FEEDING ECOLOGY AND HABITAT OF THE PROTEA SEEDEATER *Serinus leucopterus*

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Thesis presented for the degree of
Master of Science
at the University of Cape Town

December 1976

CONTENTS

INTRODUCTION

The south-western corner of South Africa is a distinct physiographic unit (Wellington 1955). A system of folded sandstone mountain ranges (Cape geological supergroup) fringes the southern African subcontinental plateau, and forms the main structural feature of the south-western and southern Cape Province. This "fold belt" follows the coast, separated from it by a narrow plain of sand, limestone and clay. The south-western Cape is characterized by a warm-temperate "Mediterranean" climate, in contrast to the rest of sub-saharan Africa. The amount and distribution of the mainly winter rainfall varies with altitude, distance from the sea, topography and longitude (Wellington 1955).

The vegetation of the south-western and southern Cape (or south-west Cape biotic zone, abbreviated to south-west Cape) is a distinctive evergreen sclerophyllous shrubland (Wicht 1945; Acocks 1975). This "fynbos" vegetation shows extraordinary floristic diversity (Good 1964), containing some endemic plant families and many endemic genera and species. The "Cape Flora" is ranked as one of the world's six floristic kingdoms, despite its relatively small area (Good 1964). Fynbos is particularly associated with sandstone and poor sandy soil. Relict patches of temperate forest survive on moister, sheltered sites. Dwarf-shrub and succulent vegetation ("karoo") penetrates the south-west Cape in association with low-lying ground receiving less than 250 mm of precipitation

per annum (Levyns 1964, Acocks 1975).

The vertebrate fauna of the south-west Cape is poorly documented and shows neither great diversity nor pronounced endemism, despite the environmental peculiarities of the region. Birds and mammals each have six distinct taxa restricted to fynbos. The mammal set comprises four rodents and two bovids (Meester 1965), between them occupying most of the area for fynbos. The bird endemics comprise a sunbird (Nectariniidae), a sugarbird (Promeropidae), a francolin (Phasianidae), a warbler (Sylviidae), an aberrant chat (Turdidae), and a finch (Fringillidae) (Winterbottom 1968a). The chat, Chaetops frenatus, and another endemic finch, Serinus tottus tottus, are represented by disjunct vicariads (sensu Cain 1944) in the Drakensberg Fynbos Grassland (Hall & Moreau 1970; McLachlan & Liversidge 1972).

The six avian fynbos endemics include two specialist nectivores (sunbird and sugarbird) inhabiting a wide variety of environments within the Cape fynbos (Winterbottom 1966a). The endemic warbler, Bradypterus victorini, and the siskin, S. tottus tottus, are inconspicuous mountain birds. The warbler is an insectivore of dense undergrowth, and the siskin is a seedeater centred on open, rocky environments. The rockjumper, C. frenatus, shares the siskin's habitat with a narrower tolerance, avoiding tall vegetation (Winterbottom 1966a).

The protea seedeater, Serinus leucopterus, appears to have the most restricted range (33 700 km^2, Hall & Moreau 1962) and habitat tolerance of all, and is believed to be one of the two "rarest" fringillids in

Africa (Hall & Moreau 1962). The bird is known only from mature Protea Fynbos on mountain slopes. It is regarded as secretive, uncommon and local. The protea seedeater is listed as a threatened species owing to man-made habitat changes, chiefly land-development and the spread of alien plants (Siegfried, Frost, Cooper & Kemp 1976). Knowledge of the ecology of the protea seedeater, still at a rudimentary stage, is a prerequisite for effective conservation of the bird.

An aspect which stimulates further interest in the protea seedeater is its relationship to a large and diverse fauna of congeners. Forty-two African species in the Fringillidae (mainly in the genera Serinus and Emberiza) constitute one of the dominant avian families in the Ethiopian region (Winterbottom 1968a). Only eight of the 23 African Serinus species have wide Ethiopian ranges, while at least nine have relatively restricted ranges at the southern extremity of the continent or in its montane areas (Hall & Moreau 1970). A large proportion (44%) of African Serinus species thus have geographical ranges including part or all of the south-western Cape Province. The Fringillidae are characterized by high species diversity in the Palaearctic region. The restriction of many African forms (including the protea seedeater) to small insular ranges or afrotemperate-montane environments has been interpreted as partly owing to an association, in common with the rest of the family, with relatively temperate environments (Winterbottom 1968a). Serinus is one of the largest genera in

the south-west Cape avifauna; and the family Fringillidae, with 15 south-west Cape species in four genera, is regarded as one of the ten "dominant" families in the region (Winterbottom 1968a). Local overlap of the geographical ranges of a large number of congeners appears to be permitted by the close interdigitation of diverse environments, resulting from the topographical and phytogeographical complexity of the south-west Cape. As many as six Serinus species have been listed from a single south-west Cape vegetation type, Mountain Fynbos (Broekhuysen 1964; Winterbottom 1968a).

The protea seedeater is a particularly interesting species because: (i) it is endemic to the fynbos environment, the world's smallest floristic kingdom; (ii) its habitat preferences are still largely unknown; (iii) it is one of the rarest southern African birds; and (iv) it is a member of one of the largest groups of sympatric congeners in South Africa.

The present study involved a description of the habitat and the feeding niche (sensu Whittaker et al 1973) of the protea seedeater, and an assessment of factors contributing to the ecological segregation between the protea seedeater and its congeners in the south-west Cape biotic zone. No similar study of an African bird has been attempted.

The questions used as guidelines for the project were:

1) Is the protea seedeater restricted to certain, definable vegetation types?
2) Is the diet of the bird a restricted one, thereby possibly limiting its distribution?

3) How do the diet and feeding behaviour of the protea seedeater compare with those of congeners and other species of finch, i.e. can the bird be regarded as replacing other, ecologically similar, finches, or is it unusual in some aspects?

A large number of localities, encompassing a wide range of altitudes, annual precipitation regimes and vegetation types, in the south-west Cape were visited on an opportunistic basis from January 1974 to October 1976. The vegetation type at each locality where protea seedeaters were encountered was preliminarily classified according to a working combination of Acocks (1975), my own experience and discussion with several ecologists . Vegetation structure and site floristics were recorded at several sites chosen within each type of environment in which the protea seedeater had been observed feeding, to document the habitat range in which the bird fed. Samples of food items were collected for identification and seed size analysis. Positions of feeding protea seedeaters in the vegetation and feeding behaviour were recorded. Food items taken by, and feeding behaviour and positions of, other Serinus species were recorded wherever possible for comparison with the protea seedeater. Members of the avifauna at sites for the protea seedeater were recorded according to presence or absence, particular attention being paid to congeners. The avifauna at one site was measured quantitatively (density of birds per ha) to relate the density of the protea seed-eater to those of associated birds. Most observations of feeding birds were made in the vicinity of Paarl and Stellenbosch

for reasons of convenience.

Detailed methodology is given at the beginning of the feeding ecology and habitat sections.

DESCRIPTION OF THE PROTEA SEEDEATER

Scientific name:

Serinus leucopterus (Sharpe)

Synonymy (S.A.O.S. List Committee 1969):

Crithagra leucoptera Sharpe

(Ann. Mag. Nat. Hist. (4) 1871);

Poliospiza leucoptera Gunning & Haagner

(Chk. Lst. Bds. S.A. 1910)

Vernacular names:

English: protea seedeater, white-winged seedeater, Layard's seedeater, protea canary;

Afrikaans: witvlerksysie.

The specific epithet is derived from the white bars on the wings. The contemporary English name refers to the bird's typical habitat and food plant.

Descriptive features and field recognition of *Serinus leucopterus* have been discussed by Skead (1960), Praed & Grant (1955) and McLachlan & Liversidge (1972). Useful identication features are (i) drab, brown general coloration without any green or yellow on the rump, (ii) conspicuous white throat patch, (iii) two whitish lines on wing-coverts, and (iv) stout, flesh-coloured bill, accentuated by blackish facial feathers. The sexes of *S. leucopterus* cannot be distinguished in the field. The species has not been shown to vary subspecifically.

Species most easily confused with the protea seedeater are the streaky-headed seedeater, *Serinus gularis*, and the white-throated seedeater, *S. albogularis*. The streaky-

headed seedeater is distinguished by its slimmer, more horn-coloured bill and conspicuous, long, whitish eyebrow stripe. The white-throated seedeater is distinguished by its larger body size and yellow-green rump.

The taxonomic relationships of S. leucopterus within its genus (sensu S.A.O.S. List Committee 1969) are unclear. It appears to be equally closely related to a number of congeners, including S. albogularis, S. gularis, S. mennelli and the central African forest species, S. burtoni (Winterbottom 1968b; Hall & Moreau 1962, 1970). The bird's similarity to these and other species in habits, voice and appearance strongly militates against its being placed in any genus other than Serinus, as some authors have suggested (S.A.O.S. List Committee 1969).

Other Serinus species discussed in this study were: S. canicollis, Cape canary; S. tottus, siskin; S. flaviventris, yellow canary; S. alario, black-headed canary; S. scotops, forest canary; S. gularis, streaky-headed seedeater; S. albogularis, white-throated seedeater; and S. sulphuratus, bully seedeater.

HABITAT

1. INTRODUCTION

It has been suggested (Skead 1960; Siegfried 1972; Winterbottom 1973) that the protea seedeater is restricted to mature, dense stands of proteoid fynbos (Macchia *sensu stricto* Acocks 1975) on the lower slopes of mountains. Winterbottom (1966a) noted that the species was apparently as closely associated with stands of members of the Proteaceae as is the Cape sugarbird, *Promerops cafer*, for which a nutritional and breeding association with *Protea* shrubs has been found (Skead 1967; Burger, Siegfried & Frost 1976).

It was necessary to define Mountain Fynbos in order to discuss the apparent restriction of *Serinus leucopterus* to this type of environment. This definition was attempted at two levels for the vegetation, structural and floristic. The structural analysis consisted of a literature review compared with the recorded structure of vegetation at sites for the protea seedeater. The floristic analysis involved the construction of a reference list, at generic level, from the literature and comparison of this with genera found at sites for the protea seedeater.

The avifauna associated with the protea seedeater was used as a third means of documenting the bird's habitat in a qualitative way. Species generally occur with highest densities at a particular point along the scale of each environmental parameter (e.g. vegetation structure, environmental moisture), occurring with lower density and finally disappearing in either direction

along the scale (Whittaker et al, 1973). The presence of a species at a particular site is thus an indication (at a certain probability level) of a particular set of environmental conditions. Data on the densities of all bird species at a particular site probably provide a very precise indication of environment. Avifaunal differences between sites, according to presence or absence, can, however, probably be used to reflect environmental differences at a more coarse-grained level sufficient for an exploratory study of this kind. Data on the avifauna were used to assist in describing the protea seedeater's habitat range, and to contribute to an assessment of the apparent restriction of the bird to Mountain Fynbos.

2. GEOGRAPHICAL DISTRIBUTION

2.1. Previously known distribution of *Serinus leucopterus* and congeners

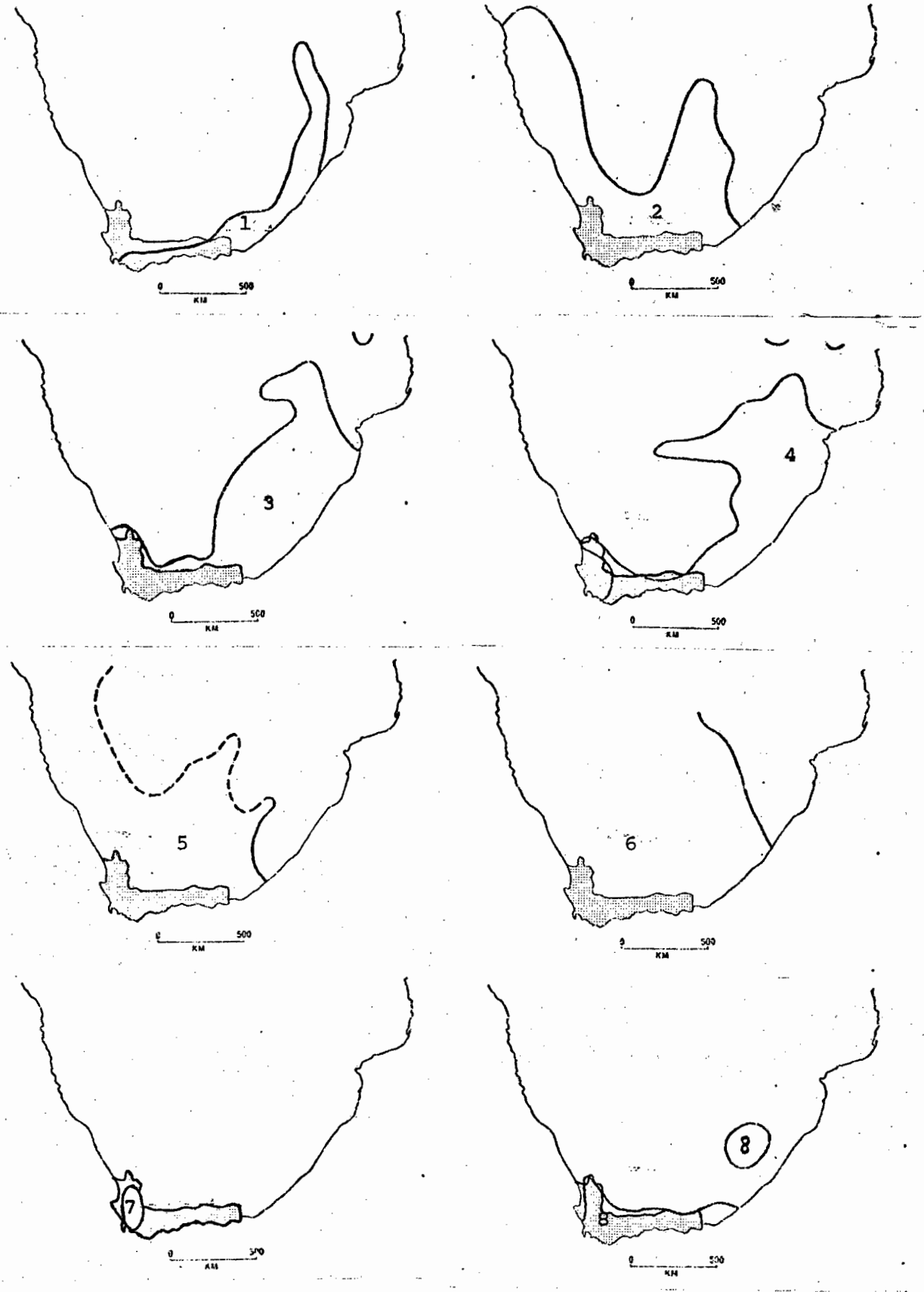
Published distribution data for *Serinus leucopterus* (Praed & Grant 1955; Skead 1960; Anon. 1963; Winterbottom 1968b; McLachlan & Liversidge 1972) has been aptly summarised: "... the western Cape mountains from Niewoudtville to Montagu (and perhaps Sevenweekspoort) but not the Cape Peninsula" (S.A.O.S. List Committee 1969).

The distributions of *S. leucopterus* and the seven congeners occurring in the south-west Cape are shown in Figure 1. Four species have relatively wide ranges including the south-west Cape, two others have ranges mainly excluding the south-west Cape and the last, *Serinus tottus*, has a disjunct range part of which corresponds to the south-west Cape.

FIG. 1 : Distribution of Serinus species in southern Africa in relation to the south-west Cape (after Skead 1960, Hall & Moreau 1970).

1= S. scotops 2= S. alario 3= S. canicollis 4= S. gularis

5= S. albogularis 6= S. flaviventris 7= S. leucopterus 8= S. tottus



2.2. Present known distribution of *Serinus leucopterus*

The area occupied by Cape fynbos (Macchia *sensu lato* Acocks 1975) was arbitrarily subdivided on the basis of vegetation, geology and geomorphological units (mainly mountain ranges). This subdivision provided 26 land-units (Table 1) within each of which several visits were made to apparently suitable environments to establish, by visual identification, the presence of the protea seedeater in each land-unit.

Figure 2 shows all known locality records (specimens and visual identification*) for the protea seedeater. Extensions to the bird's previously known range were eastwards along the west-east mountain chains (Swartberg in the north and Riviersonderend-Kouga-Cockscomb in the south), roughly as far as 25°E, the vicinity of Patensie. The only land-units in which the species was not identified were certain of the southern coastal ranges (nos. 11, 17 & 22, Table 1), the Cape Peninsula (no. 9) and certain "island" mountains in the Little Karoo (nos. 13 & 20), as well as coastal flats (nos. 24, 25 & 26). not on map.

2.3. Distribution of *Serinus leucopterus* in relation to the south-west Cape

This section comprises a review of the physiographic, climatic and biogeographic characteristics of the south-west Cape. This review, not available in this form in the literature, was necessary in order to discuss the geographical distribution of the bird in relation to its habitat.

*including Martin et al. 1975

TABLE 1: Regional subdivision of the south-west Cape, according to Acocks Veld Type and boundary Veld Types, and geology and boundary geology. Names of mountain ranges are given in parentheses.

1. Macchia, bounded by Succulent Karoo and western Mountain Karoo
   Table Mountain sandstone, bounded by Bokkeveld and Malmesbury shale, and Dwyka tillite
   (Bokkeveld, Gifberg, Nardouwsberg, Botterkloof)

2. Macchia, bounded by Strandveld (partly through Coastal Macchia) and Karroid Broken Veld (partly in transition to Coastal Rhenosterbosveld and Succulent Karoo)
   Table Mountain sandstone, bounded by Bokkeveld and Malmesbury shale, and Tertiary sand
   (Piketberg, Olifants River)

3. Macchia, bounded by Macchia and Succulent Karoo, partly through Karroid Broken Veld
   Table Mountain sandstone, bounded partly by Bokkeveld shale in transition to Witteberg quartzite
   (Cedarberg)

4. Macchia, bounded by Coastal Rhenosterbosveld and Macchia
   Table Mountain sandstone, bounded partly by Bokkeveld and Malmesbury shale
   (Cold Bokkeveld, Schurfteberg, Witzenberg, Winterhoek)

5. Macchia, bounded by Succulent Karoo and Macchia, partly through Mountain Rhenosterbosveld
   Witteberg quartzite, bounded by Bokkeveld shale and Dwyka tillite
   (Swartruggens, Gydoberg, Bonteberg)

6. Macchia, bounded by Macchia and Karroid Broken Veld, partly through Mountain Rhenosterbosveld
   Table Mountain sandstone, bounded by Bokkeveld and Malmesbury shale
   (Hex River)

7. Macchia, bounded by Macchia and Coastal Rhenosterbosveld
   Table Mountain sandstone, bounded by Malmesbury shale and Tertiary superficial deposits
   (Elandskloof, Bains Kloof, Limietberg, Slanghoek, Riebeeck Kasteelberg)

8. Macchia, bounded by Macchia and Coastal Rhenosterbosveld
   Table Mountain sandstone and Bokkeveld shale, bounded partly by Cape granite
   (Wemmershoek, Drakenstein, Paarl Mountain)

9. Macchia, bounded by the sea and Coastal Macchia
   Table Mountain sandstone, bounded partly by Cape granite and Tertiary sand
   (Cape Peninsula)

10 Macchia, bounded by the sea and Macchia
   Table Mountain sandstone, bounded partly by Bokkeveld shale and Tertiary sand
   (Hottentots Holland, Hangklip)

11. Macchia, bounded by Coastal Rhenosterbosveld and Coastal Macchia
    Table Mountain sandstone, bounded by Tertiary sand and Bokkeveld shale, partly through Malmesbury shale
    (Bot River to Bredasdorp)

12. Macchia, bounded by Coastal Rhenosterbosveld and Karroid Broken Veld, partly through Mountain Rhenosterbosveld
Table Mountain sandstone, bounded by Bokkeveld shale, partly through Malmesbury shale and Witteberg quartzite
(Boschjesveld, Riviersonderend, Langeberg, Caledon Swartberg)

13. Macchia and False Macchia, bounded by Karroid Broken Veld through Mountain Rhenosterbosveld
Table Mountain sandstone, bounded by Bokkeveld shale
(Anysberg, Warmwaterberg, Waboomsberg)

14. False Macchia, bounded by Succulent Karoo and Karroid Broken Veld, partly through Mountain Rhenosterbosveld
Witteberg quartzite, bounded by Bokkeveld shale and Dwyka tillite
(Witteberg, Elandsberg)

15. False Macchia, bounded by Succulent Mountain Scrub and Karroid Broken Veld, partly through Mountain Rhenosterbosveld
Table Mountain sandstone, bounded by Bokkeveld and Cango shale
(Swartberg)

16. False Macchia, bounded by Succulent Mountain Scrub, partly through Mountain Rhenosterbosveld
Table Mountain sandstone, bounded by Bokkeveld shale
(Roodeberg, Gamka Hill)

17. False Macchia, bounded by Karroid Broken Veld and Coastal Rhenosterbosveld
Table Mountain sandstone, bounded by Bokkeveld shale, partly in transition to Enon
(Langeberg, Attakwasberg)

18. False Macchia (& Knysna Forest) bounded by Knysna Forest and Mountain Rhenosterbosveld
Table Mountain sandstone, bounded by Bokkeveld shale and other types
(Outeniqua)

19. False Macchia, bounded by Succulent Mountain Scrub and Mountain Rhenosterbosveld
Table Mountain sandstone, bounded by Bokkeveld shale
(Kammanassie)

20. False Macchia, bounded by Karoo through Succulent Mountain Scrub
Witteberg quartzite, bounded by Dwyka and Bokkeveld shale
(Groot River Heights)

21. False Macchia, bounded by False Macchia and Succulent Mountain Scrub, partly in transition to Karroid Broken Veld and Valley Bushveld and partly through Mountain Rhenosterbosveld
Table Mountain sandstone, bounded partly by Bokkeveld shale
(Kouga, Baviaanskloof)

22. False Macchia (& Knysna Forest) bounded by Knysna Forest, the sea, False Macchia and Valley Bushveld

Table Mountain sandstone, bounded partly by Bokkeveld shale
(Tsitsikamma, Kareedouw)

23. False Macchia, bounded by Valley Bushveld and partly by karoo types
Table Mountain sandstone, bounded by Bokkeveld shale, Enon and Nama
(Winterhoek, Elandsberg)

24. Coastal Macchia (western coastal foreland)

25. Coastal Macchia (eastern coastal foreland)

26. Coastal Rhenosterbosveld

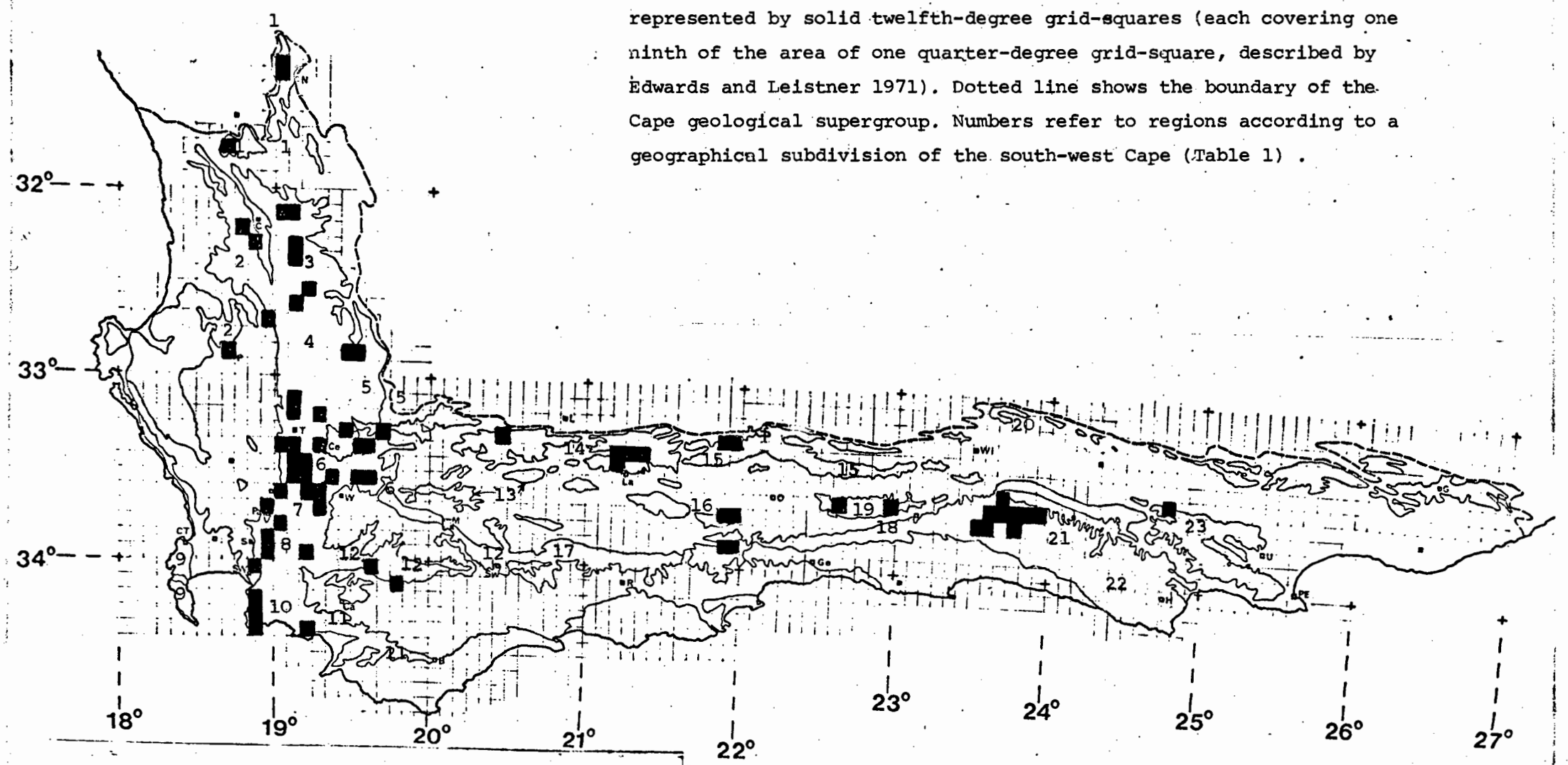


FIG. 2: Geographical distribution for the protea seedeater in relation to Acocks (1975) fynbos Veld Types. Localities for the species are represented by solid twelfth-degree grid-squares (each covering one ninth of the area of one quarter-degree grid-square, described by Edwards and Leistner 1971). Dotted line shows the boundary of the Cape geological supergroup. Numbers refer to regions according to a geographical subdivision of the south-west Cape (Table 1).

2.3.1. Physiography

2.3.1.1. Geomorphology

A mountainous "fold belt" is the dominant geomorphological element in the south-western and southern Cape Province. This belt is separated from the sea by a coastal plain and from the central plateau of southern Africa by the "Great Karoo basin" (Wellington 1955). The boundaries of the "south-west Cape (biotic zone)" are arbitrarily defined here as the limits of the Cape geological supergroup, east to 25°45' E, the longitude of Port Elizabeth (Fig. 3).

The sandstone mountain ranges of the fold belt, representing anticlines of Permo-Triassic age in the Table Mountain group (Cape supergroup), extend the length and breadth of the south-west Cape. Subsidiary quartzite ranges of the Witteberg group form the inland fringe of the fold belt adjacent to the Great Karoo basin. Overlying shale beds of the Bokkeveld group (Cape supergroup) and Karoo supergroup, also folded in the south-west Cape, have been eroded from the ranges of harder sandstone and quartzite rocks. These shales now occupy only intermontane lowlands and the inland Karoo adjacent to the fold belt (Wellington 1955).

Two main groups of mountain ranges are distinguishable (Fig. 3). A broad western group sweeps 260 km from Nieuwoudtville in the north to Worcester in the south. It

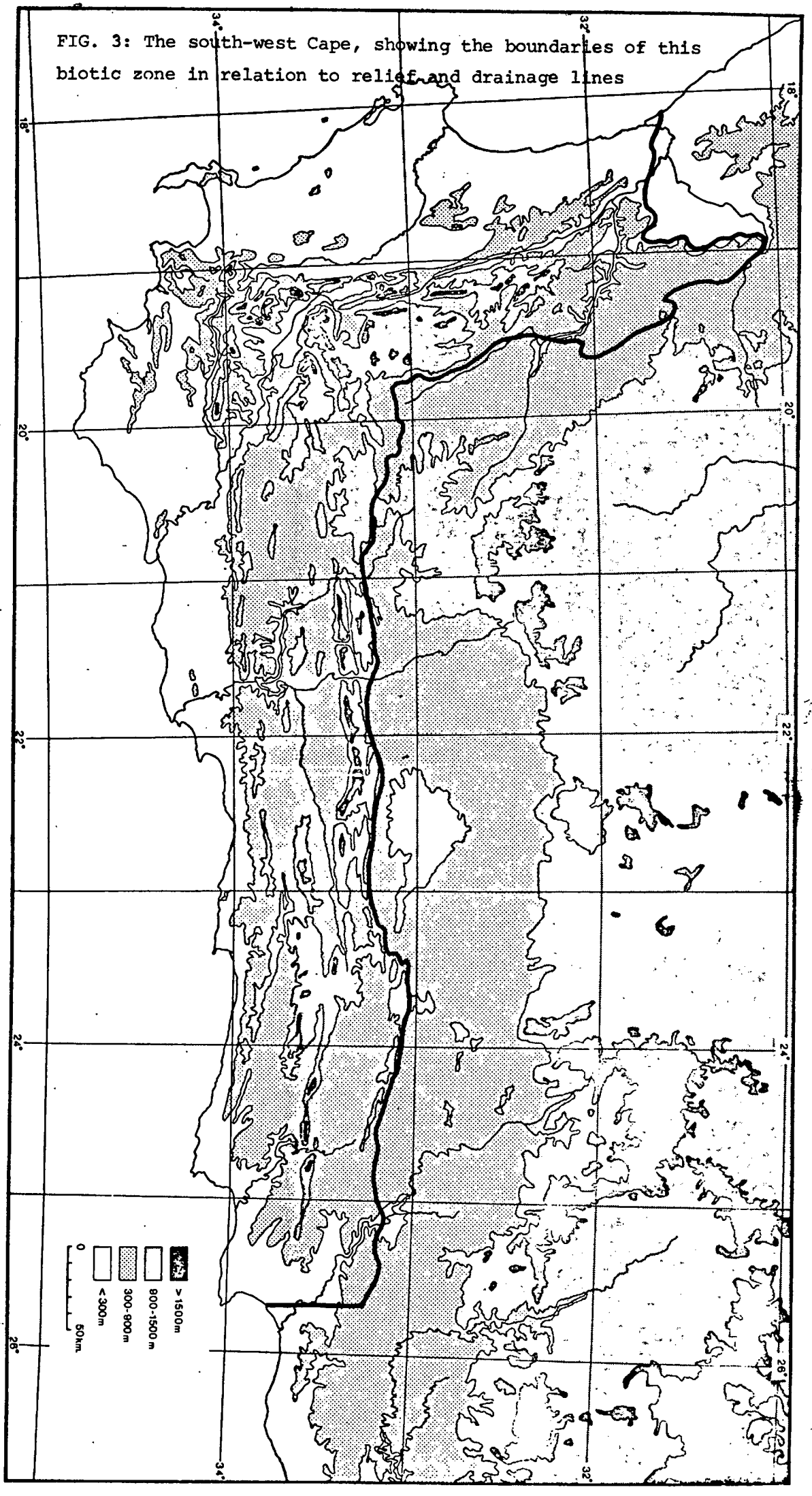


FIG. 3: The south-west Cape, showing the boundaries of this biotic zone in relation to relief and drainage lines

comprises a series of parallel Table Mountain sandstone massifs rising to 1980 m a.s.l. These massifs, variously named Matsikamma, Cedarberg, Olifants River, Cold Bokkeveld, Piketberg, Witzenberg, Elandskloof, Limiet and Hawequas, are separated from the lower-lying Karoo to the east by the Witteberg quartzite Swartruggens range (Wellington 1955).

An eastern group of ranges, comprising two main Table Mountain sandstone chains, extends 650 km eastwards from Worcester and Caledon to Port Elizabeth and beyond. The Langeberg-Outeniqua ranges rise to 1830 m and extend continuously for 480 km parallel to the coast. The Swartberg-Great Winterhoek ranges (2320 m) lie to the north of the Langeberg. A third orographic line comprises discontinuous ranges running west-east in the broad shale valley ("Little Karoo") separating the Langeberg and Swartberg. This line includes the Waboomsberg, Warmwaterberg, Touwsberg and Roodeberg, and rises to 1830 m in the east (Kammanassie and Kouga ranges). A final west-east chain (Bonteberg, Witteberg, Elandsberg, Suurberg), composed of Witteberg quartzite, closely parallels the Swartberg to the north; it runs along the edge of the shale beds of the Great Karoo basin (Wellington 1955).

The western and eastern zones of the fold belt meet in the Worcester-Stellenbosch-Caledon area. A number of complex massifs (e.g. Hottentots-Holland, Drakenstein) rise to 2000 m in this south-western corner of the Cape (Wellington 1955).

The western coastal plain of the south-west Cape is a foreland of Malmesbury slates and shales, covered with

Tertiary to Recent aeolian sands towards the coast. The southern coastal plain forms a rolling topography mainly of Bokkeveld shale. Limestone of the Alexandria beds occupies the coastal strip. Western and southern coastal plains are both broken by occasional mountain relics of sandstone or Cape granite such as Paarl Mountain and Potteberg (Wellington 1955).

Soils on the fold belt mountains are essentially pale grey, shallow, sandy and acid. These extremely well-drained lithosols are best-developed on gentle gradients and at the colluvial base of steep slopes. Extensive exposures of bedrock occur on the peaks. Shale bands in the Table Mountain sandstone weather to "moderately well-drained" soil with up to 15% surface clay. Podsols and ferricrete gravel also occur locally in the fold belt (Wicht 1945; Boucher 1972; MacVicar 1973).

The south-west Cape coastal plains are characterized by gravelly, clay-rich soils; most of these plains are now agricultural land. Exposures of granite on the lower mountain slopes (in the west) weather to loams which are deeper and less acidic than Table Mountain sandstone soils. Littoral grey aeolian sands (lithosols on the Alexandria limestone beds) occur along the coast itself. Finally, the soils of the "Little Karoo" and the Great Karoo basin fringing the south-west Cape are weakly developed, locally lime-rich and derived mainly from shale (Wicht 1945; Boucher 1972; MacVicar 1973).

2.3.1.2 Climate zones

The south-west Cape has, according to the classification of Köppen and Thornthwaite (Schulze 1965), a "humid warm climate with a dry summer", with: (i) at least one month with mean temperature below 16°C, (ii) at least eight months with mean temperature above 1°C, (iii) the coldest month above -3°C and (iv) the mean temperature of the warmest month usually below 22°C. Certain mountain areas in the south-west Cape probable have "sufficient" rain during all months, precipitation for the driest months exceeding one-third of that for the wettest month (Schulze 1965).

A "winter rainfall" or "mediterranean" climate zone ("M", Schulze 1965) is found in the extreme south-western Cape, within a radius of 200 km from Cape Town. This region is characterized by the occurrence of more than 60% of precipitation brought by north-westerly trade winds in the period May to September (Wicht 1945; Schulze 1965). The extreme north-west of the south-western Cape has a relatively low (less than 250 mm per annum) winter rainfall, and is transitional between zone "M" and the semi-arid karoo climate zone ("W", Schulze 1965) to the north.

The main variation within the "temperate, oceanic climate" of the south-west Cape is between the winter rainfall region in the west and the "constant rainfall region" along the coast towards the east (Wicht 1945). Two additional climate zones extend into the south-west Cape from the east. The southern Cape Coastal belt ("A", Schulze

1965) is generally similar in climate to zone "M". Precipitation is, however, far more evenly distributed through the year, with minor rainfall maxima in autumn and spring. The semi-arid southern Cape interior or "Little Karoo" ("K", Schulze 1965) also has a "constant rainfall regime". The amount of precipitation is, however, far lower, exceeding 750 mm per annum only at relatively high altitudes. Thunderstorms are more frequent (10-20 per year) than in zone "M"; diurnal and seasonal temperature fluctuations are far greater than in zones "M" and "A".

2.3.1.3. Precipitation

Rainfall in the south-west Cape in mainly cyclonic and orographic. Precipitation varies greatly in relation to altitude, distance from the sea and aspect, from about 250 mm per annum on the coastal flats and inland valleys to over 3000 mm locally at high altitudes (Wellington 1955; Schulze 1965).

2.3.1.4. Temperature

The south-west Cape, although climatically distinct, is lacking in peculiar thermal features in relation to the rest of southern Africa (Stuckenberg 1969). The monthly mean maximum to mean minimum range in ambient temperature in both the "winter rainfall region" (at Jonkershoek) and the "constant rainfall region" (at George) falls between 7,5°C and 31°C. This range has been described as "mild" (Wicht 1945). Hot days (ambient temperature 30°C and higher)

occur mainly in summer throughout the south-west Cape. Temperatures higher than 39°C are reached only from November to January (at Jonkershoek and George). High temperatures in the constant rainfall region are usually associated with "bergwind" conditions (Wicht 1945; Schulze 1965).

Nights in the south-west Cape are mainly "mild" (11-22,5°C) in summer and "cool" (0-11°C) in winter. Ambient temperatures lower than 2°C are recorded mainly in late winter (August at Jonkershoek and George, Wicht 1945). Diurnal temperature fluctuation (roughly 12,5°C) remains fairly constant through the seasnns; the summer average diurnal fluctuation in the winter rainfall region (17,5°C at Jonkershoek) is, however, greater than in the constant rainfall region. Seasonal variation in temperature is also greater in the winter rainfall region than in the constant rainfall region, owing mainly to higher mean maximum temperatures in summer in the west (Wicht 1945).

Much confusion exists in the literature over "which parameters of temperature express best its role as a contributory determinant of zoogeographic boundaries (Stuckenberg 1969). "Effective temperature" (ET) expresses the relative warmth and duration of the warm period of the year (Stuckenberg 1969), stressing the biological importance of the summer months. "ET measures warmth on a temperature scale, specifying temperatures at the beginning and end of the warm period, and implicating the duration of that period" (Stuckenberg 1969).

The 15° ET isoline (Stuckenberg 1969) encompasses a

large part of the higher altitude interior of South Africa, reaching the coast in the south-west. The 15° isoline in the south-west Cape corresponds with the fold belt mountain ranges, apparently excluding flatter areas towards the coast. The isoline thus agrees roughly with the limit for Mountain Fynbos (section 2.3.2.1). Precise correlation of isolines with boundaries for Mountain Fynbos in the topographically complex south-west Cape is, however, not possible with present inadequate data (Stuckenberg 1969).

2.3.2. Vegetation

2.3.2.1. Acocks' classification

Acocks (1975) subdivided South African vegetation into 70 veld types, partly on the basis of plant species composition and partly on the basis of hypothetical successional relationships. The veld types are landscape units, each with characteristic geomorphology and range of plant communities. They are thus ecological land-units.

Macchia (sensu lato Acocks 1975) or "Cape fynbos", as it is currently termed, is a distinctive evergreen shrubland vegetation type characterizing the south-west Cape. It is subdivided into: two "Temperate and Transitional Forest and Scrub Types", viz Coastal Rhenosterbosveld (veld type 46) and Coastal Macchia (veld type 47); one "Sclerophyllous Bush Type", viz Macchia (veld type 69); and one "False Sclerophyllous Bush Type", viz False Macchia (veld type 70). These fynbos veld types are heterogeneous in comparison with other veld types found in South Africa (Acocks 1975).

The veld types Macchia (sensu stricto) and False Macchia, currently jointly termed "Mountain Fynbos", occupy the folded mountain ranges of the south-west Cape. Macchia occurs west of Montagu, in the winter rainfall area. False Macchia replaces Macchia, from most of which it is "indistinguishable" except on hypothetical grounds (Acocks 1975), eastwards to the limit of the south-west Cape and beyond (Fig. 3).

Coastal Rhenosterbosveld and Coastal Macchia occupy the south-west Cape coastal plains. Karoo and forest vegetation are represented in the south-west Cape by nine veld types,

two of which may be regarded as transitional to fynbos (Acocks 1975).

2.3.2.2. Phytogeography

The south-western and southern Cape is recognized as a distinct phytogeographical unit (Marloth 1908; Weimarck 1941; Adamson 1945; Good 1964; Walter 1968; Takhtajan 1969). This unit, the "Cape floristic kingdom", has been accorded the status of one of the six phytogeographical areas which together cover the earth's land surface (Good 1964). The south-west Cape owes this floristic integrity to a large number of geographically restricted plant taxa comprising the "Cape Flora". This distinctive assemblage of plant taxa, with four endemic families, 212 endemic genera and 3500 endemic species (Weimarck 1941), is represented almost entirely in Cape fynbos vegetation (Macchia sensu lato Acocks 1975). The Cape Flora is virtually confined to this vegetation type and comprises and "exceptional number of distinctive species, genera and even families in a small area" (Cone 1973). Characteristic families include Penaeaceae, Bruniaceae, Retziaceae and Grubbiaceae (all restricted to this flora), Restionaceae, Iridaceae, Proteaceae, Ericaceae, Thymeleaceae, Rutaceae and Verbenaceae (Marloth 1905; Adamson 1945; Cone 1973).

Cape fynbos communities, delimiting the Cape floristic kingdom and thus the area for the Cape Flora, cover most of the south-west Cape. Two other phytogeographic units, represented by forest and karoo vegetation types, do, however, extend into the region from the north and east (Levyns 1964).

2.3.3. Fauna

2.3.3.1. General zoogeography

Zoogeographic subdivisions of southern Africa have been reviewed and modified by Davis (1962), Meester (1965) and Winterbottom (1972). Four "biotic zones" for mammals (Meester 1965) have been proposed:

1) South-west Cape: corresponds roughly with the area for Cape fynbos (Macchia sensu lato Acocks 1975); bounded by the South-west Arid to the north and the Southern Savanna to the east (see below); the south-west Cape, although sometimes regarded as part of the Southern Savanna, is retained as "a minor zone of endemism" for mammals (Bigalke 1968);
2) Forest: isolated patches of "montane and subtropical" evergreen forest in the east of southern Africa, one patch occurring as an enclave in the south-west Cape (biotic zone 1);
3) South-west Arid: the western part of the subcontinent, with mean annual precipitation less than 510 mm; and
4) Southern Savanna: the eastern part of the subcontinent, including the Highveld grassland region (Meester 1965).

The south-west Cape is regarded as a distinct zoogeographic zone also for Amphibia. Two-thirds of amphibian forms occurring in the south-west Cape are restricted to this region (Poynton 1962); several snake species (Reptilia: Squamata) are also endemic to the "Cape mountains" (Stuckenberg 1969).

Distribution patterns in the invertebrate "montane palaeogenic element" (Megaloptera, Onychophora and some members of Coleoptera, Diptera and Dermaptera) show a "Cape centre" (Stuckenberg 1962). This zone corresponds with the area for the Cape fold mountains. Certain members of this palaeogenic fauna (e.g. Arthroteles and Atherimorpha) appear to be closely associated with fynbos vegetation (Stuckenberg 1962).

2.3.3.2. Avian zoogeography

The south-western Cape is considered a distinct avian zoogeographic area, termed the Winter Rainfall or Macchia "sub-district" (Winterbottom 1960, 1968b & 1972; S.A.O.S. List Committee 1969). This zone has, at a more general level, been classified as part of the South West Arid district (S.A.O.S. List Committee 1969) and as part of the South Temperate district, which corresponds with the southern parts of the South West Arid (Winterbottom 1972). The south-west Cape is related most closely in these classifications to the Karoo and Highveld grassland areas on avifaunal grounds.

The south-west Cape, although regarded as zoogeographically distinct, is of minor importance as a centre of evolution for birds (Winterbottom 1968a). Six species and 12 subspecies of birds appear restricted to the area for Cape fynbos vegetation (Winterbottom 1968c). These endemic species include Promerops cafer, Nectarinia violacea, Bradypterus victorini and Serinus leucopterus, the protea seedeater. The fifth, Chaetops frenatus, is usually

regarded as conspecific with its Drakensberg vicariad C. aurantius. Francolinus capensis, listed as the sixth endemic species (Winterbottom 1968a, 1968c), has, however, been recorded from localities well beyond the boundaries of the south-west Cape (Paterson 1958; Winterbottom 1968b). The very distinct Cape form of the siskin, Serinus tottus, thus appears to be equally eligible as the sixth member of the list.

The Winter Rainfall or Macchia "sub-district" has not been clearly defined. Its area corresponds with that for Acocks' (1975) Macchia sensu lato (including outliers in the Karoo) as far east as Port Elizabeth (Winterbottom 1968b, 1972). Other outlying "Macchia" areas in the eastern Cape are included in the southern part of a south and east African lowland zoogeographic area following the coast into Tanzania (S.A.O.S. List Committe 1969; Winterbottom 1972). The entire eastern part of the south-west Cape is also included in this south-east African "district" on certain small-scale maps (Winterbottom 1972; S.A.O.S. List Committee 1969); this inconsistency appears to be attributable partly to poor documentation of the "Macchia" avifauna east of George (Winterbottom 1972) and partly to the fine inter-digitation of areas for "Karoo" and "Macchia". Difficulties arising from different mapping scales also help to explain why the zoogeographic distinctness of south-west Cape forest from the Winter Rainfall or Macchia "sub-district" (Winterbottom 1968b, 1972) is not consistently reflected on existing maps (S.A.O.S. List Committee 1969; Winterbottom 1972). In view of this vagueness of definition, it is

assumed for the present study that the south-west Cape biotic zone (Fig. 3) has an avian zoogeographical integrity and is equivalent to the "Macchia sub-district".

2.3.4. Discussion

The geographical distribution for the protea seedeater falls entirely within the south-west Cape as defined in this study, corresponding with part of the area for several biogeographical land-units. The phytogeographical unit is the "Cape floristic kingdom", while zoogeographical units are the "South-west Cape biotic zone" and, more specifically, the "Macchia" avian "sub-district". The distribution for the protea seedeater covers the major part of the south-west Cape, spanning several climate zones differing in their regimes of temperature and precipitation, particularly the proportion of rainfall falling in summer. The bird's distribution corresponds closely to the area for Acocks' Macchia and False Macchia Veld Types, mainly on sandstones and quartzites of the Cape Geological supergroup. All localities for the protea seedeater are thus within, or on the edge of, areas mapped for fynbos vegetation (Macchia sensu lato, Acocks 1975) in mountain landscapes, agreeing with Siegfried (1972).

3. HABITAT FLORISTICS

3.1. Review of floristics of south-west Cape

3.1.1. Introduction

The presence of three different floristic units (Cape, Forest and Karoo) in the south-west Cape is widely accepted, though poorly documented in the literature (Marloth 1905; Weimarck 1941; Adamson 1948; Levyns 1961; Cone 1973). Representatives of the Cape Flora, a floristic unit of major distinction even at the global scale (page are the main taxonomic constituents of Cape fynbos vegetation. The Forest floristic unit distinguishes broad-leaved evergreen forests in the south-west Cape from Cape fynbos (Adamson 1945, 1948; Levyns 1961). "The common genera in such forest ... play no part at all in the composition of the Cape Flora" (Levyns 1961). The Karoo floristic unit is, similarly, the main constituent of the dwarf shrub and succulent vegetation type called karoo. "Where the Cape Flora lies adjacent to the Karoo, there is a sudden change from one type of vegetation to another once the critical rainfall figure is reached. The flora of the Karoo bears no floristic relationship to the Cape Flora" (Levyns 1961). Three major vegetation types of the south-west Cape thus appear distinguishable on floristic grounds.

I wished to demonstrate the floristic relationships of the sets of plant taxa recorded in protea seedeater habitat, thereby testing the bird's apparent restriction to fynbos vegetation. I used lists drawn as a sample (Table 2) to construct a reference table relating fynbos, forest and karoo floristically on the basis of presence

TABLE 2 : Sources for summary of floristic relationships (at genus level) between major south-west Cape vegetation types, representing four floristic units. Additional characteristic genera for forest, fynbos and karoo were listed from Levyns (1964).

Floristic unit	Sources of lists of genera
Forest	inland forest communities at Cape Hangklip (Boucher 1972); forest at Grootvadersbosch Swellendam (Taylor 1955); forest at Marloth Nature Reserve, Swellendam (Taylor unpublished IBP report).
Fynbos	Macchia: Veld Type 69 (Acocks 1975); fynbos in Marloth Nature Reserve, Swellendam, and in Cedarberg Nature Reserve, Citrusdal (Taylor unpublished IBP reports); fynbos communities at Jonkershoek, Stellenbosch (Werger, Kruger & Taylor 1972).
Rhenosterbosveld	Mountain Rhenosterbosveld and Karroid Merxmuellera Mountain Veld: Veld Types 43 and 60 (Acocks 1975); list given for transition to fynbos, under Succulent Mountain Scrub: Veld Type 25 (Acocks 1975).
Karoo	Succulent Mountain Scrub, Karroid Broken Veld, Western Mountain Karoo and Succulent Karoo: Veld Types 25, 26, 28 and 31 (Acocks 1975).

or absence of genera (Table 3). I also included Mountain Rhenosterbosveld, a less well-defined vegetation type occurring between geographical areas for fynbos and karoo. I did not consider floristics at species level;this would have been impracticable in view of the large number of plant species in the Cape and Karoo floras, the immaturity of the taxonomic literature on many groups of plants, and problems of identification of plant material collected out of the flowering season. My floristic reference table (Table 3) is assumed to be a sufficiently representative sample to which field lists can be related, to justify the use of the terms "fynbos", "forest" and "karoo" in describing the vegetation from which the field lists were drawn.

3.1.2. Floristic reference table

Tables 3 & 4 show that a major proportion (68%) of genera occurring in fynbos is not listed for forest, karoo or rhenosterbosveld. Most of these genera listed exclusively for fynbos are referable to the Cape Flora (asterisked in Table 3). Forest and karoo are similarly shown to have 70% and 64% "exclusive" genera respectively (Table 4). Sixty-one percent of the 65 genera listed for rhenosterbosveld are shared with fynbos, while 50% are shared with karoo (Table 4); only 20% of rhenosterbosveld genera are shown to be "exclusive" to rhenosterbosveld in the literature sample used.

TABLE 3 : Floristic relationship, at genus level, of south-west Cape vegetation types. Genera are arranged, by presence or absence in the sample lists only, in columns for forest, fynbos, rhenosterbosveld and karoo floristic units. Asterisks indicate Cape Flora genera listed by Weimarck (1941).

Genus	Floristic unit			
	Forest	Fynbos	Rhenost.	Karoo
Angraecum, Apodytes, Burchellia, Calodendrum, Canthium, Cassine, Cassinopsis, Cunonia, Cussonia, Curtisia, Cyathea, Dietes, Droguetia, Elaphoglossum, Glia, Gonioma, Hemitelia, Histiopteris, Ilex, Impatiens, Knowltonia, Lachnopylis, Lachnostylis, Laurophyllus, Linociera, Ochna, Ocotea, Olinia, Peperomia, Pittosporum, Platylophus, Plectranthus, Podocarpus, Polystachya, Polytrichum, Pteris, Pterocelastrus, Pyrecantha, Rhamnus, Rothmannia, Rumohra, Secamone, Schoenoxiphium*, Scolopia, Scutia, Sideroxylon, Sparmannia, Trichocladus, Vepris, Virgilia.	X			
Blechnum, Halleria, Hartogia, Kiggelaria, Myrsine, Olea, Pellaea, Pteridium, Rapanea, Rubus, Scirpus.	X	X		
Acmadenia*, Acrosanthes, Acrostemon*, Adenandra*, Adenogramma*, Agathelpis*, Amphithalea*, Anaxeton*, Anemone, Andropogon, Argyrolobium, Aristea*, Asplenium, Athrixia, Berzelia*, Blaeria, Bobartia*, Brachysiphon*, Brunia*, Caesia*, Campylostachys*, Cannomois*, Carpacoce*, Carpha*, Cassytha, Castalis, Centella, Chironia, Chondropetalum*, Chrysanthemoides, Chrysithrix*, Coleonema*, Corymbium*, Cryptadenia*, Cullumia*, Cuscuta, Cyclopia*, Cymbopogon, Cyperus, Diastella*, Diosma*, Disparago*, Echiostachys*, Elegia*, Epischoenus*, Eremia*, Erepsia, Eroeda, Euchaetis*, Gahnia, Gazania, Geissoloma*, Gerbera, Gleichenia, Grubbia*, Haplocarpha, Helipterum, Heterolepis*, Hibiscus, Hippia*, Hypodiscus*, Juncus, Lasiochloa*, Leonotis, Leontonyx, Leptocarpus*, Leucadendron*, Leucospermum*, Lichtensteinia*, Linum, Lobelia, Lobostemon*, Macrostylis*, Merciera*, Mimetes*, Mohria, Monsonia, Nebelia*, Nylandtia, Osmites*, Osmitopsis*, Paranomus*, Penaea*, Pentameris*, Peucedanum, Pharnaceum, Phylica, Plagiochloa, Podalyria*,				

TABLE 3 (contd)

Genus	Forest	Fynbos	Rhenost.	Karoo
Polpoda, Prismatocarpus*, Protea*, Psoralea, Pseudognidia, Rafnia*, Rhynchosia, Retzia*, Rochea*, Roridula*, Saltera, Salaxis*, Scabiosa, Schizaea, Scyphogyne*, Serruria*, Simocheilus*, Sorocephalus*, Spatalla*, Staavia*, Staberoha*, Stilbe*, Stoebe*, Struthiola*, Stylapterus, Sutera, Sympieza*, Syndesmanthus*, Tittmannia*, Thamnochortus*, Venidium*, Viscum, Watsonia*, Widdringtonia, Willdenowia*, Zantedeschia.		X		
Agathosma*, Anthospermum, Aspalathus*, Cheilanthes, Cliffortia*, Elytropappus*, Erica*, Ficinia*, Gnidia, Metalasia*, Montinia*, Muraltia*, Passerina*, Philippia , Restio*, Selago, Tetraria*, Ursinia.		X	X	
Acaena, Dimorphotheca, Encephalartos, Eumorphia, Indigofera, Laisosiphon, Lasiochloa*, Machairophyllum, Melica, Melolobium, Phymaspermum, Setaria, Stachys.			X	
Aristida, Chrysocoma, Cotyledon, Delosperma, Euphorbia, Galenia, Nestlera, Pteronia, Relhania, Sporobolus, Sutera, Walafrida, Zygophyllum.			X	X
Acacia, Adromischus, Aloinopsis, Amellus, Apatesia, Argyroderma, Aridaria, Arthrosolen, Asclepias, Asaemia, Atriplex, Augea, Barleria, Blackiella, Blepharis, Cadaba, Caralluma, Cenchrus, Cephalophyllum, Cheiridopsis, Conophytum, Cyphia, Dactylopsis, Dicoma, Didelta, Digitaria, Drosanthemum, Eberlanzia, Enneapogon, Fingerhuthia, Garuleum, Glottiphyllum, Haworthia, Hebenstreitia, Hirpicium*, Huernia, Kochia, Lasiosiphon, Lebeckia, Leipoldtia, Limeum, Lotononis, Lycium, Malephora, Mesembryanthemum, Microdon*, Microloma, Monechma, Monilaria, Monochlamys, Nicotiana, Nymania, Oropetium, Pachypodium, Panicum, Pappea, Portulacaria, Prenia, Psilocaulon, Pterothrix, Putterlickia, Rhigozum, Rhinephyllum, Salsola, Sanseviera, Sarcocaulon, Sceletium, Schotia, Sericocoma, Sphalmanthus, Stapelia, Stipagrostis, Stomatium, Suaeda, Tamarix, Tarchonanthus, Tetragonia, Tragus, Trianthema, Trichodiadema.				X

TABLE 3 (contd.)

Genus	Floristic unit			
	Forest	Fynbos	Rhenost.	Karoo
Helichrysum, Rhus, Senecio.	X	X	X	X
Aloe, Crassula, Dodonaea, Ehrharta*, Eragrostis, Eriocephalus, Euryops, Felicia, Heteropogon, Lampranthus, Merxmuellera, Othonna, Pelargonium, Pentaschistis*, Pentzia, Ruschia, Themeda.		X	X	X
Buddleia, Carissa, Grewia, Rhoicissus.	X			X
Clutia.	X	X	X	
Euclea, Maytenus.	X	X		X
Berkheya, Hermannia, Lightfootia, Osteospermum*, Salvia, Thesium.		X		X
Percentages of total number of genera for each floristic unit which are shared with adjacent unit:	24	9		
		22	61	
			50	26

3.1.3. Discussion

These results semi-quantitatively reaffirm the floristic distinctness of fynbos in relation to adjacent vegetation types. The floristic distinctness of forest and karoo are similarly reaffirmed, supporting, at genus level, Adamson's (1945; 1948) and Levyns's (1961) remarks quoted above. The low proportion of "exclusive" genera in rhenosterbosveld shows this vegetation type to be floristically transitional between fynbos and karoo. Comparatively few genera are shared in the combinations forest and karoo, forest and rhenosterbosveld, and fynbos and karoo (Tables 3 & 4). The sequence forest-fynbos-rhenosterbosveld-karoo therefore reflects the most natural arrangement of the vegetation types (and floristic units) on the basis of their floristic inter-relationships.

Actual vegetation types in the south-west Cape seldom replace each other in simple, sequential fashion. Complexities of the vegetation, representing various admixtures and variations of floristic units in relation to topographic, edaphic and historical (successional) factors, exist in reality. For example, Coastal Rhenosterbosveld, Strandveld and certain tall karoo types transitional to scrub-forest (Acocks' Veld Types 23, 24 & 25) appear to represent mixtures between the three floristic units. Straight-line replacements between vegetation types (similar to that depicted in hypothetical form for floristic units by the arrangement of columns in Table 3) is, however, best illustrated in the southern Cape coastal belt. A south to north transect taken in this area

proceeds from the coast through four successive belts of vegetation types, viz forest (moist coastal plain), fynbos (moist to mesic southern slopes of the east-west mountain chain), rhenosterbosveld (mesic to xeric northern slopes) and finally karoo (dry inland plain).

Tables 3 and 4 show semi-quantitatively that Mountain Fynbos has a well-defined floristic integrity. These tables were used as a basis for testing the apparent restriction of the protea seedeater to fynbos.

TABLE 4 : Percentage of genera shared by floristic units, on the basis of Table 3 . Figures in parentheses are numbers of genera for each category.

Floristic unit	Forest (71)	Fynbos (183)	Rhenosterbosveld (65)	Karoo (125)
Forest	70 (50)	13 (17)	6 (4)	9 (9)
Fynbos	13 (17)	68(125)	16 (39)	18 (28)
Rhenosterbosveld	6 (4)	16 (39)	20 (13)	18 (33)
Karoo	9 (9)	18 (28)	18 (33)	64 (80)

3.2. Floristics of habitat of Serinus leucopterus

3.2.1. Categorization of environments

Sites from which floristic data were collected* were divided on the basis of precipitation, vegetation physiognomy and topography to give the following classification of protea seedeater environments:

-1. Dry Mountain Fynbos:

dry environments on mountain slopes and plateaux (precipitation 200-800 mm); fynbos vegetation near Mountain Rhenosterbosveld; rhenosterbos, Elytropappus rhinocerotis or E. adpressus, present (includes Acocks' "Arid Fynbos").

-1.1. Protea laurifolia Dry Mountain Fynbos:

prominent proteoid component (cover greater than 20%) which is dominated by Protea laurifolia.

-1.2. Protea arborea Dry Mountain Fynbos:

prominent proteoid component (cover greater than 30%) which is dominated by Protea arborea.

-1.3. Ericoid Dry Mountain Fynbos (and transitional scrub):

weakly represented proteoid component (cover less than 10%); vegetation low, generally below 2m (sites usually near stands of taller vegetation, e.g. in adjacent drainage lines).

-2. Kloof Scrub:

dry drainage line environments (precipitation 200-700 mm); 2-4 m high scrub vegetation, with floristic and physiognomic elements of similarity to forest, fynbos and karoo.

-3. Mesic to moist Mountain Fynbos:

mesic to moist environments on mountain slopes (precipitation 500-2000 mm); Mountain Fynbos vegetation, (rhenosterbos absent or very weakly represented)

* Appendix 1 & 2

viz Acocks' Macchia and False Macchia veld types.

-3.1. "Protea belt" Mountain Fynbos:

prominent proteoid component (cover greater than 10 %); lower slopes of mountains of Table Mountain group (Table Mountain sandstone, Bokkeveld shale or Cape granite).

-3.2. Ericoid Mountain Fynbos:

weakly represented proteoid component (cover less than 10 %); middle slopes of mountains, above the "Protea belt" but below the upper shale band; precipitation high (1600-2000 mm).

-3.3. High-altitude proteoid Mountain Fynbos:

prominent proteoid component (cover greater than 30 %) which is dominated by Protea punctata; upper slopes of mountains, above the "Protea belt", on the upper shale band (altitude above 1400 m).

3.2.2.Floristics of feeding sites for Serinus leucopterus

3.2.2.1.Dry Mountain Fynbos

Rainfall maps show that the annual precipitation at protea seedeater sites range from 200 to 2000 mm (9-80 inches). This spans virtually the entire rainfall range associated with Cape fynbos, which requires a minimum of 250 mm of precipitation per annum (Wicht 1945; Levyns 1950; Acocks 1975). "Two broad divisions of Mountain Fynbos are usually recognized: Fynbos and Arid Fynbos" (Acocks 1975).

The driest sites for Serinus leucopterus (Appendix 1) were on hills and plateaux of Table Mountain sandstone and Witteberg quartzite. These outliers were surrounded by lower-lying karoo environments in which the bird has never been recorded. The altitudinal and average annual precipitation ranges for these sites were 560-1220 m and 350-700 mm (marginally as little as 200 mm) respectively. Plant genera recorded at these sites show floristic (Fig.4) similarity to the mesic Mountain Fynbos "standard" used (App. 1 : 3.1 :10), despite the physiognomic prominence at the sites of elements such as Elytropappus rhinocerotis, which indicate a transitional nature to Mountain Rhenosterbosveld, and the geographical position of the sites (between areas occupied by Acocks' Macchia and False Macchia and areas occupied by Acocks' Mountain Rhenosterbosveld).

3.2.2.2. Kloof Scrub

The protea seedeater is regarded as largely closely associated with Mountain Fynbos (page 25). A notable extension of the bird's habitat was, however, in association with tongues of vegetation marginally penetrating the karoo environment along drainage lines arising in fynbos-covered hills. These tongues of Kloof Scrub occupied narrow, cliff-bounded shady kloofs near the edge of sandstone features, where drainage lines became levelled before entering adjoining low-lying shale landscapes. Perennial water appeared to be available in all kloofs of this type visited (e.g. Kransvlei near Clanwilliam; Nuwekloof near Willowmore; Tierkloof near Calitzdorp). Kloof Scrub varied physiognomically and floristically between sites. It may, however, be described as tall broad-leaved shrubland or short, scrub forest (kloof floor), flanked by open shrub and succulent vegetation on the adjacent rocky screes and cliffs of Table Mountain sandstone. A tall "other woody" (page 37) component (Tarchonanthus, Kiggelaria, Buddleia, Rhus, Olea) formed the canopy to a herbaceous ground cover (e.g. Mentha, Cyperaceae); the adjacent scrub included Eriocephalus, Cotyledon (e.g. C. paniculata), Crassula (e.g. C. portulacea), Aloe, Dodonaea, Rhus, Cussonia, Lachnostylis, Euphorbia and Portulacaria. Surrounding ridge crests, 0,5 km above the kloof floor, bore low scrub representing the xeric margin of Mountain Fynbos. This fynbos was composed mainly of ericoids (Phylica, Metalasia, Diosma, Passerina) and graminoids (Restio and Gramineae).

Plant genera recorded at these sites showed that Kloof Scrub in which the protea seedeater occurred was floristically distinct from Mountain Fynbos (Fig. 4). They included, however, a considerable proportion (15-20%) of genera recorded only from fynbos in the floristic sample on which this analysis was based.

3.2.2.3. Mesic to moist Mountain Fynbos

This environment constituted a major part of the area occupied by the protea seedeater, and the type to which the bird was previously believed restricted (Siegfried 1972). Figure 4 showed that plant genera recorded at sites for the protea seedeater in this environment represented a "purer" fynbos than the other two types, with a greater proportion of fynbos "exclusives" and fewer genera recorded from rhenosterbosveld.

FIGURE 4 : Floristic relationships of seedeater habitat. Upper histograms represent percentages of genera which are listed exclusively for fynbos in Table 3 ; lower histograms represent percentages of genera which are not listed for fynbos in Table 3 ; graphic line represents percentages of genera listed for rhenosterbosveld in Table 3.

1: Protea seedeater: density study site "Protea belt" Mountain Fynbos (73 genera)

2: Protea seedeater: mesic to moist Mountain Fynbos (143 genera)

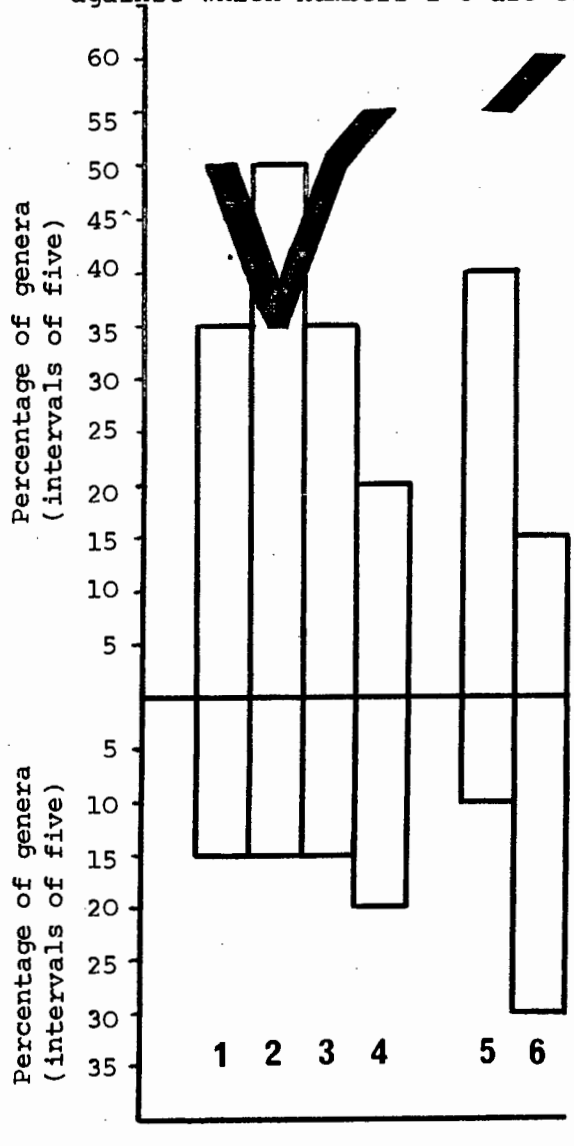
3: Protea seedeater: Dry Mountain Fynbos (99 genera)

4: Protea seedeater: Kloof Scrub (65 genera)

5: White-throated seedeater: all sites in Acocks' Macchia & False Macchia (49 genera)

6: Streaky-headed seedeater: all sites in Acocks' Macchia & False Macchia (71 genera)

Note: Number 1, representing a 4,3 ha low-altitude proteoid Mountain Fynbos study site under mesic conditions (1000 mm/annum) at which the density of the protea seedeater was measured, is used as a standard against which numbers 2-6 are compared. This site was also included in number 2.



4. HABITAT STRUCTURE

4.1. Structure of fynbos and Mountain Fynbos

No comprehensive classification of plant life-forms in fynbos, " a broad category of diverse evergreen sclerophyllous plant communities" (Kruger 1976), has been generally agreed on (van der Merwe 1966; Taylor 1969, 1972a, 1972b; Boucher 1972; Kruger 1976). Six structural (physiognomic) components of this vegetation were distinguished for the purposes of the present study, based partly on terminology already established in the literature. These components were: restioid, cyperoid and grass, forb/fern/soft woody (herbaceous components, the first two grass-like components sometimes being called the graminoid component) and proteoid, ericoid, and other woody (woody components). These six components collectively embraced virtually all plant life-forms in fynbos (Acocks' Macchia, False Macchia and Coastal Macchia), with the exception of succulent life-forms of a number of taxa (discussed below). Restioid and ericoid components are almost ubiquitous in fynbos, and do not occur in other south-west Cape vegetation types (Kruger 1976). The proteoid component, also restricted to fynbos in the south-west Cape, is absent from a large part of the area occupied by fynbos. The components cyperoid and grass, forb/fern/soft woody, and other woody are common to fynbos and other vegetation types such as forest and savanna (Werger, Kruger & Taylor 1972; Acocks 1975).

The restioid, ericoid and proteoid components lend a characteristic appearance to fynbos vegetation (Taylor 1969, 1972a; Boucher 1972; Werger, Kruger & Taylor 1972).

The restioid component consists of 0,2-2,0 m high, wiry leafless tufted graminoids of the Restionaceae, a family "characteristic" of fynbos (Taylor 1972a). The ericoid component consists of evergreen shrubs, of a height range similar to that for the restioid component, bearing small (short, narrow and often rolled) hard leaves. This component includes not only most members of the Ericaceae but also taxa of similar life-form in many other families. The proteoid component consists mainly of relatively tall (1,5-2,5 m) evergreen Proteaceous shrubs bearing large (1-6 cm broad, 5-15 cm long), leathery, ovate or oblong leaves, and reaching the stature of small "trees". These three components, of which at least one is conspicuous in almost all stands of fynbos (Kruger 1976), collectively contribute the major canopy cover in this vegetation type. A large part of the fynbos area is covered by vegetation in which restioid and ericoid components are co- or sub-dominant, all other components contributing relatively little to canopy cover. The proteoid component, conspicuous where it occurs (Taylor 1969, 1972a; Boucher 1972 ;Werger ,Kruger & Taylor 1972), is dominant or sub-dominant in some stands of fynbos but absent from others. Components other than restioid, ericoid and proteoid contribute, collectively and individually, relatively little to canopy cover in fynbos, wheras they are generally conspicuous in savanna and forest. Trees, included in "other woody", are largely absent from fynbos. Several of the six structural components may thus be absent from particular stands of fynbos; the conspicuous presence of the restioid component in a stand of vegetation may be used

as an arbitrary criterion for the use of the term "fynbos" (Taylor 1972a).

Several other structural components are regarded as absent from, or poorly represented in, fynbos, while being more characteristic of other south-west Cape vegetation types. The rhenoster component, comprising low (0,5-1,0 m) heath-like shrubs of two species of the composite genus Elytropappus, is characteristic of the transition between fynbos and karoo vegetation but virtually absent from Mountain Fynbos on mesic to moist sites (more than 450 mm per annum, Adamson 1945; Werger, Kruger and Taylor 1972). The succulent component comprises fleshy-leaved plants of a variety of life-forms in the Mesembryanthemaceae, Compositae and Liliaceae. This component, characteristic of karoo vegetation (Acocks 1975), is also present in dry stands of Mountain Fynbos, where it contributes only a small proportion to total canopy cover. The spinescent component, comprising thorn- and spine- bearing shrubs in several families (e.g. Celastraceae: Maytenus heterophylla; Leguminosae: Acacia karoo: Apocynaceae: Carissa spp.) is characteristic of strandveld and some types of karoo vegetation (Acocks 1975). The karoid component comprises small-leaved xerophytic dwarf shrubs belonging to the Compositae and several other families; this component, together with the succulent component, is characteristic of karoo vegetation. The alien component comprises broad- and needle- leaved shrubs (mainly Pinaceae, Proteaceae and Leguminosae) exotic to South Africa and invading the natural vegetation as scattered stands or thickets.

Two principal vertical strata may be distinguished in mature stands of fynbos (Taylor 1969; Werger, Kruger & Taylor 1972; Boucher 1972). The lower stratum, 0,5-1,5 m high, comprises the ericoid and restioid components as well as the other woody and the two other herbaceous components. The upper stratum, generally 3-6 m high, comprises mainly the proteoid component, minor canopy cover being contributed also by other woody and ericoid emergents in some stands. A "ground stratum", comprising the forb/fern/soft woody component (geophytes, dwarf shrubs and herbaceous annuals) is sometimes distinguished within the lower stratum (Adamson 1945; Taylor 1969).

The range of structure, as determined by the height and stratification of the vegetation and the cover of the six structural components, to be found between stands of Mountain Fynbos is similar to that for fynbos in general. Mountain Fynbos (both mature and youthful successional stages) varies from relatively low stands dominated by the restioid component ("biesieveld" sensu Kruger 1976) or ericoid component ("heath" sensu Kruger 1976) to stands in which four or more components contribute equally to total canopy cover, and to relatively tall stands of the most complex structure found in Mountain Fynbos ("sclerophyll scrub" sensu Kruger 1976) dominated by the proteoid component (Adamson 1945; Kruger 1976).

Mountain Fynbos occurs on sites covering the entire altitudinal range for the south-west Cape, i.e. between sea level and 2325 m (Wicht 1945; Acocks 1975). Three poorly defined belts of Mountain Fynbos, distinguishable on

structural grounds, correspond roughly with altitudinal belts. Relatively tall, clearly stratified proteoid fynbos is the characteristic vegetation of a "Protea belt" on foothills and lower slopes to an altitude of roughly 1000 m; low, single stratum restioid fynbos is characteristic of peak ridges and upper slopes; and ericoid fynbos, of intermediate height (0,2-1,5 m) and stratification, is characteristic of intermediate altitudes (Adamson 1945; Kruger 1976). However, the basic pattern of structural variation in relation to altitude is locally confused by variations in drainage, aspect and the frequency with which fires have occurred (Adamson 1945; Kruger 1976). The "Protea belt" can, therefore, include patches of vegetation structurally similar to those at higher altitudes. "Fully developed climax communities are in most parts by no means common nor at all extensive ... the greater part is covered by vegetation of a simpler kind, with one or at most two strata" (Adamson 1945).

The structure of Mountain Fynbos varies also in relation to mean annual precipitation, being in general taller and denser on relatively moist (but not marshy) sites, and shorter and more open on relatively dry sites (Adamson 1945; Campbell 1975). Stratification varies accordingly; stands with two strata (each almost continuous) develop under moist conditions while strata are more open or are reduced to a single stratum on drier sites (Adamson 1945). Mesic sites (450-650 mm annual precipitation) may bear a dense, clearly stratified climax stand, with a discontinuous upper stratum to a height of 4,5 m and a

continuous lower (ericoid and restioid) stratum (Adamson 1945). The driest sites (200-300 mm) occupied by Mountain Fynbos are characterized by very open vegetation, total canopy cover seldom exceeding 50% in contrast to Mountain Fynbos on sites receiving more than 300 mm which has canopy cover generally exceeding 65% (Campbell pers. comm.).

Mountain Fynbos in the eastern part of the south-west Cape is structurally similar to that further west, despite a marked difference in rainfall seasonality (page 16). One difference, however, is a particularly well-developed cyperoid and grass component locally in the eastern areas (Acocks 1975).

4.2. Structure of habitat of *Serinus leucopterus*

4.2.1. Vegetation structural components

4.2.1.1. Methods

The canopy cover (vertically projected total cover) of 11 structural components of the vegetation, as well as dead plant matter and total cover, was rated as a percentage of the 100 m^2 surface of each of 40 habitat sample plots. Each plot was the site of one or more feeding protea seedeaters.

4.2.1.2 Results & discussion

Figure 5 illustrates the importance of various structural components of the vegetation at sites for the protea seedeater as assessed by the canopy cover for each component. Fynbos components (proteoid, ericoid, restioid, forb/fern/soft woody, cyp. & grass, page 37) collectively dominated in types A to E (High-altitude proteoid Mountain Fynbos - *Protea laurifolia* Dry Mountain Fynbos). "Non-fynbos" components (e.g. other woody, page 37) dominated in the two remaining types. The proteoid component was present in all types except Kloof Scrub, although it varied from dominant (High-altitude proteoid Mountain Fynbos, cover greater than 20% in 60% of plots) to weakly represented (Ericoid Dry Mountain Fynbos). Total cover varied from 50-100% (Kloof Scrub, High-altitude proteoid Mountain Fynbos) to 60-70% (*Protea arborea* Dry Mountain Fynbos). Sites for the protea seedeater in Dry Mountain

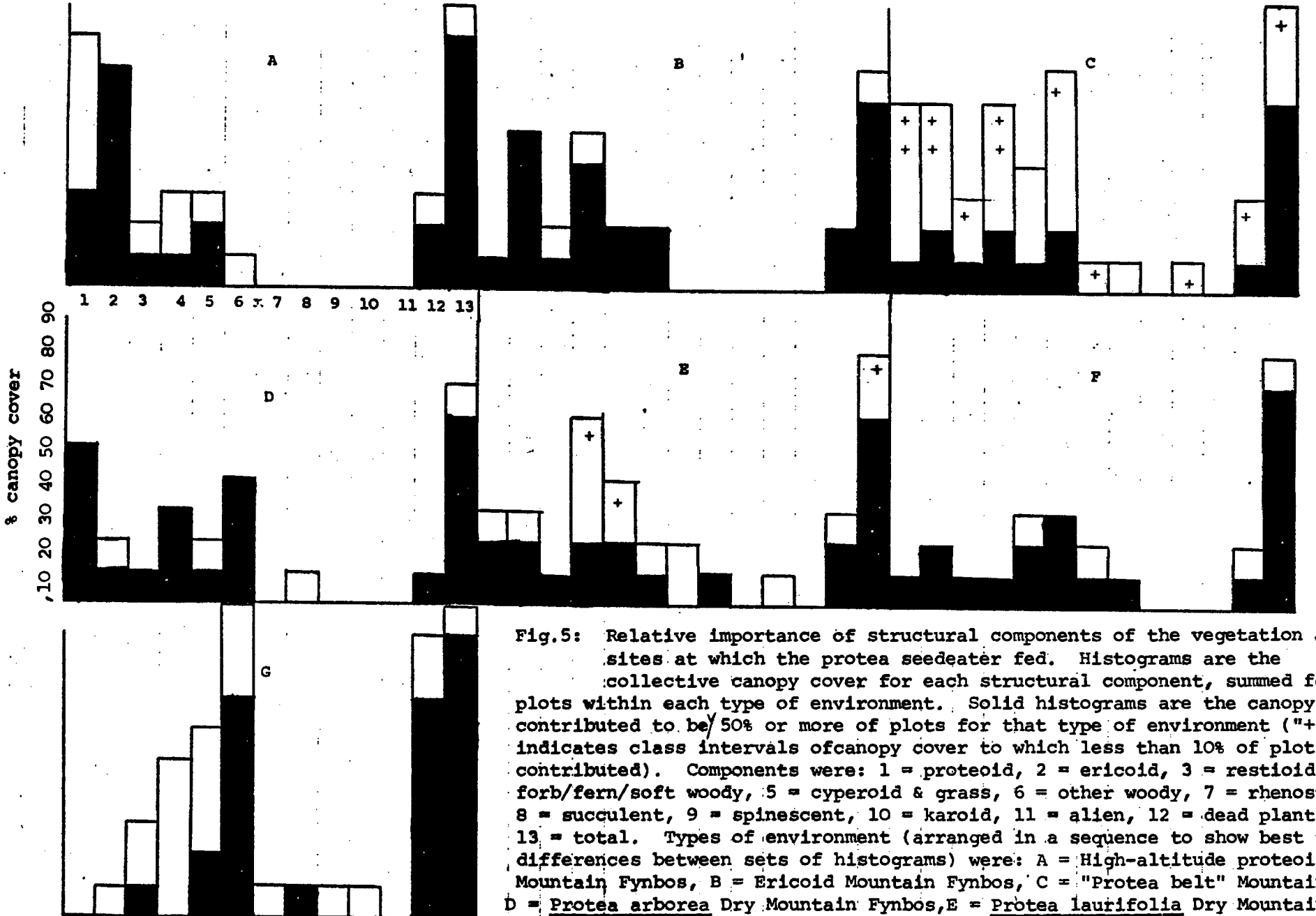


Fig.5: Relative importance of structural components of the vegetation at sites at which the protea seedeater fed. Histograms are the collective canopy cover for each structural component, summed for all plots within each type of environment. Solid histograms are the canopy cover contributed to by 50% or more of plots for that type of environment ("+" indicates class intervals ofcanopy cover to which less than 10% of plots contributed). Components were: 1 = proteoid, 2 = ericoid, 3 = restioid, 4 = forb/fern/soft woody, 5 = cyperoid & grass, 6 = other woody, 7 = rhenoster, 8 = succulent, 9 = spinescent, 10 = karoid, 11 = alien, 12 = dead plant parts, 13 = total. Types of environment (arranged in a sequence to show best the differences between sets of histograms) were: A = High-altitude proteoid Mountain Fynbos, B = Ericoid Mountain Fynbos, C = "Protea belt" Mountain Fynbos, D = Protea arborea Dry Mountain Fynbos, E = Protea laurifolia Dry Mountain Fynbos, F = Ericoid Dry Mountain Fynbos, G = Kloof Scrub. Types A-C = Mesic to moist Mountain Fynbos, types D-F = Dry Mountain Fynbos. Sample sizes (number of plots) were: A = 5, B = 2, C = 17, D = 2, E = 7, F = 2, G = 5.

Fynbos types (D & K, Fig. 5), with annual precipitation at the lower extreme for fynbos (page 33) were shown to have structure similar, with regard to components, to those in Mesic to moist Mountain Fynbos.

It was clear that the protea seedeater fed not only in stands of proteoid Mountain Fynbos (or even Mountain Fynbos sensu stricto) but occurred also in environments lacking a prominent proteoid component. This suggested that the apparent specificity of the bird to Protea stands is not absolute.

4.2.2. Vegetation height and canopy cover

Data on vegetation height and vertically projected plant cover were recorded from the same plots used for the above analysis of structural components. Total plant cover was estimated independently for successive 0,25m height strata above ground level. Plots within each of the same seven types of environment previously recognized (floristics section) were combined (Fig. 6) to show qualitatively the range in vegetation height and canopy cover for protea seedeater habitat.

These results show that the protea seedeater was observed feeding in vegetation of a relatively wide range of height and cover, from roughly 1,75 m high Ericoid Dry Mountain Fynbos (total cover roughly 50%) in which plant matter above 0,75 m covered only 10-20% of the surface of the plot, to 3,0 m and higher Kloof Scrub and types of proteoid Mountain Fynbos (total cover 80-100%) in which cover at 1,5 m was 30-70%. The protea seedeater thus fed not only in mature, tall, dense Mountain Fynbos and Kloof Scrub but also in relatively short open stands.

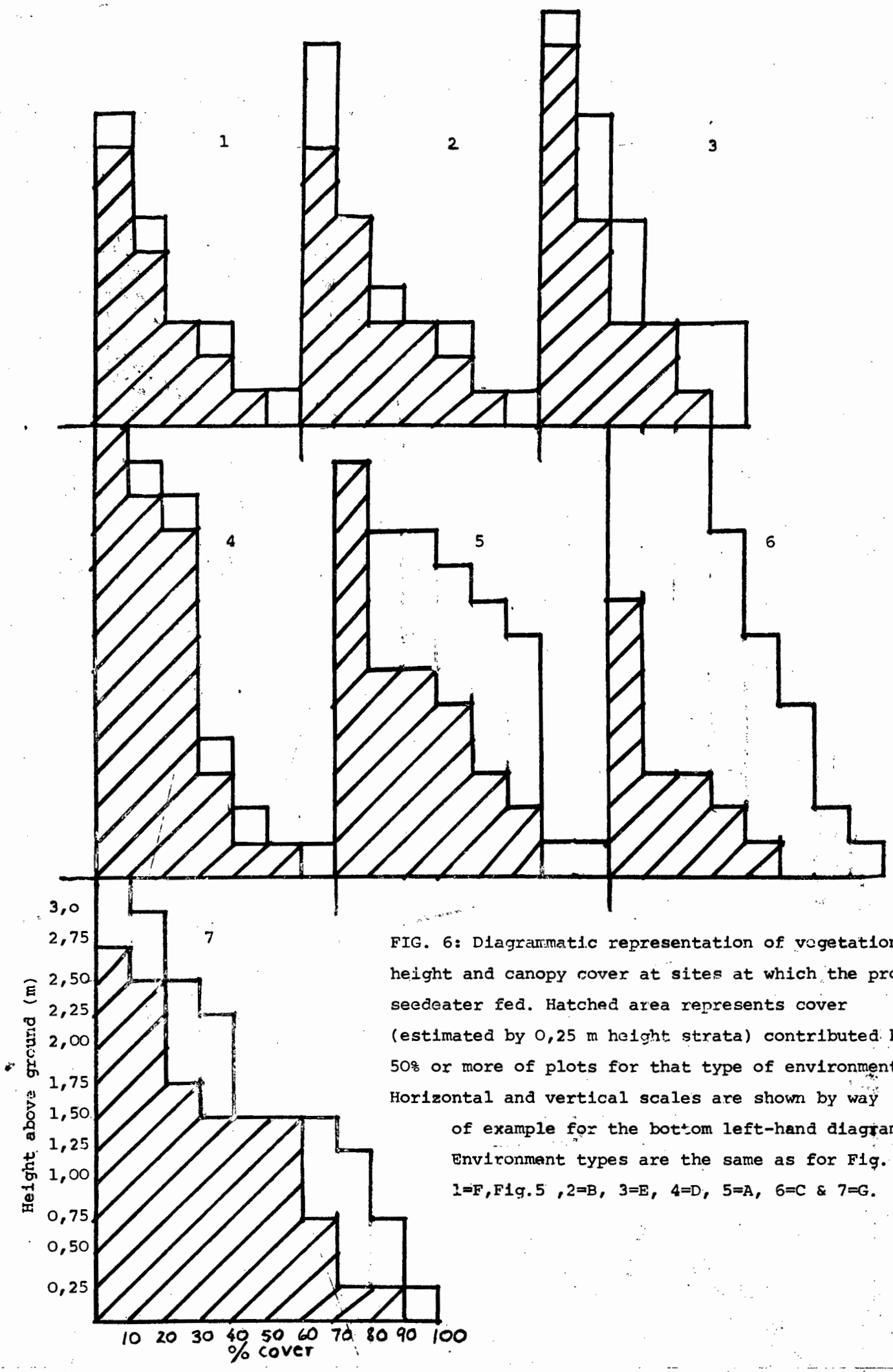


FIG. 6: Diagrammatic representation of vegetation height and canopy cover at sites at which the protea seedeater fed. Hatched area represents cover (estimated by 0,25 m height strata) contributed by 50% or more of plots for that type of environment. Horizontal and vertical scales are shown by way of example for the bottom left-hand diagram. Environment types are the same as for Fig. 5: 1=F,Fig.5 ,2=B, 3=E, 4=D, 5=A, 6=C & 7=G.

5. AVIFAUNA

5.1. Avifauna of south-west Cape environments

5.1.1. Methods

The aim of this section was to describe the avifauna associated with the protea seedeater, and to relate this to that of the south-west Cape in general.

Avifaunal relationships along an hypothetical gradient in vegetation height were first investigated. This study embraced several types of environment (including Mountain Fynbos), bearing different types of vegetation and represented by study sites at a number of localities in the Cape Peninsula-Stellenbosch area. Bird species were recorded (after Cody 1975), irrespective of the presence of the protea seedeater, as present or absent at each site.

The gross avifaunal inter-relationships of various types of environment (including Mountain Fynbos), distinguished according to topography and vegetation, in the south-west Cape were then studied. Localities in the eastern (Kammanassie range near Oudtshoorn) and western (Cape Peninsula-Stellenbosch area) parts of the south-west Cape were chosen. Study sites were thus selected to represent environments in each of two geographical sets of environment types. Avifaunal data were used, according to presence or absence, as for the first study. These two studies were expected (i) to demonstrate qualitatively the avifaunal inter-relationships between different forms of Mountain Fynbos and other types of environment in the south-west Cape, and (ii) to relate, in general terms, the occurrence of the protea seedeater to those of other members

of the avifauna, with special reference to the bird's congeners.

Finally, avifaunal data, collected specifically at sites where the protea seedeater was observed feeding, were analysed according to presence or absence of species. Avifaunal lists for sites were combined according to the classification used in the section on habitat floristics (Appendix 1). These results were discussed in relation to the foregoing analysis of avifaunal inter-relationships of south-west Cape environments. The information available (from these studies and the literature) regarding the habitat relationsips between the protea seedeater and its congeners was reviewed.

5.1.2. Avifauna in relation to vegetation height

Bird species, recorded according to presence or absence, at 13 sites were tabulated from Cody's (1975) "breeding season" census data. Cody selected sites from seven vegetation types to represent 13 stages in a range of vegetation height from 0,3 m to 23,6 m (Table 5). I arranged the matrix to show the best sequential series in the occurrences of species (Table 5). This series related those birds recorded from short, herbaceous vegetation through those recorded from Mountain Fynbos to those recorded from tall, woody (forest) vegetation. The final sequence of sites, determined by the arrangement of the table, corresponded exactly to that representing stages in a direct between-site increase in vegetation height.

Serinus leucopterus was observed only at sites 9, 10 & 11 (2,4-3,5 m high Mountain Fynbos with Protea). The "positive" section of the table (rectangle delimiting rows 10-44 in columns 9-11) for the protea seedeater embraced 34 other species. Comparison with Appendix 4 showed that 83% of the 23 bird species (asterisked in Table 5) recorded as present in a minimum of two of the three columns in the "positive" section of the table, were regarded as "characteristic" Mountain Fynbos birds. The remaining 17% comprised two species (Apalis and Melaenornis) regarded as more "characteristic" of coastal environments, and two species (Mesopicos and Streptopelia semitorquata) listed in Appendix 4 only as "possibly occurring" in Mountain Fynbos. Seventy percent of the remaining ten species in the "positive" section of the table were more "characteristic" of coastal environments than of Mountain Fynbos.

TABLE 5 : Occurrence of bird species in relation to gradient in vegetation height (after Cody 1975).

* see text

KEY: Site details, after Cody (1975), giving vegetation and localities. "Vegetation height" was not defined by Cody.

1. successional herbland, 0,30 m (Restionaceae, Compositae); Gordons Bay (coastal flats)
2. successional herbland, 0,34 m (Compositae, Iridaceae); Gordons Bay (coastal flats)
3. open ericoid fynbos, 0,58 m (Ericaceae, Restionaceae); Cape Peninsula
4. rhenosterbosveld, 0,64 m (Elytropappus); Gordons Bay
5. restioid fynbos, 1,0 m (Restionaceae); Cape Peninsula
6. rhenosterbosveld, 1,2 m (Elytropappus); Stellenbosch
7. rhenosterbosveld, 1,6 m (Elytropappus); Stellenbosch
8. Coastal Fynbos transitional to Broad-leaved Dune Scrub, 1,8 m (Metalasia, Euclea, Acacia); Swartklip
9. Mountain Fynbos, 2,4 m (Protea repens, Cliffortia, Rhus); Stellenbosch (north-facing slope)
10. open proteoid Mountain Fynbos, 3,3 m Protea arborea, Restio); Stellenbosch
11. Mountain Fynbos, 3,5 m (Protea, Cliffortia, Myrsine, Rhus); Stellenbosch (south-facing slope)
12. evergreen kloof forest, 10,9 m (Brabejum, Cunonia, Podalyria); Stellenbosch
13. evergreen forest, 23,6 m (Virgilia, Diospyros, Cunonia); Kirstenbosch

TABLE 5 : See above for explanation

Species	Sites 1	2	3	4	5	6	7	8	9	10	11	12	13
1 Anthus novaeseelandiae	X												
2 Calandrella cinerea	X		X										
3 Calendula magnirostris	X	X	X	X									
4. Anthus leucophrys		X	X										
5 Cisticola textrix	X	X	X	X	X								
6 Mirafra apiata		X		X									
7 Macronyx capensis	X	X		X		X							
8 Coturnix coturnix				X									
9 Malaconotus zeylonus				X		X		X					
10 Cisticola subruficapilla				X	X	X	X	X	X				
11 Streptopelia senegalensis						X	X						
12 Numida meleagris (naturalized)						X	X						
13 Serinus flaviventris						X	X	X					
14 Erythropygia coryphaeus						X	X	X					
15 Emberiza capensis						X	X	X					
16 Francolinus capensis					X	X	X	X	X				
17 Oena capensis							X						
18 Sphenoeacus afer*					X		X	X	X	X			
19 Euplectes capensis*					X	X	X		X	X	X		
20 Prinia maculosa*					X	X	X	X	X	X	X		
21 Parisoma subcaeruleum								X					
22 Saxicola torquata								X					
23 Nectarinia chalybea						X	X	X					X
24 Pycnonotus capensis*								X	X	X			
25 Melaenornis silens*						X				X	X	X	
26 Streptopelia capicola*						X	X	X	X	X	X	X	X
27 Onychognathus morio*								X	X	X	X		
28 Francolinus africanus*								X		X	X		
29 Serinus canicollis*							X		X	X	X	X	
30 Zosterops virens*							X	X	X	X	X	X	X
31 Cossypha caffra*							X	X	X	X	X	X	X
32 Apalis thoracica*								X	X		X	X	
33 Nectarinia violacea*									X	X	X		
34 Serinus leucopterus									X	X	X		
35 Promerops cafer*									X	X	X		
36 Monticola rupestris*										X	X		
37 Serinus sulphuratus*										X	X		
38 Cisticola fulvicapilla*										X	X		
39 Nectarinia famosa*										X	X	X	
40 Bradypterus victorini*											X		
41 Laniarius ferrugineus*									X	X	X	X	X
42 Batis capensis*									X		X	X	X
43 Mesopicos griseocephalus*										X	X		X
44 Streptopelia semitorquata*										X	X	X	X
45 Turdus olivaceus												X	X
46 Andropadus importunus													X
47 Bradypterus sylvaticus													X
48 Columba arquatrix													X
49 Muscicapa adusta													X
50 Aplopelia larvata													X
	1	2	3	4	5	6	7	8	9	10	11	12	13

5.1.3. Avifauna of a mountain area

Twelve sites, representing nine types of environment in the Kammanassie range near Oudtshoorn (Table 6), were each visited once for 2 to 3 hours in March and April 1975. All identified bird species were tabulated with type of environment in a presence/absence matrix. This was arranged to show the best sequential series in the occurrences of bird species (Table 6). This sequence related those birds recorded from short vegetation in dry environments (e.g. columns 1 & 2, Table 6), through those from proteoid Mountain Fynbos (e.g. columns 5 & 6) to those from Valley Thornveld, a form of karoo (column 9). Thus, for example, Anthus similis was observed only in short grassy successional Mountain Fynbos. Serinus leucopterus was observed only in types of Mountain Fynbos (4,5 & 7) on the southern side of the Kammanassie, ranging from mainly restioid fynbos at 1300 m a.s.l. through mainly proteoid fynbos to streamside fynbos at 800 m a.s.l. Lybius leucomelas (lower right of Table 6) was observed only in Valley Thornveld at the north base of the Kammanassie. Lanius collaris and Serinus albogularis showed an anomalous pattern, since they were observed in only two types (dry scrub and Valley Thornveld) widely separated in the table by the arrangement of the rest of the avifauna.

The sequence of sites, as determined by the arrangement of the table, could be related to a series in vegetation structure, since sites 1-9 (Table 6) represented stages along a direct hypothetical gradient from low (0,2 m), open vegetation to tall (4 m), comparatively dense

TABLE 6 : Avifaunal gradient for types of environment in the Kammanassie range, Oudtshoorn division, March-April 1975 (partly after Frost, unpublished). Location, aspect, altitude and topography are shown diagrammatically below (stippled area represents a transverse section)

KEY: Site details - vegetation :

Sites 1,4,5,6, & 7 bear Mountain Fynbos vegetation types (False Macchia, Acocks 1975). Sites 2,3 & 8 bear vegetation types transitional between Mountain Fynbos and karoo. Site 9 bears karoo vegetation (Succulent Mountain Scrub, Acocks 1975).

1 short grassy successional Mountain Fynbos

2 short dry scrub (Elytropappus rhinocerotis)

3 dry scrub (Aloe ferox) and cliffs

4 restioid Mountain Fynbos (with scattered Protea)

5 proteoid Mountain Fynbos (Protea repens, P. punctata)

6 proteoid Mountain Fynbos (Protea arborea)

7 riverine Mountain Fynbos

8 Kloof Scrub (Maytenus, Schotia, Diospyros)

9 Valley Thornveld form of karoo (Acacia, Rhus, Grewia)

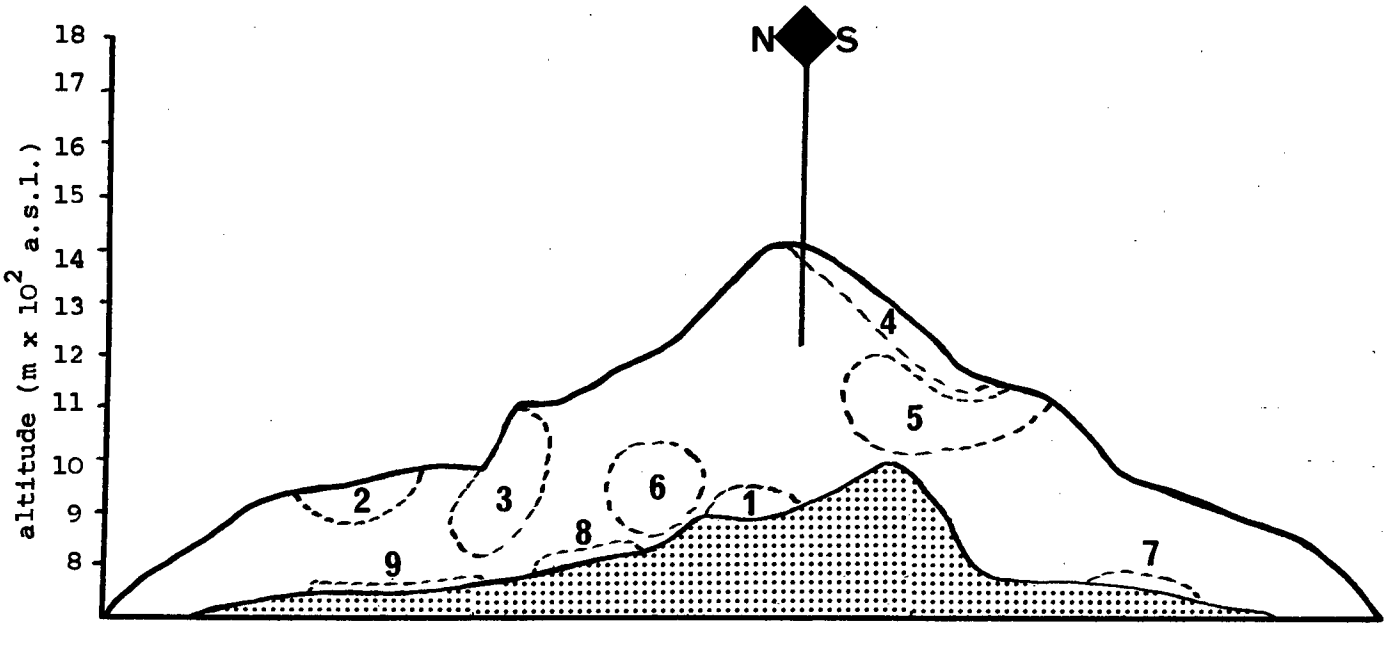


TABLE 6 : See above for explanation

	Species	Sites 1	2	3	4	5	6	7	8	9
1	Anthus similis	X								
2	Francolinus africanus	X	X							
3	Cisticola subruficapilla/lais	X	X			X				
4	Erythropygia coryphaeus		X	X						
5	Geocolaptes olivaceus			X						
6	Columba guinea			X						
7	Falco biarmicus			X						
8	Hirundo rupestris*		X	X	X		X			
9	Corvus albicollis			X	X					
10	Chaetops frenatus				X					
11	Saxicola torquata*	X			X			X		
12	Buteo rufofuscus				X					
13	Onychognathus morio*		X	X		X	X	X		
14	Cisticola fulvicapilla*			X		X	X			
15	Monticola rupestris*		X				X	X		
16	Falco tinnunculus*				X		X			
17	Bradypterus victorini*				X	X		X		
18	Serinus leucopterus				X	X		X		
19	Nectarinia famosa*				X	X	X	X		
20	Batis capensis		X			X			X	X
21	Promerops cafer*				X	X		X		
22	Zosterops virens*		X			X	X		X	X
23	Hirundo cucullata			X						X
24	Sphenoeacus afer*					X	X	X		
25	Corvus capensis						X			
26	Aquila verreauxii						X			
27	Nectarinia chalybea*						X	X		
28	Nectarinia violacea*				X	X	X	X	X	X
29	Serinus tottus*				X	X	X	X	X	X
30	Dicrurus adsimilis		X				X		X	X
31	Pycnonotus capensis*		X				X	X	X	X
32	Cossypha caffra*					X		X	X	X
33	Malaconotus zeylonus*						X	X	X	X
34	Laniarius ferrugineus*						X	X	X	X
35	Parisoma layardi								X	
36	Serinus gularis								X	
37	Tchagra tchagra							X	X	X
38	Apalis thoracica								X	X
39	Dendropicos fuscescens								X	X
40	Streptopelia capicola								X	X
41	Stenostira scita									X
42	Nectarinia afra									X
43	Ploceus capensis									X
44	Bradypterus baboecala									X
45	Indicator indicator									X
46	Lybius leucomelas									X
47	Upupa epops									X
48	Sylvietta rufescens									X
49	Colius colius									X
50	Colius striatus									X
51	Francolinus capensis									X
52	Cercomela familiaris*	x	x	x			x	x	x	
53	Prinia maculosa*		X	X	X	X	X	X	X	X
54	Emberiza capensis*		X	X	X	X	X	X	X	X
55	Lanius collaris		X							X
56	Serinus alboqularis		X							X
		1	2	3	4	5	6	7	8	9

vegetation. This, in support of the above vegetation height study, showed that a positive relationship exists between vegetation structure and the species-composition of the avifauna, agreeing with Cody (1975).

Comparison with Appendix 4 showed that 90% of the 21 bird species (asterisked in Table 6) recorded from a minimum of two of the four types of environment in the "positive" section of the table (rectangle delimiting rows 3-37 in columns 4-7) for the protea seedeater are regarded as "characteristic" Mountain Fynbos birds. Only Saxicola and Nectarinia chalybea (the remaining 10%) were regarded as being more "characteristic" of coastal environments (Appendix 4). Half of the other 16 species in the "positive" section of the table had also been listed as "characteristic" Mountain Fynbos birds (Appendix 4). The other half comprised several species (e.g. Tchagra, Dicrurus, Serinus gularis) previously recorded only as "possibly occurring" in Mountain Fynbos and two (Erythropygia, Cisticola subruficapilla) regarded as more "characteristic" of coastal environments (Appendix 4). There thus appeared to be good co-incidence between the "characteristic" species of Mountain Fynbos in the western part of the south-west Cape and the avifauna associated with the same environments as the protea seedeater, in both the Cape Town-Stellenbosch and Kammanassie areas.

5.1.4. Overall avifauna of south-west Cape environments

Avifaunal data from the Kammanassie and vegetation height studies were combined. This produced a more comprehensive view of the avifaunal inter-relationships of south-west Cape environments (including Mountain Fynbos) from geographically heterogeneous sets of localities, viz in the west and east of the region. The resultant matrix was arranged to show the best sequential avifaunal series (Appendix 3a). Discussion of this overall avifauna will be limited to congeners of the protea seedeater (page 54).

5.2 Avifauna at sites for protea seedeater

Avifaunal lists for sites where the protea seedeater was observed feeding were combined according to site topography, precipitation and vegetation (section on Habitat Floristics), as follows: 1) Mesic to moist Mountain Fynbos, 2) Dry Mountain Fynbos, and 3) Kloof Scrub. Table 7 summarises the occurrences, according to collective presence or absence, of all bird species at sites for the protea seedeater throughout the south-west Cape, in relation to these types of environment described above with regard to floristics and vegetation structure.

The set of bird species associated with the protea seedeater in Kloof Scrub (column 3, Table 7) was largely an impoverished version of that associated with the protea seedeater in Mesic to moist Mountain Fynbos (column 1). The Kloof Scrub list however included a number of species (e.g. Stenositra scita, Francolinus afer, discussed below) not recorded in Mesic to moist Mountain Fynbos. A large number of avifaunal associates was, similarly, shown to link Mesic to moist Mountain Fynbos with Dry Mountain Fynbos (column 2). Forty-five percent of associates in Mesic to moist Mountain Fynbos (e.g. Cossypha caffra, Bradypterus victorini, Laniarius ferrugineus) were, however, absent from Dry Mountain Fynbos. These appeared to be mainly species characteristic of relatively tall, dense vegetation. The seven associates (19%) restricted to Dry Mountain Fynbos were, conversely, mainly birds (e.g. Mirafra apiata, Sylvietta rufescens, Serinus alario) characteristic of dry

TABLE 7 : Avifauna at sites for protea seedeater, according to presence or absence. Data were combined according to a grouping of sites into three types of environment: 1 = Mesic-moist Mountain Fynbos; 2 = Dry Mountain Fynbos; 3 = Kloof Scrub. Crosses in parentheses indicate species marginally outside site (100-200 m from position of a perched protea seedeater).

Species	Environment type 1	2	3
Monticola explorator	X		
Sphenoeacus afer	X		
Chaetops frenatus	X		
Hirundo rupestris	X		
Pycnonotus capensis	X		
Macronyx capensis	(X)		
Francolinus capensis	X		
Colius indicus	X		
Colius striatus	X		
Laniarius ferrugineus	X		
Apalis thoracica	X		
Muscicapa adusta	X		
Turdus olivaceus	X		
Columba arquatrix	X		
Erythropygia coryphaeus	X	X	
Serinus flaviventris	X	X	
Serinus albogularis	X	X	
Estrilda astrild	X	X	
Elanus caeruleus	(X)	(X)	
Streptopelia capicola	X	X	
Cisticola subruficapilla	X	X	
Passer melanurus	X	X	
Tchagra tchagra	(X)	(X)	
Malaconotus zeylonus	X	X	
Streptopelia senegalensis	X	X	
Lanius collaris	X	X	
Geocolaptes olivaceus	X	X	
Apus melba	X	(X)	
Euplectes capensis	X	X	
Falco tinnunculus	(X)	(X)	
Serinus tottus	X	X	
Serinus canicollis	X	X	
Mirafra apiata		X	
Upupa epops		(X)	
Serinus alario		X	
Onychognathus nabouroup		(X)	
Spreo bicolor		(X)	
Oenanthe monticola		X	
Sylvietta rufescens		X	
Stenostira scita		X	X
Francolinus afer			X
Motacilla capensis			X
Euryptila subcinnamomea			(X)
Nectarinia afra			X
Cossypha caffra	X		X
Monticola rupestris	X		X
Cisticola fulvicapilla	X		(X)
Bradypterus victorini	X		X
Saxicola torquata	X		X
Batis capensis	X		X
Melaenornis silens	X		X
Serinus sulphuratus	X		X
Columba guinea	(X)		X
Serinus gularis	(X)		X
Nectarinia chalybea	X	(X)	X
Ploceus capensis	X	X	X
Cercomela familiaris	X	X	X
Serinus leucopterus	X	X	X
Zosterops virens	X	X	X
Nectarinia violacea	X	X	X
Promerops cafer	X	X	X
Onychognathus morio	X	(X)	X
Emberiza capensis	X	X	X
Nectarinia famosa	X	X	X
Prinia maculosa	X	X	X

environments bearing open, short vegetation. The following is a discussion of several species which are of biogeographical interest in relation to the habitat of the protea seedeater.

Parisoma layardi, Layard's tit-babbler, Stenostira scita, the fairy flycatcher, Onychognathus nabouroup, the pale-winged starling, Euryptila subcinnamomea, the cinnamon-breasted warbler, and Serinus alario, the blackheaded canary (discussed below), are birds characteristic of the karoo. Stenostira scita is associated with taller scrub than is P. layardi, O. nabouroup is associated with broken country and E. subcinnamomea is restricted to areas of outcropping rock (Paterson 1958; Anon. 1963; S.A.O.S. List Committee 1969; Winterbottom 1966a, 1966b & 1968b). All five species penetrate the south-west Cape, from their main ranges to the north, in association with relatively dry environments only. None of the species has previously been recorded from Mountain Fynbos (Appendix 4) nor in any of the environments in which the protea seedeater was recorded in the Kammanassie and Cape Town-Stellenbosch areas (Tables 5 & 6). Layard's tit-babbler occurred at a site for the protea seedeater at the transition between Mountain Fynbos and karoo (Acocks' Karroid Broken Veld, Grays Pass near Piketberg). The fairy flycatcher was observed at sites for the protea seedeater in Kloof Scrub at the transition from Mountain Fynbos to karoo (Acocks' Karroid Broken Veld at Kransvlei near Clanwilliam and Grays Pass near Piketberg, and Acocks' Succulent Mountain Scrub at Gamka Reserve near Calitzdorp). The flycatcher was also observed at a site for the protea seedeater in a proteoid stand of Mountain Fynbos on

Witteberg quartzite (Waboomsberg near Ceres). The starling was present at sites for the protea seedeater on a narrow outlier belt of Mountain Fynbos occupying an escarpment surrounded by karoo (Gifberg near Vanrhynsdorp). The cinnamon-breasted warbler occurred at a site for the protea seedeater in Kloof Scrub (Kransvlei near Clanwilliam) and in scrub transitional between Mountain Fynbos and karoo (Grays Pass near Piketberg); Euryptila subcinnamomea has not previously been recorded from Table Mountain sandstone environments. These four bird species and S. alario (discussed below) are considered indicative of a limit for the habitat of the protea seedeater at the transition from fynbos to karoo.

Oenanthe monticola, the mountain chat, is another karoo bird, extending into drier northern Mountain Fynbos environments (Anon. 1963; S.A.O.S. List Committee 1969). It was found to occur with the protea seedeater at a site on an outlier belt of Mountain Fynbos in the karoo (Gifberg plateau near Vanrhynsdorp). This apparently marginal sympatry is considered an indication of the protea seedeater's tolerance of relatively dry environmental conditions.

Francolinus afer, the red-necked francolin, Nectarinia afra, the greater double-collared sunbird, Tchagra tchagra, the tchagra, and Indicator minor, the lesser honeyguide, are species penetrating the south-west Cape, from their main areas of distribution to the east, mainly along a coastal strip as far west as Cape Agulhas and Montagu. The red-necked francolin, greater double-collared sunbird and lesser

honeyguide are characteristic of forest edge environments; the tchagra is known from karoo environments bearing relatively tall vegetation, also occurring in Coastal Fynbos in the west (Paterson 1958; Anon. 1963; S.A.O.S. List Committee 1969; Winterbottom 1966a, 1966b & 1968b). None of these species was recorded from sites at which the protea seedeater was observed in the Kammanassie and Cape Town-Stellenbosch areas (Tables 5 & 6). All four species were observed at sites for the protea seedeater in Kloof Scrub and stands of riverine vegetation transitional between Kloof Scrub and Mountain Fynbos in the Kouga range near Joubertina. These species are collectively considered indicative of overlap between south-western (fynbos) and eastern (forest, savanna and karoo) avifaunal elements along an environmental gradient.

Considerable heterogeneity was apparent within the avifauna collectively associated with the protea seedeater, considered qualitatively. The bird's habitat range, as expressed by its range of avifaunal associates, appears to extend to the xeric fringe of Mountain Fynbos. This is supported by data in the habitat floristics and structure sections, in which the habitat range for the seedeater was documented using more direct environmental parameters. It must be stressed however that heterogeneity of associates does not necessarily indicate a corresponding habitat tolerance for the protea seedeater. Densities of each associate would need to be measured to show, quantitatively, the "characteristic" and "marginal" parts of the range for the protea seedeater.

5.3. Congeners

Three congeners of the protea seedeater (S. flaviventris, S. canicollis and S. sulphuratus) were recorded at 13 sites representing environments of the lower mountain slopes and adjacent coastal flats of the Cape Peninsula - Stellenbosch area (Table 5). Serinus canicollis occurred in rhenosterbosveld (coastal flats), proteoid Mountain Fynbos and evergreen kloof forest (lower mountain slopes), a wide range of environments (vegetation height 1,6 - 10,9 m). Serinus sulphuratus was recorded only at sites (10 & 11) with 3,3 - 3,5 m proteoid Mountain Fynbos (lower slopes). Serinus flaviventris occurred in 1,2 - 1,8 m rhenosterbosveld and fynbos (coastal flats and dunes).

Three other congeners of the protea seedeater (Serinus tottus, S. albogularis and S. gularis) were collectively recorded in nine types of environment in the Kammanassie range (Table 6). Serinus tottus occurred in restioid Mountain Fynbos (high-altitude slopes), proteoid Mountain Fynbos including the Protea arborea form (lower to mid-altitude slopes), streamside Mountain Fynbos (lower slopes), Kloof Scrub and Valley Thornveld (drainage lines on lower slopes and at base, bearing tall karoo vegetation). It was thus present in a wide range of mountain environments, embracing vegetation of a wide height range. Serinus albogularis occurred in Valley Thornveld and in dry scrub (rhenosterbosveld, dominated by Elytropppus rhinocerotis, on the lower north-facing slopes of the Kammanassie range). Serinus gularis was observed only in Kloof Scrub (column 8, Table 6), an environment characterized by non-spinescent vegetation, replacing Valley

Thornveld higher up the drainage lines of the north base of the range and overlooked by slopes bearing Protea arborea Mountain Fynbos (Table 6).

Serinus leucopterus was observed only in restioid (with scattered Protea, high-altitude slopes), proteoid (lower to mid-altitude slopes) and streamside (lower southern slopes, Table 6) stands of Mountain Fynbos. The occurrences of S. canicollis embraced the entire environmental range (Appendix 3a) for S. leucopterus, including all three sites for the protea seedeater in the Cape Peninsula - Stellenbosch area. Serinus sulphuratus was recorded only within the environmental range shown for the protea seedeater (Table 5, Appendix 3a), viz. at sites for S. leucopterus bearing relatively tall proteoid Mountain Fynbos. Serinus tottus was recorded only at sites in mountain environments, including sites in Mountain Fynbos types at which S. leucopterus was also present. The occurrence of the siskin thus appeared to coincide broadly with that of the protea seedeater, as well as with those of S. canicollis and S. sulphuratus (Table 5, Appendix 3a).

Serinus albogularis and S. gularis, not recorded from sites in Mountain Fynbos, did not occur in the same types of environment as the protea seedeater, nor in the same types as each other (Appendix 3a). Serinus albogularis occurred in karoo (Valley Thornveld) adjacent to a mountain, as well as in drier mountain environments bearing vegetation shorter than nearby Mountain Fynbos in which the protea seedeater occurred. Serinus gularis occurred in an environment bearing vegetation as tall as Mountain Fynbos but representing a xeric fringe of Mountain Fynbos. Serinus leucopterus, S. gularis

and S. albogularis thus appeared, at least in the Kammanassie range, to replace each other in different environments. Serinus flaviventris was recorded only in vegetation shorter than that for the protea seedeater, and in a different general environment (coastal flats, not mountain slopes). Serinus flaviventris and S. leucopterus thus appear (at least on coastal flats and lower mountain slopes of the Cape Peninsula - Stellenbosch area) to replace each other in adjacent sections of the hypothetical gradient in vegetation height. The position of the yellow canary in Table 5, however, suggested marginal co-occurrence with the protea seedeater (row 13 falls within the rectangle delineated by columns 9 - 11).

The only "seed-eating passerines", other than Serinus leucopterus and its congeners, featuring in Appendix 3a were Ploceus capensis, the Cape weaver (Valley Thornveld), Euplectes capensis, the Cape widow (rhenosterbosveld and restoid Fynbos on coastal flats, and proteoid Mountain Fynbos on lower slopes) and Emberiza capensis, the Cape bunting (dry scrub, Mountain Fynbos, Kloof Scrub, Valley Thornveld, and rhenosterbosveld and fynbos on coastal flats.) The Cape bunting was apparently tolerant of a wide variety of environments (including Mountain Fynbos types in which S. leucopterus occurred), Euplectes capensis, like Emberiza, occurred both in coastal flats environments and with S. leucopterus in proteoid Mountain Fynbos. Ploceus capensis was not recorded at any of the sites for S. leucopterus.

Seven Serinus species, viz. S. albogularis, S. gularis, S. tottus, S. canicollis, S. sulphuratus, S. flaviventris and

S. alario, comprising 11% of the total number of bird species encountered, were recorded at sites where protea seedeaters fed (Table 7). Serinus canicollis and S. tottus occurred in "Protea belt" and Dry Mountain Fynbos, S. sulphuratus in "Protea belt" Mountain Fynbos and Kloof Scrub, and S. flaviventris and S. albogularis in "Protea belt" and Dry Mountain Fynbos. Serinus alario was encountered with S. leucopterus only in Dry Mountain Fynbos, and S. gularis in Kloof Scrub and (marginally) in "Protea belt" Mountain Fynbos. Several seed-eating passerine species other than congeners of the protea seedeater were also encountered. The following is a more detailed discussion of these species.

Serinus albogularis and S. gularis were observed at sites for S. leucopterus only in karoo-Mountain Fynbos transition environments, in Dry Mountain Fynbos outliers and at the borders of the Karoo, and in Protea belt Mountain Fynbos within 2 km of agricultural land, alien woodland or Acocks' Mountain Rhenosterbosveld. Serinus albogularis and S. gularis were thus absent from most of the habitat range for S. leucopterus. This was supported by the data given in section 5.1. (Tables 5 & 6) and by the literature:
S. albogularis was regarded as more "characteristic" of dry (coastal and karoo) environments than of Mountain Fynbos, while S. gularis was virtually unknown from Mountain Fynbos (Appendix 4).

Serinus tottus and S. canicollis were observed at sites for S. leucopterus, representing most of the environment types in which the protea seedeater occurred. These included,

in the case of S. tottus, proteoid Mountain Fynbos at low and high altitudes, Dry Mountain Fynbos including outliers in the karoo, and environments adjacent to Acocks' Mountain Rhenosterbosveld and agricultural land. The siskin, a "characteristic" Mountain Fynbos bird (Appendix 4), and protea seedeater clearly co-existed over a major part of the habitat range for S. leucopterus. The siskin, was, however, habitat tolerant relative to S. leucopterus, appearing to be associated with environmental rockiness (specifically the proximity of cliffs) rather than with characteristics of the vegetation (supported by data in section 4.1 and the literature, Appendix 4). The siskin was absent from certain sites bearing proteoid Mountain Fynbos at low altitudes (e.g. Paarl Mountain, Helderberg Nature Reserve) relatively far from outcropping rock features. The protea seedeater occurred in these environments at the base of mountains, part of its habitat range thus lacking the siskin. Serinus tottus, conversely, was observed during the study at mountain sites extending to the highest altitudes, occupying rocky environments bearing short restioid vegetation in which the protea seedeater was not observed. The Cape canary, although a "characteristic" Mountain Fynbos bird, was habitat tolerant (supported by data in section 5.1.2 and the literature, Appendix 4). The Cape canary appeared to coexist with the protea seedeater over virtually the entire habitat range for the seedeater, with the possible exception of a part represented by high altitude Mountain Fynbos.

Serinus sulphuratus was observed at sites for S. leucopterus in proteoid and riverine stands of Mountain Fynbos and in Kloof Scrub, all environments at relatively low altitudes. The bully and protea seedeaters coexisted over a large part of the habitat range for S. leucopterus; S. sulphuratus appeared, however, to be associated with relatively tall, dense vegetation (supported by data in section 5.1 and the literature, Appendix 4). The bully seedeater appeared absent from that part of the protea seedeater's habitat range represented by dry or relatively high altitude environments bearing relatively short vegetation.

Serinus flaviventris was observed at sites for S. leucopterus only in proteoid stands of Mountain Fynbos at the base of the mountains and in dry environments such as fynbos outliers in the karoo, most sites being within 0,5 km of agricultural land. The yellow canary and the protea seedeater had habitat ranges largely mutually exclusive (supported by data in section 5.1.2 and the literature, Appendix 4). The canary occurred in drier, flatter environments bearing shorter vegetation than those in which the seedeater occurred. The two species were, however, shown to have marginally overlapping habitats, supporting remarks on page 56. Serinus alario was observed at sites for S. leucopterus only in proteoid stands of Mountain Fynbos in dry environments adjacent to Acocks' Mountain Rhenosterbos-veld and agricultural land. The habitat range for the protea seedeater marginally overlapped with that for the blackheaded canary, a karoo bird (Winterbottom 1973): this

was supported by data in section 5.1 (S. alario was not encountered in the Cape Town - Stellenbosch or Kammanassie areas, Appendix 3a) and by the literature (Appendix 4): the blackheaded canary has not previously been recorded from fynbos.

Emberiza capensis, the Cape bunting, was observed at more than 75% of sites for S. leucopterus, representing virtually all types of environment in which the protea seedeater was found. The Cape bunting, a "characteristic" Mountain Fynbos bird (Appendix 4), was associated with S. leucopterus over virtually the entire habitat range for the seedeater, occurring in environments bearing vegetation of a height range wider than that indicated in Table 5. This tolerance was supported by the literature (Appendix 4).

Ploceus capensis, the Cape weaver, and Passer melanurus, the Cape sparrow, were observed at sites for S. leucopterus in proteoid stands of Mountain Fynbos at relatively low altitudes or in dry environments (e.g. near the transition to Acocks' Mountain Rhenostervosveld). Sites for the Cape sparrow were, however, all within 1 km of disturbed environments (alien woodland, agricultural land). Euplectes capensis, the Cape widow, was observed at sites for S. leucopterus in a wide range of environments bearing a wide range of vegetation types. Estrilda astrild, the common waxbill, was observed at sites for S. leucopterus only in proteoid and streamside stands of Mountain Fynbos.

The Cape widow, a "characteristic" Mountain Fynbos bird (Appendix 4), shared a major part of the habitat range for S. leucopterus. The Cape weaver shared a smaller part of

this habitat range than did the Cape widow; the subjective impression gained was that the numbers of the Cape weaver, a bird more "characteristic" of coastal environments than of Mountain Fynbos (Appendix 4), were subject to large seasonal fluctuations (e.g. at sites on Paarl Mountain). The occurrence of the Cape sparrow was, similarly, more marginal to the habitat range of S. leucopterus than was that of P. capensis. The common waxbill was associated with S. leucopterus over a minor part of the seedeater's habitat range. These conclusions were supported by data presented in Tables 5 & 6 and by the literature (Appendix 4).

Inverse analysis of the data in Appendix 3a was carried out to provide a numerical comparison of the sets of avifaunal associates of the protea seedeater and congeners. Inverse analysis shows the relationships of species with species, as opposed to species with samples (Field 1970). I used McConnaughey's (1964) coefficient of association, equal to $\frac{(A+B)C}{AB} - 1$, where A and B are the numbers of occurrences of species a and b respectively, and C is the number of joint occurrences. The coefficient ranges from -1(species never together) to +1(species always together)and is particularly suitable for inverse analysis of information on the presence or absence of species, collected with varying degrees of completeness from samples of undefinable (and inconsistent) spatial extent, such as marine plankton or dredge samples (McConnaughey 1964; Field 1970). The method is "suitable even when the data are very heterogeneous, that is when many of the species are absent from most of the samples (Field 1970).

Table 8 shows McConnaughey coefficients of positive association between passerine species and each of seven Serinus species including the protea seedeater. Table 9, summarizing these findings, shows that the sets of "positive associates" for S.sulphuratus and S.tottus were more than 60% similar to that for S.leucopterus, while sets for other congeners were less than 40% similar. These values can be accepted as a reflection of similarity between the habitats of the protea seedeater and its congeners, assuming that avifaunal data,as used in this study, convey valid and sufficient information about the environment.

TABLE 8:

Passerine species positively associated (McConnaughey coefficient between 0 and +1) with each of seven Serinus species including S. leucopterus, based on Appendix 3b. Associated species are listed in order of decreasing McConnaughey coefficient (shown by the solid line relative to the McConnaughey scale on the left-hand side).

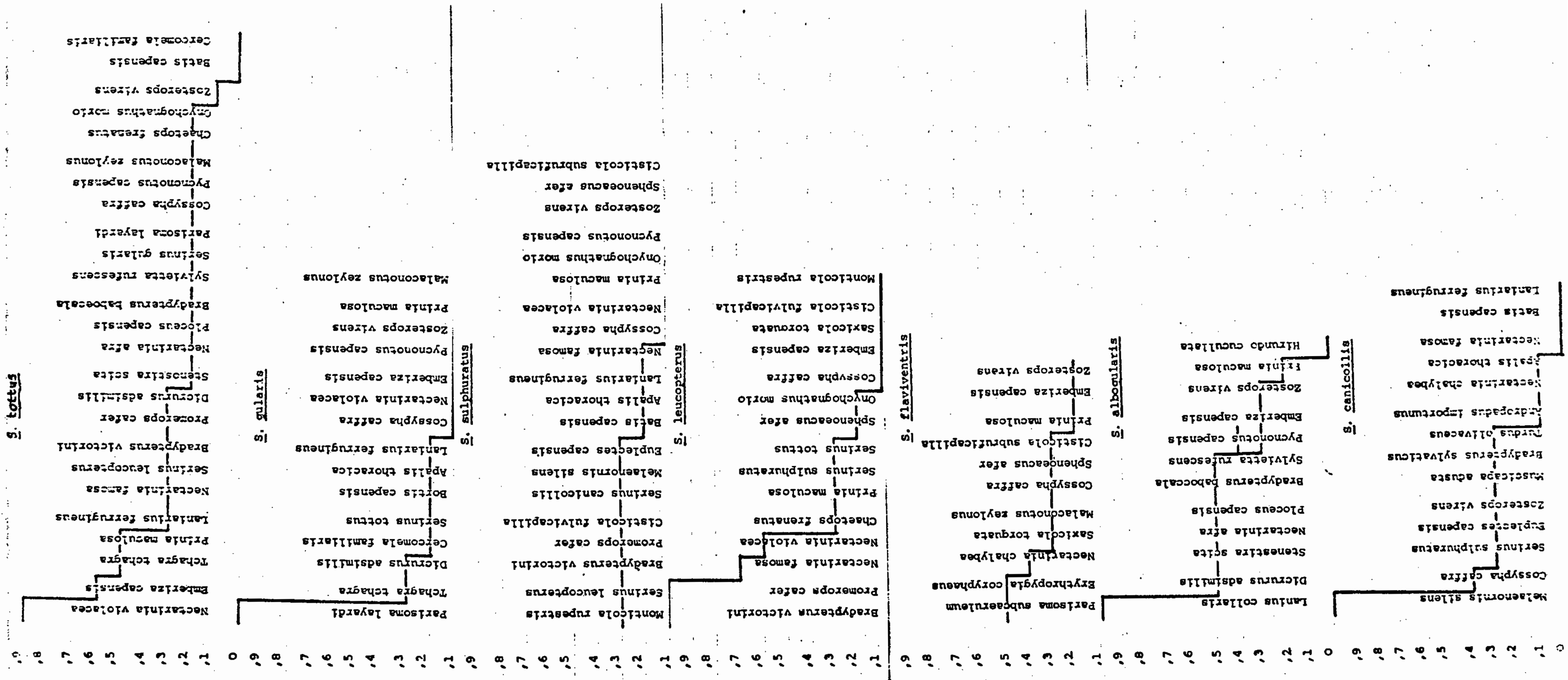


TABLE 9: Percentage similarity between sets of bird species positively associated with *Serinus leucopterus* and those positively associated with each of six congeners, based on Table 8. Only passerine species with McConnaughey coefficients of 0 to +1 were included; asterisks indicate congeners with which *S. leucopterus* was positively associated.

Serinus species					
S.sulphuratus	*S.tottus*	*S.flaviventris*	*S.gularis*	*S.canicollis*	*S.albogularis*
69%	61%	38%	33%	21%	15%

5.4. Avian density

5.4.1. Methods

The density of the protea seedeater, in relation to those of other birds occurring with it, was assessed as follows. An area of proteoid Mountain Fynbos was chosen for (i) presence of Serinus leucopterus, (ii) maturity of the stand (more than 20 years since last fire), and (iii) ease of mobility (the vegetation being open enough to allow passage through it on a predetermined course). Bird counts were made in 4,3 ha of this environment using the "strip" method (Graber & Graber 1963). This entailed walking in a straight line through the vegetation, identifying and counting all perched birds first observed within 10 m to either side of the line of progression. Pauses were made every 20-30 paces to ensure that no birds remained unobserved. A fixed bird count transect was walked 30 m to the right of a straight pylon line of known length. Six replicate counts were made (not more than one per day) from 21 January to 24 February 1976, at intervals not exceeding two weeks. Counts commenced 140-150 minutes after local sunrise, irrespective of weather conditions. Ambient air temperature, wind speed and cloud cover were recorded for each count (Appendix 5).

Protea seedeaters sighted within or beyond the transect limits were observed, while I remained stationary, until they began feeding or for a maximum of 10 minutes. The count was then resumed. Time taken observing birds outside the 10 m limits was subtracted from total time taken to complete the count. An attempt was made to limit the net duration of each count to 3 hours (net duration never exceeded 200 minutes, Appendix 5).

TABLE 10 : Numbers of birds counted within a 4,3 ha transect in proteoid Mountain Fynbos at Molenaarsrivier (Slanghoek Mountains, Worcester Division), Jan.-Feb. 1976. Species are in taxonomic order.

Species	Replicate count number					
	1	2	3	4	5	6
Falco tinnunculus	-	-	-	-	(+)	-
Aquila verreauxi	-	-	-	-	-	(+)
Merops apiaster	(+)	-	(+)	-	(+)	-
Apus melba	(+)	-	-	(+)	-	-
Streptopelia capicola*	2	3	1	(+)	1	2
Streptopelia senegalensis	-	(+)	1	-	-	(+)
Colius sp.	1	-	-	-	-	-
Pycnonotus capensis	(+)	2	-	(+)	(+)	-
Erythropygia coryphaeus	-	-	-	2	-	-
Cossypha caffra*	2	1	(+)	(+)	3	3
Cercomela familiaris	(+)	-	(+)	2	-	-
Monticola rupestris*	1	3	1	(+)	(+)	1
Muscicapa adusta	-	-	-	1	-	-
Batis capensis	-	1	2	-	-	-
Sphenoeacus afer	1	1	(+)	-	2	(+)
Prinia maculosa*	6	6	3	4	3	4
Cisticola fulvicapilla*	1	2	(+)	2	(+)	(+)
Cisticola subruficapilla*	(+)	1	(+)	1	3	(+)
Apalis thoracica	-	-	-	-	2	-
Bradypterus victorini	-	-	-	1	-	-
Malaconotus zeylonus	1	-	(+)	(+)	1	-
Laniarius ferrugineus	(+)	-	-	1	-	-
Onychognathus morio*	4	5	(+)	(+)	(+)	1
Hirundo rustica	-	-	-	(+)	-	-
Hirundo rupestris	(+)	(+)	-	(+)	-	(+)
Nectarinia violacea	1	2	2	1	(+)	-
Nectarinia chalybea*	2	1	1	1	1	1
Zosterops virens*	6	16	3	4	2	3
Promerops cafer	-	1	3	5	4	3
Vidua macroura	-	?	-	-	-	-
Estrilda astrild	1	-	-	-	-	2
Serinus canicollis	1	-	(+)	-	(+)	-
Serinus leucopterus*	2(5)@	3(4)	1(6)	3(6)	1(4)	2(5)
Serinus sulphuratus	-	-	(+)	-	(+)	(+)
Emberiza capensis	(+)	(+)	(+)	-	-	2
Unidentified	-	2	3	2	1	1

KEY: - not encountered; (+) seen or heard in the same stand of vegetation but not perched within the transect; * species observed during all six replicate counts; @ figures in parentheses indicate numbers of separate encounters with protea seedeaters during the counts (birds within or out of transects, perched or flying).

Total number of birds counted was 181 (average overall avian density was 7,0 birds/ha).

5.4.2. Density of Serinus leucopterus

The average density of Serinus leucopterus in 4,3 ha of mature proteoid Mountain Fynbos in January and February was 0,46 birds/ha (Table 10,11) or one bird per 2,17 ha. Protea seedeaters comprised 7% of the total number of birds counted (Table 10), having a high density in relation to other birds at this site. Only Zosterops, Prinia and Promerops were more commonly encountered in the transect (Table 11).

Cody (1975) estimated protea seedeater densities as 0,12-0,27 birds per ha (average 0,18 birds/ha, or one bird per 5,5 ha) at a site embracing three stands of proteoid Mountain Fynbos at Jonkershoek, Stellenbosch (Table 11). 13 percent of birds in the present study occurred with densities greater than the protea seedeater; the corresponding value in Cody's (1975) study was 30%.

Data from Jonkershoek (Cody 1975) were not strictly comparable with those from replicate counts. Cody estimated densities after a number of visits and did not define the area censused. His data were, in addition, gathered at a different time of year (in the birds' "breeding season"). Nevertheless, he indicated that Serinus leucopterus had a higher average density than most birds in the same environment, agreeing with my findings. Nectarinia (two species) and Serinus canicollis, occurring with densities higher than for Serinus leucopterus at Cody's study site, can be expected to fluctuate considerably in numbers owing to their specialized food requirements (Skead 1967; page 71). Sphenoeacus and Cossypha are skulkers, which are more likely

to have been accurately censused by Cody than by the strip count method.

5.4.3. Density of other "seed-eating" passerines

Three species (Serinus canicollis, Emberiza capensis and Estrilda astrild) were present in 4,3 ha of mature proteoid Mountain Fynbos in January and February. These occurred with average densities (Table 10,11) of 0,04-0,12 birds per ha (one bird per 8,3-23,8 ha). Bully seedeaters (6-10 birds) were seen in the vicinity during three counts, aggregated around fruiting Diospyros sp. The protea seed-eater was, however, the only "seed-eating" passerine species which was observed in all six replicate counts (Table 10).

Three "seed-eating" passerines, in addition to the protea seedeater, were found in proteoid Mountain Fynbos at Jonkershoek, Stellenbosch (Cody 1975). Serinus canicollis (0,25 birds/ha) and S. sulphuratus (0,14 birds/ha) occurred with average densities similar to that of S. leucopterus at the same site (Table 11). The ploceid Euplectes capensis was also present, with an average density of 0,06 birds per ha.

TABLE 11: Bird densities at two south-west Cape sites. Site 1: 4,3 ha of proteoid Mountain Fynbos (Molenaarsrivier, Slanghoek Mountains, Worcester Division), Jan.-Feb. 1976; data obtained during six replicate counts (see TAB.10). Site 2: three stands of proteoid Mountain Fynbos (Jonkershoek, Stellenbosch), censussed in the birds' "breeding season"; data presented by Cody (1975). Species are listed in order of decreasing density at site 1. Densities are expressed as percentage (to nearest integer) of the total of the average densities (birds/ha) of each species for each site (average was between replicate counts for site 1, and between stands for site 2). Average overall bird density at site 2 was 3,95 birds/ha. Asterisks indicate species, at site 2, with densities greater than that for Serinus leucopterus at that site.

Species		% density	
Scientific name	Vernacular name	site 1	site 2
Zosterops virens	Cape whiteye	19	6*
Prinia maculosa	karoo prinia	14	7*
Promerops cafer	Cape sugarbird	9	11*
Serinus leucopterus	protea seedeater	7	5
Onychognathus morio	red-winged starling	6	4
Streptopelia capicola	Cape turtle dove	5	2
Cossypha caffra	Cape robin	5	6*
Nectarinia chalybea	lesser double-collared sunbird	4	-
Nectarinia violacea	orange-breasted sunbird	3	8*
Monticola rupestris	Cape rock thrush	3	3
Cisticola fulvicapilla	neddicky	3	1
Cisticola subruficapilla	grey-backed cisticola	3	4
Sphenoeacus afer	grassbird	2	9*
Batis capensis	Cape batis	2	2
Estrilda astrild	common waxbill	2	-
Emberiza capensis	Cape bunting	1	-
Malaconotus zeylonus	bokmakierie	1	-
Apalis thoracica	bar-throated apalis	1	2
Erythropygia coryphaeus	karoo scrub robin	1	-
Pycnonotus capensis	Cape bulbul	1	3
Cercomela familiaris	familiar chat	1	-
Serinus canicollis	Cape canary	1	6*
Muscicapa adusta	dusky flycatcher	1	-
Bradypterus victorini	Victorin's scrub warbler	1	1
Laniarius ferrugineus	boubou shrike	1	3
Streptopelia senegalensis	laughing dove	1	-
Colius sp.	mousebird	1	-
Nectarinia famosa	malachite sunbird	-	5*
Serinus sulphuratus	bully seedeater	-	4
Francolinus africanus	grey-wing francolin	-	3
Melaenornis silens	fiscal flycatcher	-	2
Euplectes capensis	Cape widow	-	2
Francolinus capensis	Cape francolin	-	1
Streptopelia semitorquata	red-eyed dove	-	1
Mesopicos griseocephalus	olive woodpecker	-	1
Unidentified		5	-

FEEDING ECOLOGY

1. METHODS

Samples of all food items*observed taken by *Serinus leucopterus* and other seedeater species were identified. The following details were recorded for each feeding event:

i) date and time of day (to nearest quarter hour);
ii) number of (conspecific) individuals present;
iii) number of (conspecific) individuals feeding;
iv) duration of feeding behaviour (to nearest minute);
v) positions of feeding birds: whether on the ground or perched, and whether food taken from the ground or directly from the food plant;
vi) height (m) of feeding position above ground; and
vii) qualitative description of postures and foraging techniques.

A feeding occasion was defined as one continuous foraging sequence by one bird for one food item (e.g. seed, floral material) provided by one species of food organism. This is similar to the measure of feeding activity used by Newton (1967). A feeding unit was defined as 1 minute of feeding or foraging activity by one bird on or for one food item and one species of food organism; a feeding event of less than 1 minute was recorded as a single feeding unit.

* A food item was defined as an object representing a single food type (e.g. nectar, composite achene) taken from a single species or genus.

2. DIET

2.1. Diet of Serinus leucopterus

2.1.1. General

Feeding records for the protea seedeater were obtained in all months of the year combined for January 1974 to October 1976 (Fig. 8), although relatively few data (less than 16 feeding occasions each) were collected in November and December. Virtually no new food plant genera were recorded for the 20 most recent feeding occasions (Fig. 7). This indicated that the recorded diet of the protea seed-eater was a comprehensive one, at least in the area (Paarl-Stellenbosch) where most observations were made.

Serinus leucopterus was observed taking a wide variety of foods (Appendix 7, Tables 12 & 13) at sites throughout its geographical range. The bird's diet comprised 77 plant species in 44 genera and 25 families, and about five animal forms in at least three invertebrate orders.

The distributions of food "classes", "categories", types and genera in the diet of the protea seedeater, on the basis of feeding occasions and feeding units, were similar (Figs. 9 & 10). The genus Protea was taken far more frequently (Fig. 9) than any other genus; plant genera next in order of importance (Restio, Senecio) contributed less than half of feeding observations (measured both as occasions and as units) recorded for Protea.

Seed, comprising 79% of feeding occasions and 80% of feeding units (Fig. 10), was clearly the major part of the diet of the protea seedeater. Soft plant parts (nectar, fruit-pulp and foliage and flowers, 18% and 15% respectively) and invertebrates (Insecta, 3% and 4% respectively) were of minor importance.

FIG. 7 : Number of previously unrecorded food genera in consecutive sets of 10 feeding occasions. Occasions for one genus, recorded on the same day at the same place, were counted as one occasion.

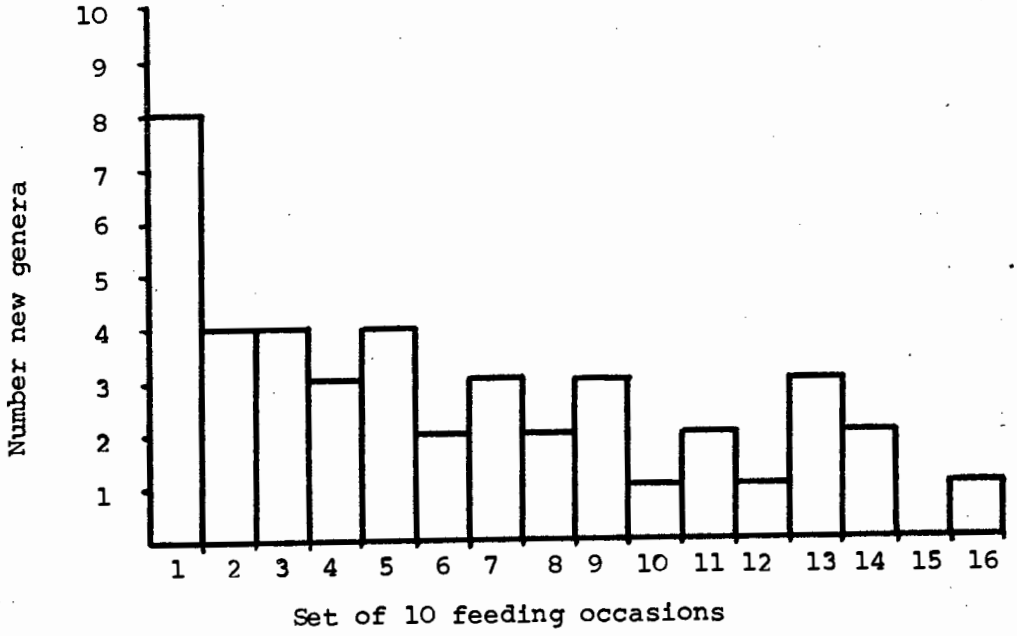


FIG. 8 : Number of feeding occasions recorded in each month, January 1974 to October 1976, for Serinus leucopterus.

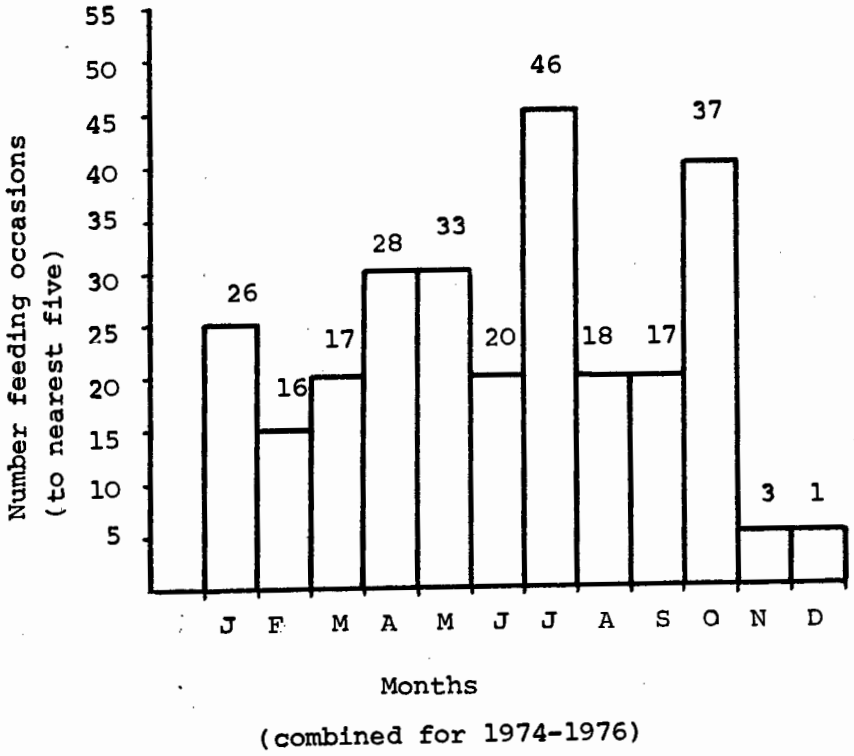


TABLE 12 : Summary of all recorded food plant genera for the protea seedeater, categorised as "classes" and "categories" (Rowan 1970) and food types.

"Class"	"Category"	Food type	Food plant genera
Seed	Seed	Graminoid seed	Tetraria, probably also Ficinia (Cyperaceae); Elegia, Leptocarpus, Restio, Thamnochortus, also Cannomois, Taylor 1961 (Restionaceae).
Seed	Seed	Composite achenes (possibly also floral parts)	Eriocephalus, Metalasia, Othonna, Senecio, Inula, Euryops, also Stoebe, Taylor 1961, and Ursinia, Broekhuysen & Martin 1965; probably also Cullumia and Gymnodiscus (Compositae).
Seed	Seed	Other small seed	Pelargonium (Geraniaceae); Chenopodium (Chenopodiaceae); Anthospermum (Rubiaceae); Erica (Ericaceae); Salvia (Labiatae); Pollichia (Caryophyllaceae)
Seed	Seed	Larger seed	Phylica (Rhamnaceae); Raphanus (Cruciferae); Psoralea (Leguminosae); Protea, Leucadendron, Hakea (Proteaceae); Diosma, probably also Agathosma (Rutaceae); also Rhus, Skead 1960 (Anarcardiaceae); possibly also Freylinia, Taylor 1961 (Scrophulariaceae).
Seed	Seed	Seed kernels in (ripe or unripe) fleshy fruit	Oftia (Myoporaceae); Olea (Oleaceae); Rhus (Anacardiaceae); Phylica (Rhamnaceae); Cassytha (Lauraceae); Maytenus (Celastraceae); probably also Diospyros (Ebenaceae).
Soft plant parts	Nectar	Nectar (possibly also floral parts)	Erica (Ericaceae); Halleria (Scrophulariaceae); Protea (Proteaceae); Salvia (Labiatae).
Soft plant parts	Fruit (taken here as ripe pulp only)	Fruit-pulp	Diospyros (Ebenaceae); Maytenus (Celastraceae); possibly also Oftia (Myoporaceae), Pollichia (Caryophyllaceae), Rhus (Anacardiaceae), and Olea (Oleaceae).
Soft plant parts	Foliage & flowers	Fresh floral parts	Euryops, Senecio, Gymnodiscus, possibly also Cullumia (Compositae); Aspalathus (Leguminosae); Zygophyllum (Zygophyllaceae); possibly Protea (Proteaceae) and Chenopodium (Chenopodiaceae).
Soft plant parts	Foliage & flowers	Foliage buds	Cliffortia (Rosaceae); very probably Rhus (Anacardiaceae) and possibly Olea (Oleaceae); also Pinus, Skead 1960 (Pinaceae).

FIG. 9 a: Major (3% or more of feeding units) plant components in the diet of the protea seedeater as shown by the percentage feeding units for each genus. Total sample size was 1374.

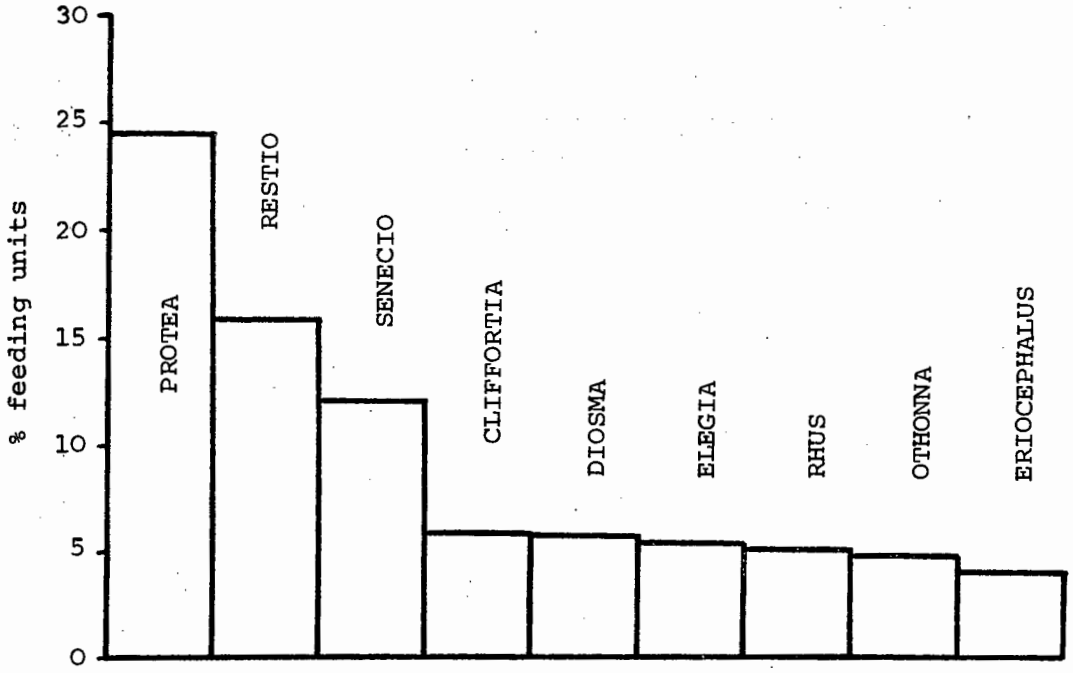
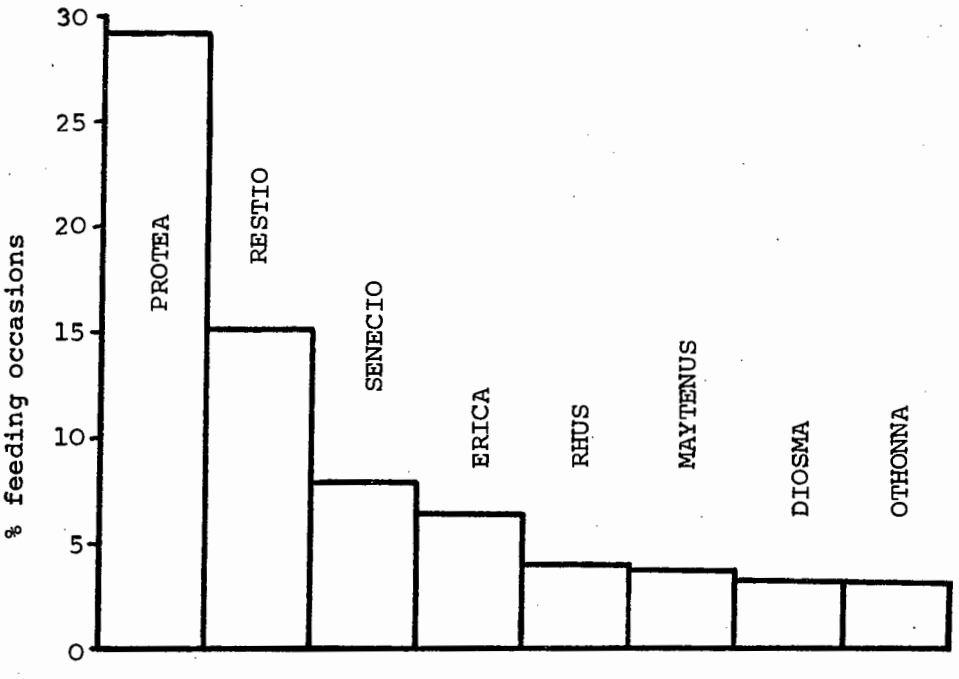


FIG.9 b: Major (3% or more of feeding occasions) plant components in the diet of the protea seedeater as shown by the percentage feeding occasions for each genus. Total sample size was 200.



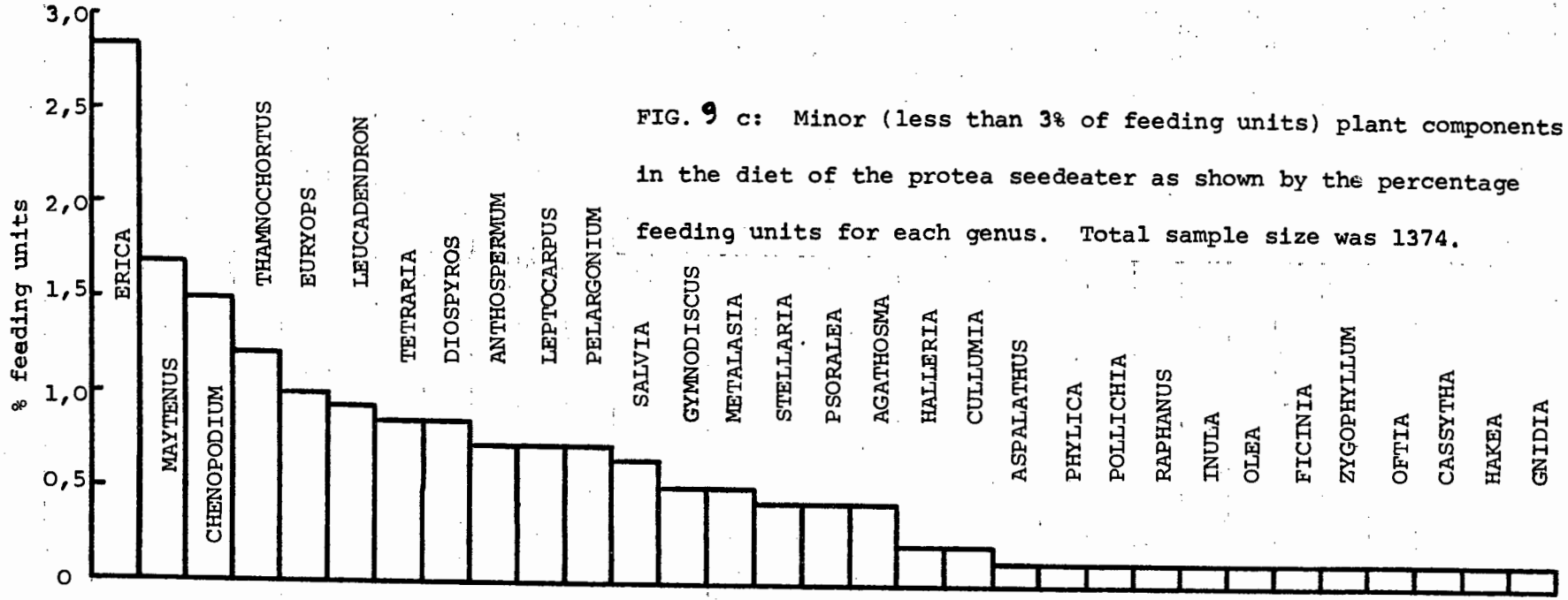


FIG. 9 c: Minor (less than 3% of feeding units) plant components in the diet of the protea seedeater as shown by the percentage feeding units for each genus. Total sample size was 1374.

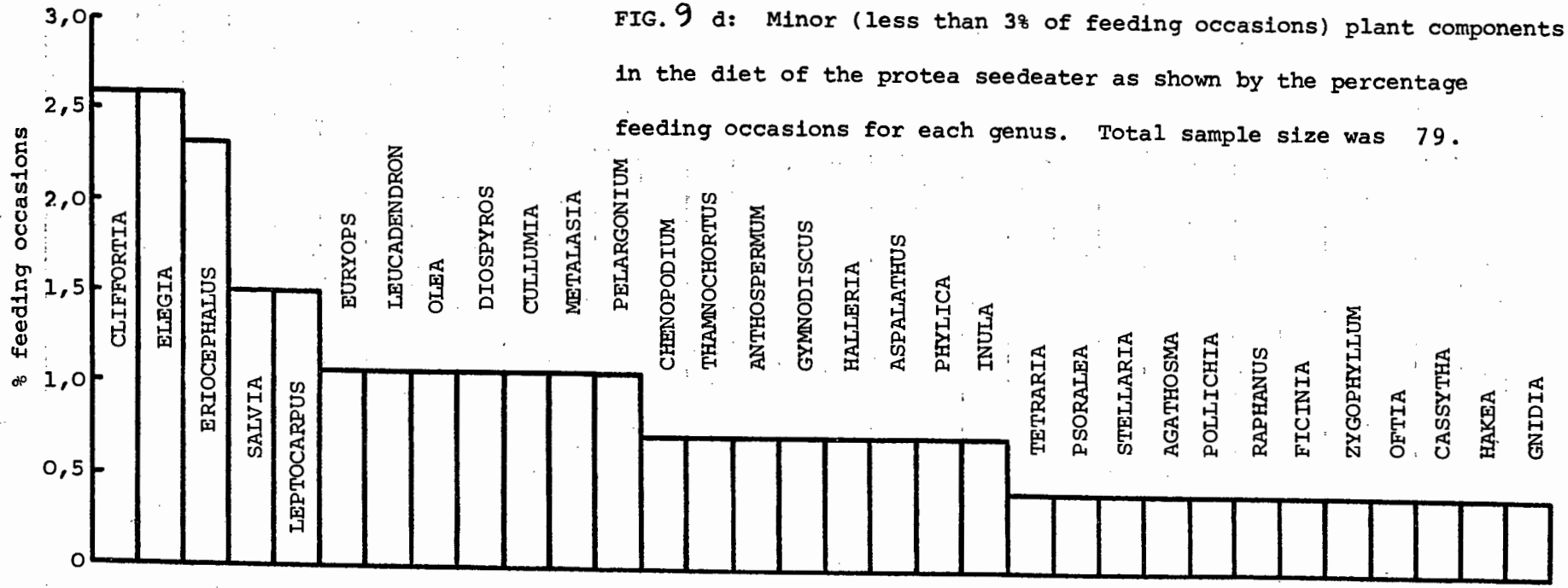
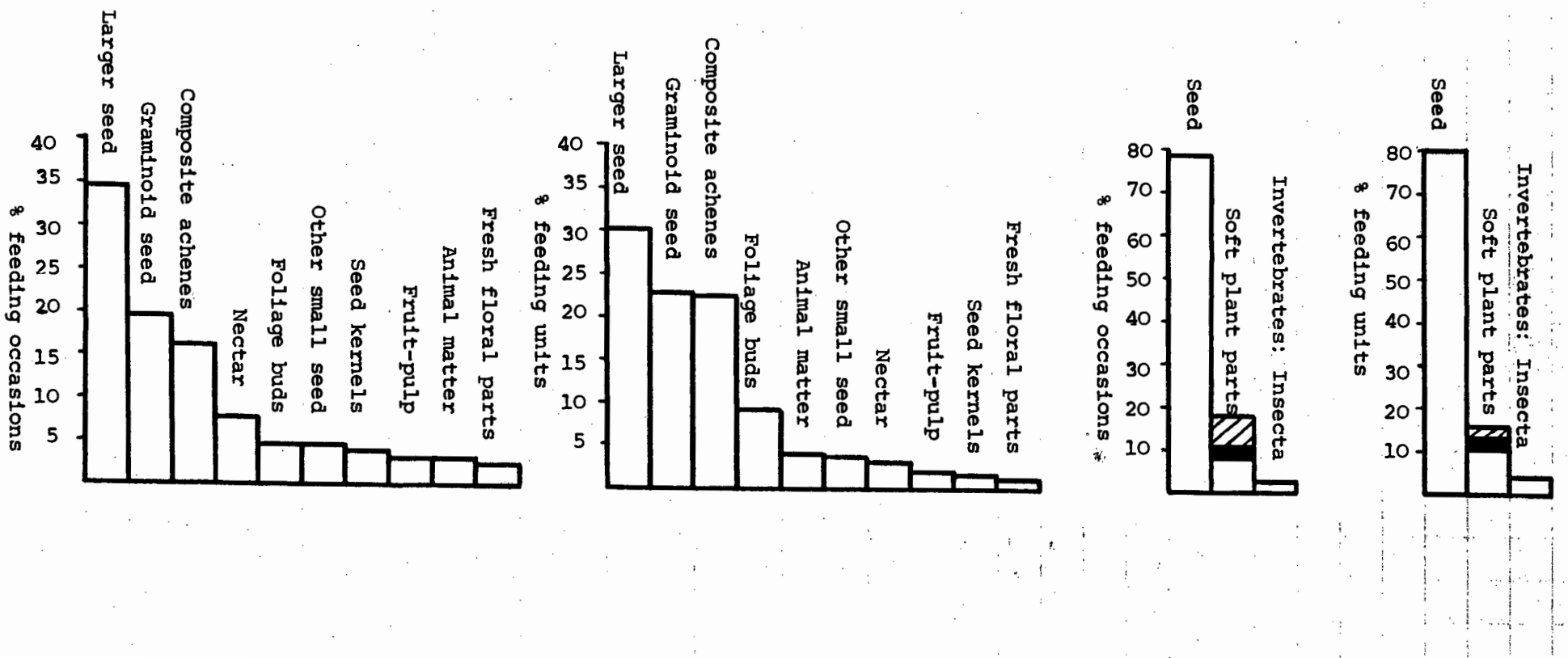


FIG. 9 d: Minor (less than 3% of feeding occasions) plant components in the diet of the protea seedeater as shown by the percentage feeding occasions for each genus. Total sample size was 79.

TABLE I3: Total numbers of feeding occasions and units for a) families of plants and b) orders of invertebrates recorded for *Serinus leucopterus*.

a. Plant family	No. feeding occasions	No. feeding units
Proteaceae	83	355
Compositae	43	298
Restionaceae	41	243
Anacardiaceae	15	69
Ericaceae	11	45
Celastraceae	9	23
Rutaceae	8	64
Rosaceae	6	43
Labiatae	5	9
Geraniaceae	3	9
Leguminosae	3	11
Ebenaceae	3	11
Rhamnaceae	2	2
Rubiaceae	2	10
Cyperaceae	2	12
Scrophulariaceae	2	3
Chenopodiaceae	2	20
Oleaceae	2	10
Cruciferae	1	2
Zygophyllaceae	1	1
Myoporaceae	1	1
Lauraceae	1	1
Caryophyllaceae	1	2
Pinaceae (Skead 1960)	unknown	unknown
b. Invertebrate order		
Homoptera	4	22
Isoptera	1	15
Coleoptera	1	15
Unidentified	3	8

FIG. 10 : Quantitative summary of the diet of Serinus leucopterus. Histograms show the percentage of feeding occasions and units for food types, "classes" (corresponding to A,B & C of Rowan 1970) and "categories" (corresponding to 2, 4 & 6 of Rowan 1970), viz ☐ foliage and flowers ▨ nectar ■ fruit-pulp. The total numbers of feeding occasions and units were respectively 272 and 1434.



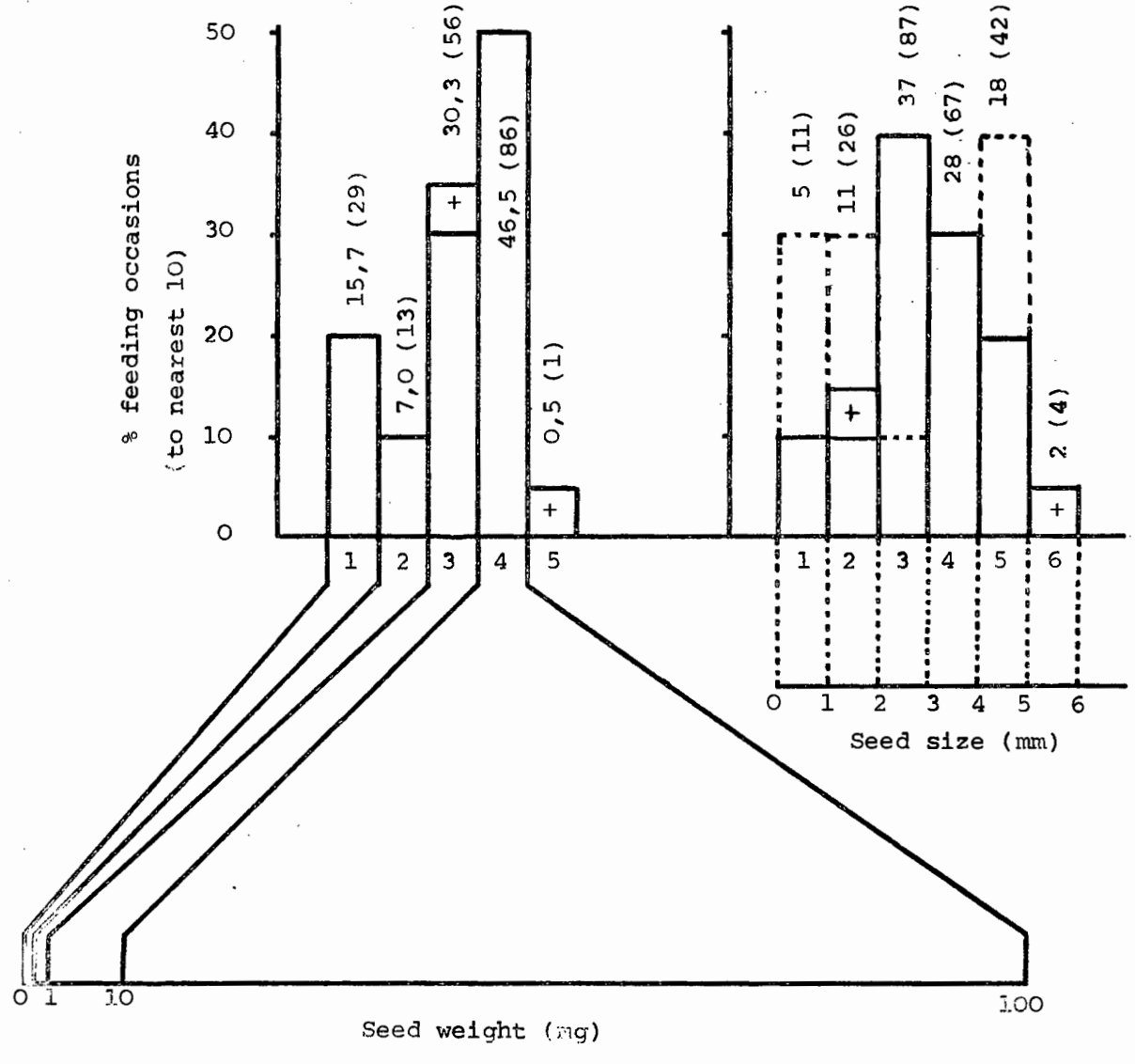
Consideration of food types in greater detail showed that "larger seed" (mainly seed of the Proteaceae, Appendix 7a , Table 12) featured far more frequently (Fig. 10) in the diet of S. leucopterus than any other type; the next most important types were graminoid and composite seeds (achenes). The percentages of feeding units for graminoid and composite seeds were greater than for feeding occasions, possibly owing to the long continuous foraging sequences for these food items. Seven other food types, comprising animal matter and various seeds and soft plant parts (Fig. 10) derived largely from genera of minor importance in the diet (Fig. 9 , Table 12), were relatively infrequent in the diet.

The seeds of Protea were shown to be by far the most frequently taken food item in the diet of the protea seedeater, agreeing with Winterbottom (1973) who speculated that the diet consisted mainly of seed of the Proteaceae but also included other seeds and buds.

2 1.2. Seed size distribution

The protea seedeater was observed taking seeds varying in fresh weight (Fig. 11) from 0,2 mg (small achenes of Compositae) to 160,0 mg and more (e.g. seeds of Protea compacta). These seeds ranged in volume from 0,02 mm^3 to 216 mm^3. Large and small seeds featured approximately equally in the diet; 47% of all observed occasions of feeding on seeds were for seeds of weight greater than 10 mg and volume greater than 27 mm^3.

FIG. 11: Quantitative distribution of seed sizes in the diet of the protea seedeater, showing the number of feeding occasions expressed as percentage classes per class of seed weight and per class of seed size. Weight classes used (related to a linear scale below the horizontal axis) are: 1 = 0-0,5 mg; 2 = 0,5-1,0 mg; 3 = 1,0-10,0 mg; 4 = 10,0-100,0 mg; 5 = over 100,0 mg. Seed size classes used, on a linear scale, are: 1 = 0-1 mm; 2 = 1-2 mm; 3 = 2-3 mm; 4 = 3-4 mm; 5 = 4-5 mm; 6 = 5-6 mm. "+" indicates percentages lower than 2%. Figures in parentheses are sample sizes; total sample sizes were 185 feeding occasions for seed weight (left) and 237 feeding occasions for seed size distribution (right). Solid lines on right-hand diagram indicate distribution of sizes of food items as taken into the bill (including e.g. whole fruits and buds). Dotted lines show distribution, based on the same sample size, using sizes of the (stripped) seed itself for feeding occasions in which birds mandibulated items, ingesting the seed and discarding the remainder.



2.1.3. Temporal variation in diet

Seeds, collectively comprising 50-100% of overall monthly feeding occasions, were taken throughout the year (Table 14). Graminoid and larger seed, and composite achenes, together forming the major part of the diet of the protea seedeater (Fig. 10) were taken in most months of the year, presumably depending to an extent on temporal and local availability. "Larger seed" contributed 14-69% of feeding occasions for 10 months of the year; graminoid seed was taken most frequently in spring (Sept.-Nov), while composite achenes were not recorded in midsummer (Dec.-Jan.). Foliage and flowers (viz floral parts and foliage buds) and nectar appeared to be taken virtually throughout the year, although nectar was apparently taken mainly in spring. Fruit-pulp was recorded taken virtually only in summer (Dec.-Feb.), while insects, a minor part of the diet (page 67), were recorded only in autumn and winter (March-Aug.).

Protea (mainly "larger seed") was the genus most frequently taken by Serinus leucopterus in the months February and April to August (Table 15). Restio ("graminoid seed") and Maytenus ("fruit-pulp" and "seed kernels") were the most frequently recorded genera respectively in September to November and January. Othonna and Senecio (mainly "composite achenes") were the most or the second most frequently recorded genera in March, April, June, October and November.

There was little support for the suggestion that abundantly seeding composites, e.g. Othonna sp., on which the protea seedeater has been recorded feeding "almost

TABLE 14 : Temporal variation in diet of Serinus leucopterus. Figures are percentage feeding occasions per month (combined for January 1974-October 1976) for each food type.

Food type	Month											
	J	F	M	A	M	J	J	A	S	O	N	D
1. Graminoid seed	7	6	6	-	4	10	17	6	56	37	25	-
2. Composite achenes	-	-	35	22	4	29	20	18	6	20	50	-
3. Other small seed	-	-	6	15	11	-	-	12	-	9	-	-
4. Larger seed	40	69	18	44	46	33	48	41	17	14	-	-
5. Seed kernels in fruits	3	6	18	-	27	-	-	-	-	-	-	100
6. Nectar	7	-	-	11	8	-	2	12	22	14	-	-
7. Fruit-pulp	27	19	-	4	-	-	-	-	-	-	-	-
8. Fresh floral parts	3	-	-	-	-	-	4	6	-	3	25	
9. Foliage buds	13	-	6	-	-	19	4	6	-	3	-	-
10. Invertebrates (Insecta)	-	-	12	4	-	10	4	-	-	-	-	-
Total feeding occasions	30	16	17	27	26	21	46	17	18	35	4	1

TABLE 15 : Relative importance of food plant genera in the diet of Serinus leucopterus. Only the three genera for which the most feeding occasions were recorded in each month (combined for Jan. 74-Oct. 76) are given. The number of feeding occasions for each genus is given in parentheses.

Month	Total feeding occs.	Food plant genera
January	30	Maytenus (8) Diosma (7) Cliffortia (4)
February	16	Protea (11) Diospyros (2) Maytenus (1)
March	17	Othonna (6) Protea (3) Olea (2)
April	27	Protea (12) Senecio (5) Salvia (5)
May	26	Protea (12) Elegia (7) Rhus (6)
June	21	Protea (6) Senecio (6) Rhus (4)
July	46	Protea (21) Leptocarpus (5) Restio (3)
August	17	Protea (6) Erica (2) Gymnodiscus (2)
September	18	Restio (10) Erica (4) Leucadendron (3)
October	35	Restio (10) Senecio (5) Pelargonium (3)
November	4	Restio (1) Senecio (1) Othonna (1)
December	1	Cassytha (1)

exclusively" in November (Praed & Grant 1955), constitute a temporarily available resource affecting time of breeding (Sept.-Nov., Winterbottom 1973) for the seedeater. It is, however, possible that the diet at any particular locality shows more pronounced seasonal patterns than were apparent from data collected throughout the south-west Cape over several years. It must be stressed that these results refer only to free-flying birds, no data on the diet of nestlings being available.

2.2. Diet of congeners in relation to that of *Serinus leucopterus*

2.2.1. General

The diets of south-west Cape congeners of *Serinus leucopterus* are given in Table 16, Figs. 12 & 13 and Appendix 7. Six of these species, for which adequate data were collected, were shown to be predominantly seed-eating (Figs. 12 & 13), agreeing with Winterbottom's (1973) speculations. *Serinus canicollis* was recorded taking only seeds and is reputed to provide its young with a similarly exclusive diet (Winterbottom 1973). My observations did not support Skead's (1960) assertion that the diets of larger *Serinus* species (e.g. *S. sulphuratus*) include a far smaller proportion of seed than those of their smaller congeners, e.g. *S. tottus* (with the possible exception of *S. canicollis*).

Relatively small seed types (composite achenes, graminoid and other small seed) formed tha major part of the diets, considered in greater detail, of *S. flaviventris*, *S. tottus* and *S. canicollis* (Fig. 13). The Cape canary's diet consisted almost entirely of small seed (mainly composite achenes). This diet was notably more restricted than those of the other species (including the siskin and yellow canary), agreeing with Winterbottom (1973): "prefers the soft green seeds of grasses and composites". *Serinus scotops*, poorly documented, is known to take a wide range of foods (Appendix 7); this species and *S. alario* (for which virtually no data are available) probably subsist mainly on small seeds, like congeners of similar size

FIG.12 : Quantitative summary of the diet of Serinus species. Histograms show the percentage of feeding occasions on which each food "class" (corresponding to A, B & C of Rowan 1970) was taken. Food class B ("soft plant parts") was further divided into food "categories" (corresponding to 2, 4 & 6 of Rowan 1970), viz ☐ foliage & flowers ▨ nectar ■ fruit-pulp. Figures in parentheses are the total number of feeding occasions for each species. Species are arranged in order of decreasing importance of seed in the diet.

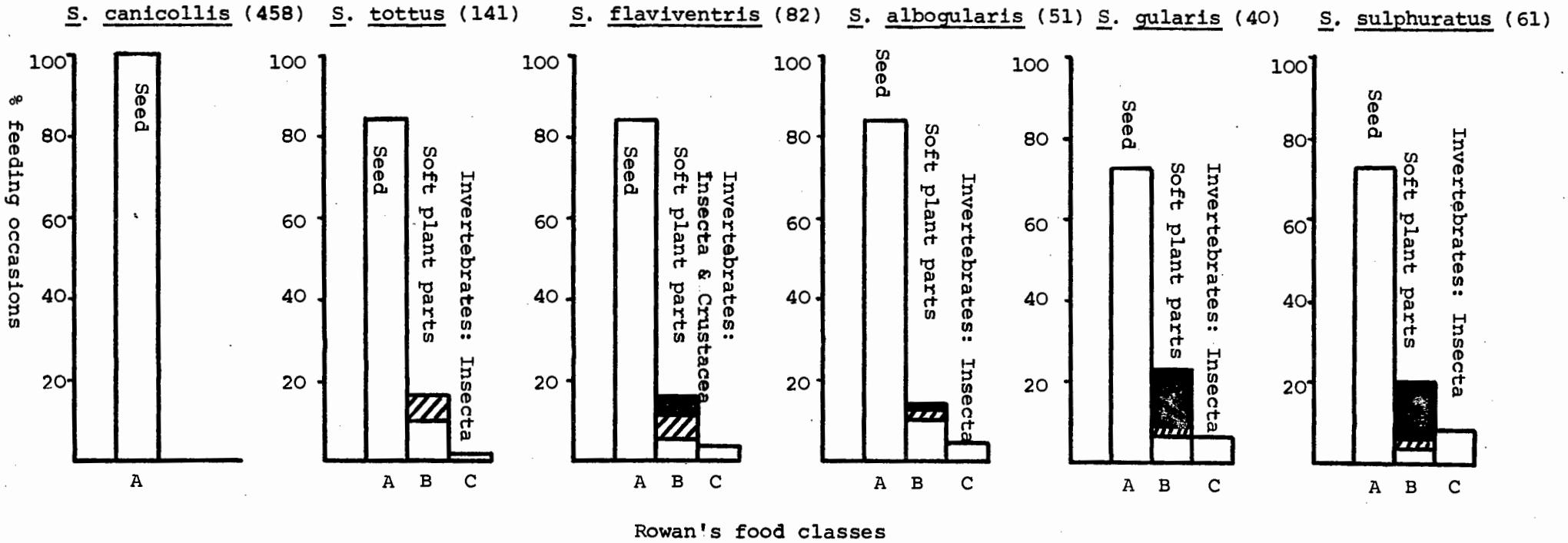


TABLE 16: Quantitative summary of diets of Serinus species, expressed as percentages of total feeding occasions for food plant genera (only south-west Cape feeding records used). Figures in parentheses are total feeding occasions for each Serinus species. "+" indicates less than 1% of feeding occasions. 1 = S. canicollis 2 = S. tottus 3 = S. flaviventris 4 = S. gularis 5 = S. albogularis 6 = S. sulphuratus.

	Serinus species					
Food plant genus	1 (530)	2 (153)	3 (89)	4 (54)	5 (52)	6 (63)
Inula	36					
Ficinia		28				
Thamnochortus		4				
Leucadendron		3				
Restio		1				
Urticaceae, genus indet. (insects?)		1				
Arctotheca			6			
Bidens			2			
Dorotheanthus			2			
Rumex			1			
Diascia			1			
Cannomois			1			
Maytenus				28		
Aspalathus				17		
Aloe				6		
Nymania				2		
Chironia				1		
Lampranthus				1		
Solanaceae, genus indet.				1		
Polycarena					11	
Zygophyllum					6	
Erodium					6	
Kleinia					4	
Emex					2	
Microloma					2	
Relhania					2	
Diospyros						9
Pelargonium						8
Pinus						2
Cassytha						2
Cotoneaster						1
Psoralea						1
Athanasia	+	5				
Metalasia	11	1				
Ericaceae, minor genus	+	5				
Ericaceae, minor genus	+	1				
Cliffortia		9	1			
Erica		5	10			
Melianthus			1	2		
Salsola				4	13	
Raphanus					8	5
Acacia					6	2
Othonna					4	2
Euryops					4	2
Chrysanthemoides					4	5
Senecio	31		3			
Gnidia	+		3			
Amaranthus	+			6		
Sonchus	2				2	
Stellaria	+					1
Elytropappus	+	3	1			
Protea (possibly partly insects)		3			2	2
Olea				2	6	43
Stoebe	9	13	2 2		2	
Eriocephalus	+		3	7	2	1
Chenopodium	7	4	50	19	10	3
Animal matter			2	4	4	8
Unidentified*	1	14	9		2	3

* in the case of S. tottus probably Stoebe, Elytropappus, Leucadendron

FIG.13 : Quantitative summary of food types in the diet of Serinus species. Histograms show the percentage of feeding occasions on which each food type was taken. Figures in parentheses are the total number of feeding occasions for each species. Species are arranged in the same order as for Fig. 12.

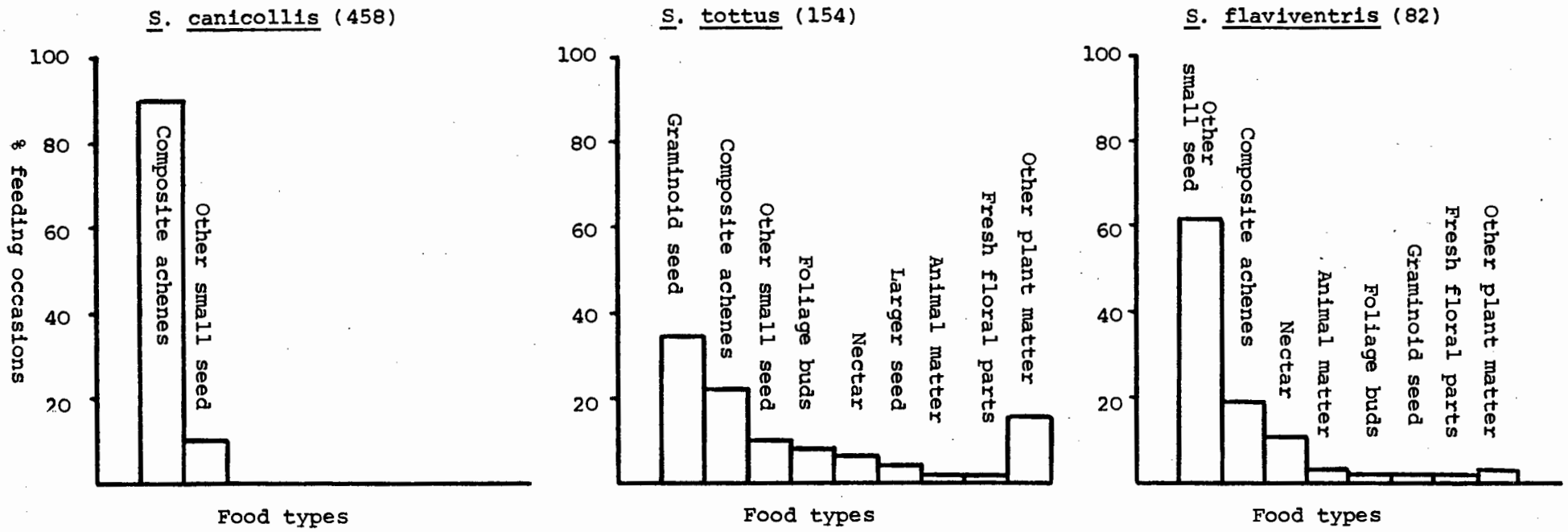
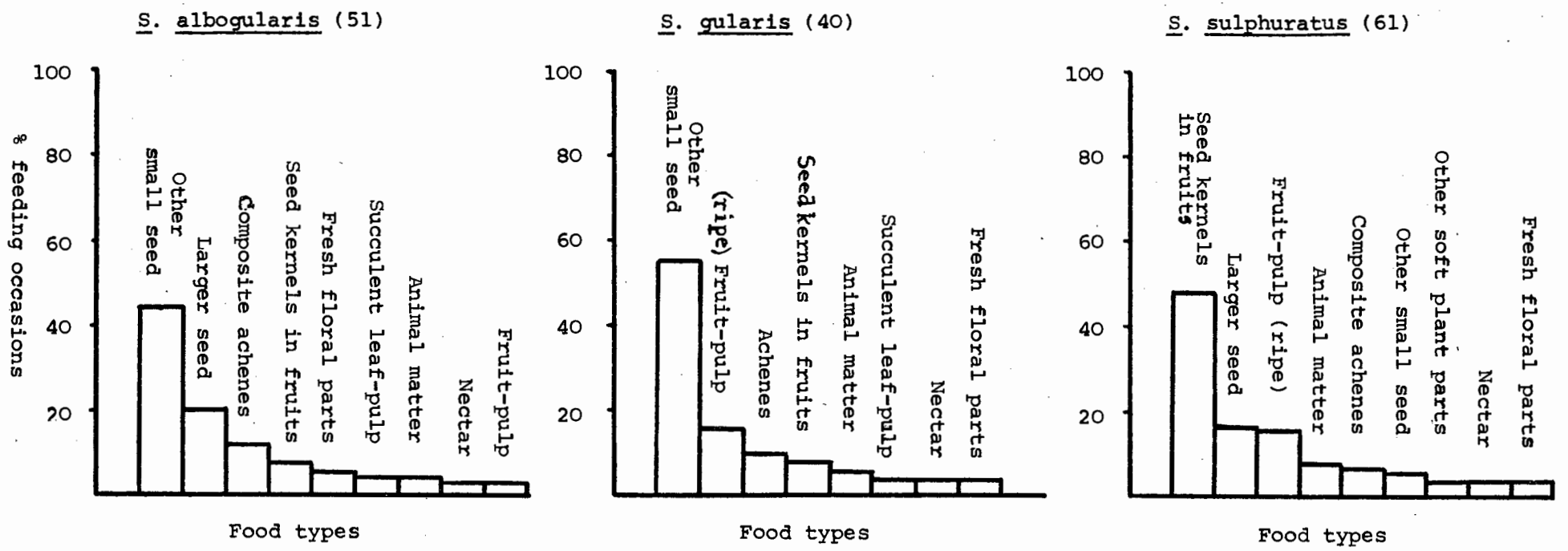


FIG.13 : continued



(Skead 1960; Winterbottom 1973). Small seeds also featured prominently in the diets of S. albogularis and S. gularis (Fig.13), their remaining diet comprising larger seed types and a wide range of soft plant parts. The bully seedeater appeared mainly to take seeds larger than those for the other species, a large proportion of the diet comprising kernels in developing fleshy fruits (Fig.13). Other species recorded taking "larger seed" or seed kernels were S. albogularis and S. tottus; "sulphuratus and albogularis, with their heavy beaks, can tackle larger and harder seeds than the other species" (Winterbottom 1973).

Soft plant parts (sensu Rowan 1970), including foliage buds, flowers, nectar and fruit-pulp, formed a minor component of the diets of all six species except S. canicollis. Instances of "casual nectivory" (Oatley & Skead 1972) for at least five Serinus species in the south-west Cape included the first records of association between Fringillidae and nectar of Proteaceae and Ericaceae in fynbos. Five species of Serinus have previously been recorded taking nectar of Aloe (Liliaceae) in savanna, S. gularis taking nectar with greater frequency than other "casual" nectivores (Oatley & Skead 1972).

My observations supported the suggestion (Skead 1960; Winterbottom 1973) that fruit-pulp is of more importance for the bully seedeater than for its congeners (Fig.13). The taking of kernels, instead of fruit-pulp, from fleshy fruits may, however, have been overlooked by previous authors; Winterbottom (1973) gave the diet of the bully seedeater as "fruit and some seeds, including larger and

harder ones than for the other species." I recorded instances of succulent leaf-pulp (a specialized form of foliage) being taken by S. albogularis and S. gularis from composite and mesembryanthemaceous plants in dry environments, suggesting that the birds' water intake was supplemented at times with moist plant food other than fruit-pulp .

Invertebrates probably constituted a minor component of the diets of all six species. Two aspects must be stressed here: firstly, occasions of feeding on invertebrates were more difficult to observe and verify than occasions of feeding on plant matter; secondly, no observations were made on the diets of nestlings, which may include a greater proportion of animal matter. Three species of Serinus, viz S. gularis, S. mozambicus, the yellow-eye canary, and S. tottus, have previously been recorded feeding insects (specifically termites, aphids and beetles) to their young (Skead 1960). Data from this study (Fig.12) did not support the suggestion (Skead 1960; Winterbottom 1973) that insects form an important part of the diet of S. tottus and its young, otherwise agreeing with Winterbottom's (1973) description of the diet of S. tottus: "seeds of Proteaceae, buds and insects."

2.2.2. Seed size distribution

The distribution of seed sizes in the diets of six south-west Cape congeners of Serinus leucopterus are shown in Figure 14. More than 60% of occasions of feeding on seed by S. canicollis, S. flaviventris and S. tottus were for seed of size (cube root of volume, Pulliam & Enders 1971) 0-1 mm. The diet of the Cape canary was virtually restricted to seed of this size, only 15% of occasions being for larger seed, while the siskin took a relatively large proportion (26%) of seeds of size 2-4 mm. The diet of S. albogularis consisted mainly of small seed (0-3 mm). This species, S. gularis and S. sulphuratus took a far wider range (0-6 mm) of seed sizes than the other three congeners. The diet of S. sulphuratus consisted mainly of large "seeds" (4-6 mm); the majority of feeding occasions for the bully seedeater were for "seed kernels" in unripe fruits (mainly Olea spp.) with diameter 6,0-7,0 mm.

FIG. 14 : Qualitative distribution of seed sizes in the diets of six Serinus species, showing the number of feeding occasions expressed as percentages per class of seed size, for each species. Size classes used are the same as in Fig. 11 . Solid lines show distribution of sizes of food items as taken into the bill (including e.g. whole fruits and buds). Dotted lines show distribution, based on the same sample sizes, using sizes of the (stripped) seed itself for feeding occasions in which birds mandibulated items, ingesting the seed and discarding the remainder. The species are (sample sizes in parenthesis): a = S. canicollis (568) b = S. tottus (125) c = S. flaviventris (69) d = S. albogularis (42) e = S. gularis (64) f = S. sulphuratus (78)

2.3. Dietary overlap between *Serinus leucopterus* and other birds

2.3.1. Congeners

The diets (summarized qualitatively in Table 17) of *Serinus leucopterus* and its eight south-west Cape congeners all included seed (*sensu* Rowan 1970). "Soft plant parts" (foliage and flowers, nectar and fruit-pulp) and animal food (invertebrates, mainly insects) featured in the diets of almost all the species; fruit-pulp has, however, not been recorded in the diets of *S. flaviventris* and *S. tottus*. Rowan's (1970) category "seed", considered in greater detail, was represented in the qualitative diets of all the species by composite achenes. Other seed types, ranging from small seeds (including those of graminoids) to "larger seed" (e.g. those of the Proteaceae) also contributed to the known diets of all except poorly documented species (e.g. *S. scotops*). Seed kernels (in fleshy fruits) were recorded taken only by *S. leucopterus*, *S. sulphuratus*, *S. albogularis*, and possibly *S. gularis*.

The diet of *S. leucopterus*, considered quantitatively, was similar at the level of food "classes" and "categories" (Fig. 10) to those of six south-west Cape congeners (Fig. 12). It bore least similarity to the diet of *S. canicollis* and most similarity to those of *S. flaviventris*, *S. albogularis* and *S. gularis*. However, consideration of food types showed far less resemblance between the diet of the protea seedeater and those of its six congeners. The food type recorded most frequently for *S. leucopterus* was "larger seed". The corresponding types for its congeners were: *S. canicollis*, composite achenes; *S. tottus*, graminoid

TABLE 17 : Occurrence of food classes (Rowan 1970) and food types in the diets of Serinus leucopterus and eight south-west Cape congeners: 1 = S. leucopterus 2 = S. albogularis 3 = S. gularis 4 = S. sulphuratus 5 = S. tottus 6 = S. flaviventris 7 = S. scotops 8 = S. canicollis 9 = S. alario. X = recorded in the diet of the species within the south-west Cape (X) = recorded in the diet in southern Africa (not within south-west Cape) + = possibly or probably recorded in the diet within the south-west Cape.

Food classes	Food types	Serinus species								
		1	2	3	4	5	6	7	8	9
Soft plant parts	nectar	X	X	X	+	X	X	+	?	
" " "	fresh floral parts	X	X	+	+	+	X	+	?	
" " "	foliage buds (leaf-buds)	X	?	(X)	+	X	+	X		
" " "	fruit-pulp (ripe)	X	X	X	X			+	(X)	
" " "	succulent leaf-pulp		X	X						
Seed	graminoid seed	X	(X)	X	(X)	X	+	(X)	X	?
"	composite achenes	X	X	X	X	X	X	X	X	?
"	other small seed	X	X	X	X	X	X	?	X	X
"	larger seed	X	X	X	X	X	+	?	+	
"	seed kernels in (ripe or unripe) fleshy fruits	X	X	X	X			+		
Invertebrates	animal matter (invertebrates)	X	X	X	X	(X)	X		(X)	
	other	?			X	X			+	

seed; S. flaviventris, S. gularis and S. albogularis other small seed; S. sulphuratus seed kernels in fruits. "Larger seed" was recorded with far lower frequency for congeners than for S. leucopterus. Smaller seed types, e.g. composite achenes and graminoid seed, were however relatively frequently recorded for the protea seedeater, in common with several congeners including S. albogularis and S. gularis. The protea seedeater thus differed from the white-throated and streaky-headed seedeaters mainly in taking "larger seed" with high, and "other small seed" with low, percentage frequency. It differed from the bully seedeater mainly in taking "larger seed" with higher percentage frequency than for seed kernels.

Comparison of food plant genera and food items taken by S. leucopterus and its congeners provided a more detailed view of dietary overlap. A large proportion (50-64%, Table 18) of plant genera for each of five congeners was recorded also in the diet of the protea seedeater; this proportion was only 21% for the sixth, the streaky-headed seedeater. However, only three of the seven"major" (3% or more of feeding occasions,

TABLE 18: Percentage of plant genera in diets of Serinus species recorded also for S. leucopterus.

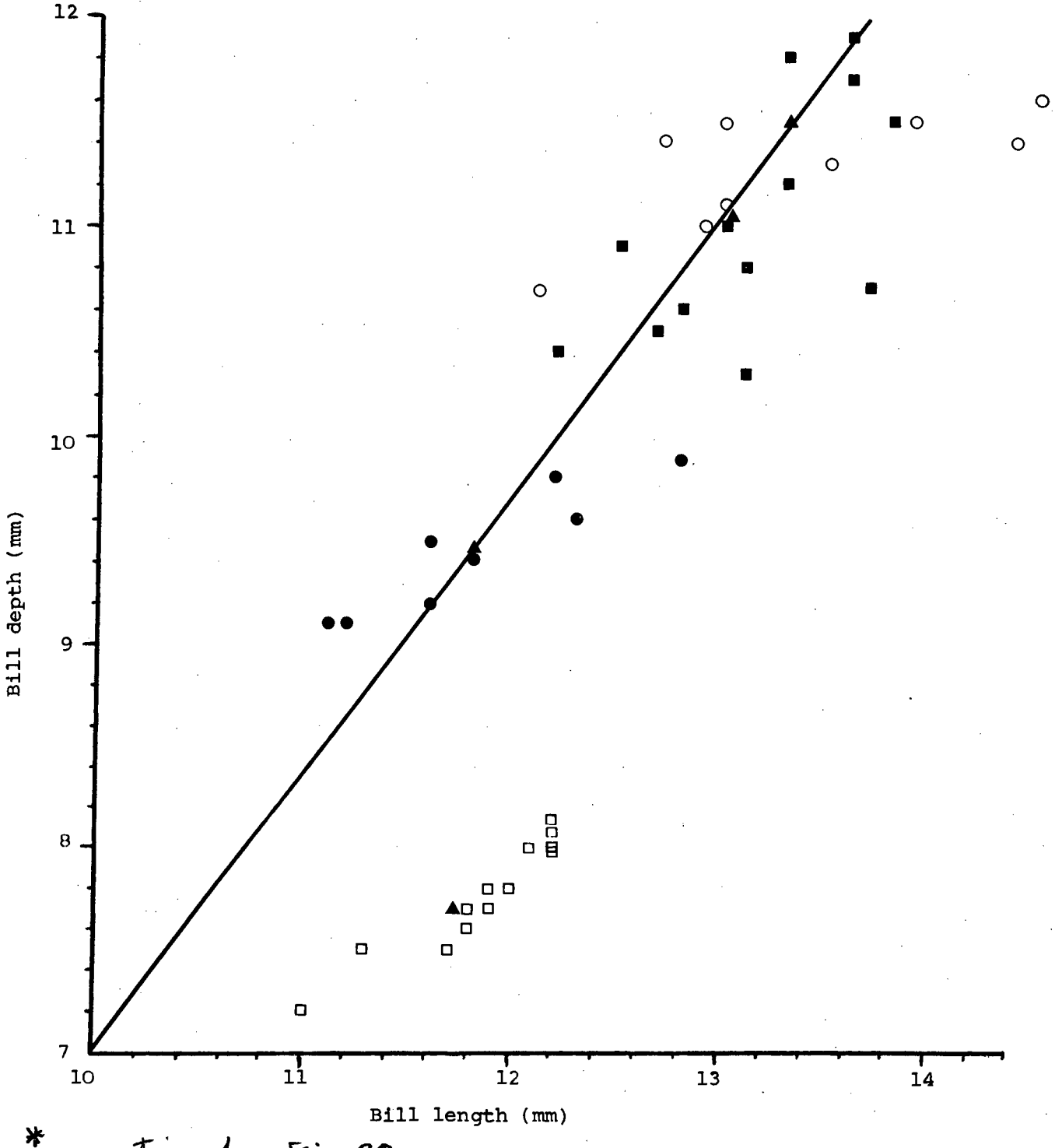
Species	Total genera recorded in diet	% of genera taken also by S. leucopterus
S. tottus	14	64
S. flaviventris	14	57
S. canicollis	16	56
S. sulphuratus	20	55
S. albogularis	22	50
S. gularis	14	21

Fig. 9) food plant genera for the protea seedeater were also taken relatively frequently (10% or more of feeding occasions, Table 16) by congeners. These genera were Senecio (31% for S. canicollis, 8% for S. leucopterus), Maytenus (28% for S. gularis, 4% for S. leucopterus) and Erica (10% for S. flaviventris, 7% for S. leucopterus).

Food items taken relatively frequently (3% or more of total feeding occasions) by and recorded exclusively for S. leucopterus were buds of Rhus, seed of Diosma and seed of Elegia. Infrequently taken items not taken by congeners included seed of Maytenus, Leptocarpus, Pollichia, Psoralea, Cullumia, Gymnodiscus, Salvia, Anthospermum and Hakea, and soft plant parts of Gymnodiscus, Halleria and Salvia. These items of minor importance were, however, almost all referable to food types (e. g. composite achenes, other small seed, nectar) well represented by other genera in the diets of several of the congeners.

Figure 15 relates the length and depth of bill of the protea seedeater to those of south-west Cape congeners of similar size (body length 146-170 mm and bill length 11-15 mm, Appendix 6). The bill of the protea seedeater was shown to be intermediate in length and depth between that of the streaky-headed seedeater and those of the white-throated and bully seedeaters, measurements overlapping in length but not in depth. The protea seedeater showed a mean bill length to depth ratio of 1,2 (11,8:9,5), in common with the bully and white-throated seedeaters but differing from the slimmer-billed streaky-headed seed-eater. The bill of the protea seedeater, although distinct in size from those of its south-west Cape congeners, was

FIG. I5 : Relationship between bill length and depth for Serinus leucopterus and three congeners, measured from 44 specimens in the South African museum. Line links intersect of mean length and depth of the three species with a length to depth ratio of roughly 1,2 (Newton 1967)*. ▲ mean ■ S. albogularis ○ S. sulphuratus ● S. leucopterus □ S. gularis.



*see caption for Fig. 20

similar in shape to those of the larger-billed bully and white-throated seedeaters, suggesting that dietary separation from these two species may be achieved primarily by different seed-size distributions in the diet.

The seed size distribution in the diet of the protea seedeater (Fig. 11) was intermediate between those for the bully and white-throated seedeaters (Fig.14). The protea seedeater took a greater proportion of seeds of smaller sizes than did the bully seedeater, and took a far greater proportion of seeds of larger sizes than did five other congeners, these differences being significant at a 0,05 level probability (Table 19). The protea seedeater was thus apparently distinguishable from the bully seedeater both in bill size and in sizes of seed* in the diet. The protea seedeater's relationship to white-throated & streaky-headed seedeaters must be interpreted with caution owing to the relative paucity of data for these species.

The diet of the protea seedeater has been shown to be similar, in broad terms, to those of six other Serinus species in the south-west Cape. Dietary overlap between each of the three congeners with habitats widely overlapping that of the protea seedeater (S. canicollis, S. tottus and S. sulphuratus, page 58) and the protea seedeater was summarized: The homogeneous food type "composite achenes" (forming 90 % of the diet of S. canicollis and 16 % of that of S. leucopterus, Figs. 10 &13), clearly presented an area of substantial dietary overlap between the protea seedeater and Cape canary. Considerable overlap was apparent also between the protea seedeater and the siskin, involving

*the term "seed" is used loosely here to embrace also whole fleshy fruits taken into the bill prior to extraction of the kernel

graminoid seed (35% for S. tottus and 19 % for S. leucopterus, Figs. 10 & 13), composite achenes (22% of the diet of S. tottus), foliage buds and nectar. Both the Cape canary and the siskin, in general, took a greater proportion of food items (e.g. composite achenes and other small seed) smaller than those for the protea seedeater. The diet of S. sulphuratus showed comparatively little similarity to that of S. leucopterus. "Seed kernels", the major food type for the bully seedeater, formed only 4 % of the diet of the protea seedeater; other food types formed the major part (96%, Fig. 10) of the diet of S. leucopterus but were of minor importance (52%, Fig. 13) for S. sulphuratus. The bully seedeater took a greater proportion of food items (e.g. Olea kernels) larger than those for the protea seedeater (Figs. 11 & 14).

The diet of the protea seedeater was shown thus to be distinct from those of its sympatric congeners when considered quantitatively.

TABLE 19: Comparison of the distribution of seed sizes in the diet of the protea seedeater with those for six congeners. The 2 x k χ^2 test (Siegel 1956) was used to test for significant differences (χ^2 greater than 11,1 was significant at a 0,05 level of probability). Data used were sizes of food items as taken into the bill (Figs. 11 & 14).

Species	χ^2
Serinus gularis	49,39
Serinus sulphuratus	65,17
Serinus albogularis	73,68
Serinus flaviventris	172,44
Serinus tottus	213,49
Serinus canicollis	315,58

The following is a detailed account of observed occasions of feeding coincidence between the protea seedeater and its congeners.

i) Serinus canicollis, Cape canary

A flock of six Cape canaries and a single protea seedeater were observed feeding together on the agricultural weedy annual Chenopodium, perched on the same plant (*g 3 ii ; a 3 ii). An extensive (1 ha) flowering stand of the biennial composite Senecio sp. aff. S. pubigerus was also taken by both S. canicollis and S. leucopterus (g 2 i; a 2 ii); a flock of Cape canaries fed consistently on the unripe achenes of this plant throughout October and into November, side-by-side with two or three protea seedeaters at a time. Similar side-by-side feeding coincidence was also observed for Senecio pubigerus and Eriocephalus africanus. Achenes of Inula graveolens, a composite weedy annual, were taken by both S. canicollis and S. leucopterus (g 2 ii; a 2 ix). Both species also fed, at separate sites, on the achenes of the ericoid shrub Metalasia, and on seed of Pelargonium.

ii) Serinus tottus, siskin

Restio and Thamnochortus (Restionaceae) bear small seeds taken by both S. tottus and S. leucopterus. Seeds of the Cyperaceae were also taken by both species (Ficinia by S. tottus, Tetraria by S. leucopterus). Buds of one of four species of Cliffortia taken by S. tottus, viz C. ruscifolia, were also taken by S. leucopterus; this provided a case of side-by-side feeding coincidence for the siskin and the protea seedeater at one site, a pair of each species foraging in a similar way (e 9 i; a 9 i).

* figures in parentheses in this section refer to Appendix 7.

A group of siskins fed on Erica plukeneti nectar on the same day and in the same area as did protea seedeaters (e 6 ii; a 6 vi). Both S. tottus and S. leucopterus are known to feed on achenes of Metalasia muricata and Stoebe and on small seeds of Chenopodium. The siskin and protea seedeater exhibited similar feeding behaviour at fresh heads of Protea punctata; the birds' spatial and temporal proximity at one locality (e 6 i; a 6 iii) amounted to direct coincidence of utilization of the food resource (probably insects, possibly nectar and/or floral parts). The siskin and protea seedeater were both recorded taking seed of Leucadendron, Protea laurifolia and P. neriifolia.

iii) Serinus sulphuratus, bully seedeater

A bully and a protea seedeater were recorded feeding side-by-side on green seeds of Raphanus raphanistrum (d 4 i; a 4 ii) and Stellaria (d 3 iii; a 3 ix). Both seedeaters also fed in a very similar way on seeds of an annual species of Pelargonium, sharing an area of youthful Mountain Fynbos (d 3 i; a 3 i); the protea seedeater was observed at this site feeding in both youthful and (adjacent) mature vegetation, taking the same food items as Cape canaries and bully seedeaters in the youthful stand. Serinus sulphuratus and S. leucopterus both fed from fruiting shrubs of Diospyros glabra at the same locality (d 7 i; a 7 i) in the same week. The two species took the fruit-pulp in a similar way. The bully and protea seedeaters were also separately recorded taking seeds of Chenopodium, Protea arborea, Phylica and Rhus,

kernels (in young fruit) of Olea africana, kernels in ripe fruit of Cassytha ciliolata, achenes of Euryops, Othonna and Eriocephalus africanus, and scale insects (Coccidae) from the leaves of shrubs.

iv) Other congeners

White-throated seedeaters, Serinus albogularis, fed side-by-side with a protea seedeater on green seeds of Raphanus raphanistrum (b 4 iv; a 4 ii) in agricultural land and in association with a number of seed-eating bird species. White-throated and protea seedeaters were observed briefly taking fresh floral parts of Euryops in proteoid Mountain Fynbos (b 8 ii; a 8 ii). Other instances of feeding coincidence were for seeds of Chenopodium, herbaceous Geraniaceae and Protea, achenes of Compositae (e.g. Senecio, Othonna, Eriocephalus) and scale insects (Coccidae) taken from the leaves of shrubs.

Streaky-headed seedeaters, Serinus gularis, and protea seedeaters fed within 100 m and 30 minutes of each other on the achenes of Eriocephalus africanus (e 2 i; a 2 i). Both species are known to take achenes from a wide range of other composites. Serinus gularis and S. leucopterus were both recorded feeding from fruiting shrubs of Maytenus oleoides (c 7 i; a 7 ii) sometimes at the same locality (S. gularis appeared to take only the fleshy capsule of the seed, while S. leucopterus was seen on one occasion also crushing the seed itself). Both seedeater species took seeds of Chenopodium in agricultural land in late winter (c 3 iii; a 3 ii), and are known also to take termites on the ground, in common with a wide range

of bird species (Skead 1960; Rowan 1970).

The yellow canary, Serinus flaviventris, and protea seedeater were both seen to take achenes of composites including Senecio pubigerus, Eriocephalus africanus and Stoebe plumosa. The two species were also recorded feeding on nectar of Erica plukeneti (using a similar method), seed of Chenopodium, Gnidia and Restionaceae, buds of Cliffortia and termite imagos.

2.3.2. Birds other than congeners

i) Fringillidae and Ploceidae

The Cape bunting, Emberiza capensis (Fringillidae), forages mainly on the ground, taking small seeds (Skead 1960). The species is known also to take the aril-like funicles of alien Acacia (D.M. Skead 1966, Ostrich,37(1):59) and invertebrates ("large spider", pupae of Diptera, Skead 1960). I observed Cape buntings feeding under seeding Inula, Metalasia, Stoebe, Salvia and Chenopodium plants, at all times picking small objects from the ground. The protea seedeater also took the seeds of these plants, in a few cases on the ground near foraging Cape buntings. A pair of buntings in recently-burnt fynbos were observed in the company of several protea seedeaters; all behaved similarly for several hours, foraging while hopping on the ground. It could not be established whether the two species were foraging for the same items. A Cape bunting was observed on another occasion feeding on termite imagos on the ground side-by-side with a protea seedeater (a 10 i). Termites were not noted as unusually abundant

at the time.

The diets of members of the Ploceidae in the south-west Cape are poorly known. The common waxbill, Estrilda astrild, takes small seeds (McLachlan & Liversidge 1972). This species probably subsists, as do its congeners elsewhere (Skead 1975), largely on small seeds of graminoids (Cyperaceae and Gramineae). The diet of the Cape sparrow, Passer melanurus, comprises seed, soft plant parts and insects (Middlemiss 1963; McLachlan & Liversidge 1972). The Cape widow, Euplectes capensis, feeds mainly on seed, also taking insects and the aril-like funicles of Acacia (Middlemiss 1963; McLachlan & Liversidge 1972). The Cape weaver, Ploceus capensis, is a mixed feeder taking invertebrates (insects, spiders, amphipods) and vegetable matter (seeds including those of Gramineae, fruit-pulp, aril-like funicles of Acacia and nectar) roughly equally (Middlemiss 1963; D.M. Skead 1966, Ostrich, 37(1): 59; McLachlan & Liversidge 1972; Rourke 1972; Elliott 1973). The Cape weaver feeds its young mainly on insects (as do other ploceines), becoming predominantly vegetarian in winter (Elliott 1973).

Neither the common waxbill nor the Cape sparrow was observed feeding in Mountain Fynbos. Both the protea seedeater and Cape sparrow were, however, separately observed feeding, while perched, on Chenopodium seeds. Cape widows were noted feeding on the seeds of large- and small-headed species of Tetraria (Cyperaceae) during June, August and September in youthful proteoid-restioid Mountain Fynbos. The species also hawked and gleaned insects (July and August) and took nectar from fresh

Protea repens heads (mature proteoid Mountain Fynbos, June) and Erica plukeneti flowers (mature ericoid-restioid Mountain Fynbos, July). Other records were of birds foraging terrestrially on cleared ground (e.g. under seeding Metalasia muricata shrubs, May) and among grass tufts and seeding agricultural herbs. It seems reasonable to suggest that seeds taken by E. capensis in fynbos are largely those of the Cyperaceae and Gramineae. The Cape weaver was observed hawking insects (May) and consistently taking nectar (possibly insects and floral material as well) by bowing deeply into fresh Protea repens and P. arborea heads (mature proteoid Mountain Fynbos, April, May and probably through June and July). Most sightings of the Cape weaver in Mountain Fynbos were in association with stands of flowering Protea species, supporting my impression that the species is, seasonally at least, largely nectivorous in this environment. Cape weavers were also seen in association with fruiting Olea stands in July and probing into mature, dry Protea (P. macrocephala, P. arborea) heads in May, at times briefly picking up seeds in the bill.

Euplectes capensis took nectar of the same species of Erica on the same day and in the same area as did protea seedeaters. Other food items common to the diets of the two species were Protea nectar and Tetraria seeds. The Cape widow took nectar with a very similar method to that of the protea seedeater, perching on the shrubs, detaching the Erica flowers at the base and inserting the bill between the side bracts of the Protea involucral cup. Evidence for feeding coincidence between the Cape weaver and the protea seedeater was restricted to records of both

species taking Protea nectar.

ii) Nectariniidae, Turdidae and Zosteropidae

An orange-breasted sunbird, Nectarinia violacea, and a protea seedeater fed simultaneously from fresh Protea laurifolia heads on the same shrub (proteoid Mountain Fynbos, Cedarberg, August). Both birds took nectar by probing their bills between the lower pink involucral bracts. The two species were also observed feeding on the nectar of Erica plukeneti on the same day and at the same locality (Mountain Fynbos, Bains Kloof, July). Orange-breasted sunbirds and protea seedeaters fed elsewhere on nectar of Protea and Erica in spatial and temporal proximity.

The familiar chat, Cercomela familiaris, was noted taking termites on the ground in the company of a protea seedeater and Cape bunting (Mountain Fynbos, Cedarberg, April). A Cape rock thrush, Monticola rupestris, was seen feeding on whole fruits of Maytenus oleoides (proteoid Mountain Fynbos, Molenaarsrivier, January). Protea seedeaters were frequently recorded removing the seed and its fleshy capsule from opened fruits of M. oleoides at this locality. One bird fed within 20 m of the feeding rock thrush.

A Cape whiteye, Zosterops virens, was observed feeding on imagos of aphids (Homoptera: Aphididae) on a shrub of Widdringtonia cedarbergensis (Mountain Fynbos, Cedarberg, June), immediately after a pair of protea seedeaters had taken the same food in the same shrub. A protea seedeater

was seen dipping its bill briefly into a fresh involucral cup of Protea arborea (presumably taking nectar) in the same way as did several whiteyes visiting the same head shortly before (proteoid Mountain Fynbos, Cedarberg, July). A whiteye fed whole seed, with its fleshy capsule, of Maytenus oleoides to a begging conspecific (proteoid Mountain Fynbos, Molenaarsrivier, February). I recorded protea seedeaters taking this food item on several occasions during the same visit.

2.3.3. Discussion

Dietary overlap between the protea seedeater and birds other than its congeners was relatively restricted. The diet of the protea seedeater was similar in broad terms to those of congeners; few food items taken by the protea seedeater were not recorded also for one or more of its congeners. However, Protea seed, contributing more than any other food item to the diet of S. leucopterus, helped more than any other food item to distinguish the species' diet from those of its congeners.

The diets of the protea seedeater and three sympatric congeners were related to each other in the order S. canicollis, S. tottus, S. leucopterus, S. sulphuratus. The diet of S. canicollis was most restricted, in terms of both food types and size of food items, while that of S. sulphuratus was least restricted, embracing many food types and a wide range of sizes. This sequential relationship of the diets of the four species could be seen in the decreasing relative importance of small items (mainly composite achenes) in the diets (highest in that of S. canicollis and lowest in that of S. sulphuratus) and in the increasing relative importance of large items (mainly "larger seed" and "seed kernels"). This sequence in the diets corresponded with a sequence in the body (and bill) sizes of the species. This relationship was, however, imperfect, S. canicollis being larger than S. tottus but having a more restricted diet consisting collectively of smaller items. The protea seedeater was thus intermediate in size between the siskin and Cape

canary on one hand and the bully seedeater on the other, and had a diet intermediate between these two sets of congeners, Serinus leucopterus was thus found to have a diet essentially consisting of similar food items and food types to those of its congeners, differing from those of sympatric congeners in the frequency with which items of different sizes were taken; these differences were consistent with the body size relationships between the protea seed-eater and these congeners.

3. FEEDING BEHAVIOUR

3.1. Feeding behaviour of Serinus leucopterus

3.1.1. Height of feeding

The protea seedeater was observed feeding mainly between 0,25 and 2,50 m above ground (Fig.16). Fifteen and 11% of recorded feeding occasions were, however, respectively below 0,25 m and above 2,50 m. Thirty percent of all feeding occasions were at heights of 0,25 to 0,75 m. Most feeding above 1,50 m was on Protea seeds. Histograms for the heights at which the protea seedeater fed (Fig.16) show that the bird foraged throughout the height range of the vegetation.

3.1.2. Time of feeding

The protea seedeater was observed feeding at all times of the day between 06h30 and 20h00 (Fig. 17). Minor proportions of feeding occasions were recorded in the early morning (06h30-09h00) and late afternoon (16h00-20h00).

The collective temporal distribution of feeding occasions for the protea seedeater was largely dictated by the hours of observation; fieldwork was seldom started before 08h00 and usually finished by 16h30. The results indicated that the bird fed throughout the daylight hours. It must be noted, however, that time intervals were fixed with respect to time of day and not to time of sunrise. Conclusinns cannot be drawn regarding differences in feeding activity within a single day at a single place, nor between days with different weather conditions. My qualitative impression was that high temperatures (30^{o}C and over) affected the activities of protea seedeaters. Birds were, for instance, observed to rest continuously

on shady perches for 1 to 2 hours around midday on hot sunny days, while inactive birds were seldom noted earlier or later in the day.

FIG.16 : Height of feeding for Serinus leucopterus, shown for 190 feeding occasions (Jan. 1974-Oct. 1976). Strata are height categories (m above ground): 0 = on the ground 1 = above ground level but below 0,25 m 2 = 0,25-0,75 m 3 = 0,75-1,5 m 4 = 1,5-2,5 m 5 = above 2,5 m. Figures in parentheses are numbers of feeding occasions.

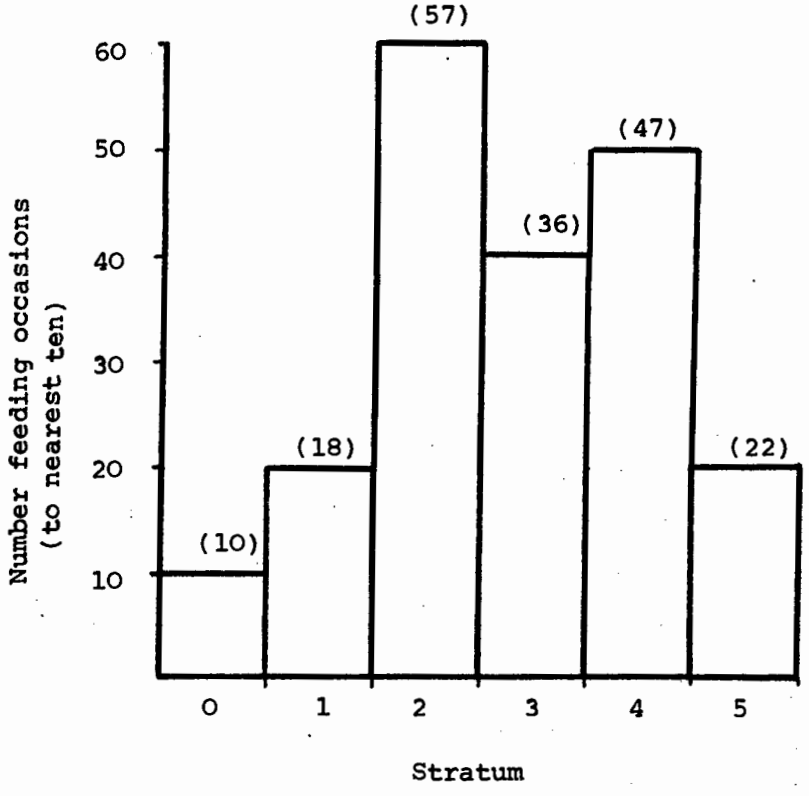
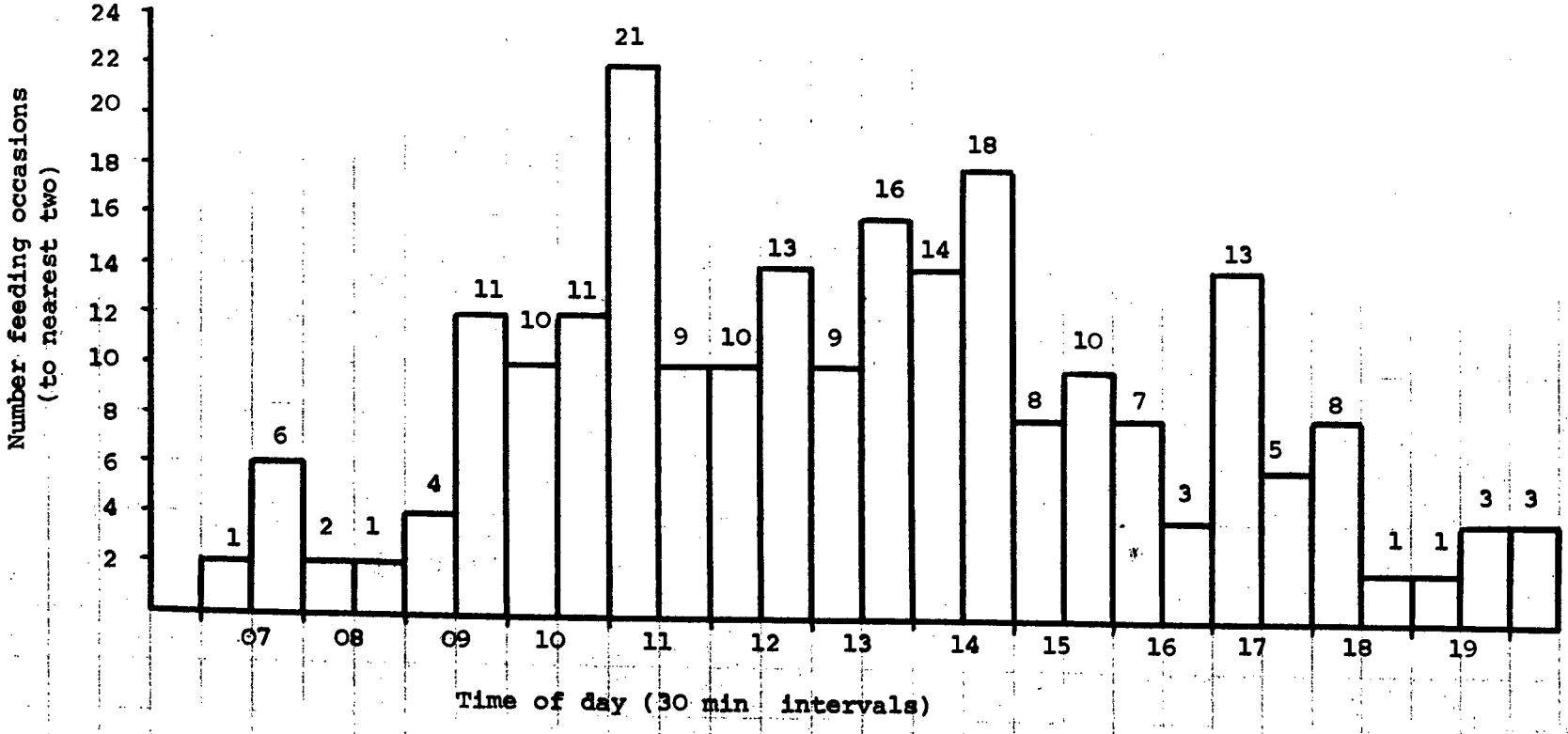


FIG. 17 : Daily temporal distribution of feeding occasions for the protea seedeater (grouped by 30 minute intervals), January 1974-October 1976. Figures are numbers of occasions collectively observed in each interval.



3.1.3. Group-size

3.1.3.1. Methods

The minimum number of protea seedeaters seen and/or heard interacting vocally was recorded for each encounter with the species. Two separate encounters were noted if birds flew into view, joining a bird already under observation.

Typical group-size ("typical number of birds per encounter") and mean group-size ("mean number of birds per encounter") were calculated. For typical group-size I used the formula $\sum y^2 / \sum y$ where y is the group-size for any particular encounter (Jarman 1974). Typical and mean group-size were calculated (i) on the basis of all encounters with one or more feeding birds, and (ii) on the basis of all encounters with the species over a three-year period.

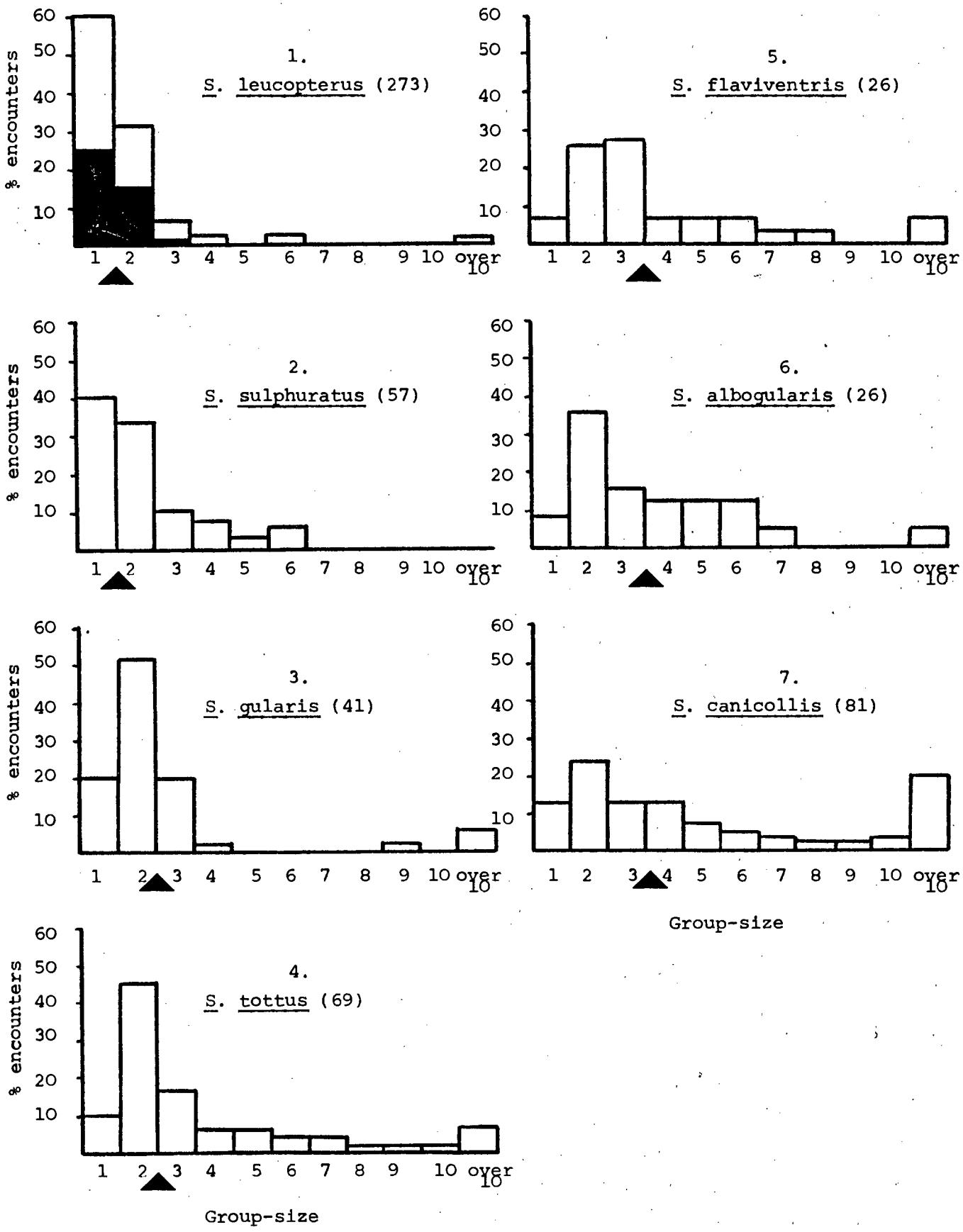
3.1.3.2. Group-size while feeding

Typical group-size for feeding birds was 1,65. Mean group-size for feeding birds was 1,43. The commonest group-size in 115 encounters with feeding birds was one (Fig. 18). The maximum number of birds seen feeding together simultaneously was three. However, on one occasion a group of 20 birds was recorded in association with recently loosened seed of Protea neriifolia, 38 days after fire.

3.1.3.3. Overall group-size

Typical and mean group-size for all birds encountered were 2,72 and 1,57 respectively. The commonest group-size

FIG. 18: Group-size for Serinus species. Histograms show the percentage of encounters at which each species was observed at a particular group size. Figures in parentheses are the total number of group-size encounters with each species. Solid histograms for S. leucopterus are the group-size while feeding (115 encounters). Species were arranged in order of mean group-size, to the nearest integer (arrowed).



in 273 encounters with the protea seedeater was one (Fig. 18). Encounters with groups of more than three birds comprised only 1,8% of all encounters. The protea seedeater was seen in groups of more than four birds only in association with temporarily abundant food-sources (e.g. 20-25 birds in a Protea stand taking dehiscing seeds 38 days after fire). Many apparently single birds proved, when observed for extended periods, to be associated with other individuals. Birds 10-100 m apart maintained sporadic vocal contact, reuniting periodically during the day.

3.1.3.4. Discussion

The protea seedeater is most commonly found as a single bird, both while feeding and during other activities. Pairs are also frequently encountered. The species appears to occur characteristically in loosely cohesive groups of two or three birds.

My observations on group-size for the protea seedeater agree with the literature: "Usually found scattered in pairs or as individuals" (McLachlan & Liversidge 1972). However, "a party of 9 or 10 was once seen ... a party of 20 was seen ... in May, and feeding flocks of 30-40 occur" (Skead 1960). However, it is not clear whether these observations were made in recently-burnt or mature vegetation.

3.1.4. General postures and methods

Seeds and floral material of low-growing herbaceous food plants (e.g. Pelargonium, Gymnodiscus, Anthospermum and Pollichia) were taken in open situations by the protea seedeater. The bird readily stood on the ground* when suitable feeding perches were lacking. A pair of protea seedeaters hopped for an extended period (2-3 hours) on recently-burnt ground in a stand of Protea arborea. The birds showed no sign of unease despite an approach to within 5 m, hopping mainly on surface rock and pecking sporadically at the ground with intermittent short flights and pauses while perching on low branches. Some wing-fluttering was observed as the protea seedeaters used the bill to chisel vigorously into the ground at the base of emerging seedlings. Cotyledon leaves of the germinating seeds, torn off in the process, were discarded; the hard test of unearthed seed was split in the bill and the endosperm apparently ingested. Freshly dehisced Protea arborea seeds were sought on the ground at the same recently-burnt site. Ground foraging was also observed in mature vegetation, after a perched bird had thrashed seed material out of an involucral cup on the P. arborea shrub above. Birds standing on the ground in vegetation one year after fire took developing seeds of annual Pelargonium with or without detaching the seed-bearing basal part of the gynoecial column from the plant. Capitula of Gymnodiscus were taken standing on the ground and reaching (or, on one occasion, jumping) up to the inflorescences of the 10 cm herbs. Protea seedeaters foraged while hopping on the

* 11% of feeding occasions, Table 20

ground also for termites and other items (probably including fallen seed).

Birds were usually observed* feeding in a variety of perching postures. Green achenes of sturdy composites (Othonna, Senecio) were taken while perched on the food plant itself. Large capitula were partly or completely dismembered without being removed from the plant. Smaller capitula (e.g. of Othonna quinquedentata) were detached whole before mandibulation. Foraging birds hopped, sidled and fluttered the wings while changing position to reach new food objects. Birds returned to more upright postures to ingest the seed after collecting a capitulum by hanging upside down, sidling and fluttering up the perch or dropping down to a new perch. The fluffy pappus of unripe achenes was worked off in the bill and could be seen as a tuft adhering to the mandible. This was removed by rubbing bill against perch during and after foraging.

Nectar of tubular flowers (e.g. Erica, Halleria) was taken by detaching individual floral tubes and mandibulating the base for several seconds. Discarded perianth tubes clearly showed marks left by the bill. Nectar of Protea laurifolia was taken by perching on leaves at the base of the head and probing the bill between the lower involucral bracts from the side. A protea seedeater, perched on the edges of the involucral cup, was observed foraging for more than 5 minutes at a single fresh head of P. punctata; the bird probed vigorously down into the open cup, tugging upwards at the base of the flowers, and appeared to glean the upper parts of remaining styles after removing the floral material on one side of the head. Nectar and insects

* 89% of feeding occasions, Table 20

were possibly ingested: subsequent examination showed that small beetles (Gastrophysa sp.) had crawled up the styles during the disturbance.

A probing motion was used while feeding on graminoid seeds. Birds perched on an adjacent branch or on the food plant itself, weighing it down towards the horizontal. Examination of intact Restio and Leptocarpus seed-heads showed clearly where the seed and its covering bracts had been removed. Gathering of densely clustered small seeds of Elegia may have been facilitated by recent soaking of the plants by rain. Birds feeding on seed of Restio dispar (and of the composite Othonna quinquedentata) were agile, leaning deeply forward and moving around in the tall, supple plants despite swaying in the wind.

Protea seedeaters used their feet to assist in feeding on seeds of Compositae (Othonna) and Restionaceae (Restio, Thamnochortus). This strategy appeared to facilitate the removal of seeds borne on supple stems offering little resistance to the force of the probing bill. The weight of birds alighting on plants of Restio gaudichaudianus and Thamnochortus spp. bent portions of the tufts towards the horizontal. Stems bearing seed heads were then drawn towards the bird (a hooking motion with the bill was sometimes used), and clasped, under one foot, to the food plant stems serving as perch. One bird was observed to draw a seed head of Restio pachystachyus towards itself, clasp the stem to its rigid twig perch, and feed uninterruptedly in this position for more than 5 minutes. A bird was also observed to use its feet to control secured seed heads of Restio gaudichaudianus for several minutes;

subsequent examination revealed that the fine green stems of the food plant had been tangled, the seed heads, wedged in the Restio bract axils, continuing to bind the thicker stems after the bird's departure. Birds drew in terminal portions of inflorescences of Othonna quinque-dentata while perched on horizontal and vertical branches of the peduncle. These portions were then clasped to the perch while the bird plucked and mandibulated the capitula. Birds occasionally sidled along the perch while still clasping a portion of an inflorescence with a foot.

The strategy of foot-use was by no means general, even for R. gaudichaudianus seeds (which I observed protea seedeaters taking many times, App 7a). The birds appeared adept at removing seeds from free, supple stems; even on a single tuft of Restio or Thamnochortus, a single foraging sequence usually included feeding both with and without foot-use.

Birds foraged in the foliage of Maytenus sp. for opening ripe fruits, by hopping, sidling, and fluttering from perch to perch. The seed with its encasing fleshy capsule was removed from the fruit. The bill appeared to be used on most occasions to strip off the capsule for ingestion; seeds were, however, retained and crushed in the bill on several occasions at least, the kernel apparently being taken. The single-seeded fruit of Cassytha was mandibulated for 1-2 minutes and the ripe fruit-pulp discarded. The skin of ripe fruits of Diospyros sp. was pared off and discarded with the seed, from which the fleshy pulp had been stripped.

Foliage buds were sought by protea seedeaters perched in shrubs. At times birds hopped through the food plant in the manner of a gleaning warbler, pecking intermittently at shoot tips and leaf-axils; insects were possibly taken on these occasions. Foraging birds in shrubs of Rhus sp. moved actively through the foliage, apparently ignoring abundant fruit, floral and gall material. Leaves were plucked at the axil; the petiole base (and, presumably, bud) was mandibulated and the leaf discarded after a few seconds.

Protea seedeaters foraged for Protea seeds while perched on the edge of the involucral cup or on an adjacent branch. The bill was used to loosen and pull out individual seeds. Considerable force was clearly required to free seeds firmly attached to the capitulum. The body of the seedeater was observed (and heard) vibrating vigorously as the bird worked the seeds loose; the tail of one tugging individual was held vertically down (at right angles to the body) for balance during this operation. One foraging individual was observed perching at various angles to a head of Protea laurifolia, frequently changing side. Examination revealed that the obstructive involucral bracts had been cut back (possibly by the bird) and almost half of the tightly attached seeding material in the cup removed. Unwanted material was flicked aside, often out of the cup. Birds retained eligible (fertile) seeds in the bill to split the papery pericarp and ingest the soft kernel. One period of mandibulation to husk the seed was timed at 12 seconds. Rejected seeds

were immediately dropped over the side of the cup. A protea seedeater was, on one occasion, seen flying intermittently with seed from a P. arborea head to an adjacent branch. It is possible that the bird was using a foot to hold the object down on a firm perch to facilitate husking with the bill. Another bird clearly experienced difficulty in husking the particularly large seed of P. compacta; the bird mandibulated a single seed for 3 minutes, putting it down on the involucral cup and picking it up again several times, attempting to split the husk by holding the seed perpendicular to the long axis of the bill, and finally flying down with the seed to a concealed perch, where the bird may have held it down with a foot to assist in husking it.

TABLE 20: Percentage feeding occasions for Serinus species in three feeding positions: 1 = perched 2 = standing on the ground, food taken from plant 3 = taken off the ground 4 = hawked aerially.

Species	% occasions				No. feeding occasions
	1	2	3	4	
S. gularis	97	-	-	3	30
S. sulphuratus	93	5	2	-	60
S. canicollis	90	-	9	-	497
S. leucopterus	89	6	5	-	238
S. flaviventris	82	8	10	-	83
S. albogularis	68	29	3	-	44
S. tottus	64	14	21	-	149

3.2. Feeding behaviour of congeners in relation to *Serinus leucopterus*

3.2.1. General

Six south-west Cape congeners of the protea seedeater all fed mainly (64-97% of feeding occasions, Table 20, least for *Serinus tottus* and *S. albogularis* and most for *S. gularis* amd *S. sulphuratus*) while perched on plants; relatively little feeding was recorded for birds standing on the ground.

Skead (1960) previously recorded several *Serinus* species, including *S. sulphuratus*, *S. flaviventris*, *S. tottus* and *S. canicollis*, feeding both perched and while on the ground. The Cape canary was, however, found to spend "much of its time" feeding on the ground, and the siskin was "not seen on the ground as often as most canaries", disagreeing with my findings.

3.2.2. Foot-use

The protea seedeater and siskin were the only south-west Cape *Serinus* species which were observed to use their feet to control food objects on more than 1% of feeding occasions (Table 21). The siskin used this feeding strategy far more frequently (38% of occasions) than did the protea seedeater (3% of occasions). This relationship between the two species was found also for those food plant genera for which foot-use was recorded; 90% of occasions of the siskin feeding on *Thamnochortus* and *Ficinia* involved foot-use, while only 16% of occasions of the protea seedeater feeding on *Thamnochortus*, *Restio* and *Othonna* involved foot-use. The siskin was frequently

observed feeding in small groups day after day for several weeks (Duiwelskloof, Groot Drakenstein, October & November) on the seeds of locally abundant Ficinia bracteata in a youthful stand of vegetation burnt 2 to 3 years previously. The birds used their feet to assist them on virtually every feeding occasion on Ficinia, feeding both perched on plants and while standing on the ground taking seed from the head of the growing plant. One bird was recorded spending an average of 2 minutes for each of five heads of Ficinia on which it fed successively.

TABLE 21 : Frequency of foot-use in feeding by seven south-west Cape Serinus species. 1 = S. sulphuratus 2 = S. albogularis 3 = S. leucopterus 4 = S. gularis 5 = S. flaviventris 6 = S. canicollis 7 = S. tottus. "+" indicates less than 1% of feeding occasions.

	Serinus species						
	1	2	3	4	5	6	7
Total feeding occasions	60	44	249	30	83	497	115
% feeding occasions for which foot-use recorded	-	-	3	-	-	+	38
No. feeding occasions on food plant genera for which foot-use was observed	-	-	43	-	-	1	49
% of (3) above for which foot-use recorded	-	-	16	-	-	100	90

3.2.3. Group-size

Five of the six south-west Cape congeners of the protea seedeater were encountered mainly as single birds or as groups of 2-4 birds (Fig. 18). Serinus tottus and S. flaviventris were encountered relatively frequently (20-30 %) as groups of 5-10 birds. The sixth species, S. canicollis, occurred frequently (20 %) as groups of more than 10 birds; the Cape canary thus appears to be a "flocking species" in contrast to its congeners.

Larger groups (15 or more birds) of all Serinus species were observed in association with temporary abundances of certain food types. For example, a group of six bully seedeaters was observed feeding in a stand of fruiting Diospyros glabra, siskins and white-throated seedeaters (groups of more than 20 birds each) were congregated respectively at patches of recently-burnt Leucadendron (seeds dehiscing from cones) and at seeding stands of the weedy annual Salsola kali. Streaky-headed seedeaters and yellow canaries were observed flocking in agricultural land where they fed on seed from a dense stand of the weedy annual Chenopodium sp. Flocks of Cape canaries were also commonly found in association with this sort of food availability (e.g. dense seeding stands of the weedy annuals Inula graveolens and Senecio spp.). It is possible that the relatively large mean group-size for Serinus canicollis (Fig. 18) is directly related to its relatively specialized diet (page 71).

4. COMPARISON WITH OTHER SEEDEATERS

4.1. The literature

Factors attending the ecological separation of species of Fringillidae include (i) the size (and hardness) of food items, determined mainly by size, shape and musculature of the bill/jaw complex, and (ii) the proportion of the vegetated environment (in three dimensions) from which the species is able to take food directly, determined mainly by the "agility" of the species (Newton 1967). Knowledge of bill morphology and feeding behaviour is thus necessary and sufficient to measure feeding aspects of ecological separation (Cody 1974). "Feeding behaviour determines which food items will be encountered, and bill morphology determines which of those encountered will be accepted ... As bird species seem to be largely opportunistic ... every food item encountered and found to be manageable will be incorporated into the diet" (Cody 1974).

4.2. Diet

Finches provide major evidence for the value of bill structure as an index of ecological similarity. Competition for food in Galapagos finches (Geospizinae) has given rise to adaptive radiation. Bill differences have been correlated with dietary differences (Lack 1947); in particular, association of large food items with large bills, and hard items with deep bills, has been shown for Geospiza species (Bowman 1963). British finches (Fringillidae: Carduelinae) also provide direct correlations between

seed size preference and bill structure. Small-billed species are restricted to small seeds. Large-billed species take a wide range of sizes, but large seeds can be husked efficiently and are preferred (Kear 1962; Newton 1967). Analysis of stomach contents of, and experimentation with, North American finches (Fringillidae: Emberizinae and Richmondeninae) has further illustrated divergence in choice of seed size and hardness (Hespenheide 1966; Willson 1971; Pulliam & Enders 1971). Large-billed finches (e.g. the cardinal Richmondena sp., culmen length 14 mm) takes a wide range of seed sizes. Joint consideration of several large-billed species produced evidence for significant selection of larger seeds in comparison to species with smaller bills, considered jointly; the cardinal was not, however, found to "prefer" large seeds (Willson 1971). A large bill appears principally to enable the finch to take an extensive range of seed sizes from large to the smaller ones taken by species with smaller bills. Species with "small bills did not husk small seeds faster than [those with] large bills" (Willson 1971).

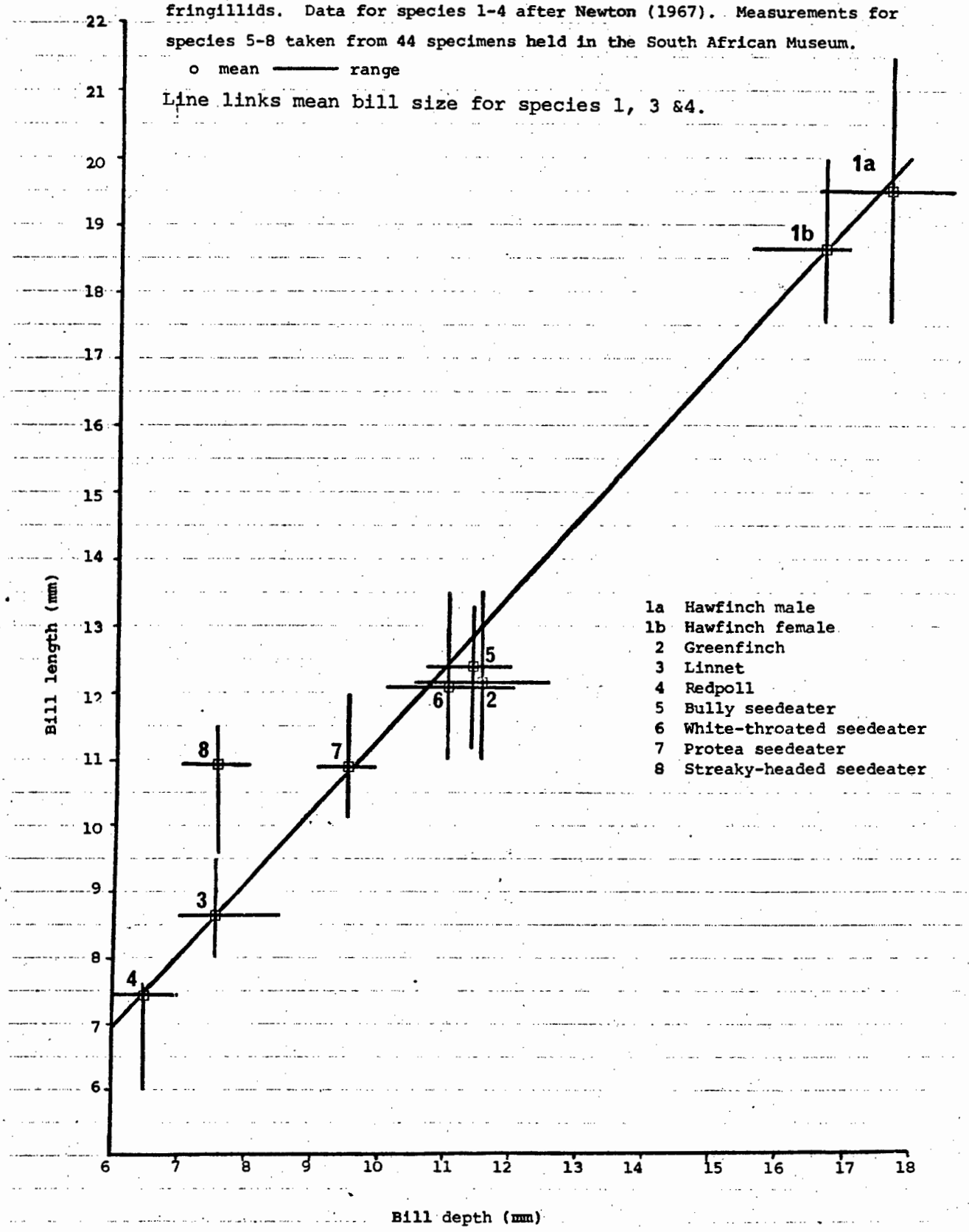
Figure 19 related bill shape for the protea seedeater to those for four British finches studied by Newton (1967), viz hawfinch, Coccothraustes coccothraustes, greenfinch, Carduelis chloris, linnet, Carduelis cannabina, and redpoll, Carduelis flammea. The British species differed from each other and from the protea seedeater in bill size (length and depth) but showed, in common with the protea seedeater, a linear relationship of bill length to depth. The shape of the protea seedeater's bill thus appeared similar to those of the British finches, suggesting that valid dietary

FIG. 19 :

Relationship between bill depth and length for European and South African fringillids. Data for species 1-4 after Newton (1967). Measurements for species 5-8 taken from 44 specimens held in the South African Museum.

o mean ——— range

Line links mean bill size for species 1, 3 &4.



comparisons can be made between the protea seedeater and the four British species in relation to bill size (as reflected by length or depth).

Newton (1967), studying four seed-eating finch species (Fringillidae: Carduelis and Coccothraustes), demonstrated that the distribution of seed weights in the diets of finches was correlated with bill depth. Diets were determined mainly from observation of feeding finches, as in the present study. Newton's correlation enabled me to predict the bill depth of the protea seedeater on the basis of the distribution of seed weights in its diet (Fig. 20). The predicted range, 10-11 mm, is similar to the actual bill depth (9,1-9,9 mm, $\bar{x}$ 9,5 mm, Appendix 6) for the species, suggesting that the protea seedeater's diet is related to its bill morphology in the same way as for British finches.

Pulliam and Enders (1971) compared the distribution of sizes of food items (mainly seeds) in the qualitative diets of five seasonally insectivorous North American finches (Emberizinae : Spizella, Melospiza, Junco, Zonotrichia and Richmondeninae: Richmondena). This was done on the basis of plant species identified from seed (and "fruit", presumably including seed kernels) in "hundreds" of analysed stomachs of birds shot in all parts of each species' range, over a 70 year period. Pulliam and Enders used "length", obtained from cube root of volume, (rather than weight) as a parameter of size of items; the formula used was $(\underline{h} \times \underline{l} \times \underline{w})^{1/3}$, where $\underline{h}$, $\underline{l}$ and $\underline{w}$ are the lengths (mm) of the three axes of the seeds. Their correlation between bill length (not depth, used by Newton) and size

of food items enabled me to predict the bill length of the protea seedeater on the basis of the distribution of seed sizes in the diet of this species (Fig. 21). The predicted bill length, 11-14 mm, is similar to the actual bill length (11,1-12,8 mm, $\bar{x}$ = 11,8 mm) for the protea seedeater, supporting the conclusion that Serinus leucopterus shows a relationship between bill morphology and (seed) diet similar to those for other (taxonomically diverse) finches.

FIG. 20 : see overleaf for caption

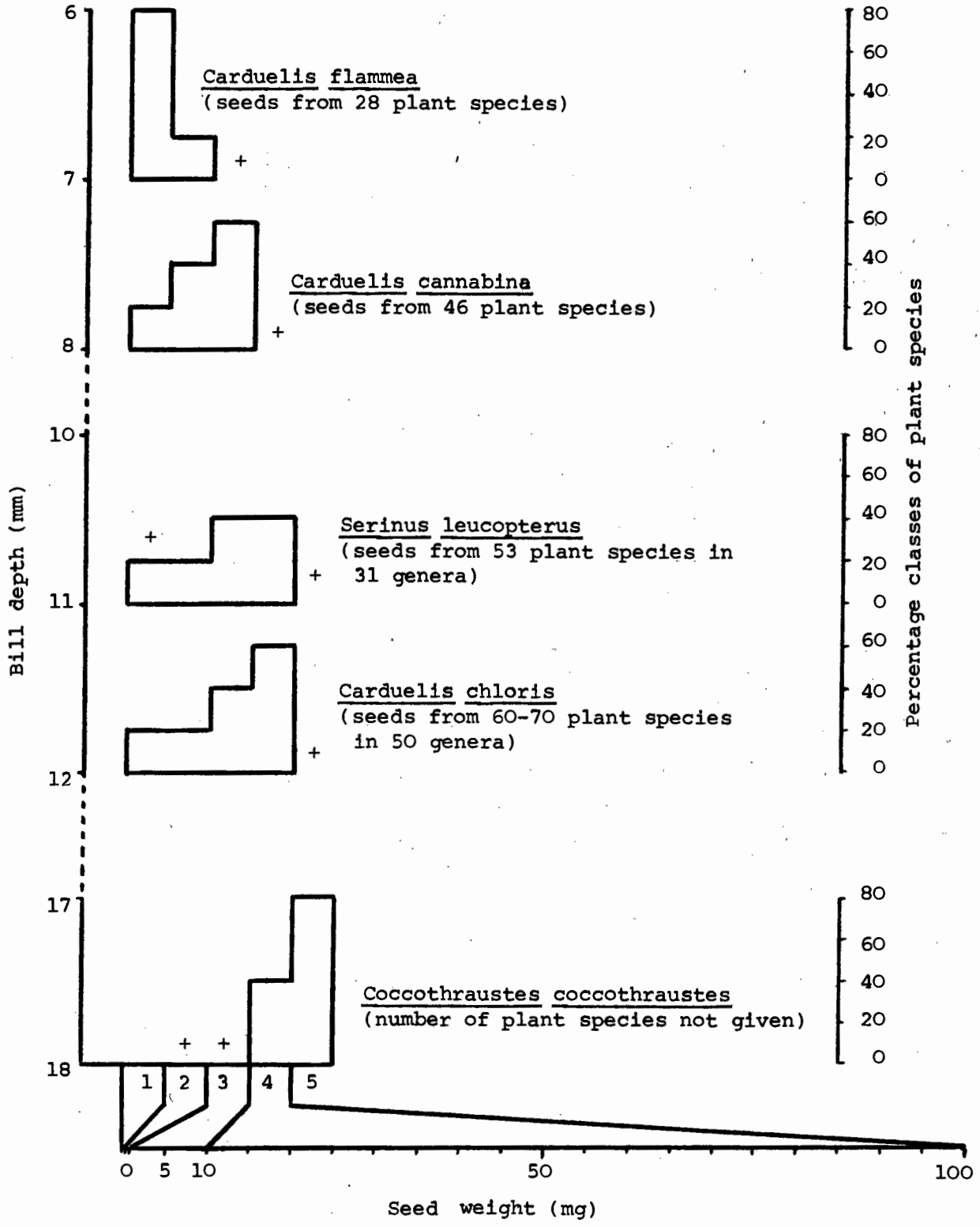


FIG. 21 : see overleaf for caption

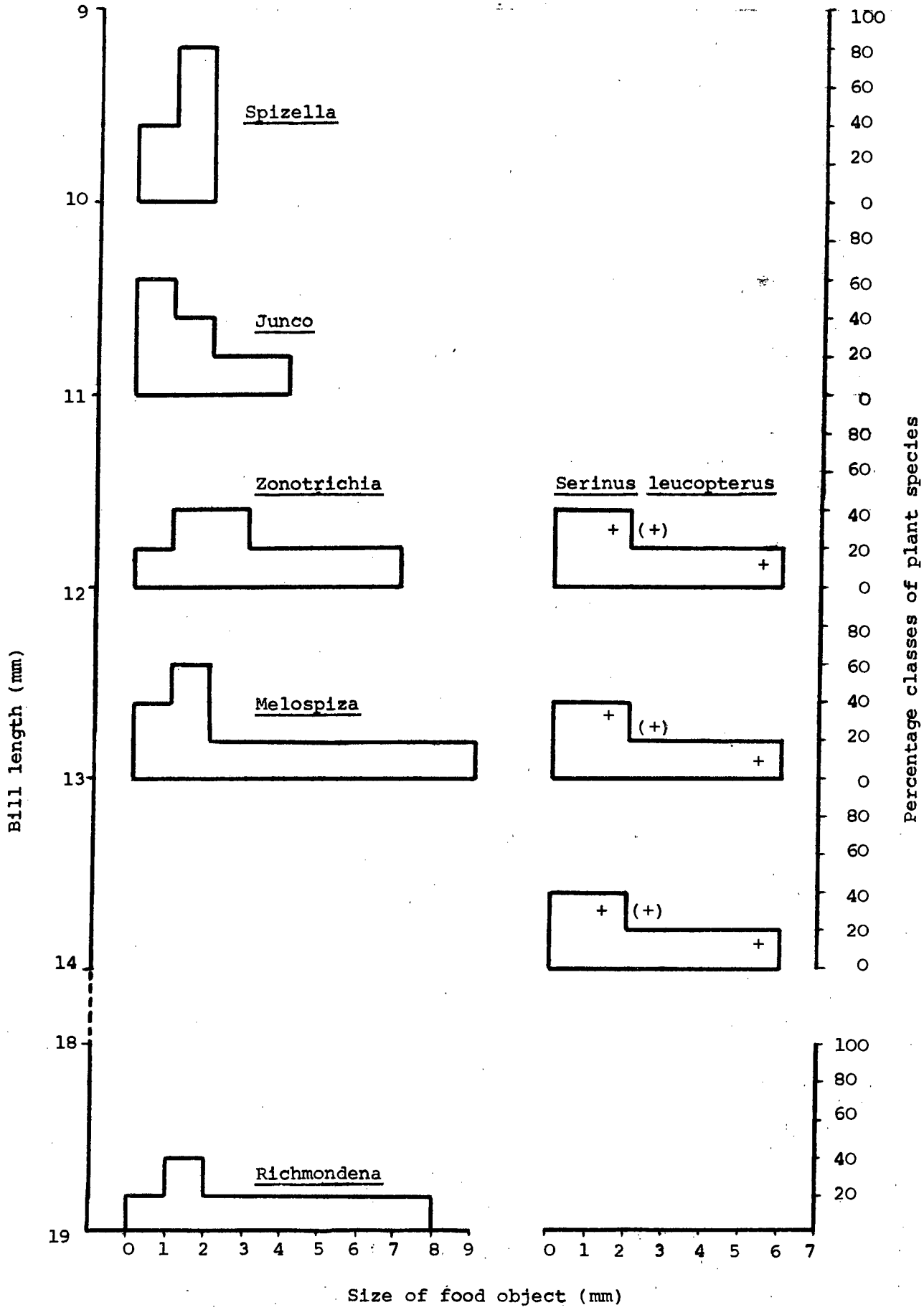


FIG. 20: Distribution of seed weights in the diets, considered qualitatively, of the protea seedeater and four British finch species (after Newton 1967). Vertical axis shows the percentage classes of the total number of plant species recorded as seed in the diet of each finch species (+ indicates value of 5% or less). The horizontal axis shows classes of seed weight for all plant species represented by seed in the diets of the finches. Weight classes used (related to a linear scale below the axis) were: 1 = 0-0,5 mg; 2 = 0,5-1,0 mg; 3 = 1,0-10,0 mg; 4 = 10,0-100,0 mg; 5 = over 100,0 mg. Finch species were ranked (after Newton 1967) in order of mean bill depth (vertical axis). Histograms for seed weights in the diet of the protea seedeater were incorporated into the figure according to the pattern established for the four British species. This position gave the predicted bill depth of the protea seedeater as 10-11 mm.

FIG. 21: Distribution of seed sizes in the diets, considered qualitatively, of the protea seedeater and five North American finch species (after Pulliam & Enders 1971). The vertical axis shows the percentage classes of the total number of identified plant species recorded in the diet as seed or "fruits". The horizontal axis shows size classes for food objects; "foods ... greater than about 3,5 mm in size were soft fruits, while almost all foods less than 3,5 mm were hard seeds" (Pulliam & Enders 1971). Finch species were ranked in order of bill length (vertical axis). Histograms for seed sizes in the diet of the protea seedeater, assessed by the same method but considering seeds only, were incorporated into the figure in several positions all fitting the pattern established for the four North American species. These positions gave the predicted bill length of the protea seedeater as 11-14 mm.

4.3. Feeding behaviour

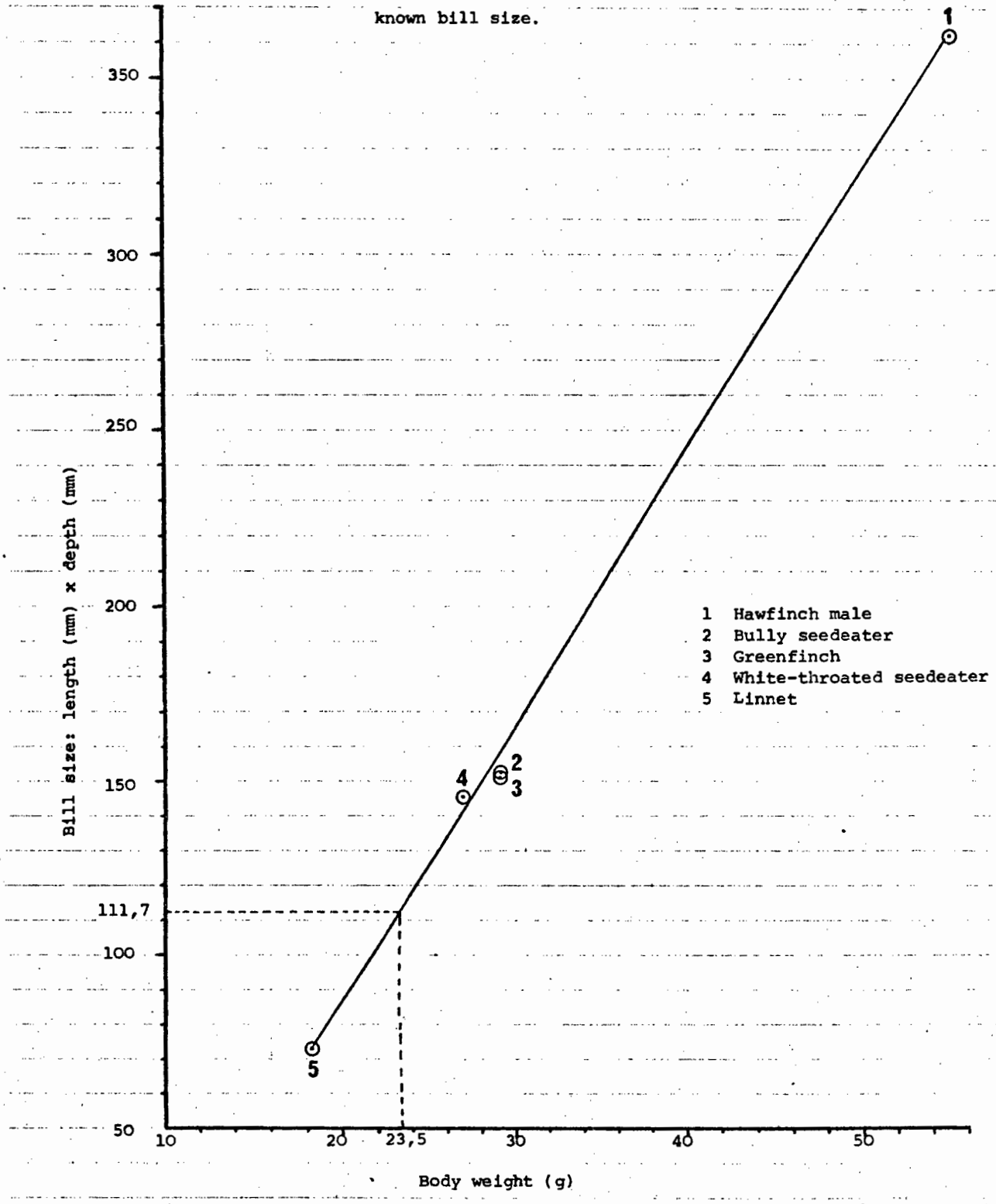
The proficiency of birds in a variety of feeding postures, or "agility", is determined partly by the ratio of body size to leg length, and partly by the ability to use the feet to clasp food-bearing objects to the perch (Newton 1967). Finches which are proficient in a wide variety of feeding postures are those which control food objects with their feet, and are generally the smaller species: "body weight is the most important factor affecting the agility of [British] finches ... Larger, less agile species take a major proportion of their food from the ground" (Newton 1967).

I was reluctant to collect protea seedeaters (for which no weight data were available) simply to obtain body weights. I therefore estimated weight by comparison of known body measurements (specifically bill size and body length) for the bird with those of congeners for which weight data were available.

Bill size (bill length x depth) was calculated for the bully and white-throated seedeaters and three British fringillids studied by Newton (1967). All of these species have a bill length to depth ratio of roughly 1,2 (page 77). Bill size was found to bear an approximately linear relationship to body weight (Fig. 22). The protea seed-eater, for which bill size was known, and for which the ratio of 1,2 held (page 77), was estimated, from this relationship, to have a body weight of 23,5 g.

Total body lengths for the protea seedeater and five congeners were obtained from the literature (Appendix 6). The protea seedeater was intermediate in length between two congeners, the range in its length overlapping with

FIG. 22: Relationship between bill size (length x depth) and body weight for five fringillids. Data for species 1, 3 & 5 were after Newton (1967). Body weight of the protea seedeater was predicted (dotted lines) from its known bill size.



those for the bully and streaky-headed seedeaters but mainly with that for the streaky-headed seedeater. The combined range for these three species was distinct from that for the three smaller congeners Serinus canicollis, S. flaviventris and S. tottus, as pointed out by Winterbottom (1973). Body weight of S. leucopterus was thus predicted as 21-29 g from the known weights of the bully and streaky-headed seedeaters, assuming that Serinus species bear a weight relationship to each other similar to that for body length.

Four south-west Cape Serinus species, including the protea seedeater, and four British fringillid species (Newton 1967) were collectively arranged in a series with regard to agility as reflected by foot-use. This series related species, viz hawfinch (British) and bully seedeater (Cape), never recorded using their feet to assist in feeding, to species, viz redpoll (British) and siskin (Cape), which used their feet relatively frequently in two or three different ways (Table 22). This series in frequency of foot-use for the species corresponded to body weight, from the heaviest species (hawfinch) to the lightest (redpoll). The only species departing from the correlation was the Cape canary, which, only occasionally recorded using its feet in only one way (placing a foot on a food-bearing object on the ground), was ranked next to the greenfinch (which weighed roughly twice as much) in the foot-use series.

TABLE 22: Incidence of foot-use while feeding (Newton 1967) for four British fringillids and four south-west Cape Serinus species (weights of British species after Newton 1967).

Vernacular name	Area	Mean Body wt (g)	Type of foot-use A	B	C
Hawfinch	Britain	55,0	-	-	-
Bully seedeater	SW Cape	29,0	-	-	-
Greenfinch	Britain	29,0	O	-	-
Cape canary	SW Cape	15,3	O	-	-
Protea seedeater	SW Cape	21-29*	-	O	?
Linnet	Britain	18,5	F	O	O
Siskin	SW Cape	13-14*	F	F	O
Redpoll	Britain	11,5	F	F	F

KEY:

- foot-use not observed; O foot-use observed occasionally;

F foot-use observed frequently (F & O after Newton 1967; O defined here for south-west Cape spp. as less than 5% of feeding occasions; F more than 5% of occasions).

Types of foot-use:

A placing foot on food-bearing object on ground

B pulling in flexible food-bearing plant stem with bill and placing stem under foot (while perched)

C placing detached food object under foot for control

* estimated weights

DISCUSSION AND CONCLUSIONS

The protea seedeater has a wide distribution within the south-west Cape. The previous poor state of knowledge of its distribution is probably owed to overlooking and misidentification, and the paucity of ornithological surveys carried out in the eastern part of the region. Three points about the range of the protea seedeater deserve mention. Firstly, the species is present along the karoo fringe of the south-west Cape in relatively tall stands of the driest form of Mountain Fynbos ("Arid Fynbos" sensu Acocks 1975) on Witteberg quartzite. Secondly the species is absent from the Cape Peninsula, where environments similar to those in which it is known to occur, albeit very restricted in area, persist. Thirdly, the species appears to be absent from certain of the moist southern Cape coastal mountains, e.g. the Langeberg and Outeniqua ranges.

This study demonstrated several other points about the habitat of the protea seedeater. The bird is endemic to the Mountain Fynbos biotope, which embraces a wide range of vegetation occupying a corresponding physiographic range. The protea seedeater has been found to occur in only some of the environments within Mountain Fynbos, including its "characteristic" environments in the "Protea belt" on the lower mountain slopes. That part of the environmental range which is occupied by the protea seedeater straddles the boundary between Mountain Fynbos and an adjacent biotope, karoo. The bird thus occurs in environments (definable on the basis of floristic and structural characteristics of the vegetation) which are not Mountain Fynbos, although they are marginal to

this biotope.

The absence of records of the protea seedeater from the Cape Peninsula and coastal ranges contributes to the impression that the bird is inexplicably absent from certain apparently suitable environments. The protea seedeater occurs on the False Bay eastern coast on slopes near the sea, which bear vegetation very similar to that found at Smitswinkel Bay on the Cape Peninsula. Certain sites visited in the Swellendam, Knysna and Plettenberg Bay areas bear proteoid Mountain Fynbos similar to, although moister and denser than, vegetation of the bird's characteristic environments in the Caledon and Joubertina areas. Geographical isolation from the Cape Peninsula appears unlikely, since the bird occurs on Mountain Fynbos "islands" in the Karoo (e.g. near Calitzdorp) similarly separated from the main ranges, and since it is a powerful flier. Siegfried's (1972) suggestion that the seedeater was previously present on the Cape Peninsula, disappearing with the shrinking of suitable environments owing to land-development, appears tenable. The bird's absence from the coastal ranges, if real, possibly reflects a preference for, or restriction to, drier forms of Mountain Fynbos. However, relatively little apparently suitable habitat remains on the coastal ranges today, much of their southern slopes having been repeatedly burnt or used for plantations of exotic trees. The protea seedeater, in summary, appears to have a habitat range almost as heterogeneous as the Mountain Fynbos biotope itself, but excluding certain "Protea belt" environments similar to those representing its "characteristic" habitat.

The establishment of a salient environmental factor

common to all parts of the habitat range for the protea seedeater is difficult. All protea seedeater sites are in mountain environments, most appear close to perennial surface water, and most bear an open stratum of large (2,0-4,0 m high) shrubs emergent above a 0,5-1,5 m high, more continuous stratum, giving the vegetation an "orchard-like" appearance. The qualitative impression was gained that the protea seedeater is, for example, to be found in virtually all stands of the arborescent Protea arborea, although occurring as well in environments altogether lacking this or any physiognomically similar plant. There may thus possibly be a further factor in the bird's virtual restriction to mature stands of fynbos, involving a preference for "pseudo-savanna" (sensu Taylor 1969), with large shrubs of optimum size scattered at an optimum distance from each other. Data for this study, collected from small (100 m^2) sample plots, were not sufficient for an assessment of this factor. Suitable information could possibly be collected by recording canopy cover for several strata of the vegetation while walking two randomly-chosen bisecting transects through each of a number of stands in which the density of the protea seedeater is known. A positive correlation might be found between high density of the bird and vegetation with "hourglass- shaped" foliage profiles (characterized by an emergent canopy not touching the main lower stratum), as opposed to "pyramidal" profiles representing stands in which the crowns of the tallest shrubs barely emerge from the main stratum.

Another profitable line of research to elucidate the habitat -preferences of the protea seedeater might be to

assess the bird's year-round density at each of several points along an hypothetical gradient in environmental dryness. Several sites could be chosen for mature vegetation as similar as possible with regard to height and canopy cover of structural components, the extremes being represented by "Arid Fynbos" (e.g. Gamka Reserve, Calitzdorp) and "Hygrophilous Fynbos" successional to forest (e.g Natures Valley). Density relationships between the protea seedeater and its congeners could help to isolate possible cases, within the genus, of species replacement along environmental gradients. My field impression, based on eight visits to sites bearing tall, dense proteoid Mountain Fynbos at the edge of forests, was that the protea seedeater is absent from the moist extreme, the avifauna at this extreme representing a mixture of fynbos and forest elements.

The protea seedeater appears to be as habitat-specialized as any other southern African avian endemic. Other endemics are specific to karoo, grassland, forest and "montane" environments. The protea seedeater appears equivalent in degree of habitat specialization to Bradypterus victorini, Victorins scrub warbler, also restricted to part of the Mountain Fynbos biotope. The habitat range for B. victorini, however, appears to overlap only partly with that for S. leucoptrus; the warbler is characteristic of moist heathy (ericoid) slopes at mid- to high altitudes, extending into some stands of proteoid Mountain Fynbos characteristic also for S. leucopterus but absent from that part of the protea seedeater's habitat range represented by relatively open vegetation in relatively dry environments.

The findings of this study have bearing on the

conservation of the protea seedeater. The bird is now known to have a sufficiently wide distribution and habitat range to justify its removal from the endangered list for the present. A large part of the area occupied by the protea seedeater, moreover, comprizes dry environments unsuitable for "replacing" forms of land-use (e.g. plantations, agriculture). However, the protea seedeater does appear dependent on relatively mature stands of fynbos, agreeing with Siegfried (1972); conservation of the birds present population probably depends on the preservation of much of its habitat in its present state in a system of State Forest reserves, the effective control of invasive woody aliens and the avoidance of burning rotation periods too short to allow the vegetation to become mature, since the protea seedeater has not adapted to man-made environments to the same degree as its congeners. The protea seedeater can possibly be used as an indicator of successful conservation management of stands of fynbos.

It has been suggested that habitat specialists are usually feeding generalists, and vice versa (Cody 1974). The protea seedeater appears to qualify for the term "habitat specialist", but cannot be regarded as having a generalized diet. It takes a range of foods apparently more restricted than those taken by several other birds in its habitat, e.g. Cossypha caffra and Zosterops virens. The protea seedeater does, however, appear to have a far less specialized feeding niche than e.g. nectar- and insect-feeding sunbirds (Nectarinia spp.) or ripe fruit pulp- and foliage-feeding mousebirds (Colius spp.). Specialists are generally subject to pronounced local movement in search of temporarily available food resources; the protea seedeater does not appear

to show an association to this degree with Protea seed, apparently residing in environments lacking Protea, where it takes other available seeds. The diet of fledglings must, however, be known before the degree of specialization of the protea seedeater's feeding niche can be established.

The protea seedeater appears to be ecologically "vicarious" with several congeners, occupying a similar niche in a different habitat under a different specific identity. The bird cannot, however, be matched closely on morphological grounds with any local congener; it can be regarded simply as "replacing" another congener only if it is accepted that species are modified by different habitats to fill equivalent niches with slightly different morphology. The protea seedeater may possibly be morphologically suited to exploiting a food resource peculiar to its habitat, viz Protea seed.

SUMMARY

1. The protea seedeater, Serinus leucopterus (Passeriformes: Fringillidae), is endemic to the south-western and southern coastal area of South Africa.
2. The species is associated with the Mountain Fynbos biotope, a range of natural environments distinguishable as a unit on physiographic, biogeographic and vegetational grounds.
3. The protea seedeater is restricted to part of the Mountain Fynbos biotope, viz relatively mesic to dry environments bearing vegetation ranging from tall, dense riverine and proteoid stands of Mountain Fynbos (characterized by distinctive generic composition and physiognomy of the vegetation) to Kloof Scrub of sheltered drainage lines and dry mountain scrub transitional to karoo. Kloof Scrub and dry scrub represent the xeric fringe of the Mountain Fynbos biotope, showing a mixture of floristic and vegetation structural characteristics.
4. The avifauna associated with the bird's habitat shows, at a qualitative level, heterogeneity consistent with that demonstrable on floristic and structural grounds for the bird's habitat range.
5. The protea seedeater has a predominantly herbivorous diet, feeding largely on seed taken directly from a wide range of plants growing naturally in its habitat. The bird's diet is similar in character to those of its congeners, differing quantitatively in a way

consistent with the differences in body- and bill-size between it and its congeners. Three sympatric congeners are separable from S. leucopterus on the basis of feeding niche.

6. The protea seedeater feeds more frequently on the seed of Protea, a genus of shrubs characteristic of part of its habitat range, than on any other food item but does not appear to be a "specialist" feeder. The feeding behaviour of the bird, like its diet, conforms with principles established from studies of other Serinus species and other "seed-eating passerines" in Europe and North America. The feeding niche of S. leucopterus thus appears to be similar in principle to those established for other seed-eating birds taking food directly from plants.

ACKNOWLEDGEMENTS

I wish to thank Professor W.R. Siegfried and Dr E.J. Moll, my supervisors. Dr J.M. Winterbottom, Mr C.J. Vernon, Professor R.C. Bigalke, Dr C.H. Elliott and the late Dr G.J. Broekhuysen gave valuable advice and encouragement. Dr J.G. Field assisted with statistical analyses. Miss E. Esterhuysen of the Bolus Herbarium, U.C.T., assisted with the identification of plant specimens. Mrs M.K. Rowan, Mrs A.I. Linder and Messrs A.E. Moore, A.E. Burger, R. Martin, P.G.H. Frost, R. Burroughs, B. Campbell, G.P. Bligh and N. Myburgh made observations on seedeaters available to me.

The opportunity to undertake fieldwork while employed on a survey (director Dr A.V.Hall), under the National Programme for Environmental Sciences, is gratefully acknowledged.

I am grateful to Miss C. Davidge for typing the manuscript.

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APPENDIX 1 : Details of study sites: (i) altitude, average annual precipitation, topography; (ii) geographical location, nearest town, fynbos area number (Fig. 3); (iii) qualitative description of vegetation; and (iv) sample plot numbers. All sites were protea seedeater feeding sites (except where indicated).

1.1. Protea laurifolia Dry Mountain Fynbos

1. (i) 1220 m, 700-800 mm, ridge on plateau; (ii) northern fringe of Hex River range, Ceres, 6; (iii) mature open proteoid 3 m high Dry Mountain Fynbos/Mountain Rhenosterbosveld; (iv) 103 & vicinity.

2. (i) 1070 m, 370-380 mm, plateau; (ii) Cold Bokkeveld west of Swartruggens range, Ceres, 5; (iii) mature open proteoid Dry Mountain Fynbos; (iv) 101 & vicinity

3. (i) 700 m, 380-430 mm, plateau; (ii) Gifberg escarpment, Vanrhynsdorp, 1; (iii) mature fairly open proteoid Dry Mountain Fynbos; (iv) 84.

4. (i) 760-790 m, 380-420 mm, plateau; (ii) Bokkeveld escarpment, Niewoudtville, 1; (iii) mature open to fairly dense proteoid Dry Mountain Fynbos with well-developed restioid stratum in parts (iv) 85, 86 & vicinity.

5. (i) 750m, 500-550 mm, flats of broad intermontane valley; (ii) southern Cedarberg, Citrusdal, 3; (iii) mature proteoid Dry Mountain Fynbos; (iv) 94, 95 & vicinity.

1.2. Protea arborea Dry Mountain Fynbos

1. (i) 950 m, 400 mm, upper reaches of kloof; (ii) Gamka hill, Calitzdorp, 16; (iii) mature proteoid Dry Mountain Fynbos with Dry Scrub on immediately adjacent north-facing slope; (iv) 70 & vicinity.

2. (i) 1050 m, 600-650 mm, north-facing kloof slope near drainage line; (ii) Klein Swartberg range, Ladismith, 14; (iii) mature open proteoid Dry Mountain Fynbos; (iv) 23.

3. (i) 366 m, 550-650 mm, north-facing valley slope near minor drainage line and cultivated fields; (ii) Attakwas range, Mossel Bay, 17; (iii) mature open disturbed proteoid Dry Mountain Fynbos; (iv) no plot - collection made from vicinity of feeding record.

1.3. Ericoid Dry Mountain Fynbos (and transitional scrub)

1. (protea seedeater not seen feeding; perched in the sample plot and drank in adjacent drainage line) (i) 610 m, 350-450 mm, hill slopes near kloof; (ii) Gamka hill, Calitzdorp, 16; (iii) mature open low scrub with the grass Merxmuellera arundinacea, transitional between Mountain Fynbos and karoo; (iv) 61.

2. (i) 800-950 m, 500-700 mm, foothill slopes a) south-facing and b) north-facing; (ii) Kouga range, Joubertina, 21; (iii) mature open transitional Dry Mountain Fynbos a) dominated by Diosma prama, b) marginal to open proteoid Dry Mountain Fynbos; (iv) a) no plot, collection made from vicinity of feeding record, b) 100 & vicinity.

3. (i) 560 m, 600-650 mm, foothill ridge near valley bottom; (ii) Kouga range, Joubertina, 21; (iii) mature open relatively low Dry Mountain Fynbos with Elytropappus rhinocerotis, transitional to Dry Scrub and near taller kloof floor vegetation; (iv) 60 & similar site on adjacent ridge.

2. Kloof Scrub

1. (i) 360 m, 400-450 mm, junction of foothill kloof floor and sides; (ii) Kransvlei mountains, Clanwilliam, 2; (iii) Kloof Scrub between dry ericoid shrubland and reedland of watercourse; (iv) 76 & 81.

2. (i) 410 m, 200-300 mm, kloof floor and adjacent scree between floor and kloof side; (ii) Gamka hill, Calitzdorp, 16; (iii) Kloof Scrub: broad-leaved scrub-forest and adjacent open semi-succulent scree scrub; (iv) 72, 73 & vicinity.

3. (i) 600 m, 600-700 mm, foothill kloof floor near kloof side and major stream; (ii) Kouga range, Joubertina, 21; (iii) roadside scrub between drainage line fynbos, succulent Dry Scrub and Scrub-forest; (iv) no plot - collection made from vicinity of feeding record.

4. (i) 715-810 m, 600-700 mm, valley bottom; (ii) Kouga range, Joubertina, 21; (iii) "Valley Scrub" and drainage line fynbos near ericoid dry fynbos, open grassy disturbed area and Dry Scrub; (iv) 54, 56 & vicinity.

3.1. "Protea belt" Mountain Fynbos

1. (i) 365 m, 1200-1400 mm, lower mountain slope near drainage line; (ii) Groot Drakenstein range, Stellenbosch, 8; (iii) proteoid Mountain Fynbos (partly youthful, partly mature) with well-developed restioid component and streamside scrub; (iv) 28, 29, 30, 31 & vicinity.

2. (i) 665 m, ? mm, kloof slopes; (ii) southern lower slopes of Cockscomb range, Patensie, 23; (iii) fairly youthful open Protea arborea Mountain Fynbos with arborescent Aspalathus and Loxostylis, mainly graminoid bottom stratum; (iv) 88, 89, 90.

3. (i) 960 m, 450-550 mm, kloof on lower north slopes of mountain; (ii) Keeromsberg range, Worcester, 6; (iii) youthful proteoid Mountain Fynbos with well-developed restioid component in parts; (iv) 13, 14, 15 & vicinity.

4. (i) 560-600 m, 1400 mm, hill slopes with shallow kloof; (ii) Paarl Mountain, Paarl, 8; (iii) mature dense proteoid Mountain Fynbos; (iv) 104, 105 & vicinity.

5. (i) 800-850 m, 600 mm, mountain slopes; (ii) southern Cedarberg, Citrusdal, 3; (iii) mature, overbrowsed proteoid dry Mountain Fynbos; (iv) no plot - collection made from vicinity of nest.

6. (i) 955 m, ? mm, middle slopes of mountain; (ii) southern Cedarberg range, Citrusdal, 3; (iii) mature proteoid Mountain Fynbos; (iv) 83.

7. (i) 580-630 m, 1200-1400 mm, mountain slopes; (ii) Witzenberg range, Ceres, 6; (iii) youthful proteoid Mountain Fynbos with well-developed restioid component; (iv) 63 & 64.

8. (i) 800-1200 m, 650-800 mm, mountain slopes adjacent to kloofs with minor streams; (ii) Kouga range, Joubertina, 21; (iii) mature dense proteoid Mountain Fynbos, lower strata recently burnt in plot 59; (iv) 55 & 59 and collections made from vicinity of feeding records.

9. (i) 280-330 m, 650-750 mm, lower mountain slopes near major stream; (ii) Elandskloof range, Tulbagh, 7; (iii) mature open proteoid dry Mountain Fynbos, marginal to ericoid Dry Mountain Fynbos; (iv) no plot - collection made from vicinity of feeding records.

10. (i) 300-320 m, 950-1050 mm, mountain slope; (ii) Molenaarsrivier, Slanghoek range, 7; (iii) mature open to fairly dense proteoid Mountain Fynbos with well-developed ericoid stratum; (iv) no plot; collection made from vicinity of feeding records at density study site.

11. (i) 305 m, ? mm, lower mountain slope (north slope of foothill ridge); (ii) Riviersonderend range, Greyton, 12; (iii) mature fairly open proteoid Mountain Fynbos with well-developed ericoid stratum; (iv) 102 & vicinity.

12. (i) 896 m, 400-450 mm, hill slope and shallow kloof; (ii) Gamka Reserve, Calitzdorp, 16; (iii) recently burnt fairly tall Protea arborea dry Mountain Fynbos; (iv) 71 & vicinity.

13. (i) 914 m, 600 mm, montane flats with boulder outcrops; (ii) northern Cedarberg range, Clanwilliam, 3; (iii) mature Mountain Fynbos, mainly restioid on open flats with proteoid/other woody scrub around outcrops; (iv) 43 & 44.

3.2. Ericoid Mountain Fynbos

1. (i) 790-850 m, 1600-2000 mm (plots at 1900 mm), valley and kloof slopes at base of rocky buttress below upper shale band, near minor streams; (ii) Slanghoek range, Wellington, 7; (iii) fairly mature restioid-ericoid Mountain Fynbos and streamside scrub; (iv) 106, 107 & collections made from vicinity of feeding sites.

3.3. High-altitude proteoid Mountain Fynbos

1. (i) 1417-1420 m, 800-900 mm, upper mountain slope just above shale band "ledge"; (ii) Kammanassie range, Uniondale, 19; (iii) mature dense proteoid Mountain Fynbos with well-developed ericoid stratum; (iv) 50, 51, 52 & 53.

2. (i) 1646-1768 m, 850-1000 mm, mountain slope on shale band "ledge"; (ii) Klein Swartberg, Ladismith, 15; (iii) mature dense proteoid Mountain Fynbos interrupted patchily by bare boulder-scree; (iv) 18, 19, 21 & 22.

APPENDIX **2** : Plant taxa recorded at sites for the protea seedeater, grouped by physiognomic components of the vegetation. Groupings and numbers are according to Appendix 1; numbers in parentheses indicate species present in the area but not in the sample plot or plots.

1.1. Protea laurifolia Dry Mountain Fynbos

PROTEOID
Protea laurifolia 1 2 3 4 5, P. repens 1 (2) (4), Leucadendron salignum 1 (4) 5, L. rubrum 1, L. glaberrimum 2, L. pubescens 2, L. remotum 4.

ERICOID
Anthospermum sp. or spp. aff. A. aethiopicum 3, Metalasia muricata & allies 2 3 4, Stoebe plumosa 4, S. nervigera 4, Stoebe (or Disparago?) sp. aff. S. spiralis 2, Cullumia pectinata 4, Eriocephalus sp. aff. E. capitellatus 2, E. africanus 5, Elytropappus sp. aff. E. gnaphaloides 3, Elytropappus sp. aff. E. scaber 1 4 5, Nestlera sp. 1, Compositae, sp. indet. 3, Cliffortia spp. 1 2 3, Selago &/or Walafrida spp. 2, Diosma spp. 1 3 4, Agathosma sp. 3, Prismatocarpus sp. 3, Phylica agathosmoides 4, P. cephalantha 4, P. spp. 1 2 3 4 5, Ericaceae, minor genera, spp. indet. 2 3 5, Passerina glomerata 2 3 4, Struthiola sp. or spp. 3, Gnidia sp. 4? Aspalathus sp. aff. A. hispida 4, A. spp. 2 4.

RENOSTER
Elytropappus rhinocerotis 1 (2) 3 (4), E. adpressus 1 2 5.

KARROID
Chrysocoma tenuifolia 1 3 4 5.

SPINESCENT
Putterlickia pyracantha (4), Nylandtia spinosa (4), Indigofera sp. (4).

OTHER WOODY
Protea sp. 2, Paranomus bracteolaris 4, Leucadendron brunioides 2, Olea africana 4, Rhus angustifolia 4, Rhus sp. aff. R. undulata 4, R. incisa 3, Hermannia sp. or spp. 3 4, Salvia sp. 5, Struthiola sp. 5, Rafnia sp. 3, Montinia caryophyllacea 3 5, Polygala or Nylandtia sp. 3, Thesium sp. aff. T. strictum 4, Relhania squarrosa 1 4 5, R. spp. 2, Ursinia sp. 5, Athanasia trifurcata 3, Felicia filifolia & allies 1 2, F. sp. 3, Lobostemon sp. aff. L. pearsonii 4, L. spp. 2 3 5, Dodonaea viscosa 4, Maytenus oleoides 5, Myrsine africana 4, Euclea crispa & allies 3 4, Diospyros austro-africana (4), Cliffortia ruscifolia 1 3 4 5, Clutia sp. aff. C. alaternoides 1 2, C. sp. or spp. 3 5, Aspalathus sp. aff. A. vulnerans 4, A. spp. 1 3.

RESTIOID
Restio cuspidatus 1 3 4 5, R. gaudichaudianus (4) 5, R. virgeus 2 R. sieberi 1 5, R. macer 4, R. filiformis 1, R. monanthus 3 4, R. spp. indet. 2, Staberoha distachya 4, Elegia parviflora 4, Cannomois acuminata & allies 1 4, Thamnochortus punctatus 4, Thamnochortus spp. aff. T. schlechteri & comptonii 2 4, Hypodiscus neesii 2, Willdenowia arescens 2, W. striata 4, W. spp. 5, Leptocarpus vimineus & allies 2,3 4 5, L. sp. 2.

CYP. & GRASS
Ficinia spp. 1 2 4 5, Tetraria sp. or spp. aff. T. cuspidata 1 2, T. spp. 1 2 4 5, Cyperaceae, sp. indet. 4, (?) Merxmuellera sp. aff. M. stricta 1 2, Ehrharta sp. or spp. aff. E. ramosa 4 5, E. spp. 1 2 4, Pentaschistis sp. aff. P. eriostoma 3, P. sp. aff. P. rupestris 5, Gramineae, spp. indet. 1 2 3 4 5.

FORB/FERN/SOFT WOODY
Helipterum canescens 3 5, Corymbium sp. 1, Helichrysum spp. 1 2 3 4 5, Osteospermum sp. 3, Gymnodiscus capillaris 4 5, Ursinia subflosculosa 4, Senecio sp. 4, Pelargonium spp. 3 4, Lightfootia sp. 3, Centella sp. 3, Oxalis sp. aff. O. flava 4 5, O. spp. 4, Asparagus sp. or spp. aff. A. africanus 3 4, Euphorbia tuberosa 4, E. sp. 3, Rafnia sp. aff. R. perfoliata 4, Chironia baccifera 5, Cassytha ciliolata 5, Anthospermum sp. 3.

SUCCULENT
Ruschia sp. or spp. 4 5, Lampranthus sp. or spp. 3 4, Carpobrotus edulis 4, Zygophyllum sp. 5, Mesembryanthemaceae, spp. indet. 2 4 5, Crassula spp. 1 3 4 5,

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1.2. Protea arborea Dry Mountain Fynbos

PROTEOID
Protea arborea 1a (1c) 2 3, Leucadendron salignum 1a 3,

ERICOID
Agathosma sp. 1a, Ericaceae, minor genus, sp. indet. 1a, Erica sp. 3, Cliffortia ramosissima 1a, C. sp. or spp. 3, Passerina obtusifolia 1a, Stoebe burchellii 1a 2, Eriocephalus sp. aff. E. africanus 1a 1b, Senecio pinifolius 1a, Metalasia sp. aff. M. muricata 3, Phylica sp. 1b, Selago or Walafrida sp. or spp. 1b 3, Anthospermum sp. 3.

RENOSTER
Elytropappus rhinocerotis (1c) 3, E. adpressus (1).

KARROID
Chrysocoma tenuifolia 2.

OTHER WOODY
Tarchonanthus camphoratus (1c), Rhus sp. aff. R. lucida (1a) 1b (1c), Rhus sp. aff. R. tomentosa (1c) 2, Diospyros sp. (1c), Euclea sp. aff. E. crispa 1a 1b, Maytenus oleoides (1c) 2, Dodonaea viscosa 1b (1c), Felicia sp. or spp. aff. F. filifolia 1b (1c), Chrysanthemoides monilifera (1a) 1b 2, Relhania squarrosa (1a) 1b 2, Printzia sp. 1a, Pentzia dentata 1b, Pentzia sp. aff. P. elegans 1b, Athanasia sp. 3, Eroeda sp. 3, Helichrysum sp. 1b, Polygala sp. 1b, Montinia caryophyllacea (1a) 1b 2, Hermannia sp. 2 3, H. spp. 1b 3, Rafnia sp. 3, Aspalathus sp. aff. A. hystrix 1a 1b, Cliffortia pulchella 1a, Muraltia sp. 1a, Pelargonium sp. aff. P. laevigatum 1a, Asparagus sp. aff. A. aethiopicus 1a, Clutia sp. 3.

RESTIOID
Restio gaudichaudianus (1c) 2, R. triflorus 1a, R. fruticosus 3.

CYP. & GRASS
Gramineae, indet. 1a 1b (1c) 2 3, Pentaschistis sp. aff. P. angustifolia 1a, P. sp. or spp. (1c) 2, Themeda triandra 1a 1b, Ehrharta ramosa var. aphylla 1a 2, Merxmuellera arundinacea (1c),

Merxmuellera sp. aff. M. stricta 1b, Cyperaceae indet. 2, Ficinia sp. aff. F. ramosissima 1a 2, F. sp. or spp. (1c) 3.

FORB/FERN/SOFT WOODY
Mohria caffrorum 1a (1c) 2, Cheilanthes contracta (1c), C. parviloba (1c), C. multifida 2, Pellaea 3, Pelargonium sp. (1c), Ptychomitrium sp. 2, Cassytha ciliolata 3, Galium sp. 1a, Crassula sp. 1a, Cyphia sp. 1a, Berkheya sp. 3, Helichrysum sp. aff. H. nudifolium 1a, H. sp. 3, Asparagus sp. 1a.

SUCCULENT
Aloe ferox 1b, A.sp. aff. A. comptonii (1c) 2, Haworthia sp. 2, Carpobrotus sp. aff. C. acinaciformis 1b, Eurphorbia mauritanica (1c), Crassula sp. aff. C. perfoliata (1c) , C. spp. (1c) 2 3, Adromischus sp. 2, Ruschia sp. 2, Lampranthus sp. (1c),

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1.3. Ericoid Dry Mountain Fynbos (and transitional scrub)

PROTEOID
Protea arborea (1), P. repens 3, P. neriifolia (2b), Leucadendron salignum (2b).

ERICOID
Campanulaceae, sp. indet. 2a, Passerina obtusifolia 3, Eriocephalus sp. or spp. aff. E. africanus 2a 2b 3, Stoebe burchellii 2b, Phylica sp. or spp. aff. P. lachneaeoides 2a 2b, Aspalathus sp. 2a, Cliffortia sp. aff. C. castanea 2b, Selago or Walafrida sp. 2a 3, Diosma prama 2a, Agathosma sp. 2b, Erica kougiensis 2b, Anthospermum sp. aff. A. aethiopicum 2a, Sutera sp. 2b.

RENOSTER
Elytropappus rhinocerotis 1 2b 3, E. adpressus 2b.

OTHER WOODY
Montinia caryophyllacea 2a 2b 3, Tarchonanthus camphoratus 1, Rhus sp. aff. R. lucida 1 2b, R. spp. 1, Felicia sp. aff. F. filifolia 1, Chrysanthemoides monilifera 2b, Relhania squarrosa 2b 3, Ursinia sp. 2a, Cullumia bisulca 2b, Berkheya or Blepharis sp. 2a, Dodonaea viscosa 1 2b 3, Diospyros sp. 1, Pterocelastrus tricuspidatus or Maytenus oleoides 1 3, Struthiola sp. 2a, Gnidia sp. 2b, Euclea polyandra 2a 2b, Colpoon compressum 2b, Rhyticarpus sp. 2b, Indigofera sp. 2b, Clutia sp. 2b, Agathosma sp. aff. A. apiculata 2a 2b, A. sp. 2a, Asparagus sp. aff. A. aethiopicus 2b.

RESTIOID
Hypodiscus striatus 2a 3, H. neesii 2b, Thamnochortus sp. 3, Restio gaudichaudianus 1 2a 2b, Restio sp. aff. R. sieberi 2a, R. fruticosus 2a 2b, R. cuspidatus 2b.

CYP. & GRASS
Gramineae, indet. 1 2a 2b 3, Merxmuellera arundinacea 1, Ehrharta sp. or spp. aff. E. ramosa 2a 3, E. sp. 2a, Themeda triandra 2b, Pentaschistis sp 1, Ficinia sp. aff. F. ramosissima 2b, F. sp. or spp. 1 2a, Tetraria sp. 2a.

FORB/FERN/SOFT WOODY
Cheilanthes contracta 1 2b 3, C. parviloba 1, Pellaea leucomelas 2a, Mohria caffrorum 1 2b, Cineraria sp. 2a, Senecio sp. 2b, Pelargonium sp. 1, Lobelia sp. 2a, Knowltonia sp. 2b.

SUCCULENT
Crassula sp. aff. C. perfoliata 1 2a, Crassula sp. aff. C. lycopodioides or muscosa 2a, C. spp. 1 2a 2b 3, Cotyledon orbiculata 3, Aloe sp. aff. A. comptonii 1, Euphorbia mauritanica 1, Othonna sp. 2a, Kleinia sp. 2a, Ruschia esterhuyseniae 2a 2b, R. spp. 2a 3, Lampranthus sp. 1

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2. Kloof Scrub

ERICOID
Stoebe burchellii 3 4, Eriocephalus sp. aff. E. africanus 1, Eriocephalus sp. aff. E. capitellatus 3, Anthospermum spp. aff. A. aethiopicum 3 4, Erica sp. aff. E. decipiens 4.

RENOSTER
Elytropappus rhinocerotis 4.

KARROID
Chrysocoma tenuifolia 4.

SPINESCENT
Maytenus heterophylla 4, Carissa haematocarpa 3.

OTHER WOODY
Rhus sp. aff. R. undulata 1 2, Rhus sp. aff. R. macowanii 4, R. incisa 1, R. spp. 3, Dodonaea viscosa 1 2, Olea africana 1 2 3, Felicia dregei 1, F. filifolia 1, Chrysanthemoides monilifera 4, Heliophila sp. 1, Hermannia sp. 1, Kiggelaria africana 1, Lachnostylis bilocularis 2, Nymania capensis 2, Buddleia saligna 2, B. salviifolia 2 4, Diospyros sp. or spp. 2, Jasminum sp. 2, Clematis thunbergii or brachiata 2, Pterocelastrus tricuspidatus 1 3, Rapanea melanophloeos 3, Salix mucronata 3, Widdringtonia schwarzii 3, Cliffortia strobilifera 3, Cliffortia sp. aff. C. integerrima 4, Maytenus sp. aff. M. undata 3, Colpoön compressum 3, Euclea crispa 4, Lobostemon sp. 4, Clutia spp. 4, Myrica sp. aff. M. serrata 4, Myrsine africana 4.

RESTIOID
Cannomois virgata 4, Leptocarpus paniculatus 3, Elegia capensis 4, Restio sieberi 4, R. gaudichaudianus 3.

CYP. & GRASS
Gramineae, spp. indet. 4, Sporobolus capensis 1, Eragrostis sp. aff. E. curvula 1, E. sp. 4, Ehrharta sp. aff. E. ramosa 1 4, Pennisetum sp. aff. P. macrourum 1, Cyperaceae, spp. indet. 4, Ficinia sp. aff. F. ramosissima 4.

FORB/FERN/SOFT WOODY
Arctotis sp. or spp. 1, Berkheya sp. 1, Helichrysum spp. 1, Senecio spp. 2 3, Asparagus spp. 1 3 4, Pelargonium sp. aff. P. luridum 4, P. spp. 2 3 4, Selago sp. 4, Asplenium adiantum-nigrum 4, Blechnum australe 4, B. punctulatum 1, Pteridium aquilinum 4, Cheilanthes capensis 1, C. parviloba 2, Watsonia sp. 4, Mentha sp. aff. M. longifolia 1 2, Melianthus spp. 1 2, Oxalis spp. 1, Pollichia campestris 2, Sutera sp. 2, Solanum sp. or spp. 2.

SUCCULENT
Crassula portulacea 2, C. spp. 1 2 3, Cotyledon paniculata 1 2, Aloe sp. aff. A. comptonii 2, Carpobrotus sp. aff. C. acinaciformis 4, Mesembryanthemaceae, sp. indet. 2, Portulacaria afra 2, Euphorbia mauritanica 1.

3.1. "Protea belt" Mountain Fynbos

PROTEOID
Protea arborea 1 2 3 4 5 6 10 11 12, P. laurifolia 3 5 6 7 9 10, P. neriifolia 8a c d, P. repens 4 7 8a b 10 11, P. pulchra 4, P. lorifolia 8b, P. punctata 8c, Leucadendron salignum 1 2 4 5 6 7 8d 10 11 12, L. eucalyptifolium 8d, L. concavum 13, L. rubrum 1 4 7 10, L. glaberrimum 5, L. spp. 8c 9, Leucospermum cuneiforme 8a 11 12, Brabeium stellatifolium 10.

ERICOID
Cullumia spp. 3 11, Anaxeton sp. 1, Stoebe aethiopica 10 11, Stoebe spp. aff. S. plumosa 1 2 3 4 6 7 9 10 11 13, S. burchellii 8b, S. or Disparago sp. 11, Felicia sp. 3, Metalasia sp. or spp. aff. M. muricata 3 4 6 7 9 10 11 12 13, Elytropappus sp. or spp. aff. E. gnaphaloides 4 10, Elytropappus sp. or spp. aff. E. glandulosus 5 6 7 9 10 13, Euryops sp. 2, Helichrysum teretifolium 4, Eriocephalus africanus 9, Senecio sp. 2, Ursinia sp. 5, Berzelia sp. aff. B. intermedia 2 12, Berzelia sp. aff. B. lanuginosa 1, Brunia sp. aff. B. nodiflora 8a c, Phylica sp. aff. P. lachnea eoides 8a, P. spp. 2 4 8c 10, Indigofera sp. 4, Aspalathus sp. aff. A. pedunculata 8a, A. spp. 2 4, Rubiaceae, spp. indet. 4 5 6, Anthospermum spp. aff. A. aethiopicum 1 3 4 5 6 7 9 10 11 13, Ericaceae, spp. indet. 1 2 3 7 9 11 12, Erica nudiflora 7, E. kougiensis 8c, E. strigilifolia 8c, E. pectinifolia 8a, E. parilis 7, E. plukeneti 1 4 10 11, E. pinea 10, E. coccinea 1, E. fastigiata 10, E. subulata 10, E. cerinthoides 4, Erica sp. aff. E. paniculata 4, E. spp. 3 8a c 12, Eremia totta 1 7, Cliffortia sp. aff. C. juniperina 4, Cliffortia sp. aff. C. stricta 8c, C. spp. 2 7 10, Selago/Walafrida spp. 2 3, Lobelia sp. 7, Heliophila sp. 7, Muraltia spp. 5 7, Thymeleaceae spp. indet. 1, Passerina sp. or spp. aff. P. vulgaris 1 4 9 10 11, Struthiola sp. 10, Clutia sp. 2, Agathosma spp. 2 3 6 10, Diosma hirsuta 6 10, D. sp. 4, Macrostylis sp. 13.

RENOSTER
Elytropappus rhinocerotis 2 (4), E. adpressus 5.

KARROID
Chrysocoma tenuifolia 5 6 10

ALIEN
Hakea sericea 1, Acacia mearnsii 1, A. melanoxylon 1.

OTHER WOODY
Rhus sp. aff. R. lucida 1 2 4 10 12 13, R. angustifolia 1 4 10, R. tomentosa 4 10, R. rosmarinifolia 4 6 7 10 11, Rhus sp. aff. R. undulata 4 9 10, R. sp. 2, Myrica sp. aff. M. serrata 1, Myrica sp. aff. M. humilis 12, Metrosideros angustifolius 1 10, Myrsine africana 2 4 6 10, Maytenus oleoides 1 3 4 6 7 10 11 13, Diospyros glabra 1 4 6 9 10 11 13, Montinia caryophyllacea 1 4 5 6 7 8d 9 10 11 12, Heeria argentea 1 4 10 11 13, Penaea sp. aff. P. mucronata 2 Halleria elliptica 1 10, Colpoon compressum 10, Thesium strictum 1 9, T. spp. (2) 7 10, Hartogia schinoides 10, Cassine parvifolia 4, Phylica sp. or spp. aff. P. buxifolia 9 13, P. sp. or spp. 4, Lobostemon sp. aff. L. glaucophyllus 11, L. spp. 4 5 7 9, Euclea sp. aff. E. crispa 12, E. sp. 2, Peucedanum galbanum 10, Secamone alpini 10, Loxostylis alata 2, Felicia filifolia 10, Osteospermum spinosum 1 4 10, O. or Dimorphotheca spp. 2 3, Artemisia sp. 8b, Chrysanthemoides monilifera 1 4 10, Heterolepis aliena 10, Othonna

rigens 1, O. spp. 3 7 11, Ursinia crithmoides 1, U. spp. 6 9 10, Eroeda sp. aff. E. capensis 11, Euryops abrotanifolius 10 11, E. sp. (2), Printzia sp. 2, Relhania squarrosa 3 10, Helipterum canescens 3 5 9, Athanasia trifurcata 4 5 11, Senecio sp. 2, Cliffortia ruscifolia 1 3 6 9 10 12 13, C. polygonifolia 4 10, C. sp. aff. C. ilicifolia 8b, Protea sp. aff. P. nana 7, P. pityphylla 7, Paranomus candicans 3, Paranomus sp. aff. P. bracteolaris 6, P. esterhuyseniae 8c, P. spp. 10 11 12, Serruria sp. aff. S. acrocarpa 11, Indigofera frutescens 1 10 11, Psoralea aphylla 1, P. sp. or or spp. 2, Cyclopia sp. 8c, Aspalathus teres 2, Aspalathus sp. aff. A. perfoliata 6, A. spp. 1 10 11, Hypocalyptus sophoroides 10 12, Podalyria sp. or spp. 4, Rafnia spp. 1 10, Viscum capense 4 10, Selago sp. 13, Kiggelaria africana 4, Olea africana 4 10, O. capensis 10 Polygala spp. 2 11, Pelargonium sp. aff. P. laevigatum 8a b, P. spp. 6 11, Dodonaea viscosa 5 9 10, Agathosma sp. aff. A. apiculata 8b, A. spp. 8c 9 11, Adenandra sp. 10, Hermannia spp. 2 4 6 9 11, Salvia spp. aff. S. chamelaeagnea 4 11, S. spp. 9, Gnidia sp. aff. G. ciliata 8a, G. sp. 2, Struthiola argentea 11, Hebenstreitia sp. 1, Clutia sp. aff. C. alaternoides 1 5 10 11, Clutia sp. aff. C. polygonifolia 11, C. spp. 2 6 7 8a b, Asparagus sp. aff. A. aethiopicus 11, Dolichos gibbosus 10.

RESTIOID

Restio gaudichaudianus 1 3 4 5 6 7 10 11, R. filiformis 3 10, R. cuspidatus 1 4 7 10 11, R. sieberi & allies 2 3 6 8b c 12 13, Restio sp. aff. R. sejunctus 2, Restio sp. aff. R. laniger 13, Restio sp. aff. R. tenuissimus 9, R. hystrix 8c, R. monanthus 13, R. curviramis 9, R. triticeus 8a 10, R. rhodocoma 12, R. triflorus 4, R. fruticosus 8b, R. ocreatus 5, R. spp. 2 8a 9, Elegia parviflora 1 7, E. capensis 1, Elegia sp. aff. E. juncea 8c, E. sp. 3, Hypodiscus argenteus 7 10 11, H. striatus 3 8a b 11, H. neesii 3, Hypodiscus sp. aff. H. synchroolepis 8c, H. sp. 2, Thamnochortus dichotomus 1 11, T. argenteus 12, T. sporadicus 10, T. spp. 6 13, Leptocarpus paniculatus 1, L. vimineus & allies 5 6 10, Willdenowia spp. aff. W. arescens 6 8b c 11, Cannomois sp. aff. C. dregei 3, C. virgata 2, C. sp. or spp. 5 8a b c.

CYP. & GRASS

Gramineae, spp. indet. 1 2 3 4 6 8a b 9 10 12, Themeda triandra 1 2 9 10 11, Ehrharta sp. or spp. aff. E. ramosa 1 2 5 6 10 11 13, Hyparrhenia glabra 1, Pentaschistis sp. aff. P. eriostoma 6, P. sp. 9, Plagiochloa sp. aff. P. uniolae 9, Cyperaceae, spp. indet. 2 4 7 10 11 13, Neesenbeckia punctoria 1, Tetraria sp. or spp. aff. T. cuspidata 1 4 13, T. spp. 1 (2) 3 7 8a c 9 10 13, Ficinia bracteata 1 10 11, F. spp. 4 6 8b 9 10 12 13, Juncus sp. 9, Fuirena sp. 9.

FORB/FERN/SOFT WOODY

Pteridium aquilinum 1 (2) 4 10, Pellaea pteroides 1 9 10, P. leucomelas 8b 11, Cheilanthes induta 10, C. hirta 1, C. contracta 3 9, Mohria caffrorum 1 12, Asplenium sp. aff. A. rutaefolium 1, Cassytha ciliolata 3 9 10 11, Microloma sp. aff. M. sagittatum 6, Corymbium scabridum 1, C. spp. 1 3 5 6 10, Senecio sp. aff. S. carroensis 1, Senecio sp. aff. S. pubigerus 1 4 9, S. spp. 1 3 4 12, Helichrysum sp. aff. H. felinum 2 8a, Helichrysum sp. aff. H. auriculatum 4, H. sp. aff. H. nudifolium 2 8a, H. spp. 1 2 4 6 9 10, Inula graveolens 4, Arctotis semipapposa 10, Othonna sp. 6, Ursinia sp. 10, Helipterum sp. aff. H. gnaphaloides 10, Gerbera sp. 10, Silene clandestina 1, Cliffortia graminea 1, Knowltonia sp. aff. K. capensis 10, Anthospermum ciliare 1, Oftia africana 1 3 4 10, Oxalis spp. 9, Rafnia sp. 13, Pelargonium sp. aff. P. tabulare 1, P. saniculaefolium

1, P. triste 1, P. cucullatum 1, P. spp.1 3 5 6 12, Zantedeschia aethiopica 1, Asparagus sp. aff. A. africana 1 11, A. asparagoides 4, A. spp. 1 5 6 10 12, Watsonia sp. 8a, Aristea spp. 1 4 7 10 13, Bobartia sp. or spp. (2) 12, Tritoniopsis sp. 3, Aspalathus sp. 4, Centella spp. 1 4 9, Selago spuria 10, Sutera sp. 2, Stachys sp. aff. S. aethiopica 11, S. sp. 2, Anthospermum capensis 1 10, Anthospermum ciliare 1 10, Chironia baccifera 4 10.

SUCCULENT
Zygophyllum spp. aff. Z. fulvum 10 11, Kleinia sp. 11, Aloe plicatilis 10, A. sp. 11, Adromischus sp. or spp. 10 11, Crassula sp. aff. C. dejecta 3, C. sp. 1 4 5 9 10 11, Lampranthus sp. aff. L. tenuifolius 1, L. scabrida & allies 3 10, L. capillaceus 10, L. sp. 1, Semnanthe lacera 6, Erepsia gracilis 10, E. sp. 4, Ruschia schollii 11, R. spp. 9 13, Carpobrotus sp. aff. C. acinaciformis 8b, Mesembryanthemaceae, spp. indet. 1 2 10 12, Euphorbia burmannii 9.

3.2. Ericoid Mountain Fynbos
(parentheses indicate species collected only at margin of "Protea belt"). Collected at one site only.

PROTEOID
Leucadendron salicifolium, Protea repens, Protea cynaroides, (Leucadendron salignum).

ERICOID
Steobe sp. aff. S. plumosa, Metalasia muricata, Metalasia sp. aff. M. barnardii, Stoebe sp. aff. S. spiralis, Berzelia lanuginosa, Erica plukeneti, E. hispidula, E. glauca, (E. nudiflora), E. chionophila, (E. sp.), (Clutia sp.), Cliffortia sp.

OTHER WOODY
Brachylaena neriifolia, Diospyros glabra, Widdringtonia nodiflora, Othonna sp. aff. O. quinquedentata, Euryops abrotanifolius, Hetero-lepis aliena, Cassine parvifolia, Rhus sp. aff. R. lucida, Cyclopia sp., Thesium sp., (Olea capensis), (Heeria argentea), (Myrsine africana), (Hartogia schinoides).

RESTIOID
Restio dispar, R. sieberi, R. pachystachyus, Restio sp. aff. R. perplexus, R. sp., Hypodiscus aristatus, Elegia grandis, E. juncea, Cannomois virgata, (Thamnochortus dichotomus).

CYP. & GRASS
Ficinia spp., Tetraria sp. aff. T. thermalis, Tetraria sp. aff. T. cuspidata, T. sp. aff. T. brevicaulis, Gramineae, spp. indet., Ehrharta sp. or spp. aff. E. ramosa.

FORB/FERN/SOFT WOODY
Blechnum capense, B. punctulatum, Schizaea pectinata, Todea barbara, Aristea sp., Anthospermum ciliare, Cassytha ciliolata, Centella sp., Villarsia sp., Viola sp., Thesium sp., (Arctotis semipapposa), Asparagus sp.

3.3. High-altitude proteoid Mountain Fynbos

PROTEOID
Protea punctata 1 2, Leucadendron rourkei 1, L. album 2.

ERICOID

Ericaceae, spp. indet. 1 2, Erica sp. aff. E. decipiens 1, E. hispidula 2, E. curviflora 2, Erica sp. aff. E. inamoena 2, E. arcuata 2, E. spp. 2, Agathosma sp. or spp. 2, Metalasia sp. aff. M. muricata 1, Stoebe sp. aff. S. cinerea 1, S. plumosa 2, Cullumia sp. 1, Selago sp. or spp. 1, Berzelia sp. aff. B. intermedia 1, Rubiaceae, spp. indet. 2, Anthospermum sp. aff. A. aethiopicum 1, Cliffortia burchellii 1, Cliffortia sp. aff. C. stricta 1, C. eriocephalina 2, Psoralea sp. or spp. 1, Passerina sp. 2.

OTHER WOODY

Cliffortia sp. 1, Cyclopia sp. or spp. 1 2, Clutia sp. 1, Senecio sp. 1, Athanasia sp. 2, Athanasia sp. aff. A. trifurcata 1, Protea sp. aff. P. acaulos 1, Boraginaceae sp. indet. 2.

RESTIOID

Restio brachiatus 2, R. triticeus 1, Restio sp. aff. R. sejunctus 1, Restio sp. or spp. aff. R. sieberi 1 2, R. distractus 2, R. sp. or spp. 2, Elegia sp. aff. E. juncea 1 2, Hypodiscus albo-aristatus 1, Thamnochortus sp. aff. T. papyraceus 2.

CYP. & GRASS

Gramineae, spp. indet. 1 2, Ehrharta ramosa 1 2, E. spp. 2, Pentameris dregeana 1, Cyperaceae, spp. indet. 1, Tetraria sp. or spp. 1, Crysithrix sp. 2.

FORB/FERN/SOFT WOODY

Polytrichum sp. aff. P. lucidum 2, Bobartia sp. or spp. 1, Watsonia sp. 1, Scabiosa sp. 2, Senecio sp. aff. S. vestitus 1, S. sp. 1, Helichrysum cymosum 1, Helichrysum sp. aff. H. felinum 1, H. sp. 1, Felicia aethiopica 2, Anthospermum sp. aff. A. ciliare 1.

Appendix 2a : Plant taxa recorded at sites for Serinus gularis and S. albogularis

S . albogularis : A= Klondyke, Lakenvlei, Ceres B= Theronsberg Pass, Ceres C= Witteberg, Matjiesfontein D= Witzenberg, Ceres

S . gularis : 1= Meiringspoort, Swartberg 2= Gamka Hill, Calitzdorp 3= Tulbagh Waterfall 4a= Towerwaterkloof, Kouga Range 4b= Dwarsrivier, Kouga 5= Base of Paarl Mountain

PROTEOID

Protea laurifolia (3) A C, P. arborea BD, P. repens A, P. canaliculata C, P. lorifolia C, Leucadendron saligmum A B, L. rubrum A, Leucospermum wittebergense C, L. cuneiforme 4b.

ERICOID

Ericaceae, spp. indet C (3), Erica sp. aff. E. speciosa C, E. cerinthoides C, E. sp. C, Eremia totta, D, Anthospermum sp. or spp. aff. A. aethiopicum 3 4ab B D, Metalasia sp. aff. M.muricata 3 D, Nestlera spp. A B, Elytropappus sp. aff. E. glandulosus D (3), Elytropappus sp. aff. E. scaber A D, Stoebe sp. or spp. aff. S. plumosa 4a D, Eriocephalus sp. or spp. aff. E. africanus B C 3 5 4b, Passerina sp. aff. P. glomerata C, Passerina sp. aff. P. vulgaris 3 5, Agathosma sp. (3), Diosma sp. aff. D. hirsuta D, D. sp. A, Cliffortia spp. A C, Phylica spp. A B D, Clutia sp. 4a, Aspalathus spp. 4a 4b, Selago or Walafrida sp. 4a.

RENOSTER

Elytropappus rhinocerotis A B C 1 4a 4b, E. adpressus A B.

KARROID

Pteronia sp. aff. P. incana B, Chrysocoma tenuifolia A B 4a.

SPINESCENT

Maytenus heterophylla 1 4b, Lycium sp. aff. L. campanulatum 1, Carissa sp. aff. C. haematocarpa 4b, Acacia karoo 1.

OTHER WOODY

Felicia sp. or spp. aff. F. filifolia A C 3, Senecio sp. D, Relhania squarrosa A B D 4a 4b, Athanasia trifurcata 4, Euryops abrotanifolius D, E. virgineus 4a, Chrysanthemoides monilifera D 5 4b, Othonna sp. aff. O. rigens D, Printzia sp. 4b, Tarchonanthus camphoratus 1 4b, Dodonaea viscosa B C (2) 3 4a, Montinia caryophyllacea B D 3 4a, Protea convexa C, Leucadendron cadens C, Leucospermum obtusatum C, Maytenus acuminata A, Maytenus oleoides D, Thesium sp. D, Rhus sp. aff. R. undulata 1 (2) 3 5, Rhus rosmarinifolia D, Rhus sp. aff. R. tomentosa B, Rhus sp. aff. R. lucida 4a 4b, Rhus sp. aff. R. laevigata B 4a, Diospyros sp. aff. D. austro-africana B 4b, D. glabra B D, Buddleia saligna (2), B. salviifolia (2), Nymania capensis (2), Heeria argentea D, Aspalathus sp. A, Dolichos gibbosus 1, Indigofera sp. 4b, Kiggelaria africana 1, Cliffortia ruscifolia A B C D 3, Clutia sp. or spp. aff. C. alaternoides A B D, Salvia sp. or spp. aff. S. chamelaeagnea 3 B D, Muraltia heisteria D, Asclepias fallax D, Clematis thunbergii or brachiata (2), Olea africana (2) 5, Lachnostylis bilocurais (2), Leonotis sp. 1, Malvastrum sp. 1, Jasminum sp. (2), Lobostemon sp. or spp. aff. L. glaucophyllus 3 4b, Phylica sp. aff. P. buxifolia 3, Myrsine africana 4b, Hermannia spp. 3 4a, Euclea sp. or spp. aff. E. crispa 4a 4b, Rhamnus sp. 4a, Asparagus sp. aff. A. aethopicus 1.

RESTIOID

Thamnochortus sp. aff. T. dichotomus D, T. argenteus C, Cannomois sp. aff. C. acuminata A D, C. parviflora C, Leptocarpus sp. aff. L. vimineus B, L. paniculatus 5, Restio gaudicha u dianus (3) D, R. cuspidatus A D, R. marlothii C, R. sieberi A, R. ocreatus C, R. filiformis A, Hypodiscus neesii C,

CYP. & GRASS

Gramineae, spp. indet. 1 4a A B D, Ehrharta sp. or spp. aff. E. ramosa A D, Merxmuellera sp. aff. M. stricta A, Themeda triandra 3 4a, Pentaschistis sp. 4a, Cymbopogon marginatus 4a, Ficinia sp. aff. F. ramosissima 4 b, F. spp. A D, Tetraria sp. aff. T. cuspidata A, T. sp. A.

FORB/FERN/SOFT WOODY

Pelargonium sp. aff. P. capitatum 1, P. sp. or spp. D (2) 4a 4b, Mentha sp. aff. M. longifolia (2), Artemisia sp. 4a, Senecio sp. (2), Helichrysum spp. A D 5, Corymbium sp. 4, Sutera spp. 3 4a, Melianthus sp. (2), Cheilanthes capensis B, C. hirta 4a 4b, C. contracta (3) 4b, C. parviloba (2), Nemesia sp. 1, Pollichia campestris (2), Chironia baccifera 4a B, Solanaceae, sp. indet.1, Solanum sp. or spp. (2), Oxalis spp. 3, Zantedeschia aethiopica 5, Anthospermum sp. aff. A. ciliare D, Asparagus capensis B, Cassytha ciliolata C, Microloma sp. aff. M. sagittatum B.

SUCCULENT

Aloe ferox 4a 4b, Aloe sp. aff. A. comptonii (2), Crassula sp. aff. C. perfoliata 4a, Crassula sp. aff. C. dejecta D, C. portulacea (2), Crassula sp. aff. C. lycopodioides 4b, C. spp. A 1 (2) 4a 5, Cotyledon paniculata (= orbiculata) (2), C. spp. 1, Carpobrotus sp. aff. C. acinaciformis 4a, Erepsia gracilis D, Ruschia spp. (3) 4a, Mesembryanthemaceae, spp. indet. (2) 4a, Portulacaria afra (2), Eurphorbia mauritanica 1, E. sp. 3.

APPENDIX 3a : See overleaf for explanation

	Species	Environment types														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	Anthus novaeseelandiae	X															
2	Calandrella cinerea	X	X														
3	Calendula magnirostris	X	X														
4	Anthus leucophrys	X	X														
5	Mirafra apiata	X	X														
6	Cisticola textrix	X	X		X												
7	Coturnix coturnix		X														
8	Macronyx capensis	X	X			X											
9	Anthus similis			X													
10	Streptopelia senegalensis					X											
11	Oena capensis					X											
12	Serinus flaviventris					X	X										
13	Parisoma subcaeruleum						X										
14	Cisticola subruficapilla		X	X	X	X	X	X				X	X				
15	Erythropygia coryphaeus					X	X	X	X								
16	Lanius collaris							X									X
17	Serinus alboqularis							X									X
18	Francolinus africanus			X			X	X					X				
19	Hirundo cucullata								X								X
20	Falco biarmicus								X								
21	Geocolaptes olivaceus								X								
22	Columba guinea								X								
23	Euplectes capensis				X	X							X				
24	Saxicola torquata			X			X			X				X			
25	Hirundo rupestris							X	X	X	X						
26	Malaconotus zeylonus		X			X	X				X			X	X		X
27	Francolinus capensis				X	X	X						X				X
28	Corvus albicollis								X	X							
29	Chaetops frenatus									X							
30	Buteo rufofuscus									X							
31	Sphenoeacus afer				X	X	X				X	X	X	X			
32	Cercomela familiaris			X				X	X		X			X	X		
33	Streptopelia capicola					X	X						X		X	X	X
34	Serinus canicollis					X							X			X	
35	Melaenornis silens					X							X			X	
36	Prinia maculosa				X	X	X	X	X	X	X	X	X	X	X		X
37	Falco tinnunculus									X	X						
38	Onychognathus morio						X	X	X		X	X	X	X			
39	Emberiza capensis					X	X	X	X	X	X	X		X	X		X
40	Pycnonotus capensis						X	X			X		X	X	X		X
41	Zosterops virens					X	X	X			X	X	X		X	X	X
42	Aquila verreauxi										X						
43	Corvus capensis										X						
44	Cisticola fulvicapilla								X		X	X	X				
45	Nectarinia chalybea					X	X				X			X		X	
46	Dicrurus adsimilis							X			X				X		X
47	Monticola rupestris							X			X		X	X			
48	Serinus leucopterus									X		X	X	X			
49	Bradypterus victorini									X		X	X	X			
50	Promerops cafer									X		X	X	X			
51	Nectarinia violacea									X	X	X	X	X	X		X
52	Serinus sulphuratus												X				
53	Nectarinia famosa									X	X	X	X	X		X	
54	Serinus tottus									X	X	X		X	X		X
55	Cossypha caffra					X	X					X	X	X	X	X	X
56	Batis capensis							X				X	X		X	X	X
57	Apalis thoracica						X						X		X	X	X
58	Laniarius ferrugineus										X		X	X	X	X	X
59	Streptopelia semitorquata												X			X	
60	Mesopicos griseocephalus												X			X	
61	Tchagra tchagra													X	X		X
62	Serinus gularis														X		
63	Parisoma layardi														X		
64	Dendropicos fuscescens														X		X
65	Aplopelia larvata															X	
66	Muscicapa adusta															X	
67	Columba arquatrix															X	
68	Bradypterus sylvaticus															X	
69	Turdus olivaceus															X	
70	Andropadus importunus															X	
71	Stenostira scita																X
72	Nectarinia afra																X
73	Ploceus capensis																X
74	Bradypterus baboecala																X
75	Indicator indicator																X
76	Lybius leucomelas																X
77	Upupa epops																X
78	Sylvietta rufescens																X
79	Colius colius																X
80	Colius striatus																X

APPENDIX 3b

	S.flaviventris	S.albogularis	S.canicollis	S.leucopterus	S.sulphuratus	S.totttus	S.gularis
1-7							
20							
21							
22							
8	-,2		-,3				
9							
10	,5		,3				
11							
12	+		-,2				
13	,5						
15	,5	-,3	-,4				
16		+				-,3	
17		+				-,3	
19		0				-,3	
42						,2	
43						,2	
46		,5				,3	,3
26	,3	-,4	-,5	-,6		,2	,1
27	,4	-,3	-,1	-,6	,2	-,6	
45	,4		,1	-,6		-,3	
32		-,3		-,6		0	,2
33	,3	-,3	,5	-,6	,2	-,3	,2
18	,3	-,3	-,4	-,5	,3		
25		-,3		-,5		-,2	
23	-,2		,3	-,4	,3		
34			+1	-,4	,3		
35	-,2		+1	-,4	,3		
14	,3	-,4	-,1	-,3	,1	-,7	
28				-,3		-,3	
37				-,3		,3	
41	,2	,2	,3	-,3	,1	,1	,1
40	-,4	,3	-,5	-,2	,1	,2	,1
24	,3			0		-,2	
44			-,4	0	,3	-,2	
47		-,3	-,4	0	,3	-,2	
39	,2	,2	-,6	,1		,6	,1
31	,3		-,1	,2	,1	-,1	
38	-,4	-,4	-,5	,2	,1	,2	
29				,3		,2	
30				,3		,2	
36	,2	,2	-,2	,3	,1	,5	,1
48			-,4	+1	,3	,3	
49			-,4	+1	,3	,3	
50			-,4	+1	,3	,3	
53			0	,7	,2	,3	
51		-,4	-,5	,6	,1	,9	,1
52			,3	,3			
54		-,3		,3		+1	,2
55	,3	-,4	,4	,1	,1	,2	,1
56		-,3	0	-,2	,2	0	,2
58		-,3	0	-,2	,2	,3	,2
59			,7	-,3	,5		
60			,7	-,3	,5		
61		-,2		-,4		,5	,3
57	-,3	-,3	,1	-,6	,2	-,3	,2
62						,2	+1
63						,2	+1
64		0				,3	,5
65			,3				
66			,3				
67			,3				
68			,3				
69			,3				
70			,3				
71		,5				,2	
72		,5				,2	
73-80		,5				,2	

Appendix 3a:
Avifaunal data for types of environment in the south-west Cape, representing a combination of data from Tables 5 and 6 (see text). Environment types (columns) are : 1 = 1 & 2, Table 5; 2 = 3 & 4, Table 5; 3 = 1, Table 6; 4 = 5, Table 5; 5 = 6 & 7, Table 5; 6 = 8, Table 5; 7 = 2, Table 6; 8 = 3, Table 6; 9 = 4, Table 6; 10 = 6, Table 6; 11 = 5, Table 6; 12= 9, 10 & 11, Table 5; 13 = 7, Table 6; 14 = 8, Table 6; 15 = 12 & 13, Table 5; 16 = 9, Table 6. Rows and columns are arranged according to the best sequence of occurence symbols from top left to bottom right of the table. Rectangle delineates occurence symbols in columns representing the series of environment types in which the protea seedeater (number 48) occurred.

Appendix 3b:
McConnaughey coefficients of association for each of seven Serinus species, including S. leucopterus, with bird species listed in Appendix 3a. Left hand column of figures refers to species numbers in Appendix 3a. Blank spaces indicate McConnaughey coefficient of -1.

APPENDIX 4 : Literature review of avifauna of Mountain Fynbos

Explanation: Appendix 4a-c:

Winterbottom (1966a) analysed daily lists to show the frequency of occurrence of bird species in Mountain Fynbos and other environments in the south-west Cape. Macchia (Mountain Fynbos), Coastal Macchia and Coastal Rhenosterbosveld (Acocks 1975) were all shown to be avifaunally distinct (Winterbottom 1972). The avifauna of False Macchia, poorly known (Winterbottom 1972), appeared to be "very similar" to that of Macchia (Winterbottom 1968a).

I listed bird species (frequency on daily lists greater than 1%) recorded from Macchia, using Winterbottom's (1966a) frequency data. I then divided the list into (i) species half as frequent in Macchia as in Coastal Macchia (i.e. Mountain Fynbos birds more "characteristic" of coastal environments, Appendix 4b) and (ii) remaining species ("characteristic" Mountain Fynbos birds, Appendix 4a). Possible additional Mountain Fynbos bird species (Appendix 4c) were drawn from checklists (Paterson 1958; Anon. 1963; Winterbottom 1968 b) covering the south-west Cape. This candidate list includes three types, viz forest birds (most south-west Cape forest is fragmentary within areas for Mountain Fynbos), distributionally restricted birds which appear to occur in Mountain Fynbos in the east or north only, and low-density, secretive and/or habitat-specific birds whose occurrence in Mountain Fynbos is unlikely to be adequately reflected by frequency data (Winterbottom 1966a).

Explanation: Appendix 4d:

The following is a summary of published information on habitat and status for all Ploceidae and Fringillidae ("seed-eating" passerines) in the south-west Cape, with reference to the occurrence of the species in Mountain Fynbos. The grouping of species follows that of Appendix 4a-c.

APPENDIX 4a: Characteristic bird species of Mountain Fynbos, after Winterbottom 1966a (see text).

Falco tinnunculus rock kestrel, Aquila verreauxi black eagle, Buteo rufofuscus jackal buzzard, Buteo buteo[x] steppe buzzard, Francolinus africanus grey-wing francolin, Columba guinea rock pigeon, Streptopelia capicola* Cape turtle dove, Streptopelia senegalensis laughing dove, Apus barbatus black swift, Apus melba alpine swift, Geocolaptes olivaceus ground woodpecker, Hirundo albigularis[x] white-throated swallow, Hirundo cucullata[x] greater striped swallow, Hirundo rupestris rock martin, Corvus albicollis white-necked raven, Parus afer grey tit (extremely infrequent in fynbos - Winterbottom 1966a), Chaetops frenatus rufous rockjumper, Pycnonotus capensis[+] Cape bulbul, Turdus olivaceus olive thrush(essentially an encroacher from forest - Winterbottom 1966a), Monticola rupestris Cape rock thrush, Cercomela familiaris familiar chat, Cossypha caffra*[+@] Cape robin, Bradypterus victorini Victorin's scrub warbler, Sphenoeacus afer*[+] grassbird, Cisticola fulvicapilla*[+] neddicky, Prinia maculosa*[+@] karoo prinia, Batis capensis Cape batis (regarded as an encroacher from forest - Winterbottom 1966a), Anthus leucophrys plain-backed pipit (extremely infrequent in fynbos - Winterbottom 1966a), Lanius collaris fiscal, Laniarius ferrugineus boubou, Malaconotus zeylonus* bokmakierie, Onychognathus morio*[+] red-winged starling, Promerops cafer*[+@] Cape sugarbird, Nectarinia famosa*[+@] malachite sunbird, Nectarinia violacea*[+@] orange-breasted sunbird, Zosterops virens*[+] Cape whiteye, Euplectes capensis Cape widow, Serinus tottus siskin, Serinus canicollis* Cape canary, Serinus sulphuratus bully seedeater, Serinus leucopterus protea seedeater, Emberiza capensis[+] Cape bunting.

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[x] migrants

* "dominant" (i.e. frequency 40% or greater) in Macchia (Winterbottom 1972)

[+] "dominant" in Macchia (Winterbottom 1966a)

[@] "dominant" in the dense Protea form of Macchia (Winterbottom 1966a).

APPENDIX 4b: Mountain Fynbos birds more characteristic of coastal vegetation, after Winterbottom, 1966a (see text).

Ardeola ibis cattle egret, Elanus caeruleus black-shouldered kite, Francolinus capensis Cape francolin, Burhinus capensis Cape dikkop, Oena capensis Namaqua dove, Colius striatus speckled mousebird, Colius colius white-backed mousebird, Upupa epops hoopoe, Mirafra apiata clapper lark, Certhilauda albescens karoo lark, Hirundo rustica[x] European swallow, Corvus albus pied crow, Saxicola torquata stonechat, Erythropygia coryphaeus karoo robin, Sylvietta rufescens crombec, Apalis thoracica bar-throated apalis, Cisticola tinniens Levaillant's cisticola, Cisticola subruficapilla grey-backed cisticola, Melaenornis silens fiscal flycatcher, Motacilla capensis Cape wagtail, Macronyx capensis orange-throated longclaw, Spreo bicolor pied starling, Nectarinia chalybea lesser double-collared sunbird, Passer melanurus Cape sparrow, Ploceus capensis Cape weaver, Estrilda astrild common waxbill, Serinus albogularis white-throated seedeater, Serinus flaviventris yellow canary.

APPENDIX 4c: Possible additional Mountain Fynbos birds.

Falco biarmicus lanner, Accipiter rufiventris red-breasted sparrowhawk, Francolinus levaillantii redwing francolin, Francolinus afer red-necked francolin, Coturnix coturnix[x] African quail, Turnix hottentotta Hottentot button-quail, Columba arquatrix rameron pigeon, Streptopelia semitorquata red-eyed dove, Turtur tympanistra tambourine dove, Turtur chalcospilos emerald-spotted dove, Aplopelia larvata cinnamon dove, Tauraco corythaix Knysna loerie, Cuculus solitarius[x] red-chested cuckoo, Clamator jacobinus[x] jacobin cuckoo, Chrysococcyx klaas Klaas's cuckoo, Chrysococcyx caprius didric cuckoo, Centropus superciliosus white-browed coucal, Tyto alba barn owl, Ciccaba woodfordii wood owl, Bubo capensis Cape eagle owl, Bubo africanus spotted eagle owl, Caprimulgus tristigma freckled nightjar, Halcyon albiventris brown-hooded kingfisher, Merops apiaster European bee-eater, Indicator indicator greater honeyguide, Indicator minor lesser honeyguide, Campethera notata Knysna woodpecker, Dendropicos fuscescens cardinal woodpecker, Mesopicos griseocephalus olive woodpecker, Psalidoprocne holomelaena black saw-wing swallow, Campephaga phoenicea

black cuckoo-shrike, Coracina caesia grey cuckoo-shrike, Dicrurus adsimilis fork-tailed drongo, Oriolus larvatus black-headed oriole, Phyllastrephus terrestris terrestrial bulbul, Andropadus importunus sombre bulbul, Monticola explorator sentinel rock thrush, Oenanthe monticola mountain chat, Seicercus ruficapillus yellow-throated warbler, Acrocephalus baeticatus African reed-warbler, Bradypterus sylvaticus Knysna scrub warbler, Cisticola juncidis fantail cisticola, Cisticola lais wailing cisticola, Muscicapa adusta dusky flycatcher, Terpsiphone viridis[x] paradise flycatcher, Anthus similis long-billed pipit, Anthus crenatus rock pipit, Tchagra tchagra tchagra, Chlorophoneus olivaceus olive bush shrike, Dryoscopus cubla puffback shrike, Nectarinia afra greater double-collared sunbird, Nectarinia amethystina black sunbird, Ploceus velatus masked weaver, Estrilda melanotis swee waxbill, Vidua macroura pin-tailed whydah, Serinus scotops forest canary, Serinus alario black-headed canary, Serinus gularis streaky-headed seedeater, Emberiza flaviventris golden-breasted bunting.

Symbols for Appendices 4b & 4c as for Appendix 4a.

Appendix 4d:

i) "Characteristic" species of Mountain Fynbos

Euplectes capensis, Cape widow

This species is a widespread breeding resident in the south-west Cape (Paterson 1958; Winterbottom 1968b), characteristic of dense vegetation near water (Winterbottom 1966a). It occurs "regularly" in fynbos (26-40%, including 17% in dense Protea; 2 birds per hr, Broekhuysen 1964). The frequency of the Cape widow in Mountain Fynbos (Macchia: 25%, Winterbottom 1966a) is similar to its frequency in other south-west Cape environments (Coastal Macchia: 29%; Coastal Rhenosterbosveld: 35%, Winterbottom 1966a).

Serinus tottus, siskin

This species, known to be relatively habitat-specific, is a breeding resident in the mountains of the south-west Cape (Skead 1960; Anon. 1963; Winterbottom 1966a, 1968b). It occurs "regularly" in fynbos (26-40%, including 29% in dense Protea; 2 birds per hr, Broekhuysen 1964). The siskin is very infrequent in all south-west Cape environments other than Mountain Fynbos (Winterbottom 1966b; Coastal Macchia & Coastal Rhenosterbosveld: 3-5%; Macchia: 25%, Winterbottom 1966a).

Serinus canicollis, Cape canary

This species is a breeding resident in the south-west Cape (Winterbottom 1968b). It occurs in a wide variety of natural and man-made environments (Skead 1960). The Cape canary is the only Serinus species occuring in "woodlands of mixed exotics", is recorded from "tree-lined rivers" and "wattle plantations", and is the most frequent member of its genus in "pastures", "gardens", and "farm-yards" (Winterbottom 1973). It occurs "regularly" in fynbos (26-40%, including 22% in dense Protea; 2 birds per hr, Broekhuysen 1964). Its frequency in Mountain Fynbos (Macchia: 36%, Winterbottom 1966a), greater than that for any congener, is greater than its frequency in other south-west Cape environments (Coastal Macchia: 20%; Coastal Rhenosterbosveld: 33%, Winterbottom 1966a, 1973).

Serinus sulphuratus, bully seedeater

This species is a breeding resident in the south-west Cape, occurring in relatively well-watered, open "bushy" environments (Paterson 1958; Skead 1960; Winterbottom 1966a, 1968b; Middlemiss & Langley 1975). It has adapted to stands of "alien trees", e.g. "tree-lined rivers" (Winterbottom 1973). The bully seedeater is infrequent in fynbos (6-10%, including 2% in dense Protea; 9 birds in 43 hr, Broekhuysen 1964). It is,

however, more frequent in fynbos environments ("winter rainfall area") than in the Karoo (Winterbottom 1968b, 1973). The species appears to be more frequent in Mountain Fynbos (Macchia: 5%, Winterbottom 1966) than in other south-west Cape environments (Coastal Macchia & Coastal Rhenosterbosveld: 2%, Winterbottom 1966a).

Serinus leucopterus, protea seedeater

This species is known as a breeding resident only in dense Protea Mountain Fynbos (Skead 1960; Anon. 1963; Winterbottom 1966a, 1968b). It occurs "rarely" in fynbos (1-5%, including 5% in dense Protea; 5 birds in 43 hr, Broekhuysen 1964). The protea seedeater is very infrequent in Mountain Fynbos (Macchia: 5%, including 4% in dense Protea, Winterbottom 1966a). It appears, however, restricted to Mountain Fynbos, "with a few records from other sclerophyll [fynbos] habitats" (Winterbottom 1973), e.g. Coastal Rhenosterbosveld (2%, Winterbottom 1966a).

Emberiza capensis, Cape bunting

This species is a widespread breeding resident in the south-west Cape (Paterson 1958; Winterbottom 1968b; Middlemiss & Langley 1975). It is characteristic of rocky environments bearing a variety of vegetation types (Skead 1960). The Cape bunting occurs frequently in fynbos (41-55%, including 17% in dense Protea; 2 birds per hr, Broekhuysen 1964). Its frequency in Mountain Fynbos (Macchia: 48%, Winterbottom 1966a) is similar to its frequency in other south-west Cape environments (Coastal Macchia & Coastal Rhenosterbosveld: 44-47%, Winterbottom 1966a).

ii) Mountain Fynbos species more "characteristic" of coastal environments

Passer melanurus, Cape sparrow

This species is a widespread breeding resident in the south-west Cape (Paterson 1958; Winterbottom 1968b). It is characteristic of dry areas, human habitation and agricultural land (Winterbottom 1966b, 1972). Frequency data for the Cape sparrow show a gradient from dry environments (Karroid Broken Veld: 71%, Winterbottom 1966b) to better-watered environments (Macchia: 5%, Winterbottom 1966a). The species is generally infrequent in fynbos (6-10%, Broekhuysen 1964), preferring drier fynbos environments (Coastal Macchia: 46%, Winterbottom 1966a). The Cape sparrow clearly has a very low relative frequency in Mountain Fynbos.

Ploceus capensis, Cape weaver

This species is a widespread breeding resident in the south-west Cape (Paterson 1958; Winterbottom 1968b). It is partly associated with agricultural land (Anon. 1963) and other "man-created food supplies" (Winterbottom 1966a). The Cape weaver occurs "fairly frequently" in fynbos (11-25%; 12 birds in 43 hr, Broekhuysen 1964). It occurs relatively infrequently in Mountain Fynbos (Coastal Rhenosterbosveld & Coastal Macchia: 30-40%; Macchia: 13%, Winterbottom 1966a).

Estrilda astrild, common waxbill

This species is a widespread breeding resident in the south-west Cape (Paterson 1958; Winterbottom 1968b). It is characteristic of rank grass near water (McLachlan & Liversidge 1972). The common waxbill is infrequent in fynbos (6-10%, including 5% in dense Protea; 4 birds in 43 hr, Broekhuysen 1964). Its frequency in Mountain Fynbos (Macchia: 9%, Winterbottom 1966a) is similar to this overall frequency in fynbos.

Serinus flaviventris, yellow canary

This species is a breeding resident characteristic of low open vegetation on coastal and inland flats in the south-west Cape (Skead 1960; Winterbottom 1968b; McLachlan & Liversidge 1972; Middlemiss & Langley 1975). It has adapted almost as successfully to man-made environmental changes as has S. canicollis, occurring in "wattle plantations", "gardens", "farm-yards" and "pastures" (Winterbottom 1973). The yellow canary occurs relatively infrequently in fynbos (6-10%; 21 birds in 43 hr, Broekhuysen 1964), being, with S. albogularis, the most frequent Serinus species in the south-west Cape (27-46%, Winterbottom 1966b). The species is most frequent in dry environments within the fynbos area (Strandveld: 74%; Coastal Macchia: 36%, Winterbottom 1966a), and is the most frequent member of its genus in Coastal Macchia and Coastal Rhenosterbosveld (Winterbottom 1973). The yellow canary is extremely infrequent in Mountain Fynbos (Macchia: 2%, Winterbottom 1966a).

Serinus albogularis, white-throated seedeater

This species is a breeding resident characteristic of karoo and the dry coastal flats in the south-west Cape (Skead 1960; Winterbottom 1966a, 1966b, 1968b). It has adapted successfully to man-made environmental changes, occurring in "wattle plantations", "gardens", "pastures" and "farm-yards", and is one of the most frequent Serinus species along "tree-lined rivers" (Winterbottom 1973). The white-throated seedeater occurs infrequently in fynbos (6-10%, including 2% in dense

Protea; 7 birds in 43 hr, Broekhuysen 1964); it is less frequent than S. flaviventris or S. canicollis in Coastal Macchia and Coastal Rhenosterbosveld (Winterbottom 1973). Frequency data for the species show a gradient from dry to better-watered environments (Karroid Broken Veld & Strandveld: 30-55%; Coastal Rhenosterbosveld: 25%; Coastal Macchia: 15%; Macchia: 4%; Winterbotton 1966b, 1968b). The white-throated seedeater clearly has a very low relative frequency in Mountain Fynbos.

iii) Possible additional Mountain Fynbos species

Ploceus velatus, masked weaver

This species occurs in the interior of the south-west Cape (Paterson 1958; Winterbottom 1968b). It has been recorded as a "vagrant" (0-1%, Broekhuysen 1964) in fynbos.

Estrilda melanotis, swee waxbill

This species occurs in the southern part of the south-west Cape (Paterson 1958; Anon. 1963; Winterbottom 1968b). It is found at the edges of forests (Anon. 1963) and occurs rarely in fynbos (1-5%, Broekhuysen 1964).

Vidua macroura, pin-tailed whydah

This species is widespread in the south-west Cape (Paterson 1958; Winterbottom 1968b). Its occurrence is dependent on that of the common waxbill Estrilda astrild (Anon. 1963; Winterbottom 1968b; McLachlan & Liversidge 1972). The pin-tailed whydah has not been recorded from fynbos.

Serinus scotops, forest canary

This species is a breeding resident in the south-west Cape and is restricted to forest and dense bush (Skead 1960; Winterbottom 1968b). It has not been recorded from fynbos.

Serinus gularis, streaky-headed seedeater

This species penetrates the eastern part of the south-west Cape as a breeding resident (Paterson 1958; Winterbottom 1968b). It occurs very infrequently in fynbos (0-1%, Broekhuysen 1964; Winterbottom 1973) and is most frequent along "tree-lined rivers" on the southern Cape coastal plain (Winterbottom 1973).

Emberiza flaviventris, golden-breasted bunting

This savanna species penetrates the eastern part of the south-west Cape (Paterson 1958; Skead 1960; Winterbottom 1968b). It has not been recorded from fynbos.

iv) Other "seed-eating" passerines in the south-west Cape

Euplectes orix, red bishop

This species is widespread in the south-west Cape (Paterson 1958; Winterbottom 1968b). It is characteristic of reedbeds and agricultural land (McLachlan & Liversidge 1972). The red bishop occurs extremely infrequently in fynbos (Coastal Macchia: 1%, Winterbottom 1966a). It has not been recorded from Mountain Fynbos (Winterbottom 1966a).

Ortygospiza fuscocrissa, quail finch

This widespread species penetrates the south-west Cape locally (Paterson 1958; Anon. 1963; Winterbottom 1968b). It is restricted to short west grassland (Anon. 1963; McLachlan & Liversidge 1972). The quail finch has not been recorded from fynbos.

Serinus mozambicus, yellow-eye canary

This savanna species apparently penetrates the eastern part of the south-west Cape as a breeding resident (Paterson 1958). It has not been recorded from fynbos.

Serinus alario, black-head canary

This karoo species is widespread in the south-west Cape, penetrating the southern coastal area partly as a winter visitor (Skead 1960; Winterbottom 1966b, 1973). There are no references in the literature to its occurrence in fynbos.

Emberiza impetuani, lark-like bunting.

This karoo species penetrates the northern and western parts of the south-west Cape (Paterson 1958; Skead 1960; Anon. 1963; Winterbottom 1968b). It occurs rarely in fynbos (1-5%, Broekhuysen 1964).

The forest weaver, Ploceus bicolor, (forest), the yellow-throated sparrow, Petronia superciliaris, (Acacia), the blue-billed fire-finch, Lagonosticta rubricata, (thickets) and the red-headed finch, Amadina erythrocephala, (karoo) also penetrate the eastern part of the south-west Cape (Paterson 1958; S.A.O.S. List Committee 1969). None of these species has been recorded from fynbos.

APPENDIX 5 : Details for replicate bird counts in proteoid Mountain Fynbos at Molenaarsrivier (Slanghoek Mountains, Worcester Division), January-February 1976. Total effective area censussed was 25,8 ha (2150 m x 20 m x 6).

Replicate count number	Date	Duration (minutes)		Weather			
		total	corrected*	Wind (Beaufort scale)	Temperature: observer's record	Temperature: ambient temp. (midday; °C in shade)	Cloud cover (% of sky)
1	21/1/76	155	155	2	warm	30	50
2	27/1/76	207	195	3	cool	28	80
3	9/2/76	190	180	4	warm	30	30
4	14/2/76	195	170	1	warm	30	5
5	17/2/76	182	169	3	hot	34	10
6	24/2/76	245	197	2	warm	30	50

* time taken observing birds outside the transect limits was subtracted from total time taken to complete the count.

APPENDIX 6 : Measurements and weights for south-west Cape Serinus species. All measurements and weights refer to the races occurring in the south-west Cape, except where otherwise stated. Sources were: 1 = P.G. Frost pers. comm; 2 = Liversidge 1968; 3 = Middlemiss 1967; 4 = J.M. Winterbottom pers. comm.; 5 = Winterbottom 1973; 6 = McLachlan & Liversidge 1972; 7 = Skead 1960.

Species	Body weight (g)				Body measurements (mm)					
					total length (range)	wing length (range)	bill length			
	mean	range	n	sources			sources	mean	range	sources
S. sulphuratus	29,0	26,0-32,0	21	1,2,3	150-170	76-85	1,5,6,7	13,3	13,0-15,0	5,7
S. leucopterus	23-24+	21-29+			150-160	70-78	6,7		12,0-17,0	6,7
S. canicollis	15,2	13,0-17,0	11	1,3,4	125-139	72-82	1,6,7		9,5-11,0	7
S. tottus					122-131	68-72	7		9,0-10,5	7
S. albogularis	27,0	22,0-31,0	19	4	152		7		12,0-15,0	7
S. gularis	22,2	20,2-26,0	29	2,4	146-159		6,7	11,8	12,0-15,0	7
S. flaviventris	15,5	12,5-19,4	30	2,4*	127-140	66-76	4,6	13,9	13,0-15,0	4

\+ estimated

* northern Cape and South West African race (south-west Cape race is smaller)

APPENDIX 7: Feeding records for Serinus species, giving food type, plant species, vegetation, month, locality. Numbers after vegetation type refer to classification of environments in text of Habitat Floristics section

a. Serinus leucopterus

1. Graminoid seed (herbaceous and semi-herbaceous perennials)

i) Tetraria sp. aff. T. eximia JAN.
open proteoid Mountain Fynbos: 3.1 near indigenous forest patch (Winterhoek, TULBAGH)

ii) Ficinia bracteata OCT.
(probable record) youthful open proteoid-restioid Mountain Fynbos: 3.1 (Duiwelskloof, GROOT DRAKENSTEIN)

iii) Thamnochortus dichotomus OCT.
youthful open proteoid-restioid Mountain Fynbos: 3.1 (Duiwelskloof, GROOT DRAKENSTEIN)

iv) Thamnochortus schlechteri JUNE
mature proteoid Mountain Fynbos: 1.1 (between Liberty & Katbakkies, west of SWARTRUGGENS RANGE)

v) Leptocarpus vimineus JULY, possibly OCT.
mature proteoid Mountain Fynbos: 3.1 (Elandskloof and possibly also Kaffirkop, southern CEDARBERG); mature proteoid Mountain Fynbos: 1.1 (Grasberg & Van Rhyns Pass Road, Bokkeveld Plateau, NIEUWOUDTVILLE)

vi) Elegia parviflora MAY, possibly OCT.
open restioid Mountain Fynbos near proteoid Mountain Fynbos: 3.1 or 3.2 (Michells Pass, CERES)

vii) Restio cuspidatus JUNE, AUG., possibly SEPT., OCT.
youthful open proteoid Mountain Fynbos: 3.1 (Duiwelskloof, GROOT DRAKENSTEIN); mature open proteoid Mountain Fynbos: 3.1 (Rooi Els, GORDONS BAY; Wolfkloof, Greyton, RIVIERSONDEREND RANGE; very probably also Kaffirkop, southern CEDARBERG)

viii) Restio dispar SEPT.
restioid-ericoid Mountain Fynbos: 3.2 on rocky site near streams (Baviaanskloof, BAINS KLOOF)

ix) Restio gaudichaudianus JAN., SEPT., OCT., NOV.
youthful open proteoid Mountain Fynbos: 3.1 (Duiwelskloof, GROOT DRAKENSTEIN); mature proteoid Mountain Fynbos: 3.1 (Molenaarsrivier, SLANGHOEK & possibly also Kaffirkop, southern CEDARBERG)

x) Restio pachystachyus FEB.
restioid-ericoid Mountain Fynbos: 3.2 on rocky site (Baviaans-kloof, BAINS KLOOF)

xi) Restio sieberi MARCH
youthful open proteoid Mountain Fynbos: 1.1 (Saw Edge Peak, WORCESTER)

xii) Restio triticeus JULY
open proteoid Mountain Fynbos: 3.1 near stream (Cockscomb range, PATENSIE)

xiii) Restio sp. nov. aff. R. triticeus JULY
(probable record) ericoid Mountain Fynbos: 3.1 near stream and proteoid Mountain Fynbos (Cockscomb range, PATENSIE)

xiv) Cannomois virgata JULY
(beside a stream, Laastedrif, HEX RIVER RANGE, Taylor 1961)

2. Composite achenes (herbaceous annuals and woody perennials)

i) Eriocephalus africanus JULY, AUG.
proteoid Mountain Fynbos: 3.1, adjacent to open disturbed area and alien woodland (Waterfall, TULBAGH; Paarl Mountain, PAARL)

ii) Eriocephalus sp. aff. E. capitellatus MAY
roadside in streambed in Kloof Scrub: 2 (between Scrub-forest, Dry Scrub and Riverine Fynbos) (Sipreerivier, KOUGA RANGE)

iii) Euryops abrotanifolius JULY
Mountain Fynbos: 3.2 (Hotel & Baviaanskloof, BAINS KLOOF)

iv) Metalasia muricata JULY
Mountain Fynbos: 3.1 (Waaihoek, HEX RIVER RANGE, and Helderberg, SOMERSET WEST) (Burger, pers. comm.)

v) Othonna rigens (=amplexicaulis) possibly SEPT., possibly OCT., NOV.
Mountain Fynbos: 3.1 (Duiwelskloof, GROOT DRAKENSTEIN); also Skead (1960) and Praed & Grant (1955)

vi) Othonna quinquedentata MARCH
mature Mountain Fynbos: 3.1 (Hotel, BAINS KLOOF)

vii) Senecio pubigerus & allies JUNE, OCT.
Mountain Fynbos: 3.1 (Middelberg, central CEDARBERG); youthful Mountain Fynbos: 3.1 on marshy site (Duiwelskloof, GROOT DRAKENSTEIN); roadside in mature proteoid Mountain Fynbos: on granite (Paarl Mountain, PAARL)

viii) Senecio sp. aff. S. vestitus APRIL
roadside in mature Mountain Fynbos: 3.3 (Mannetjiesberg, KAMMANASSIE RANGE)

ix) Inula graveolens APRIL
roadside in mature proteoid Mountain Fynbos: 3.1 (Paarl Mountain, PAARL); also Skead (1960)

x) Cullumia bisulca OCT.
(floral parts possibly also taken) ericoid Mountain Fynbos: 1.3 (Sipreerivier catchment, KOUGA RANGE)

xi) Stoebe plumosa JULY
(beside a stream, Laastedrif, HEX RIVER RANGE, Taylor 1961)

xii) Ursinia pinnata (=filiformis)
Mountain Fynbos: 3.1 or 3.2, top of FRANSCHHOEK PASS, "tearing apart the small yellow flowers", Broekhuysen & Martin 1965)

xiii) Gymnodiscus capillaris (see 8: iii)

xiv) unidentified species AUG.
birds were observed "... tearing to pieces such blossoms as had already dropped their petals" (Orchard, HEX RIVER VALLEY, Hare 1954)

3. Other small seed (herbaceous annuals and woody perennials)

i) Pelargonium sp. aff. P. tabulare OCT.
(green & dry seeds both taken) youthful proteoid Mountain Fynbos: 3.1 (Duiwelskloof, GROOT DRAKENSTEIN)

ii) Chenopodium spp. APRIL , AUG.
weedy olive grove, 200 m from Mountain Fynbos:3.1 (Paarl Mountain, PAARL); weedy vineyard 0,5 km from Mountain Fynbos:3.1 (Paarl Mountain, PAARL).

iv) Anthospermum ciliare MAY
youthful Mountain Fynbos: 3.1 (Duiwelskloof, GROOT DRAKENSTEIN)

v) Erica curviflora MARCH
(probable record) mature dense proteoid Mountain Fynbos: 3.3 (Towerkop, KLEIN SWARTBERG)
("withered flowers" of E. plukeneti recorded also by Skead 1960)

vi) Salvia chamelaeagnea APRIL
roadside in mature dense proteoid Mountain Fynbos: 3.1 on granite (Paarl Mountain, PAARL)

vii) Pollichia campestris MAY
Kloof Scrub: 2, between Succulent Mountain Scrub form of karoo and Mountain Fynbos: 1.3. (Gamka Reserve, CALTIZDORP)

viii) Gnidia laxa APRIL
(probable record) mature proteoid Mountain Fynbos: 3.1 on granite (Paarl Mountain, PAARL)

ix) Stellaria sp. AUG.
(possible record) weedy vineyard 0,5 km from proteoid Mountain Fynbos: 3.1 (Paarl Mountain, PAARL)

4. Larger seed (woody perennials except for Raphanus, an herbaceous annual)

i) Phylica pubescens JAN.
mature dense proteoid Mountain Fynbos: 3.1(Jonkershoek, STELLENBOSCH)

ii) Raphanus raphanistrum AUG.
(green seed) weedy orchard 0,5 km from mature proteoid Mountain Fynbos: 3.1 (Winterhoek, TULBAGH)

iii) Psoralea aculeata JAN.
youthful open proteoid Mountain Fynbos: 3.1 (Helderberg, SOMERSET WEST)

iv) Protea laurifolia JAN., FEB., MARCH, JUNE, JULY, AUG.
disturbed mature proteoid Mountain Fynbos: 1.1 (Gifberg plateau, VAN RHYNSDORP and Geelberg, southern CEDARBERG); mature proteoid Mountain Fynbos: 1.1 (Grasberg, Bokkeveld plateau, NIEUWOUDTVILLE); mature proteoid Mountain Fynbos: 3.1 (Kaffirkop, Elandskloof and Sandfontein, southern CEDARBERG; Molenaarsrivier, SLANGHOEK); open proteoid Mountain Fynbos: 1.1 near stream (Saw Edge Peak, WORCESTER); mature proteoid Mountain Fynbos: 1.1 (between Liberty & Katbakkies, west of SWARTRUGGENS RANGE); mature proteoid Mountain Fynbos: 1.1 /Mountain Rhenosterbosveld transition (Klondyke, Swaarmoed, CERES)

v) Protea pulchra APRIL, AUG.
mature dense proteoid Mountain Fynbos: 3.1 on granite (Paarl Mountain, PAARL)

vi) Protea neriifolia APRIL, MAY, OCT.
recently-burnt dense proteoid Mountain Fynbos: 3.1 (Dwarsrivier, KOUGA RANGE); mature proteoid Mountain Fynbos: 3.1 (Towerwater-kloof, KOUGA RANGE and Rooi Els, GORDONS BAY)

vii) Protea macrocephala
(Myburgh pers. comm.) proteoid Mountain Fynbos: 3.1 (Helderberg, SOMERSET WEST)

viii) Protea compacta AUG.
mature proteoid Mountain Fynbos: 3,1 (Helderberg, SOMERSET WEST)

ix) Protea repens JAN., APRIL, MAY,JUNE, OCT.
mature open proteoid Mountain Fynbos: 3.1 (Graslaagtekloof, KOUGA RANGE and Paarl Mountain, PAARL; Wolfkloof, Greyton, RIVIERSONDEREND RANGE); probably also ericoid Mountain Fynbos: 1.3 near perennial stream (Sipreerivier, KOUGA RANGE)

x) Protea arborea JAN.-AUG.
mature proteoid Mountain Fynbos: 3.1 (Kaffirkop, southern CEDARBERG, Molenaarsrivier, SLANGHOEK and Jonkershoek, STELLENBOSCH); mature proteoid Mountain Fynbos: 1.2 (Gamka Reserve, CALITZDORP and Seven Weeks Poort, SWARBERG); recently-burnt proteoid Mountain Fynbos: 3.1 (Gamka Reserve, CALITZDORP); mature proteoid Mountain Fynbos: 3.1 near indigenous forest or Riverine Fynbos (Winter-hoek, TULBAGH and Hotel, BAINS KLOOF); proteoid Mountain Fynbos: 3.1 near stream (Cockscomb range, PATENSIE); youthful & mature proteoid Mountain Fynbos: 3.1 , with Hakea thickets (Duiwels-kloof, GROOT DRAKENSTEIN); mature proteoid Mountain Fynbos: 3.1 on granite (Paarl Mountain, PAARL)

xi) Protea longiflora
(Burger pers. comm.) proteoid Mountain Fynbos: 3.1 (Helderberg, SOMERSET WEST)

xii) Protea punctata MARCH
mature proteoid Mountain Fynbos: 3.3 (Towerkop, Klein Swartberg, LADISMITH)

xiii) Diosma hirsuta JAN. NOV.
mature open proteoid Mountain Fynbos: 3.1 (Kaffirkop, southern CEDARBERG); mature proteoid Mountain Fynbos: 3.1 (Eikebos, southern CEDARBERG)

xiv) Diosma prama OCT.
mature ericoid Mountain Fynbos: 1.3 (Towerwaterkloof, KOUGA RANGE)

xv) Agathosma sp. aff. A. apiculata OCT.
mature dense proteoid Mountain Fynbos: 3.1 near fallow land (Graslaagtekloof, KOUGA RANGE)

xvi) Hakea sericea JUNE
(probable record; foraging behaviour at open fruits on the growing shrubs) mature proteoid Mountain Fynbos: 3.1 with Hakea thickets (Duiwelskloof, GROOT DRAKENSTEIN)

xvii) Leucadendron rubrum SEPT.
mature proteoid Mountain Fynbos: 3.1 on granite (Paarl Mountain, PAARL)

xviii) Rhus "anacardia" (Skead 1960)

xix) germinating seed (species unknown) MAY
recently-burnt proteoid Mountain Fynbos 3.1 (Gamka Reserve, CALITZDORP)

xx) Freylinia lanceolata JULY
(part taken not specified) (Sanddrif kloof, HEX RIVER RANGE, Taylor 1961)

xxi) Phylica lachneaeoides JULY
(Manson pers. comm.) restioid-ericoid Mountain Fynbos: 3.2 (Towerwater, KOUGA RANGE)

5. Seed kernels in (ripe or unripe) fleshy fruits (woody and soft-woody perennials)

i) Oftia africana MARCH
(possibly fruit-pulp) proteoid Mountain Fynbos: 3.1 near stream (Saw Edge Peak, WORCESTER)

ii) Olea africana MARCH, MAY
mature Mountain Fynbos: 3.1 (Hotel, BAINS KLOOF); Olea grove in mature proteoid Mountain Fynbos: 3.1 on granite (Paarl Mountain, PAARL)

iii) Rhus sp. aff. R. macowanii MAY
Valley Scrub: 2 near Mountain Fynbos: 1.3 (Dwarsrivier, KOUGA RANGE); Riverine Fynbos: 2 (Grootrivier, KOUGA RANGE)

iv) Cassytha ciliolata DEC.
disturbed open proteoid Mountain Fynbos: 3.1 near stream (Waterfall, TULBAGH)

v) Maytenus oleoides (see 8)

vi) Diospyros glabra (see 8)

6. Nectar (woody perennials)

i) Protea arborea JULY
mature proteoid Mountain Fynbos: 3.1 (Elandskloof, southern CEDARBERG)

ii) Protea laurifolia AUG.
mature proteoid Mountain Fynbos: 1.1.(Sandfontein, southern CEDARBERG)

iii) Protea punctata APRIL
(possible record: bird thrashed with bill in fresh head, pulling out floral parts) mature 3.3. proteoid Mountain Fynbos (Mannetjies-berg, KAMMANASSIE RANGE)

iv) Erica verecunda JAN.
(possibly fresh floral parts, not nectar, taken) mature open proteoid-ericoid Mountain Fynbos (Kaffirkop, southern CEDARBERG) 3.1.

v) Erica coccinea MAY
youthful open proteoid Mountain Fynbos 3.1. (Duiwelskloof, GROOT DRAKENSTEIN)

vi) Erica plukeneti JULY, AUG., SEPT., OCT.
mature proteoid Mountain Fynbos: 3.1.on granite (Paarl Mountain, PAARL); mature and youthful proteoid Mountain Fynbos: 3.1. with Hakea (Duiwelskloof, GROOT DRAKENSTEIN); Mountain Fynbos: 3.2.(Hotel,& Baviaanskloof, BAINS KLOOF); also Skead 1960 (withered flowers; see above)

vii) Erica parilis MAY
(fresh floral parts possibly taken) youthful Mountain Fynbos: 3.1. (Michells Pass, CERES)

viii) Halleria elliptica OCT.
open proteoid Mountain Fynbos: 3.1.near stream (Duiwelskloof, GROOT DRAKENSTEIN)

ix) Salvia chamelaeagnea APRIL
mature proteoid Mountain Fynbos: 3.1.on granite (Paarl Mountain, PAARL)

7. Fruit-pulp (woody perennials)

i) Diospyros glabra FEB., possibly APRIL & MAY
mature proteoid Mountain Fynbos: 3.1.(Molenaarsrivier, SLANGHOEK); probably also youthful Mountain Fynbos: 3.1.(Duiwelskloof, GROOT DRAKENSTEIN)

ii) Maytenus oleoides JAN., FEB.
(kernel also taken at times) mature Mountain Fynbos: 3.1. (Winterhoek, TULBAGH); mature proteoid Mountain Fynbos : 3.1. (Molenaarsrivier, SLANGHOEK); transition between mature proteoid Mountain Fynbos and Acacia mearnsii Riverine Woodland (Molenaar-srivier, SLANGHOEK)

8. Fresh floral parts (herbaceous annuals and woody perennials)

i) Zygophyllum sp. aff. Z. fulvum JULY
disturbed Mountain Fynbos: 1.2.(Attakwas range, MOSSEL BAY)

ii) Euryops munitus JULY
Mountain Fynbos: 3.1.(Cockscomb range, PATENSIE)

iii) Gymnodiscus capillaris AUG.
(whole capitula, including achenes, probably taken) mature proteoid Mountain Fynbos: 1.1. (Sandfontein, southern CEDARBERG)

iv) Senecio burchellii OCT.
open proteoid Mountain Fynbos: 3.1. (Duiwelskloof, GROOT DRAKENSTEIN)

v) Senecio sp. aff. S. carroensis NOV.
open proteoid Mountain Fynbos: 3.1. (Duiwelskloof, GROOT DRAKENSTEIN)

vi) Aspalathus perfoliata JAN.
mature proteoid Mountain Fynbos: 3.1. (Winterhoek, TULBAGH)

vii) Aspalathus teres JULY
proteoid Mountain Fynbos: 3.1. near stream (Cockscomb range, PATENSIE)

9. Foliage buds (woody perennials)

i) Cliffortia ruscifolia JAN.
mature Mountain Fynbos: 3.1. (Kaffirkop, southern CEDARBERG): probably also youthful Mountain Fynbos (Duiwelskloof, GROOT DRAKENSTEIN)

ii) Cliffortia sp. aff. C. ilicifolia OCT.
disturbed proteoid Mountain Fynbos: 3.1. (Graslaagtekloof, KOUGA RANGE)

iii) Cliffortia eriocephalina MARCH
mature dense proteoid Mountain Fynbos: 3.3. (Towerkop, KLEIN SWARTBERG)

iv) Cliffortia dregenana (Skead 1960)

v) Rhus sp. aff. R. undulata JUNE, JULY
Kloof Scrub: 2. near stream between karoo and Mountain Fynbos (Kransvlei, CLANWILLIAM)

vi) Olea africana JUNE
(probable record) olive orchard near proteoid Mountain Fynbos: 3.1. on granite (Paarl Mountain, PAARL)

vii) Rhus sp. or spp. aff. R. undulata (MAY, JUNE, JULY)
(possible records) Kloof Scrub: 2. between karoo and Mountain Fynbos (Kransvlei, CLANWILLIAM and Gamka Reserve, CALITZDORP)

viii) Pinus pinaster (Skead 1960)

Possible additional food plants, by type:

1. Elegia sp. aff. E. parviflora (Cedarberg); Hypodiscus sp. or spp. H. striatus (Kouga and Cockscomb); Staberoha distachya (Groot Drakenstein); Briza sp. (Jonkershoek).

2. Relhania squarrosa (Cedarberg); Pteronia camphorata (Klein Swartberg)

3. Aspalathus perfoliata (Tulbagh)

4. Secamone alpini (Groot Drakenstein); Rhus angustifolia (Tulbagh); Widdringtonia nodiflora (Bains Kloof)

5. Rhus sp. or spp. (Groot Drakenstein and Gamka Reserve); Olea sp. (Piketberg garden); Crataegus sp. (Piketberg garden); Chrysanthemoides monilifera (Groot Drakenstein)

6. Erica pinea (Bains Kloof); Erica lucida (Hex River range)

8. Euryops ericoides (Attakwas range); Chrysanthemoides monilifera (Groot Drakenstein); Indigofera frutescens (Groot Drakenstein); Aspalathus sp. (Saw Edge, Worcester); Brabeium stellatifolium (Jonkershoek); Arctotis semipapposa (Slanghoek); Oxalis spp. (Rooi Els); Osteospermum spinosum (Groot Drakenstein)

11. Animal food (all Insecta)

i) Isoptera (termite imagos) APRIL
(taken from ground) mature open Mountain Fynbos: (Pakhuis Pass, northern CEDARBERG)

ii) Coleoptera: Gastrophysa polygoni APRIL
(fresh hard remains of imagos found at flowering head of Protea punctata at which bird foraged) mature proteoid Mountain Fynbos:
(Mannetjiesberg, KAMMANASSIE RANGE)

iii) Homoptera: Aphididae (aphid imagos) JUNE
(taken from swarm on branch of Widdringtonia cedarbergensis)
Mountain Fynbos: (Middelberg, central CEDARBERG)

iv) Homoptera: Coccidae (scale insect imagos) MARCH
(taken from green leaves of Protea punctata) mature proteoid
Mountain Fynbos: (Towerkop, KLEINSWARTBERG)

v) Unidentified small insect imagos JULY
(taken from under rolled edges of green leaves of Protea laurifolia)
mature proteoid Mountain Fynbos: (Elandskloof, southern CEDARBERG)

vi) Unidentified insect larvae JUNE, JULY
(on green foliage of Rhus sp. aff. R. undulata) Kloof Scrub:
near stream between karoo and Mountain Fynbos (Kransvlei, CLANWILLIAM)

b. Serinus albogularis

1. Graminoid seed: "grasses and weeds" (Skead 1960)

2. Composite achenes

   i) Euryops abrotanifolius JULY
   (unripe achenes &/or petals) mature open proteoid Mountain Fynbos: 0,5 km from farmed flats (Schurfteberg, CERES)

   ii) Stoebe plumosa AUG.
   (probable record) mature Mountain Fynbos: 3.1.(Rooiland, Klein Winterhoek, TULBAGH)

   iii) Relhania sessiliflora APRIL
   short grassy Coastal Rhenosterbosveld (Bontebok Park, SWELLENDAM)

   iv) Sonchus sp. aff. S. asper AUG.
   herbaceous roadside in Coastal Rhenosterbosveld (Faure, CAPE FLATS)

   v) Othonna coronopifolia SEPT.
   (flowers and seed-heads taken, LANGEBAAN, Rowan pers. comm.)

   vi) Eriocephalus sp. aff. E. africanus
   (birds take achenes, discarding pappus, Rowan pers. comm.)

   vii) Compositae, including Senecio (Skead 1960)

3. Other small seed:

   i) Chenopodium sp. JUNE
   roadside weedland near agriculture and dry Mountain Fynbos (near Excelsior, COLD BOKKEVELD)

   ii) Erodium moschatum AUG., SEPT.
   herbaceous roadside in Coastal Fynbos/Broad-leaved Dune Scrub with alien Acacia (Faure and Faure Road, CAPE FLATS)

   iii) Polycarena sp. JULY
   agricultural field in dry proteoid Mountain Fynbos: 1.2 (Gifberg/ Matsikamma, VANRHYNSDORP)

   iv) Salsola kali MAY, JUNE
   disturbed Mountain Rhenosterbosveld near transition to karoo (Beukesfontein, SWARTRUGGENS RANGE); roadside in Karroid Broken Veld (Nieuweveld range, BEAUFORT WEST); Salsola sp. also taken in July at LANGEBAAN, Rowan pers. comm.

   v) Zygophyllum sp. aff. Z. morgsana APRIL
   riverside Succulent Karoo (Doring River, TANQUA KAROO)

4. Larger seed

   i) Emex australis SEPT.
   agricultural field in Strandveld/Coastal Fynbos transition (Mooimaak, LANGEBAAN)

ii) Acacia cyclops AUG.
Coastal Fynbos/Broad-leaved Dune Scrub with alien Acacia (Faure, CAPE FLATS)

iii) Protea laurifolia MARCH, possibly JULY
(feeding behaviour at mature heads - seeds possibly taken) undisturbed mature arid proteoid Mountain Fynbos (Witteberg, MATJIESFONTEIN). Protea repens probably also taken, CERES, July.

iv) Raphanus raphanistrum AUG.
weedy orchard 0,5 km from proteoid Mountain Fynbos: (Winterhoek, TULBAGH); herbaceous roadside in Coastal Fynbos/ Broad-leaved Dune Scrub with alien Acacia (Faure Road, CAPE FLATS); herbaceous roadside in Coastal Rhenosterbosveld (Faure, STELLENBOSCH)

v) Aloe (Skead 1960)

vi) Helianthus annuus (Skead 1960)

5. Seed kernels

i) Chrysanthemoides incana AUG.
(developing seed in green drupes) strandveld (Melkbos, CAPE TOWN)

ii) Olea exasperata JULY
(kernel of developing seed in unripe fruit) Broad-leaved Dune Scrub (Bellville South, CAPE FLATS)

6. Nectar (probable records)

i) Erica sp. aff. E. speciosa MARCH
undisturbed mature arid proteoid Mountain Fynbos (Witteberg, MATJIESFONTEIN)

ii) Microloma sagittatum JUNE
Namaqua Broken Veld (southern NAMAQUALAND)

iii) Tecomaria sp. AUG.
(20 flowers plucked in 5 min, Grahamstown, Rowan pers. comm.)

7. Fruit-pulp

i) Chrysanthemoides incana AUG.
(ripe fruit-pulp taken, kernel discarded) strandveld (Melkbos, CAPE TOWN)

ii) "berries" (Skead 1960; Winterbottom 1973)

8. Fresh floral parts

i) Zygophyllum sp. aff. Z. morgsana SEPT.
(Strandveld, LANGEBAAN, Burger pers. comm.)

ii) Othonna coronopifolia & Euryops abrotanifolius: see 1: (i) & (v)

iii) Buds (foliage &/or floral) of Euphorbia (Skead 1960; Winterbottom 1973)

iv) "Flowers" (Winterbottom 1973)

9. Foliage buds (see 8: iii)

10. Leaf pulp (taken by hollowing out succulent leaves)

i) Kleinia sp. SEPT.
(Strandveld, LANGEBAAN, Burger pers. comm.)

11. Animal food

i) Scale insect imagos (Homoptera: Coccidae) JULY
(taken from underside of young leaves on flowering shrubs of Rhus glauca) Broad-leaved Dune Scrub (Bellville South, CAPE FLATS)

Other records, part eaten not clearly observed:

Lycium campanulatum; Restio sp. aff. R. curviramis; and Protea laurifolia (head just past flowering, JULY)

C. Serinus gularis

1. Graminoid seed: Gramineae including Zea mays (maize) and Pennisetum typhoideum (bullrush millet)(Skead 1960). See addenda

2. Composite achenes

i) Eriocephalus africanus JULY
Ericoid Dry Mountain Fynbos: 1.3 adjacent to proteoid Mountain Fynbos, settlement, agricultural land and alien woodland (Waterfall, TULBAGH)

ii) Compositae in general (Skead 1960)

3. Other small seed

i) Solanaceae, sp. indet. (herbaceous annual) JULY
Kloof Scrub with Acacia karoo near Mountain Fynbos: 1.2.
(Meirings Poort, SWARTBERG)

ii) Amaranthus sp. AUG.
successional agricultural field, 0,5 km from proteoid Mountain Fynbos: 3.1 (Winterhoek, TULBAGH)

iii) Chenopodium sp. (possibly floral parts also) JULY
successional agricultural field in Succulent Mountain Scrub form of karoo (Drinkrivier, DE RUST)

iv) Salsola kali JUNE
disturbed Mountain Rhenosterbosveld near the transition to karoo (Beukesfontein, SWARTRUGGENS RANGE)

v) Aspalathus perfoliata JAN.
mature proteoid Mountain Fynbos: 3.1 near indigenous forest patch and agricultural land (Winterhoek, TULBAGH)

vi) Chironia baccifera (see 7: ii)

vii) Tecomaria capensis, Nicotiana, Stellaria, Cassia (Skead 1960)

4. Larger seed

i) Aloe ferox OCT.
(green seeds taken by boring into the fleshy capsule; recorded also by Skead 1960) Ericoid Dry Mountain Fynbos/Dry Scrub transition: 1.3 (Towerwaterkloof, KOUGA RANGE)

ii) Opuntia sp. (bird bored into fruit to take seed)
(Bushveld, Albany District, C.J. Skead 1947, Ostrich, 18(2): 155-165; also Skead 1960)

iii) Pinus, Casuarina, Acacia karoo (kernels in seeds from green pods), Asimina triloba (kernels in seeds), Zea mays (see 1), Helianthus, (Skead 1960)

5. Seed kernels

i) Aloe ferox (see 4: i)

ii) Opuntia , Acacia, Asimina (see 4: ii & iii)

6. Nectar (floral parts possibly also taken)

i) Melianthus sp. aff. M. comosus JULY
Kloof Scrub with Acacia karoo, near Mountain Fynbos: 1.2
(Meirings Poort, SWARTBERG).

ii) Aloe sp. or spp. (Oatley & Skead 1972; birds pull out flowers, using feet, and take nectar, Rowan pers. comm.)

iii) Tecomaria sp. (Skead 1960; Rowan pers. comm.

7. Fruit-pulp

i) Maytenus oleoides JAN. :3.1.
mature proteoid Mountain Fynbos near indigenous forest patch and agricultural land (Winterhoek, TULBAGH)

ii) Chironia baccifera MAY
(fruit-pulp taken contained small seeds) Dry Scrub near stream and Mountain Fynbos: 1.3 (Dwarsrivier, KOUGA RANGE)

iii) Olea africana AUG., SEPT.
road verge in agricultural land, formerly Mountain Fynbos/Coastal Rhenosterbosveld transition (PAARL)

iv) Morus sp. ("fairly ripe mulberries", Oct., PRETORIA, Milstein 1973)

v) Ripe and unripe fruit e.g. Ficus, Lantana (Skead 1960)

8. Fresh floral parts

i) Nymania capensis JULY
(nectar possibly also taken) Kloof Scrub with Acacia karoo, near Mountain Fynbos: 1.2 (Meirings Poort, SWARTBERG)

ii) Euphorbia ingens
("buds & flowers", Rowan pers. comm.)

iii) Floral heads, spikes, buds, stamens and petals of Aloe, Prunus, Rumex (Skead 1960; Rowan pers. comm.); Aloe developing anthers taken from unopened flowers (Skead 1960)

9. Foliage buds

i) "Sprouting leaf buds" (Skead 1960)

ii) possibly Euphorbia (see 8: ii)

10. Succulent leaf-pulp

i) Lampranthus sp. JUNE
Dry Scrub at Mountain Fynbos/Karroid Broken Veld transition (Grays Pass, PIKETBERG/CITRUSDAL)

11. Animal food

i) insect imago MARCH
hawked aerially (behaviour recorded also by Skead 1960)
drainage line with Acacia karoo in Karroid Broken Veld (LAINGSBURG)

ii) insect larvae OCT.
(in gall on shoot of Tarchonanthus camphoratus) Valley Scrub near Mountain Fynbos:1.3, Riverine Fynbos and Dry Scrub (Sipree River, KOUGA RANGE)

iii) termites (Insecta: Isoptera) and larvae (Insecta: Lepidoptera) (Skead 1960)

d. Serinus sulphuratus

1. Graminoid seed

i) Digitaria horizontalis (Wits. Bird Club Newsletter; grass seed also recorded by Skead 1960)

2. Composite achenes

i) Euryops virgineus OCT.
(fresh capitula; developing achenes probably taken)
Valley Scrub between Mountain Fynbos and Dry Scrub (Dwarsrivier, KOUGA RANGE)

ii) Othonna rigens AUG.
(fresh flowering head) youthful proteoid Mountain Fynbos: 3.1 (Duiwelskloof, GROOT DRAKENSTEIN)

iii) Eriocephalus africanus AUG., SEPT.
road verge in cultivated Coastal Rhenosterbosveld (Suid Agter PAARL; probably also Klawer Vlei, STELLENBOSCH)

iv) Compositae, e.g. Ursinia (Skead 1960; Rowan pers. comm.)

3. Other small seed

i) Pelargonium sp. aff. P. tabulare OCT.
youthful proteoid Mountain Fynbos: 3.1 (Duiwelskloof, GROOT DRAKENSTEIN)

ii) Chenopodium sp. AUG.
weedy vineyard near Coastal Rhenosterbosveld (Klawer Vlei, FAURE)

iii) Stellaria sp. AUG.
(probable record) weedy vineyard, 0,5 km from Mountain Fynbos: 3.1 (PAARL)

4. Larger seed

i) Raphanus raphanistrum AUG.
(seed in green pods) weedy orchard 0,5 km from proteoid Mountain Fynbos 3.1 (Winterhoek, TULBAGH); herbaceous roadside near Acacia thicket and Coastal Fynbos (Faure, CAPE FLATS); also Skead 1960; Rowan pers. comm.

ii) Chrysanthemoides monilifera OCT.
(probably kernels in young drupes) disturbed Dry Scrub near Mountain Fynbos (Towerwaterkloof, KOUGA RANGE)

iii) Acacia cyclops MAY
(seeds &/or aril-like funicles) disturbed dry Coastal Fynbos, with Acacia thicket, on shale (Elim, BREDASDORP)

iv) Protea arborea JULY
(fallen seed, taken from foliage) mature proteoid Mountain Fynbos: 3.1 (Paarl Mountain, PAARL)

v) Pinus pinaster MAY
mature proteoid Mountain Fynbos: 3.1 with tall pines (Paarl Mountain, PAARL); also McLeod 1952; seeds of Pinus recorded also by Skead (1960)

vi) Euphorbia (green and dry seeds), Emex australis, Helianthus annuus (Skead 1960)

vii) Widdringtonia sp. aff. W. nodiflora (Rowan pers. comm.)

5. Seed kernels

i) Olea africana APRIL, JUNE, JULY, AUG.
(kernel of developing seed in green fruit and, on one occasion (Aug.), in ripe fruit). Olea stand in mature proteoid Mountain Fynbos: 3.1 (Paarl Mountain, PAARL)

ii) Olea exasperata JULY, AUG.
(kernel of developing seed in green fruit) Broad-leaved Dune Scrub (Bellville South, CAPE FLATS; also Swartklip, FALSE BAY, (Frost pers. comm.)

iii) Cassytha ciliolata MAY
(ripe fruit-pulp also?) mature streamside Mountain Fynbos: 3.1 (Helderberg, SOMERSET WEST)

iv) Cotoneaster sp. (birds discard flesh of berries, taking seeds, Rowan pers. comm.; recorded also by Middlemiss 1974; part taken not specified)

v) Crataegus sp. (cultivated hawthorn) (suburban CAPE TOWN, part of fruits taken not specified, Middlemiss 1974)

vi) Scutia myrtina (from green fruits, Bushveld, Albany District, C.J. Skead 1947, Ostrich, 18(2): 155-165)

vii) Chrysanthemoides monilifera (see 4: ii)

viii) Rhus spp. (kernels &/or fruit-pulp) disturbed Coastal Scrub with Acacia thicket and vlei (Rondevlei, CAPE FLATS, Langley pers. comm.); possibly also Dry Scrub (KOUGA RANGE, Oct.)

6. Nectar

i) Psoralea aphylla MAY
(nectar &/or fresh floral parts) streamside Mountain Fynbos: 3.1 Duiwelskloof, GROOT DRAKENSTEIN)

ii) Nectar (Oatley & Skead 1972)

7. Fruit-pulp

i) Diospyros glabra FEB.
(ripe fruit-pulp; possibly also kernels) disturbed mature proteoid Mountain Fynbos: 3.1 (Molenaarsrivier, SLANGHOEK)

ii) Olea africana MAY, AUG.
Olea stand in mature proteoid Mountain Fynbos : 3.1 on granite (Paarl Mountain, PAARL)

iii) Pyracantha sp. (possible that kernels, and not fruit-pulp, taken) (suburban gardens, STELLENBOSCH, "Autumn", Siegfried 1968); ripe berries recorded also by Rowan (pers. comm.)

iv) Ehretia, Lycium, "Australian Privet" (Skead 1960); "berries" (MacLeod 1952)

v) "Wild grenadilla" (Eastern Cape, A.J. Tree 1970, Ostrich, 41(3): 220)

8. Fresh floral parts

i) Euphorbia ingens (flowers & buds, Rowan pers. comm; buds of Euphorbia recorded also by McLachlan & Liversidge 1972)

ii) Psoralea (possibly, see 6: ii)

iii) Leucospermum calligerum SEPT.
(floral parts, nectar or insects possibly taken) Coastal Rhenosterbosveld near dry Mountain Fynbos: 1.2 (Paardeberg, MALMESBURY)

9. Foliage buds: possibly Euphorbia (see 8: ii)

10. -

11. Animal food

i) Eggs of moth sp. (Insecta: Lepidoptera: Saturniidae) MAY
(taken from leaves of fruiting shrubs of Rhus angustifolia)
mature streamside Mountain Fynbos: 3.1 (Helderberg, SOMERSET WEST)

ii) Scale insect imagos (Homoptera: Coccidae) JULY
Broad-leaved Dune Scrub; taken from underside of young leaves on flowering shrubs of Rhus glauca (Bellville South, CAPE FLATS)

iii) Imagos of Diptera AUG.
(taken from foliage of flowering Maytenus oleoides (probable record)
youthful proteoid Mountain Fynbos (Duiwelskloof, GROOT DRAKENSTEIN)

iv) Insecta: Isoptera (termites, hawked aerially, Natal Bird Club Newsletter, 1953)

c. Serinus tottus

1. Graminoid seed

i) Ficinia bracteata SEPT., OCT., NOV.
(birds appeared also occasionally to take young shoots from under leaf-sheaths) youthful Mountain Fynbos: 3.1 (Duiwelskloof, GROOT DRAKENSTEIN)

ii) Ficinia sp. aff. F. involuta APRIL
mature Coastal Fynbos on limestone (San Sebastian, CAPE INFANTA

iii) Restio sp. aff. R. sejunctus APRIL
high-altitude Mountain Fynbos: 3.3 (Towerkop, KLEIN SWARTBERG)

iv) Thamnochortus punctatus JULY
mature proteoid Mountain Fynbos: 1.1 (Bokkeveld Escarpment, NIEUWOUDTVILLE)

v) Thamnochortus sp. nov. Esterhuysen 32463 APRIL
mature Coastal Fynbos on limestone (San Sebastian, CAPE INFANTA)

vi) "grasses" (Skead 1960)

2. Composite achenes

i) Stoebe sp. aff. S. cinerea APRIL
mature proteoid Mountain Fynbos: 3.3 (Mannetjiesberg, KAMMANASSIE RANGE)

ii) Stoebe sp. aff. S. spiralis JULY
mature ericoid-restioid Mountain Fynbos: 3.2 (Baviaanskloof, BAINS KLOOF)

iii) Stoebe plumosa possibly MAY & JUNE, July
mature Mountain Fynbos: 3.1 near agricultural land (Agter Witzenberg, CERES); possibly also dry disturbed Mountain Fynbos: 1.3 (birds foraging on ground under shrubs of this species)(near Excelsior, COLD BOKKEVELD and Merwede, Hex River range, CERES)

iv) Elytropappus rhinocerotis JUNE
(E. adpressus possibly also taken: see 8: ii) roadside in arid Mountain Fynbos: 1.3/Mountain Rhenosterbosveld transition (near Katbakkies, SWARTRUGGENS RANGE)

v) Athanasia sp. aff. A. hirsuta APRIL
mature proteoid Mountain Fynbos: 3.3 (Mannetjiesberg, KAMMANASSIE RANGE)

vi) Athanasia sp. aff. A. trifurcata JUNE
(probable record, birds foraging on ground under seeding shrubs of this species) dry disturbed Mountain Fynbos: 1.2 (near Excelsior, COLD BOKKEVELD)

vii) Metalasia muricata SEPT.
mature ericoid-restioid Mountain Fynbos: 3.2 (Baviaanskloof, BAINS KLOOF)

3. Other small seed

i) Chenopodium sp. or spp. JUNE
weedland near agriculture and dry Mountain Fynbos: 1.2 (near Liberty and near Excelsior, COLD BOKKEVELD)

ii) Ericaceae, minor genera, sp. or spp. indet. JUNE, probably AUG.
mature open proteoid Mountain Fynbos (Wolfkloof, Greyton, RIVIERSONDEREND RANGE; probably also Rooi Els, GORDONS BAY)

iii) Brunia sp. MARCH
(St. James, CAPE PENINSULA, Rowan pers. comm.)

iv) Cliffortia spp. (possible records: see 9: iii & iv)

4. Larger seed

i) Leucadendron eucalyptifolium MARCH
mature Mountain Fynbos: 3.2 (Towerkop, KLEIN SWARTBERG)

ii) Leucadendron meridianum MAY
mature proteoid Coastal Fynbos on limestone (Hagel Kraal, PEARLY BEACH; possibly also San Sebastian, CAPE INFANTA)

iii) Leucadendron salignum probably JUNE
(seeds taken from dehiscing cones after fire) Mountain Fynbos near Valley Bushveld (Rooikrantz farm, UITENHAGE, anon. pers. comm.)

iv) Leucadendron sp. FEB.
(seeds taken from open cones, Hout Bay, CAPE PENINSULA, Rowan pers. comm.)

v) Protea neriifolia OCT.
(seed, prematurely dehisced after fire, taken from ground) burnt proteoid Mountain Fynbos: 3.1 (Graslaagtekloof, KOUGA RANGE)

vi) Protea laurifolia JULY
(foraging behaviour at mature, open heads; seed picked up in bill) mature arid proteoid Mountain Fynbos: 1.1 /Mountain Rhenosterbosveld transition (Winterberg, Klondyke, Lakenvalley, CERES)

vii) Leucadendron & Protea (Skead 1960)

5. Seed kernels: no records

6. Nectar

i) Protea punctata MARCH, APRIL
(fresh head: nectar &/or insects &/or floral parts taken) mature proteoid Mountain Fynbos: 3.3 (Mannetjiesberg, KAMMANASSIE RANGE; Towerkop & Toringberg, KLEIN SWARTBERG)

ii) Erica plukeneti JULY
mature ericoid-restioid Mountain Fynbos: 3.2(Baviaanskloof, BAINS KLOOF)

7. Fruit-pulp: no records

8. Fresh floral parts: recorded by Skead (1960)

9. Foliage buds (recorded also by Skead 1960)

i) Cliffortia ruscifolia JAN., MARCH
mature dry proteoid Mountain Fynbos: 3.1 (Kaffirkop, southern CEDARBERG & Theronsberg Pass, Waboomsberg, CERES)

ii) Cliffortia serpyllifolia MARCH, APRIL
very mature (40 years since last fire) Mountain Fynbos: 3.1 near indigenous forest (Marloth Nature Reserve, SWELLENDAM)

iii) Cliffortia sp. aff. C. castanea OCT.
(seeds &/or buds taken) mature proteoid Mountain Fynbos: 3.1 (Graslaagtekloof, KOUGA RANGE)

iv) Cliffortia sp. aff. C. polygonifolia JULY
(seeds &/or buds taken) roadside in dry Mountain Fynbos: 1.2 (Bonniedale road, ATTAKWAS RANGE)

10. -

11. Animal food

i) insects, taken from Eucalyptus trees (Kirstenbosch, CAPE PENINSULA, Dyer pers. comm.)
ii) "Insects" (Skead 1960) (see also 6 i)

11. Unidentified foods, taken from the ground

i) Michells Pass, CERES, Dec., bird fed under shrubs including Passerina and Phylica

ii) Erfdeel, Matroosberg, CERES, July, birds fed under shrubs of Cliffortia ruscifolia and seeding Elytropappus adpressus

iii) Urticaceae, sp. indet. (forb, part eaten unknown, insects possibly taken), Oct., Coastal/Mountain Fynbos transition (Hangklip, BETTYS BAY)

iv) Graslaagtekloof, KOUGA RANGE, Oct., birds fed under shrubs of Leucadendron spp. setting seed 38 days after fire.

f. Serinus flaviventris

1. Graminoid seed

i) Cannomois acuminata MARCH
(probable record) mature Coastal Fynbos on sand, with Acacia saligna thicket (Mamre Road, MALMESBURY)

ii) Thamnochortus punctatus MAY
(probable record) mature restioid-ericoid Coastal Fynbos on sand, with Acacia saligna thicket (Mamre Road, MALMESBURY)

2. Composite achenes

i) Bidens pilosa AUG.
successional weedfield in orchard 0,5 km from proteoid Mountain Fynbos: 3.1 (Winterhoek, TULBAGH)

ii) Stoebe plumosa JULY
mature Mountain Fynbos: 3.1 near agricultural land (Agter Witzenberg, CERES).

iii) Elytropappus rhinocerotis JUNE
Mountain Rhenosterbosveld (near Katbakkies, SWARTRUGGENS RANGE)

iv) Senecio pubigerus JULY
weedy agricultural field near Coastal Rhenosterbosveld (Klapmuts, PAARL)

v) Arctotheca calendula SEPT.
herbaceous roadside in cultivated Coastal Rhenosterbosveld (Blouberg, CAPE TOWN; Romans River WOLSELEY)

vi) Eriocephalus africanus AUG., SEPT.
Coastal Rhenosterbosveld near agricultural land (Klawer Vlei, FAURE; Hercules Pillar, PAARL)

(Eriocephalus sp. taken also in July, Darling, MALMESBURY, Rowan pers. comm.)

vii) Microstephium populifolium ("unripe seed heads", Skead 1960)

3. Other small seed

i) Chenopodium sp. or spp. JUNE, AUG.
weedfield near agricultural land and dry Mountain Fynbos: 1.2 (near Liberty & near Excelsior, COLD BOKKEVELD); weedy vineyard near Coastal Rhenosterbosveld (Klawer Vlei, FAURE).

ii) Gnidia sp. aff. G. squarrosa SEPT.
roadside in cultivated Coastal Rhenosterbosveld (between Klapmuts & Suid Agter Paarl, PAARL)

iii) Diascia sp. SEPT.
roadside in Strandveld/Coastal Fynbos transition (Mooimaak, LANGEBAAN)

iv) Rumex acetosella SEPT.
weedfield in cultivated Coastal Rhenosterbosveld (Romans River, WOLSELEY)

v) small seeds recorded also by Skead (1960); McLachlan & Liversidge (1972)

vi) Dorotheanthus oculatus SEPT.
(herbaceous annual: part taken unknown, possibly seed or fleshy seed capsule) Strandveld/Coastal Fynbos transition (Mooimaak, LANGEBAAN)

4. Larger seed: no records

5. Seed kernels: no records

6. Nectar

i) Erica plukeneti APRIL
mature proteoid Coastal Fynbos on sandstone (San Sebastian, CAPE INFANTA)

7. Fruit-pulp: no records

8. Fresh floral parts

i) Melianthus sp. AUG.
(fresh petals, Rowan pers. comm.)

9. Foliage buds

i) Cliffortia ruscifolia possibly JUNE, JULY
(foliage buds probably taken) disturbed dry Mountain Fynbos: 1.2 (Outuin holding, Bokkeveld Plateau, NIEWOUDTVILLE; possibly also near Liberty, COLD BOKKEVELD)

10. –

11. Animal food

i) Crustacea: Amphipoda: Talorchestia quadrispinosa ("sand hopper") intertidal zone, Cape of Good Hope Nature Reserve (Skead 1966)

ii) Insecta: Diptera (fly pupae) intertidal zone, Cape of Good Hope Nature Reserve (Skead 1966)

iii) "termites" (McLachlan & Liversidge 1972)

9. Serinus canicollis

1. Graminoid seed

i) Eragrostis curvula
(Natal, D.M. Skead 1967, Ostrich, 38(1): 36)

ii) Brachymeris sp.
(Transvaal, Wits. Bird Club Newsletter, 60, 1967)

iii) small soft green seeds of "grasses and weeds" (Skead 1960; Winterbottom 1973)

2. Composite achenes

i) Senecio pubigerus & allies APRIL, MAY, JUNE, OCT., NOV.
roadsides in mature proteoid Mountain Fynbos: 3.1 on granite (Paarl Mountain, PAARL); youthful marshy Mountain Fynbos:3.1 (Duiwelskloof, GROOT DRAKENSTEIN); mature proteoid Mountain Fynbos:3.1 (Helderberg, SOMERSET WEST)

ii) Inula graveolens APRIL, MAY
roadside in mature proteoid Mountain Fynbos:3.1 on granite (Paarl Mountain, PAARL)

iii) Metalasia muricata APRIL, MAY, JUNE, JULY
mature proteoid Mountain Fynbos: 3.1 on granite (Paarl Mountain, PAARL); mature proteoid Mountain Fynbos: (Helderberg, SOMERSET WEST)

iv) Stoebe plumosa JUNE, JULY
mature proteoid Mountain Fynbos: 3.1 (Gydo Pass, CERES); mature Mountain Fynbos:3.1 near agricultural land (Agter Witzenberg, CERES); disturbed dry Mountain Fynbos: 1:2 (near Excelsior, COLD BOKKEVELD)

v) Athanasia trifurcata APRIL
roadside in mature proteoid Mountain Fynbos: 3.1 (Paarl Mountain, PAARL)

vi) Elytropappus gnaphaloides MAY
roadside in vineyard near mature proteoid Mountain Fynbos: 3.1 (Paarl Mountain, PAARL)

vii) Eriocephalus africanus AUG., SEPT.
mature proteoid Mountain Fynbos: 3.1 (Paarl Mountain, PAARL)

viii) Eriocephalus racemosus OCT.
Coastal Fynbos with Acacia thicket (Eerste River, FAURE)

ix) Sonchus spp. JUNE, SEPT, NOV.
urban environment in Succulent Karoo (VANRHYNSDORP); herbaceous roadside in cultivated Coastal Rhenosterbosveld (Blouberg, CAPE TOWN) weedfield in cultivated Coastal Rhenosterbosveld (Romans River, WOLSELEY); weedy lawn in garden adjacent to indigenous scrub forest (Nature's Valley, PLETTENBERG BAY)

x) Sonchus oleraceus
disturbed coastal scrub with Acacia thicket and vlei (Rondevlei, CAPE FLATS, Middlemiss 1974)

xi) unripe achenes of Compositae, e.g. Ursinia (including U. annua), Senecio,(including S. juniperinus), Osteospermum & Venidium, (Skead 1960; Rowan pers. comm.)

3. Other small seed

i) Amaranthus sp. AUG.
weedy orchard 0,5 km from mature proteoid Mountain Fynbos: 3.1 (Winterhoek, TULBAGH)

ii) Chenopodium sp. or spp. JUNE, AUG.
weedy vineyard 0,5 km from mature proteoid Mountain Fynbos: 3.1 (Paarl Mountain, PAARL); weedy vineyard near Coastal Rhenosterbosveld (Klawer Vlei, STELLENBOSCH); weedland near agricultural land and dry Mountain Fynbos: 1.2 (near Liberty & near Excelsior, COLD BOKKEVELD)

iii) Ericaceae, minor genus, sp. indet JUNE
mature open proteoid Mountain Fynbos: 3.1 (Wolfkloof, Greyton, RIVIERSONDEREND RANGE)

iv) Ericaceae, minor genus, sp. indet. AUG.
mature open proteoid Mountain Fynbos: 3.1 (Steenbras River Mouth, GORDONS BAY)

v) Gnidia sp. aff. G. squarrosa AUG.
relict of vegetation in vacant lot, formerly Coastal Rhenosterbosveld (suburban SOMERSET WEST)

vi) Stellaria media SEPT., NOV.
suburban garden (U.C.T. campus, CAPE TOWN); Nature's Valley (Ashmead Park, KNYSNA)

vii) Raphanus raphanistrum ("green pods", Rowan pers. comm.)

4. Larger seed: no records

5. Seed kernels: no records

6. Nectar: see 8: (i)

7. Fruit-pulp

i) fruit of "loquats and guavas" (Skead 1960)

8. Fresh floral parts

i) "flowers" (including nectar?) of Salvia sp. (Skead 1960)

9. Foliage buds: no records
10. -
11. Animal food

i) "large insect" (Insecta: Orthoptera?)
(Drakensberg, W.L. Chiazzari 1952, Ostrich, 23(2): 127)

h. Serinus scotops

1. Graminoid seed

i) Panicum deustum NOV.
(Wilderness, GEORGE, Rowan pers. comm.)

2. Composite achenes

i) Senecio sp. aff. S. pubigerus APRIL
edge of indigenous forest near very mature (40 years since last fire) Mountain Fynbos: 3.1 (Marloth Nature Reserve, SWELLENDAM)

3. Other small seed

i) "seeds of weeds and indigenous shrubs" (Skead 1960)

4. Larger seed: no records other than possibly seeds in fruits (see 7: i-iii)

5. Seed kernels: no records other than possibly kernels in fruits (see 7 i-iii) (see addenda)

6. Nectar

i) Virgilia oroboides MARCH
(floral parts possibly taken) edge of indigenous forest near pine plantation and fynbos (Kliprivierkloof, SWELLENDAM)

7. Fruit-pulp

i) Fagara capensis
(Alexandria forest, ALEXANDRIA, Harkus pers.comm.)

ii) Trema orientalis JULY
(NKUTU FALLS, Natal Bird Club newsletter, 1965)

iii) Anthospermum sp.; "berries and small wild fruits" (Skead 1960)

8. Fresh floral parts

i) tentative record for "flowers", plant species not recorded (Alexandria forest, ALEXANDRIA, Harkus pers. comm.)

ii) Virgilia oroboides (possible record; see 6: i)

9. Foliage buds

i) Cliffortia serpyllifolia APRIL
edge of indigenous forest near pine plantation and fynbos (Kliprivierkloof, SWELLENDAM)

ii) Ptaeroxylon obliquum (ends of petioles of young leaves, Skead 1960)

iii) several tentative records, plant species not recorded Alexandria forest, ALEXANDRIA (Harkus, pers. comm.)

10. –

11. –

APPENDIX 7 : Addenda

c. Serinus gularis

1. Graminoid seed

ii) Ehrharta calycina & E. erecta NOV.

disturbed site in Coastal Dune Scrub at edge of indigenous scrub forest (Nature's Valley, PLETTENBERG BAY)

iii) Briza maxima NOV.
disturbed site in Coastal Dune Scrub at edge of indigenous scrub forest (Nature's Valley, PLETTENBERG BAY)

3. Other small seed

viii) Passerina vulgaris NOV.
Coastal Dune Scrub at edge of indigenous scrub forest (Nature's Valley, PLETTENBERG BAY) (possibly also Pelargonium capitatum at same site)

d. Serinus sulphuratus

3. Other small seed

iv) Pelargonium capitatum NOV.
disturbed site in Coastal Dune Scrub at edge of indigenous scrub forest (Nature's Valley, PLETTENBERG BAY)

v) Passerina vulgaris NOV.
Coastal Dune Scrub at edge of indigenous scrub forest (Nature's Valley, PLETTENBERG BAY)

4. Larger seed

viii) Rhus crenata NOV.
(seed in dried fruits) Coastal Dune Scrub at edge of indigenous scrub forest (Nature's Valley, PLETTENBERG BAY)

ix) Phylica lasiocarpa NOV.
Coastal Dune Scrub at edge of indigenous scrub forest (Nature's Valley, PLETTENBERG BAY)

e. Serinus tottus

3. Other small seed

v) Passerina vulgaris NOV.
Coastal Dune Scrub at edge of indigenous scrub forest (Nature's Valley, PLETTENBERG BAY); ericoid Coastal Fynbos near broad-leaved scrub on Table Mountain sandstone (Robberg, PLETTENBERG BAY)

g. Serinus canicollis

1. Graminoid seed

iv) Poa annua NOV.
(immature birds) lawn in disturbed parkland adjacent to indigenous forest (Ashmead Park, KNYSNA)

2. Composite achenes

xii) Senecio ilicifolius NOV.
open proteoid Mountain Fynbos: 3.1 (PLETTENBERG BAY)

xiii) Arctotheca sp. aff. A. calendula NOV.
(adult and immature birds) lawn in disturbed parkland adjacent to indigenous forest (Ashmead Park, KNYSNA); road-verge lawn in indigenous forest (Deepwalls, KNYSNA).

xiv) Hypochoeris glabra NOV.
weedy lawn in garden adjacent to indigenous scrub forest (Nature's Valley, PLETTENBERG BAY)

3. Other small seed

viii) Passerina vulgaris NOV.
Coastal Dune Scrub at edge of indigenous scrub forest (Nature's Valley, PLETTENBERG BAY)

ix) Pelargonium capitatum NOV.
disturbed site in Coastal Dune Scrub at edge of indigenous scrub forest (Nature's Valley, PLETTENBERG BAY)

x) Caryophyllaceae, sp. indet. (weedy annual) NOV.
weedy lawn in garden adjacent to indigenous scrub forest (Nature's Valley, PLETTENBERG BAY)

11. Animal food

ii) insects possibly taken from shrubs (Knysna, NOV.)

h. Serinus scotops

3. Other small seed

i) Passerina vulgaris NOV
(possible record) (Nature's Valley, PLETTENBERG BAY)

5. Seed kernels

i) Carissa bispinosa NOV.
(seed taken from green fruits half the size of ripe fruit by removing part of the fleshy fruit-wall without detaching the fruit) indigenous forest (Nature's Valley, PLETTENBERG BAY)