Onderstepoort J. Vet. Res. (1967), *Vol.* 34 (1), 161–218.
Printed in the Republic of S. Afr. by the Government Printer, Pretoria

A SURVEY OF THE OCCURRENCE OF POTENTIALLY HARMFUL AMOUNTS OF SELENIUM IN THE VEGETATION OF THE KAROO

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INTRODUCTION

The presence of potentially dangerous amounts of selenium in various plants taken from the areas where geeldikkop and enzootic icterus are prevalent was noted in a preliminary report by Brown & de Wet in 1962. The element was found to occur in high concentrations in the livers and kidneys of animals suffering from enzootic icterus and in lesser, but still significant amounts, in the same tissues from typical cases of geeldikkop (Brown & de Wet, 1962). Some thoughts on the possible role of selenium in the aetiology of these two conditions, as well as in that of various ill-defined syndromes occurring in the same areas, were advanced in the same report. The symptomatology, pathology and incidence of naturally occurring selenosis throughout the world were reviewed at the same time and compared with those of various syndromes, thought to be of a similar nature, which occur in the Karoo. More information on the occurrence of potentially harmful amounts of selenium in the tissues of animals raised in the Karoo and Cape Midlands appeared in subsequent publications by the authors (Brown, 1962, 1963, 1964; Brown & de Wet, 1963).

In the present paper the results are presented of an extensive preliminary survey of the occurrence of the element in the dominant vegetation of the areas where geeldikkop and enzootic icterus are established. The epizootiology of these two conditions in relation to the geology, botany, climatology and farming practices of the areas concerned is discussed elsewhere (Brown, 1959a; Brown & de Boom, 1966).

THE GEOLOGY AND VELD TYPES OF THE AREAS COVERED BY THIS SURVEY

Plants were collected for these studies from the areas in which the worst annual epizootics of geeldikkop and enzootic icterus have occurred within recent years. The investigations covered a roughly rhombiform tract of country bounded by the centres Prieska, Hopetown, Fauresmith, Middelburg, Aberdeen, Beaufort West, Fraserburg and Calvinia (Fig. 1). The geological formations of this area consist of shales and sandstone of the Beaufort Series of the Karoo System which are extensively invaded by dykes and sills of Karoo dolerite.

Received for publication on 19 July 1966.—Editor

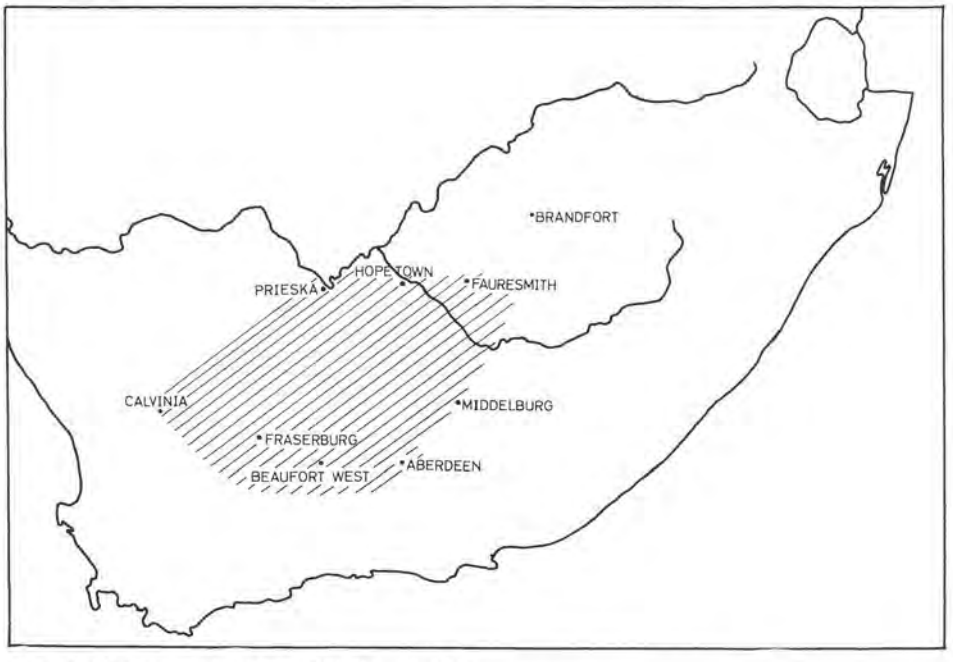

FIG. 1: The area covered by this investigation.
The centres mentioned in the text are indicated.

The Karoo system is the dominant and most widely spread system of the Republic of South Africa, in which it occupies one half of the whole territory. It occurs in the form of an enormous very shallow basin, occupying the great central area of the Cape Province north of the Cape Folded Belt, almost all of the Orange Free State, the western portion of Natal and large tracts of the south-eastern Transvaal. In the more northerly area the Karoo rocks take the form, mainly, of isolated patches or outliers from which the lower members of the system are practically absent. In the southern area—that is in the Cape geosyncline—the succession is complete and unbroken, and the system attains a maximum thickness in the neighbourhood of 25,000 feet; but in the northern area certain members are partially or entirely absent and the total thickness is very considerably reduced, often to only 2,000 to 3,000 feet. Except in the Cape Folded Belt, the strata lie flat or at faint angles, but may be locally disturbed.

The type area is the Karoo and it is there that the maximum development is attained. In general the system may be regarded as a huge thickness of shales and sandstones having as a base a thick glacial tillite and a roof of basaltic lavas. Four main divisions are recognized, namely, the Dwyka Series, the Ecca Series, the Beaufort Series and the Stormberg Series (Fig. 2).

The Dwyka Series has three divisions of which only the middle group is really extensive in the area we are concerned with, notably Upper Dwyka Shales, Dwyka Tillite and Lower Dwyka Shales. In its typical development Dwyka Tillite is a hard, bluish, sandy mudstone with boulders and pebbles of a great variety of rocks scattered through it. The pebbles and boulders are often faceted and striated, and the whole group is a typically glacial deposit. In the extreme south it is partly bedded and was apparently largely deposited in water from melting ice. Farther

north it was laid down on land as a morainic deposit, and the striated ancient land surfaces over which it moved are often visible where denudation has just removed the overlying rocks. The thickness of the tillite is over 2,000 feet at its maximum southerly development but thins out considerably northward in the area. This widespread glacial formation cannot be younger than of Upper Carboniferous age (Hamilton & Cooke, 1948).

The Ecca Series follows the Dwyka conformably in Natal and the Cape Province and attains its maximum development of over 6,000 feet next to the Cape Folded Belt, but thins out very considerably northward. The series is divided into Lower, Middle and Upper Shale beds. The Lower Ecca Shales consist of soft dark-blue shales and flagstones which rest conformably on the Dwyka. The Middle Beds which contain many extensive coal seams amongst grits, sandstones and carbonaceous shales do not concern us here, since they are best developed in Natal, the Transvaal and the northern Orange Free State. Similarly the Upper Ecca beds which form a thin group of uniform, soft dark shales overlying the Coal Measures need not be considered. The age of the series is Lower Permian (Hamilton & Cooke, 1948).

The Beaufort Series follows the Ecca quite conformably and probably occupies a greater part of the Republic than any other series or formation. It is exposed over the whole of the Great Karoo, most of the Orange Free State, western Natal, the Transkei and the Eastern Province, and also occupies a very small area in the south-eastern Transvaal. The total thickness at its maximum development is probably about 10,000 feet in the south-east of the Cape and the entire sequence is made up of sandstones and shales.

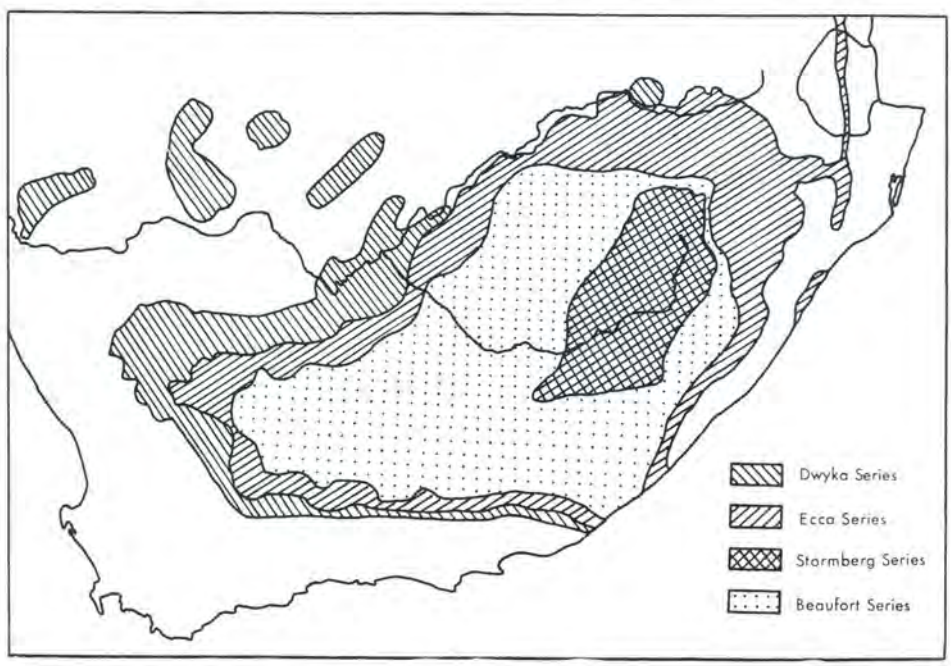

FIG. 2: Map showing the location of the Dwyka, Ecca, Stormberg and Beaufort Series in South Africa

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On lithological grounds it is divided into three groups:—

Upper Beaufort or Burghersdorp Beds Middle Beaufort Beds.....	Lower Triassic
Lower Beaufort Beds.....	Upper Permian

(Hamilton & Cooke, 1948).

The Lower Beaufort Beds consist of massive yellow-weathering felspathic sandstones alternating with blue, green, red and purple mudstones and shales reaching, at their maximum development in the southern Karoo, a thickness of some 7,000 to 8,000 feet. The Middle Beaufort Beds consist of 500 to 1,000 feet of sediments, the lower portion being made up of bright red, purple and greenish shales and the upper of yellow sandstones with thin bands of mudstones and shales. The Upper Beds consist of widely spread yellow or buff-weathering fine or medium-grained, often blue, felspathic sandstones alternating with red, blue and green shales. A band of dark-greenish, black-weathering ferruginous sandstone occurs near the top of the group. The Beaufort Series as a whole is extremely rich in vertebrate fossil remains.

The Stormberg Series, which covers the whole of Basutoland and parts of western Natal and the eastern Free State need not be considered here, except for a brief mention of one stratigraphic group of the series, namely the Drakensberg Volcanics. This group comprises some 4,000 feet of lava flows of basatls with occasional andesites. In the Stormberg area where enzootic icterus has apparently become established within recent years, bedded tuffs and agglomerates also occur near the base of the series.

During the outpouring of the Drakensberg Volcanics, the whole of Southern Africa, with the singular exception of the Cape Folded Belt in the south, was invaded by innumerable dykes and sills of dolerite. The sills, some of which are almost of laccolithic dimensions, are mainly confined to the horizontal or gently inclined Karoo sediments, but the dykes are ubiquitous. That the period of intrusion extended until after the earlier outpourings of the Drakensberg Volcanics at least is proved by the presence of long and persistent thin dykes cutting through the volcanic rocks, but it is most probable that such dykes represent feeding fissures which supplied the material for the lava flows (Hamilton & Cooke, 1948).

The characteristic Karoo dolerite consists of a fresh-looking, generally very dark, medium-grained rock made up of augite and plagioclase-felspar intergrown. Olivine is often present, giving rise to a more basic type, or the rock may very occasionally be more acid, resulting in quartz-dolerites and even granophyre or micro-granite. The dolerites are of Jurassic age (Hamilton & Cooke, 1948). The copper content of Karoo dolerite is consistently high, but abnormally so in only a few specimens which have been examined. It appears to be low in the sandstones and shales from which the soils of this region are derived (Brown & de Boom, 1966).

Photographs 1 to 4, Plate 1 are typical of the topography and geology of the areas in which this investigation was conducted.

The sandy soils of the region are derived in part from the doleritic intrusions and mainly from the rocks and shales of the Beaufort Series. Wind erosion in the Karoo is severe and in areas where enzootic icterus, particularly, is present, the topsoil is poor and shallow and the residual sandstone and shale soil types support the less palatable and inferior bushes noted in this report rather than the more valuable types. Such soils deteriorate rapidly if mismanaged (Brown & de Boom, 1966).

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PLATE 1: Illustrations typical of the geological formations of the area covered by our investigation:—

(1) Dwyka tillite; southwest of Fraserburg

(2) Sandy plains of the Beaufort Series; northeast of Fraserburg

(3) Sandstone and shale formations typical of the Beaufort Series; Nuweveld Mountains near Beaufort West

(4) Typical dolerite-capped hills in the Beaufort Series; Three Sisters near Victoria West

The veld types within the area covered by this investigation are defined by Acocks (1953) as Karroid Broken Veld [subtype (*a*) the Great Karoo], Central Upper Karoo, Western Mountain Karoo, Arid Karoo, Central Lower Karoo, false arid Karoo, false upper Karoo and false karroid broken veld (Acocks' types 26–30 and 35–37). The interested reader is referred to Acocks' monograph (1953) for full details of the botanical features of these veld types. The following brief descriptions are taken from this work.

The Great Karoo occupies undulating stony plains receiving a rainfall ranging from under five inches to about eight inches per annum; mostly in autumn; elevation above the sea ranges from 1,500 to 3,500 feet. Succulents are usually relatively scarce, but grass species are surprisingly numerous, though usually rare as regards number of individual plants. The stony plains are so completely denuded of soil *that it is difficult to imagine them in any other condition.* (The italics are ours.) The vegetation today is sparse Karooveld with stunted shrubs, especially in rocky (as distinct from stony) places, and thornveld along the rivers.

The Central Upper Karoo is well marked veld type occupying the central part of the upper plateau south of the Orange River, at altitudes ranging from 3,500 to 5,500 feet above sea level, and receiving seven to ten inches of rain per annum, the rainy season being in late summer. It is flat country dotted with dolerite hills and ranges of hills and mountains, especially south-westwards. In general the plains are stony (shale, sandstone and calcareous tufa), though sometimes covered with shallow red, sandy loam, and there are wide, silty flats or flood plains along the rivers. The hills and mountains are more grassy than the plains, but there is not the great difference that there is in the False Karoo (see below). The vegetation is a fairly grassy Karoo (the grasses being of the " white " type and represented mainly by *Eragrostis lehmanniana* and *Aristida congesta*) with bigger shrubs (*Lycium* spp. and *Rhigozum trichotomum*) mainly on the flood plains of the rivers and on and around the hills. The characteristic shrub of the hills themselves is *Rhus undulata* var. *burchelli*. On the plains, the flora is regularly richer in the stony parts than elsewhere. The flood plains sometimes retain a very dense, grassy short Karoo. The whole of this veld type is to some degree invaded by elements of the Arid Karoo and sheet eroded.

The Western Mountain Karoo occupies very stony country, mostly shale, fine grained sandstone and granite, with a topography ranging from gently undulating to steeply rolling. Rocky outcrops are few. Soil is conspicuous by its absence, except in some of the valleys and flatter parts. It has two variations: (*a*) The upper, or typical form is a tall, almost non-succulent Karoo, which merges into the Central Upper Karoo near Fraserburg, from there stretching westwards along the northern slopes of the Roggeveld mountains to the Hantamsberge near Calvinia and beyond. It is the wetter and cooler form at elevations of 3,000 to 5,000 feet above the sea and receiving 5 to 10 inches of rain per annum. It borders on the winter-rainfall area eastwards, extending into it north-westwards. The bushes grow up to three feet high, even *Pentzia incana*, which in the Central Upper Karoo and Central Lower Karoo is usually only 2 to 6 inches high. This is the dominant and characteristic bush of this veld type, except on excessively overgrazed hillsides, where *Galenia africana* becomes the dominant. Perennial grasses other than *Ehrharta calycina* and rarely *Danthonia stricta* are very scarce in this veld type. (*b*) The lower, or semi-succulent form. At lower elevations and in drier country, along the south-western foot of the Roggeveld mountains, between Calvinia and Nieuwoudtville and north of Loeriesfontein, is this shorter, semi-succulent form, which tends to break down into weedy succulent Karoo, with much *Salsola zeyheri*. It ranges in altitude from 2,000 to 3,000 feet above sea level and receives five inches and less of rain, mostly in winter. This form contains the same species as the former, though of normal stature and in different proportions, e.g. *Salsola zeyheri* tends to be common, but *mesembryanthemums* are commoner and more species occur, tending to become dominant in excessively overgrazed parts.

The Arid Karoo occupies the driest part of the Republic, with a rainfall ranging from 2 to 7 inches per annum. The altitude is mostly about 3,000 feet above sea level sloping gently to 4,000 feet along the southern margin and down to 1,500 feet along the edge of the Orange River valley in the north. The rain falls mostly in autumn, but is extremely erratic. The country is extremely flat, with few hills, except in the southern portion along the northern foot of the Roggeveld mountains. It is by nature an even grassier region than the Central Upper Karoo but the chief grasses are silvery white desert species. In parts, because they can regenerate from seed more quickly than the Karoo bushes they have become the only perennial plants. Species of Karoo bushes are plentiful, though sparser than

in the Central Upper Karoo; but larger shrubs are rare and entirely absent over large areas. There are three main variations of the Arid Karoo, viz. (*a*) *Salsola tuberculata* veld of calcareous tufa, mostly along the northern edge of the plateau. The veld is typically a uniform and fairly dense growth of *Salsola tuberculata* with *Aristida obtusa* and *A. ciliata* and no other dominants, though the flora is quite rich. The ground is often surprisingly well covered with short grasses. Annuals and geophytes are plentiful. (*b*) *Rhigozum trichotomum* veld of gravelly and stony soil, mostly in the central part and mostly on Dwyka shales and tillite and Ecca shales ranging in colour from brown to black. The soil, what there is of it, is silty rather than sandy or gravelly. Almost the whole of this form of the Arid Karoo has been reduced to virtual desert. The general bareness of this veld is not a natural condition, but rather the result of continuous grazing and the excessive heating of the exposed dark surface. The generally dominant bush is *Pentzia spinescens* with *Eriocephalus spinescens* important in the dark stony parts. *Rhigozum trichotomum* tends to occur in patches and narrow belts, forming more or less a honeycomb pattern. Succulents are sometimes fairly common. At times annuals are abundant and it sometimes happens in the barer parts eastwards that a complete cover of *Tribulus terrestris* will appear after rain. (*c*) Semi-succulent Karoo of calcareous tufa and stony soil in the southern part, south of the Carnarvon-Calvinia main road. This is not so flat nor so arid as the preceding type. It is dominated by *Salsola tuberculata* (including a form which links this species with *S. rabieana*), but less completely than in type (*a*). *Rhigozum trichotomum* does not occur, except along the northern margin. *Aristida obtusa* and *A. ciliata* are still the commonest grasses but *Mesembryanthemum* are more plentiful.

The Central Lower Karoo is related to the Arid Karoo and also occupies flat stony country, but at a rather lower elevation of 2,400 to 3,500 feet and not quite so arid, receiving 5 to 10 inches of rain per annum, nowhere less than five inches. It is partly on calcareous tufa, partly on stony sandstone and shale and partly on silty flats and flood plains. The flora is much like that of the Arid Karoo but shorter and denser, sometimes so dense as to be almost a complete cover. *Pentzia incana* and various succulents play an important part, while the grasses, predominantly *Aristida obtusa* and *A. ciliata* are of the Arid Karoo type. In this denser veld, annuals are less important than they are in the arid Karoo; *Galenia* spp. are the commonest.

The False Karoo types are those in which the original type has been so completely invaded by elements of the Arid Karoo that the veld is little different from the latter except that it retains many of its own species. The False Arid Karoo is such a part of the Central Upper Karoo. It lies mainly below 4,000 feet. Much of it has suffered through sheet erosion. The dominant grass is now *Aristida obtusa* instead of *Eragrostis lehmanniana* and its associates. An important point to remember for the purposes of this paper is that many of the Arid Karoo plants have a power of resisting conditions which hold the Central Upper Karoo species in a dormant state, e.g. following early and effective rains and subsequent hot dry spells during the growing season of the latter types, Arid Karoo types like *Aristida obtusa*, *Asaemia axillaris*, *Aptosimum marlothii* and *Mesembryanthemum* may be flourishing and in full flower while the Central Upper Karoo types may be shrivelled up and dormant during the dry spells.

The development of the False Upper Karoo constitutes the most spectacular of all the changes in the vegetation of South Africa, and is graphically described by Acocks (1953). The conversion of 20,000 square miles of grassveld into eroded

Karoo *can only be regarded as a national disaster.* (The italics are ours.) This veld as regards the plains, scarcely differs in appearance from the Central Upper Karoo, except that it has much more grassiness in the form of *Aristida* spp. The pioneer of this type is *Chrysocoma tenuifolia.* The False Karoo types are inclined to be sparser than the genuine Karoo types, especially near their upper margins, because, until the grassveld soil has eroded away, the Karoo has no secure foothold. This veld type has been invaded by elements of the Arid Karoo to a smaller extent than the Central Upper Karoo.

The False Karroid Broken Veld resembles the Great Karoo form of the Karroid Broken veld, but, occurring in a less arid region, is taller, denser and slightly less desert-like. Its origins are well described by Acocks (1953).

The distribution of the veld types described above, relevant to this investigation, is shown in Fig. 3, while the appearance of some of these types is illustrated by Figures 1 to 6, Plate 2.

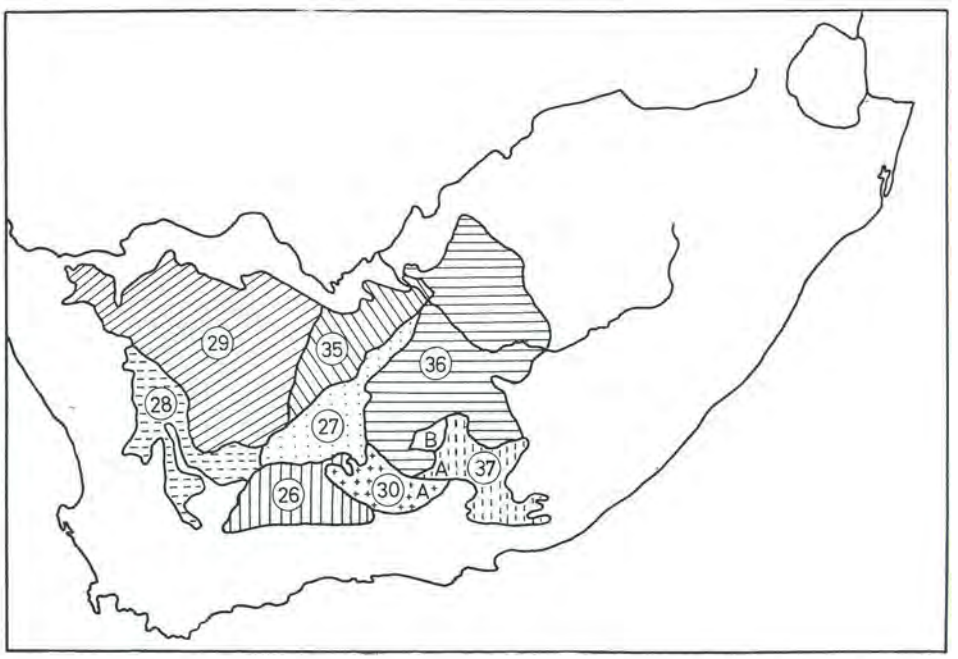

FIG. 3.—Distribution of the Veld Types mentioned in this survey. The numbers are those given by Acocks to these veld types and are as follows:—

(26) Karroid Broken Veld; type (*a*) The Great Karoo
(27) Central Upper Karoo
(28) Western Mountain Karoo
(29) Arid Karoo
(30) Central Lower Karoo
(35) False Arid Karoo
(36) False Upper Karoo
(37) False Karroid Broken Veld

A and B are areas in which a number of veld types occur, some of which are not represented in this survey, e.g., A contains *inter alia* Karroid Broken Veld, while B includes Danthonia Mountain Veld, Danthonia Mountain Veld replaced by Karoo, etc.

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PLATE 2: Illustrations typical of the Veld Types from which the plants studied in this survey were collected:—

(1) Karroid Broken Veld of the Great Karoo; Three Sisters
(2) Central Upper Karoo; De Aar District
(3) Western Mountain Karoo, Fraserburg District
(4) Arid Karoo; Fraserburg District
(5) False Arid Karoo; Vosburg District
(6) Central Lower Karoo; Beaufort West District

MATERIALS AND METHODS

Plants for this survey were collected from farms, within the area defined earlier, which were known to have the highest incidence of either geeldikkop or enzootic icterus, as judged by the results of recent field investigations (Brown, 1966; Brown & de Boom, 1966). A number of farms or localities where the incidence of both

diseases is very low were also selected for comparative studies. The farms or localities chosen for study are representative of the various veld types described above and are listed in Table 1. The names listed in this table are those which will be used to denote the localities where plants were collected in the text which follows. The dominant veld type on each farm or locality is also indicated in this table. The reader may thus refer back to the foregoing text for a brief description of the type of vegetation in each instance. Where a farm or locality varies considerably in topography, as for instance those in the Fraserburg area, the site of collection is further indicated in the relevant text or following tables as mountainside, river-bed plains, etc. Where such indications are not given, the plants have been collected on the sandy plains typical of the area concerned. Where plants have been collected on a type of soil markedly different from the main sandstone-shale types this is also indicated in the text and tables which follow, e.g. limestone soil, etc.

TABLE 1.—*Farms or localities and their veld types where plants were collected for this investigation*

District	*Farm or Locality*	*Veld Type*
Calvinia	Roadside	Arid Karoo.
	Below Hantamberge	Western Mountain Karoo
	Ratelfontein	Arid Karoo
	Rooivlakte	Arid Karoo
	Klipfontein	Arid Karoo
Williston	Sak River-bed	Arid Karoo
Sutherland	Verlatekloof pass	Western Mountain Karoo
	Sutherland–Fraserburg roadside	Western Mountain Karoo
Fraserburg	Showgrounds	Arid Karoo
	Blomfontein	Central Upper Karoo
	Grootfontein	Central Upper Karoo
	Klipfontein	Central Upper Karoo
	Daggafontein	Central Upper Karoo
	Avondrus	Western Mountain Karoo
	Celeryfontein	Western Mountain Karoo
	Droogvoetsfontein	Arid Karoo
Beaufort West	Teekloof pass	Karroid Broken Veld type (*a*)
	Klawervlei	Central Upper Karoo
	Luttig	Karroid Broken Veld, type (*a*)
	Aar Doorns	Central Lower Karoo
	Nuwejaarskraal	Central Lower Karoo
	Toornitzkuil	Central Lower Karoo
	Remainder	Central Lower Karoo
Loxton	Roadside	Central Upper Karoo
Victoria West	Meltonwold	Central Upper Karoo
	Hebron	Central Upper Karoo
	Wagenaarskraal	Central Upper Karoo
Vosburg	Vosburg–Carnarvon roadside	False Arid Karoo
	Mierfontein	False Arid Karoo
De Aar	De Aar–Britstown roadside	False Upper Karoo
Three Sisters	Three Sisters	Karroid Broken Veld, type (*a*)
Cradock	Cradock–Middelburg Road	False Karroid Broken Veld
Hopetown	Prieska–Hopetown Road	Central Upper Karoo
Murraysburg	De Hoop	False Upper Karoo
	Rietpoort	False Upper Karoo
	Poortje	False Upper Karoo
Aberdeen	Kleinplaats	False Upper Karoo
	Karigas River-Bed	Central Lower Karoo
Middelburg	Brentwood	False Upper Karoo
Fauresmith	Veld Reserve	False Upper Karoo
Trompsburg	Ruigtevlei	False Upper Karoo
Brandfort	Valerie	Dry Cymbopogon–Themeda Veld.

The farms Celeryfontein (Fraserburg), Klawervlei (Beaufort West), De Hoop, Rietpoort and Poortje (Murraysburg) have a very low incidence of either syndrome and have been selected for comparative purposes. The farm, Valerie (Brandfort), is situated in the centre of the Free State, where both conditions are unknown and makes an interesting comparison since its veld type is Cymbopogon-Themeda grassveld (Acocks' type 50). Immediately south and west of this farm, i.e. the Bloemfontein district, there is already extensive invasion by False Upper Karoo types and geeldikkop has within recent years made a sporadic appearance in parts of this district.

The Fauresmith Veld Reserve is situated in the heart of the southern Orange Free State and is surrounded by farms on which bad outbreaks of geeldikkop have occurred and on which enzootic icterus is not entirely unknown. Plants were collected for study from various experimental plots in this Reserve.

The Teekloof and Verlatekloof passes are situated in the Nuweveld and Roggeveld mountain ranges respectively, both in areas where enzootic icterus is severe. The mountain sides of the passes themselves, where the plants were collected, are badly eroded and in places virtually denuded of topsoil.

Where a locality is indicated as " roadside ", plants have been collected where the vegetation is typical of the veld type indicated and on the sandy plains alongside such roads, unless otherwise specified. This was often done in instances where good specimens of a particular species were observed while travelling.

All plants were collected in the mature flowering stage of growth and unless otherwise stated only the leaves were used for the analysis described. Where possible grass specimens were collected in the seeding growth stage and the seeds were analysed for selenium concurrently with the parent plant. Where specimens are indicated in the tables which follow by a generic name only, such plants were past the flowering stage and could not be identified with certainty. In most cases these specimens were in a very dry dormant state when collected.

Whenever a particular plant was collected, either a flowering part of that plant or an immediately adjacent plant of the same species was taken for identification purposes. Acknowledgement for identifications is made in the appropriate place. Portions of plants or plants taken for this purpose were killed by immediate immersion in kerosene, allowed to dry and were then pressed. Pressed speciments were finally preserved by brief immersion in a solution of $HgCl_2$, 14 oz, Phenol crystals, 7 oz, Glycerine, 6 oz, in 4 gallons of 96 per cent ethanol. Such specimens were then allowed to dry before final mounting.

Material for selenium analysis was wind-dried to a constant weight in sheds in the areas concerned or in our laboratory, the perfectly dry leaves then being stripped from the parent plant and reduced to a fine powder in a small laboratory mill. Wherever possible analyses were run in duplicate and sometimes in triplicate when high values were encountered.

Analysis for selenium was done using the method of Brown (1961), which is based on those of Davidson (1939) and Gortner & Lewis (1939). The method is only suitable for detecting amounts of selenium higher than 2 micrograms Se per gram of dry plant material. Values indicated as O in the tables which follow are thus in actual fact $<2\mu g/gm$. For the purpose of this investigation amounts of selenium in this range were of no significance, since the work was aimed at detecting

potentially harmful amounts of the element in the Karoo vegetation. Since most of the initial work was carried out in this survey, a very sensitive diamino-benzidine method was developed for use with plant, animal, soil and rock specimens. This method which was used to check many of the results will be published later.

The classification of the Karoo flora used in this report is largely that of Goosens (1953). Where various species were not listed by him use was made of the classification of Phillips (1926) and the checklist drawn up by Verdoorn & Mogg (1947). Where the three listings are at variance with one another in difficult cases, the classification of Goosens has been used. The common names, where they exist, of the plants mentioned in this report are given in Appendix 8. These names have been taken from lists drawn up by Marloth (1917), Henrici (1947), Verdoorn & Mogg (1947) and Whitlock (1957). Common names of grasses were drawn from these sources and from the monograph by Chippindall (Chippindall; Bull. 265). Steyn's work on poisonous plants was also consulted (Steyn, 1949).

Systematic Investigation into the Selenium Content of the Karoo Vegetation

A. *The Family Gramineae*

The results of selenium analyses on the grasses are presented in Table 2. It is obvious from this table that the various grasses in the area under consideration are capable of absorbing and storing considerable amounts of selenium given the appropriate soil conditions. Too few specimens of each species represented have been examined to indicate whether any particular type takes up more of the element than others. From the few data available it appears that annual types like *Bromus* and *Hordeum* and weakly perennial to probably annual types like *Setaria* or *Sporobolus* contain generally lower amounts of selenium than the hardier and larger-growing perennials which constitute the bulk of the specimens examined. This may be entirely fortuitous (cf. e.g. the Se values for the weak perennial *Schismus*).

Table 2.—*The Family Gramineae*

(All results are expressed as micrograms selenium per gram of dry plant material)

Plant	*μg Se*	*Farm or Locality*
Aristida namaquensis	0·0	Fraserburg; Droogvoetsfontein; hillside
Aristida namaquensis	1·0	Fraserburg; Avondrus; plains
Aristida species	0·0	Beaufort West; Klawervlei; plains
Bromus catharticus	3·0	Fraserburg; Showgrounds
Chloris gayana—		
Leaves	5·8	Fauresmith; Veld Reserve
Seeds	19·8	Fauresmith; Veld Reserve
Digitaria eriantha—		
Leaves	12·7	Fauresmith; Veld Reserve
Seeds	22·6	Fauresmith; Veld Reserve
Digitaria sp.	0·0	Brandfort; Valerie
Eragrostis lehmanniana	5·8	Fraserburg; Showgrounds
Leaves	22·6	Fauresmith; Veld Reserve
Seeds	10·0	Fauresmith; Veld Reserve.
Eragrostis superba—		
Leaves	4·5	Fauresmith; Veld Reserve
Seeds	26·8	Fauresmith; Veld Reserve
Eragrostis truncata—		
Leaves	1·0	Fauresmith; Veld Reserve
Seeds	7·0	Fauresmith; Veld Reserve
Eragrostis sp.	5·8	Victoria West; Meltonwold
Hordeum sp.	5·8	Fraserburg; Showgrounds
Lolium sp.	3·0	Fauresmith; Veld Reserve

TABLE 2 (contd.)

Panicum makarikariensis—		
Leaves	15·5	Fauresmith; Veld Reserve
Seeds	12·7	Fauresmith; Veld Reserve
Cenchrus ciliare—		
Leaves	29·6	Fauresmith; Veld Reserve
Seeds	11·5	Fauresmith; Veld Reserve
Pennisetum sphacelatum—		
Leaves	4·5	Fauresmith; Veld Reserve
Seeds	4·5	Fauresmith; Veld Reserve
Phragmites communis	7·0	Fraserburg; Avondrus; garden
Schismus sp.	0·0	Fraserburg; Showgrounds
Setaria sp.	11·5	Fraserburg; Showgrounds
Sporobolus sp.	4·5	Fraserburg; Showgrounds
	3·0	Victoria West; Hebron; vlei
Tetrachne dregei—		
Leaves	3·0	Fauresmith; Veld Reserve
Seeds	14·0	Fauresmith; Veld Reserve
Themeda triandra—		
Leaves	5·8	Fauresmith; Veld Reserve
Seeds	10·0	Fauresmith; Veld Reserve
Themeda triandra	0·0	Brandfort; Valerie
Tragus koelerioides—		
Leaves	3·0	Fauresmith; Veld Reserve
Seeds	4·5	Fauresmith; Veld Reserve

In general, higher levels of the element appear to be present in the seeds than in the foliage. This is a general finding with regard to the gramineae elsewhere (Rosenfeld & Beath, 1964).

Most of the species were collected on Central Upper Karoo and False Upper Karoo veld types. No particular difference in selenium uptake is apparent between the two types.

B. *The Family Liliaceae*

Only three genera were collected during the investigations reported, of which only *Asparagus suaveolens* is well represented. The selenium content of the specimens examined is shown in Table 3. The few results which are available indicate that given the correct conditions these plants may also take up significant amounts of selenium from the soil. It is interesting to note that the farm Mierfontein, Vosburg district, from which the specimen of *A. suaveolens* highest in selenium was collected is one of the farms on which the incidence of geeldikkop is the highest in the district.

TABLE 3.—*The Family Liliaceae*

(All results are expressed as micrograms selenium per gram of dry plant material)

Plant	*μg Se*	*Farm or Locality*
Androcymbium melanthioides	8·5	Trompsburg; Ruigtevlei
	8·5	Trompsburg; Ruigtevlei
Dipcadi crispum	0·0	Beaufort West; Nuwejaarskraal
Asparagus suaveolens	7·0	Trompsburg; Ruigtevlei
	4·5	Fauresmith; Veld Reserve
	28·0	Vosburg; Mierfontein
	10·0	De Aar–Britstown roadside
	1·0	De Aar–Britstown roadside
	0·0	Beaufort West; Nuwejaarskraal
	0·0	Beaufort West; Nuwejaarskraal
	7·0	Beaufort West; Aar Doorns

C. *The Families Loranthaceae and Polygonaceae*

Only one specimen of a single genus of each was collected namely *Viscum rotundifolium* (Loranthaceae) (Se content = 19·8 μg per gm) and *Rumex lanceolatus* (Polygonaceae) (Se content = 4·5 μg per gm). The first plant was collected on a

mountainside on the farm Kleinplaats (Aberdeen) and the latter in a vlei on Hebron (Victoria West). No conclusions can be drawn from these two results other than the fact that given the proper conditions *Viscum rotundifolium* might take up appreciable amounts of selenium from its host (see later under Discussion).

D. *The Family Chenopodiaceae*

This family which contains some of the most important fodder plants of the Karoo and Karroid regions, e.g. of the genera *Salsola* and *Atriplex*, is very well represented in the areas investigated. Because of the large number of specimens collected it is convenient to consider the data from the representative genera in separate tables.

(*a*) *The genus Atriplex.*—The data obtained from the various species which were collected, are presented in Table 4. From these figures it is apparent that the genus as a whole is able to take up selenium from the soil in significant amounts given the appropriate conditions. With the data available it seems likely that these conditions can vary to a marked degree without affecting the rather generally high rate of absorption and storage of the element in this genus. Likewise, with the data available no pattern of uptake as regards veld type is rapidly discernible. Almost consistently elevated values for the element were found in the case of *A. nummularia*. Some species like *A. suberecta* and *A. capensis* can, given the appropriate milieu, apparently accumulate dangerously high levels of the element in their tissues. An interesting point regarding the genus as a whole is that values for selenium of 10 μg per gm and above are encountered in *Atriplex* species growing on farms where enzootic icterus is rife (or may occur sporadically as in the Fauresmith area) while values in the order of 5 to 10 μg per gm are encountered in plants growing where generally only geeldikkop is seen. This must not be construed by the reader as an attempt to incriminate these plants in the aetiology of these syndromes. One must think rather in terms of their being *possibly* sensitive indicators as to the availability of selenium for other more dangerous and undesirable plants of ubiquitous occurrence in the affected areas.

TABLE 4.—*The Genus Atriplex* (Chenopodiaceae)

(All results are expressed as micrograms selenium per gram of dry plant material)

Plant	*µg Se*	*Farm or Locality*
Atriplex nummularia	14·0	Fauresmith; Veld Reserve
	3·0	Beaufort West; Nuwejaarskraal
	11·5	Sutherland–Fraserburg roadside
	15·5	Fraserburg; Avondrus; garden
	5·8	Aberdeen; Karigas River-bed
	10·0	Victoria West; Meltonwold; vlei
	10·0	Victoria West; Meltonwold; vlei
Atriplex suberecta	53·4	Fraserburg; Showgrounds
	5·8	Sutherland; Verlatekloof pass
	4·5	Sutherland; Verlatekloof pass
	7·0	Calvinia; Ratelfontein
	1·0	Calvinia; Ratelfontein
Atriplex vestita	7·0	Victoria West; Meltonwold; vlei
	0·0	Victoria West; Meltonwold; vlei
Atriplex semibaccata	4·5	Fraserburg; Showgrounds
	7·0	Calvinia; roadside
	4·5	Fauresmith; Veld Reserve
Atriplex inflata	4·5	Beaufort West; Nuwejaarskraal
	8·5	Beaufort West; Nuwejaarskraal.
	0·0	Vosburg–Carnarvon roadside
	11·5	Fraserburg; Showgrounds
	7·0	Calvinia; roadside
Atriplex capensis	22·6	Fauresmith; Veld Reserve
	24·0	Fauresmith; Veld Reserve
Atriplex mulleri	8·5	Fauresmith; Veld Reserve

(*b*) *The genus Salsola.*—The results of work on the various members of this genus, which were collected, are presented in Table 5. Most of the species examined seem capable of accumulating moderate to high values of selenium given the correct soil conditions. When compared with the genus *Atriplex*, however, the preponderance of low values (below 5·0 μg Se per gm) in most of the *Salsolas* is obvious. *S. kali* is a notable exception.

TABLE 5.—*The Genus Salsola* (Chenopodiaceae)

(All results are expressed as micrograms selenium per gram of dry plant material)

Plant	*μg Se*	*Farm or Locality*
Salsola tuberculata	5·8	Fauresmith; Veld Reserve
	31·0	Vosburg; Mierfontein
	4·5	Beaufort West; Aar Doorns
	0·0	Beaufort West; Nuwejaarskraal
	0·0	Beaufort West; Remainder
	1·0	Fraserburg; Klipfontein
	4·5	Fraserburg; Avondrus; river-bed
	3·0	Fraserburg; Droogvoetsfontein
	0·0	Fraserburg; Daggafontein
	0·0	Fraserburg; Avondrus; mountainside
Salsola geminiflora	8·5	Murraysburg; De Hoop
	7·0	Vosburg; Mierfontein
	5·8	Victoria West; Meltonwold
	10·0	Fraserburg; Blomfontein
Salsola glabrescens	15·5	Fauresmith; Veld Reserve
	0·0	Beaufort West; Aar-Doorns
	1·0	Beaufort West; Klawervlei
	1·0	Fraserburg; Avondrus
	7·00	De Aar–Britstown roadside
Salsola kali	15·5	Williston; Sak River-bed
	15·5	Williston; Sak River-bed
	3·0	Aberdeen; Karigas River-bed
	18·4	Three Sisters; Three Sisters
	12·7	Brandfort; Valerie
Salsola kali var. *tenuifolia*	11·5	Fraserburg; Showgrounds
Salsola aphylla	8·5	Williston; Sak River-bed
Salsola nigrescens	18·5	Fauresmith; Veld Reserve
Salsola rabieana	8·5	Fauresmith; Veld Reserve
Salsola sp.	4·5	Beaufort West; Klipbank
	0·0	Beaufort West; Klawervlei
	5·8	Fraserburg; Blomfontein
	3·0	Victoria West; Hebron
	1·0	Victoria West; Hebron; vlei
	4·5	Victoria West; Hebron; vlei
	4·5	Victoria West; Wagenaarskraal
	0·0	Victoria West; Wagenaarskraal
	4·5	Aberdeen; Karigas River-bed

There is a general correlation between the highest values for each species (excluding *S. kali*) and the incidence of geeldikkop. The farms Mierfontein (Vosburg) and Three Sisters and the Fauresmith and Victoria West areas are noted for severe annual epizootics of the disease, while the Beaufort West localities are subject to more or less sporadic (but sometimes also severe) outbreaks of geeldikkop. In the former localities the deterioration of the veld on affected farms is alarming (Brown, 1959b) and conditions have possibly been created by veld mismanagement under which the valuable *Salsola* species are apparently able to concentrate fair to dangerous amounts of the element.

No such apparent correlation between high selenium values and the farms on which enzootic icterus is rife (e.g. all those in the Fraserburg and Aberdeen areas) is apparent from a study of Table 5. These farms show even more evidence of

mismanagement than those in the geeldikkop areas and *Salsola* species are difficult to find in large numbers on many of them. Those that were collected for this investigation were taken from patches where a good mixture of the vegetation of the veld type of the area concerned had survived for various reasons. Apparently in such patches the Salsolas were still growing in an ideal milieu. Those labelled *Salsola* sp. were in general in a dry dormant state and were collected on badly deteriorated veld.

Salsola kali forms a notable exception to the behaviour of the genus as a whole. Specimens of this plant contained almost consistently high amounts of selenium irrespective of the veld type on which they were collected. It is the only plant collected from the farm Valerie, in the Brandfort district which contained significantly high levels of the element (cf. Tables 2, 15, 22, 23, 34 and 29). The plant (" Russian Tumble-weed ") is a brittle succulent annual which is a proclaimed noxious weed in many parts of the country. It produces seed in abundance and the seed is disseminated by wind or water or in fodder and impure crop seed samples. The young stalks are tender and succulent and at this stage of growth the plant is said to be a good feed which cattle and sheep relish (Dyer, 1937; Landsdell, 1927). As the plant matures it changes its character. The stem becomes hard and woody, ridged and streaked with dark green lines. The first leaves fall away and those of later growth are not more than half an inch long and are awl-shaped, nearly cylindrical with strong spiny tips. The plant is consequently not grazed down much at this stage. We have encountered many specimens in a mature stage of growth which emit a particularly obnoxious odour when bruised or crushed. Odours of this nature are often associated with highly seleniferous plants (Rosenfeld & Beath, 1964).

(*c*) *The genera Chenopodium, Kochia and Sueda.*—A limited number of representatives of these genera were collected and examined. The results of these examinations are shown in Table 6.

TABLE 6.—*The Genera Chenopodium, Kochia and Sueda* (Chenopodiaceae)

(All results are expressed as micrograms selenium per gram of dry plant material)

Plant	*µg Se*	*Farm or Locality*
Chenopodium album	7·0	Victoria West; Hebron; vlei
	1·0	Victoria West; Hebron; vlei
	14·0	Beaufort West; Klawervlei
Chenopodium murale	3·0	Fraserburg; Showgrounds
Chenopodium sp.	4·5	Beaufort West; Luttig
	10·0	Williston; Sak River-bed
Kochia pubescens	11·5	Murraysburg; De Hoop
	0·0	Beaufort West; Luttig
	12·7	Sutherland Fraserburg Road; Limestone
	10·0	Three Sisters; Three Sisters
	5·8	Three Sisters; Three Sisters
	15·5	Victoria West; Meltonwold
Sueda fruticosa	14·0	Victoria West; Meltonwold; vlei
	12·7	Williston; Sak River-bed

All the species of the genera appearing in this table appear to be able to con centrate fair to moderate amounts of selenium in their foliage irrespective of the veld type in which they occur. This ability is particularly marked in the species *Kochia pubescens.* It is noteworthy that *Sueda fruticosa* is also a plant of obnoxious odour and like *Salsola kali* is poorly grazed in its mature state.

The Chenopodiaceae, at least in so far as the representative species which were examined are concerned, appear to be able to take up selenium in potentially dangerous amounts from the soil given the appropriate soil conditions. This ability is noteworthy in the case of the genera *Atriplex*, *Kochia* and possibly *Sueda*, but appears to be rather restricted in the case of the genus *Salsola* with the remarkable exception of the weed, *S. kali*.

E. *The Families Nyctaginaceae, Phytolaccaceae, Portulaccaceae, Papaveraceae and Capparidaceae*

Only a few isolated specimens representing these families were collected. The results of the selenium analyses are presented in Table 7. Plants collected from Fauresmith Veld Reserve and Trompsburg (Ruigtevlei) contain fair to moderate amounts of the elements, while levels of selenium in the two *Cadaba* species are most variable. They appear, however, to be able to take up potentially harmful amounts of selenium under certain conditions.

TABLE 7.—*The Families Nyctaginaceae, Phytolaccaceae, Portulaccaceae, Papaveraceae and Capparidaceae*

(All results are expressed as micrograms selenium per gram of dry plant material)

Plant	*μg Se*	*Farm or Locality*
Phaeoptilum spinosum (Nyctaginaceae)	8·5	Fauresmith; Veld Reserve
Limaeum aethiopicum (Phytolaccaceae)	15·5	Fauresmith; Veld Reserve
	3·0	Beaufort West; Luttig
	0·0	Murraysburg; De Hoop
Talinum caffrum (Portulaccaceae)	5·8	Fauresmith; Veld Reserve
Argemone mexicana (Papaveraceae)	10·0	Trompsburg; Ruigtevlei
Cadaba juncea (Capparidaceae)	1·0	Beaufort West; Aar Doorns
	18·4	Cradock–Middelburg roadside
Cadaba aphylla	15·5	Aberdeen; Kleinplaats
Cadaba sp.	1·0	Sutherland–Fraserburg roadside
	3·0	Murraysburg; De Hoop

F. *The Family Cruciferae*

Only one genus of this large family was well represented in our collection for this work, viz. *Lepidium divaricatum*. Figures obtained from this plant are presented in Table 8, together with one result from a solitary specimen of *Sisymbrium burchelli*. Both species are able apparently to take moderate amounts of the element, highest levels for *L. divaricatum* being from plants growing on the silt soils of river-beds. Various members of the Cruciferae can concentrate considerable amounts of selenium (Rosenfeld & Beath, 1964). These findings were not entirely unexpected.

TABLE 8.—*The Family Cruciferae*

(All results are expressed as micrograms selenium per gram of dry plant material)

Plant	*μg Se*	*Farm or Locality*
Lepidium divaricatum subsp. *linoides*	3·0	Fraserburg; Showgrounds
Lepidium divaricatum	5·8	Williston; Sak River-bed
	10·0	Williston; Sak River-bed
	10·0	Aberdeen; Karigas River-bed
	0·0	Victoria West; Meltonwold
Sisymbrium burchelli	15·5	Victoria West; Hebron; vlei

G. *The Family Ficoidaceae*

This large family is very well represented in the areas covered by our investigations. The classification we have used for this family is that of Goossens (1953). [In other classifications, e.g. that of Verdoorn & Mogg (1947) all the genera reported upon here are listed under the Aizoaceae A. Br.]. For the purpose of this work we concentrated largely on collecting species which in certain areas have become dominant in the veld types concerned, e.g. *Galenia*, *Psilocaulon* and *Mesembryanthemum* spp. and others which are extensively grazed, e.g. *Tetragonia arbuscula* and *Plinthus karroicus*, rather than on the numerous small succulent genera of this family. A few of the more commonly encountered of the latter were, however, included and the results obtained from them are interesting.

(*a*) *The genus Galenia.*—Results of the investigations into the selenium content of these plants are presented in Table 9.

TABLE 9.—*The Genus Galenia*

(All results are expressed as micrograms selenium per gram of dry plant material)

Plant	*µg Se*	*Farm or Locality*
Galenia africana	15·5	Fauresmith; Veld Reserve
	0·0	Middelburg; Brentwood
	3·0	Aberdeen; Kleinplaas
	28·0	Victoria West; Wagenaarskraal
	5·6	Victoria West; Meltonwold
	3·0	Victoria West; Meltonwold
	3·6	Victoria West; Meltonwold
	4·5	Calvinia; Ratelfontein
	4·5	Calvinia; Klipfontein
	7·0	Calvinia; below Hantamsberge
	3·0	Sutherland; Verlatekloof pass
	0·6	Sutherland; Verlatekloof pass
	1·0	Sutherland; Verlatekloof pass
	3·0	Sutherland; Verlatekloof pass
	0·0	Sutherland; Verlatekloof pass
Galenia sarcophylla	5·6	Fraserburg; Showgrounds
	0·0	Three Sisters; Three Sisters
Galenia procumbens	14·0	Beaufort West; Klawervlei
	8·5	Beaufort West; Klawervlei
	1·0	Calvinia; Ratelfontein
Galenia pubescens	38·0	Trompsburg; Ruigtevlei

The figures reproduced in this table are on the whole reminiscent of those obtained from the *Salsola species*. In most instances the selenium content of these plants was found to be low especially in *G. africana* which is well represented. Occasional high values were found depending no doubt upon peculiar sets of circumstances which favoured selenium uptake in these instances.

(*b*) *Psilocaulon absimile.*—This rather unattractive annual shrub is from the veterinarian's viewpoint a most controversial plant. It is listed by Acocks (1953) as a normal constituent of many of the veld types in the areas under consideration. We have seen numerous farms on which grazing mismanagement is only too obvious where the plant has become a dominant factor in the vegetation. Whole camps are often taken over by the plant under such circumstances. Opinions differ amongst farmers as to its value as a fodder plant. In some areas, e.g. Fraserburg, many farmers set great store by it particularly in a dry state, while in other areas, e.g. the better parts of the Victoria West area it is regarded as being useless as a fodder plant. This view is shared by Watt & Breyer-Brandwijk (1962). The toxicity of the plant has been established by Rimington and his co-workers (1933a, 1933b,

1934a, 1934b). It is known to contain at different times up to 8·6 per cent of oxalic acid and 4·5 per cent of piperidine (Rimington *et al.*, 1933, 1934). Furthermore the poisonous alkaloid psilocauline has been isolated from various specimens and the plant has been incriminated in the aetiology of urolithiasis in small stock in the Karoo (Steyn, 1949). The plant yields up to 24·6 per cent of ash (Watt & Breyer-Brandwijk, 1962) which is very rich in calcium and potassium. The ash has been used as a lye for soap-making from the earliest days of farming in the Karoo. This still no doubt accounts for some of the high regard with which the plant is held in certain areas.

We have found the plant to take up moderate to high amounts of selenium under a wide variety of veld conditions. The results of our work on this plant so far are presented in Table 10.

TABLE 10.—*Psilocaulon absimile*

(All results are expressed as micrograms selenium per gram of dry plant material)

Plant	*µg Se*	*Farm or Locality*
P. absimile	7·0	Fauresmith; Veld Reserve
	11·5	Vosburg: Mierfontein
	3·0	Victoria West; Hebron; vlei
	10·0	Victoria West; Hebron; vlei
	15·5	Victoria West; Hebron; flats
	11·5	Victoria West; Hebron; flats
	18·4	Victoria West; Wagenaarskraal
	18·4	Three Sisters; Three Sisters
	10·0	Three Sisters; Three Sisters
	5·8	Beaufort West; Luttig
	10·0	Beaufort West; Luttig
	3·0	Aberdeen; Kleinplaats; Mountain
	7·0	Fraserburg; Showgrounds
	4·5	Fraserburg; Showgrounds

The data show a fairly consistently high uptake pattern, particularly where the plant grows on the sandy plains of the areas concerned.

(*c*) *The genus Mesembryanthemum.*—The representative species occurring in the area concerned comprise many valuable fodder succulent plants. Many of the specimens collected during this work were in a desiccated dormant state and could not be identified with certainty. Most of those designated *Mesembryanthemum* sp. in Table 11 in which the relevant data are presented, were probably *M. spinosum.*

TABLE 11.—*The Genus Mesembryanthemum*

(All results are expressed as micrograms selenium per gram of dry plant material)

Plant	*µg Se*	*Farm or Locality*
Mesembryanthemum spinosum	0·0	Beaufort West; Aar Doorns
	0·0	Beaufort West; Aar Doorns
	0·0	Fraserburg; Celeryfontein
	5·5	Fraserburg; Droogvoetsfontein
Mesembryanthemum spinescens	8·5	Beaufort West; Klawervlei
Mesembryanthemum saxicolum	10·0	Fauresmith; Veld Reserve
Mesembryanthemum sp.	3·0	Beaufort West; Luttig
	0·0	Beaufort West; Luttig
	0·0	Beaufort West; Luttig
	4·5	Aberdeen; Kleinplaats
	7·0	Victoria West; Meltonwold
	3·0	Vosburg–Carnarvon roadside

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These plants as a whole appear to contain relatively low levels of selenium irrespective of where they were collected. The solitary specimen of *M. saxicolum* taken from the Fauresmith Veld Reserve gave the highest value. A very large proportion of the different plants taken from this locality were found to be high in selenium (see previous and following tables).

(*d*) *The genus Aridaria.*—The genus includes some of the larger succulents growing in the areas concerned. Considerable difficulty was experienced in preserving specimens of these plants for identification. Since, in most instances, this was uncertain we have designated these plants *Aridaria* sp. in Table 12 which contains the relevant data.

TABLE 12.—*The Genus Aridaria*

(All results are expressed as micrograms selenium per gram of dry plant material)

Plant	*µg Se*	*Farm or Locality*
Aridaria sp.	1·5	Fraserburg; Showgrounds
	5·8	Fraserburg; Showgrounds
	8·5	Fraserburg; Showgrounds
	5·8	Fraserburg; Avondrus; mountain
	3·0	Fraserburg; Avondrus; mountain
	18·9	Fraserburg; Avondrus; mountain
	8·5	Fraserburg; Klipfontein; plains
	5·8	Fraserburg; Daggafontein; plains
	0·0	Fraserburg; Daggafontein; plains
	3·0	Sutherland–Fraserburg; roadside
	1·0	Aberdeen; Karigas river-bed

As will be seen from the table most of the specimens were collected from the Fraserburg district. The veld types concerned are Arid Karoo, Western Mountain Karoo and Central Upper Karoo. Selenium uptake as a whole is low to fair (and high in isolated instances only) on these veld types.

(*e*) *The Genera Delosperma, Hyperstelis, Mestoklema, Plinthus and Tetragonia:* Only a few specimens of each were taken for the sake of comparison with the rest of the family, except in the case of *Tetragonia arbuscula*, which is an important fodder plant (Botha, 1939). Some of the species are small bushes with succulent leaves, e.g. *Delosperma*, *Mestoklema* and *Tetragonia*, while *Hyperstelis* and *Plinthus* are non-succulent types. The relevant data are reproduced in Table 13.

TABLE 13.—*The Genera Delosperma, Hyperstelis, Mestoklema, Plinthus and Tetragonia*

(All results are expressed as micrograms selenium per gram of dry plant material)

Plant	*µg Se*	*Farm or Locality*
Delosperma sp.	21·2	Trompsburg; Ruigtevlei
Hyperstelis verrucosa	8·5	Fauresmith; Veld Reserve
Mestoklema tuitum	7·0	Trompsburg; Ruigtevlei
Plinthus karroicus	5·8	De Aar–Britstown roadside
	7·0	Victoria West; Hebron
Tetragonia arbuscula	25·4	Fauresmith; Veld Reserve
	14·0	Fauresmith; Veld Reserve
	5·8	Victoria West; Hebron; vlei
	22·6	Fraserburg; Showgrounds
	10·0	Fraserburg; Avondrus; river-bed
	7·0	Fraserburg; Avondrus; mountain
Tetragonia schenkii	0·0	Fauresmith; Veld Reserve

It is obvious that given suitable soil or veld conditions all the species represented in this table are capable of taking up fair to high amounts of selenium and are similar in this respect to other members of the family, e.g. *Aridaria*, *Psilocaulon* and *Galenia* species.

Tetragonia arbuscula occurs in many parts of the Karoo and is generally regarded as a most excellent pasture plant. It is well eaten by sheep in all stages of growth and during any season of the year. Its decrease in parts of the Karoo is, in fact, thought to be due largely to its excellent palatability, for since it is eaten readily by sheep at all times, it has little chance of propagating and maintaining itself, owing to lack of protection (Botha, 1939). The dry matter of *Tetragonia* is highly digestible and compares very favourably in nutritive value with lucerne, tending to be superior to lucerne in certain respects (Botha, 1939). Although the selenium values which we have cited for this plant are in general moderately high, it must be remembered that our specimens have either been taken from localities in which serious veld mismanagement has occurred (e.g. Fraserburg) or areas on which the vegetation in general is moderately high in the element (Fauresmith Veld Reserve).

The Family, Ficoidaceae, as represented by the genera we have studied, possesses the ability of taking up in general fair to moderate amounts of selenium depending largely upon soil and veld conditions. *Galenia* and *Mesembryanthemum* species appear to contain in general low levels of the element while *Psilocaulon* and possibly *Tetragonia* species concentrate moderate to dangerous amounts of selenium under certain circumstances. The succulent or bush types, e.g. *Aridaria*, *Mestoklema*, *Plinthus*, etc. seem to fall between the two extreme groups.

H. *The Family Leguminosae and sub-Family Papilionaceae*

Only two representatives of the Leguminosae were collected during the present investigations, both from Fauresmith Veld Reserve, viz. *Lotononis divaricata* and *Sutherlandia microphylla*. Both plants contained relatively large amounts of selenium, 17·0 and 14·0 μg per gram respectively. We have at the moment no information on plants of these genera growing elsewhere.

The various members of the Papilionaceae which we have examined are shown in Table 14. We have included in this table figures obtained from five *Crotalaria* spp. grown in the garden of poisonous plants at Onderstepoort. This genus was noted in a previous report as being one which could possibly take up large amounts of selenium from the soil (Brown & de Wet, 1962). At the time of our investigation a search for *Crotalaria* sp. in all the localities visited was unsuccessful. We therefore had recourse to growing some of the commonly occurring species in the garden of the Department of Toxicology at Onderstepoort. The values obtained from these plants, given in Table 14, should be compared with those from the plants which follow growing on the same soil and selected at random (selenium values are given in parenthesis following the systematics of the plant concerned). The soil concerned is a heavy black clay, overlaying a deposit of decayed calcareous gravel and small boulders. The plants taken for comparison were *Tribulis terrestris* (Zygophyllaceae; 1·0); *Mentha spicata* var. *crispum* (Labiatae, 0·0); *Thymus vulgaris* (Labiatae, 0·0); *Salvia officinalis* (Labiatae, 0·0); *Ocimum basilicum* (Labiatae, 0·0); *Solanum auriculatum* (Solanaceae, 0·0); *Osteospermum ecklonis* (Compositae, 5·8); *Brassica chinensis* var. *pekinensis* (Cruciferae, 3·0); *Chicorium intybus* (Compositae, 8·5); *Borago officinalis* (Boraginaceae, 0·0); *Lantana camara* (Verbenaceae, 7·5) and *Lippia rehmanni* (Verbenaceae, 5·0).

TABLE 14.—*The Sub-Family Papilionaceae*

(All results are expressed as micrograms selenium per gram of dry plant material)

Plant	*μg Se*	*Farm or Locality*
Vicia varia	10·0	Onderstepoort; garden
Crotalaria podocarpa—		
Leaves	28·0	Onderstepoort; garden
Seeds	3·0	Onderstepoort; garden
Crotalaria lotoides—		
Leaves	34·0	Onderstepoort; garden
Seeds	14·0	Onderstepoort; garden
Crotalaria damarensis—		
Leaves	28·0	Onderstepoort; garden
Seeds	8·5	Onderstepoort; garden
Crotalaria juncea (Young plant—leaves only)	8·5	Onderstepoort; garden
Melolobium candicans	3·0	Fauresmith; Veld Reserve
	5·8	Beaufort West; Aar Doornrs
	1·5	Victoria West; Hebron
	3·0	Fraserburg; Avondrus; mountains
	4·5	Fraserburg; Avondrus; mountains
	4·5	Fraserburg; Avondrus; mountains
	3·0	Fraserburg; Daggafontein; mountains
Melolobium calycium	10·0	Trompsburg; Ruigtevlei
Lessertia annularis	19·8	Fraserburg; Klipfontein
	1·0	Fraserburg; Klipfontein
	11·5	Victoria West; Wagenaarskraal
Lessertia inflata	1·0	Fraserburg; Showgrounds
Lessertia pauciflora	8·5	Prieska–Hopetown roadside
Lessertia sp.	12·7	Fauresmith; Veld Reserve
Lebeckia spinescens	12·7	Vosburg; Mierfontein
	8·5	Vosburg; Mierfontein
Medicago sativa	7·0	Onderstepoort; garden
	1·0	Murraysburg; De Hoop
	10·0	Fraserburg; Avondrus; garden
Indigofera alternans	4·5	Trompsburg; Ruigtevlei

From this table and the foregoing data it is obvious that the *Crotalaria* species possess a very marked ability to take up selenium from the soil even if such soils are not seleniferous, e.g. as that in the Onderstepoort garden. The wide variety of plants growing on the same soil selected for comparison show in general negligible to reasonably low values for the element. A noteworthy feature of the *Crotalaria* species is that in the mature plants examined the foliage contains more selenium than the seeds (compare these data with those obtained from grasses, in which the position is reversed).

Other genera of the Papilionaceae are also apparently able to take up reasonably large amounts of the element, e.g. *Lessertia*, *Lebeckia* and *Medicago* spp. Our findings regarding the Papilionaceae agree with those described by Rosenfeld & Beath (1964) for lucerne and other species of this sub-family, e.g. vetches, peas and beans. They mention a correlation between the age of lucerne and its selenium content. Young lucerne was uniformly more seleniferous than the older growths. The selenium content of lucerne was found to depend also on the availability and form of the element in the soil (Rosenfeld & Beath, 1964). *Lessertia annularis* has an interesting toxicological history in South Africa, which is reviewed briefly by Watt & Breyer-Brandwijk (1962). It was first suspected of being the cause of *cotyledonosis* (" krimpsiekte "), but was later shown to be innocuous in this respect (Watt & Breyer-Brandwijk, 1962; Hutcheon 1882, 1884). Sim in 1907 drew an analogy between a stock disease in India, known as " Crotalism " and the condition then known in the Cape Province as styfsiekte thought possibly to be caused not only

by Crotalaria but *perhaps by Indigofera, Lessertia or Tephrosia* (our Italics.) Subsequently it became clear that " styfsiekte " (crotalariosis) in cattle results from the ingestion of *Crotalaria burkeana* Benth (Watt & Breyer-Brandwijk, 1962). *Lessertia annularis* none the less, appears to be toxic (Pole Evans, 1920; Watt & Breyer-Brandwijk, 1962).

We have previously expressed our views on the relationship of the symptoms of bovine crotalariosis to those of chronic selenosis (Brown & de Wet, 1962). The present data lend more weight to this assertion. Further studies on the *Lessertia* spp. may prove fruitful in this regard, particularly in view of some of the past work cited.

Melolobium candicans has been suspected in the past of causing poisoning in stock but no detailed toxicological studies have ever been done on the plant (Watt & Breyer-Brandwijk, 1962). It is generally held to be an inferior fodder-plant in the Karoo. Values for selenium in this plant were found to be generally low, but high in a single specimen of the related *M. calycium*.

I. *The Family Zygophyllaceae*

The family is represented in the areas covered by our work, mainly by the genera *Zygophyllum* and *Tribulus*. The latter is of particular interest to this work, since it was in the past incriminated in the aetiology of geeldikkop (Brown, 1959b). The data we have collected pertaining to these two genera are presented in Table 15.

TABLE 15.—*The Family Zygophyllaceae*

(All results are expressed as micrograms selenium per gram of dry plant material)

Plant	*µg Se*	*Farm or Locality*
Zygophyllum gilfillani	14·0	Prieska–Hopetown roadside
	18·5	Fauresmith; Veld Reserve
Zygophyllum microphyllum	10·0	Beaufort West; Aar Doorns
	0·0	Beaufort West; Nuwejaarskraal
	3·0	Fraserburg; Showgrounds
	3·0	Vosburg; Mierfontein
	10·0	Three Sisters; Three Sisters
Zygophyllum suffruticosum	5·8	Prieska–Hopetown roadside
Zygophyllum microcarpum	14·0	Fauresmith; Veld Reserve
Zygophyllum sp.	5·8	Aberdeen; Kleinplaats
Tribulus terrestris	1·0	Onderstepoort; garden
	0·0	Onderstepoort; veld
	0·0	Onderstepoort; veld
	3·0	Fauresmith; Veld Reserve
	21·2	Fauresmith; Veld Reserve
	0·0	Brandfort; Valerie
	0·0	Calvinia; Ratelfontein
	0·0	Calvinia; Rooivlakte
	0·0	Calvinia; Rooivlakte
	0·0	Beaufort West; Luttig
	3·0	Beaufort West; Luttig
	3·0	Beaufort West; Luttig
	7·0	Murraysburg; De Hoop
	1·5	Murraysburg; De Hoop
	15·5	Fraserburg; Showgrounds
	0·0	Fraserburg; Avondrus

Some specimens of *Tribulus terrestris* collected on the heavy black clay soil at Onderstepoort have also been included for comparison.

It is obvious that the various *Zygophyllum* spp. examined are able, like many of the plants studied so far, to take up moderate amounts of selenium depending on soil conditions. The fast-growing annual *Tribulus terrestris*, on the other hand,

is in general low in the element and only under probably special circumstances do isolated individuals appear to take up significant amounts of selenium. (Compare e.g. the two specimens from the Fauresmith Veld Reserve. Both were adult fruiting plants.)

J. *The Families Melianthaceae, Malvaceae, Sterculiaceae, Thymeleaceae, Gentianaceae, Apocynaceae, Asclepiadaceae, Convolvulaceae and Boraginaceae*

These families are in general poorly represented in our collection and it is therefore not possible to express any definite opinion regarding selenium uptake by the few representative specimens we have collected except in a few instances.

Some specimens of the following plants, which were examined, were found to contain moderate to significant amounts of selenium (the family, locality where the plant was collected and the selenium content are given in that order in parenthesis immediately after the systematic name of the plant):—

Melianthus major (Melianthaceae; Verlatekloof; 1·0; 7·0);
Melianthus comosus (Melianthaceae; Victoria West, Wagenaarskraal, 10·0 and Beaufort West, Klawervlei, 1·0);
Malva parviflora (Malvaceae; Fraserburg, Showgrounds, 10·0);
Sebaea pentandra (Gentianaceae; Fraserburg, Klipfontein, 4·5; Victoria West, Hebron, 0·0; Loxton roadside, 0·0);
Sebaea compacta (Gentianaceae; Trompsburg, Ruigtevlei, 7·0);
Carissa haematocarpa (Apocynaceae; Aberdeen, Kleinplaats, 4·5;
Asclepias fruticosa (Asclepiadaceae; Vosburg-Carnarvon roadside, 4·5 and 7·0);
Microloma massonii (Asclepiadaceae; Fraserburg, Avondrus, 11·5);
Convolvulus ulosepalus (Convolvulaceae; Fraserburg, Showgrounds, 10·0);
Anchusa capensis (Boraginaceae; Beaufort West, Klawervlei, 12·7), and
Lithospermum cinereum (Boraginaceae; Vosburg, Mierfontein, 8·5).

The Sterculiaceae and Thymeleaceae are represented in our collection by the genera *Hermannia* (four species) and *Arthrosolen* (one species) respectively. The results of analyses on these plants are presented in Table 16.

TABLE 16.—*The Families Sterculiaceae and Thymeleaceae*

(All results are expressed as micrograms selenium per gram of dry plant material)

Plant	*µg Se*	*Farm or Locality*
(A) Sterculiaceae		
Hermannia desertorum	4·5	Fraserburg; Avondrus
	3·0	Calvinia; below Hantam mountains
	7·0	Calvinia; below Hantam mountains
Hermannia coccocarpa	8·5	Fauresmith; Veld Reserve
	7·0	Fraserburg; Daggafontein, mountains
Hermannia pallens	8·5	Fauresmith; Veld Reserve
	0·0	Fraserburg; Daggafontein, mountains
Hermannia linearifolia	7·0	Fraserburg; Avondrus
	0·0	Murraysburg; Rietpoort
	3·0	Fauresmith; Veld Reserve
(B) Thymeleaceae		
Arthrosolen polycephalus	4·5	Fraserburg; Showgrounds
	11·5	Prieska–Hopetown roadside
	5·8	De Aar–Britstown roadside
	0·0	De Aar–Britstown roadside
	5·8	Murraysburg; Rietpoort
	3·0	Victoria West; Hebron; vlei
	17·0	Victoria West; Wagenaarskraal
	8·5	Vosburg; Mierfontein

Various *Hermannia* species are widely used in the Folk medicine of South Africa for various purposes in the form of externally applied lotions, cataplasmata and decoctions for oral administration (Watt & Breyer-Brandwijk, 1962). Some like *H. pallens* are eaten readily by sheep and are valuable fodder plants, while some are only eaten when stock can find no other food, e.g. *H. candicans* (not studied). Our data indicate a fairly low selenium uptake by these plants.

Arthrosolen polycephalus is widespread in South Africa and well-known as a poisonous plant (Watt & Breyer-Brandwijk, 1962: Steyn, 1929, 1949) the toxicity varying with the locality and the season. It is a gastro-intestinal irritant and the dust from the powdered dry plant is highly irritant to the respiratory tract (Steyn, 1929). The plant has been found to contain a dihydroxy-coumarin glycoside (Rindl, 1933). It not only flowers during winter which tends to facilitate poisoning by offering tempting food to the animal, but seems to be more toxic at this season (Watt & Breyer-Brandwijk, 1962; Steyn, 1929). From our data in Table 16, it is apparent that the plant is able to take up fair to moderately high amounts of selenium from the soil under certain conditions.

K. *The Families Labiatae and Solanaceae*

Very few members of these two important families were to be found in the areas concerned at the time of our investigations.

With regard to the Labiatae, a few specimens of *Stachys cuneata*, *S. spathula* and *S. linearis* were examined. In no instance was there found to be more than 3·0 μg per gm of selenium present in dried material. Four specimens of *Mentha longifolia* were examined. In only one was a value as high as 7·0 μg/gm found; the rest contained negligible amounts of the element. Two *Salvia* species were examined, viz. *S. clandestina* and *S. rugosa*. The highest selenium value obtained was 8·5 μg per gm of dried material as opposed to negligible amounts in all the other specimens.

The Solanaceae, are likewise poorly represented in our collection. One plant of common occurrence in the areas covered by our investigation is *Lycium oxycladum*. A number of specimens of this plant has been examined and the highest value for selenium so far obtained has been 8·5 μg per gm of dried material. All other specimens have contained negligible amounts of the element. A single species of *Radyera urens* from the Fraserburg Showgrounds was found to contain 1·0 μg per gm of selenium.

L. *The Family Scrophulariaceae*

Our collection of this large family comprises three genera only namely *Aptosimum*, *Nemesia* and *Sutera* of which only the first is well represented. *Aptosimum* and *Sutera* spp. are well-known in South African Folk medicine. Species of the former genus are common and widely distributed in the areas concerned in this investigation. *Sutera atropurpurea* is a commercial source of a saffron substitute. The data relating to these genera appear in Table 17.

TABLE 17.—*The Family Scrophulariaceae*

(All results are expressed as micrograms selenium per gram of dry plant material)

Plant	*μg Se*	*Farm or Locality*
Aptosimum leucorrhizum	14·0	Fraserburg; Showgrounds
Aptosimum depressum	0·0	Middelburg; Brentwood
	1·0	Murraysburg; De Hoop
	8·5	Aberdeen; Kleinplaats
	4·5	Fraserburg; Showgrounds
Aptosimum spinescens	3·0	Beaufort West; Aar Doorns
	1·0	Vosburg; Mierfontein
Aptosimum marlothii	14·0	Vosburg; Mierfontein
	4·5	Fauresmith; Veld Reserve
Nemesia capensis	3·0	Beaufort West; Klawervlei; plains
	5·8	Beaufort West; Klawervlei; mountain
Sutera atropurpurea	7·0	Trompsburg; Ruigtevlei

Apart from two isolated moderately high values of selenium, our specimens of the family were in general fairly low in the element.

M. *The Family Selaginaceae*

The genera of this family which are common in the Karoo are *Walafrida* and *Selago*. The former is very well represented in our collection. Nine specimens of *Walafrida saxatilis* taken mainly from the sandy plains on farms in the Fraserburg and Beaufort West areas all yielded selenium values of less than 3 μg per gm of dry material. *Walafrida paniculata*, *W. geniculata* and *W. basutica*, taken from farms in the Three Sisters, Aberdeen and Trompsburg areas and from the Fauresmith Veld Reserve (one specimen of *W. geniculata*) all yielded values of less than 5·8 μg per gm of dry material, with the exception of one specimen of *W. paniculata* (7·0 μg per gm) from the farm " Three Sisters ". These bushes are all considered as excellent fodder plants.

A single specimen of *Selago albida* which we were able to collect on the Fraserburg Showgrounds was found to contain 1·0 μg per gm of dry material of the element.

N. *The Families Bignoniaceae, Rubiaceae, Cucurbitaceae, Lobeliaceae and Campanulaceae*

Our data on these families, as they are represented in the Karoo flora are very incomplete. We have examined a few specimens of *Rhigozum trichotomum* and *R. obovatum* (Bignoniaceae) which were in a fairly green state when collected. These shrubs tend to become dominant on many farms in the northerly parts of the area covered by this investigation but when seen most were in an advanced state of desiccation consisting mainly of the remnants of woody stems and thus unsuitable for sampling.

One specimen of *R. trichotomum* taken from the Prieska-Hopetown roadside was found to contain 19·8 μg per gm of dry material of selenium, while the highest value found in *R. obovatum* was 7·0 μg per gm.

The Rubiaceae are represented in our specimens by *Anthospermum dregei* and *Nenax microphylla*. A specimen of the former from the farm " Klawervlei ", Beaufort West, was found to contain negligible amounts of the element, but specimens of the latter bush from the Fauresmith Veld Reserve and Trompsburg (Ruigtevlei) were found to contain 11·5 and 10·0 μg per gram of selenium respectively.

One specimen of *Cucumis leptodermis* (Cucurbitaceae), taken at Beaufort West, was found to contain dangerously high levels of selenium, notably 21·2 μg per gm of dry material.

The specimens of *Lobelia inflata* (Lobeliaceae) which we have taken mainly from vleis on the farm Hebron (Victoria West), have yielded figures for selenium of no higher than 1 μg per gm.

Lightfootia spp. (Campanulaceae) are common and well eaten Karoo bushes. Our collection includes specimens of *L. nodosa* and *L. tenella* taken from Aberdeen, Fraserburg and Trompsburg. The highest selenium value recorded was 5·8 μg per gm (*L. nodosa*). All other specimens were considerably lower in the element.

O. *The Family Compositae*

The bulk of our collection consists of members of this huge family. Some of the genera which occur in the Karoo are extremely valuable and highly regarded fodder plants, e.g. the *Pentzia* spp., some are valueless unpalatable plants of a highly invasive nature, e.g. *Euryops* and *Elytropappus* spp., while some genera contain frankly toxic species, e.g. *Geigeria*, *Osteospermum* and *Senecio*. Some genera were previously shown to be capable of taking up large and dangerous amounts of selenium from the soil, e.g. *Chrysocoma*, *Eriocephalus* and *Nestlera* spp. (Brown & de Wet, 1962). The family as a whole is of considerable importance in the aetiology and epizootiology of both geeldikkop and enzootic icterus (Brown, 1962, 1963; Brown & de Wet, 1962; Brown & de Boom, 1966). Large numbers of specimens of the genera of importance in these respects have consequently been examined and the discussion which follows is largely a consideration of these individual important genera in turn.

(*a*) *The genus Chrysocoma:* The commonest species in the area covered by our investigations is *C. tenuifolia*. This hardy bush is a powerful invader of many of the veld types in this area (Acocks, 1953) and on many farms where veld mismanagement is only too obvious it has become the dominant plant in many of the camps. The plant is well eaten by sheep and goats in spite of its bitter resinous taste. It has been incriminated in the aetiology of enzootic alopecia (" kaalsiekte ") in sheep and goats (Steyn, 1931a, 1932b, 1934, 1949; Watt & Breyer-Brandwijk, 1962) and in that of geeldikkop and enzootic icterus (Brown, 1962, 1963; Brown & de Wet, 1962). The results of our investigations on this plant are presented in Table 18.

TABLE 18.—*Chrysocoma tenuifolia*

(All results are expressed as micrograms selenium per gram of dry plant material)

Specimen No.	*Farm or Locality*	*μg Se*
775	Fauresmith; Hillside near Veld Reserve	0·0
596	Trompsburg; Ruigtevlei	11·5
561	De Aar; De Aar–Britstown roadside	8·5
554	De Aar; De Aar–Britstown roadside	0·0
134	Vosburg; Mierfontein	3·0
505	Middelburg; Brentwood	14·0
504	Middelburg; Brentwood	4·5
521	Murraysburg; Rietpoort	1·0
512	Murraysburg; Poortje	0·0
401	Victoria West; Hebron; vlei	3·0
393	Victoria West; Hebron; vlei	5·8
49	Victoria West; Hebron; plains	28·0
4	Victoria West; Wagenaarskraal	3·0
54	Victoria West; Wagenaarskraal	1·5

Specimen No.	*Farm or Locality*	*μg Se*
144	Victoria West; Meltonwold	1·0
1	Three Sisters; Three Sisters	64·5
466	Beaufort West; Luttig	0·0
56	Beaufort West; Klawervlei	1·5
76	Aberdeen; Kleinplaats; mountainside	0·0
47	Aberdeen; Kleinplaats; plains	3·0
484	Aberdeen; Kleinplaats; plains	3·0
265	Fraserburg; Blomfontein	12·7
10	Fraserburg; Daggafontein; dam	3·0
41	Fraserburg; Daggafontein; plains	0·0
55	Fraserburg; Daggafontein; plains	4·5
52	Fraserburg; Daggafontein; plains	4·5
60	Fraserburg; Daggafontein; mountains	0·0
58	Fraserburg; Daggafontein; mountains	13·0
9	Fraserburg; Daggafontein; dam	59·0
37	Fraserburg; Droogvoetsfontein; plains	0·0
66	Fraserburg; Droogvoetsfontein; vlei	7·0
64	Fraserburg; Avondrus; plains	4·5
57	Fraserburg; Avondrus; mountains	1·5
53	Sutherland; Sutherland–Fraserburg roadside	4·5
51	Sutherland; Sutherland–Fraserburg roadside (limestone)	14·0
59	Sutherland; Sutherland–Fraserburg roadside	1·5
13	Sutherland; Verlatekloof pass	3·0
63	Sutherland; Verlatekloof pass	0·0
221	Calvinia; below Hantam mountains	4·5

It is apparent from the figures in this table that, in general, the plant contains very low levels of selenium when growing on a wide variety of soils and veld types. It is equally obvious that under certain circumstances, which are possibly exceptional, the plant may accumulate dangerously high levels of the element. Most of the specimens used in this work were mature flowering plants. We are thus not able to correlate selenium content with stage of growth as yet.

Four specimens of *Chrysocoma coma-aurea* have been examined. One, taken from sandy plains on the farm Avondrus (Fraserburg) was found to contain 53·4 μg selenium per gram of dry material. The other three specimens taken from farms in the same area contained 3·0, 0·0 and 0·0 μg Se per gm respectively. *Chrysocoma peduncularis* is represented by three specimens; two from the farm Meltonwold (Victoria West) containing 3·0 and 0·0 μg per gm of the element respectively, and one from a mountain slope on the farm Daggafontein (Fraserburg) which contained 4·5 μg Se per gm of dry material. The remarks made in connection with *C. tenuifolia* probably apply to these two species as well.

(*b*) *The genus Eriocephalus:* Plants of this genus are widely distributed throughout the Karoo and are generally regarded by farmers as good fodder plants. We have examined four species of this genus; *E. spinescens*, *E. ericoides*, *E. pubescens* and *E. glaber*. The first three are regarded by Acocks (1953) as normal constituents of the various true Karoo veld types mentioned in this report. *E. ericoides* is a strong invader of the northern thornveld types particularly where veld mismanagement is severe, while *E. spinescens* is considered as an invader in the False Arid Karoo types (Acocks, 1953). The results of our work on this genus are presented in Table 19. Some of these species have been previously noted in connection with the aetiology of enzootic icterus (Brown & de Wet, 1962).

TABLE 19.—*The Genus Eriocephalus*

(All results are expressed as micrograms selenium per gram of dry plant material)

Plant	*µg Se*	*Farm or Locality*
Eriocephalus ericoides	28·0	Fauresmith; Veld Reserve
	4·5	Vosburg; Mierfontein
	0·0	Middelburg; Brentwood
	0·0	Murraysburg; Poortje
	3·0	Victoria West; Hebron
	3·0	Victoria West; Hebron
	1·5	Victoria West; Hebron; vlei
	11·5	Victoria West; Wagenaarskraal
	1·5	Victoria West; Meltonwold, vlei
	59·0	Three Sisters; Three Sisters
	0·0	Beaufort West; Aar Doorns
	0·0	Beaufort West; Klawervlei
	1·0	Aberdeen; Kleinplaats
	0·0	Aberdeen; Kleinplaats
	11·5	Aberdeen; Kleinplaats
	0·0	Aberdeen; Kleinplaats
	7·0	Fraserburg; Showgrounds
	8·5	Fraserburg; Klipfontein
	1·0	Fraserburg; Avondrus; mountain
	4·5	Fraserburg; Avondrus; river-bed
	3·0	Fraserburg; Daggafontein
	8·5	Fraserburg; Daggafontein
	0·0	Fraserburg; Droogvoetsfontein
	17·0	Sutherland–Fraserburg roadside
	5·8	Sutherland–Fraserburg roadside
	36·5	Sutherland–Fraserburg roadside (limestone)
	4·5	Calvinia; below Hantam mountains
Eriocephalus glaber	3·0	Fauresmith; Veld Reserve
	0·0	De Aar–Britstown roadside
	7·0	Murraysburg; De Hoop
	0·0	Murraysburg; Rietpoort
	1·0	Murraysburg; Poortje
	4·5	Middelburg; Brentwood
Eriocephalus pubescens	7·0	Fraserburg; Avondrus; plains
Eriocephalus spinescens	8·5	Fauresmith; Veld Reserve
	12·7	Trompsburg; Ruigtevlei
	0·0	Beaufort West; Nuwejaarskraal
	28·0	Beaufort West; Klawervlei
	3·0	Fraserburg; Klipfontein; dam
	0·0	Fraserburg; Droogvoetsfontein
	0·0	Sutherland–Fraserburg roadside

The *Eriocephalus* species present a very similar picture to that of the *Chrysocoma* spp. as regards their uptake of selenium and the remarks made for the latter genus probably apply here as well with equal force. All four species of *Eriocephalus* examined probably behave in the same manner towards selenium in the soil. In general they appear to contain low to moderate amounts of the element. Under certain circumstances they may contain dangerously high levels of selenium.

(*c*) *The genus Euryops:* The various members of this genus are in general unpalatable resinous plants seldom grazed by small stock unless nothing else is available. They are apt to be strong invaders of mismanaged veld and often become dominant on mountain slopes after burning. *E. multifidus* is given by Acocks (1953) as a normal constituent of some of the veld types in the areas under consideration. The results obtained from this genus are presented in Table 20.

TABLE 20.—*The Genus Euryops*

(All results are expressed as micrograms selenium per gram of dry plant material)

Plant	*μg Se*	*Farm or Locality*
Euryops candollei	1·0	Beaufort West; Klawervlei
Euryops lateriflorus	0·0	Beaufort West; Klawervlei
	10·0	Fraserburg; Avondrus; river-bed
	8·5	Fraserburg; Droogvoetsfontein
	8·5	Fraserburg; Klipfontein
	8·5	Sutherland–Fraserburg roadside
Euryops multifidus	17·0	Fauresmith; Veld Reserve
	10·0	Fraserburg; Droogvoetsfontein
Euryops oligoglossus	5·8	Fraserburg; Daggafontein
	8·5	Sutherland; Verlatekloof pass
Euryops racemosus	17·0	Fauresmith; Veld Reserve
Euryops sulculatus var. *densifolius*	7·0	Beaufort West; Klawervlei
Euryops sp.	4·5	Murraysburg; Rietpoort
	0·0	Murraysburg; Poortje
	3·0	Victoria West; Hebron
	1·0	Victoria West; Wagenaarskraal
	3·0	Fraserburg; Daggafontein

The genus, as represented in our collection, appears on the whole to be capable of taking up fair to high amounts of selenium under a wide variety of veld conditions. The highest values, 17·0 μg per gm, were from plants growing in the Fauresmith Veld Reserve where many plants have been found to be high in selenium (see previous tables).

(*d*) *The genus Helichrysum:* Various species of this genus are widespread in the Karoo and are generally considered as useful fodder plants. The results of our investigations are presented in Table 21.

TABLE 21.—*The Genus Helichrysum*

(All results are expressed as micrograms selenium per gram of dry plant material)

Plant	*μg Se*	*Farm or Locality*
Helichrysum anomalum	0·0	Fauresmith; Veld Reserve
	0·0	Fauresmith; Veld Reserve
Helichrysum hamulosum	0·0	Fraserburg; Daggafontein
	0·0	Sutherland; Verlatekloof pass
Helichrysum lucilioides	1·0	Vosburg; Mierfontein
Helichrysum parviflorum	0·0	Fauresmith; Veld Reserve
Helichrysum pentzioides	7·0	Middelburg; Brentwood
	0·0	Murraysburg; Poortje
	0·0	Murraysburg; De Hoop
	1·0	Victoria West; Meltonwold
Helichrysum zeyheri	0·0	Fauresmith; Veld Reserve
	0·0	Murraysburg; Rietpoort
Helichrysum sp.	3·0	Beaufort West; Luttig
	8·5	Trompsburg; Ruigtevlei
	0·0	Victoria West; Hebron
	3·0	Vosburg; Mierfontein

It is apparent that the genus as a whole is uniformly low in selenium under a wide variety of veld conditions. (Note the low values in the specimens from Fauresmith.)

(*e*) *The genus Nestlera:* Plants of this genus are widespread in the Karoo and are typical members of the flora of many Karoo veld types, e.g. the Central Upper Karoo and Central Lower Karoo (*N. conferta, N. humilis* and *N. prostrata*), Western

Mountain Karoo (*N. prostrata*) and Arid Karoo (*N. humilis*) (Acocks, 1953). *N. prostrata* has been incriminated in the aetiology of enzootic icterus (Brown & de Wet, 1962; Brown & de Boom, 1966). The results of our work on this genus are presented in Table 22.

TABLE 22.—*The Genus Nestlera*

(All results are expressed as micrograms selenium per gram of dry plant material)

Plant	*μg Se*	*Farm or Locality*
Nestlera conferta	4·5	Fauresmith; Veld Reserve
	10·0	Trompsburg; Ruigtevlei
	0·0	Beaufort West; Luttig
Nestlera humilis	3·0	Fauresmith; Veld Reserve
	1·0	Vosburg; Mierfontein
	8·5	Aberdeen; Kleinplaats
	3·0	Victoria West; Hebron
	1·0	Fraserburg; Daggafontein
	1·0	Beaufort West; Nuwejaarskraal
Nestlera prostrata	14·0	Fauresmith; Veld Reserve
	70·0	Fraserburg; Klawervlei
	31·0	Fraserburg; Avondrus; river-bed
	0·0	Fraserburg; Avondrus; river-bed
	8·5	Beaufort West; Aar Doorns
	0·0	Beaufort West; Toornitzkuil
	0·0	Beaufort West; Toornitzkuil
	0·0	Beaufort West; Remainder
	3·0	Aberdeen; Kleinplaats
	5·8	Sutherland; Verlatekloof pass
Nestlera sp.	3·0	Aberdeen; Kleinplaats
	0·0	Brandfort; Valerie

The genus, as a whole, appears to be very similar to *Chrysocoma* and *Eriocephalus* spp. with regard to selenium uptake. Although some plants, particularly specimens of *N. prostrata* have yielded extremely high values for this element, the greater majority of specimens contain reasonably low or negligible amounts of selenium on a wide variety of veld types.

(*f*) *The genus Osteospermum:* Some members of this genus are known to be toxic, containing cyanogenetic glucosides, e.g. *O. ecklonis* (Watt & Breyer-Brandwijk, 1962). The results of our investigations are presented in Table 23.

TABLE 23.—*The Genus Osteospermum*

(All results are expressed as micrograms selenium per gram of dry plant material)

Plant	*μg Se*	*Farm or Locality*
Osteospermum ecklonis	5·8	Onderstepoort; garden
Osteospermum leptolobum	1·5	Fraserburg; Klipfontein
	0·0	Fraserburg; Klipfontein
	1·0	Fraserburg; Klipfontein
	3·0	Fraserburg; Avondrus
Osteospermum muricatum	7·0	Fauresmith; Veld Reserve
	8·5	Beaufort West; Luttig
Osteospermum scariosum	10·0	Trompsburg; Ruigtevlei
	1·0	Sutherland; Verlatekloof pass
Osteospermum sinuatum	1·5	Three Sisters; Three Sisters
Osteospermum spinescens	4·5	Fauresmith; Veld Reserve
	0·0	Victoria West; Hebron; vlei
	4·5	Victoria West; Hebron; plains
	8·5	Victoria West; Meltonwold
	8·5	Fraserburg; Showgrounds
Osteospermum sp.	0·0	Beaufort West; Remainder
	4·5	Brandfort; Valerie

Too few specimens of each species were examined to discern any particular pattern of uptake of selenium. The genus as a whole appears to take up negligible to moderate amounts of the element depending on soil conditions.

(*g*) *The genus Pentzia:* There are numerous species and many varieties of these representing this genus in South Africa. Although some of these varieties differ widely in appearance, habit of growth, palatability and smell, many are very much alike in some of these respects and may therefore easily be confused with one another. The fact that all varieties bear the same type of yellow flower makes differentiation between the different types a very difficult matter for the layman.

Some of the Pentzias are grazed very sparingly, if at all, while others are very palatable and eagerly eaten by sheep. *Pentzia incana*, a large flowered variety, is probably one of the best grazed of them all. It is a vigorous grower and may reach a height of twelve inches or more. It is superior to lucerne hay in the preflowering stage in feeding value since it is able to supply almost the same amount of protein and is a good deal better in energy-providing properties (Botha, 1939). It is one of the important species in the Lower Karoo, Central Lower Karoo, Central Upper Karoo and Karroid Broken Veld, Veld Types. It is dominant in the upper form of the Western Mountain Karoo except in overgrazed types (Acocks, 1953). *P. sphaerocephala* occurs in the mountains and hills and on stony outcrops in the Karoo. It is a large flowered variety, not easily confused with the other Pentzias that normally occur in this area. It is an important member of the vegetation of the Central Upper Karoo and Orange River Broken Veld Types (Acocks, 1953). Although its protein content appears to be low it is palatable, being very well grazed by sheep and cattle alike, and contains a high percentage of digestible carbohydrates (Botha, 1939).

P. globosa is considered to be an inedible and valueless type with marked encroaching propensities on mismanaged veld (Botha, 1939). It is typical of the Karroid Broken Veld, Central Upper Karoo, Orange River Broken Veld and Tarchonanthus Thornveld and is a prominent invader of the Kalahari Thornveld (especially on hills and calcareous tufa), Pan Turfveld where calcareous tufa is exposed, Cymbopogon-Themeda Grassveld and Karoo Danthonia Mountain Veld (Acocks, 1953).

P. spinescens is typical of the Karroid Broken Veld, Arid Karoo (especially on overgrazed veld) and the Central Upper Karoo. It is a prominent invader of the False Arid Karoo (Acocks, 1953) and is generally considered as an inferior grazing type.

P. calcarea and *P. virgata* typical of limestone soils of the Central Upper Karoo and Tarchonanthus Thornveld have been incriminated in the aetiology of " bewerasiesiekte ", a disease simulating paralytic myoglobinuria, amongst horses and mules in the western and south-western Orange Free State and Griqualand West (Steyn, 1949). *P. virgata* is a notable invader of the Kalahari Thornveld and Pan Turfveld where calcareous tufa is exposed.

P. globifera was at one time incriminated in the aetiology of enzootic icterus (Steyn, 1929) but this has never been established to be the case.

P. punctata is found mainly on the mountains of the Karoo where it invades the Karoo Danthonia Mountain Veld (Acocks, 1953).

Besides the above species which we have examined and report on in Table 24 numerous other species occur in the characteristic vegetation of the veld types concerned in this investigation, e.g. *P. annua*, *P. viridis*, *P. argentea*, *P. lanata*, *P. pinnatisecta*, etc., but are of less frequent occurrence than those we have collected.

TABLE 24.—*The Genus Pentzia*

(All results are expressed as micrograms selenium per gram of dry plant material)

Plant	*μg Se*	*Farm or Locality*
Pentzia albida var. *annua*	1·0	Beaufort West; Klawervlei
	3·0	Fraserburg; Showgrounds
Pentzia calcarea	4·5	Prieska–Hopetown; roadside
Pentzia globosa	8·5	Fauresmith; Veld Reserve
	5·8	Trompsburg; Ruigtevlei
	0·0	Middelburg; Brentwood
	5·8	Fraserburg; Showgrounds
	4·5	Fraserburg; Klipfontein
	1·0	Fraserburg; Daggafontein
	3·0	Victoria West; Hebron; vlei
	5·8	Victoria West; Wagenaarskraal
Pentzia incana var. *forma*	8·5	Fauresmith; Veld Reserve
Pentzia incana	0·0	Beaufort West; Luttig
	10·0	Beaufort West; Luttig
	0·0	Beaufort West; Nuwejaarskraal
	0·0	Beaufort West; Toornitzkuil
	0·0	Beaufort West; Klawervlei
	7·0	Calvinia; below Hantam mountains
	7·0	Aberdeen; Kleinplaats
	0·0	Middelburg; Brentwood
	4·5	Murraysburg; Rietpoort
	5·8	Murraysburg; Poortje
Pentzia punctata	8·5	Fraserburg; Daggafontein
	0·0	Fraserburg; Avondrus
Pentzia spinescens	3·0	Fraserburg; Avondrus
	1·5	Fraserburg; Daggafontein
	10·0	Beaufort West; Klawervlei
	0·0	Beaufort West; Klawervlei
	1·0	Vosburg; Mierfontein
Pentzia sphaerocephala	7·0	Fauresmith; Veld Reserve
	3·0	Beaufort West; Luttig
	3·0	Murraysburg; De Hoop
	0·0	Murraysburg; Rietpoort
	4·5	Murraysburg; Poortje
Pentzia sp.	5·8	Fauresmith; Veld Reserve
	1·5	Beaufort West; Klawervlei
	4·5	Victoria West; Hebron
	8·5	Victoria West; Meltonwold
	1·0	Fraserburg; Droogvoetsfontein
	0·0	Fraserburg; Klipfontein
	3·0	Fraserburg; Avondrus
	0·0	Brandfort; Valerie

Although some of the species examined contained isolated values for selenium as high as 10μg per gm of dry material, uptake by the species in our collection appears to be low on the whole and in many instances negligible. A fairly wide variety of soil and veld conditions is represented by the farms on which these plants were collected.

(*h*) *The genus Pteronia:* This very large genus is well represented in most of the veld types considered in this report. Acocks (1953) lists 26 species in his Veld Types of South Africa of which approximately 22 occur in the Karoo and Little Karoo and 12 are given as typical of the various veld types in the area covered by this

investigation. We have been able to examine seven of these latter species and a number of unidentified specimens of Pteronias. Our results are presented in Tables 25 and 26. Of these species *P. glauca* is typical of the Central Upper Karoo, Western Mountain Karoo, Arid Karoo, and the Danthonia Mountain Veld within those types; *P. glaucescens* is typical of the Central Upper Karoo; *P. glomerata* of the Great Karoo, Central Upper Karoo, Western Mountain Karoo, Arid Karoo, and is a well-known invader of the thornveld types further north. *P. mucronata* is at home in the Arid Karoo and occurs as an invader of False Arid Karoo areas; *P. pallens* and *P. paniculata* are typical Little Karoo types which appear to have become established on some of the Western Mountain Karoo farms in fairly large numbers and *P. tricephala* is a typical mountain species in the areas concerned.

All are considered unpalatable and poor fodder plants and some like *P. pallens* are known to be violently toxic to small stock under certain circumstances (Steyn, 1929, 1934, 1949).

TABLE 25.—*The Genus Pteronia*

(All results are expressed as micrograms selenium per gram of dry plant material)

Plant	*μg Se*	*Farm or Locality*
Pteronia glauca	3·0	Vosburg; Mierfontein
	0·0	Middelburg; Brentwood
	4·5	Aberdeen; Kleinplaats
	0·0	Beaufort West; Aar Doorns
	0·0	Beaufort West; Klawervlei
	3·0	Beaufort West; Klawervlei
	0·0	Fraserburg; Klipfontein
	41·0	Fraserburg; Klipfontein
	0·0	Sutherland; Verlatekloof pass
Pteronia glaucescens	10·0	Victoria West; Meltonwold
	1·0	Fraserburg; Klipfontein
	1·0	Fraserburg; Klipfontein
Pteronia glomerata	3·0	Victoria West; Hebron
	0·0	Victoria West; Hebron
	0·0	Beaufort West; Klawervlei
	0·0	Aberdeen; Kleinplaats
	0·0	Fraserburg; Droogvoetsfontein
	3·0	Fraserburg; Klipfontein
	2·4	Fraserburg; Daggafontein
	7·0	Sutherland–Fraserburg roadside
	5·0	Sutherland–Fraserburg roadside

TABLE 26.—*The Genus Pteronia* (continued)

(All results are expressed as micrograms selenium per gram of dry plant material)

Plant	*μg Se*	*Farm or Locality*
Pteronia mucronata	14·0	Prieska–Hopetown roadside
	7·0	Fraserburg; Avondrus; mountains
	7·0	Fraserburg; Avondrus; mountains
	1·0	Fraserburg; Avondrus; mountains
	0·0	Fraserburg; Daggafontein; dam
	3·0	Fraserburg; Daggafontein; dam
	0·6	Fraserburg; Daggafontein; mountains
	0·0	Fraserburg; Daggafontein; plains
	3·0	Fraserburg; Daggafontein; plains
	0·0	Calvinia, below Hantam mountains
Pteronia pallens	3·0	Sutherland; Verlatekloof pass
Pteronia paniculata	10·0	Fraserburg; Avondrus; mountains
	7·0	Fraserburg; Avondrus; mountains
	10·0	Sutherland–Fraserburg roadside
	3·0	Sutherland; Verlatekloof pass

Plant	*μg Se*	*Farm or Locality*
Pteronia tricephala	0·6	Beaufort West; Klawervlei
	0·0	Fraserburg; Daggafontein; plains
	4·5	Fraserburg; Daggafontein; plains
	0·0	Fraserburg; Daggafontein; plains
	3·0	Fraserburg; Daggafontein; mountains
	1·0	Fraserburg; Klipfontein
Pteronia sp.	18·4	Vosburg; Mierfontein
	3·0	Murraysburg; De Hoop
	3·0	Beaufort West; Aar Doorns
	7·0	Beaufort West; Nuwejaarskraal
	3·0	Beaufort West; Remainder

Out of 47 specimens representing this genus, we found only 11 containing amounts of selenium of over 5 μg per gm of dried material and of these only six were dangerously high. Inspection of Tables 25 and 26 will show that the genus, as represented by our specimens, contains in general negligible amounts of the element. Under circumstances which are possibly exceptional most of the species represented may, however, take up dangerous amounts of selenium from the soil. All specimens were taken in a flowering state and we cannot as yet correlate selenium content with stage of growth.

(*i*) *The genera Asaemia, Aster and Geigeria:* These genera are of general interest since they all contain species which are or apparently have been responsible for stock losses in South Africa. *Asaemia axillaris* is described as being able to evoke a photosensitization and icterus syndrome in sheep similar to geeldikkop in appearance (Steyn, 1949). We have never been able to confirm these observations.

Aster filifolius has been incriminated in a number of cases of mortality amongst small stock (Steyn, 1931a, 1932b, 1934, 1949). *A. muricatus* is considered as an excellent pasture plant in sheep farming. It is very palatable, well grazed by sheep at all times and when in good condition is superior to good meadow hay in most respects (Botha, 1939). Numerous *Aster* spp. have been listed by Rosenfeld & Beath (1964) as " secondary selenium absorbers " on American soils. None of these species appear to occur in the Karoo.

Geigeria spp. notably *G. aspera, G. africana, G. zeyheri, G. pectidea* and *G. passerinoides* are known to cause the disease " vermeersiekte " (lit. " vomiting disease ") in sheep and cattle (Steyn, 1934, 1949; Watt & Breyer-Brandwijk, 1962; Grosskopf, 1964). The results of our investigation into these genera are presented in Table 27.

TABLE 27.—*The Genera Asaemia, Aster and Geigeria*

(All results are expressed as micrograms selenium per gram of dry plant material)

Plant	*μg Se*	*Farm or Locality*
Asaemia axillaris	0·0	Beaufort West; Aar Doorns
	0·0	Beaufort West; Remainder
	5·8	Beaufort West; Luttig
	3·0	Beaufort West; Luttig
	1·0	Fraserburg; Grootfontein
Aster barbatus	4·5	Murraysburg; De Hoop
Aster filifolius	1·0	Cradock–Middelburg roadside
	0·0	Prieska–Hopetown roadside
Aster hyssopifolius	0·0	Fraserburg; Showgrounds
Aster muricatus	4·5	Fauresmith; Veld Reserve
	8·5	Trompsburg; Ruigtevlei
	1·0	Murraysburg; De Hoop
	0·0	Beaufort West; Luttig
Geigeria africana	10·0	Fauresmith; Veld Reserve
	25·4	Trompsburg; Ruigtevlei
	12·7	Prieska–Hopetown roadside
	5·8	Prieska–Hopetown roadside

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The only consistently high selenium values amongst this group of specimens are to be found in those of *G. africana*. Both *Asaemia axillaris* and *Aster* spp. appear to contain, in general, negligible amounts of the element.

(*j*) *The genera Elytropappus and Hertia: E. rhinocerotis* is a well-known encroaching plant in many of the veld types of the Karoo. It is both undesirable and useless as a fodder plant in the areas concerned. The whole plant is bitter and resinous and has found some use in Folk-medicine as a stomachic, bitter and astringent (Watt & Breyer-Brandwijk, 1962).

Hertia (*Othonna*) *pallens* and *H. cluytiaefolia* have been described as the cause of some instances of mortality amongst small stock (Steyn, 1934, 1949). The results of our work on these plants appear in Table 28.

TABLE 28.—*The Genera Elytropappus and Hertia*

(All results are expressed as micrograms selenium per gram of dry plant material)

Plant	*μg Se*	*Farm or Locality*
Elytropappus rhinocerotis	4·5	Fraserburg; Avondrus; plains
	0·0	Fraserburg; Avondrus; river-bed
	0·0	Fraserburg; Avondrus; mountain
	0·0	Fraserburg; Celeryfontein
	5·8	Fraserburg; Daggafontein; mountain
	0·0	Sutherland; Verlatekloof pass
	1·0	Beaufort West; Luttig
Hertia cluytiaefolia	4·5	Victoria West; Wagenaarskraal
Hertia pallens	0·0	Vosburg; Mierfontein
	3·0	Vosburg; Mierfontein
	15·5	Vosburg; Mierfontein
	11·5	Fauresmith; Veld Reserve
	1·0	Aberdeen; Kleinplaats
	5·8	Middelburg; Brentwood

E. rhinocerotis appears to contain in general low to negligible amounts of selenium, while *H. pallens* can accumulate dangerous amounts of the element given the appropriate conditions.

(*k*) *The genera Berkheya and Phymaspermum:* The *Berkheyas* are thistle-like or spiny bushes occurring in the more arid parts of the area investigated. They are seldom eaten by sheep. Three species were examined, viz. *B. pinnatifida*, *B. onopordifolia* and *B. heterophylla*. Two specimens of the first species, from Beaufort West and Vosburg respectively were found to contain negligible amounts of selenium. One specimen of each of the latter two species was examined. Both were taken from the farm Ruigtevlei, Trompsburg, and contained 7·0 and 15·5 μg Se per gm of dry material respectively. Since many other specimens of a variety of plants from this farm show fair to high values for the element, it is apparent that given the appropriate soil conditions, the *Berkheyas* may take up significant amounts of selenium.

Phymaspermum parvifolium is met with in many parts of the Karoo and generally on the plains. It is moderately well grazed by sheep. *Phymaspermum* is generally regarded as hardy and drought-resistant and an excellent stand-by in times of drought. It contains a fairly high percentage of protein, whose digestibility is moderately high (Botha, 1939). In all other respects and especially in crude fibre, low coefficients of digestion have been obtained in feeding trials and the plant is considered to be on the whole of low nutritive value (Botha, 1939). Four specimens, two from the Fauresmith Veld Reserve, one from Ruigtevlei, Trompsburg and one from Brentwood, Middelburg, have been examined. Selenium values were

4·5, 3·0, 12·7 and 7·5 μg per gram of dry material respectively. Like the foregoing species the plant may under certain circumstances contain moderate amounts of selenium.

(*l*) *The genus Senecio:* A large number of well-known very toxic plants belong to this genus most of which are rare in the areas under consideration. Two species were collected, viz. *S. burchelli*, a common proclaimed weed and *S. niveus*. The results of our work on these plants appear in Table 29.

TABLE 29.—*The Genus Senecio*

(All results are expressed as micrograms selenium per gram of dry plant material)

Plant	*μg Se*	*Farm or Locality*
Senecio burchelli	10·0	Victoria West; Meltonwold
	11·3	Three Sisters; Three Sisters
	0·0	Beaufort West; Klawervlei
	0·0	Beaufort West; Luttig
	1·0	Beaufort West; Aar Doorns
	1·0	Brandfort; Valerie
Senecio niveus	1·0	Victoria West; Wagenaarskraal
	0·0	Victoria West; Hebron
	4·5	Fraserburg; Showgrounds
	0·0	Beaufort West; Luttig

S. burchelli is apparently able to accumulate moderately large amounts of selenium given the appropriate conditions.

(*m*) *Miscellaneous genera.*—A large number of genera is represented in our collection by single specimens only. We have presented in Table 30 the results from specimens in which the selenium content was found to be above 5·0 μg per gm of dry material.

TABLE 30.—*Miscellaneous Genera of the Compositae*

(All results are expressed as micrograms selenium per gram of dry plant material)

Plant	*μg Se*	*Farm or Locality*
Amellus strigosus	18·4	Prieska-Hopetown roadside
Cineraria aspera	21·2	Fraserburg; Daggafontein, hillside
Erigeron floribundus	8·3	Sutherland; Verlatekloof pass
Gamolepis chrysanthemoides	14·0	Trompsburg; Ruigtevlei
Gazania krebsiana	8·5	Fraserburg; Showgrounds
Gnaphalium purpureum	5·0	Victoria West; Meltonwold
Lasiospermum bipinnatum	10·0	Fraserburg; Showgrounds
Parthenium argentatum	17·0	Fauresmith; Veld Reserve
Pegolettia retrofracta	7·0	Vosburg; Mierfontein

Some of these plants apparently take up dangerously large amounts of the element. More work will have to be done on such plants to establish whether these figures have any significance or not.

P. *The trees and larger shrubs of the Karoo and their relatives*

Although these plants are largely of little importance as fodder plants in the areas concerned some of them are eaten by sheep and goats. They have been included in our collection largely for interest. The results of our analyses on these plants are presented in Table 31. A number of smaller relatives or representatives of the families concerned are also included in this table. The analyses were performed on dried foliage only.

TABLE 31.—*The Trees and Larger Shrubs of the Karoo*

(All results are expressed as micrograms selenium per gram of dry plant material)

Plant	*μg Se*	*Farm or Locality*
Anacardiaceae		
Rhus erosa	4·5	Trompsburg; Ruigtevlei
Schinus molle	17·0	Fraserburg; Showgrounds
Celastraceae		
Gymnosporia buxifolia	1·0	Beaufort West; Teekloof pass
	0·0	Beaufort West; Nuwejaarskraal
Ebenaceae		
Diospyros austro-africana	3·0	Fraserburg; Daggafontein
Euclea ovata	18·4	Trompsburg; Ruigtevlei
Royena hirsuta	1·0	Trompsburg; Ruigtevlei
Royena pallens	4·5	Trompsburg; Ruigtevlei
Royena pubescens	0·0	Trompsburg; Ruigtevlei
Royena sp.	14·0	Trompsburg; Ruigtevlei

Some of these species are apparently able to take up and store significant amounts of selenium, e.g. *Schinus molle*, *Euclea ovata* and *Royena* sp.

DISCUSSION

The selenium content of the rocks and soils of the Karoo will form the subject of a further report. For the purposes of this discussion we need note only some relevant points in this regard. Rosenfeld & Beath (1964) have given an excellent account of the geochemistry of selenium and its occurrence in the various rock formations in the seleniferous areas of America and the origin of selenium in such formations is also described.

As will be seen from Fig. 2 the area covered by our investigation consists mainly of beds of the Beaufort Series, of Upper Permian or Lower Triassic age. Formations of the Triassic age in the seleniferous areas of the United States of America support an abundance of highly seleniferous plants (Rosenfeld & Beath, 1964). The formations concerned are described as brilliant red and brown rocks, shales, sandstones, conglomerates, limestones and volcanic rocks. The similarity of these formations to those of interest to us in this regard is striking and it is probable that selenium was incorporated in our formations in the same manner as in America.

The Dwyka Tillite and Lower Ecca shales are present in the western part of the area covered by our investigation. They are of upper Carboniferous and Lower Permian age respectively. In America, the marine limestones, sandstones and shales of these ages support a number of highly seleniferous " indicator " plants, but apparently not the abundance found on geological formations of Triassic or the later cretaceous ages (Rosenfeld & Beath, 1964).

Shales were found to contain more selenium than limestones and other sedimentary rocks. The Mesozoic and Paleozoic appear to have been the eras of most extensive selenium deposition in shales (*op. cit.*). Limestones were found to be generally low in the element and volcanic tuffs to contain variable amounts. Sandstones in contact with carbonaceous shale beds were often highly seleniferous (*op. cit.*)

In how far these findings pertain to the Karoo formations remains to be seen. There seems to be at the moment no reason why there should be any difference except probably in the amount of selenium deposited.

It is obvious from all the foregoing data that most of the representative vegetation of the areas concerned is capable of taking up fair to moderate amounts of selenium from the soil given the appropriate conditions. The selenium content of the Karoo vegetation is, however, far lower than that in the seleniferous areas of America. Numerous plants, however, appear to be able to take up potentially or frankly dangerous amounts of the element under favourable conditions.

The accumulation of selenium in plants depends on the species of plant, environmental factors, age and phase of growth of the plant, seasonal factors and the nature and availability of selenium compounds in the soil (Rosenfeld & Beath, 1964). The selenium content of various plants growing in the same soil represents the *relative ability of species* to accumulate selenium (*op. cit.*; our italics). During the present survey no studies were made of factors like stage of growth since the primary object was to indicate the extent to which the element occurs in possibly hazardous amounts in the Karoo vegetation. There seems to be little correlation between families and selenium content of the Karoo species. Some families, e.g. the Gramineae, Chenopodiaceae, Ficoidaceae, etc., appear to contain more seleniferous plants than others but it must be remembered that only representatives of these growing in the Karoo, and only those which we encountered, were collected for this work. Some families are well represented in the Karoo flora and others very poorly. By the same tokens there appears to be poor correlation between genera examined and their selenium content. We have too few data to confirm or refute this particular point. It is, however, apparent that quite a number of species of widely separated genera are able to accumulate dangerous amounts of the element.

Rosenfeld & Beath (1964) have divided seleniferous plants into groups according to their ability to accumulate selenium:

Group 1: Primary selenium indicator (" converter or accumulator ") plants; containing from 1,000 to 10,000 ppm of the element. Selenium is present in the plants mainly as water soluble compounds of small molecular weight. Such plants may cause acute selenosis or " blind staggers " in grazing animals.

Group 2: Secondary selenium absorbers. These rarely contain more than a few hundred ppm of the element on an air dried basis. A large percentage of the selenium is present in the plant as selenate and lesser amounts in organic forms. Such plants may cause acute or chronic selenosis in grazing animals.

Group 3: Most cultivated crop plants, grains and native grasses which generally accumulate low concentrations of the element (maximum: 30 ppm). Selenium is associated mainly with the plant proteins. Plants of this nature produce " alkali disease " in grazing animals.

Primary selenium indicator or converter plants are those which apparently require selenium for their growth and development, and their growth is consequently restricted to seleniferous areas, e.g., *Astragalus*, *Xylorrhiza*, *Oonopsis* and *Stanleya* spp. There is considerable species variation as regards selenium uptake within these genera, e.g. a number of *Astragalus* spp. are non-indicator plants and occur on both seleniferous and non-seleniferous soils. Even when growing in proximity to the selenium accumulating species on seleniferous soils they are free of selenium or contain only traces (Rosenfeld & Beath, 1964). None of these genera are known to occur in South Africa and we have not been able to find any plants of this nature.

An interesting point noted in the work of Rosenfeld & Beath (1964) is that a number of indicator species possess an offensive odour, the intensity of which may be used as a qualitative indication as to the amount of selenium which is present in these plants. We have noted this obnoxious odour in a few plants which contain moderately large amounts of selenium, e.g. *Salsola kali* and *Sueda fruticosa*.

Indicator plants are also known as " converter " plants since they convert selenium in the soil into soluble compounds which when returned to the soil are readily available for absorption by all types of plant vegetation. In many regions enrichment of the upper soil may have gone through countless cycles of growth and decay of indicator plants. In areas of dense growth the converters contribute considerable amounts of available selenium to crop plants (Rosenfeld & Beath, 1964). Even though we do not have plants of this nature in South Africa, as far as we know, local soil enrichment with selenium due to growth and decay of other plants high in the element may be of considerable importance. We will return to this point again shortly.

Secondary selenium absorbers are defined as plants that absorb moderately large quantities of selenium when they grow on soils that contain high concentrations of the element in an available form (Rosenfeld & Beath, 1964). They belong to a number of genera, e.g. *Aster*, *Atriplex*, *Castillega*, *Comandra*, *Grayia*, *Grindelia*, *Gutierrhiza*, *Machaeranthera*, etc. Although some of these genera, e.g. *Aster* and *Atriplex* are well represented in South Africa none of the American species concerned are known to occur here. Some of our *Atriplex* species are undoubtedly able to accumulate dangerous amounts of selenium. Plants of this nature are not restricted to seleniferous soils as are the indicator plants.

It is of interest to note that the species concerned of some of these genera are partial parasites, e.g. *Castillega* and *Comandra* spp. and some like *Comandra* sp. contain only selenium when its parasitic roots are attached to a seleniferous plant. The solitary example in our collection of this type of plant is the partial parasite *Viscum rotundifolium* (Loranthaceae) which was found to contain 19·8 μg selenium per gm of dry matter. This plant taken on the farm Kleinplaats (Aberdeen District) was growing on the aerial parts of a specimen of *Carissa haematocarpa* (Apocynaceae), the dried foliage of which contained 4·5 μg Se per gm. Considerable concentration of the element had obviously occurred in its movement from the soil, through the host into the parasite. Such plants when they decay might conceivably enrich the soil upon which they fall to a considerable degree.

Regarding farm crops, Rosenfeld & Beath (1964) state: " Farm crops in order to accumulate and store selenium (5 ppm or more) must be rooted in soils that contain selenium ", and " In most farming areas the virgin soils contain so little available selenium that cultivated crops are unable to absorb more than traces of the element. If seleniferous soils are kept free of indicator or selenium converter plants they do not become seleniferous under cultivation ". We have not had the opportunity of examining crop plants, apart from some lucerne, in the areas concerned with this investigation, since for various reasons these are not generally cultivated (Brown & de Boom, 1966). The position with regard to lucerne has been mentioned earlier. It is, however, worthwhile noting, for the purposes of this discussion, some of the high values found for certain crop plants raised in seleniferous areas in America, since relatives of these are of importance in our survey. Asparagus (Liliaceae) is cited as containing 2·7 to 11·0 ppm of selenium; onions (Liliaceae) as containing 0·4 to 17·8 ppm and rutabagas (Cruciferae) as containing 1·7 to 6·0 ppm.

" Grains " on the whole were found to contain 1 to 30 ppm of the element (Rosenfeld & Beath, 1964). These values may be compared with those we have found for the members of the families concerned.

At the present time there is considerable evidence to indicate that selenium is involved in the protein metabolism of crop plants. Large amounts of nitrogenous organic substances (in the growth medium) allow greater selenium accumulation by crop plants (Rosenfeld & Beath, 1964). These findings must be taken into consideration when considering the occasional high selenium values found in Karoo bushes, generally regarded as highly nutritious and valuable fodder plants.

Miller & Byers (1937) classified plants with reference to selenium absorption and placed grasses amongst the low selenium absorbers. Only in the true " poison areas " where the soil contains substantial amounts of available selenium are the native grasses highly seleniferous (Rosenfeld & Beath, 1964). The plant population or plant association is of importance as to the amount of selenium which grasses accumulate. Native grasses absorb high concentrations of selenium when growing in proximity to selenium-bearing weeds. Primary and secondary selenium accumulators increase the selenium content of grasses. When grown next to such plants the selenium content of grasses may rise as high as 70 ppm (Rosenfeld & Beath).

Our findings as regards the Gramineae are on the whole the same as those of the American workers. The strong perennial species contain in general high levels of selenium than the weaker annual types. The high levels of selenium in grasses taken from the Fauresmith Veld Reserve is noteworthy in view of the rather high levels of the element in many diverse plants collected from this locality. The fact that grasses concentrate higher levels of selenium in their seeds than in their foliage is well-known and important (Rosenfeld & Beath, 1964). The grasses we have studied have proved to be no exception. Certain grasses like *Agropyron smithii* (" Western wheat grass ") which is the most highly seleniferous of the grasses in western South Dakota (0·0 to 84·0 ppm Se, average 11·5 ppm) have been suggested for use as indicators of the availability of selenium from the soil for other species of grasses (Rosenfeld & Beath, 1964). We have as yet too few data to tell whether any of our native species may be used in this way, although a glance at the data given later in Appendix 2, dealing with the vegetation of the Fauresmith Veld Reserve indicates species like *Cenchrus ciliare*, *Eragrostis lehmanniana* and *Panicum makarikariensis* as possibilities in this regard.

We have, in Appendix 1, attempted a very tentative and preliminary classification of the Karoo vegetation according to apparent ability to take up selenium. This has been judged by considering the selenium content of the specimens examined. The classification is modelled on that presented by Rosenfeld & Beath (1964)., discussed earlier. Group 1 (which as yet remains blank) and Group 2 of plants present few difficulties. The plants which have been placed in the latter group owe their presence there to the fact that some specimens of each have presented values for selenium in the order of that defined for the group even though the bulk of specimens of such plants have yielded considerably lower values for the element.

The plants which we have grouped under the third part of this classification present numerous difficulties as to their correct placing, the most prominent of which are due to lack of sufficient data. Group 3, which includes plants containing 0 to 30 μg Se per gm, has been subdivided into three sub-groups depending on the selenium content found. Sub-group (*a*) consists of plants in which values for the element were almost consistently in the upper range of the qualifying selenium levels.

These plants are all to be considered potentially dangerous as regards their selenium content and the only difficulty which arises in placing them in this group is that some, e.g. the *Atriplex* species, *Galenia africana* and *Geigeria africana* may yet have to be moved up into Group 2 once more data is available.

Sub-group (*b*) consists of plants in which the selenium content was found to lie between 10 to 30 μg per gm in a few specimens amongst a number of specimens examined of the plant concerned and plants in which *the few* specimens examined had a selenium content within this range. The main difficulty here is the decision as to whether such values are exceptional for the species concerned or whether the plants belong in the first sub-group. Since our knowledge of these plants is very incomplete regarding their selenium metabolism they should be regarded with suspicion until we know more about them.

Sub-group (*c*) contains plants in which the selenium content was found to lie between 5 to 10 μg per gm. The difficulties of classification mentioned for the previous sub-group pertain here as well. It is, however, likely that on properly managed farms most of these plants will not constitute a hazard to animal health as far as their selenium content is concerned. Some like *Asclepias fruticosa* and *Osteospermum* spp. are known to be toxic by virtue of poisonous principles other than selenium.

Group 4 embraces a number of species in which the selenium content was found to be negligible even when such plants were growing in close proximity to more seleniferous types. In some instances the genus as a whole appears to take up little selenium, e.g. *Helichrysum* and *Walafrida*. In other instances the majority of species in a particular genus appear to have the same property, e.g. *Mesembryanthemum*. One of the main difficulties as regards this latter genus is identification of the different species by lay people. Since isolated values of up to 10 μg/gm have been found in some species like *M. saxicolum* and *M. spinescens* it is probably safer from a practical point of view to consider this genus with a measure of suspicion.

The annual or weakly perennial grasses are represented in this group, the placing being based on the few results we have obtained and on experience elsewhere in the world. Until more information regarding our native grasses of this nature is available, an open mind should be kept on the subject.

We have collected all our data on the vegetation of the Fauresmith Veld Reserve together in Appendix 2. For some reasons, as yet unknown but obviously connected with enrichment of the topsoil (see previous remarks on this point), the soil of this Reserve contains significant amounts of freely available selenium. In view of the fact that a large number of the species which we have examined can take up moderate amounts of selenium given the appropriate conditions, these data are of importance in showing what can happen to the vegetation in general under such circumstances. The percentage distribution of selenium in these plants is shown in Table 32.

TABLE 32.—*The percentage distribution of selenium in the vegetation of the Fauresmith Veld Reserve*

Number of plants examined	67
Percentage of specimens above 30 μg/gm	0
Percentage of specimens in the range 10-30 μg/gm	40·9
Percentage of specimens in the range 5-10 μg/gm	27·7
Percentage of specimens below 5 μg/gm	33·3

It is apparent from these figures that two-thirds of the plants examined contained potentially dangerous levels of selenium. The distribution of the different species (Appendix 2) within the four ranges of selenium content given in this table makes an interesting study when compared with our classification of the Karoo plants presented in Appendix 1. Besides lending some weight to the placing of many plants in this classification, the data will, when compared with those in the following Appendices, illustrate many of the difficulties inherent in attempting a classification of this nature.

Since a lowgrade subclinical selenium intoxication has been incriminated in the aetiology of geeldikkop and enzootic icterus (Brown, 1962, 1963, 1964; Brown & de Wet, 1962) it is of interest to compare the selenium content of the vegetation of farms on which either disease occurs with that in areas where the syndromes are unknown. The relevant data are presented in Appendices 3 to 7.

Appendix 3 contains the data from all the plants collected on the Fraserburg Showgrounds. This centre lies slightly to the west of the main area in which enzootic icterus is rife. The veld type is Arid Karoo and the plants were taken from within the relatively sheltered confines of the fenced-off showgrounds. The vegetation here represents plants which have escaped the attention of the showground attendants and may be remnants of the original vegetation or may have come in from the surrounding veld due to dissemination of seeds by wind, water and animals. Grazing or clearing of vegetation is limited to short periods when the showground is in use. (Perhaps twice or three times yearly.) During the intervening periods growth of the plants is allowed to proceed unchecked.

Appendix 4 contains all the data collected from the farms Daggafontein, Klipfontein and Avondrus situated in the Nuweveld mountains (Fraserburg District). Annual outbreaks of enzootic icterus are very severe on these farms and mortality is high (Brown & de Boom, 1966). The veld type is Central Upper Karoo in the case of the first two farms and Western Mountain Karoo in the case of Avondrus. At the time of the investigation these farms had been severely mismanaged and considerable deterioration of the veld was in evidence everywhere (Brown & de Boom, 1966).

The farm Mierfontein in the Vosburg district is one on which some of the severest outbreaks of geeldikkop have occurred within recent years. Numerous cases showing features of both the geeldikkop and enzootic icterus syndromes have been encountered in this area (Brown, 1966; Brown, le Roux & Tustin, 1960). The veld type is False Arid Karoo and over-grazing has been severe and continuous. The data obtained from the vegetation of this farm are presented in Appendix 5.

Appendix 6 embraces a number of farms in the Beaufort West district on which geeldikkop makes a sporadic and sometimes severe annual appearance. Morbidity and mortality rates are in general far lower than in the Vosburg area. The veld types represented are Central Lower Karoo in the case of the farms Aar Doorns, Toornitzkuil, Nuwejaarskraal and Remainder and Karroid Broken Veld in the case of the farm Luttig. At the time of our investigation all these farms were more or less heavily stocked and overgrazing was clearly apparent in some of the camps concerned.

In Appendix 7, we have presented data from areas in which neither syndrome is known to occur naturally. Plants have been collected from widely scattered points in South Africa representing in most instances markedly different veld types and soil conditions, e.g. Onderstepoort (Turf Thornveld), Rustenburg and Vaalwater

(Mixed Bushveld); Harrismith (High Sourveld); Brandfort (Dry Cymbopogon-Themeda Veld), Adelaide (False Thornveld of the Eastern Province), Albany (Valley Bushveld), East London (Coastal Forest and Thornveld) and Thornhill (Alexandria Forest). The site of plant collections is indicated in this table. Plants like the *Crotalaria* spp., *Vicia varia* and *Salsola kali* have been included for a comparison within the table. They will be omitted from the calculations which follow since they are not typical of the area concerned (e.g. *Crotalaria* or *Vicia*) or are exceptional with respect to their behaviour towards selenium.

The percentage distribution of selenium in the plants contained in Appendices 3 to 7 is taken together in Table 33 for ready comparison.

TABLE 33.—*The percentage distribution of selenium in the vegetation of areas where geeldikkop and enzootic icterus are rife and areas where the diseases do not occur naturally*

	Fraserburg Showgrounds (Appendix 3)	Farms on which enzootic icterus is severe (Appendix 4)	Farms on which geeldikkop is severe (Appendix 5)	Farms on which geeldikkop occurs sporadically (Appendix 6)	Areas in which geeldikkop and enzootic icterus do not occur (Appendix 7)
Percentage of plants containing more than 30 μg Se per gm.....	2·5	4·2	4·3	0	0
Percentage of plants containing from 10–30 μg Se per gm.....	25·6	10·6	21·7	7·1	0
Percentage of plants containing from 5–10 μg Se per gm.....	28·2	19·1	21·7	14·2	22·2
Percentage of plants containing less than 5 μg Se per gram.....	43·5	65·9	52·1	78·5	77·7
Number of specimens....	39	94	23	56	54

There appears to be a definite correlation between the selenium content of the vegetation and the occurrence of geeldikkop and enzootic icterus in the areas concerned. Where enzootic icterus alone occurs (Fraserburg) or where cases of the mixed syndrome are common (Vosburg) a significantly higher percentage of the vegetation contains more than 10 μg Se per gm than on farms where only geeldikkop is known (Beaufort West). Similarly the percentage of plants containing less than 5 μg Se per gm is significantly lower on the former group of farms than on those where only geeldikkop occurs. These findings are consistent with the severity of the histo-pathological changes and biochemical disturbance observed in the two conditions. Enzootic icterus is the more severe and rapidly fatal of the two syndromes (Brown, 1962, 1963, 1964, 1966; Brown & de Wet, 1962; Brown & de Boom, 1966).

The percentage of plants which contain more than 10 μg Se per gm is significantly higher in areas where only geeldikkop or enzootic icterus or the mixed syndrome occur in a severe form than in areas where the diseases are not established.

The same percentage constitutes the major difference between areas in which geeldikkop occurs sporadically and those in which it is unknown. Where geeldikkop and enzootic icterus occur in severe annual epizootics there is a significantly higher percentage of plants containing more than 5 μg Se per gm than in areas free of these conditions or those in which geeldikkop makes a sporadic appearance. The latter two areas are marked by a significantly higher percentage of plants containing less than 5 μg Se per gm than those in which the incidence of the two conditions is regularly high.

When all the data given in this paper are considered there appears to be little correlation between the veld types represented in the areas covered by this investigation, the selenium content of the respective vegetation and the incidence of geeldikkop or enzootic icterus. When any particular veld type is, however, severely mismanaged inferior, unpalatable and undesirable plants often invade and assume a dominant role in the plant associations concerned (Brown, 1959a; Brown & de Boom, 1966). These latter plants include many of those in Groups 1 and 2 of our classification. There is thus a correlation between mismanaged veld types and the incidence of the disease conditions.

Many of the figures for selenium which we have cited in this report may be lower than they actually should be. Rosenfeld & Beath (1964) have indicated quite clearly that native seleniferous vegetation may lose considerable amounts of selenium from the time it is collected until it becomes air dry. Owing to the extremely large number of samples involved in this work there was a considerable time lapse between collection of the plants and the completion of the last analysis. A number of specimens or the only specimen of each species, as the case may be, were analysed first and the bulk of specimens of each species (where many such specimens were involved) were done subsequently. This may account for some discrepancies such as the very high values and very low values found for specimens of the same species often from the same farm, e.g. in the case of *Chrysocoma tenuifolia*, the *Eriocephalus* and the *Nestlera* spp.

Summary

The selenium content of the vegetation of the Karoo has been investigated. It is clear that given suitable conditions numerous species of plants in this area can take up moderate to dangerous amounts of the element. A tentative classification of these plants on the basis of apparent selenium uptake has been attempted. Correlation between selenium content of the vegetation and the incidence of geeldikkop and enzootic icterus is demonstrated. The effects of veld mismanagement in relation to these disease problems are indicated.

Acknowledgements

We are most grateful to the Chief and staff of the National Herbarium, Division of Botany, Pretoria, for performing most of the hundreds of identifications of the specimens used in this work. A number of specimens were also identified for us by members of the staffs of the Fauresmith Veld Reserve and the Department of Botany, Rhodes University College, Grahamstown. Mr. Lloyd Whitlock of Victoria West identified many of the plants collected from this and the Fraserburg area and assisted materially in locating many plants for us which we particularly wanted to include in this survey.

Dr. M. Terblanche of the Department of Toxicology, Onderstepoort, was one of our most enthusiastic collectors during this survey and was responsible for sorting, preserving and cataloguing most of our specimens. He and Dr. T. W. Naude of the same Department have maintained our collection of specimens as part of their herbarium and have contributed much of the material from parts other than the Karoo.

Veterinarians M. J. Taylor, B. Weaver and T. Foulkes did most of the *spade work* involved in the collection of our Karoo specimens whilst still students at this Institute. We are most grateful to them for the tremendous amount of assistance which they gave us during a time when they should have been enjoying their normal summer vacations.

Drs. K. M. van Heerden, M. van Tonder, C. Wilkins and F. St. J. van der Riet of the Department of Veterinary Field Services and Private Practitioner D. J. Thornton of Graaff-Reinet are thanked for the very material assistance which they gave at various times during this work.

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APPENDIX 1

CLASSIFICATION OF KAROO VEGETATION ACCORDING TO APPARENT UPTAKE OF SELENIUM. (AS JUDGED BY SELENIUM CONTENT)

Group 1: selenium "converter" or indicator plants (Se content 400 μg/gm). None have as yet been found in South Africa.

Group 2: Secondary selenium absorbers (Se content 30–400 μg/gm).

Crotalaria podocarpa
C. lotoides
C. damarensis
Possibly other Crotalarias as well
Galenia pubescens
Chrysocoma tenuifolia
C. coma-aurea
Eriocephalus ericoides
Nestlera prostrata
Pteronia glauca

Group 3: Accumulators of low but significant concentration of selenium under a variety of circumstances (Se content 0–30 μg/gm).

The subgroups which follow are highly tentative and will probably be amended when more information is available.

Subgroup (a): Plants which show consistently high values for selenium in a number of specimens. (These are therefore all considered potentially dangerous plants in this respect).

Atriplex nummularia
A. capensis
Salsola kali
Kochia pubescens
Lepidium divaricatum
Galenia africana
Psilocaulon absimile
Tetragonia arbuscula
Arthrosolen polycephalus
Euryops laterifolius
Geigeria africana

Subgroup (b): Plants in which a few specimens amongst a number were found to have a selenium content of 10–30 *μg/gm or plants in which the few specimens examined fell within this range.* (The former may thus be potentially dangerous under certain, and probably special, circumstances. Too little information is available to place the latter types accurately. These are indicated with an asterisk).

*Digitaria eriantha**
*Eragrostis lehmanniana**
*Panicum makarikariensis**
*Cenchrus ciliare**
Setaria sp.*
Asparagus suaveolens
*Viscum rotundifolium**
Atriplex inflata
Salsola tuberculata
S. glabrescens
*S. nigrescens**
*Chenopodium album**
*Sueda fruticosa**
Limaeum aethiopicum
*Argemone mexicana**
*Cadaba juncea**
*C. aphylla**
*Sisymbrium burchelli**
*Galenia procumbens**
Delosperma sp.*
*Melolobium calycium**
*Lessertia annularis**
*Lebeckia spinescens**
*Medicago sativa**
*Lotononis divaricata**
*Sutherlandia microphylla**
*Zygophyllum gilfillani**
Z. microphyllum
*Z. microcarpum**
*Melianthus comosus**
*Malva parviflora**
*Microloma massonii**
*Convolvulus ulosepalus**
*Anchusa capensis**
*Aptosimum leucorrhizum**
*A. marlothii**
*Rhigozum trichotomum**
*Cucumis leptodermis**
*Nenax microphylla**
Eriocephalus spinescens
*Euryops multifidis**
*E. racemosus**
*Nestlera conferta**
*Osteospermum scariosum**
Pentzia incana
P. spinescens
*Pteronia glaucescens**
Pteronia mucronata
*Pteronia paniculata**
Hertia pallens
*Berkheya heterophylla**
Senecio burchelli
*Phymaspermum parviflorum**
*Amellus strigosus**
*Cineraria aspera**
*Gamolepis chrysanthemoides**
*Lasiospermum bipinnatum**
*Parthenium argentatum**
*Schinus molle**
*Euclea ovata**
Royena sp.*

Subgroup (c): Plants in which the selenium content of a few specimens amongst a number was found to be in the order of 5–10 *μg/gm or plants in which the few specimens examined fell within this range.* (The former might be dangerous under special circumstances, particularly if ingestion is continuous. Too little information is available to place the latter types accurately. These are indicated with an asterisk as before.)

*Chloris gayana**
*Eragrostis superba**
Hordeum sp.*
*Phragmites communis**
*Themeda triandra**
*Androcymbium melanthoides**
*Atriplex mulleri**
*A. semibaccata**
*A. vestita**
†*Salsola geminiflora**
*S. aphylla**
*S. rabieana**
*Phaeoptilum spinosum**
††*Aridaria* sp.
*Hyperstelis verrucosa**
*Plinthus karooicus**
*Lessertia pauciflora**
††*Tribulus terrestris*
*Melianthus major**
*Sebaea compacta**
*Asclepias fruticosa**
*Lithospermum cinereum**
Hermannia desertorum
*H. coccocarpa**
*H. pallens**
*H. linearifolia**
*Lycium oxycladum**
*Rhigozum abovatum**
Eriocephalus glaber
*E. pubescens**
*Euryops oligoglossus**
*E. sulculatus**
Nestlera humilis
*Osteospermum muricatum**
O. spinescens
Pentzia globosa
*P. punctata**
P. sphaerocephala
Pteronia glomerata
Aster muricatus
*Berkheya onopordifolia**
*Gazania krebsiana**
*Pegolettia retrofracta**

(† This plant showed values within this range in all specimens examined.
†† One value higher than the range was found amongst a number of specimens).

Group 4: Plants which appear to take up negligible amounts of selenium under normal conditions in the Karoo. (Se content 2 μg/gm.)

Aristida spp.?
Bromus catharticus?
Schismus spp.?
Sporobolus spp.?
Tetrachne dregei?
Tragus koelerioides?
Mesembryanthemum spinosum
†*Mesembryanthemum* spp.
Melolobium candicans
Walafrida basutica
W. geniculata
W. paniculata
W. saxatilis
Lightfootia nodosa
L. tenella
Helichrysum anomalum
H. hamulosum
H. lucilioides
H. parviflorum
H. pentzioides
H. zeyheri
Asaemia axillaris
Elytropappus rhinocerotis

(† Isolated values of up to 10 μg/gm have been found in some species, e.g. *M. saxicolum*, *M. spinescens*.)

Appendix 2

Selenium Content of the Vegetation of the Fauresmith Veld Reserve

(All results are expressed as micrograms selenium per gram of dried plant material)

Plant	*μg Se*	*Plant*	*μg Se*
Eriocephalus ericoides	28·0	*Galenia africana*	15·5
Cenchrus ciliare	29·6	*Limaeum aethiopicum*	15·5
Tetragonia arbuscula	25·4	*Salsola glabrescens*	15·5
Atriplex capensis	24·0	*Panicum makarikariensis*	15·5
Atriplex capensis	22·6	*Sutherlandia microphylla*	14·0
Eragrostis lehmanniana	22·6	*Nestlera prostrata*	14·0
Tribulus terrestris	21·2	*Atriplex nummularia*	14·0
Salsola nigrescens	18·5	*Tetragonia arbuscula*	14·0
Zygophyllum gilfillani	18·5	*Digitaria eriantha*	12·7
Euryops multifidus	17·0	*Lessertia* sp.	12·7
Euryops racemosus	17·0	*Hertia pallens*	11·5
Parthenium argentatum	17·0	*Nenax microphylla*	11·5
Lotononis divaricatum	17·0	*Nenax microphylla*	10·0

Plant	*μg Se*
Geigeria africana	10·0
Mesembryanthemum saxicolum	10 0
Pentzia incana	8·5
Pentzia globosa	8·5
Eriocephalus spinescens	8·5
Hermannia pallens	8·5
Hermannia coccocarpa	8·5
Phaeoptilum spinosum	8·5
Atriplex mulleri	8·5
Salsola rabieana	8·5
Psilocaulon absimile	7·0
Osteospermum muricatum	7·0
Pentzia sphaerocephala	7·0
Walafrida geniculata	5·8
Talinum caffrum	5·8
Pentzia sp.	5·8
Chloris gayana	5·8
Themeda triandra	5·8
Salsola tuberculata	5·8
Atriplex semibaccata	4·5
Asparagus suaveolens	4·5
Pennisetum sphacelatum	4·5
Eragrostis superba	4·5
Nestlera conferta	4·5
Osteospermum spinescens	4·5
Phymaspermum parviflorum	4·5
Phymaspermum parviflorum	3·0
Nestlera humilis	3·0
Eriocephalus glaber	3·0
Hermannia linearifolia	3·0
Tribulus terrestris	3·0
Melolobium candicans	3·0
Tragus koelerioides	3·0
Tetrachne dregei	3·0
Eragrostis truncata	1·0
Tetragonia schenkii	0·0
Chrysocoma tenuifolia	0·0
Chrysocoma tenuifolia	0·0
Helichrysum anomalum	0·0
Helichrysum anomalum	0·0
Helichrysum parviflorum	0·0
Helichrysum zeyheri	0·0

APPENDIX 3

SELENIUM CONTENT OF THE VEGETATION OF THE FRASERBURG SHOWGROUNDS

(All results are expressed as micrograms selenium per gram of dried plant material)

Plant	*μg Se*
Atriplex suberecta	53·4
Tetragonia arbuscula	22·6
Schinus molle	17·0
Tribulus terrestris	15·5
Aptosimum leucorrhiza	14·0
Salsola kali	11·5
Atriplex inflata	11·5
Setaria sp.	11·5
Malva parviflora	10·0
Convolvulus ulosepalus	10·0
Lasiospermum bipinnatum	10·0
Lycium oxycladum	8·5
Aridaria sp.	8·5
Osteospermum spinescens	8·5
Gazania krebsiana	8·5
Eriocephalus ericoides	7·0
Psilocaulon absimile	7·0
Hordeum sp.	5·8
Eragrostis lehmanniana	5·8
Aridaria sp.	5·8
Pentzia globosa	5·8
Galenia sarcophylla	5·6
Senecio niveus	4·5
Aptosimum leucorrhiza	4·5
Arthrosolen polycephalus	4·5
Psilocaulon absimile	4·5
Atriplex semibaccata	4·5
Sporobolus sp.	4·5
Bromus catharticus	3·0
Chenopodium murale	3·0
Lepidium divaricatum	3·0
Zygophyllum microphyllum	3·0
Pentzia albida	3·0
Aridaria sp.	1·5
Lessertia inflata	1·0
Radyera urens	1·0
Selago albida	1·0
Schismus sp.	0·0
Aster hyssopifolius	0·0

APPENDIX 4

SELENIUM CONTENT OF THE VEGETATION ON THE FARMS DAGGAFONTEIN, KLIPFONTEIN AND AVONDRUS (FRASERBURG DISTRICT)

(All results are expressed as micrograms selenium per gram of dried plant material)

Plant	*μg Se*
Chrysocoma tenuifolia	59·0
Chrysocoma coma-aurea	53·4
Pteronia glauca	41·0
Nestlera prostrata	31·0
Cineraria aspera	21·2
Lessertia annularis	19·8
Aridaria sp.	18·9
Atriplex nummularia	15·5

Plant	*μg Se*
Chrysocoma tenuifolia	13·0
Microloma massonii	11·5
Tetragonia arbuscula	10·0
Medicago sativa	10·0
Pteronia paniculata	10·0
Euryops laterifolia	10·0
Euryops laterifolia	8·5
Eriocephalus ericoides	8·5
Eriocephalus ericoides	8·5
Aridaria sp.	8·5
Pentzia punctata	8·5
Hermannia coccocarpa	7·0
Sebaea pentandra	7·0
Pteronia mucronata	7·0
Pteronia mucronata	7·0
Pteronia paniculata	7·0
Eriocephalus pubescens	7·0
Hermannia linearis	7·0
Tetragonia arbuscula	7·0
Phragmites communis	7·0
Aridaria sp.	5·8
Elytropappus rhinocerotis	5·8
Euryops oligoglossus	5·8
Aridaria sp.	5·8
Pteronia tricephala	4·5
Chrysocoma tenuifolia	4·5
Chrysocoma tenuifolia	4·5
Chrysocoma tenuifolia	4·5
Chrysocoma peduncularis	4·5
Pentzia globosa	4·5
Elytropappus rhinocerotis	4·5
Eriocephalus ericoides	4·5
Hermannia desertorum	4·5
Melolobium candicans	4·5
Melolobium candicans	4·5
Salsola tuberculata	4·5
Aridaria sp.	3·0
Melolobium candicans	3·0
Osteospermum leptolobum	3·0
Pentzia spinescens	3·0
Pteronia glomerata	3·0
Dispyros austro-africanus	3·0
Pteronia tricephala	3·0
Pteronia mucronata	3·0
Pteronia mucronata	3·0
Euryops sp.	3·0
Eriocephalus ericoides	3·0
Eriocephalus spinescens	3·0
Chrysocoma tenuifolia	3·0
Melolobium candicans	3·0
Pteronia glomerata	2·4
Pentzia spinescens	1·5
Osteopermum leptolobum	1·5
Chrysocoma tenuifolia	1·5
Aristida namaquensis	1·0
Salsola glabrata	1·0
Eriocephalus ericoides	1·0
Pteronia mucronata	1·0
Pteronia tricephala	1·0
Pteronia glaucescens	1·0
Pteronia glaucescens	1·0
Osteospermum leptolobum	1·0
Lessertia annularis	1·0
Pentzia globosa	1·0
Nestlera humilis	1·0
Pteronia tricephala	0·0
Pteronia tricephala	0·0
Pteronia mucronata	0·0
Pteronia mucronata	0·0
Pteronia glauca	0·0
Pentzia sp.	0·0
Pentzia sp.	0·0
Pentzia punctata	0·0
Nestlera prostrata	0·0
Salsola tuberculata	0·0
Salsola tuberculata	0·0
Helichrysum hamulosum	0·0
Chrysocoma tenuifolia	0·0
Chrysocoma tenuifolia	0·0
Chrysocoma coma-aurea	0·0
Hermannia pallens	0·0
Lightfootia nodosa	0·0
Aridaria sp.	0·0
Osteospermum leptolobum	0·0
Tribulus terrestris	0·0
Elytropappus rhinocerotis	0·0

Appendix 5

Selenium Content of the Vegetation of the Farm Mierfontein (Vosburg District)

(All results are expressed as micrograms selenium per gram of dried plant material)

Plant	*μg Se*
Salsola tuberculata	31·0
Asparagus suaveolens	28·0
Pteronia sp.	18·4
Hertia pallens	15·5
Lebeckia spinescens	12·7
Psilocaulon absimile	11·5
Lithospermum cinereum	8·5
Lebeckia spinescens	8·5
Arthrosolen polycephalus	8·5
Salsola geminiflora	7·0
Pegolettia retrofracta	7·0
Eriocephalus ericoides	4·5
Zygophyllum microphyllum	3·0
Chrysocoma tenuifolia	3·0
Helichrysum sp.	3·0
Pteronia glauca	3·0
Hertia pallens	3·0
Aptosimum spinescens	1·0
Helichrysum luciloides	1·0
Nestlera humilis	1·0
Pentzia spinescens	1·0
Hertia pallens	0·0
Berkheya pinnatifida	0·0

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Appendix 6

Selenium Content of the Vegetation of the Farms Aar Doorns, Toornitzkuil, Nuwejaarskraal, Remainder and Luttig (Beaufort West District)

(All results are expressed as micrograms Selenium per gram of dry plant material)

Plant	μg Se
Cucumis leptodermis	21·2
Psilocaulon absimile	10·0
Zygophyllum microphyllum	10·0
Pentzia incana	10·0
Atriplex semibaccata	8·5
Nestlera prostrata	8·5
Osteospermum muricatum	8·5
Asparagus suaveolens	7·0
Pteronia sp.	7·0
Psilocaulon absimile	5·8
Melolobium candicans	5·8
Asaemia axillaris	5·8
Salsola tuberculata	4·5
Salsola sp.	4·5
Atriplex semibaccata	4·5
Chenopodium sp.	4·5
Atriplex nummularia	3·0
Limaeum aethiopicum	3·0
Tribulus sp.	3·0
Tribulus sp.	3·0
Aptosimum spinescens	3·0
Walafrida saxatilis	3·0
Helichrysum sp.	3·0
Pentzia sphaerocephala	3·0
Pteronia sp.	3·0
Pteronia sp.	3·0
Asaemia axillaris	3·0
Nestlera humilis	1·0
Senecio burchelli	1·0
Dipcadi crispum	0·0
Asparagus suaveolens	0·0
Salsola tuberculata	0·0
Salsola tuberculata	0·0
Salsola glabrescens	0·0
Kochia pubescens	0·0
Mesembryanthemum spinosum	0·0
Mesembryanthemum spinosum	0·0
Zygophyllum microphyllum	0·0
Chrysocoma tenuifolia	0·0
Eriocephalus ericoides	0·0
Eriocephalus spinescens	0·0
Walafrida saxatilis	0·0
Nestlera prostrata	0·0
Nestlera prostrata	0·0
Nestlera prostrata	0·0
Osteospermum muricatum	0·0
Pentzia incana	0·0
Pentzia incana	0·0
Pentzia incana	0·0
Berkheya pinnatifida	0·0
Pteronia glauca	0·0
Asaemia axillaris	0·0
Asaemia xaillaris	0·0
Aster muricatus	0·0
Senecio burchelli	0·0
Senecio niveus	0·0

Appendix 7

Selenium Content of Plants collected from Localities in which Geeldikkop and Enzootic Icterus do not occur naturally

(All results are expressed as micrograms Selenium per gram of dry plant material)

Plant	μg Se
Crotalaria lotoides[1]	34·0
C. podocarpa[1]	28·0
C. damarensis[1]	28·0
Salsola kali[2]	12·7
Vicia varia[1]	10·0
Crotalaria juncea[1]	8·5
Foeniculum vulgare[1]	8·5
Cliffortia linearifolia[3]	8·5
Rhus lancea[4]	8·5
Sesbania bispinosa[5]	8·5
Sesbania bispinosa[5]	8·5
Lantana camara[1]	7·5
Medicago sativa[1]	7·0
Acacia karroo[4]	7·0
Matricaria nigellaefolia[6]	7·0
Acacia tortilis[4]	5·8
Osteospermum ecklonis[1]	5·8
Lippia rehmanni[1]	5·0
Osteospermum sp.[2]	4·5
Dactylis glomerata[3]	4·5
Rhoicissus sp.[7]	4·5
Euclea sp.[4]	4·5
Senecio retrorsus[8]	4·5
Brassica chinensis[1]	3·0
Chicorium intybus[1]	3·0
Panicum laevifolium[3]	3·0
Mesembryanthemum sp.[4]	3·0
Matricaria nigellaefolia[7]	3·0
Tribulus terrestris[1]	1·0
Tribulus terrestris[1]	1·0

Footnote.—The origin of the plants in the above table is identified as follows: [1] = Onderstepoort; [2] = Valerie, Brandfort; [3] = Cypherfontein, Thornhill; [4] = Nooitgedacht, Rustenburg; [5] = Famona, Bulawayo; [6] = One Oak, Adelaide; [7] = Nurney, Albany; [8] = East London district; [9] = Middeldeel, Harrismith and [10] = Vaalwater district.

Plant	*μg Se*	*Plant*	*μg Se*
Senecio burchelli[2]	1·0	*Parinari capense*[10]	0·0
Acacia giraffae[1]	1·0	*Protea tenex*[7]	0·0
Grewia flavacana[1]	1·0	*Tribulus terrestris*[2]	0·0
Senecio concolor[8]	1·0	*Tribulus terrestris*[1]	0·0
Aster filifolius[7]	1·0	*Osteospermum ecklonis*[1]	0·0
Aster filifolius[1]	1·0	*Mentha spicata* var. *crispum*[1]	0·0
Matricaria nigellaefolia[6]	1·0	*Thymus vulgaris*[1]	0·0
Pygmaeothamnus zeyheri[10]	1·0	*Salvia officinalis*[1]	0·0
Pygmaeothamnus zeyheri[10]	1·0	*Ocimum basilicum*[1]	0·0
Fadogia monticola[10]	0·0	*Solanum auriculatum*[1]	0·0
Matricaria nigellaefolia[7]	0·0	*Borago officinalis*[1]	0·0
Erica demissa[7]	0·0	*Pentzia* sp.[2]	0·0
Ochna pulchra[10]	0·0	*Nestlera* sp.[2]	0·0
Securidaca longipedunculata[10]	0·0	*Themeda triandra*[2]	0·0
Burkea africana.[10]	0·0	*Digitaria* sp.[2]	0·0

Appendix 8

Common Names of the Plants discussed in this Paper

Acacia giraffae	Kameeldoring.
A. karoo	Soetdoring.
A. tortilis	Haak-en-Steek.
Amellus strigosus	Bloublom, Kalkbloublom(metjie).
Anchusa capensis	Forget-me-not, Ostong.
Androcymbium melanthioides	Bobbejaanskoen, Patrysblom.
Anthospermum dregei	Granaatbos.
Aptosimum depressum	Brandbossie, Carpet plant, Karooviolet, Seeroogbossie.
A. leucorrhizum	
A. marlothii	Koffiepit-(karo), Koffiekaro.
A. spinescens	
Argemone mexicana	Bathurst burweed, Bloudissel, Mexican poppy, Steekbossie.
Aridaria sp.	Brakslaai, Kanna, Kougoed, Wit vygie.
Aristida ciliata	Bushman grass, Boesmangras, Twagras(s).
A. congesta	Aapstertsteekgras, Buffalo grass, Duin(e) steekgras, Klossaad, Kortbeensteekgras, Long steekgras, Steekgras, Stickgrass, Rotstertsteekgras, White Steekgras.
A. namaquensis	Bamboo aristida, Bamboo grass, Bushman Quick, Hay grass, Heidegras, Hooigras, Steekgras, Steekkweek, Steekriet, Ysterkweek, Vleigras.
A. obtusa	Beesgras, Bushman grass, Fyntwa(gras), Gemsbokgras, Kleinboesmansgras, Kliptwa(gras), Kortbeenboesmansgras, Kortbeentwa(gras), Twa(gras).
Arthrosolen polycephalus	Besembos, Januariebos.
Asaemia axillaris	Vuursiektebos.
Asclepias fruticosa	Firesticks, Gansies, Milkweed, Melkbos, Tontelbos, Wild cotton, Wildekapok.
Asparagus suaveolens	Katdoring, Katstert.
Aster barbatus	Bloublom(metjie), Groot bloublommetjie.
A. filifolius	Draaibos, Gombos, Noembossie, Pers draaibos, Wilde roosmaryn.
Aster hyssopifolius	
A. muricatus	Bloublommetjie.
Atriplex capensis	Australian saltbush, Australiese soutbos, Vaalbrak.
A. inflata	
A. mulleri	Queensland saltbush.
A. nummularia	Australian saltbush, Australiese soutbos, Brakbos, Oldman saltbush, Oumansoutbos, Saltbush.
A. semibaccata	Amper lusern, Creeping saltbush, Kruipsoutbos, Wilde lusern.
A. suberecta	
A. vestita	Brakbos, Salt bush, Vaalbrak.

Berkheya heterophylla	Dissel.
B. onopordifolia	Dissel.
B. pinnatifida	Dissel, Wilde karmedik.
Borago officinalis	Borage.
Brassica chinensis	Chinese cabbage.
Bromus catharticus	Beesgras, Bronchogras, (Hang) hawergras, Maandgras, Osgras, Perdegras, Pienaarsgras, Reddingsgras, Rysgras, Soetgras, Tuingras, van der Merwegras, Wintergras.
Burkea africana	Sandsering, Wilde sering, Wild syringa.
Cadaba aphylla	
C. juncea	Swartstorm.
Carissa haematocarpa	Noem-noem, Num-Num.
Chenopodium album	Goosefoot, Hondepisbossie, Varkbossie, White goosefoot.
C. murale	Gansvoet, Goosefoot.
Chicorium intybus	Chicory, Sigorei.
Chloris gayana	Rhodes grass(-gras), Rhodesian Blue grass.
Chrysocoma coma-aurea	Beeskaroo, Bergbitterbos, Groot bitterbos.
C. tenuifolia	Beesbos, Bitterbos, Bitterkaro, Hantamkaroo.
Cineraria aspera	
Cliffortia linearifolia	
C. ulosepalus	
Crotalaria damarensis	
C. juncea	Sunn Hemp, Sunn hennep.
C. lotoides	
C. podocarpa	
Cucumis leptodermis	Bitterappeltjie, Bitter apple, Bitter komkommer(-tjie), Gifappeltjie, Wild cucumber, Wilde komkommer(-tjie).
Dactylis glomerata	Akaroa, Cocksfoot, Kropaar(gras), Orchard grass.
Danthonia stricta	Bokbaard(-gras), Olifantsgras, Suurpol.
Delosperma sp.	Donkievygie, Skaapvygie.
Digitaria eriantha	Bloukruisgras, Fingergrass, Hoenderspoor, Kruisgras, Vingergras.
Digitaria sp.	Vingergras.
Diospyros austro-africana	Jakkalsbessie.
Dipcadi crispum	Gifbol, Malkopui.
Ehrharta calycina	Polgras, Rooisaadgras.
Elytropappus rhinocerotis	Renosterbos (bush).
Eragrostis lehmanniana	Blousaad(gras), (Blou) soetgras, Eastern Province vlei grass, Growwe vleigras, Klein soetgras, Knietjiesgras, Litjiesgras, Lovegrass, Vleigras.
E. superba	Buffelsgras, Hartjiesgras, Heartseed grass, Knoppiesgras, Lovegrass, Plakkiesgras, Platsaad(gras), Soetgras, Visgras, Weeluis(saad)gras.
E. truncata	Bloupolgras, Kalkkweek.
Eragrostis sp.	Oulandsgras, Lovegrass.
Erica demissa	
Erigeron floribundus	
Eriocephalus ericoides	Draaibos, Kapokbos, Regte kapok.
E. glaber	Bitterbos, Bitterkaro, Kapokbos.
E. pubescens	Kapokbos.
E. spinescens	Doringkapok, Kleinkapok, Veerkapok, Veerkaro.
Euclea ovata	Ghwarriebos.
Euryops candollei	Harpuisbos.
E. lateriflorus	Bergharpuis, Harpuisbos.
E. multifidis	Harpuisbos, Geelmagriet, Sandharpuis, Soetharpuis, Resinbush.
E. aligoglossus	Resinbush, Waterharpuis.
E. racemosus	Bitterharpuis, Waterharpuis.
Euryops sulculatus	
Euryops sp.	Harpuis.
Fadogia monticola	
Foeniculum vulgare	Fennel, Vinkel.
Galenia africana	Geelbos, Kraalbos, Waterpensbos(sie).
G. procumbens	Bekkerbos, Kraalbossie, Waterpensbossie.
G. pubescens	Brakbossie.

G. sarcophylla	Joubertsbrak, Koggelmandersvoet, Perslein, slaai, Van Wykshout.
Gamolepis chrysanthemoides	
Gazania krebsiana	Botterblom, Buttercup, Gousblom.
Geigeria africana	Vermeerbos.
G. aspera	Vermeerbos.
G. passerinoides	Vermeerbos.
G. pectidea	Vermeerbos.
G. zeyheri	Vermeerbos.
Gnaphalium purpureum	Cudweed, Roerkruid.
Grewia flavacana	Rosyntjiebos.
Gymnosporia buxifolia	Lemoendoring, pendoring.
Helichrysum anomalum	
H. hamulosum	
H. lucilioides	Bergkerrie(bos), Bokboegoe, Sewejaartjie.
H. parviflorum	
H. pentzioides	Everlasting, Kerriebos, Rivierdraaibos, Vaalbos.
H. zeyheri	Bergkaro, Sewejaartjie, Vaalbergkaro.
Hermannia coccocarpa	Ouma-se-kappie.
H. desertorum	
H. linearifolia	Pleisterbossie, Rooipleisterbos.
H. pallens	Geelpleisterbos.
Hertia cluytiaefolia	Ertjiebos.
H. pallens	Springbokbos(-kos).
Hordeum sp.	Barley, Gars (wild or wilde-).
Hyperstelis verrucosa	Braksuring.
Indigofera alternans	Wilde ertjie.
Kochia pubescens	Ink-bush/bos, Swartganna.
Lantana camara	Tick-berry.
Lasiospermum bipinnatum	Ganskweek.
Lebeckia spinescens	Ertjiebos.
Lepidium divaricatum subsp. *linioides*	
L. divaricatum	Cape cress, Cape pepper, Sterkgras, Sterkkos.
Lessertia annularis	Krimpsiektebos(sie).
L. inflata	
L. pauciflora	Kankerbossie, Kleingansie.
Lightfootia nodosa	Muistepelkaro.
L. tenella	Muistepelkaro.
Limaeum aethiopicum	Koggelmandervoetkaro.
Lippia rehmanni	Beukesbossie.
Lithospermum cinereum	
Lobelia inflata	
Lolium sp.	Darnel, Drabok, Roggras, Ryegrass.
Lotononis divaricata	Karoo-ertjie, Rivierleeubekkie.
Lycium oxycladum	Kriedoring.
Malva parviflora	Cheesewood, Kaasie(s), Kaasieblaar, Kissieblaar, Mallow.
Matricaria nigellaefolia	Staggers weed, Stoot(siekte)bos(sie).
Medicago sativa	Alfalfa, lucerne, lusern.
Melianthus comosus	Kruidjie(Truitjie-)-roer-my-nie.
M. major	Kriekiebos, Kruidjiebos, Kruidjie-roer-my-nie.
Melolobium calycium	Gifseerbossie.
M. candicans	Boontjiekaroo, Geelheuningkaro, Heuningbossie.
Mentha longifolia	Kuisement, River mint, Wild mint.
M. spicata var. *crispum*	Curly mint, Garden mint, Kruisement.
Mesembryanthemum saxicolum	Klipvygie.
M. spinescens	Doringvygie.
M. spinosum	Doringvy(gie).
Mestoklema tuitum	Donkievygie.
Microloma massonii	Kannetjies.
Nemesia capensis	Weeskindertjies, Wit leeubekkie.
Nenax microphylla	Dagga(bos), Daggaputkaro, Granaatbos.
Nestlera conferta	Perde-bos (-kool, -karo).
N. humilis	Gemsbokkaro, Volstruiskaro.
N. prostrata	Bekkerbos, Hartebeeskaro, Perdebos, Roggebos.
Ocimum basilicum	Basil, Soetbalsemkruid, Steentiemie, Sweet basil.
Ochna pulchra	Lekkerbreek, Pypsteelhout.

Osteospermum ecklonis	Bietou, Van Stadens daisy.
O. leptolobum	Appelbos, Goudbos, Rivierdraaibos.
O. muricatum	Bermuda Brak.
O. scariosum	Doringbietou.
O. sinuatum	
O. spinescens	Appelbos, Draaibos.
Panicum laevifolium	Blousaad(gras), Bluegrass, Buffalo grass, Buffelsgras, Old land(s) grass, Oulandegras, Soetgras, Sweet grass, Vleigras.
P. makarikariensis	Buffalo grass, Buffelsgras.
Parinari capense	Sand apple.
Parthenium argentatum	Vaalkos.
Pegolettia retrofracta	Bergdraaibos.
Pennisetum cenchroides	Buffelsgras.
P. sphacelatum	Bulgras, Taaipol.
Pentzia albida var. *annua*	Stinkkruid.
P. calcarea	Bewerasiekaro, Meerkatkaro, Papkaro, Perdeflou, Slapkaro.
P. globosa	Bitterkaro, Gansiekaro, Goedkaroo, Grootblomkaro, Skaapbos, Vaalkaroobos, Vleikaroo.
P. incana var. *forma*	Ankerkaro, Goeie karo, Kleingansie, Kortbeenkaro, Skaapkaro.
P. incana	Ankerkaroo, Skaapbossie.
P. punctata	
P. spinescens	Karoo, Skaapbos(sie).
P. sphaerocephala	Berggansie(karoo), Bergkaroo, Groot berggansie.
Phaeoptilum spinosum	Brosdoring.
Phragmites communis	(Common) reed, Fluitjiesgras, (Fluitjies)riet, Vaderlandsgras.
Phymaspermum parviflorum	Swartkaroo, Vaalbos, Vaalkaroo, Wit heuningkaroo.
Plinthus karroicus	Karooganna.
Protea tenex	Suikerbos.
Psilocaulon absimile	Asbos, Litjiesbos, Loogbos, Lye-bush.
Pteronia glauca	Boegoekaroo, Perdekaroo, Spekbos, Springbokganna, Suikerkannetjie.
P. glaucescens	Geelbergdraaibos.
P. glomerata	Gombos, Swartbekbos.
Pteronia mucronata	
P. pallens	Aasvoëlbos, Scholtzbos, Witbossie, Witgatbossie.
P. paniculata	
P. tricephala	Biltongbos.
Pygmaeothamnus zeyheri	Goorappel.
Rhigozum obovatum	Driedoring, Geelberggranaat, Granaatbos.
R. trichotomum	Driedoring, Geelgranaat.
Rhoicissus sp.	
Rhus erosa	Besembos, Besemkaree, Soettaaibos.
R. lancea	Karee(boom).
R. undulata var. *burchelli*	Garra, Ghwarriebos(-hout), Koennibos, Taaibos.
Royena hirsuta	Kritikom.
R. pallens	Bloubos.
R. pubescens	Monkey apple, Tolbos, Tolletjie.
R. sp.	Bloubos.
Rumex lanceolatus	Sorrel, Suring.
Salsola aphylla	Brakganna, Soutganna.
S. geminiflora	
S. glabrescens	Beesganna, Rivierganna, Rooilootganna.
S. kali	Russian thistle, Russian tumbleweed, Saltwort, Rolbos.
S. nigrescens	Swartganna.
S. rabieana	Bloupanganna, Rabie se ganna.
S. tuberculata	Blomkoolganna.
S. zeyheri	Ganna.
S. sp.	Rooilootganna.
Salvia clandestina	Wilde salie.
S. officinalis	Sage, Salie.
S. rugosa	Grootblousalie, Jakob Jong, Vaaltee, Wilde salie.
Schinus molle	Peperboom, Pepper tree.
Schismus sp.	Haasgras.
Sebaea compacta	

S. pentandra	
Securidaca longipedunculata	Krinkhout.
Selago albida	Bergaarbossie, Suurkaroo, Witaarbossie.
Senecio burchelli	Ragwort, Sprinkaanbos.
S. concolor	
S. niveus	
Sesbania bispinosa	
Setaria sp.	Millet.
Sisymbrium burchelli	
Solanum auriculatum	Bug tree, Wild tobacco.
Sporobolus sp.	Dropseed gras, Fyn (blousaad) gras, Vleigras.
Stachys cuneata	
S. linearis = *S. rugosa*	Boesmantee, Wilde boesman.
S. spathula	
Sueda fruticosa	Ink (bush or -bos), Swartganna.
Sutera atropurpurea	Saffraan, Verfblommetjie, Verfbossie, Witheuningkaroo.
Sutherlandia microphylla	Cancerbush, Gansies, Klein kankerbos.
Talinum caffrum	Ystervarkbos.
Tetragonia arbuscula	Klappiesbrak, Groot rooilootganna.
T. schenkii	Klappiesbrak van Keetmanshoop.
Tetrachne dregei	Bill's cocksfoot, Fauresmith cocksfoot, Hoenderspoorgras, Kropaar(gras), Vreemde gras, Wildebees(te)gras.
Themeda triandra	Asgras, Hoëveld rooigras, Platgras, Red grass, Rooiangel, Rooi(saad)gras, Rooihawergras, Soetgras, Swartangel.
Thymus vulgaris	Thyme, Tiemie.
Tragus koelerioides	(Creeping) carrot (seed) grass, Goatsbeard, K(r)op(h)aar-(gras), Kruipgras, Kruipwortelsaad, Olifantskweek, Rooi-been(gras), Wortelsaad(gras).
Tribulus terrestris	Devil's thorn, Dubbeltjie(-doring), Duiweltjie(doring)(-s), Duifdoring, Môrester, Volstruisdoring.
Vicia varia	
Viscum rotundifolium	Mistel, Mistletoe, Voëlent.
Walafrida basutica	Bitter aarbossie, Witaar(bossie).
W. geniculata	Aarbossie, (Blou/Pers) aarbossie, Waterfinder.
W. paniculata	Witaarbossie.
W. saxatilis	Bitteraar(bossie), Cocoanutplantjie, Witaarbos.
Zygophyllum gilfillani	Spekbos.
Z. microphyllum	Jakkalspis, Trekbos, Ysterbos.
Z. suffruticosum	Groot-teebossie.