the region of 70 μm in diameter[2] and, generally, a marked reduction in the volume application rate (VAR[3]). The cohesion of the cloud is greatly enhanced by controlled droplet application when the droplet size is optimum for the operation planned. Rotary atomisers allow more precise control of droplet size than other spray mechanisms. The range of drop sizes produced by a sprayer, its *spectrum,* can be characterised by the Volume Median Diameter (VMD). This is the diameter at which half the volume of spray is in larger drops, and half in smaller drops.

The spray cloud A considerable amount of research has been conducted into the behaviour of the droplets as they fall through the vegetation into a colony. This is done by spraying the droplets under a variety of different atmospheric conditions and capturing the droplets at various sites and heights throughout the colony. Such work has led to recommendations which should be followed as carefully as possible. If a record is kept of each control operation, and its result, the spray team will be able to build up a picture of the efficacy of their operations and, hopefully, improve them as they gain experience.

The length of time the spray droplets remain in the air is essentially dependent on three forces acting on them: gravity pulling them to the ground, the wind deflecting them from a vertical path and turbulence mixing them up as well as down.

In the laboratory, spray droplets of water fall in still air at a speed directly proportional to their size, the smaller they are the longer they take to fall. In practice this will vary according to the rate at which the droplets evaporate and this depends on their volatility, the temperature and, in the case of water-based formulations, the humidity at the time the droplets are released into the air. The less volatile the various ingredients in the formulation, the better it is.

All sprayers produce a range of droplet sizes. Conventional hydraulic nozzles produce a wide range of sizes whereas rotary atomisers produce a relatively narrow range. The large drops will fall faster than the smaller ones so there will be some vertical dispersal of the spray cloud. It is impossible to calculate the precise time the droplets will be in the air during a control operation due to the complexity of the factors affecting them as they pass through the vegetation. In absolutely still conditions, apparent when smoke rises vertically from a fire, there will be no drift and spray droplets will not

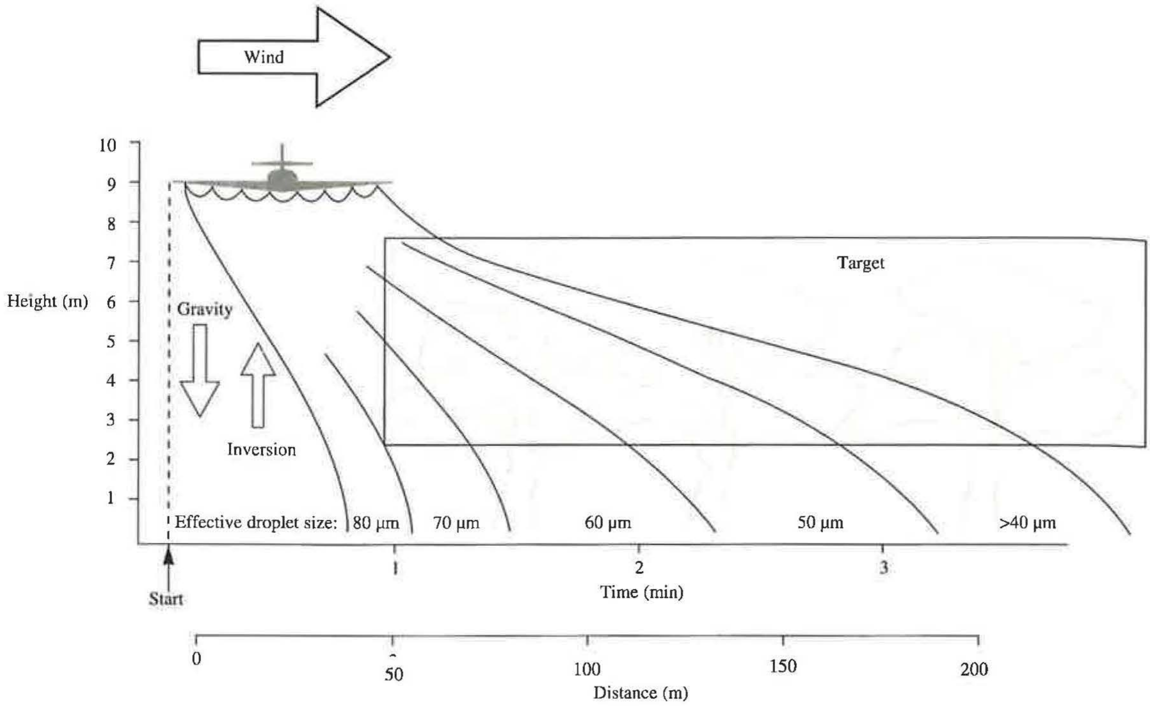


Figure 28 Diagram showing the distribution of droplet size in a spray cloud

remain airborne long enough to effectively dose the birds. Any slight air movement or wind will drift the droplets and set up turbulence. This air movement and turbulence is necessary to spread the drops downwind and mix them upwards and downwards, thus making them available for longer to impact the birds. However, wind and turbulence also have the negative effect of increasing impaction on vegetation so that drops are gradually filtered out of the air. Any drops entering deep into the vegetation will be protected from wind and turbulence and will fall almost vertically onto vegetation or onto the ground. The resultant spray cloud will be diffuse, some small droplets being scattered upwards by turbulence and drifted out of the target area, some filtered out onto the vegetation, and some precipitously sedimented leaving a reduced volume of airborne droplets to impact the birds (Figure 28).

Temperature inversion In daylight the air temperature is not affected by the direct radiation from the sun but indirectly by the heat radiated and conducted from the earth's hot surface. For this reason, in conditions of still air, there is a gradual decrease in temperature with height above the ground. On days when there is little cloud and the air temperature is high, the ground loses its heat rapidly by radiation and cools the air near to it causing a marked drop in the ground temperature in the evening when the sun is low on the horizon. This can result in a reversal of the temperature gradient near the ground towards sunset with the temperature at ground level being lower than that immediately above. This is called a temperature *inversion* and is very important in its effect on spray droplets. At dusk the layer of air where cooler air meets the blanket of warmer air above, the inversion layer, generally forms 2–4 m above ground level and is some 3–5 m deep, more or less in the area where nesting colonies are established. When there is a temperature inversion there is very little turbulence and, in a light cross wind, this allows a spray cloud of small droplets to drift. Inversion causes all droplets of the same size to behave more or less similarly, falling gently according to their size while being carried along by the wind. A slowly sedimenting, cohesive cloud of spray droplets is ideal for Quelea spraying therefore, when there is an inversion, control is improved. The presence, or absence, of a temperature inversion can be detected quite easily, immediately prior to spraying, by using a smoke canister (see Figure 29) or lighting a smoky fire at the spray site. If there is an inversion the smoke will rise to a certain height and then drift for some distance at that height within the inversion layer.

Volume application rate The final aspect of the application is the amount of chemical which should be sprayed in order to cover the area under treatment. Although the application is designed as a **space spray**, (i.e. one designed to occupy a particular volume of space) to some extent it can also be considered as an **area spray** (i.e. one designed to cover a particular area). Colonies cover such a large range in size from 1 ha to well over 100 ha that in order to ensure adequate cover a sliding scale has been suggested to give a high dosage to small colonies and a lower dosage to large colonies. The logic in this is that it would be easy to miss a high proportion of the birds in the one to two runs necessary to apply the theoretical optimum spray to small colonies whereas the larger colonies should be adequately covered at a lower overall dosage rate. The application rates for different colony sizes, using the standard Queletox 60% ULV formulation (containing 640 g of the active ingredient per litre), is summed up in the following table.

Colony size ha	**Volume application rate** (VAR) l/ha	**Area dosage** g a.i./ha
1 to 5	8	4880
6 to 40	4	2560
>40	2	1280

Spraying parameters In general a spray aircraft fitted with **ultra low volume (ULV) application equipment is used to spray very small droplets (50 to 60 µm VMD) of avicide above the target at a VAR on a sliding scale of 2–8 l/ha depending on the size of the colony**. The birds fly through the spray and become contaminated. Usually by morning most of them are dead. Optimum results are obtained under conditions of light wind (1–3 m/second) and temperature inversion. The strength of the wind should be such that it is just felt on the face but the marker flags (see below) are barely moving. At sundown an inversion layer may form when the smallest ULV droplets remain suspended longer in the air and the birds are exposed to the avicide for longer than would be the case if there were no inversion. In order to take advantage of the inversion it is necessary for the application to be made into the layer. This means that **the aircraft must be flown at a height of no more than 2 m above the colony**. In practice this means that the aircraft will fly 2 m above the highest tree, or object, in the colony – not ideal but a compromise between theory and practice. If the inversion layer is very deep, i.e. if the smoke drifts a long way up before being carried laterally, then the pilot can spray at a slightly greater height above the target, for safety reasons, as the drift of the spray particles will not be affected. **Spray operations should not be undertaken in rain and if rain should occur after the operation has commenced it should be aborted and recommenced under more suitable weather conditions.**

Figure 29 Detection of inversion layer using a smoke canister

Spray system The spray system generally used on aircraft for ULV application is a rotary atomiser. This consists of spinning discs, usually with serrated edges, a spinning 'cage', or other rotating device capable of breaking up the spray liquid into droplets of relatively uniform size. The spray liquid is fed into the rotary atomiser under pressure through an adjustable restrictor. On release into the atomiser the spray is thrown by centrifugal force to the edge of the spinning disc, other rotary device or the mesh of the spinning cage, where it is broken up into fine streams of droplets the size of which depends on the speed of rotation of the rotary atomiser, the shape of the atomiser surface and the air shear across it. The speed of rotation may be controlled electrically, hydraulically or, in systems where the atomiser is attached to a fan with adjustable blade angles, by the speed of the aircraft and angle of the fan blades. The person in charge of the operation should familiarise himself with the equipment being used and ensure that the aircraft engineer has made the correct settings of the flow rate and rotation speed of the atomiser according to the manufacturers recommendations for the type of aircraft in use, the number of atomisers mounted and the droplet size and VAR required.

Constraints Control operations should never be undertaken unless ideal conditions prevail for two major reasons. First the operation is unlikely to be successful. It may be thought at the time that a delay will be costly in terms of both manpower and the overall success of an operational plan; however, a respray will almost inevitably be required. This will increase the cost and put pressure on the operator to ensure a near-perfect operation to recover the extra cost and this could well mean a longer wait for ideal conditions. The second reason for delaying a ULV operation until ideal conditions prevail is that otherwise the environmental contamination is usually greater. This is due both to the increased drift of the spray threatening a larger number of non-target organisms and to the greater number of weakened birds, those which have received a sublethal dose of avicide attracting predators which will succumb to the toxicant if they feed on a sufficient number of poisoned birds.

There may be times when spraying under less than ideal conditions cannot be avoided such as when an aircraft is only available for a limited period. Under such conditions, i.e. too high or too low a wind speed, a larger droplet size of 90 to 120 μm VMD must be applied from a greater height above the target and at a VAR of at least 5 litres per hectare. The success of this application will depend on the birds being in the spray as it is applied otherwise they will not receive a lethal dose.

Control operations

- Flight pattern: The pattern of spraying a colony of birds differs, in a number of ways, from the usual method used in insect control. The reasons for this must be clearly understood by all concerned in any control operation. The basic difference stems from the fact that the birds are a moving target. Disturbed by the spray aircraft, they will fly from its path but will quickly return if the colony is at the correct stage for control and the timing of the application is correct. The behaviour of the birds determines the application technique. **Uniquely, in bird control operations against Quelea colonies, the first swath is laid along the upwind side of the target.** The reason for this is that in so doing the plane will not be over-flying the colony on this run and birds disturbed by the aircraft will tend to move further into the colony. This is in direct contravention of the normal guide-lines for ULV spraying against insect, plant pathogen or weed targets which advocate starting at the downwind edge and moving upwind at each successive spray pass. The reason for normally moving upwind is to reduce the chance of the sprayer moving through spray drift left from the previous pass, and in the case of ground spraying, to prevent it moving through contaminated vegetation. In downwind Quelea spraying, therefore, care must be taken by the ground controller and the pilot to gauge the wind speed, and time and distance between passes to prevent contamination of the aircraft.

- Marking the colony: The target colony must be well marked and the pilot advised on the layout of the markers. Ideally the pilot will make a reconnaissance of the site with the officer in charge of the operation. This is necessary as the poor light at the time of application makes it essential for the pilot to know the potential hazards he may encounter on his flight path. He may require markers for the hazards and these must be properly sited. Markers are generally flags made of bleached calico about 1 m square. Hurricane lamps or other suitable markers may be used but the pilot must be satisfied that whatever is used will be visible to him at dusk when the operation is to be carried out. Sometimes strips of bleached calico may be placed on the ground anchored with stones to mark the colony.

  Occasionally it may not be possible to organise a marking system due either to difficult access to the site or lack of resources. The pilot, in such situations, will have to rely on his skills and judgement to decide where to make the spray runs. As an alternative to marking he may, during his daylight survey of the area to be sprayed, identify specific features, such as tall trees or tracks, which will serve as markers for the spray operation. Ideally the spray aircraft can be fitted with an electronic track guidance system which will allow the pilot to find the target and spray it without ground markings. In this case he only needs to survey the site in daylight with the ground control officer, enter the data into the navigation system and set his track spacing according to the recommendations of the control officer.

  The first consideration is to establish a base line where the first spray run will be made. The base line will be outside the colony, on the upwind side and at right angles to the wind direction. The pattern used to place the markers will depend on the shape of the target. A well marked colony is shown diagramatically in Figure 30.

  Assuming a wind speed of less than 3 m/second the first swath will be applied about 40 m upwind of the colony, to drift the spray droplets into it. The aircraft will then make a circuit allowing a little time for the birds to settle, and the spray cloud to disperse, before starting the second run in the same direction as the first but about 20 m downwind from it. The spraying will continue in this fashion until the downwind edge of the colony is reached. Inevitably the shape of the colony will determine the flight path of the spray aircraft and the angle of this to the angle of the wind will determine the track spacing to be flown. The track spacing decided on can be marked on the ground by flags placed outside the colony where each spray run is to start.

- Ground controller: An observer should be present on the ground during spraying (Figure 30). He should be positioned upwind of the target and be in radio contact with the pilot. He will inform the pilot of wind and other local conditions and

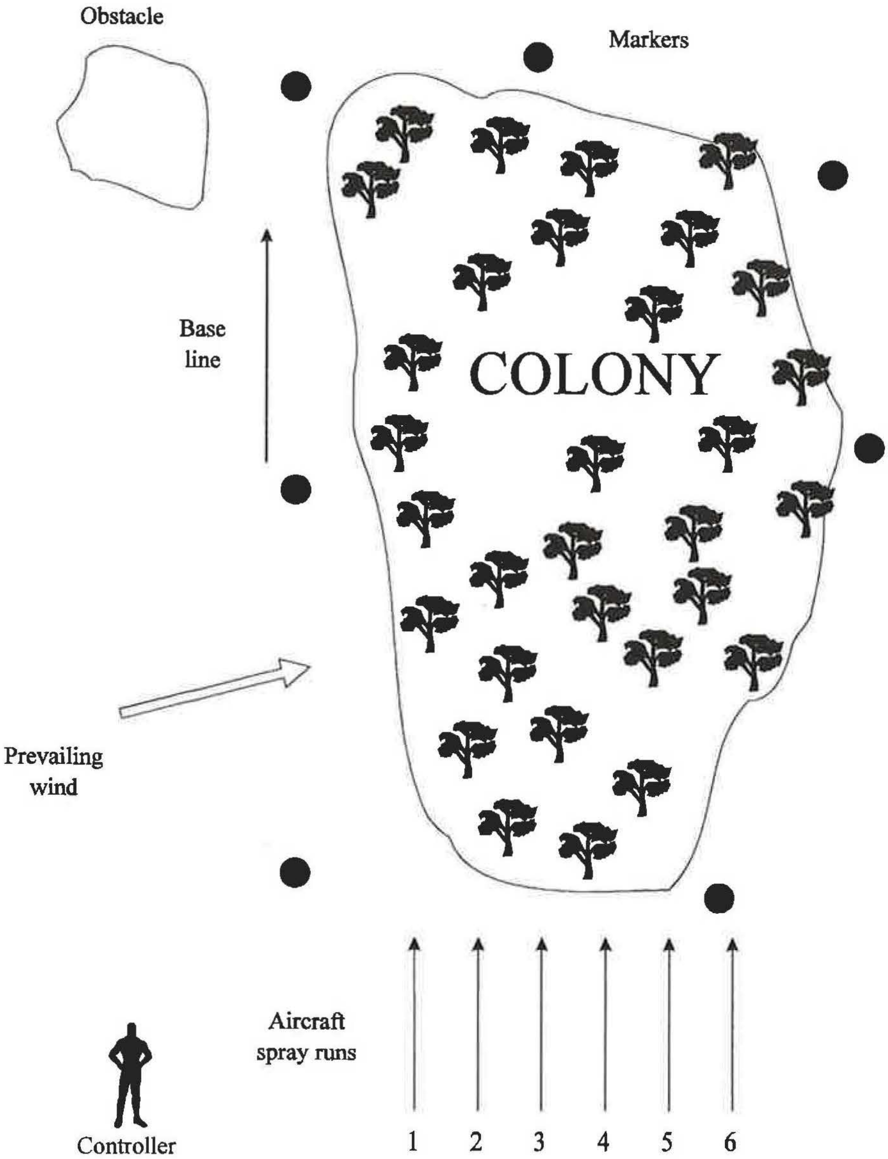


Figure 30 A well marked colony for aerial spraying

advise him where additional spray runs are required or when to abort an operation. The ground observer may hold off the aircraft between each spray run until the birds scared off by the operation return, in order to maximise their contact with the avicide.

- Assessment: The recommended method of controlling a breeding colony will result in a high kill which will be obvious on the day following the operation without the need for an elaborate estimation of the percentage kill. However, monitoring the population of birds in a colony and estimating the number killed after a control operation will provide a record which can be used to assess the overall effect on crop damage in the area and the cost effectiveness of control. Not all the birds in the target area will be killed however well the recommendations have been followed, especially as three different degrees of control can occur as follows.

(1) Males only are found dead in the colony. This occurs during the second week after establishment of the colony when the females are incubating the full clutch at night and remain in the nest during the spray operation. The effect on the colony cannot be assessed immediately but the likelihood is that most of the colony will not survive to fledging as the females will be unable to brood the eggs, feed the nestlings and themselves, for the four weeks remaining before dispersion of the colony.

(2) Adults and nestlings are killed. This occurs during the third week of the colony when all the eggs have hatched and the females are brooding the nestlings at night. The nestlings are still without a developed plumage and the females leave the nest, when disturbed by the aircraft, picking up a lethal dose of avicide as they fly through the spray cloud. The nestlings are contaminated either by spray droplets which may penetrate the nest or from the plumage of the female returning to brood after the disturbance is past. Complete silence in the colony on the day following the control operation indicates effective control. Markedly reduced noise, intermittent flights in and out of the colony, and unco-ordinated birds which do not readily take flight, some obviously dying, indicates partial control. No change from pre-treatment activity is obviously a failed operation.

(3) Adults only are killed, the nestlings escaping because of the protection afforded by the nest. This occurs when the colony is in its fourth week and the females have stopped brooding the nestlings, most of which have a well developed nestling plumage. The effect of the operation is not easy to assess by a visit on the morning following the operation as the colony will still be noisy and surviving adults can give a false impression of poor control. A visit late in the day will give a better impression as many of the nestlings, seeking food, will have fallen from the nest and their numbers on the ground, dead or dying, will give a rough impression of the overall effect of the operation.

A visit must be made to the colony on the day after a control operation to assess the above effects. If a full assessment is not possible, due to pressure of work or other compelling reason, the observer, or observers, must at least make a zigzag traverse of the colony examining corpses and recording what they see.

A good assessment of the effectiveness of a control operation against a colony is time-consuming but is worth doing if time permits. Assuming that the operation is to be undertaken when the colony is at the right age for control, at least 10 sample sites should be chosen at random within the colony before the operation. Quadrats 5–10 m square should be marked out at each site, the size depending on the density and canopy size of the shrubs in which the colony is established. For example, if the colony is in Acacia bushes standing apart from one another, and averaging from 4–10 m in diameter from the outer edge of the canopy on one side to the outer edge on the opposite side, then one shrub per quadrat will be adequate. If the shrubs are smaller, or entwined, then the sample should be made up of those shrubs with stems standing within the quadrat. Having clearly defined the quadrats, any dead birds found in them should be removed and the number of occupied nests counted. It is impossible, without cutting down the bushes or every nest in them, to do this accurately but a

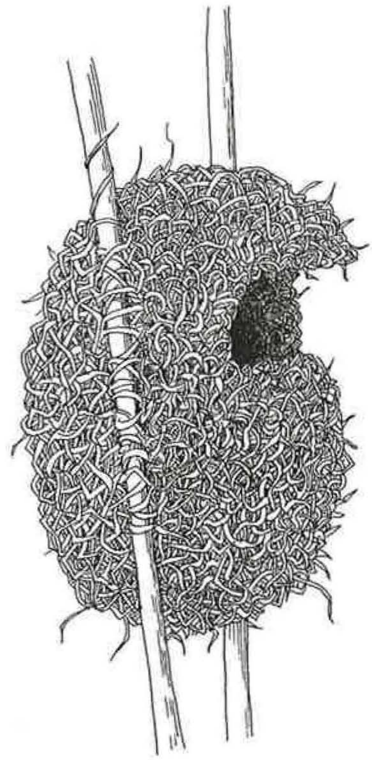


Figure 31 Complete Quelea nest with 'porch'

best estimate should be made counting occupied nests as those which are obviously complete and substantial. The presence of a 'porch' on a nest (Figure 31) indicates that it is complete and solidity of the nest indicates a substantial structure.

Occasionally, however, a colony in arid country may have comparatively insubstantial nests through which daylight can be seen and sometimes porches may be absent from occupied nests. Usually, in such cases, the whole colony is affected and occupied nests have to be identified more carefully. After the nest count has been made 10 nests, from those within the quadrat, should be cut down and examined. The content of each nest should be recorded separately, particularly clutch size and age of nestlings.

On the day following the control operation, all dead birds within each quadrat should be counted and recorded as adult males, adult females, nestlings or fledglings. A further 10 nests should be removed and the contents noted as was done before the operation. The total numbers of dead males and dead females recorded in the 10 quadrats divided by the total number of occupied nests recorded and multiplied by 100 gives a rough estimate of the percentage of each category killed. A successful aerial spray application can be expected to kill more than 90% of the Quelea in a colony. If significant numbers of birds survive, bearing in mind the stipulations made above concerning the birds likely to be killed by the control operation, the officer-in-charge may have to organise a respray after identifying the cause of the poor kill.

Ground control
Colonies may, under certain circumstances, be controlled by the use of ground sprayers. The methods used are outlined on p. 154.

PROTECTION METHODS FOR NON-BREEDING SEASON CROPS

Cereal crops are not generally grown in the non-breeding season, which corresponds to the dry season, except under irrigation or, at higher elevations where unseasonal rains may occur and grain-eating birds may migrate temporarily. Cereal production under irrigation is costly and therefore losses to birds are unacceptable. In the dry season, cereals are very prone to attack by grain-eating birds as their natural food becomes scarce. Birds, which are not obligate seed-eaters, may not be attracted to the crops but others are and large concentrations of seed-eaters may descend on the crops as they ripen. Direct protection, as outlined above for the protection of crops during the breeding season, can be effective, but some obligate seed-eaters, such as the Quelea, become so habituated that they can almost be caught by hand when feeding in unseasonal crops. Indirect protection, directed against the night roosts, is the only effective way to protect vulnerable crops from the Quelea and a few birds like them.

Direct Protection

Non-lethal Control

Irrigated crops
Modification of the cropping practice is the only non-lethal direct crop protection method likely to be effective in preventing damage to irrigated crops. In general irrigated crops are grown over too large an area for the recommended scaring methods to be economical or feasible and, where overhead irrigation is practised, quite impractical. Another option is to grow the crops at such a time that they are not in the susceptible stage when grain-eating birds are likely to be in the area: either before, or after, the season when migrant seed-eaters are passing through.

Rainfed crops
Crops grown at high altitude where rainfall seasons are prolonged or unseasonal can attract lowland grain-eating birds in some areas. Such crops are often grown in small fields which may be suitable for protection by scaring or trapping. The scaring method outlined previously is recommended for small plots. Larger fields may be more difficult to protect and, depending on the number of birds involved, indirect lethal control may be the only effective option.

Lethal Control

Chemical control and trapping can play a part in crop protection during the non-breeding season but their application is limited and more difficult during this season. Birds are not nesting within, or close to, crops so that they are more difficult to trap. Water traps, which are more effective in the dry season, cannot be employed in irrigation schemes for obvious reasons and chemical control of field edges is, as always, a last resort. The management of shooting rights in irrigation schemes is an alternative which is worth consideration.

Shooting
Ducks and doves, which may cause damage to irrigated crops, are birds from which revenue can be obtained from hunters shooting for sport and the pot. Organised shoots, when properly managed, can be useful in reducing crop damage in rice schemes and can bring a cash reward to tenant farmers. The hunters may prefer to take up positions on the edge of the scheme where ducks are flighting into and out of the rice fields. This may optimise the bag but will not necessarily deter birds from entering the crop. Hunters should be required to shoot from within the fields starting from daybreak until flight ceases in the heat of the day and then continuing, when flight resumes in the evening, until nightfall.

Other cereals grown during the dry season may attract large numbers of doves. Shooting can reduce crop damage but it will not deter the birds from entering the crop. In this case it is necessary to shoot as many birds as possible if a real impact is to be made on the level of damage. Doves can be difficult to shoot and skilful hunters are essential if crop damage is to be reduced.

Indirect Protection

Non-lethal Control

Non-lethal control methods are similar to those outlined for the indirect protection of breeding season crops.

Lethal Control

Poisoning
Poisoning water sources is too dangerous and indiscriminate to be considered unless a soporific is used. This requires very careful supervision as the quantity of material dissolved in water must be below the lethal dose and affected non-target birds must be carefully kept in the shade until they make a full recovery after which they must be released.

Trapping
A variety of ingenious traps is used throughout Africa to capture birds for food and sale. None is particularly effective in reducing the damage caused by grain-eating birds except in the case of direct control methods in the field mentioned above. On moonless nights in Chad Quelea are driven into nets folded into the trees in which they are roosting. The birds are collected in thousands in bags held under the nets as they are shaken. The trapped birds are sold as food generating a reasonably lucrative trade but having little effect on the overall Quelea numbers, although five million are reportedly sold annually in N'Djamena.

Perhaps worth exploring, is the use of live bait to trap Quelea birds. At the end of the dry season when food is scarce and before the rains come people in Africa have traditionally induced winged (*alate*) termites to emerge prematurely by imitating 'rainfall'.

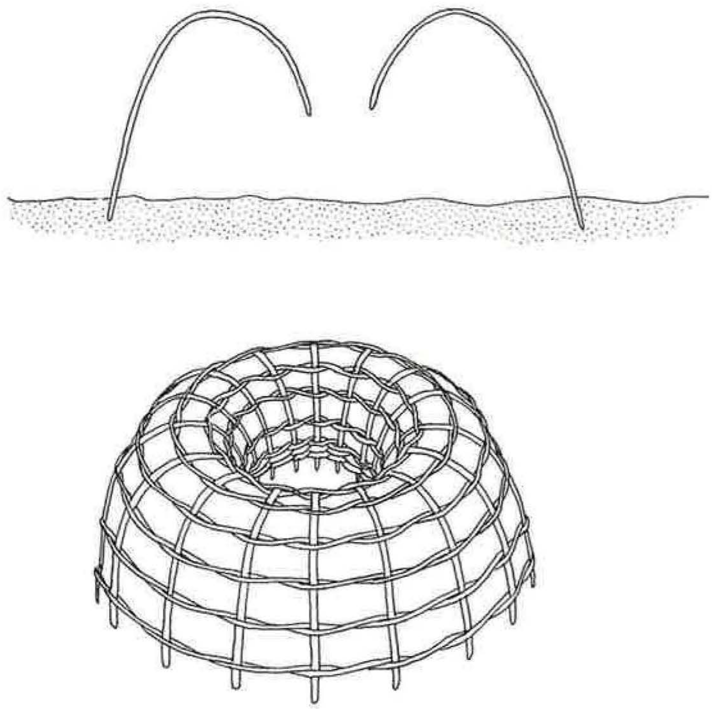


Figure 32 Traditional basketwork trap - birds enter through the central hole, attracted by alate termites. They are then unable to find their way out again.

The emerging termites are taken for food or used as bait to trap birds, which are also eaten. Two methods are used. The simplest, which requires only a few termites, is to attach the alates to sticks coated in 'bird lime'. This simple trap catches too few birds and is too indiscriminate to be recommended and should really be discouraged. A more effective trap, and one which can be more discriminate in the birds it catches, is a basketwork trap (Figure 32) baited with free flying alate termites.

First the termites have to be induced to emerge from their termitaria. The entrance to a termitarium is located and carefully enlarged (Figure 33a). Loose boards are placed over a termitarium and beaten to simulate heavy rainfall (Figure 33b) and water is poured carefully into a passageway. The passage is extended as a damp chamber with leaves and wet clay. Once the winged termites begin to emerge they are gathered into a container prebaited with worker termites (Figure 33c). This may be an accidental application of science – the alates remaining head down in the tin under the influence (possibly pheromonal) of the workers! The winged termites remain packed and quiescent in the container (Figure 33d) and from there are released, a few at a time, into the traps.

Many traps are set together where Quelea are feeding and the termites emerge slowly through the traps and take flight. The Quelea, which are quickly attracted to the flying termites, enter the traps and are caught in large numbers although, again, insufficient to have any real impact on their population. Nonetheless, it is possible that this method could be improved by using larger traps which could capture significant numbers of Quelea and fuel a small, short-lived, cash flow to the trappers.

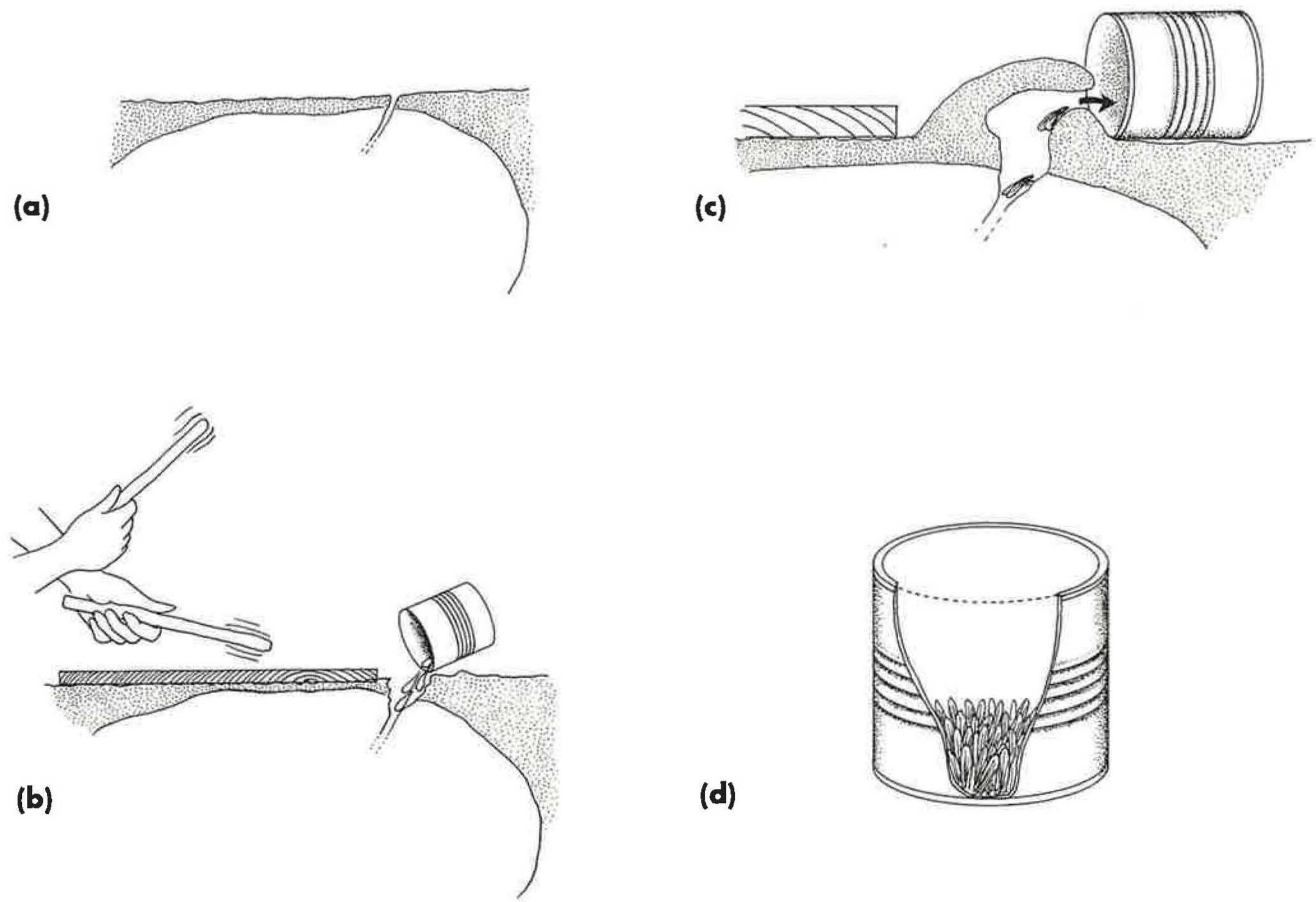


Figure 33 Procedure for capturing termites

The firebomb

Small Quelea roosts of 1 ha or less in tall trees, such as Eucalyptus, up to 25 m in height may be successfully controlled by the use of firebombs. A firebomb is made by filling 200 l drums two-thirds full with a 50:50 mixture of petrol and diesel and dynamiting them into the roost where the exploding fuel mixture ignites. The dynamite is detonated by a double line of instantaneous detonating fuse wire ignited by detonators which are set off by a slow-burning fuse. The dead, charred birds, uncontaminated by pesticides, can be collected and eaten by interested people in the vicinity of the operation. A major drawback to the firebomb is its high cost and the risk to the operator.

The roost site to be controlled is measured and a grid of 20 x 20 m squares is pegged out on the ground (Figure 34).

A hole is made at each peg large enough to take a pack of 36 gelignite sticks. The sticks are carefully bound with tape and a double loop of Cordtex® instantaneous detonating fuse is taped round the gelignite pack before it is placed in the ground (Figure 35). The charge is lightly covered with soil and the drum of fuel is then rolled into place on top of the charge. The Cordtex® is linked in a network to all the gelignite packs at the site. Additional charges may be placed in the trees above the drums in order to ensure ignition of the fuel (Figure 35). The additional charges are also linked to the instantaneous fuse network.

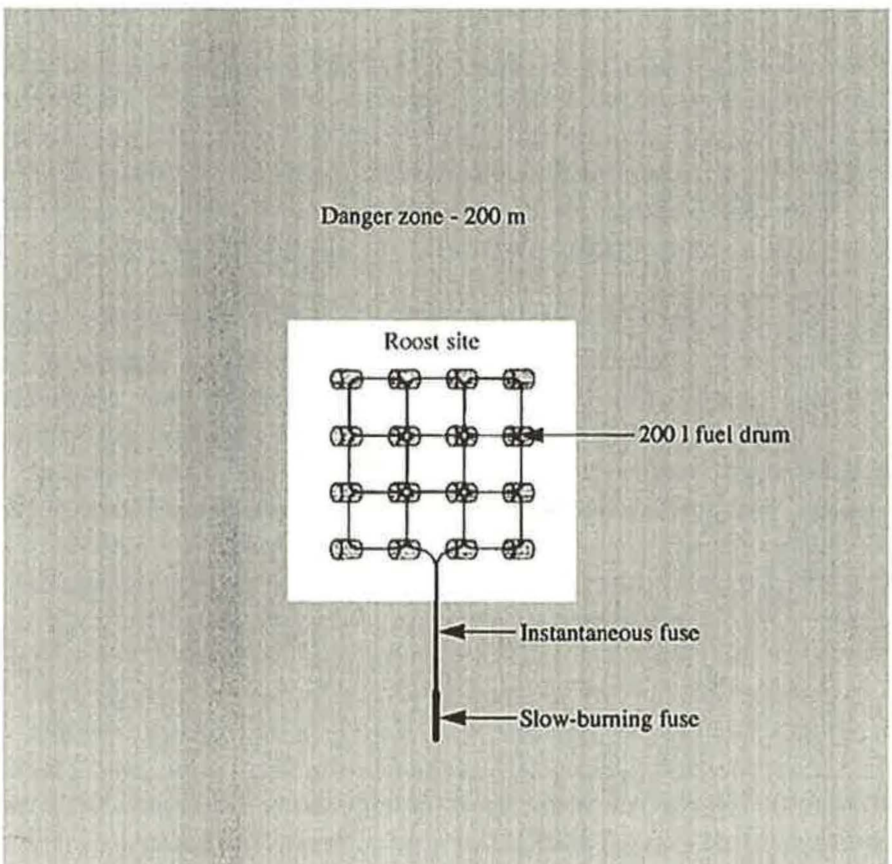


Figure 34 Layout diagram for setting up a firebomb

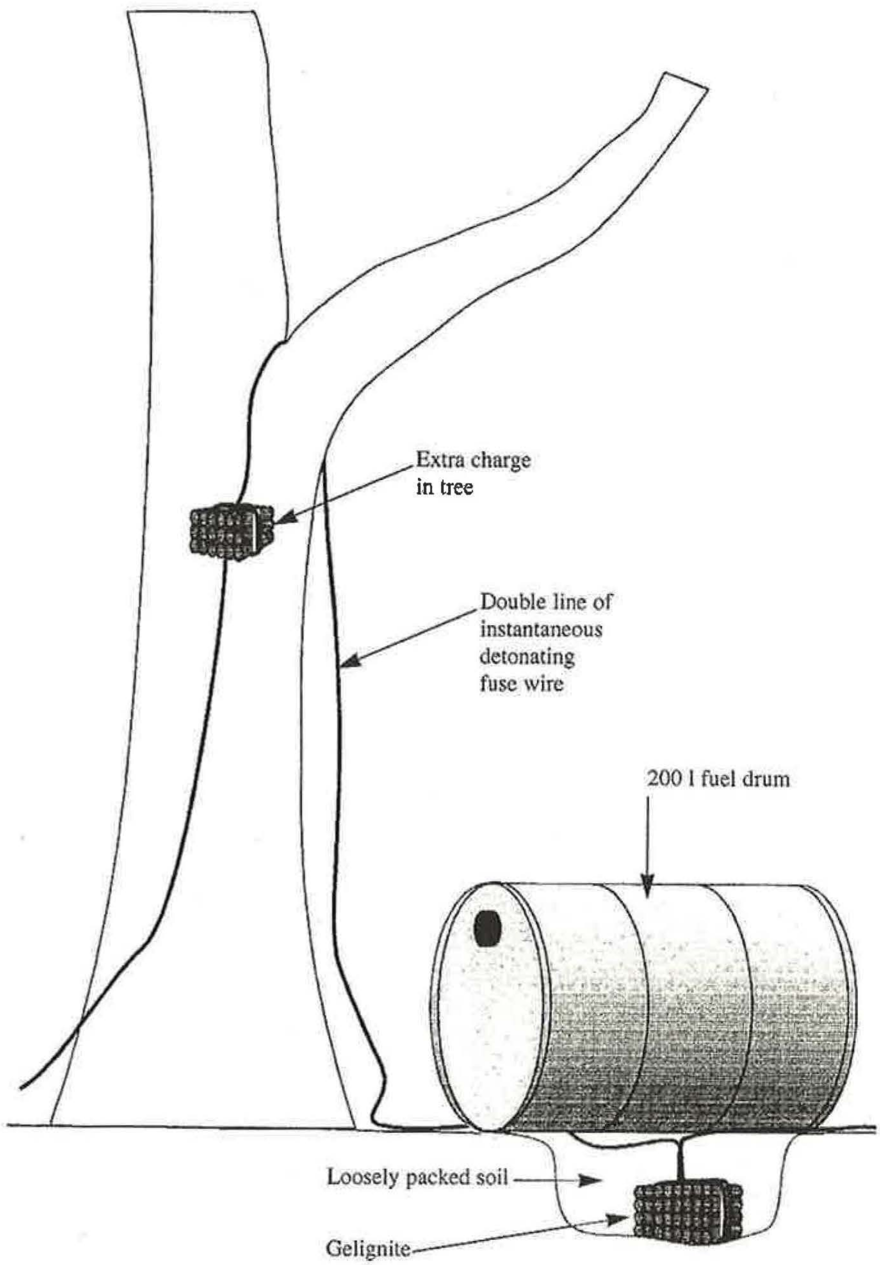


Figure 35 Placement of additional charges for firebomb control

The blast from such an explosion is severe and all people within at least 5 km of the area to be blasted must be warned so that windows can be left open to prevent damage. Great care must be taken to ensure that nobody enters the danger zone which extends some 200 m in all directions around the site.

When all the birds have entered the roost and silence has fallen, the blasting officer lights the slow burning fuse and withdraws to a safe place until the charge ignites. In the event of a misfire the blasting officer must carefully remove the detonators from the instantaneous fuse by cutting it close to the detonators. If the detonators have ignited the Cordtex® but none of the charges has fired he must carefully follow the track of the fuse wire until he finds where the fault lies. At the site of the fault the fuse wire must be cut and removed. The blow up will have to be postponed until the following night and all the fuse wire and charges must be removed from the site. On the following day, having identified the cause of the misfire the blasting officer will have to re-lay his charges as before.

Should the misfire involve only some of the drums, the same de-fusing procedure will have to be performed but it is unlikely that the surviving birds will return to the roost the following evening. In this case a survey will have to be conducted to find the new roost site.

A successful blast will still have to be inspected by the blasting officer. He will have to ensure that all charges have fired and that no explosive materials remains in the site before allowing any access to it.

The technique has been most successfully carried out in mature Eucalyptus trees in Kenya. In some localities the same windbreak of trees has been blasted for at least 20 years almost annually. No trees have ever caught fire, and none have been severely damaged by the blast. Small fires have broken out in the leaf litter at the foot of the trees and these have had to be put out by the field staff engaged in the exercise. Fire beaters should be available at the site for this purpose. There is no doubt that the application has more potential for further development. Smaller (1–5 l) plastic containers suspended from wires stretched over a roost in a wetland site (see Figure 36) have been suggested as a possible development but this has not, as yet, been successfully carried out.

The technique is environmentally friendly and when used correctly is very successful. However, it must be stressed that **it is dangerous and can only be undertaken by an officer licensed to handle explosives.**

Aerial spraying

Roosting behaviour In principle roost spraying is the same as colony spraying but there are special factors to be taken into consideration. In the first place the behaviour of the birds is different. The birds generally return later to a roost than to a colony because food is scarcer and the birds tend to feed right up to last light under severe conditions. This means that the spraying has to be delayed until all the birds are in the roost. The normal method by which the birds return to the roost can take time, the flocks assembling in staging areas as they approach the roost. The final move into the roost is made to the periphery, then inwards to the core by stages: the centre becoming progressively more densely packed. The final move in to the roost proper can be very rapid and sudden. When feeding grounds are far from the roost, the birds may return in one long column pouring directly into the roost, packing in ever more tightly as the column continues to fly in. In large roosts of over five million birds this can take 15 to 30 minutes from the time of arrival of the first birds in the column until the last has settled in. If a roost has been established for some time its exact position and area can easily be seen and measured in the absence of the birds. The accumulation of fresh white droppings (*guano*) on the ground and on the foliage is a sure sign of an active

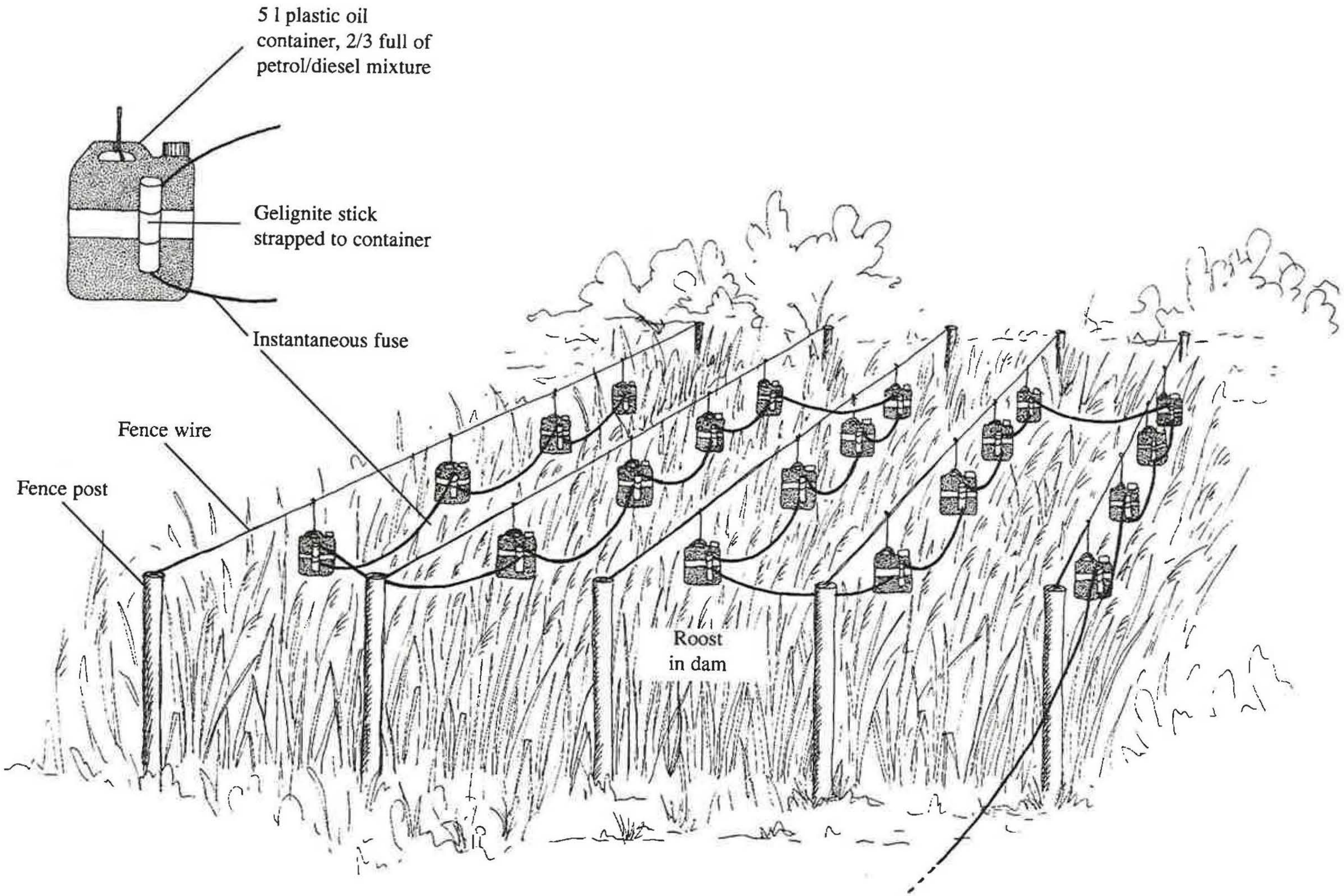


Figure 36 Suggested method for firebombing a roost in a wetland site

night roost. Generally a roost is considerably smaller than a colony. Roosts reportedly larger than 10 ha in area should be carefully observed to make sure that it is the core roost which is being measured. Sometimes staging areas may be included in the measurement by mistake. This will happen if the roost is measured too early in the evening.

Another aspect of the birds' behaviour is that they react more vigorously to the presence of the aircraft. A small, recently formed, roost can be abandoned altogether, the birds establishing a temporary roost nearby when disturbed by the spray plane. After a few spray runs large flocks may take off from established roosts and circle quite widely before returning to the roost. For this reason it is essential when spraying roosts to have a ground observer directing the pilot as to when and where to carry out his spray runs.

Roosts in the breeding colonies In a colony, which has either eggs or unfeathered nestlings in the nests, the female Quelea will sleep in the nest overnight. The males will roost alone on, or near to, the nest. When the nestlings become feathered the adults tend to form into small feeding, and food gathering, flocks and the males establish a night roost in, or close to, the colony. At the time of dispersal of a breeding colony the females and the more precocious fledglings will have joined the males in the night roost. For this reason **a colony in the late stage of development must be treated as a roost for control purposes.**

Temporary roosts After the end of the breeding season the adults, moulting out of their breeding plumage, move further and further away from the breeding area searching for good feeding grounds. At this time they form comparatively small, temporary roosts and, if causing crop damage, are difficult to control because of their lack of attachment to the site. As the non-breeding season advances and food becomes scarcer, more and more of the roosts join as the birds are drawn together in the most suitable feeding areas. Here semi-permanent, often traditional, roosts are formed and these can be very large. The traditional roosts are more easily controlled as the birds are heavily concentrated and strongly attached to the sites.

Roosting sites Roosts are established in a much greater variety of vegetation than are colonies. They may be formed in tall stands of Eucalyptus trees, in Acacia scrub, tall grasses, sugarcane plantations, maize fields or reeds. The only difficulty concerning the site of a roost is that those established over water, such as **roosts in reedbeds, should not be controlled by spraying.** This is because of the high toxicity of fenthion to aquatic invertebrates. Chemical control may be considered if the reedbed is in a farm dam, or similar site, and if the water is not used for drinking or washing purposes by people or livestock.

Time and method of application Roosts should be sprayed as late as possible during the twilight period following sunset. Large flocks can leave the roost quickly and avoid contact with the spray mist if spraying is carried out earlier than this, when the birds are still packing into their final roosting places within the roost. The first pass of the spray aircraft over the roost, when undertaken at the right time, activates only those birds roosting on the outside (the periphery) to react to the sound of the aircraft. The birds roosting on the periphery are generally the weaker in the roost and only

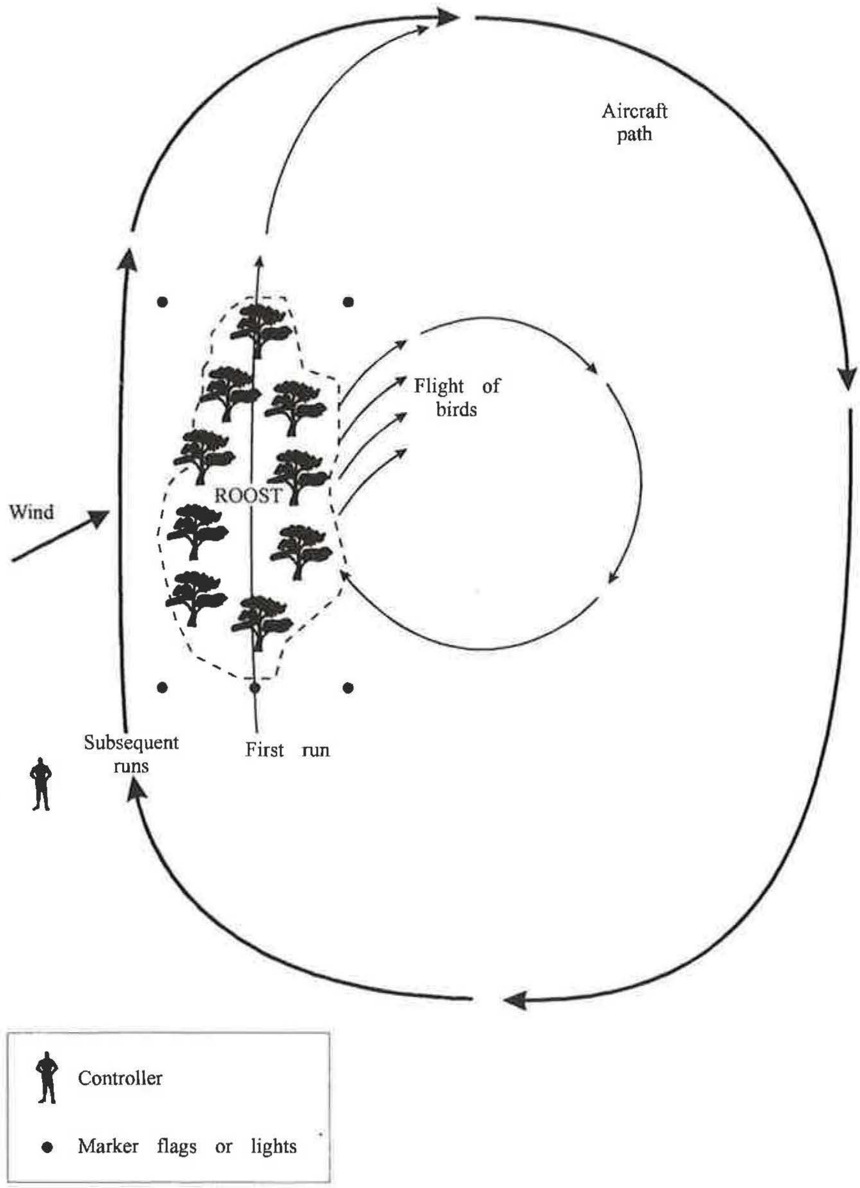


Figure 37 Aerial spraying of roost

shift outwards to allow the stronger core birds room for escape. For this reason the first pass, instead of down the upwind side of the roost can be directed through the middle of the site at right angles to the wind direction. This releases a cloud of spray droplets into the downwind half of the roost before any birds have left the site (Figure 37). Subsequent runs will depend on the shape of the roost site. With any luck, a second pass, some 30 m outside the roost and running along its length on the upwind side, followed by one or two runs, each 50 m further downwind, can be flown before any substantial movement out of the roost occurs. Once this happens the ground controller should call a pause to the spraying until he is satisfied that the displaced birds have returned. Subsequent spray runs can then be directed by the ground supervisor according to the behaviour of the birds.

The roosting birds, being a more compact target than breeding birds, can be controlled from a greater height and with a larger median droplet size. In general, bearing in mind that there is really no general case, the aircraft can increase the height of application to 5 m above the top of the canopy and increase the droplet VMD to between 80 and 120 µm. The larger droplet means that wind speeds up to 5 m/second (a light breeze sufficient to extend a light-weight flag) are acceptable.

The small size of roosts with their dense concentrations of birds requires more than one or two passes of the spray plane to ensure adequate cover of the target, the mass of birds. Hence a VAR of more than 1 to 2 l/ha is generally applied. Too few runs would give rise to a potentially large margin for error and too low a dose in the spray cloud would not kill the birds. To overcome this the sliding scale recommended for colonies is applied to roosts in a simpler form. **Roosts of less than 4 ha in area should be treated at a VAR of 8 l/ha, and those of more than 4 ha at a VAR of 4 l/ha.**

Marking the site Marking a roost is, in principle, the same as marking a colony but the flight path is different and may be altered constantly by the ground controller. A generalised plan for marking is shown in Figure 30.

Assessment The assessment of the operation against a roost must be carried out at first light before the birds leave the roost. The success, or otherwise, of the spray application is judged by the number of birds seen leaving the roost at dawn following the operation, compared with the number seen entering the evening before.

Ground spraying

Ground spraying of Quelea colonies and roosts has had a long development history. The most successful line of development has been in mist blowers the latest of which are two Micronair® sprayers, the AU8000 and the AU8110. Both were available as self-contained kits for mounting on a pick-up vehicle but the AU8000 atomiser head is currently only used attached to a motorised knapsack mistblower. This is not considered to be a viable option for bird control as the spray head is carried too low to give adequate cover. Also the operator, moving at dusk over rough ground, is at risk of contamination from spillage and injury from falling.

Both Micronair® rotary atomisers are spinning cages attached to a fan with adjustable blades driven by air from a blower powered by a petrol engine, 2-stroke in the case of the AU8000, and 4-stroke in the case of the AU8110 SC-kit. The avicide is pumped to the atomiser head through a variable restrictor unit giving flow rates from 20 ml to 1.2 l/minute with the AU8000, and 20 ml to 2 l/minute with the AU8110. The droplet size is controlled by the engine speed and the blade angle and is adjustable from 40 to 200 µm VMD in both models. The manufacturer's instructions should be followed carefully when setting the flow rate and droplet size before spraying. The AU8110 is available with an optional 4 m high extension frame and this is necessary for effective Quelea control.

Another ground sprayer developed and used in Zimbabwe is the Spray Quip mist-blower. Instead of a rotary atomiser, the Spray Quip uses six venturi nozzles* in an air blast of 160 kph produced by a fan driven by the power take off (pto) of a 45, or greater, horsepower tractor. The avicide is pumped under pressure to the venturi nozzles. The pressure is critical and is maintained at a constant of 200 kP by a restrictor of 5.6 mm diameter in the feed line and an adjustable valve on a return line to the tank.

Assessment of the efficacy of ground spray operations is undertaken in the same way as recommended for aerial spray operations.

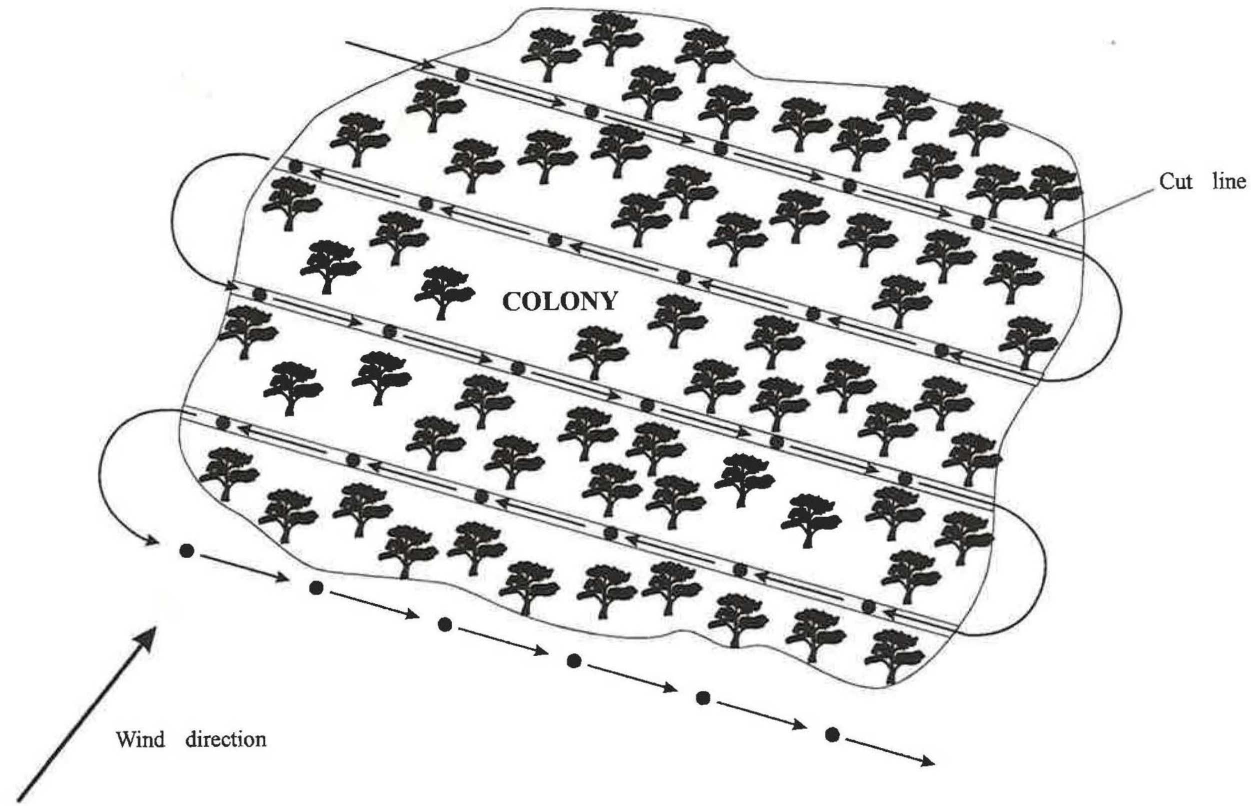
Colonies The ground sprayer has been used for spraying small colonies in vegetation no more than 5 m in height. A colony of 20 ha is about the maximum size of colony which can be treated and this would probably require the use of at least four vehicle-mounted sprayers. Instead of spraying at dusk, as usually practised during aerial spraying, control operations with ground sprayers can start 45 minutes before sunset. The avicide is applied at intervals from different positions within the site. Lane cutting may be necessary in sites where the vegetation is thick. The lanes are cut during the daytime. Hurricane lamps can be distributed along the lanes for better visibility at night. Only side-lights are used on the spray vehicle to minimise disturbance during the operation.

The FAO recommendation for treating colonies with a ground sprayer is that the spray vehicle travels on a track perpendicular to the wind direction stopping every 30–50 m to spray the avicide for 2–5 minutes into the flight path of Quelea birds returning to their nests. The vehicle proceeds along parallel tracks 50–80 m apart until the area of the colony has been covered (Figure 38).

The minimum time it would take one vehicle to follow this routine through a colony of 5 ha (say 300 x 160 m) would be about 30 minutes, assuming a speed of 5 km/hour and only 2 minutes spent spraying at each of the 12 spray points along two tracks, 80 m apart and 300 m in length. The longest application time for one vehicle to treat a 5 ha colony (say 330 x 150 μm) would be just over 3 hours, with the vehicle stopping every 30 m for 5 minutes and proceeding along three lanes 50 m apart. This suggests that the maximum colony size which can be treated by one vehicle would be about 5 ha. If more than one vehicle is operating in the same colony the vehicles should be staggered to avoid spraying each other. Each downwind vehicle will start to spray one site ahead of the next vehicle upwind of it.

The principles for the application of a spray cloud to the colony are the same for ground spraying as they are for aerial spraying. The spray equipment should be able to produce droplets in the 50 μm VMD size range and give an output in the range of 300 ml to at least 4 l/min. It is difficult to recommend an exact VAR or dosage for ground sprayer application because of the intermittent use during the period of

* A venturi nozzle is an open tube through which the spray liquid is sucked by the vacuum formed in the tube mouth when air at high pressure is driven across it. The spray liquid is sheared into small droplets at the tube's rim.



● Position for spraying at 50 to 80 m intervals along cut lines

Figure 38 Ground spraying a large colony

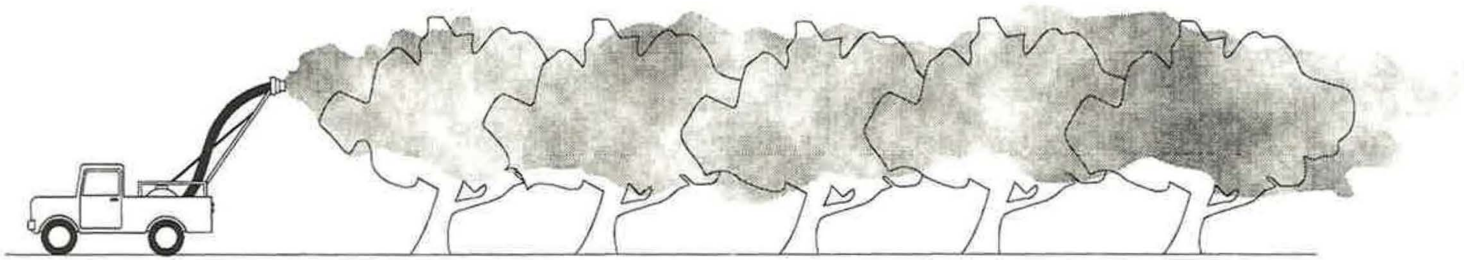


Figure 39 Ground spraying a roost where the trees are less than 5 m in height

application. This is determined by the rate of arrival and behaviour of the flocks entering the roost. Essentially the VAR should not exceed the aerial rate of application (i.e. 8 l/ha).

Roosts Quelea roosts up to 5 ha in extent, and accessible by vehicle, can be economically sprayed with one stationary mistblower mounted on a pick-up vehicle, or tractor, provided that the roost is not in trees above 5 m in height (Figure 39).

The recommended method for spraying roosts is to position the vehicle in the most suitable site from which to drift the spray over the flight lines of the birds entering the roost or into its densest part. Spraying from a static vehicle starts when the first flocks are entering the roost and continues until nightfall. The spraying need not be continuous but can be switched on and off as flocks approach or enter the roost. The technique is particularly successful if all the birds enter the roost by the same route and the sprayer is set up to drift the spray cloud into the flight path.

One of the most successful methods of reducing crop damage by spraying roosts with a ground sprayer is that practised in some parts of Zimbabwe. Irrigated wheat fields, ripening towards the end of the dry season, are frequently invaded by Quelea which cause considerable damage to the crop. The birds at this time of year are roosting in reedbeds in dams and along rivers. A tall fodder grass such as Elephant or Napier Grass, *Pennisetum purpureum*, or sugarcane, *Saccharum officinarum*, is grown between the crop and the natural roost and this attracts the birds which quit their natural roost in favour of this site, the so-called **'trap roost'**, which is nearer to the crop. The Napier Grass stand must be dense and vigorous to be attractive. The trap roost is planted in such a way that it is accessible to the spray vehicle on all sides. Ideally there should be no bush nearby and a drinking water source should be reasonably close to the roost.

The equipment used to spray trap roosts in Zimbabwe is a tractor-mounted, modified coffee sprayer, the Spray Quip, which is capable of drifting spray 100 m down wind in a light breeze. The roost vegetation should not exceed 3 m in height and the plantation should be 100 m square or less (Figure 40). Instead of spraying at dusk, or when the birds are entering the roost, the trap roost spraying is carried out after dark when the birds have completely settled.

The spray machine is driven down the windward side of the roost at 23 kph with the engine revs at 2500 to 2600 rpm spraying at full volume. The application is not ULV and the Queletox solution recommended for use with the Spray Quip is a miscible oil containing 60% a.i. diluted to 30 g a.i./l applied at a VAR of 20 l/ha. If a ULV sprayer is used in a 100 m x 100 m trap roost, additional lanes have to be cut through the Napier Grass dissecting it into four 50 m x 50 m squares. Good cover would be obtained by spraying from the upwind corner of each of the four squares in succession (Figure 41).

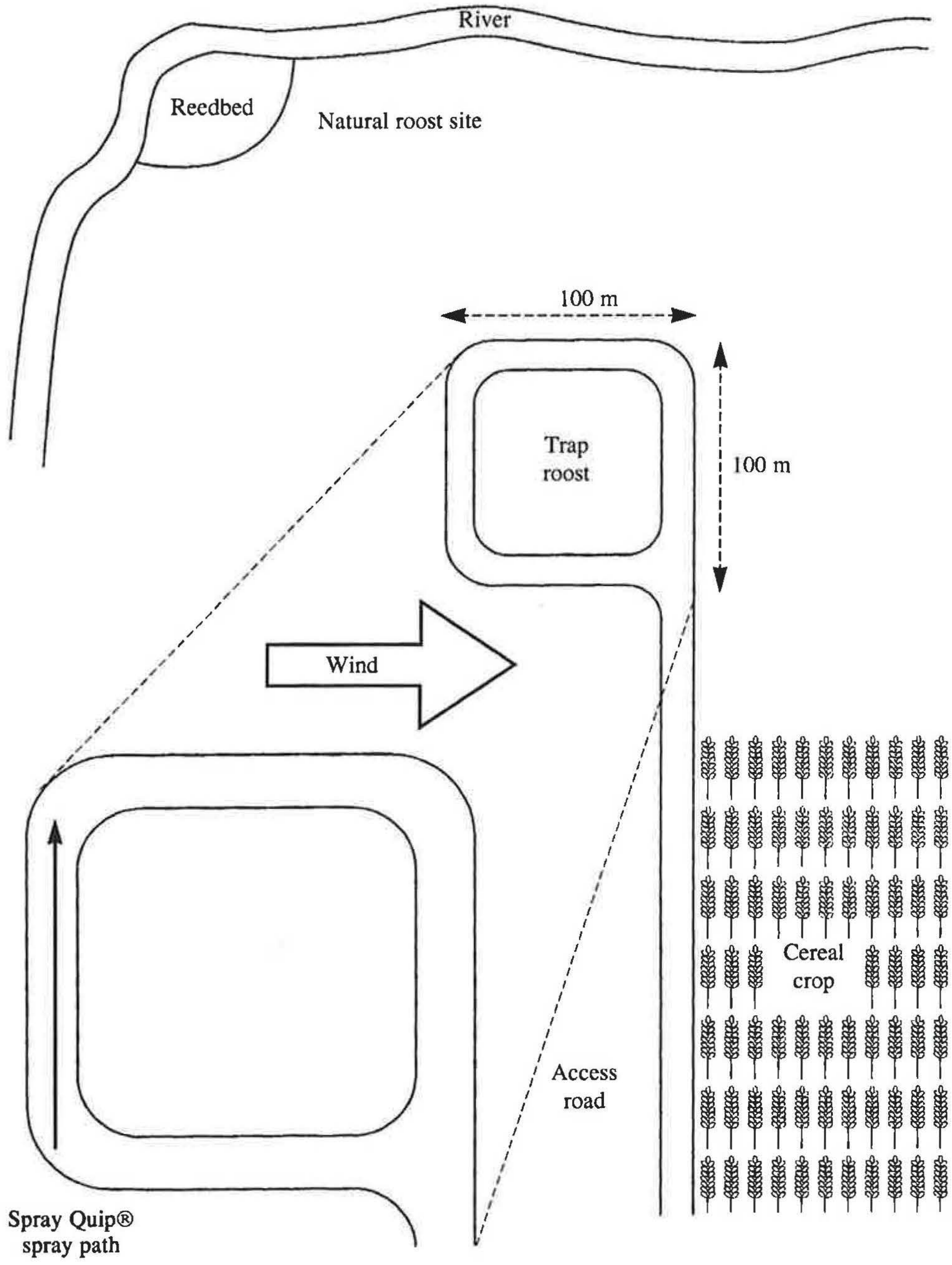


Figure 40 Spraying a trap roost with a Spray Quip

Guide-lines for Ground Spraying Roosts or Colonies

Ground spraying is a technique which requires very careful consideration and preparation. The site reported to contain a sufficient number of birds causing crop damage should be visited and carefully surveyed. The following guide-lines should be followed in order to ensure success with the method.

1. Is the colony/roost suitable for control by ground sprayer?

   All these criteria must be met before ground spraying is undertaken.

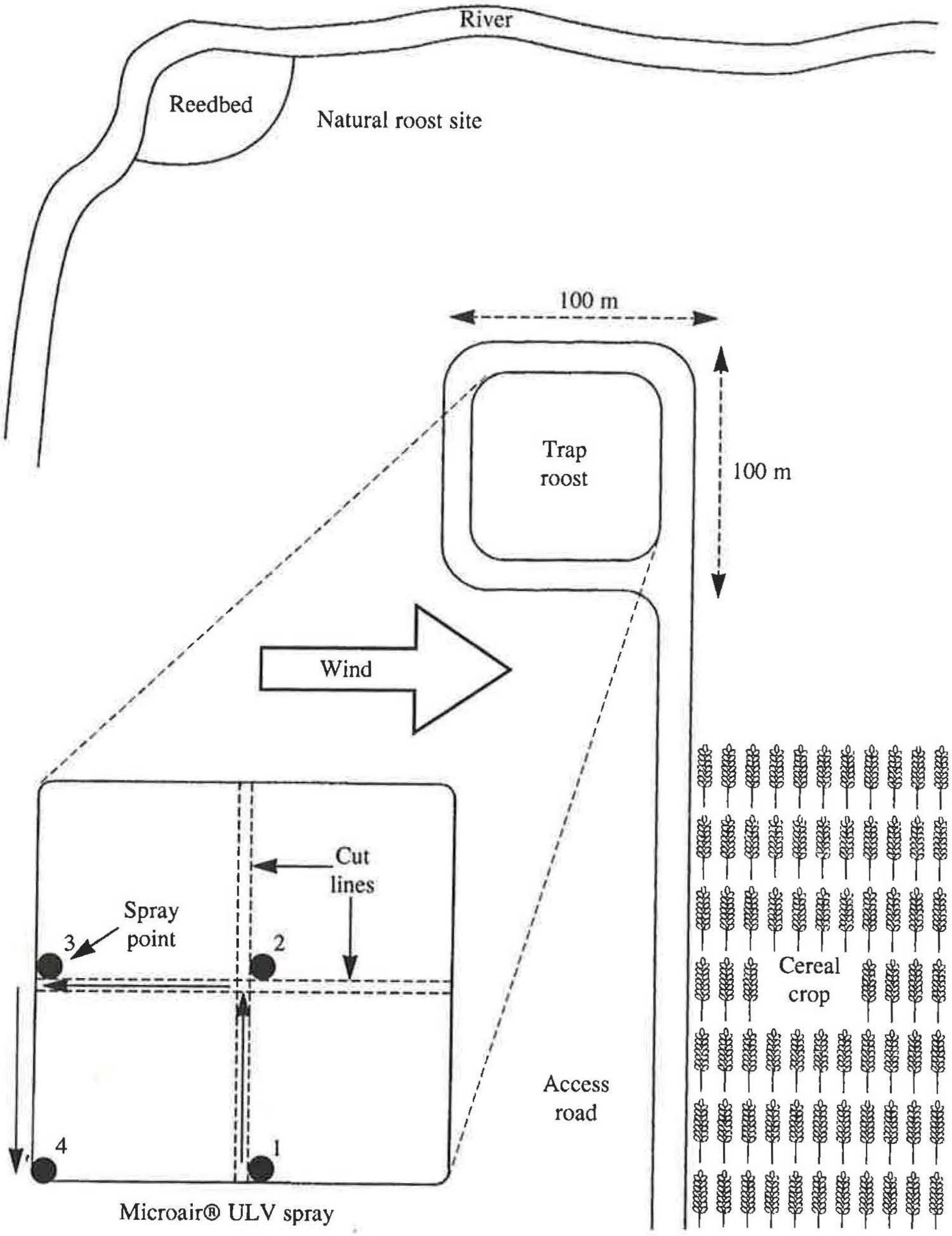


Figure 41 Spraying a trap roost with a ULV sprayer such as a Micronair AU4110®

- If it is a roost – is it less than 5 ha in extent?
- If it is a colony – is it less than 20 ha in extent?
- Is all the vegetation occupied less than 5 m in height?
- Is the ground surface suitable for the passage of a vehicle?
- Do tracks have to be cut for the spray vehicle?
  If so, is a sufficient labour force available to cut the tracks?

- Is the wind direction at nightfall constant and will it remain so until the operation is completed?
  This will determine the direction of the cut lines which should be as near to 90° to the prevailing wind direction as possible.

- Is there any reason to believe that non-target species may be at risk?
  If so can anything be done to avoid this? (e.g. scaring roosting egrets from the site or dispersing a roost of palaearctic migrants from the site or nearby).

- Is contamination of water likely?
  In the case of a roost can this be moved to another site by disturbing the birds from it?

2. What should the lane interval be? (50–80 m).

   This is determined by the density of the roost site, the likely wind speed and the angle of the wind to the spray line. If the wind speed is less than or equal to 1 m/second. and the site is dense then a swath of 50 m should be chosen. At a wind speed of 3 m/second and an open site 80 m lane intervals would be sufficient.

3. What time should be spent at each spray site? (minimum 2 to maximum 5 minutes).

   This depends on the behaviour of the birds. If they are very active and flock out of the site at any disturbance, then 5 minutes should be spent at each site. If they are quiet and return quickly after a disturbance then 2 minutes is enough.

4. What droplet size (VMD) should be used? (minimum 50 µm to maximum 80 µm VMD).

   This will be determined by two factors. The presence of a temperature inversion and the behaviour of the birds.

   - Temperature inversion. In the presence of an inversion, determined by the use of a smoky fire or a smoke canister, the smaller droplet should be used – 50 µm VMD.

   - No inversion. Use a larger droplet of 80 µm VMD or so to ensure that droplets fall within the target area.

   - If the wind speed does not exceed 1 m/second, use a droplet size of 50 µm VMD.

   - If the wind speed is more that 1 m/second but does not exceed 3 m/second then select a droplet size of 80 µm VMD.

The VAR will be determined by the time the sprayer is operated at each spray site and the setting of the flow rate. This is controlled by a variable restrictor in the avicide pipeline of the sprayer. The density of the spray cloud will determine the dosage birds will receive when they fly through it. Over-dosage is a waste of chemical and a risk to non-target species through drift. Under-dosage means a poor kill and also a risk to non-target species, such as predators attracted by sickening birds. Achieving optimum dosage is therefore a necessary skill acquired only through experience. Four spray cloud types may be obtained with the following flow rates and spray times.

- **A short-lived, low density cloud** of spray droplets. Assuming four spray sites per hectare and a stop of 2 minutes per site, then a flow rate of 340 ml/minute (the minimum output of an AU8110-SC vehicle-mounted sprayer) will deliver the lowest possible VAR of 2.72 l/ha. This will give a short-lived, low density cloud which will only be effective if the birds are comparatively inactive and the vegetation is sparse. Such a situation may arise in a small, low density colony.
- **A longer-lived low density cloud** of spray droplets will be achieved by a flow rate of 400 ml/minute and a 5 minute stop at each site. This gives a VAR equivalent to 8 l/ha. This will be effective when birds are relatively inactive but densely crowded. A roost sprayed in total darkness may be treated at this rate.
- **A short-lived dense cloud** can be achieved using a flow rate of 1 l/minute with a stop of 2 minutes per spray site. This will also represent a VAR of 8 l/ha. This will be suitable for a small, dense colony or a roost with active birds which remain in the roost flying actively as the application is made.
- **A longer-lived dense cloud.** If birds are very active and flying quickly through the cloud then a larger number of droplets per unit volume will be required. If the birds are less active and remaining longer in the spray cloud then a less dense cloud of droplets is required. The longer the cloud is in the air the better the kill. Two settings can achieve this both resulting in a VAR of 8 l/ha; 666 ml/minute delivered for 3 minutes per site and 500 ml/minute delivered for 4 minutes per site. i.e. either 0.5 or 0.66 l/minute depending on the activity of the birds – highly active or disturbed birds should be treated with the higher rate and the lower rate should be used for less disturbed birds.

Experience is the best guide to successful control operation planning but the above guide-lines will help a field officer to make the right decisions.

PRODUCTS USED IN THE MANAGEMENT OF BIRD PESTS

Introduction

The only recommended pesticide currently used to kill birds is fenthion, an organophosphorus insecticide. **No other chemical is recommended for the control of birds in Africa.** Fenthion is moderately toxic, hazardous to human beings, birds, mammals, insects and fish. Poisoning can occur by absorption through the skin, by swallowing (*ingestion*), or by breathing in (*inhalation*) the vapour or spray droplets. All forms of animal life are at risk and knowledge of the total effect of the spray is all part of safe handling procedures. The formulation used for bird control is commercially available as 'Queletox 60®' containing 640 g of the active ingredient per litre. Fifty percent of the birds in a large sample, the average weight of which is 19 g, will die if administered 0.038 mg of the active ingredient through the bill. This is referred to as the **acute oral LD50** and is equivalent to 2 mg/kg. The dose required to kill a rat is some 100 times higher suggesting that the toxicity to mammals is not great. The skin (*dermal*) or contact toxicity of fenthion to a laboratory rat is about 300 mg/kg which indicates a low, but significant, mammalian toxicity particularly as recovery is slow and repeated exposure may have a cumulative effect. It must be borne in mind however that the most susceptible mammal reported is the domestic calf for which the LD50 is only 40 mg/kg. Adequate safety precautions must be taken when fenthion is handled and adequate protective clothing must be worn during control operations. Safe handling techniques help to reduce the risk of poisoning while the chemical is in use.

Safe Handling

Storage

Fenthion should be stored in a well ventilated building, or in a shaded compound which should be securely locked. The chemical is generally supplied in 200, 50 or 20 l drums. The drums must be protected from direct sunlight. Drums should be stored on their sides with the bungs on the lowermost half of the end-on drum to ensure that the bungs are fully covered by the contents. Labels on all drums should be inspected regularly for legibility.

Stocks should be regularly inspected for leakage and drums found to be leaking should be decanted, as soon as possible, into new drums. Any used drums must be disposed of safely according to local regulations. This may involve holing the drums, incinerating them and burying the remains or disposal possibly through a central waste disposal authority

Loading

Before a ground or aerial control operation is launched a suitable loading station must be chosen. The aircraft loading station will obviously be at the site from which the aircraft will operate. This may be a small commercial airstrip or a simple grass strip in the bush. The loading site for a ground-based sprayer will be at, or close to, the operational site.

One of the major advantages of ULV applications for bird control is that there will rarely be any need for refilling the spray tank during a single operation. It is obvious, from the time limitation for optimum control, that more than one sortie per day is unlikely. Consequently, for aerial spray operations a single 200 l drum is usually more than enough chemical to be in place at the loading site. The vehicle on which the chemical is transported, or the aircraft, should have a hydrocarbon pump available for loading the chemical into the spray tank. This pump must be clearly distinguished from the aircraft's fuel pump, preferably by being clearly painted in a distinctive colour. The smaller, more easily handled, drums are to be preferred in which case a chemical pump is unnecessary as the chemical can be loaded directly into the spray tank. A sturdy and durable filter should be incorporated in the pump output hose or in the neck of the spray tank. The filter must be able to give good filtration at a high flow rate (i.e. 400 l/min).

A runway of 500 m minimum length must be available for the spray aircraft within easy reach of the site to be sprayed. The site requires to be lit to allow for night landing and a space cleared at one side of the downwind end of the landing strip for the service vehicle. A strobe light fitted to the roof of the service vehicle can assist the pilot in locating a bush airstrip in the dark. The service vehicle will be under the control of the aircraft engineer and will carry the aircraft fuel and avicide to the site. If the strip is not a commercial one equipped for night landings, the service vehicle will also carry a sufficient number of landing lights, either paraffin lamps or better. A windsock should also be carried and erected to assist the pilot in determining his landing approach. The aircraft engineer will be entirely responsible for setting the spray equipment to give the flow rate and droplet spectrum requested by the officer-in-charge of the operation. Facilities must be available for washing down the aircraft after spraying and for washing through the spray system. The detergent solution used for cleaning the aircraft and for irrigating the system should be disposed of properly by burial or flushing into a chemical disposal unit. A fire extinguisher must be available at the airstrip and must be in full working order.

The loading site for the vehicle-mounted sprayer should be a clearing in, or close to, the site to be treated. Grass and other vegetation should be cleared from the site which should be at least twice the area of the number of vehicles taking part in the operation. The spray tanks should not be filled until it is decided that conditions are optimum and the operation is to take place. All equipment except the sprayers should be unloaded from the vehicles and stored carefully at the loading site. This equipment will include fuel and oil for the spray pumps, the avicide, lamps to light the spray tracks, fire extinguishers, water drums and detergents for cleaning the vehicles and sprayers after the operation.

Protective Equipment

Toxic materials should only be handled when wearing appropriate protective clothing. The moderate toxicity of fenthion means that it cannot be handled carelessly particularly as its toxic effects are cumulative.

Appropriate clothing for handling fenthion is as follows (Figure 42):

- rubber boots
- overalls (legs worn outside boots, not tucked in)
- rubber gloves
- a hat
- goggles or an eye shield (to be worn when loading the pesticide tank)
- a respirator approved for organophosphorus compounds (with spare cartridge, valve and talc) regularly inspected for proper functioning of the valves.

Each mask should be labelled with the name of the owner and have the date recorded when a new cartridge was last fitted. The cartridge should be changed after 60 hours of use or as directed by the manufacturers. The valves can be tested for leaks by placing the hand over the air intake while trying to breathe in. The mask must be cleaned daily and dusted with talc.

Eating, drinking and smoking while handling toxic materials should be absolutely forbidden.

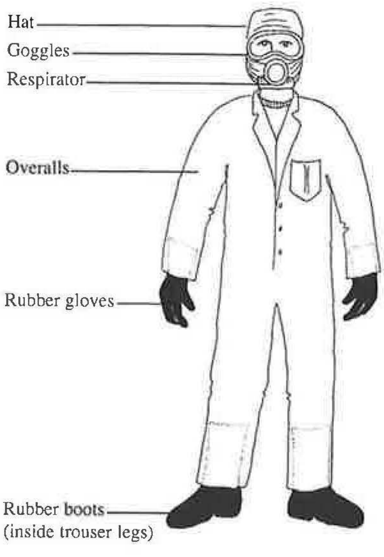


Figure 42 Recommended protective clothing

Protective clothing should be removed immediately after working with fenthion. The overalls should be regularly washed in detergent to avoid the build-up of residues which might pass through to contaminate the skin. Particular care should be taken to prevent the contamination of the inside of gloves and boots.

All spillage should be washed away. Any operator feeling sick, suffering from disturbed vision or headaches should immediately report the condition and should cease to work with organophosphorus chemicals until their health has been checked.

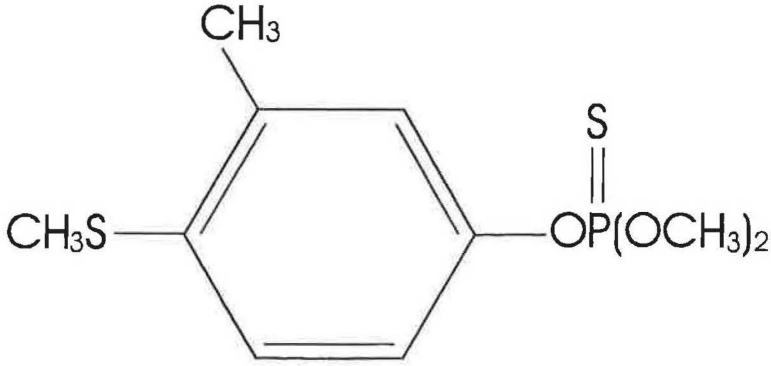
Soap and water must be available at the spray site in case of accidental contamination. All team members should wash thoroughly after each operation and before eating, drinking or smoking.

Fenthion ('Queletox')

An organophosphorus insecticide of moderate mammalian toxicity which may be absorbed through the skin, from the intestinal tract and by inhalation. It is metabolised into the more toxic oxygen analogue which becomes the active ingredient inhibiting cholinesterase. After acute poisoning the symptoms tend to be prolonged.

Chemical name of active ingredient: *O,O*-dimethyl O-[3-methyl-4-(methylthio)phenyl] phosphorothioate

Structural formula:



Trade names: 'Queletox', 'Baytex', 'Lebaycid', 'Tignuon'

Formulations: 60% miscible oil, ULV 100% concentrate

Physico-chemical properties:

Active ingredient: When pure colourless, almost odourless, oily liquid of boiling point 87°C at 1.4 Pascal. The technical material is a 95–98% pure, brown, oily liquid with a weak garlic odour.

Solubility: In water 4.2 mg/l. In dichloromethane, toluene and isopropanol > 1000 g/l, in hexane 30–100 g/l (all at 20°C).

Stability: Stable up to 210°C and to light. Relatively stable in acidic conditions and moderately stable in alkaline conditions.

Volatility: Vapour pressure 0.37 mPa (20°C), 0.74 mPa (25°C), 5.1 mPa (40°C), i.e. slightly volatile.

Flash point: >100°C (technical material)

Formulations:	Queletox 60	ULV 100%
Active ingredient/litre	640 g	1000 g
Density	1080	1197
Viscosity	3.9–2.4	9.1–5.8
Flash point: Formulation	35°C	44°C

Toxicity: Absorbed by the intact skin as well as by inhalation and from the gastro-intestinal tract. It inhibits cholinesterase after metabolic conversion to the more toxic analogue in the body.

Acute oral LD50:	Calf (most susceptible mammal)	40.0 mg/kg
	Rat (male and female)	250.0 mg/kg
	Quelea	6–10 mg/kg
	Golden Sparrow	1.3 mg/kg

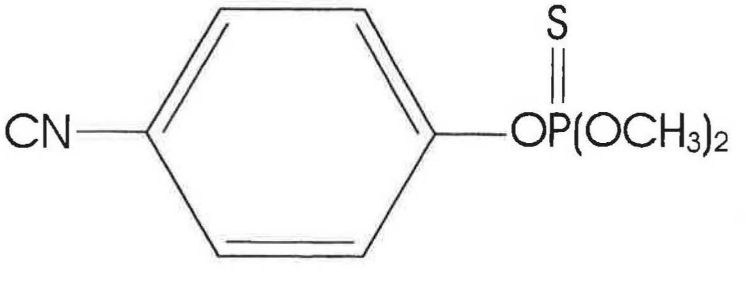
	House Sparrow	5.6 mg/kg
	Pigeon	1.8 mg/kg
	Starling	5.3 mg/kg
	Bobwhite Quail	7.2 mg/kg
5-day dietary LC50	Bobwhite Quail	60 mg/kg
	Mallard	1259 mg/kg
Acute percutaneous LD50	Rat (male and female)	700 mg/kg (24 hours)
	Rabbit (M)	Not irritating to skin and eyes
Inhalation LC50	Rat (male and female)	*c.* 0.5 mg/l air (4 hours aerosol)
Toxicity to fish LC50 (96 h)	Bluegill Sunfish	1.6–1.7 mg/l
	Rainbow Trout	0.87 mg/l
	Golden Orfe	2.7 mg/l
Toxicity to Daphnia EC50 (48 hours)	0.0052–0.0057 mg/l	

Cyanophos

An insecticide of moderate mammalian toxicity and brief persistence. Tested experimentally as an alternative to fenthion because of its lower toxicity. Shows a delayed lethal effect, birds dying more slowly than when treated with fenthion. This would increase the danger of secondary poisoning and therefore the use of cyanophos is not recommended.

Chemical name of active ingredient: *O*-(4-cyanophenyl) *O,O*-dimethyl phosphorothioate

Structural formula :



Trade names: 'Cyanox', 'Toritox', S-4080

Physico-chemical properties:

Active ingredient: Yellow to reddish liquid with a faint characteristic odour. Melting point: 14–15°C.

Solubility:	In water 46 mg/l (30°C) In methanol, acetone, chloroform > 50% (20°C).
Stability:	Stable under normal storage conditions. Rapidly decomposed under alkaline conditions, and on exposure to light.
Formulation:	Technical cyanophos (85% a.i.) is not miscible in diesel oil. ML 30 ready for use but can be mixed with diesel oil. Active ingredient 300 g/l.
Density:	0.99
Viscosity (20–40°C)	2.1 to 1 cSt (mm^2/s)

Toxicity:

Acute oral LD50	Male rat	710 mg/kg
	Female rat	730 mg/kg
	Mice	1000 mg/kg
	Quelea	3 mg/kg
	Golden Sparrow	2.5 mg/kg
	Pigeon	6 mg/kg
Acute dermal LD50	Rats	>1500 mg/kg
	Golden Sparrow	6.6 mg/kg
Inhalation LC50	Rats (4 hours)	880 mg/kg

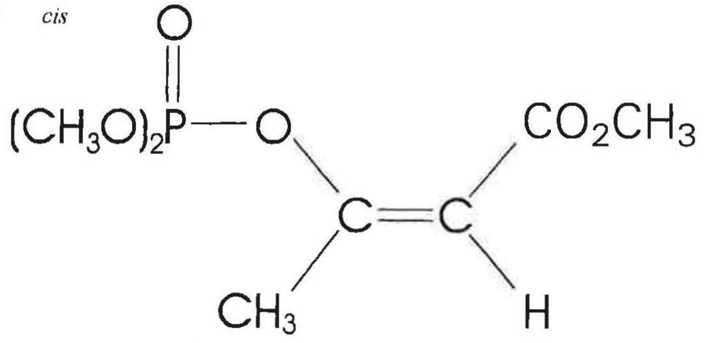
Mevinphos

An organophosphorus insecticide of very high mammalian toxicity which may be absorbed from the gastro-intestinal tract, by inhalation and through the intact skin. The high solubility in water renders the material particularly suitable for treating drinking water. The toxicity is due to cholinesterase inhibition. SHOULD ONLY BE USED IN SPECIAL CIRCUMSTANCES AND MUST BE CAREFULLY MONITORED TO PREVENT KILLING NON-TARGETS.

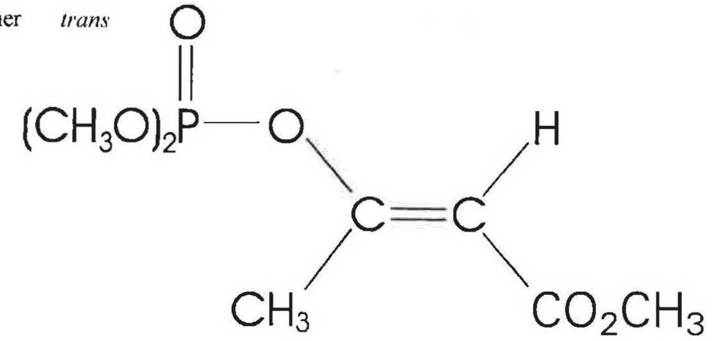
Chemical name of active ingredient: Methyl 3-[(dimethoxyphosphinyl)oxy]-2-butenoate. The *cis* isomer is considerably more toxic than the *trans* and technical material contains at least 60% of the *cis* isomer.

Structural formula:

(E)-isomer *cis*



(Z)-isomer *trans*



Trade name:	Phosdrin
Formulations:	10% to 24% emulsifiable concentrates 10% wettable powder and 1% to 5% granules

Physico-chemical properties:

Characteristics:	Colourless liquid. The technical material is a pale yellow to orange liquid of 99–103°C/0.3 mm Hg boiling point.
Solubility:	Completely miscible with water and most organic solvents, e.g. alcohols, ketones, aromatic hydrocarbons and chlorinated hydrocarbons. Slightly soluble in aliphatic hydrocarbons, petroleum ether, ligroin and carbon disulphide.
Stability:	Stable at ambient temperatures but hydrolysed in aqueous alkaline solution. Diffuses slowly through polythene.
Volatility:	2.9×10^{-3} mm Hg at 21°C.

Toxicity:

Acute oral LD50:	Rats	3–12.00 mg/kg
	Mice	7–18.00 mg/kg
	Quelea	1.43 mg/kg
	Mallard	4.63 mg/kg

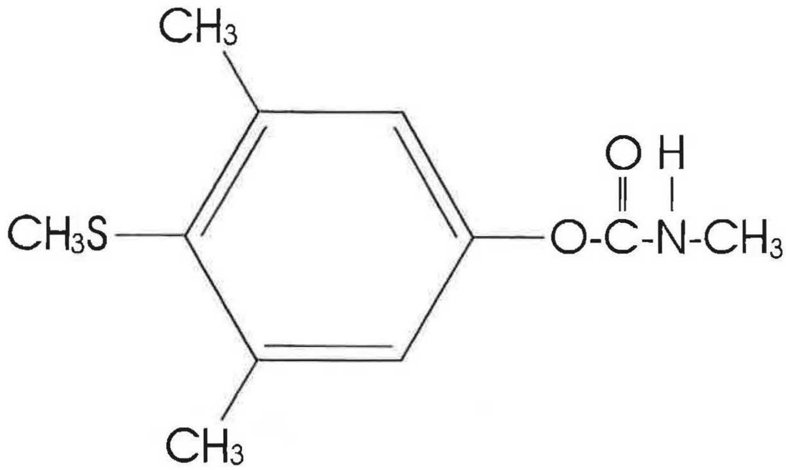
	Chickens	7.52 mg/kg
	Pheasants	1.37 mg/kg
Acute dermal LD50	Rats	4–90 mg/kg
	Rabbits	16–33 mg/kg

Methiocarb

A carbamate bird repellent, molluscicide and insecticide of moderate mammalian toxicity. Degradation in soil and in light is rapid, the half-life being 7 days with little residue remaining after 14 days. Very toxic to fish. Extensively used in the United States as a bird repellent. In Africa many field trials have been undertaken and a VAR of 2–3 kg/ha has been established as optimal. Formulations applied to flood irrigated crops and crops maturing in the dry season do not require a sticking agent but those applied to rainfed or overhead irrigated crops do. In Senegal applications of methiocarb have doubled yields of sorghum crops and in the Sudan three successive applications to sorghum and wheat have reduced damage by birds from 85% to 30% in experimental situations. Methiocarb is a cholinesterase inhibitor.

Chemical name and active ingredient: 3,5 – dimethyl 4 – (methylthio)-phenyl methyl carbamate

Structural formula:



Trade name: Mesurol, Bayer 37344

Formulations: For use as a bird repellent 50% and 75% wettable powders

Physico-chemical properties:

Characteristics: Colourless crystals with a phenol-like odour

Solubility: In water 27 mg/l (20°C). In dichloromethane >200, isopropanol 50–100, toluene 20–50, hexane 1–2 (all in g/l at 20°C).

Stability:	Unstable in highly alkaline media. Photodegradation contributes to the overall elimination of methiocarb from the environment.	
Volatility:	Practically immeasurable. Vapour pressure 0.015 mPa.	

Toxicity:

Acute oral LD50	Rat (m)	52–58.0 mg/kg
	Guinea-pig (M)	40.0 mg/kg
	Dogs	25.0 mg/kg
	Mallard (M)	7.1–9.4 mg/kg
	Japanese Quail	5–10.0 mg/kg
	House Sparrow	10–32.0 mg/kg
	Quelea	4.2 mg/kg
Acute dermal LD50	Rat (M)	200–400 mg/kg
Inhalation LC50	Bobwhite Quail	7 days no signs of toxicity as birds were repelled.
	Bluegill Sunfish	96 hours: 0.754 mg/kg
	Rainbow Trout	0.436–4.7 mg/kg
	Golden Orfe	3.8 mg/kg

Not toxic to bees

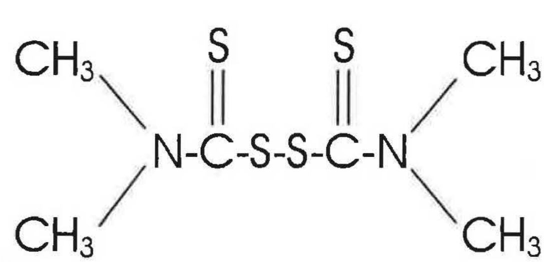
Thiram

Thiram is a well known contact fungicide. It has a low mammalian toxicity when given orally to rats. It is irritant to the skin and eyes and is very toxic to fish. When fed to chickens at 35 ppm it inhibited egg laying.

Thiram is repellent to birds, hares and rodents. It is inexpensive but, to date, little is known of its repellency to African granivorous birds. A field trial in Senegal suggested that it was unpromising. Its fungicidal properties alone make it a useful seed dressing chemical and, even if only mildly bird repellent, its use where sown seeds are eaten by birds should be of some benefit.

Chemical name of active ingredient: Tetramethylthiuram disulphide

Structural formula:



Trade names:	Arasan 42-5, TMTD
Formulation:	80% wettable powder

Physico-chemical properties:

Characteristics:	Colourless crystals
Solubility:	In water, 18 mg/l (room temperature). In hexane, 0.04, toluene, 18: dichloromethane, 170: isopropanol, 0.7 (all in g/l at 20°C).
Stability:	Decomposed in acidic media. Some deterioration on prolonged exposure to heat, air or moisture.
Volatility:	Vapour pressure 2.3 x 10^{-3} Pa (25°C)

Toxicity:

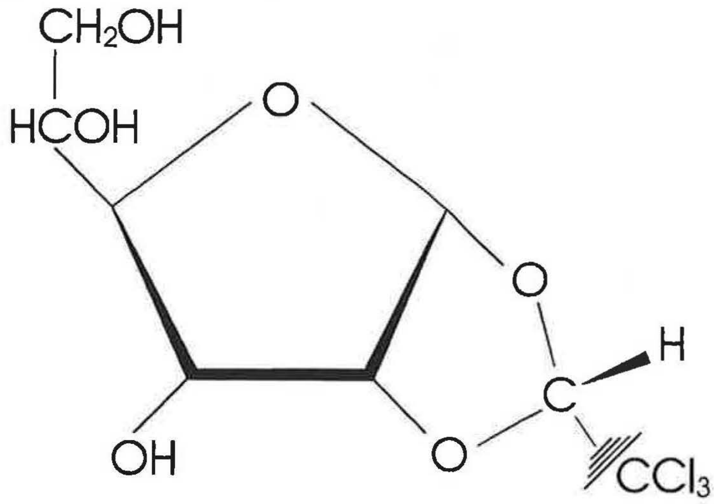
Acute oral LD50:	Rats	1800 mg/kg
	Mice	1500–2000 mg/kg
	Rabbits	210 mg/kg
	Japanese Quail	695 mg/kg
	Redwing Blackbird	300 mg/kg
Acute dermal LD50	Rats	>1000 mg/kg
	Humans	Application of the dry powder produced very slight erythema in 9% of cases
Inhalation LC50	Rats	4.40 mg/l air (4 hours)
	Bluegill Sunfish	0.23 mg/l water (48 hours)
	Trout	0.13 mg/l
	Carp	4.00 mg/l

Not toxic to bees

α-Chloralose

An organic rodenticide used as a narcotic which renders birds easier to kill by other means. Made up as a bait with grain or in water, narcotised birds are removed from areas where they are causing a problem. May have certain applications in Africa particularly in urban areas. Moderately toxic to mammals.

Structural formula:



Chemical name: (*R*)-1,2-*0*-(2,2,2-trichloroethylidene)α–D-glucofuranose

Trade names: Alphakil, Glucochloralose, Chloralose

Formulation: 97% powder

Physico-chemical properties:

Characteristics:	Crystalline powder
Solubility:	In water 4.44 g/l (15°C). Soluble in alcohols, diethyl ether and glacial acetic acid. Sparingly soluble in chloroform. Practically insoluble in petroleum ether.
Stability:	Converted by acids and alkalis into glucose and chloral. Stable in water.
Volatility:	Negligible at room temperature

Toxicity:

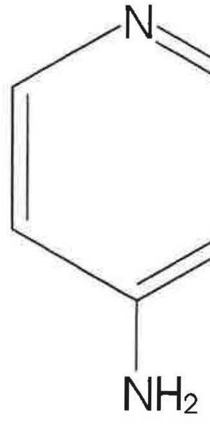
Acute oral LD50	Rats	400 mg/kg
	Mice	32 mg/kg
	Quelea	90 mg/kg
	Golden Sparrow	95 mg/kg
	Pigeon	130 mg/kg
LD90	Quelea	1.3 g/l water

4-Aminopyradine

An organic compound which acts as a bird repellent by inducing abnormal behaviour in affected birds which alarms other birds of the same flock so that they leave the area. Highly toxic to mammals.

Used as a bait in treated grain. Only a small proportion of the grains in a bait is treated so that only a few of the birds feeding on the bait will be affected. Over baiting, or dosage, will kill the birds. Frequently used around airports.

Structural formula:



Trade name: Avitrol.

Formulations: 25% miscible concentrate, 50 % powder and various made-up baits

Toxicity:

Acute oral LD50	Rat (M)	20.00 mg/kg
	Quelea	5.62 mg/kg

Aluminium Ammonium Sulphate

Sulphate of ammonia is applied at the rate of 5 to 10 kg/ha as a repellent. Damage to sorghum has been reduced by 9% and 22% by its use experimentally. Harmless to mammals.

Commercial names: Curb, Cropguard

NOTES

[1] ULV. This spray technique was developed in East Africa in the late 1940s for the control of the Desert Locust by aerial spraying using DNOC in dieseline. It was first used for aerial spraying of crops in 1963 for the control of cotton insects with malathion. Control of Quelea by ULV was first undertaken in 1971 in Nigeria.

[2] μ is the symbol for microns, the unit of measure of the volume median diameter (vmd) of droplets measured in micrometres (μm). 1μ is equivalent to one millionth of a metre (10^{-6}m).

[3] ULV application generally implies a volume application rate (VAR) between 0.5 and 5 1/ha. The low volume applied is usually atomised to produce droplet sizes within the range 30–150 μm which form a spray cloud.

Useful References

All the information on Quelea birds has been brought together in two books published in 1989. Either of the books should be referred to when further information is required about this bird, which is the most destructive in terms of cereal losses in the Afrotropical region. Information on other bird pests is scattered through the literature and is in separate papers in local journals published throughout Africa. It would be tedious to make a reference to all the papers and those seeking information on any of the birds causing damage in their area are recommended to seek the advice of local ornithologists, most easily found through the National Museums of their country.

Identification of the birds which may occur in cereal crops is superficially covered in the handbook but there are variations in many of the species through their range. It is recommended that reference be made to local field guides if any difficulties are encountered. Some of the more widely available guides are listed below.

Finally reference is made to three guides which contain more detailed information on the principles of aerial spraying than is contained in the handbook. The information will be useful for aircraft engineers and senior staff responsible for supervising aerial spray operations.

Textbooks on Quelea Management

Bruggers, R.L. and Elliot, C.C.H. (1989) *Quelea quelea: Africa's Bird Pest.* Oxford, U.K.: Oxford University Press.

Mundy, P. and Jarvis, M. (1989) *Africa's Feathered Locust.* Harare, Zimbabwe: Baobab Books.

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Ash, J.S. and Miskall, J.E. (1983) Birds of Somalia: their habitat, status and distribution. *Scopus, Special Supplement,* **1**: *1–97.*

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Carroll, R.W. (1988) Birds of the Central African Republic. *Malimbus,* **10**: 177–200.
Cave, F.O. and MacDonald, J.D. (1955) *Birds of the Sudan.* Edinburgh and London, U.K.: Oliver & Boyd.
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Irwin, M.P.S. (1981) *The Birds of Zimbabwe.* Harare, Zimbabwe: Quest Publications.
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Sinclair, J.C. (1984) *Field Guide to the Birds of Southern Africa.* Cape Town, R.S.A.: C. Struik.
Williams, J.G. and Arlott, N. (1980) *A Field Guide to the Birds of East Africa.* London, U.K.: Collins.

Control Procedures

Elliot, C.C.H. and Allan, R.G. (1979) Quelea control strategies in practice. Chapter 22. In: *Quelea quelea, Africa's Bird Pest.* (Bruggers, R.L. and Elliot, C.C.H., eds). Oxford, U.K.: Oxford University Press.
FAO (1979) *Crop Protection Manual—African Grain-eating Birds.* Rome, Italy: FAO/UNDP Publication AGOA, RAF/73/005.
FAO (1996) *Pesticide Storage and Stock Control Manual.* Rome, Italy. Field document GCP/INT/572/NET (M.P.K. Lambert, NRI).
FAO (1993) *A Guide to Migrant Pest Management in Africa.* (W.F. Meinzingen) Nairobi, Kenya: General Printers.
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Environmental Impact Assessment

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Annex

The occurrence of a particular species of grain-eating bird in any particular location in the Afrotropical Zoogeographic Region is determined by a variety of factors which play a part in the bird's distribution.

The region can be divided in a number of different ways to describe the ranges of the various grain-eating birds. The simplest, and more usual, division of a region is into the compass points north, south, east and west. Unfortunately the shape of Africa, a rather fat seven, makes this division meaningless and a different geographical division is necessary. Five divisions have been used, namely west and northern central, eastern, west central, southern central and southern. This division is quite arbitrary but it does allow a sub-regional division which is more or less equivalent to some of the more important sub-divisions of climate and vegetation.

Another major division is the political one into the different countries which occur in the region. This is useful as anyone interested in identifying a bird can refer to the field guide for the country in which it has been seen and eliminate from consideration those which are known not to occur there. It also allows reference to be made to the national check-list to find out what the range of any bird is within the borders of the country.

A third most important division of the region is the physical division into areas such as islands, coasts, rivers, lakes, altitude which is divisible into zones of altitudinal range (i.e. sea-level–500 m, 500–1000 m altitude, 1000–1500 m and > 1500 m), rift valleys and such features as deserts and swamps. The divisions in this case are all self-explanatory and easily identifiable from a physical map of the area.

Divisions which are more meaningful in the distribution of birds are those of climate and vegetation. The most influential climatic element is rainfall and, as this is the principal factor affecting vegetation, it is the best indicator of the habitat most likely to be occupied by certain birds such as the grain-eaters.

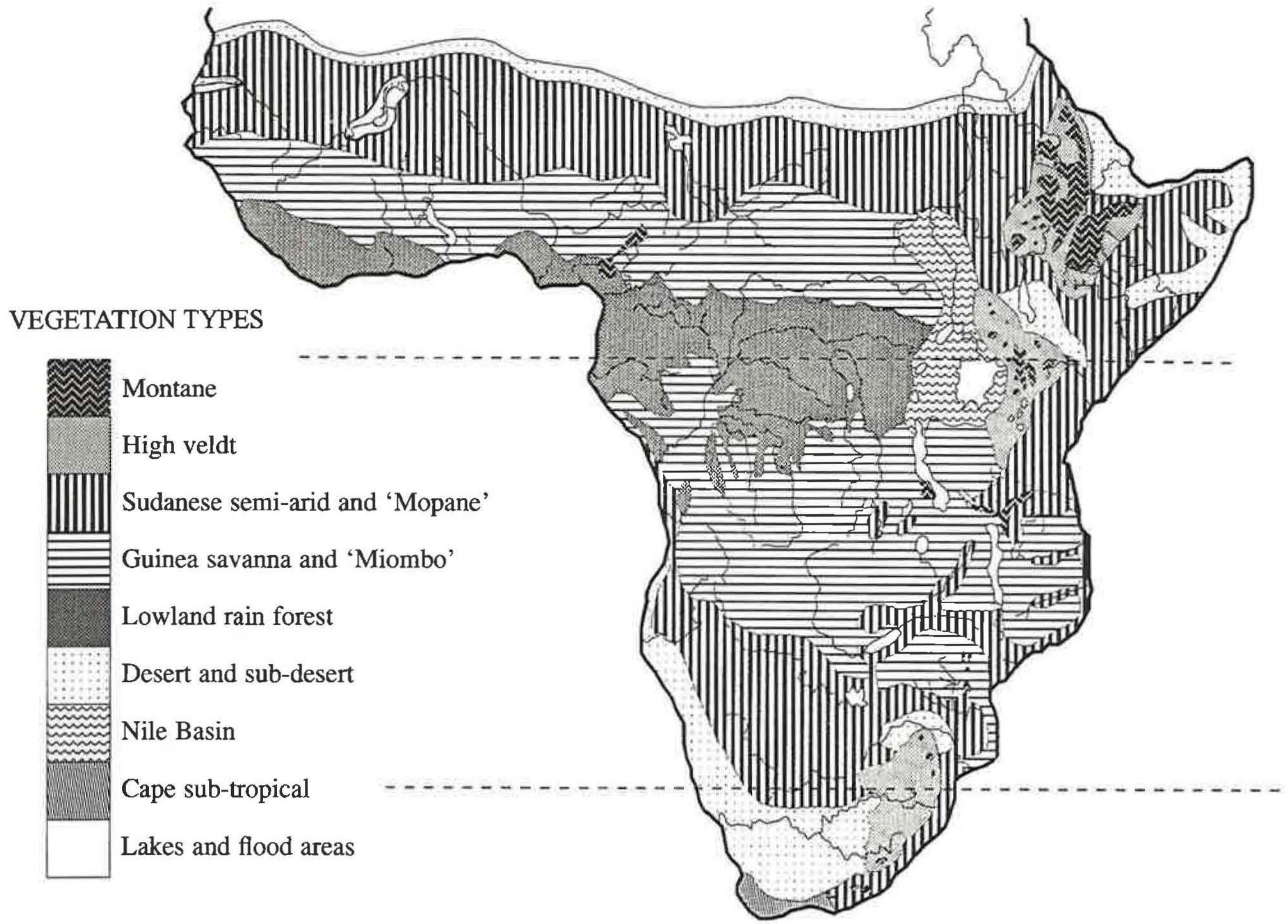
Average Annual Rainfall (mm)	Vegetation Type	Climatic Type	Dry Season
< 250	Arid	Desert	11–12 months
100–250	Sub-desert scrub	Desert edge	> 8 months
250–500	Acacia short grass savanna	Sahelian Zone (arid)	7–8 months
500–1000	Acacia tall grass savanna	Sudan Zone (semi-arid)	5–7 months
1000–1500	Deciduous wooded savanna	Guinean Zone (sub-humid)	4–5 months
1500–3000	Forest	Humid Zone	2–3 months
>3000	Tropical rainforest	Super-humid Zone	none

In West and northern-central Africa the rainfall follows a comparatively straightforward north-south banding of increasingly dry belts starting from the south coast, where the annual rainfall is some 2000 mm on average, and ending up at the limit of the Afrotropical region where the rainfall averages only 250 mm annually. The rainfall bands correspond, more or less, to the vegetation bands so that the descriptive names in the table are to some extent interchangeable.

Within this sub-region there are three important flooded areas which are very important agriculturally and where grain-eating birds are abundant. They are the Senegal River Basin, the interior delta of the Niger River in Mali, and Lake Chad. All three areas are in the Sahel but carry an abundance of vegetation as they are independent of the capricious Sahelian rainfall due to the seasonal flooding.

The situation is much more complex in the East African sub-region due to the extensive areas over 2000 m in height and coastal monsoon rains from the Indian Ocean. The sub-region also straddles the equator with the result that the Inter-Tropical Convergence Zone brings rains twice in the year (*bimodal* rains) to much of the area as it passes north and south over the equator. From the Red Sea Coast in the Sudan a thin coastal fringe of arid country extends down into Somalia where it widens into an area covering the whole of the Horn of Africa. This arid zone thins out again as it continues southwards into Kenya where it finally ends in a broad zone in the north terminating at Lodwar to the west of Lake Turkana. The Sudan zone more or less ends on the boundary of the Sudan with Ethiopia, Kenya and Uganda where a bimodal rainfall zone separates it from the arid tongue stretching down from Somalia. The zone of bimodal rains in East Africa includes the highlands bordering the eastern and western Rift Valleys and peters out southwards down the Tanzanian coast. The Nile Basin is an extensive flat swampy area of this sub-region characterised by comparatively high rainfall and humidity combined with a relatively short dry season. Several of the great lakes of Africa are in the basin: Lake Victoria, Lake Albert, Lake Edward and Lake Kyoga.

In southern-central and southern Africa the Sudan zone is replaced by the sparse leguminous [*Brachystegia* (5 spp.) and *Jubernardia* (2 spp.)] woodlands of the Miombo between 5° and 17° south. The hotter and dryer low-lying parts of Zambia, Zimbabwe, northern Botswana and the Transvaal compare with the Sahel and are characterised by Mopane (*Colophospermum mopane*) woodland. Southwards and westwards from central Botswana, an arid area extends to the west coast continuing up into Angola. This desert area is fringed on the landward side by semi-desert in the same way as the southern Sahara is fringed by semi-desert.



Map 2 African vegetation zones

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Page numbers in bold indicate illustrations.