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DIETS OF THE RED-BILLED QUELEA (QUELEA QUELEA) IN THE AWASH RIVER BASIN OF ETHIOPIA

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INTRODUCTION

An understanding of the feeding ecology of the red-billed quelea *(Quelea quelea)* is necessary for a comprehensive assessment of the potential impact of this species on cereals development. Queleas are reported to subsist primarily on wild Gramineae (Ward 1965a; Gaston 1976), but their mobility and tendency to feed in large aggregations readily adapts them to becoming a major cereal crop pest (Dyer & Ward 1977). Currently, conflicting evidence exists as to the factors involved in attacks on cereals and the relationship of depredation to the availability of wild foods. In Nigeria, Ward's (1965a) findings indicated queleas prefer small wild grass seeds, with cultivated sorghum being extensively damaged only when the supply of grass seeds was depleted. In Ethiopia, however, Jaeger, Erickson & Jaeger (in press) have found queleas dispersing from grassland regions into areas of cereals cultivation where appreciable damage occurs to ripening sorghum at a time when wild grass seeds should be abundantly available. At present the factors affecting depredation of cereals are poorly understood.

This paper examines the overall diets of *Quelea quelea aethiopica* (Sundevall) by sex and age in relation to depredation of the five cereals cultivated in the Awash River Basin and in terms of the types and sizes of food items eaten. Samples were collected over a one-year period from two ecologically diverse agricultural zones of the Basin, and findings are compared with those of Ward (1965a) from a considerably different ecological setting in the Lake Chad zone of Nigeria.

STUDY AREAS

The Awash River Basin, 70,000 km^2, is conventionally divided into four ecological zones; tropical highlands, 1800 m and above; hot subtropical, 1100-1800 m; semi-arid, 600-1100 m; and arid, below 600 m (F.A.O. survey 1965). Sampling sites were established in both the hot subtropical and semi-arid zones. The hot subtropical zone sites were located in the upper Awash River region (Fig. 1). The area is intensively cultivated with rainfed cereals: maize *(Zea mays)*, tef *(Eragrostis tef)*, sorghum *(Sorghum biocolor)*, wheat *(Triticum durum)*, and barley *(Hordeum vulgare)*. Natural vegetation includes scattered Acacia spp. and prevalent Gramineae of Paniceae and Andropogoneae. The long-term rainfall average is 820 mm per year, with the main rains falling from late June into September; an erratic short rains period occurs from March to May in most years. The elevation of the area ranges from 1500-1700 m.

The semi-arid zone sampling sites were located in the middle Awash River region. The area is characterized by extensive tracts of dry bush and short-grass savanna with prominent vegetation of thornbush scrub *(Acacia* spp.), shrubs of *Cadaba rotundifolia*, and common Gramineae of Chloridaea, Eragrostideae, and Panicaea. Cultiviation, limited to the Awash River floodplain, consists primarily of cotton production on irrigated state farms, with maize grown on small tracts at times. The general elevation of the area is 750 m. The yearly rainfall average is 520 mm with the main rains in July and August; the early rains period from February through March is extremely variable and unpredictable.

METHODS

Data were collected from May, 1977 through April, 1978, alternating months between the hot subtropical and semi-arid zones. Each month three sites were selected for collecting; however, in some months samples could be obtained from only one or two sites.

The birds were collected with nylon fowling nets (3.2 cm mesh, 12 x 2 m). Samples were obtained from birds entering night roosts whenever possible or from feeding assemblages and/or day roosts. Generally, 3-4 days were spent collecting samples at each site.

In most months 50 males and 50 females were collected at each site. Only those birds with one-half or more of the crop filled were used for food-sample analysis. An equal volume of food items from each bird's crop was extracted with a small plastic receptacle (c. 0.4 cc). Food samples were pooled by sex, and in months when juveniles were present samples were separated into both sex and age groups. Sex determination was by gonad examination, while age was determined by the extent of cranial pneumatization based on a 0-4 index (Ward 1973). Cranial indices of 0-2 were considered as juveniles, and indices of 3-4 classed as adults.

In the laboratory, food samples were subsampled according to the method described by Ward (1965a) for queleas. Each type of food item was sorted from the subsample by hand, counted, oven dried at 100ºC for 24 h to remove excess moistures and weighed (mg). The percentages of each food item by both weight and numbers were calculated. Seeds in the samples were identified by comparison with a reference collection established from seeding plants collected in the vicinities of sampling sites and by extraction of seeds from herbarium collections.

For determination of the sizes of seeds eaten, 1000 seeds of each type were oven dried (100ºC for 24 h) and weighed (mg); and 50 seeds of each were measured (length x width mm^2). Seed dimensions less than 2 mm in size were measured to the nearest 0.1 mm on a micrometer slide, while those with greater dimensions were measured with a vernier calipers. Seed-size categories were chosen on the basis of discernable differences in the sizes and weights of the seeds and parallel Ward's (1965a) class limits.

RESULTS

Seasonal distributions of queleas

Semi-arid zone

Quelea samples were collected in all sampling months, but seasonal fluctuations in numbers were apparent. Queleas were most numerous in the rainy season, as birds from both zones congregated in the area prior to breeding. A quantitative comparison of the numbers occurring across both zones could not be assessed during the study year; but an indication of the relative numbers was obtained in 1978, when three breeding colonies were located and measured, with over 7,000,000 adults and young present (Erickson in prep.). However, it is likely one or two other colonies may have have been undetected. In the early dry season a post-breeding dispersal from the area occurred, with adults leaving before juveniles; but by December the birds were returning to the area in low numbers. The population, largely males, continued to increase through the dry season until April, when few birds were present in the sampling area as the study terminated. Possibly the birds remained somewhere in the semi-arid zone, as large, late dry-season aggregations have been recorded in the area in 1976, 1977, and 1979.

Hot subtropical zone

In the hot subtropical sampling zone queleas were present throughout the year, and population fluctuations were not as notable as in the semi-arid zone. Numbers were relatively low in the main rains but increased considerably in October, as birds dispersed from the semi-arid zone breeding colonies. Both sexes were present in equal numbers throughout this period. As the dry season progressed, fewer queleas appeared to be in the sampling area. The population present significantly favored females at a time when males prevailed in the semi-arid zone (Jaeger, Erickson & Jaeger in press).

Yearly diets

Food items

During the study year, across both ecological zones, queleas consumed some 30 types of wild grass seeds, all five cultivated cereals, 10 non-grass seed items, and insects, primarily beetles (Coleoptera) and grasshoppers (Orthoptera). Those food items, comprising 1.0% or more of the yearly diets within each sampling zone, are presented in Table 1. Between sampling zones, a wider range of food items was eaten in the hot subtropical zone where cereals comprised a substantial proportion of the diets. Cereals were eaten in large quantities in five of the six sampling months, but most were gathered off the ground. Tef and wild grass seeds of *Sorghum* spp. accounted for the major share of the diets in this zone. In the semi-arid zone, the diets were confined mainly to wild grass seeds with *Echinochola* spp. proliferating in irrigated fields and ac-

counting for nearly one-half of the yearly diets. Maize also was eaten but, although ripening in several months, was taken largely in the month after harvest.

Seed sizes

The composition of the yearly diets, based on the sizes of seeds consumed, is illustrated in Figure 2 by both weights and numbers of size categories eaten within both zones. Insects are included by weight to depict their importance in the diets in comparison to the seeds eaten, Maize, and often sorghum, is eaten when unripe, so individual seeds could not be counted; both are disregarded by numbers of seeds eaten. In the hot subtropical zone a considerably wider range of seed sizes was eaten than in the semi-arid zone where small seeds predominated in the diets. Much of this difference resulted from the large consumption of minute tef seeds and very large seeds of sorghum, wheat, and barley in the hot subtropical zone.

Seasonal diets

Early dry season

The seasonal diets differed markedly between the two sampling zones, beginning in the early dry season. In the hot subtropical zone, the diets shifted to different food items and to a greater variety of seed sizes than were eaten during the rains (Fig. 3), with ripening sorghum, wild *Sorghum* spp. and tef seeds the principal foods eaten. Tef and wild *Sorghum* spp. continued to be major foods throughout the dry season; but small seeds of *Echinochloa colona* were eaten in considerable amounts at one collection site in January, while maize was eaten across all three sites. In the semi-arid zone, those few juveniles, which had not yet dispersed by late October, fed almost exclusively on *Echinochloa* spp. which was available in a maize field. As queleas began returning to this area in December, *Echinochloa* spp. and *Panicum meyerianum* were profusely seeding in the irrigated cotton fields; and these small seeds comprised the bulk of the diets until the late dry season. Maize also was eaten in this zone in February when doughy seeds were available on the ground after mechanical threshing of the crop.

Late dry season/short rains

By the late dry season/short rains, within both zones, the birds were consuming large amounts of several food items that were not previously eaten. Tef and wild *Sorghum* spp. were major foods in the hot subtropical zone; but the diets also encompassed larger seeds of ripened sorghum, wheat, barley, and ultra-minute seeds of *Eragrostis papposa.* In the semi-arid zone *Echinochloa* spp. was the primary food eaten during this period; but seeds of *Setaria acromelaena* also were consumed in large quantities in one month, and insects and large beetles were fed on at one site.

Wet season

During the main rains the food items eaten within both zones differed considerably from the dry season diets, being mostly small seeds of the fast maturing wild grasses, which begin seeding soon after the establishment of the rains. These were mainly *Tetrapogon'tenellus* and *Tetrapogon cenchriformis* in the semi-arid zone, while in the hot subtropical zone both *Tetrapogon* spp. were eaten along with *Echinochloa* spp., *Urochloa* spp., and *Setaria pallidifusca.* Tef was also an important food in July when seeds were gleaned from sown fields.

Intraspecific diets

By age

The diets of adults and juveniles were compared from sites where both age groups were collected together (Table 3). From the hot subtropical zone, this included two sites in November and one site in March; from the semi-arid zone, one site in December and two sites in February. Overall both age groups ate a large proportion of cereals, particularly juveniles, and fed on the same range of food items. Differences in the diets were most notable at one collection site in November when juveniles concentrated on tef seeds, while adults ate mostly ripening sorghum and wild *Sorghum* spp.; at one site in February juveniles ate substantially more maize than the adults. At all other collection sites there were no apparent differences in the diets between the age groups.

By sex

Within neither of the ecological zones were major differences evident in the diets between the sexes in the yearly totals (Table 1) or at individual collection sites. Both sexes consumed a considerable amount of cereals in the hot subtropical zone; and within each sampling zone, the sexes fed on the same range of food items.

DISCUSSION
Yearly diets

Food items

The results have depicted the importance of cereals in the queleas' diets, but most cereals were eaten after harvest and do not represent damage to the crops. Sorghum is the one cereal, however, which is commonly eaten and often appreciably damaged by queleas when susceptible as a standing crop. Sorghum is not widely grown in the hot subtropical zone sampling area because of the quelea problem, even though it is the cereal most suitably adapted to the low and erratic rainfall conditions. However, sorghum was an important food for queleas in this area, being eaten both when ripening and after harvest when seeds were gathered from bare fields and threshing floors. Ripening sorghum comprised nearly 4% of the yearly diets; and at one night roost in November, 80% of the diets of adults. Quantitative damage assessments undertaken on a 12 ha research field in the area depicted losses of over 36% of the crop in both 1976 and 1977 (Jaeger in prep.). In Nigeria, sorghum accounted for 4% of the yearly diet of queleas when damage was considered extensive (Ward 1965a). Sorghum was not grown in the semi-arid zone during the study year, but previous attempts at cultivation on state farms and research fields have consistently been depredated by queleas. In 1976/77, for example, 160 ha of sorghum was grown on a state farm in this zone, but attacks by queleas resulted in a loss of nearly 80% of the crop (Jaeger 1978).

Along the western and southern boundaries of the Basin and on the Jijiga plain to the east, major sorghum producing regions in the hot subtropical zone, ripening sorghum is commonly attacked by queleas dispersing from the semi-arid zone breeding grounds. Samples were not collected from these areas as part of the present study, but 12 samples obtained over three years in the early dry season have featured ripening sorghum as the principal food at this time. Damage in any one area may vary considerably from year to year; but it is estimated that the loss to grain-eating birds, primarily queleas, averages a minimum of 5% over the 150,000-200,000 ha of cultivated sorghum associated with the Awash River Basin (Jaeger pers. comm.).

Tef was a major food of queleas in the hot subtropical zone where the cereal is widely grown; but despite its importance in the diets, it was not found to be depredated as a standing crop. Tef seeds were taken in greatest amounts after harvest when seed was available on bare fields, stacked piles, and at threshing sites. It is surprising that tef was not eaten in September when ripening; but at this time the seeding of wild grasses was at its peak, and the birds concentrated on the abundant seeds available on the ground. Although queleas have been seen feeding on standing tef (Jaeger pers. comm.), depredation would probably be serious only in intermittent years when the production of wild grass seeds is low, a situation which has been reported for other cereals (Williams 1954; Disney & Haylock 1956; Ward 1965a). Tef also was gleaned from fields in July, when the uncovered sown seeds appeared to provide an easy food supply; however, the effect of this depredation on the germination of the crop is not known.

Maize was eaten in significant amounts in both sampling zones of the Basin, but queleas are apparently not a major depredator of this cereal. Although maize was the third most commonly consumed food item in the semi-arid zone, it was eaten largely in one month when doughy kernels were available on the ground after mechanical threshing of a small field of 50 ha. In the hot subtropical zone maize was not eaten when ripening, even though widely grown in the area; it was taken in major quantities only in the mid-dry season, long after harvest. Moreover, ripening maize can only be fed on by queleas when the cobs are opened by larger pest species, such as *Ploceus cucullatus;* and in such instances the maize seems to be damaged more by the larger bird pests, insects, and rot from rains, than by queleas.

Wheat and barley are grown in the hot subtropical zone but were not seen to be damaged when susceptible before harvest, as neither cereal was featured in the diets at that time. Both cereals were major food items in May, 1977 and March, 1978 in the late dry season. Wheat was also an important food in two dry season samples collected outside the study year. However, these months were long after the harvest season, the seeds presumably being gathered off the ground in harvested fields or at threshing sites. The fact that these cereals were not eaten when susceptible is of interest because in other areas of Africa, such as northern Tanzania, queleas do considerable damage to ripening wheat (Ward pers. comm.).

Both Ward (1965a) and Gaston (1976) have stated that the normal foods of queleas are small, wild, grass seeds, primarily Paniceae types such as *Panicum, Echinochloa, Setaria,* and others which abound on wet, fertile soils. This was not the situation in the hot subtropical zone, where cultivated seeds and other grass types comprised the bulk

of the diets. Unseasonal rains may have affected the types of foods available in this zone during the study year, as will be mentioned later, but cereals and wild *Sorghum* spp. have commonly been major foods in samples collected prior to the study year. Small wild seeds of Paniceae were eaten throughout most of the year in the semi-arid zone where seasonal distributions and feeding habits of queleas appear to be greatly influenced by the abundance of these grasses in irrigation schemes. Vast areas of natural grassland were utilized by queleas only during the late dry season and during main rains when seeds were not available in the irrigated fields. At present there are over 12,000 ha under irrigation in this area, and projections are for more than 115,000 ha over both the semi-arid and arid zones (Awash Valley Development Authority pers. comm.). It is also note-worthy that one breeding colony located in 1978 was associated with an irrigated farm where the abundance of *Echinochloa* spp., and insects in 750 ha of cotton fields provided a food supply for more than 3,000,000 adults and young (Erickson in prep.).

Non-grass seeds and insects were eaten by queleas within both zones but were of little importance in the yearly diets. Similar to Ward's (1965a) findings in Nigeria, only one non-grass item was eaten in significant quantities over the year. Insects did feature in the yearly diets in the semi-arid zone but were taken largely in one month, at one of two sites, only, by a small sample of birds (n = 30), and were probably an insignificant food for the total population present in the area. In neither study zone were samples collected in the early wet season when swarming termites have been found to be an important food in other regions of Africa (Ward 1965a; Ward & Jones 1977). However, insects were eaten by fledgelings collected at a breeding colony in 1978. Here, grasshoppers and small beetles comprised 10.8% of the diet, indicating they are of importance for queleas during the breeding season when higher levels of protein and specific amino-acids are required (Ward 1965b; Jones & Ward 1976).

Seed sizes

No preference for any specific seed-size category was evident from the findings of the present study. In Nigeria, Ward's (1965a) study indicated that queleas prefer small seeds, while in cage trials larger seeds of 8-15 mg have been preferred (Manikowsky & DaCamara-Smeets 1975). However, it appears that seed selection also is determined to a great extent by other factors, including the quantities and possibly the qualities of items available. The biomass of available seeds in concentrated patches is probably the major factor governing seed selection, and this is dependent on both the sizes and densities of prey (Royama 1970). The prevalence of small seeds of *Echinochloa* spp. and *Panicum meyerianum* in the semi-arid zone diets was certainly related to their densities in the irrigated fields, where these grasses predominated in dense stands. The wide variety of seed sizes eaten in most months in the hot subtropical zone also suggests that queleas, similiar to redshank (Goss-Custard 1977), will select the combination of size classes that provide higher rates of intake than any alternative selection.

The nutritional requirements of queleas, of which little is known outside the breeding season, might also have an influence on the choice of seed items. The nutritional composition of most of the foods eaten by queleas is not known, but differences probably exist. Sorghum, for example, contains 7.6% protein (Agren & Gibson 1968), while some *Panicum* spp. reach 14%; and differences may also exist between seed types in vitamins, metals, specific amino-acids, and other qualities (Ward pers. comm.). Overall, it is likely that the foraging strategy of queleas favors the selection of seed sizes and types which are of most benefit in quickly and efficiently fulfilling food requirements.

Seasonal diets

Early dry season

In Nigeria, Ward (1965a) found that the small wild Paniceae seeds eaten during the rains continued to be fed on by queleas well into the dry season; and other foods, including ripening sorghum, were eaten mainly when the preferred foods became scarce. Within the hot subtropical zone, the extreme change in diets by November also was likely aggravated by a scarcity of the previously eaten seeds. The early-maturing grasses were seeding in profusion in September, but the seeds were covered and germinated in the high rains of October. The subsequent lack of rainfall resulted in a relative scarcity of these seeds throughout the dry season, and the birds shifted to the available cultivated seeds and later-maturing wild seeds. It is uncertain whether this change in diets is a regular occurrence; but, in other years when the rains normally end in early September, sorghum is commonly a principal food of queleas when ripening in October-November.

In the semi-arid zone queleas dispersed in the early dry season, even though the small grass seeds eaten during the rains remained available and grasses were beginning to seed in the irrigated fields. The adults might have dispersed to search for suitable

areas to breed again (Ward 1971); but there was no evidence to indicate this, as both adults and juveniles moved into the sorghum growing regions. Possibly this dispersal might be a traditional movement related to past experience of a more profitable food supply. Examination of the daily crop-filling patterns did indicate that queleas fed better during this period of cereal depredation than at any other time of the year. As the birds began returning to the semi-arid zone in December, they concentrated entirely on the abundant supply of grass seeds available in the irrigated fields.

Late dry season/short rains

In the hot subtropical zone diets, the inclusion of several important food items not eaten in other seasons did suggest that previously eaten foods may have been becoming scarcer. In both the late dry season/short rains of 1977 and 1978, the birds spent considerable time feeding on ultra-minute seeds which, by numbers, were eaten in large amounts; but being so small, they contributed little to the total food intake. In both years the large amount of cereal detritus still available probably helped to sustain queleas through the late dry season/short rains when the wild foods were becoming scarcer.

The availability of grass seed appeared to greatly influence the late dry season distribution of queleas in the semi-arid zone. Cotton fields were cultivated by the late dry season, but the presence of irrigated maize in 1977 provided a plentiful supply of small seeds in the fields, and the numerous queleas concentrated on these. In 1978, maize was not grown at this time and the few birds which did not leave the area were having difficulty finding food. Yet, the largest roost of queleas observed in this zone over four years was recorded in April-May, 1979. The birds were feeding entirely in grassland and there was no evident food shortage. Apparently the late dry season food situation can vary markedly from year to year.

Wet season

Contrary to findings in the Lake Chad Basin, there was no evidence to indicate that insects or non-grass foods were important in the queleas' diets in the early wet season, when shortages of grass would likely be critical (Ward 1965a). However, data is inconclusive as samples were not collected within either zone as the rains were beginning. Yet, collections during the main rains did suggest it may have been a difficult period for the birds. In both zones, the majority of grasses were only beginning to ripen in July-August, with crop-filling patterns indicating the birds were having difficulty finding foods. In the hot subtropical zone, however, the sowing of the tef crop did provide an additional food source at a time when other cereals and seeds of later-maturing grasses were not yet available.

Intraspecific Diets

By Age

The differences, which occurred in the diets between age groups at two of the six collection sites, are probably not indicative of any major differences in feeding habits, based on the types or sizes of foods eaten. Although adults did consume more ripening sorghum, this was not consistent with findings in other years when feeding flocks of juveniles have often been found feeding mainly on sorghum. In 1976, for instance, juvenile aggregations had tremendous impact on ripening sorghum on the Jijiga plain, resulting in a loss of more than 40% of the crop over 4000 ha assessed (Jaeger 1978). In all likelihood, differences in the diets at two collection sites in the present study arose from the segregation of feeding flocks between age groups emanating from a common roost. Differential dispersal of age groups from breeding colonies and feeding flocks and roosts of predominently one age group have been commonly recorded in the Awash River Basin (Jaeger, Erickson & Jaeger in press). The reasons for this segregation are still unclear; but, over the three years recorded, it has not resulted in any overall differences in the kinds of foods eaten by adults and juveniles.

By Sex

There were no major differences in the diets between the sexes within either zone to suggest that the sexes feed on different foods at any time of the year. However, feeding flocks of predominently one sex were commonly found within both zones, and between zones there was an increasing imbalance in the sex ratio as the dry season progressed (Jaeger, Erickson & Jaeger in press). Ward (1965c) noted an increasing percentage of males in the population in Nigeria as the dry season progressed and postulated that the larger males were able to out-compete females when food resources were limited. Supporting evidence for male dominance in feeding encounters was provided by Dunbar and Crook (1975). The reasons for sexual segregation in the Awash Basin are still not understood, but between zones it does result in an overall difference in the relative amounts of the foods eaten by the sexes. Additionally, recent findings from southern Ethiopia have denoted segregation between the sexes. Here, males were found feeding

in large aggregations, while females were feeding in smaller, scattered groups and on different food items (Jaeger & Erickson in prep.). Possible segregation might come about due to different food requirements of the sexes, but more information is needed before this can be determined.

SUMMARY

(1) Queleas were found to eat a wide variey of seed types and sizes, including wild grass seeds of *Echinochloa,* wild *Sorghum, Panicum, Tetrapogon, Urochloa, Setaria,* and cultivated cereals of sorghum, tef, maize, wheat, and barley. Seed selection appears to be influenced more by the availability of seeds in concentrated patches than by any specific preferences for a certain type or size of seed.

(2) In the intensively-cultivated, hot subtropical zone, all five cereals were eaten; but most were gleaned off the ground after harvest, and only sorghum sustained damage as a standing crop.

(3) The semi-arid zone diets were confined mainly to small wild grass seeds, particularly Echinochloa spp., which thrive in irrigation schemes. The abundance of grass seeds in irrigated cotton fields appears to influence not only feeding habits but seasonal distribution and breeding localities as well.

(4) In areas associated with the Awash River Basin, considerable damage occurs to ripening sorghum in the early dry season following a post-breeding dispersal from the semi-arid zone.

(5) Intraspecific diets differed more between age groups than between sexes. There was no evidence to indicate that the sexes feed on different foods within zones, but a partial segregation of sexes between zones throughout the dry season does result in an overall difference in the foods eaten.

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TABLE 1. Yearly diets of *Quelea quelea* by sex from hot subtropical and semi-arid zones of the Awash River Basin in 1977-78.

FOOD ITEM	By Percent Dry Weight			
	Hot Subtropical Zone		*Semi-arid Zone*	
	Male (n = 725)	Female (n = 803)	Male (n = 514)	Female (n = 432)
Cultivated seeds:				
Sorghum bicolor	11.7	7.6	-	-
Eragrostis tef	18.8	27.1	-	-
Zea mays	7.9	4.0	13.3	11.0
Triticum durum	6.7	5.3	-	-
Hordeum vulgare	1.6	2.2	-	-
TOTAL	46.7	46.4	13.3	11.0
Wild grass seeds:				
Sorghum spp.	22.5	21.3	3.8	2.2
Echinochloa spp.	8.0	5.6	40.9	44.8
Urochloa spp.	6.6	6.6	4.2	6.2
Eriochloa mayeriana	-	-	16.4	16.9
Eriochloa sp.	2.3	2.5	-	-
Tetrapogon roxellus	2.3	2.5	4.0	3.7
Tetrapogon cenchriformis	3.8	2.3	7.1	6.4
Eragrostis papposa	1.9	2.9	-	-
Setaria pallidifusca	2.9	4.4	-	-
Setaria acromelaena	-	-	2.0	2.7
Hyparrhenia anthistiroides	-	2.3	-	-
Cenchrus spp.	-	-	2.1	-
Unidentified seed 'b'	-	-	1.3	-
TOTAL	50.3	50.6	81.8	82.5
Non-grass seeds:				
Commelina sp.	1.0	1.4	-	-
Insects:	-	-	2.7	2.2

Note: Food items comprising less than 1.0% of the diet are not listed.

TABLE 2. Sizes and weights of the principal seed items eaten by *Quelea quelea* in the Awash River Basin.

Seed Type	*Seed Size* length X width (mm²)	*Seed Weight* gms/1,000
Ultra-minute:		
Eragrostis pappose	.4	.094
Portulaca sp.	.5	.094
Minute:		
Eragrostis tef	.8	.262
Digitaria velutina	.8	.199
Diplachne fusca	1.0	.237
Cynodon dactylon	1.2	.293
Small:		
Lintonia nutans	1.6	.493
Eriochloa meyeriana	1.6	.575
Echinochloa spp.	1.8	.764
Setaria pallidifusca	1.9	.716
Cenchrus spp.	1.9	.775
Setaria acromelaena	2.1	1.290
Unidentified seed 'b'	2.1	1.296
Tetrapogon cenchriformis	2.3	.800
Tetrapogon tenellus	2.4	1.005
Urochloa spp.	2.5	.880
Hyparrhenia anthistiroides	2.6	.869
Medium:		
Commelina sp.	5.7	5.640
Sorghum spp.	6.0	5.046
Very large:		
Sorghum bicolor	15.4	20.800
Triticum durum	18.6	24,153
Hordeum vulgare	21.8	15.160

TABLE 3. Diets of adult and juvenile *Quelea quelea* from sites in the Awash River Basin where age groups were collected together in 1977-78.

FOOD ITEM	By Percent Dry Weight	
	Adult (n = 442)	Juvenile (n = 375)
Cultivated seeds:		
Sorghum bicolor	13.2	4.5
Zea mays	10.0	24.3
Eragrostis tef	16.1	23.1
Triticum durum	1.2	1.5
TOTAL	40.5	53.4
Wild grass seeds:		
Sorghum spp.	18.5	9.4
Echinochloa spp.	14.1	15.1
Eriochloa meyeriana	13.3	16.4
Cenchrus spp.	1.1	---
Eragrostis papposa	2.1	1.0
TOTAL	49.1	41.9

Note: Food items comprising less than 1.0% of the diet are not listed.

Appendix 1. Collection sites from the hot subtropical and semi-arid zones of the Awash River Basin.

Hot Subtropical Zone

Saluki (Sl):A seasonally flooded grassland-woodland comprised of scattered *Acacia* spp. and a dense shrub layer of *Balanites aegyptica* which is commonly used as a roosting site. Gramineae consist primarily of *Echinochloa colona, Cynodon dactylon,* and *Eleusine floccifolia,* which are heavily grazed. *Sorghum arundinaceum, Bothriochloa radicans, Hyparrhenia anthistiroides, Setaria pallidifusca,* and *S. verticillata* are other common grasses. Maize, tef, wheat, barley, and sorghum fields surround the site.

Sodere (Sd):A state farm bordering the Awash River, cultivating citrus fruits and cereals of maize and tef with sorghum, wheat, and barley also grown in the vicinity. Small tracts of sugarcane and Napiergrass are often used for roosting. Prevalent grasses include *Sorghum* spp., *Digitaria scalarum,* and *Eragrostis* spp., with other grasses of *Urochloa panacoides, Echinochloa* spp., *Hyparrhenia anthistiroides, Eriochloa nubica, Panicum maximum,* and *Setaria* spp..

Tabila (Tb):A state farm along the Awash River, cultivating maize and tef with sorghum grown in nearby area. Grasses of *Sorghum* spp., *Urochloa* spp., *Cenchrus* spp., *Tetrapogon* spp., *Setaria* spp., and *Panicum atrosanguineum* are common.

Melkasa (Ml):An agricultural area, with seasonally flooded swamps, bordering the Awash River. Maize is the major cereal on the site, but sorghum, tef, wheat, and barley are grown in the surrounding area. *Sorghum* spp. abound along the swamp fringes, other common grasses including *Cynodon dactylon, Echinochloa* spp. *Urochloa* spp., *Digitaria scalarum, Setaria verticillata,* and *Eragrostis* spp..

Lake Koka (Ko):A woodland-scrub area of *Acacia* spp. adjacent to a large reservoir. Less agriculturally important than other sites but some maize and tef are grown in the area. Grasses of *Cynodon dactylon* and *Bothriochloa* spp. prevail on the site.

Semi-arid Zone

Melka Werer (MW):The site borders the Awash River adjacent to the Institute of Agricultural Research farm and consists mainly of scattered *Acacia* spp. with shrubs of *Salvadora persica* and *Cadaba rotundifolia.* Grass cover is sparse on the site, which seems to be used mostly by birds moving to roosting and watering areas.

Melkasadi (MS):A state farm, primarily producing bananas but with small tracts of maize grown throughout the year. Irrigated fields abound in grasses such as *Echinochloa* spp. and *Urochloa* spp. along with other common grasses of *Setaria verticillata, Eriochloa nubica, Paspalidium desertorum, Brachiaria eruciformis, Cenchrus ciliaris,* and *Sorghum* spp..

Ambash (Ab):A state farm cotton production, bordering the Awash River. In the irrigated cotton fields grasses of *Echinochloa* spp. flourish along with *Panicum meyeriana* and the less common *Sorghum* spp., *Urochloa* spp. and *Digitaria velutina.* Shrubs along the river are utilized as the major night roost in the area.

Belain (Bl):A tall reed-grass marsh surrounded by dry bush. *Diplachne fusca* and *Sporobolus consimilis* abound as aquatic grasses while *Echinochloa colona* and *Lintonia nutans* are less prevalent on the peripheries of the marsh. On the upland grasses of *Tetrapogon cenchriformis, Paspalidium desertorum, Dactyloctenium aegyptcum* and *Tragus* spp. prevail with scattered *Acacia* spp. and *Cadaba rotundifolia.* The marsh is occasionally used as a night roost.

Appendix 2. Habitats and distributions of the major grass species eaten by queleas in the Awash River Basin.

Cenchrus spp.:Both *C. ciliaris* and *C. setigerus,* perennials, occur in both ecological zones in open bush and grassland, with *C. ciliaris* being most common. Seeds not identifiable to species.

Echinochloa spp.:E. colona, an annual, occurs in both zones in swampy areas and seasonally flooded grassland, especially abundant in irrigated fields of the semi-arid zone. *E. haploclada,* a perennial is common in the semi-arid zone in similar habitats and possibly occurs in the hot subtropical zone. The species are difficult to distinguish and seeds are identical.

Eragrostis papposa:Perennial, occurring in the hot subtropical zone. Habitats unknown.

Hyparrhenia anthistiroides: Annual. Common in grassland and roadsides in the hot subtropical zone.

Eriochloa meyeriana:Perennial. On wet, black cotton soils, particularly abundant along ditches of irrigated fields in the semi-arid zone.

*Setaria acromelaena:*Annual. Common on brack, waterlogged soils in grassland of the semi-arid zone.

*Setaria pallidifusca:*Annual, growing as a very common weed of arable land in the hot subtropical zone.

Sorghum spp.:Species are difficult to identify as many hybridize, but *S. arundinaceum* is apparently the commonest. On arable land and swamp fringes.

*Tetrapogon cenchriformis:*Annual or short-lived perennial. Abundant in dry bush in the semi-arid zone; less common in the hot subtropical zone.

*Tetrapogon tenellus:*Annual, common in the semi-arid zone in dry bush and on rocky ground; uncommon in the hot subtropical zone.

Urochloa spp. *panacoides,* an annual, is common in both zones on sandy soils and loams, grassland, and as a weed of arable land. *U. pullulans,* a perennial, is also common in the semi-arid zone. Seeds are not identifiable to species.

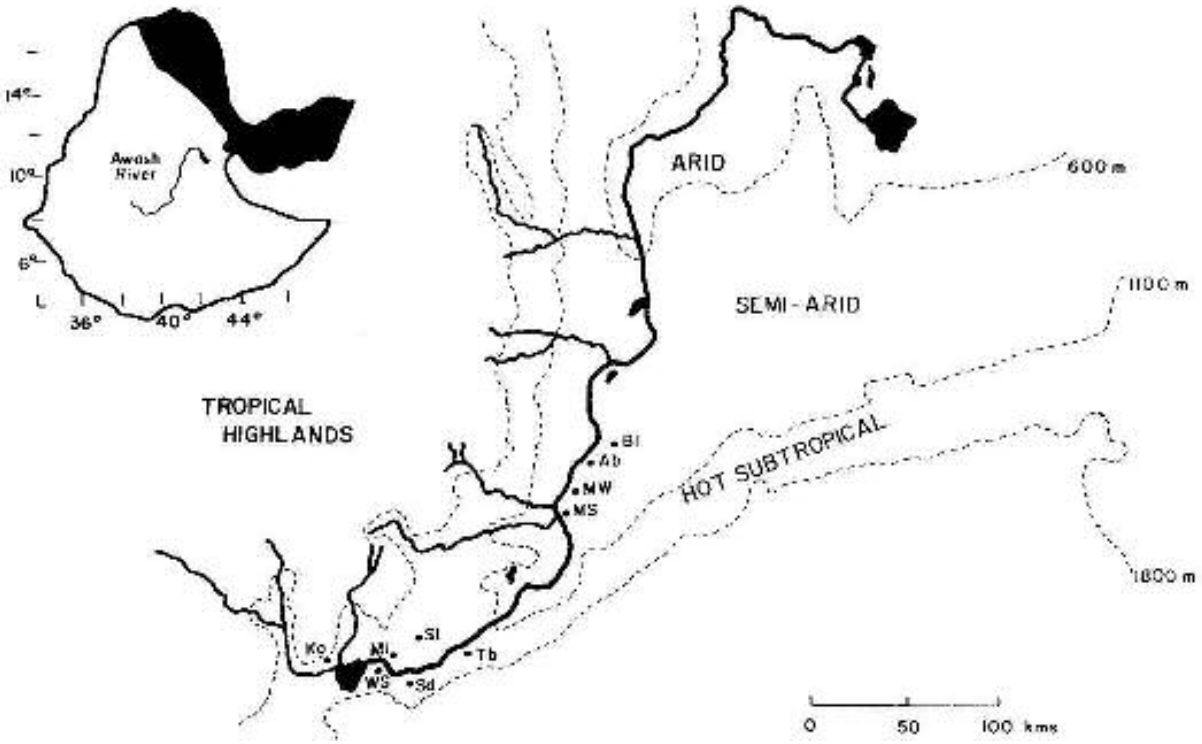

FIGURE 1. Map of the Awash River Basin with *Quelea quelea* collection sites Ko, WS, M1, Sd, S1, and Tb in the hot subtropical zone and sites MS, MW, Ab, and B1 in the semi-arid zone.

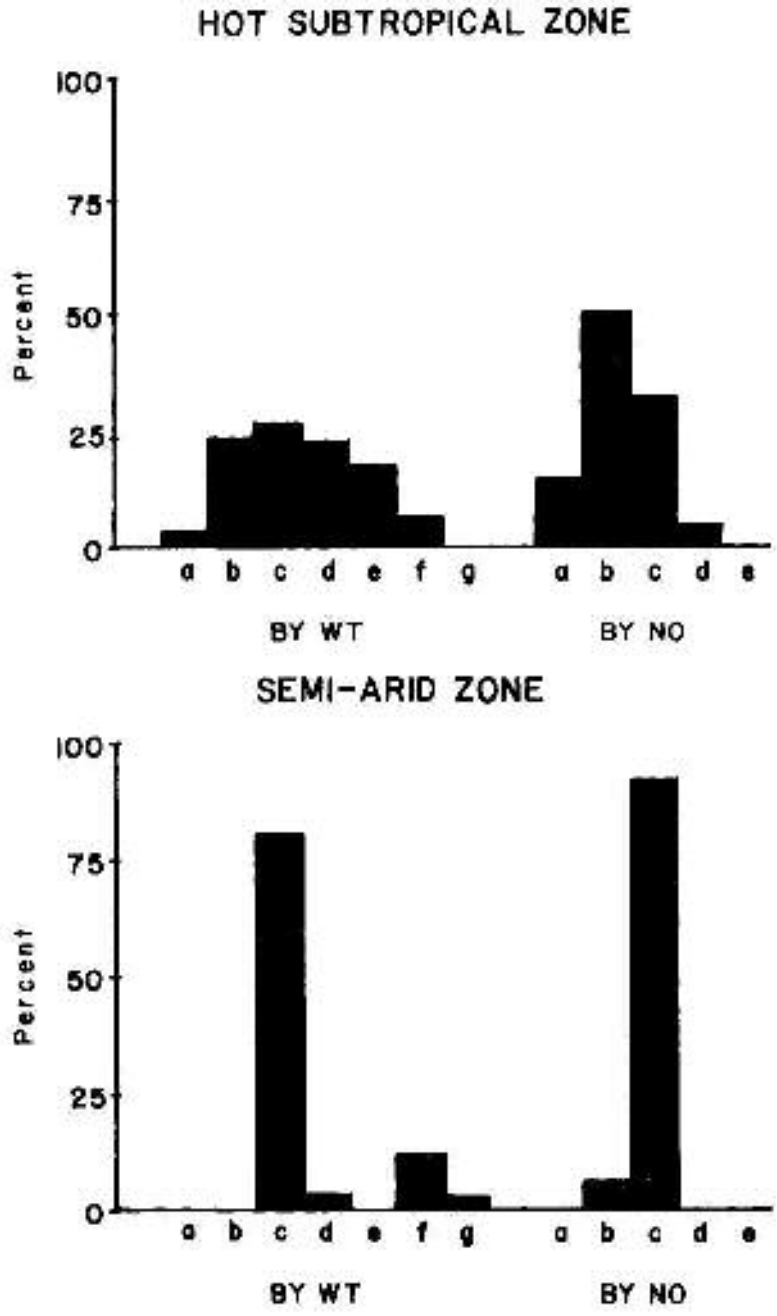

FIGURE 2. Yearly seed-size categories eaten by *Quelea quelea* from the hot subtropical and semi-arid zones of the Awash River Basin in 1977/78: (a) Ultra-minute, (b) Minute, (c) Small, (d) Medium, (e) Very Large, (f) Maize, (g) Insects.

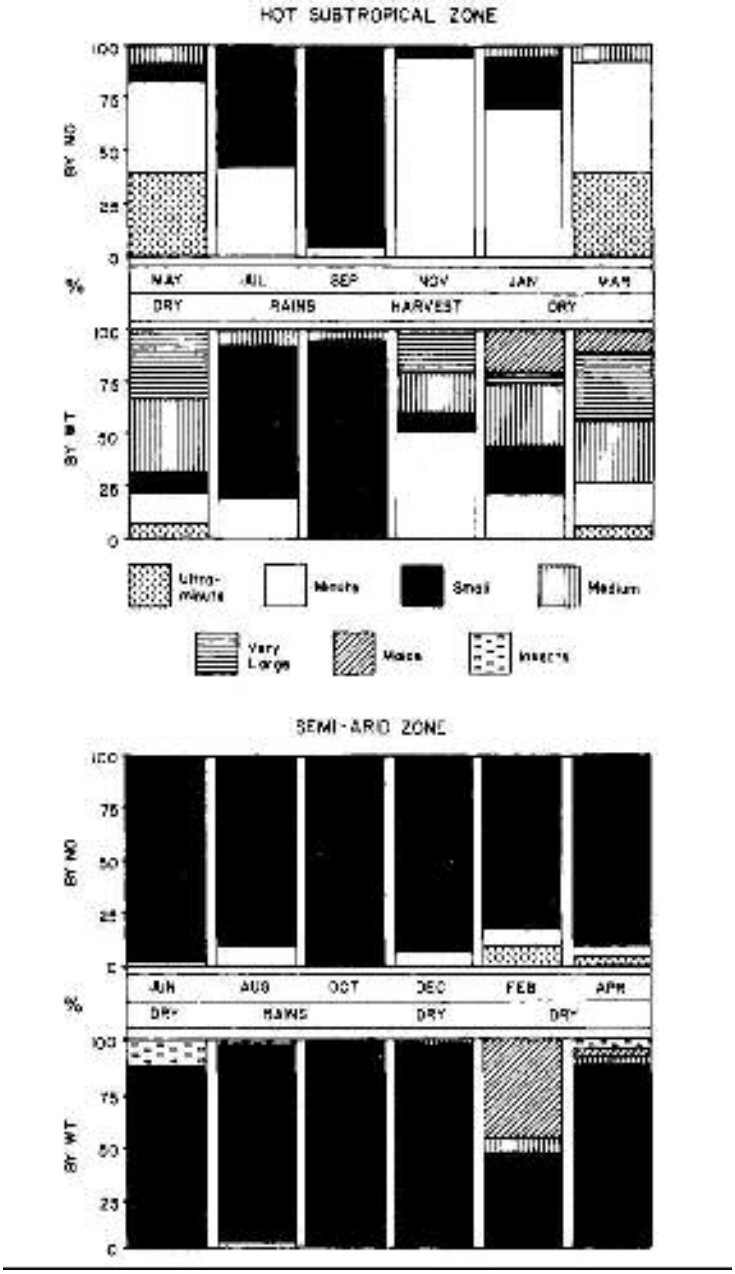

FIGURE 3. Bimonthly seed-size categories eaten by *Quelea quelea* from the hot subtropical and semi-arid zones of the Awash River Basin in 1977/78.